Multidisciplinary Strategies for Earthquake Hazard Mitigation — Earthquake Insurance

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SUMMARY REPORT
CUREe–Kajima Research Project
University of California, Berkeley

MULTIDISCIPLINARY STRATEGIES FOR EARTHQUAKE HAZARD MITIGATION — EARTHQUAKE INSURANCE

Henry J. Lagorio, Team Leader

INTRODUCTION
This project led to the preparation of five papers on various socioeconomic earthquake hazard mitigation issues. They include a discussion of earthquake insurance in the U.S., a summary of the socioeconomic impacts of several U.S. earthquakes, an examination of the decision-making processes involved in two base isolation decisions, a summary of design lessons learned by prominent earthquake engineers during their careers, a paper outlining a comprehensive approach to earthquake hazard mitigation, and a set of recommendations to improve knowledge transfer.

FIVE PAPERS

Earthquake Insurance

The report on earthquake insurance in the U.S. summarizes the current state of law, regulation, and practice in this field. It also describes some of the key policy issues now being debated at the state and national levels of government. The recently established earthquake insurance program in California, which is in its early stages of a difficult implementation, is also discussed in detail. The paper summarizes the content and recent history of earthquake insurance legislation which has been proposed in the U.S. Congress.

Socioeconomic Lessons

The paper on socioeconomic lessons learned examined data from five U.S. earthquakes (Great Alaska Earthquake of 1964, San Fernando Earthquake of 1971, Coalinga Earthquake of 1983, Whittier Narrows Earthquake of 1987, and the Loma Prieta Earthquake of 1989). In addition to some basic socioeconomic data about each of these earthquakes, the paper presents some general conclusions about formal and informal emergency response; casualties, rescue, and building occupant behavior; families and social groups; public information and the media; recovery and reconstruction; and other socioeconomic lessons learned.
Base-isolation Decision Making Process

Two buildings — one new and one old — have had base isolation foundation systems installed. The paper examining base isolation as an engineering innovation examined the decision-making processes involved in the two buildings. Its purpose was to identify the factors that favored the use of this innovation. Several were identified, including an organizational culture that encouraged innovation, internal leadership, agreement among members of the technical community, special considerations of the buildings themselves, economic justification, the existence of examples to learn from, and the presence of an effective decision-making process.

Lessons From Prominent Engineers

For several years, oral histories have been collected from U.S. leaders in earthquake engineering, earth sciences, and hazard reduction. This paper synthesizes some of the main conclusions drawn from the numerous and extensive interviews. Among the key subjects addressed are early professional development, influences on the design and construction processes, and the nature of engineering firms who have specialized in earthquake engineering.

Framework for a United Hazard Mitigation Strategy

The last paper, which builds on the Kajima Corporation's 1991 report, "Long Road, Earthquake Hazard Mitigation," discusses a framework for preparing a "unified hazard mitigation strategy." The concept is based on the need for the public, private firms, and government agencies to form a partnership to achieve mitigation. The paper notes the importance of various social and technical interdependencies, the role of knowledge of transfer in stimulating action, and how studies of innovation contribute to understanding how the process of adopting and implementing mitigation actions take place.

The recommendations resulting from the Year One work on knowledge transfer are included in the report, and they are being sent separately to a variety of professional and technical organizations. The CUREe-Kajima research team hopes that such organizations will implement and publicize the recommendations so that the application of research will be accelerated.

CONCLUSION

The Year Two papers are intended to support the Year Three project which focuses on the conceptual development of a "Socioeconomic Consequences Model." It is possible that such a model could be used for improving future earthquake loss estimates and planning scenarios; identifying cost-efficient mitigation measures; and rapidly estimating probable impacts of actual earthquakes to improve emergency response activities.
"CUREe-KAJIMA RESEARCH PROJECT"
Topic Number 8, Multidisciplinary Strategies

YEAR TWO FINAL REPORT

Submitted by
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EXECUTIVE SUMMARY

This Year Two report contains five papers on various socioeconomic earthquake hazard mitigation issues. They include a summary of the socioeconomic impacts of several U.S. earthquakes, a discussion of earthquake insurance in the U.S., one that examines the decision-making processes involved in two base isolation decisions, another that summarizes design lessons learned by prominent earthquake engineers during their careers, a paper outlining a comprehensive approach to earthquake hazard mitigation, and a set of recommendations to improve knowledge transfer that resulted from the Year One report.

The paper on socioeconomic lessons learned examined data from five U.S. earthquakes (Great Alaska Earthquake of 1964, San Fernando Earthquake of 1971, Coalinga Earthquake of 1983, Whittier Narrows Earthquake of 1987, and the Loma Prieta Earthquake of 1989). In addition to some basic socioeconomic data about each of these earthquakes, the paper presents some general conclusions about formal and informal emergency response; casualties, rescue, and building occupant behavior; families and social groups; public information and the media; recovery and reconstruction; and other socioeconomic lessons learned.

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how the process of adopting and implementing mitigation actions takes place.

The recommendations resulting from the Year One work on knowledge transfer are included in the report, and they are being sent separately to a variety of professional and technical organizations. The team hopes that such organizations will implement and publicize the recommendations so that the application of research will be accelerated.

These Year Two papers will support the Year Three project which focuses on the conceptual development of a "Socioeconomic Consequences Model." It is possible that such a model could be used for improving future earthquake loss estimates and planning scenarios; identifying cost-efficient mitigation measures; and rapidly estimating probable impacts of actual earthquakes to improve emergency response activities.

A technical report also will result from Year Three’s work. It will be based on a literature survey of manual and computer-based loss estimation techniques, suggestions of how to modify existing techniques to more realistically simulate socioeconomic phenomena, case study data to verify the recommended techniques, and final recommendations for the most appropriate techniques for evaluating the socioeconomic consequences of large earthquakes.

The Center for Environmental Design’s Research Team gratefully appreciates the continuing support of both the California Universities for Research in Earthquake Engineering (CUREe) and the Kajima Corporation, especially our counterpart project team led by Dr. Kaoru Mizukoshi, Chief Research Engineer, and his colleagues, Dr. Masamitsu Miyamura, Mr. Yoshikatsu Miura, Mr. Toshirou Yamada, Dr. Mitsuharu Nakahara, and Mr. Hiroshi Ishida.

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Mr. Stanley Scott, Research Political Scientist
SOCIOECONOMIC LESSONS LEARNED
FROM SELECTED U.S. EARTHQUAKES
1.0 INTRODUCTION AND OBJECTIVE

Systematic investigations of the social and economic impacts of U.S. earthquakes are a relatively recent phenomenon. While some very limited reports were done occasionally for earlier earthquakes, the Great Alaska Earthquake of 1964 inaugurated the modern era of postearthquake social science investigations. Especially since the 1971 San Fernando earthquake, social scientists have been regular members of postearthquake research and investigation teams. Only now is there beginning to emerge coherent data about the social and economic impacts of such events. Fortunately, social science studies of other disasters have a somewhat longer history (beginning in the mid-1950s). This research has provided useful data, analytical frameworks, research methods, and conclusions to support comparable investigations of earthquakes.

Five U.S. earthquakes have been selected as data sources for this report. This paper's objective is to synthesize the lessons learned about the socioeconomic impacts from these events. The selected events include the Great Alaska Earthquake of 1964, the San Fernando Earthquake of 1971, the Coalinga Earthquake of 1983, the Whittier Narrows Earthquake of 1987, and the Loma Prieta Earthquake of 1989.

Table 1.1 summarizes the major characteristics of these earthquakes. The material for this report was obtained from two principal sources: (1) studies of specific earthquakes, and (2) syntheses of lessons learned from several events (more than the five used here).

The fundamental lesson is that it is the failure of or damage to the works of man that cause social and economic disruption. Consequent social problems will be lessened to the degree that future damage can be eliminated through improved new construction or the strengthening or removal of older hazardous structures and facilities.

Figure 1.1, taken from a recently issued report by VSP Associates for the California Office of Emergency Services, is helpful in understanding the postearthquake time periods in which socioeconomic impacts occur and the length of time--possibly 10 years or more--that they might last.
### TABLE 1.1

**Socioeconomic Impacts of Selected U.S. Earthquakes**

<table>
<thead>
<tr>
<th>DATE</th>
<th>LOCATION</th>
<th>MAGNITUDE</th>
<th>DEATHS</th>
<th>INJURIES&lt;sup&gt;1&lt;/sup&gt;</th>
<th>ESTIMATED HOMELESS</th>
<th>LOSSES&lt;sup&gt;2&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 24, 1964</td>
<td>Alaska</td>
<td>8.4</td>
<td>115</td>
<td>200-300</td>
<td>Unknown</td>
<td>$335 million</td>
</tr>
<tr>
<td>February 9, 1971</td>
<td>San Fernando, CA</td>
<td>6.6</td>
<td>58</td>
<td>2,543</td>
<td>Unknown</td>
<td>$511 million</td>
</tr>
<tr>
<td>May 2, 1983</td>
<td>Coalinga, CA</td>
<td>6.7</td>
<td>0</td>
<td>200</td>
<td>1,000</td>
<td>$31 million</td>
</tr>
<tr>
<td>October 1, 1987</td>
<td>Whittier Narrows, CA</td>
<td>5.9</td>
<td>8</td>
<td>1,350</td>
<td>10,000</td>
<td>$350 million</td>
</tr>
<tr>
<td>October 17, 1989</td>
<td>Loma Prieta, CA</td>
<td>7.1</td>
<td>62</td>
<td>3,750</td>
<td>12,000</td>
<td>$6-10 billion</td>
</tr>
</tbody>
</table>

**FOOTNOTES**

1. Reported; many slight injuries are unreported.
2. In U.S. dollars at the time of the event.
2.0 LESSONS LEARNED

The most important lessons learned have been organized into six topics. Each one is discussed below, and the order of the subjects does not indicate any special importance. Also, many of these socioeconomic impacts are interactive and are difficult to separate. For example, damages to someone's dwelling and place of work can result in both individual and employer losses, the need for shelter and temporary housing, unemployment, and other consequences.

2.1 Formal and Informal Emergency Response.

1. Formal emergency plans and procedures and regular training of individuals and organizations helps assure the taking of effective emergency actions. However, they must be based on realistic concepts of how people and organizations behave in emergencies and what their needs usually are.

2. Communications systems are especially important to effective emergency response, but they are vulnerable to earthquake damage and overuse in times of crisis. This leads to difficulties in managing response forces and resources.

3. Damage assessment begins immediately and continues for a long time, with the assessments being continually refined. Uncoordinated damage assessments inhibit a clear understanding of the total problem, and therefore, impede recovery.

4. The effectiveness of emergency response plans and related efforts depends greatly on coordination with other levels of government and with key elements of the private sector, such as utilities, telephone, transportation, and other companies.

5. In the disaster area, new groups, largely composed of local residents and volunteers, emerge immediately to help victims and themselves without waiting for outside help to arrive.

6. The great majority of people act rationally and in socially helpful ways after a disaster, but such behavior may only last a short time as their personal needs take precedence in the face of limited resources.

7. People from outside the disaster area arrive to help, check on conditions, or to observe. Large quantities of donated materials may arrive in the area also. These can increase the problems for emergency response personnel as well as the local residents and officials.

8. Especially after a disaster, critical structures, such as hospitals, fire stations, potential shelters, communications facilities, utilities systems, and others, are of great importance to the community. It is important that such services be restored quickly or remain functional.
2.2 Casualties, Rescue, and Building Occupant Behavior

1. The numbers of deaths and injuries following earthquakes can be reduced by the ready availability and effectiveness of emergency services organizations, especially those responsible for fire protection, urban search and rescue, and emergency medical services.

2. The behavior of occupants of buildings during earthquakes is conditioned by who they are with, their companions’ behavior, their prior emergency experience and previous emergency training.

3. More research is needed on the actual and expected nature, distribution, rates, and types of injuries so that emergency medical response planning and search and rescue operations can be improved.

4. Volunteers and local residents save most lives by providing immediate search and rescue and medical attention. Specialized rescue organizations usually arrive later and undertake the more difficult rescues, but they are fewer in number.

2.3 Families and Social Groups

1. Immediately following earthquakes family members try to communicate with or locate other members, and the family unit becomes of paramount importance.

2. Except for those most severely effected, most households and families return to their normal routines within weeks after the earthquake.

3. There are economic winners and losers because an earthquake at least temporarily redistributes the stricken area’s income, expenses, and wealth. However, economic losses are spread unevenly, but are more visible in rural areas where there is no regional economy to absorb the losses or to provide resources.

4. While there are always problems associated with the administration of various disaster relief programs, most victims are highly satisfied with the services they receive.

2.4 Public Information and the Media

1. People need information following earthquakes, and they will seek it from many sources. Some of these may be more reliable than others. Television and radio are the most common sources of information.

2. Initial reports by the news media tend to focus on prominent ("newsworthy") cases of severe damage, and can overemphasize the general extent of damage in the area. People may think the event is a greater disaster than it really is.

3. The media can and does play an important educational role, but this service is secondary to news reporting, and may come too late and too infrequently to be of much use.
4. The media, if given good information in a useable format, can be of great help in communicating information about expected aftershocks, how to respond to them, and other emergency information.

2.5 Recovery and Reconstruction

1. If improved materials, construction practices, and building codes are used during reconstruction, cities are less vulnerable to damage from future earthquakes.

2. Money is the key to recovery. The availability and distribution of money for reconstruction largely determines what gets rebuilt or replaced first. The sources of such funds can be governmental, insurance payments, private savings, borrowing, or other mechanisms depending on the situation.

3. The ability to establish new earthquake hazard mitigation policies declines over time as communities desire to return to normal, other issues take precedence, and the memory of the earthquake recedes.

4. Changes in land use are possible in limited circumstances, but usually are restricted to relatively small areas, can be impeded by the existence of undamaged buildings, and often is a very controversial local issue.

5. The provision of temporary housing and the repair or replacement of permanent housing is one of the most critical issues to successful recovery. Without effective measures to provide housing, people will lose confidence in the ability to recover from an earthquake.

6. Community officials who are familiar with redevelopment authorities and programs are better able to initiate postearthquake reconstruction projects than those with limited redevelopment experience.

7. Like emergency planning, communities can develop plans for long term postearthquake recovery. Those that do will be better prepared to initiate effective programs and to take full advantage of outside sources of aid.

2.6 Other Socioeconomic Lessons

1. The ground effects of earthquakes can change legally defined property boundaries, leading to the need to resurvey such lands and reassess their market values and tax rates.

2. Community conflict over public access to the damaged areas to retrieve inventories, inspect properties and for other purposes, and the need by governmental officials to provide public safety in such areas will be a continuing problem.

3. It is very important that adequate numbers of trained engineers and building inspectors be available to inspect buildings and to recommend actions to repair or demolish them. These decisions are essential to earthquake recovery.
3.0 RECOMMENDATIONS

The following recommendations are quoted from the "Social Sciences" chapter of the book by the Earthquake Engineering Research Institute titled Reducing Earthquake Hazards: Lessons Learned From Earthquakes.

3.1 Selection of Events

The EERI report notes that: "...studies of societal response to significant, but not necessarily devastating, earthquakes should be included in social science investigations. While engineers and geoscientists may not learn a great deal from low-intensity events, social scientists might be able to learn how individuals interpret such events (possibly as precursors to larger quakes or as geophysical events that reduce the likelihood of a major earthquake) and how emergency management organizations use these earthquakes to assess their response capabilities. Since there are so few damaging earthquakes, it is difficult to identify the determinants of societal response; smaller earthquake events may be 'socially relevant,' providing additional clues about which social factors have important effects on response." [p. 182]

3.2 Nature of Social Science Postearthquake Research

The EERI report notes that: "...social science requires a type of research approach and strategy different from that engineering. The research subjects for social scientists are not immobile, nor can it be assumed that they will continue to remain static after a disaster for any period of time. The dynamics of social response are the focus of the social scientist's investigations. Since response changes as situational factors change, it is important for an investigation team to be onsite for an extended period of time in order to monitor changes in individuals' behavior, explanations of events, organizational reactions, and systematic response and recovery. The team should return periodically for updates across time." [p. 182]
REFERENCES


1.0 INTRODUCTION

Earthquake insurance in the United States is currently the subject of intense public policy debates: at the federal level, in the state of California, and within the private insurance industry. At present, most regulation of insurance companies in the United States occurs at the state level, not the federal level, although the Federal flood insurance program is an exception to this general policy. Within the private sector, a consortium of insurance companies has reviewed the current status of earthquake insurance and suggested that the federal government should play an important role. Two competing proposals for federal earthquake insurance and/or reinsurance programs have been introduced in the U.S. Congress. In California, the legislature passed a mandatory earthquake insurance law for homeowners. This law was supposed to go into effect on July 1, 1991, but several fundamental problems delayed implementation until January 1, 1992.

Traditionally, insurance (of whatever type) depends on the availability of actuarial loss statistics. For example, fire insurance rates are based on the statistical frequency of fire losses and thus insurance companies are able to set insurance rates which are commensurate with expected losses. In this traditional insurance context, earthquakes have been considered as uninsurable risks, because they occur so infrequently (with generally poorly determined probabilities) that it has been impossible to establish actuarially sound loss expectations.

The uninsurable nature of earthquakes is compounded by the possibility that a great earthquake in an urban area might cause such huge losses that insurance companies would be bankrupted and unable to pay all loss claims. In the United States, the problem of potentially catastrophic losses in great earthquakes is amplified by tax laws which effectively prevent insurance companies from accumulating reserves to cover possible infrequent, uncertain, catastrophic future events. Despite the actuarial problems with earthquake insurance, a considerable amount of earthquake insurance has been written in the United States. In 1990, premiums for earthquake insurance in California totaled about $385 million (Garamendi, 1990).

There are, however, several widely-recognized major problems with the current status of earthquake insurance in the United States:

1) too few people are insured, and thus too many people rely on governmental disaster assistance after an earthquake,

2) adverse selection, by which a disproportionate fraction of insurance is written for buildings which are the most vulnerable to earthquake damage because of location and/or construction, may be common,

3) present earthquake insurance policies provide very little, if any, incentive for seismic hazard mitigation, and

4) insurance companies believe that they are vulnerable to potentially bankrupting catastrophic losses in the event of a great earthquake.
The perceived vulnerability of insurance companies is not inconsistent with the relatively small fraction of people with earthquake insurance, because much of the insured losses will be from commercial, rather than residential insurance, and from non-earthquake lines of insurance coverage such as fire and general liability. In the 1989 Loma Prieta earthquake, total damages and losses reached about $8 billion, of which about $1 billion was covered by insurance of all types (California Seismic Safety Commission, 1992). In larger earthquakes in major urban areas, total damages and losses could be $50 to $100 billion (Applied Technology Council, 1991).

Because relatively few people have earthquake insurance, there is a heavy dependence on disaster assistance after an earthquake. In the United States, disaster assistance is primarily a Federal government role, with smaller roles played by state and local governments and private volunteer organizations such as the Red Cross. If a natural disaster, such as an earthquake is sufficiently large to result in a Presidential declaration of disaster, then a variety of disaster assistance programs become available to victims. These assistance programs include small individual and family grants, low interest loans to homeowners and businesses, tax relief, and a wide range of smaller assistance programs. If, however, a Presidential disaster declaration is not made, most of these disaster relief programs are not available to disaster victims. There are several widely recognized problems with relying on disaster assistance after an earthquake (U.S. Senate, 1987):

1) it is costly to the Federal government and to taxpayers,
2) it subsidizes disasters and thus provides a disincentive for people to take actions to reduce hazards before an earthquake,
3) it does not provide adequate assistance to all victims and is thus inequitable, and
4) it does not allow people to choose the amount of protection they desire.

In light of the problems with relying on disaster assistance, it is widely believed that it is desirable for more people to carry earthquake insurance. For example, compared to disaster assistance, earthquake insurance would probably have the following benefits (U.S. Senate, 1987):

1) provide greater incentives to reduce risks,
2) provide more complete compensation for damages,
3) provide more equitable disaster compensation,
4) be less expensive to the Federal government,
5) give people more control over their extent of coverage, and
6) be quicker and more efficient in dispensing payments after an earthquake.
Despite the apparent advantages of earthquake insurance, relatively few people buy earthquake insurance. Understanding why people buy or don’t buy earthquake insurance is a very complicated socio-economic problem. Typical reasons why homeowners do not buy earthquake insurance include: 1) high rates and high deductibles, 2) unenthusiastic marketing of earthquake insurance by insurance companies, 3) a reluctance of homeowners to choose insurance to protect themselves unless required to, and 4) a belief that disaster assistance will cover losses (U.S. Senate, 1987). A National Science Foundation sponsored study of disaster insurance purchasing decisions (Kunreuther and others, 1978) found that most people do not purchase disaster insurance because they refuse to worry about low probability losses. Consumers tend to view insurance for low probability risks, including earthquake insurance, as a poor investment, rather than as a protective mechanism. Thus, voluntary insurance programs have generally been ineffective in encouraging most people to buy insurance. For example, most people did not purchase other types of more common insurance; such as fire and automobile insurance, until it was required.

A major study of earthquake insurance in California which focused on reasons why people do or do not buy earthquake insurance has recently been completed (Palm and others, 1990). Their were four major findings from this study:

1) the percentage of homeowners buying earthquake insurance has greatly increased over the last 20 years, but is still a minority of all homeowners

2) there are no demonstrable statistical relationships between purchase of earthquake insurance and demographic or economic characteristics, such as education level or age.

3) perceived earthquake risk is unrelated to actual geophysical risk, and

4) perceived risk of potential damage or destruction of the home is the factor most closely correlated with the purchase of earthquake insurance.

These findings suggest that strictly voluntary efforts to encourage homeowners to buy earthquake insurance may increase the percentage somewhat, but are unlikely to result in all or nearly all homeowners obtaining insurance coverage.

2.0 EARTHQUAKE INSURANCE IN CALIFORNIA: HISTORICAL PERSPECTIVE AND CURRENT SITUATION

a) Historical Perspective

Virtually all homeowners in California carry homeowners’ insurance which covers fire and most other perils. Homeowners insurance is mandated by banks and other financial institutions which hold homeowners mortgages. Homeowners who do no have mortgages are not required to have homeowners insurance, but almost such owners still carry the insurance, primarily for protection from fire losses. Standard homeowner policies, however, exclude earthquake damage.
Separate earthquake insurance for homeowners is more widely carried in California than in other states, at least in part because of the higher perceived earthquake risk. Nevertheless, prior to 1985, only about 7 to 8 percent of California homeowners carried earthquake insurance. Beginning on January 1, 1985, a California law (Assembly Bill No. 2865) required that insurance companies offer earthquake insurance to all holders of other residential policies (such as fire insurance). Each time a homeowner's policy is renewed, the insurance company must offer earthquake insurance. After the passage of Assembly Bill 2865, the percentage of homeowners deciding to purchase earthquake insurance increased significantly and has continued to increase gradually, particularly after well-publicized damaging earthquakes. However, as of 1990, only about 20 percent of homeowners had decided voluntarily to purchase earthquake insurance (Mittler, 1991). Only about 5% of small businesses in California carry earthquake insurance (Roth, 1991).

Assembly Bill 2865 also removed "concurrent causation" which had become a major problem for insurance companies. Typical homeowner's policies are "all risk" policies that insure against all risks not explicitly excluded. The standard policy excluded damage due to earth movements. However, courts in California and several other states ruled that if a loss is due in part to two perils, one of which is excluded and one of which is not, that an "all risk" policy must pay the loss. Since in almost all cases some cause other than earthquake contributed to damage (for example, fire or poor construction from possible builder negligence), these court decisions effectively granted every insurance holder earthquake insurance coverage, without requiring payment of premiums specifically for earthquake insurance. Assembly Bill 2865 reversed these court decisions by specifying that if earthquake losses are excluded from a policy then earthquake losses are not compensable by insurance, even though other causes acted with earthquakes to produce the loss.

A typical homeowners' insurance policy covers most perils, excluding earthquakes. Rates vary by location, but typically would be about $450 per year for a $125,000 house in California. In addition to providing coverage for the house, typical homeowners' policies provide coverage for other structures up to 10% of the house value, for contents up to 50% of the house value, for additional living expenses if the house becomes uninhabitable due to damage, personal liability coverage ($100,000 is common) and limited medical coverage ($5000 is common). Earthquake insurance rates also vary with location, but an additional premium of $250 per year is typical for a $125,000 woodframe house; rates are much higher for masonry houses. The typical earthquake insurance policy written in California has a 10% deductible (10% of the house value, not 10% of the earthquake damage). Thus, for a $125,000 house the earthquake insurance deductible would be $12,500. These figures are from the California Department of Insurance, as reported by the California Seismic Safety Commission (1990).

b) California's Mandatory Earthquake Insurance Program for Homeowners

In September of 1990, the Governor of California signed into law Senate Bill 2902 which mandated earthquake insurance for all residential property owners in the state. This is the first time that government at any level in the United States has enacted an earthquake insurance program (Mittler, 1991). However, the State of California has a long history of innovative legislation with respect to earthquake hazards, including the State Dam Act (1929) which incorporated seismic provisions for dam design, the Field Act (1933) which gave the
state authority of the design and construction of schools, the Alquist-Priolo Special Studies Zones Act which limited develop in areas subject to fault zone rupture, and the Hospital Seismic Safety Act (1972) which gave the state authority over the design and construction of hospitals. More recently, in 1989 (before the Loma Prieta earthquake), Assembly Bill 1890 required that after July 1, 1991 all new or replacement water heaters be anchored, strapped, or braced, to prevent any movement that could be caused by earthquakes (and thus cause a fire hazard). Assembly Bill 3561 required that an owner of a residential structure in Hazard Zone 4 would have to tie the structure to the foundation in compliance with current building codes before the property could be sold; this bill was passed by the legislature, but vetoed by the Governor. Finally, the Seismic Safety Commission supported Proposition 127 which was approved by the electorate in November 1990. This proposition encourages retrofitting of seismic hazards by prohibiting local tax assessors from raising assessments, and thus property taxes, after the completion of earthquake improvements to residential structures.

The main provisions of California’s earthquake insurance legislation are summarized in Figure 1. The primary intention of this legislation was to provide coverage for the earthquake damages that are excluded from normal earthquake insurance policies because of the high (10 percent) deductible. Except for very great earthquakes, or in poor soil areas, most well-built wooden-frame single-family houses are unlikely to experience structural damage exceeding 10 percent of the value of the house.

The law establishing California’s earthquake insurance program also specified that rates range from a minimum of $12 per year to a maximum of $60 per year. Eight hazard rating zones were established as shown in Figure 2. Rates vary from zone to zone and also within a zone depending on the type of structure as shown in Figure 3. Masonry structures, for example, are charged higher rates than wood structures, except in higher risk zones where the statutory limit of $60 is imposed on all structures.

Until 1990, the California Seismic Safety Commission believed that the private insurance industry was capable of meeting the insurance needs of the state’s homeowners (Mittler, 1991). The Commission supported private offering of earthquake insurance and sponsored research to increase insurance acceptance among California homeowners. There were five main reasons why this situation changed in 1990 (Mittler, 1991):

1) hearings following the 1987 Whittier Narrows and the 1989 Loma Prieta earthquakes indicated that privately offered earthquake was inadequate to meet the needs of homeowners (even though no organized citizen groups or the insurance industry lobbied for a state earthquake insurance program),

2) legislative committees with a long-standing interest in earthquakes were already in existence and had knowledgeable members and staff,

3) Governor Deukmejian made passage of an earthquake insurance bill one of his high priorities for the 1990 legislative session.
FIGURE 1

PROVISIONS OF THE 1990 CALIFORNIA EARTHQUAKE INSURANCE PROGRAM

1. The original legislation became effective July 1, 1991; this was subsequently amended to begin January 1, 1992.

2. The state earthquake insurance covers the first $15,000 in structural damage (excluding damage to contents).

3. The deductible is 1/2 of 1 percent of the amount of fire insurance, but not less than $1000 or more than $3500.

4. The program will be administered by the California Insurance Commissioner, with fees collected by private insurance companies as a surcharge on homeowner’s policies. Premiums will accumulate in a special state fund. Up to $1 billion in taxable revenue bonds could be issued to supplement money received from homeowner surcharges.

5. If, after January 1, 1994, the fund has at least $750 million, the maximum payment will be increased to $19,000 and if a dwelling is uninhabitable due to damages from an earthquake, the fund will provide an additional $1,000 for living expenses.

6. If, after January 1, 1996, the fund has at least $1.25 billion, the maximum payment will be increased to $24,000 and the fund will pay an additional $2,000 for the purpose of reconstruction costs required to bring the structure up to currently required building codes.

7. When the fund exceeds specific dollar thresholds, money from the fund can be used to issue low-interest loans for the purpose of seismic retrofitting of residences. Once $1 billion is accumulated, 2 percent of the amount above $1 billion can be loaned. The loan authorization rises to 4 percent and 5 percent when the fund exceeds $2 billion and $3 billion, respectively.

8. The state has no liability for demands in excess of the amount available in the fund when an earthquake occurs. If total claims exceed the amount in the fund, then claims will be paid pro rata.

9. Premiums from homeowners will be collected by private insurance companies who hold homeowners policies and then sent to the State.

10. The act also appropriated $100,000 for the Department of Insurance to study the availability, cost, and adequacy of commercial insurance in covering property and business interruption losses encountered by small businesses.
FIGURE 2
CALIFORNIA EARTHQUAKE INSURANCE ZONE MAP

Source: (Holden, 1991)
FIGURE 3

CALIFORNIA EARTHQUAKE INSURANCE RATE ZONE TABLE

<table>
<thead>
<tr>
<th>Construction Type/Age</th>
<th>Zone A</th>
<th>Zone B</th>
<th>Zone C</th>
<th>Zone D</th>
<th>Zone E</th>
<th>Zone F</th>
<th>Zone G</th>
<th>Zone II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (1-4 units)</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$12.00</td>
<td>$15.00</td>
<td>$16.00</td>
</tr>
<tr>
<td>Woodframe Pre-1940</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$55.00</td>
<td>$33.00</td>
<td>$60.00</td>
<td>$12.00</td>
<td>$15.00</td>
<td>$13.00</td>
</tr>
<tr>
<td>Masonry</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$15.00</td>
<td>$26.00</td>
<td>$42.00</td>
</tr>
<tr>
<td>Mobile homes</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$55.00</td>
<td>$18.00</td>
<td>$60.00</td>
<td>$12.00</td>
<td>$13.00</td>
<td>$14.00</td>
</tr>
<tr>
<td>Condominium</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$55.00</td>
<td>$44.00</td>
<td>$60.00</td>
<td>$12.00</td>
<td>$16.00</td>
<td>$13.00</td>
</tr>
<tr>
<td>Force-placed policies (all construction types/ages)</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
<td>$60.00</td>
</tr>
</tbody>
</table>

Notes:
1. The amounts in each of the surcharge rate cells represent the annual dollar rates adopted by the Insurance Commissioner.
2. The construction types correspond to the following residential property insurance-related categories:
   - Residential = Single family units or duplexes, triplexes, or quadplexes units that are not owned by an association or group of persons, covered by policies issued to the unit owner. These residences are categorized into the following construction types:
     - Woodframe = frame, masonry veneer, mixed, noncombustible, fire resistant, and unknown
     - Masonry = masonry and masonry non-combustible
     - Mobilehome = mobile homes
     - Condominium = Multi-unit residential structures covered by policies issued to condominium associations or a group of persons.
3. Force-placed policies, regardless of construction type or age, are assigned a single surcharge rate pursuant to SB 413 provisions.
4. Allowances for seismic retrofits are not included in 1992 surcharge rates because allowable CRER Fund surcharges are below actuarial rates.

Source: Holden (1991)
4) the Seismic Safety Commission had become an active policy making body since its inception in 1975 and was able to advise the Governor and the Legislature on this issue, and

5) everyone agreed that the Federal government was not going to act on earthquake insurance in the near future and thus it was up to California to take the first steps.

The recognition that the Federal government was unlikely to act on earthquake insurance in the near future played an important role in California’s decision to enact a State earthquake insurance program. It is widely recognized that only the Federal government has the financial resources to deal with a great earthquake which results in $50 or $100 billion in damages. California’s earthquake insurance program was not, therefore, designed to be a comprehensive solution to earthquake insurance problems. Rather, this limited legislation was designed to fill the gap left by the large deductible in private earthquake insurance policies. There were also two other objectives (Mittler, 1991):

1) as more people understand the limited coverage provided by the State insurance and the risks to their property, they will be encouraged to purchase private insurance, and

2) with the State assuming some of the risks of earthquake insurance and with a larger pool of policyholders, it was hoped that private earthquake insurance premiums would drop, thus encouraging even more homeowners to purchase private insurance.

c) Implementation of California’s Earthquake Insurance Law

After passage of this innovative legislation, there were several concerns raised about potential problems with the legislation. These concerns resulted in the implementation of the law being delayed from July 1, 1991 to January 1, 1992.

As originally planned, the earthquake insurance program had an average premium of about $36 per year. However, estimates of the expected annual costs were up to three times higher than the average premium and thus there was a fear that the insurance program was significantly underfunded and might not have funds available to pay claims. Separate from the rate issue was a problem that if an earthquake occurred early in the program then only a small reserve would have accumulated and thus, as per the terms of the law, only a small percentage of actual damages would be paid on a pro rata basis.

A second major problem occurred because while the program was intended to be mandatory, the law did not establish any enforcement provisions or penalties for homeowners who chose not to buy the "mandatory" earthquake insurance. Without truly mandatory provisions, it was believed that a relatively small fraction of homeowners would actually buy the coverage. In October, 1991 the California Department of Insurance proposed that homeowners who refused to buy the insurance would have their fire insurance revoked. Because all mortgage holders require fire insurance, this would effectively mandate purchase
of earthquake insurance as well. However, there was strong political opposition to a person losing fire insurance for not paying for earthquake insurance and thus this plan was not implemented.

An alternative enforcement mechanism was selected before the insurance program was begun on January 1, 1992. Homeowners who refused to pay for the earthquake insurance would have a lien attached to their property and the payment due under this lien would be added to the annual property tax payment. To avoid foreclosure for non-payment of taxes, the homeowner is then forced to pay the insurance premium. With this enforcement mechanism, the mandatory insurance program has now been implemented. Private insurance companies have begun to collect the earthquake insurance premiums as homeowners renew their homeowner’s policies.

During the last half of 1991, there was a vigorous debate in the legislature and in the press about the merits and problems with the earthquake insurance law. Newspaper reports of this debate, along with some newspaper editorials are contained in the Appendix to this report. During this time period, the California Insurance Commissioner, John Garamendi, who had supported the authorizing legislation, announced that the insurance program was “unworkable” because of underfunding and the lack of an enforcement mechanism and he urged repeal of the law (Garamendi, 1991). However, at this time, the Department of Insurance had already determined hazard zones and had issued rate charts to insurance companies (Holden, 1991). This seeming contradiction, where the Insurance Commissioner was denouncing the program as unworkable at the same time he was implementing the program is, however, not as difficult to understand as it might first seem. On one hand, Commissioner Garamendi has been a long standing supporter of earthquake insurance and thus he took actions to implement the legislation, following the requirements specified in the law. On the other hand, as an elected official, Commissioner Garamendi may have been concerned about receiving criticism if the program did not work. Thus, by announcing the shortcomings of the program in advance, Commissioner Garamendi may have been seeking to protect himself politically if the program failed (for example, if there were a large earthquake early in the program and only a small percentage of claims could be paid).

3.0 A FEDERAL ROLE IN EARTHQUAKE INSURANCE?

In 1990, two bills to create a federal role in earthquake insurance were introduced in the United States Congress. One bill was sponsored by the insurance industry, while the other was developed by concerned members of the House of Representatives.

The history of federal interest in earthquake insurance has been recently reviewed by Mittler (1990). A detailed chronology of federal studies and actions pertaining to earthquake insurance is given in Figure 4.

Beginning after the Alaska earthquake of 1964, a number of studies of a possible federal role in earthquake insurance were undertaken. However, no such federal role in earthquake insurance was actually begun. The primary reasons for no federal action being taken were somewhat contradictory. On one hand, because earthquakes were believed to be unpredictable, it was believed to be impossible to set actuarially sound insurance rates. On
the other hand, private companies were writing earthquake insurance and thus it was concluded that a federal role was not necessary.

However, gradually over this time period, there was an increasing consensus that a great earthquake in an urban area could have devastating financial consequences for the United States. Fear of catastrophic losses in a great earthquake also motivated the private insurance industry. The Earthquake Project (a coalition of insurance companies and their trade associations) began its study of a possible Federal role in earthquake insurance in 1987 and completed their report in 1989 (Earthquake Project, 1989). In addition, the 1989 Loma Prieta earthquake focused attention on the earthquake problem in the United States. The Federal government contributed about $3 billion dollars in disaster relief following this earthquake. Earthquake insurance was considered as a possible way to reduce future Federal expenditures for disaster relief.

The major features of the two Federal earthquake insurance bills introduced in the United States Congress are summarized in Figure 5. HR 4480, the bill sponsored by the Earthquake Project, was introduced by Congressmen Al Swift (Washington) and David Dreier (California). This bill would create a national primary insurance and reinsurance program to provide residential earthquake insurance and to make property and casualty reinsurance available, thereby limiting the liability of the private insurance industry in a catastrophic earthquake. Under this bill, most of the details were left to be worked out by a governing Corporation to be established. Homeowners whose mortgage was directly or indirectly backed by the Federal government would be required to purchase the insurance. Mitigation activities were not directly required or connected to the earthquake insurance. Rather, the issue of mitigation was to be studied by the Corporation to determine cost-effectiveness and workability.

The second federal earthquake insurance bill, HR 4462, was introduced by Congressmen George Brown (California) and Sherwood Boehlert (New York). Subsequently this bill was slightly modified and reintroduced as HR 4915. This bill had mitigation as a primary feature of the bill and mandated local loss reduction measures as a prerequisite to the issuance of residential earthquake insurance. Many features of this bill were based on the National Flood Insurance Act which includes loss reduction methods.

Neither of these two bills was enacted during the 1990-1991 legislative session. However, interest in a possible Federal role in earthquake insurance remains high and sponsors of these bills are expected to reintroduce similar bills and to continue their efforts to establish a Federal earthquake insurance program.
FIGURE 4
CHRONOLOGY OF FEDERAL EARTHQUAKE INSURANCE STUDIES AND ACTIONS

YEAR | EVENT | OTHER EVENTS
--- | --- | ---
1964 | Following Hurricane Betsy, the U.S. Congress enacts the Southeast Hurricane Disaster Relief Act; because of the Alaskan earthquake the year before, Section 5 directs that studies be undertaken by the Federal Insurance Administration (FIA) of the Department of Housing and Urban Development to investigate the feasibility of insurance to protect against flood and earthquake losses. | The Alaska earthquake occurs. |
1968 | The FIA in its earthquake insurance report concludes that setting actuarially sound rates is not feasible because the technological basis for creating earthquake hazard maps are inadequate and there should be no direct federal role in earthquake insurance. | The National Flood Insurance Program (NFIP) is enacted. |
1971 | A National Association of Insurance Commissioners - National Committee on Property Insurance (NAIC-NCP) study of the potential insurance industry loss from a catastrophic California earthquake concludes that the potential loss would be so great that federal reinsurance would be required if such an eventuality took place. | The San Fernando earthquake occurs. |
1974 | The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) is enacted in October. Section V directs that the role of insurance in moderating the effect of earthquakes be determined. | The Disaster Recovery Act is enacted. |
1977 | In hearings before the Housing and Community Development Subcommittee of the House Banking, Finance and Urban Affairs Committee in July, Ronald K. Sheip of the American International Group testifies about the necessity for federal reinsurance in the event of a catastrophic earthquake and presents a draft bill to create a "Federal Earthquake Reinsurance Plan." | Mt. St. Helens erupts. As a consequence, FEMA undertakes a study to evaluate whether California is prepared for a catastrophic earthquake and produces a report, "An Assessment of the Consequences and Preparations for a Catastrophic California Earthquake: Findings and Actions Taken." |
1980 | The Reinsurance Association of America (RAA) opposes a federal reinsurance plan because it would be unwieldy. They propose a bill that the federal government create a "Federal Catastrophe Loan Plan," which would enable private industry to borrow money from the federal government for prompt payment of claims and maintenance of the existing financial community. To meet the directive of the Earthquake Hazards Reduction Act, the Federal Emergency Management Agency (FEMA) and the FIA award the J. H. Wiggins Company a contract to study the earthquake insurance market and examine the role of insurance in promoting increased mitigation efforts. The J. H. Wiggins Company produces four reports: "Earthquake Insurance Issues Workshop", "Earthquake Insurance Practices", "Federal Disaster Assistance and Earthquake Insurance", and "Earthquake Insurance: A Public Policy Analysis." | The Coalinga earthquake occurs. |
1986 | The Earthquake Project (a coalition of insurance companies and their trade associations) is formed to examine the impact of a catastrophic earthquake on the U.S. economy and the role to be played by the property-casualty insurance industry. | The Robert T. Stafford Disaster Relief and Emergency Assistance Act is enacted. |
1987 | FEMA and the FIA contract Dames and Moore to identify feasible loss reduction measures for inclusion into a national earthquake insurance program. | Hurricane Hugo occurs. |
1988 | The Earthquake Project issues its report, "Catastrophic Earthquakes: The Need to Insure Against Economic Disaster." The report recommends the creation of a federal corporation to establish and operate a national earthquake insurance program. Draft legislation to create a "Federal Earthquake Insurance and Reinsurance Corporation" is included. | The Loma Prieta earthquake occurs. |
1989 | Congressmen Al Swett (D-Washington) and David Dreier (R-California) introduce H.R. 4480, the Federal Earthquake Insurance and Reinsurance Act, in April. This bill is drafted with the assistance of The Earthquake Project. | |
1990 | Congressmen George Brown (D-California) and Sherwood L. Boehlert (R-New York) introduce H.R. 4462, the National Earthquake Insurance and Reinsurance Act of 1990, in April. This bill is drafted with the assistance of George K. Bernstein, former Administrator of the FIA. In May, this bill is revised slightly and introduced as H.R. 4915 to amend the Earthquake Hazards Reduction Act of 1977. | |

Source: Mittler (1990)
FIGURE 5

COMPARISON OF 1990 FEDERAL EARTHQUAKE INSURANCE BILLS

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>HR 4480</th>
<th>HR 4462*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislative Sponsor</td>
<td>Al Swift &amp; David Dreier</td>
<td>George Brown &amp; Sherwood Boehlen</td>
</tr>
<tr>
<td>Author</td>
<td>The Earthquake Project</td>
<td>George Bernstein</td>
</tr>
<tr>
<td>Basis</td>
<td>Primary insurance and reinsurance</td>
<td>Flood Insurance Act</td>
</tr>
<tr>
<td>Primary Focus</td>
<td>(none)</td>
<td>Hazard mitigation</td>
</tr>
<tr>
<td>Secondary Focus</td>
<td>Earthquakes and volcanic eruptions</td>
<td>Primary insurance and reinsurance</td>
</tr>
<tr>
<td>Disasters Covered</td>
<td>Federal Earthquake Insurance</td>
<td>Earthquakes</td>
</tr>
<tr>
<td>Agency in Charge</td>
<td>and Reinsurance Corporation</td>
<td>FEMA</td>
</tr>
<tr>
<td>Director</td>
<td>Director, FEMA</td>
<td>Director, FEMA</td>
</tr>
<tr>
<td>Composition of Board</td>
<td>11 members inc. 4 from insurance</td>
<td>15 member advisory committee</td>
</tr>
<tr>
<td></td>
<td>industry</td>
<td>inc. 1 insurance industry</td>
</tr>
<tr>
<td>Insurance Rates</td>
<td>Established by Corporation; can</td>
<td>Risk based</td>
</tr>
<tr>
<td></td>
<td>be risk based</td>
<td></td>
</tr>
<tr>
<td>Method of Compliance</td>
<td>None given</td>
<td>None</td>
</tr>
<tr>
<td>Local Eligibility</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Requirements</td>
<td>Decision of Corporation</td>
<td>Decision of Corporation</td>
</tr>
<tr>
<td>Risk Determination</td>
<td>None mentioned</td>
<td>None mentioned</td>
</tr>
<tr>
<td>Method of Enforcement</td>
<td>By private insurance company</td>
<td>By mortgage lender</td>
</tr>
<tr>
<td>Notification Procedure</td>
<td>None</td>
<td>Federal instrumentalities</td>
</tr>
<tr>
<td>Ineligible Structures</td>
<td></td>
<td>Only those in violation of</td>
</tr>
<tr>
<td></td>
<td></td>
<td>state or local laws or in</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nonparticipating communities</td>
</tr>
<tr>
<td>Residential Insurance</td>
<td>None</td>
<td>$50,000 and up to $125,000</td>
</tr>
<tr>
<td>Limits</td>
<td>95% in excess of 8% of net</td>
<td>additional at premium rates</td>
</tr>
<tr>
<td></td>
<td>written premium</td>
<td></td>
</tr>
<tr>
<td>Federal Reinsurance</td>
<td>5%</td>
<td>90% in excess of 10% of net</td>
</tr>
<tr>
<td>Obligation</td>
<td>No new arrangement</td>
<td>written plan</td>
</tr>
<tr>
<td>Co-insurance</td>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>Private Insurance</td>
<td></td>
<td>Those representing 80% of</td>
</tr>
<tr>
<td>Company Involvement</td>
<td></td>
<td>homeowners not written</td>
</tr>
<tr>
<td></td>
<td></td>
<td>premium must participate</td>
</tr>
<tr>
<td>Losses in Excess of</td>
<td>90% borrowing from Federal</td>
<td>100% borrowing from Federal</td>
</tr>
<tr>
<td>Fund</td>
<td>Treasury, 10% paid by insurance</td>
<td>Treasury; no payback</td>
</tr>
<tr>
<td></td>
<td>companies; payback from future</td>
<td>procedures</td>
</tr>
<tr>
<td></td>
<td>premiums</td>
<td></td>
</tr>
<tr>
<td>Recommended Mitigations</td>
<td>National seismic standards;</td>
<td>Detailed mapping;</td>
</tr>
<tr>
<td></td>
<td>Community based building codes;</td>
<td>Control development in high</td>
</tr>
<tr>
<td></td>
<td>Retrofitting;</td>
<td>risk areas;</td>
</tr>
<tr>
<td></td>
<td>License design professionals;</td>
<td>Retrofitting;</td>
</tr>
<tr>
<td></td>
<td>Mandatory pre-safe inspection of</td>
<td>Brace water heaters;</td>
</tr>
<tr>
<td></td>
<td>structure</td>
<td>Mandatory pre-sale inspection</td>
</tr>
<tr>
<td>Fiscal Incentives To</td>
<td>Lower property tax;</td>
<td>Lower deductibles</td>
</tr>
<tr>
<td>Adopt Mitigations</td>
<td>Possibly lower deductibles or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>premiums</td>
<td></td>
</tr>
</tbody>
</table>

* HR 4462 was modified slightly and then reintroduced as HR 4915. The comments in this column refer to both bills.

Source: (Mittler, 1990)
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California Seismic Safety Commission (1992), Loma Prieta's Call to Action, Report SSC 91-06.

Earthquake Project of the National Committee on Property Insurance (1989), Catastrophic Earthquakes: The Need to Insure Against Economic Disaster, The Earthquake Project, Boston, Massachusetts.

Garamendi, John (California State Insurance Commissioner), (1990), California Earthquake Zoning and Probable Maximum Loss Evaluation Program, California Department of Insurance, Los Angeles, California.

Garamendi, John (California State Insurance Commissioner), (1991), Sacramento Bee, November 7.


APPENDIX

STATE OF CALIFORNIA EARTHQUAKE INSURANCE PROGRAM

NEWSPAPER ARTICLES AND EDITORIALS
Quake fund shaken up

The Loma Prieta temblor in 1989 prompted a bumper crop of legislative proposals for various forms of earthquake insurance for California homeowners. That kind of coverage makes sense if an equitable and financially sound system of apportioning risks, revenues and reimbursements can be devised. But the plan that the Legislature came up with and that former Gov. George Deukmejian signed last year has fallen flat on its face before it started. The idea, as Deukmejian outlined it, was to set up a public program to help homeowners cover the losses that private insurance policies do not. Generally, homeowners policies do not cover earthquake damage, and those who pay extra for supplemental coverage often find that it doesn't provide the protection they need. That's because standard quake policies have deductibles for the first 10 percent of the value of the policyholder's home and its contents. That's a big help if the house is destroyed. But 24,000 homes damaged in the Loma Prieta event suffered an average of $8,000 in losses; few of those homeowners would have been able to collect even if they had earthquake coverage.

Under the program Deukmejian approved, homeowners in California were supposed to be required to pay an average of $36 more per year on their current premiums in order to create a pool of funds that the state could draw on to reimburse quake victims for their initial losses up to a limit of $15,000. Sounds good — so what went wrong?

Part of the problem was that the insurance industry and Deukmejian's appointed insurance commissioner, Roxani Gillespie, opposed the program at the outset. Even after Deukmejian signed it into law, Gillespie assigned not a penny in her budget to implement it. Worse, all of her actuarial calculations, which were the basis for those schedules of premiums and payments, turned out to be wrong by a wide margin. And, though the bill says those $36 surcharges are mandatory, the Legislature failed to define any penalties if nobody pays, which means the law can be ignored with impunity.

As a result, the newly elected insurance commissioner, John Garamendi, inherited a program that was bankrupt even before it opened for business. Garamendi succeeded in persuading Gov. Wilson to delay the startup until January 1, 1992; but it will need more than fine tuning. The costs will be more than three times higher — an average of $119 Garamendi estimates — and he says they have to be truly mandatory if the program's to work at all.

If the Legislature tries to make those changes, however, that will just stiffen the resistance of homeowners in areas of the state that aren't prone to earthquakes who object to paying anything to help provide coverage for people elsewhere who are at risk. The recent shake-up in Pasadena is a reminder of how important the problem is. But a solution at this-point seems as elusive as before.
A firestorm over quake insurance
Homeowners could lose house without coverage

By Mary Anne Ostrom
Knight-Ridder Newspapers

SAN JOSE — Next year, California homeowners will either have to buy state-sponsored earthquake insurance or run the risk of losing their houses, if state Insurance Commissioner John Garamendi has his way.

Under regulations slated to take effect Jan. 1, the Department of Insurance plans to bar any homeowner who doesn't buy $15,000 in earthquake protection from getting crucial fire insurance. And without fire coverage, lenders can legally block a house purchase or foreclose on an existing mortgage.

Garamendi also is proposing premiums for the new quake insurance that would average $70 a year for the state's 6 million homeowners, nearly twice the $36 originally proposed when quake-insurance legislation passed last year.

The penalties in particular are likely to face legal and political challenges. They are already drawing a firestorm of protest from legislators, consumer advocates and insurers, some of whom are labeling it "asinine," "draconian," and "political suicide for Garamendi."

But Department of Insurance officials contend only the threat of withholding fire coverage will make the program workable.

"Legislators were afraid to put their name on anything with penalties," said Richard Holden, the Department of Insurance's quake insurance project manager. "This is the only possible avenue we have now to make it mandatory through regulation. ... the program will fall apart."

State-sponsored quake insurance, proposed a few months after the Loma Prieta earthquake by then-Gov. George Deukmejian, was to go into effect last July. But the date was delayed to January 1992 after Garamendi found flaws in the legislation.

Deukmejian sold his plan as a way to help homeowners cope with the deductibles of private coverage, which usually run to 10 percent of a home's insured value. It also would reduce the state's liability to pay for emergency aid in future quakes, he argued.

Although it was labeled a mandatory program, the legislation held no penalties until Garamendi proposed them.

About one quarter of the state's homeowners now opt for more expensive private quake insurance and plenty aren't eager for the state's plan.

"They'll have to put a gun to my head before I pay," said Steve Ferry, homeowner.

"They'll have to put a gun to my head before I pay."
— Steve Ferry, homeowner

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Sacramento Bee, October 13, 1991
Quake insurance 'unworkable'

Garamendi says flaws outweigh benefits, urges repeal of new law

By Mary Lynne Vellinga
Bee Staff Writer

A law requiring all California homeowners to start paying for earthquake insurance on Jan. 1 is unworkable and should be repealed, the man charged with implementing it said Wednesday.

State Insurance Commissioner John Garamendi surprised and angered leaders of the Senate Subcommittee on Earthquake Insurance when he showed up at a hearing on how the law works.

Garamendi said he'll do his best to go forward on Jan. 1. But it's not at all clear that the insurance industry is prepared to start charging earthquake insurance premiums at that time.

"The slowness with which the insurance department has produced its rules and regulations has left insurance companies without enough time to reprogram their computers and underwrite policies," said Garamendi, who noted that the Legislature is prepared to do it.

Garamendi has argued that the law contains fundamental flaws and can't be salvaged without action from the Legislature.

If the law is not repealed, Garamendi said he'll do his best to go forward Jan. 1. But it's not at all clear that the insurance industry is prepared to start charging earthquake insurance premiums at that time.

"The slowness with which the insurance department has produced its rules and regulations has left insurance companies without enough time to reprogram their computers and underwrite policies," said Garamendi, who noted that the Legislature is prepared to do it.

The law requires more than 6 million Californians to pay annual premiums ranging from $12 to $60, depending on the type of structure they own and their area's propensity to earthquakes. The fund would provide $15,000 of coverage after a minimum deductible of $1,000.

Garamendi has argued that the premium levels set in the law won't come close to providing enough money to cover claims, especially if an earthquake occurs soon after the law takes effect. He has argued that premiums should be increased to the $45 to $75 range, and the minimum deductible raised to $2,000.

The law contains fundamental flaws and can't be salvaged without action from the Legislature.

If the law is not repealed, Garamendi said he'll do his best to go forward Jan. 1. But it's not at all clear that the insurance industry is prepared to start charging earthquake insurance premiums at that time.
State quake plan needs more money

Higher premiums, less coverage

SACRAMENTO (AP) — Insurance Commissioner John Garamendi, hunting for new money for the state's earthquake insurance program, has proposed quadrupling the deductible and cutting the payout by one-third to boost the state-run pool.

The financing is needed to provide funding quickly for the program, which is scheduled to provide minimum coverage for up to 6.3 million California property owners beginning Jan. 1.

The program, inspired by the 1989 Loma Prieta earthquake, would provide low-cost coverage to homeowners to supplement their existing quake insurance. Under existing provisions, the program would offer up to $15,000 to cover the far larger deductibles of a homeowner's main quake policy.

For example, conventional coverage on a $200,000 home could have a $20,000 deductible. The state quake insurance law would cover up to $15,000 of that deductible. The state plan's deductible is $1,000 to $3,500.

But Garamendi said the plan as outlined would not provide enough money quickly for the program. He proposed increasing the average annual premium from $36 to $61, with a maximum of $75. He also proposed increasing the deductible to a minimum of $4,000 and reducing the maximum payout to $10,000.

He said the changes would provide more money for the first year of the program, then could be gradually phased downward as the pool received more money.
California's misguided earthquake insurance

Leo Levinson is an environmental policy consultant and a doctoral student in public policy at the University of California, Berkeley.

By Leo Levinson

California's new earthquake insurance plan is a multibillion-dollar fiasco in the making. Due to go into effect Jan. 1, it will be a nightmare to administer, will encourage massive fraud and will be miserably inadequate for those suffering the most serious losses.

It was pushed through the Legislature after the Loma Prieta earthquake. Under the plan, the state would collect a surcharge of $12 to $68 on fire-insurance policies statewide and would provide up to $15,000 coverage for earthquake damage, above a deductible of $1,000 for most homes. The idea was to cover the high deductibles of private earthquake insurance plans, though many people carry no such private insurance. The state plan was intended to be mandatory, but neglected any penalties for people not paying the surcharge.

Now, picture this: After the plan goes into effect, a major earthquake (magnitude 7.0 or higher) occurs centered near the San Francisco or Los Angeles metropolitan areas, shaking millions of homes. Property owners quickly learn that they can claim money from the state if they can find over $1,000 worth of earthquake damage. People scrutinize the cracks in their walls, chimneys and foundations, thinking: "Was this there before the quake? Who knows? Why not try to get some money from the state?" Hundreds of thousands of valid, inflated and fraudulent claims flood the Department of Insurance.

Meanwhile, thousands of people whose homes are substantially destroyed and who have no private insurance are furious. On the street, their life savings gone, former homeowners find the state's check for $15,000 pitifully inadequate. Their anger grows when they hear of all the people in perfectly habitable houses who have manipulated the system to get $15,000. And of course, tenants who become homeless get nothing from the program.

Why did our legislators pass such a crazy plan? It appears that after Loma Prieta, politicians heard numerous complaints about the high deductibles in private insurance plans. Then-Gov. Deukmejian may have thought it would be politically popular to respond. All the pesky administrative details could be worked out later.

Unfortunately, the plan's problems are much too fundamental for a little tinkering to solve. Insurance Commissioner John Garamendi, who helped pass the program when he was in the Legislature, now acknowledges some of its flaws and is seeking to delay the program's start. But even the reforms Garamendi wants -- making the program really mandatory and raising the deductible -- are not enough to prevent the administrative nightmare that would ensue following the next major quake!

Meanwhile, Insurance Commissioner John Garamendi, who helped pass the program when he was in the Legislature, now acknowledges some of its flaws and is seeking to delay the program's start. But even the reforms Garamendi wants -- making the program really mandatory and raising the deductible -- are not enough to prevent the administrative nightmare that would ensue following the next major quake!

Meanwhile, the Legislature and Gov. Wilson have been reluctant to agree to any delay in program implementation.

The Legislature and Wilson should accept Garamendi's plea to prevent the current misguided plan from taking effect. Natural disasters are bad enough without adding governmental disasters.
Quake insurance gets shaky start

By Mary Lynne Vellinga  
Bee Staff Writer

California's mandatory earthquake insurance law kicked in this week, requiring every homeowner in the state to pay at least a few dollars a year for earthquake protection.

Yet even as the program began, problems remain. Some of the insurance companies didn't put the earthquake surcharge on their customers' January statements, Burt said. Yet even as the program goes forward,

The earthquake insurance law requires all 1 million homeowners in the state to pay $12 to $60 a year for earthquake coverage, depending on the house and how earthquake prone their region is.

Sacramentans will pay relatively little — $13 to $15 annually, said Kenneth Burt, a spokesman for the state Department of Insurance. Owners of wood-frame houses built before 1940 will have to pay $13, he said, while those with wood-frame houses built after 1940 will be assessed $15.

The earthquake insurance surcharge will be tacked on to homeowners' insurance policies as they come up for renewal. Some insurance companies already included the surcharge on their customers' January statements, Burt said.

Some of the insurance companies didn't put the earthquake surcharge on their January statements, and now they're arguing with the Insurance Department over whether those customers will be covered by earthquake insurance even if they aren't billed until next year.

John Kozero, spokesman for Fireman's Fund Insurance Co. in Novato, said the Insurance Department took too long to send out final information, making it impossible for his company to reprogram its computers in time.

"We don't expect to be sending out a bill before early spring," Kozero said.

Among other problems, state Insurance Commissioner John Garamendi, administrator of the program, continues to argue that it should be scrapped in favor of an earthquake disaster relief fund. Garamendi made this proposal at a Nov. 6 hearing by the Senate Subcommittee on Earthquake Insurance, prompting a letter from Gov. Pete Wilson, who scolded Garamendi for undermining the credibility of state earthquake insurance.

"John (Garamendi) still believes a relief fund would be a better alternative than the current system, and that it would save taxpayers millions of dollars each year," Burt said. However, he added, "The direction I've gotten is to go ahead with this assuming we're going to do the best job possible."

Passed after the 1989 Loma Prieta quake, the mandatory earthquake insurance program was designed to provide every homeowner with $15,000 in earthquake coverage, enough to pay for relatively minor damage or cover the large deductible on private policies.

But since the insurance program is financed entirely by premiums, it won't raise enough money to protect homeowners from a major earthquake for at least several years.

The department estimates that the insurance fund will contain $313 million after a year, provided all homeowners in the state pay their bills.
BASE ISOLATION AS AN ENGINEERING INNOVATION
1.0 INTRODUCTION

The modern era of using base isolation for new and existing buildings in the United States started in the late 1970's and early 1980's. While the theory of isolating structures from earthquake and other vibratory motions is over a century old, and Frank Lloyd Wright used a cushion of mud to isolate the Imperial Hotel in Tokyo (which survived the 1923 Kanto Earthquake), modern application began with the use of elastomeric rubber bearings on bridges. Its use then spread to buildings for a variety of reasons that are important to understanding the adoption and implementation of base isolation as an engineering innovation.

In about 10 years base isolation has moved from use in rare instances to now where one observer recently noted "that the most sophisticated design firms routinely consider seismic isolation as well as other emerging alternatives for major new designs or retrofits." [Turner]

The conceptual approach to studying this innovation was on user decision-making. We examined the factors that influenced decisions to use base isolation. Regardless of ownership, the user was not an autonomous actor. The user introduced a technology new to the locality or owning organization, and this required decisions involving building codes, design criteria, financing, and others. Hence, the user was an organization operating in a public, political, economic, and technical environment.

The first two buildings in the U.S. to use modern base isolation foundations (elastomeric bearings) are the Foothill Communities Law and Justice Center in San Bernardino County and the City and County Administration Building in Salt Lake City, Utah. The justice building is a new building dedicated in 1985 while the administration building is an historic structure completed in 1894. The purpose of this paper is to explain the reasons why base isolation was selected for the foundation system in these two cases. They both were "yes" decisions meaning base isolation was chosen, but more research is needed on other affirmative decisions and on "no" decisions to better determine which factors have more or less influence on the choices to accept or reject the use of an engineering innovation.

The lessons learned about these decision-making processes are very important to understanding a more fundamental question: What does it take to move from engineering research and theory to practice? In general, the process of technological innovation goes through several steps: 1) theory development, research and testing, 2) awareness of the innovation by potential users, 3) decisions to adopt the innovation over other alternatives, 4) implementation of the decision into the design and construction process, and 5) securing general acceptance of the innovation through subsequent inclusion into building codes and standards, design practices, and construction.

2.0 BACKGROUND: BASE ISOLATION ARRIVES IN THE U.S.

How did knowledge of modern base isolation techniques reach the U.S.? A research and development program was started in the early 1970's by the Malaysian Rubber Producers Research Association (MRPRA) at its lab in the United Kingdom to help find new markets for natural rubber. One possibility was the potential application of base isolation to buildings
using some form of rubber bearings. This was preceded by a long history of isolating bridges to allow for normal thermal expansion and contraction. For buildings, the initial intent was to isolate them from underground railway and heavy road traffic vibrations.

In the early 1970's MRPRA and Atkins Research and Development completed a computer-based study of an earthquake’s effects on a building with and without rubber bearings. The results were considered positive, showing reduced motions from an isolated foundation. During 1974 a leading researcher from this program visited several seismically active countries (India, New Zealand, Japan and U.S.

Partly as a result of this visit, a small group of practicing engineers and researchers began a cooperative research program between U.C. Berkeley’s Earthquake Engineering Research Center’s (EERC) and the Malaysian Rubber Producers Research Association. About 1980, the work had reached the stage where the only thing to do next was to try it out in practice. The challenge then was to find a candidate building and someone or an organization willing to be the first U.S. user of base isolation.

3.0 CASE STUDY 1: SAN BERNARDINO COUNTY’S FOOTHILL LAW AND JUSTICE CENTER

In 1977 Robert Rigney, then Administrator of San Bernardino County’s Environmental Improvement Agency (which included the building inspection department), was elected Chairman of the California Seismic Safety Commission. He had been active in the earlier efforts that led to the creation of the Commission so he was well informed about earthquake hazard mitigation in California. In July 1980 Rigney was appointed to be the County’s Chief Administrative Officer, becoming responsible for managing all of the County’s departments and agencies and playing a key role between them and the County’s elected Board of Supervisors.

At the Seismic Safety Commission’s meeting on September 10, 1981 Robert J. Kuntz, President of the California Engineering Foundation, and Dr. Alexander G. Tarics of Reid & Tarics, a San Francisco engineering firm advocating use of base isolation technology, made an informational presentation to the Seismic Safety Commission. Mr. Rigney showed great interest in the subject and stayed after the meeting with then Executive Director Robert Olson to discuss the concept further with Mr. Kuntz, Dr. Tarics, and others. Mr. Kuntz said it was this informal meeting that started the process of using base isolation in California. [Kuntz]

During 1981 through 1983 Rigney managed a process to further explore --and finally to decide to use--base isolation on a new county building. These activities included meetings with base isolation consultants and researchers; a tour to Malaysia for a technical conference where he was a featured speaker; trips by he and county elected and other appointed officials to see applications of base isolation in France and England (January 1983) and in Malaysia and New Zealand (February 1983).

This process led to Rigney’s recommendation and the Board of Supervisors’ decision on March 28, 1983 to modify plans for the new law and justice center building to include a base isolated foundation. Rigney stipulated that the building would be a "critical facility," and
therefore it must be functional quickly after an earthquake. This introduced a major change in the performance criteria being considered by the engineers. It forced consideration of non-traditional designs which would exceed the minimum requirements of the normal building code.

The decision was contingent on a series of studies and design reviews that would determine if base isolation was feasible, technically and economically, and funds were provided for these studies. These studies were completed, the building was redesigned, independent review processes were established, and the building was constructed. It was dedicated for use in 1985. A more detailed history with research notes is included as Appendix 1.

4.0 CASE STUDY 2: THE CITY AND COUNTY BUILDING IN SALT LAKE CITY, UTAH

Dedicated in 1894, the City and County Administration Building is one of most important buildings in Utah’s history. Salt Lake City was incorporated before Utah became a state, and the administration building housed the Territorial and then the first State of Utah Legislature. Since 1894 the building has been occupied by city and county government agencies, including the courts. In 1979 the consolidated city and county government was terminated, and separate ones were created. The administration building is now occupied only by city agencies.

Funds were provided every year for repairs and maintenance, but obsolescence and deterioration meant that something major would have to be done, or the building would have to be demolished at some time. A study in the early 1970s noted that in addition to continuing maintenance problems, "the building was woefully inadequate, seismically, and would require extensive modification." [Bailey and Allen 2].

Debate over the building’s future and the recurring costs continued until 1979 when Salt Lake’s first City Council asked that a long term plan be prepared for the administration building. Disagreement about whether or not to save the building led to a study to examine the full range of possibilities. This study, and visits by city officials to the Earthquake Engineering Research Center at U.C. Berkeley, where they saw the shaking table and the testing of base isolation bearings for the San Bernardino building, and to the newly restored California State Capitol (not base isolated) resulted in their decision to restore Salt Lake City’s administration building. This was followed by a public opinion poll that showed residents’ attitudes were in favor of restoration over demolition.

Palmer DePaulis was elected to serve on the new City Council from 1980 to 1984. Choosing not to seek office again, the Mayor recruited DePaulis to head the city’s Department of Public Works. Because of his council membership, he was aware of the problem of what to do about the administration building, but he was busy with the results of the disastrous 1983 and 1984 floods. His flood disaster experiences increased his awareness about hazard mitigation and disaster preparedness.
On October 28, 1983 the Borah Peak, Idaho earthquake occurred. Although hundreds of miles from Salt Lake City, the long period motion forced the evacuation of the administration building. This further increased the city’s willingness to seismically strengthen the building.

During 1985 the City Engineer attended a conference in San Francisco on base isolation. He concluded that Salt Lake City should seriously consider it as an alternative for the administration building "because it would allow most of the historic features to remain in place." [Peterson, 1-2] He also noted that the building should be able to function after a major earthquake in the Salt Lake Valley. Three engineering alternatives were then considered. One was the approach contained the Uniform Building Code (UBC). It was considered too expensive, would require the relocation of the occupants for an extended period, and would harm the historic integrity of the building. A second method ("ABK Method") was examined. It was being used in California to strengthen unreinforced masonry buildings. It also was not selected because it was a minimal life safety approach, and under expected earthquake motions this method might not meet the historic preservation criteria and the need for the building to remain functional. The base isolation approach was finally selected. While it was expensive, the decision was based on potential savings from damages avoided from future earthquakes, the protection of the historic interior and exterior elements of the building, its ability to function after expected earthquakes, and the prospect of lower repair costs after such events.

In the meantime, DePaulis was reappointed to the City Council to fill a vacancy, and he ran for election that Fall. Part of his election campaign focused on the administration building. His position was "Choose me and the building, or vote for my opponent." [Erickson, 1] He was elected and became Salt Lake City’s Mayor, and he initiated the base isolation design studies for the City and County Administration Building.

Financing was provided by the voters through a bond issue passed in 1986. The project was completed within the $30 million approved by the voters and ahead of July 1989 completion date. The success of this project has resulted in further earthquake vulnerability studies being done for other critical buildings, including the city’s fire stations, another office building, and several schools. The City and County Administration Building was the first existing structure in the U.S. retrofitted with a base isolation system. Appendix 2 contains a more detailed chronology of events.

5.0 RELATED EVENTS

Once San Bernardino County chose to install a base isolation system for its new Foothill Communities Law and Justice Building, the apparent willingness to explore this technique to reduce the transfer of earthquake motions to new and existing buildings has been accelerating in the U.S. It was soon followed by Salt Lake City’s decision to retrofit its historic City and County Administration Building with a base isolation foundation system. Increasing acceptance of base isolation as an engineering innovation is also suggested by the Structural Engineers Association of California’s preparation of proposed standards for base isolation systems in the new version of the recommended Uniform Building Code. If adopted by most communities, this code will become the governing law in these jurisdictions, and
engineers will have legal protection for using base isolation. Base isolation will have become accepted practice ("institutionalized").

There is an increasing number of vendors and consulting engineers that offer isolation-related services and products. One such firm stated that it had done analyses of 20 to 25 buildings to determine if base isolation would be an effective earthquake-resistant technique.

The California Engineering Foundation held a special conference on the subject in late January 1989 to help explain and publicize the values and limitations of base isolation to the potential "user" community.

On March 1, 1989 the California Legislature's Joint Committee on Emergency Services held a special hearing on what state government could do to enhance the use of base isolation systems. The California Legislature adopted Assembly Concurrent Resolution 55, which requested the State Architect to give "full consideration" to "new technologies" to protect state-owned or approved buildings. As a result, one state office building in San Francisco is being retrofitted with a base isolation system.

The Building Safety Board (BSB) of California's Office of Statewide Health Planning and Development (OSHPD) appointed a Base Isolation Subcommittee to examine the potential application of base isolation to new hospital construction. A draft of its standards was sent by the OSHPD to the Structural Engineers Association of California (SEAOC). It formed its own subcommittee. The subcommittee prepared its own document on base isolation from the viewpoint of general application to all buildings. The proposed standards were returned to OSHPD in 1986 and were adopted in 1987. New California hospitals can use base isolation if they follow these standards. The structural engineers' work now is being submitted to the formal building code writing process managed by the International Conference of Building Officials (ICBO).

6.0 LESSONS LEARNED ABOUT ENGINEERING INNOVATIONS

A widely shared concern among policy-makers, researchers, and practitioners is how to better encourage innovation and the speedier implementation of existing knowledge. Using base isolation foundation systems for buildings as a focus, this study examined how the process works and defined some of the critical variables influencing innovative design decisions. The following factors have been identified as important to making positive decisions to use base isolation foundation systems for new and existing buildings.

1. A general institutional or organizational culture that encourages innovation and experimentation is critical. Such a setting allows for the development of new ideas and encourages their consideration. San Bernardino County has a general reputation for innovation in government services.

2. It is clear that the presence of internal champions, such as Robert Rigney and Palmer DePaulis, in influential appointed or elected positions is very important. It is important that such leaders also understand the earthquake hazard, possibly have disaster related experiences, and can guide the discussions about the importance of mitigation.
3. Strong agreement among members of the engineering and technical community on the use of an innovation is also important. Where there is substantial disagreement among equally qualified technical people, general managers and elected officials are more likely to do nothing because of the conflicting views they hear. It is also important for credibility purposes that the engineers and other technical people involved in the decision-making be familiar with the research and literature on the subject.

4. Above normal criteria for the protection of the building seems important. San Bernardino’s justice center was defined as a critical facility, and Salt Lake’s building was of historical importance. Therefore, each of these buildings is "special" for some reason, and they differ from normal commercial buildings in their importance to the owner and to the community.

5. A key point seems to be that the use of base isolation is justifiable on a benefit-cost basis. While it appears that base isolation increases initial costs, when long term life cycle costs, earthquake damages avoided, lower repair costs, and less interruption are considered the benefit-cost ratio becomes positive.

6. Another important factor is the existence of examples. The proposer can show "we are not the first" to use base isolation. It was important to San Bernardino’s decision makers that visits were made to other countries to see base isolated buildings. It was important to Salt Lake City’s officials that San Bernardino had used base isolation for its building.

7. The presence of an effective decision-making process is very important. Partly this is a function of leadership, but just as important is that the subject reaches top management. In both cases the deliberations and studies involved the highest authorities in each community. Because an innovative approach is being used, it may also require special procedures and organizational arrangements outside of normal ones to implement the decision.
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APPENDIX 1: CHRONOLOGY - CASE STUDY #2
FOOTHILL COMMUNITIES LAW AND JUSTICE CENTER
SAN BERNARDINO, CALIFORNIA

1970-74: Robert B. Rigney joins and is selected as Vice-Chairman of the volunteer Advisory Group on Governmental Organization and Performance to the California Legislature’s Joint Committee on Seismic Safety (the predecessor of the Seismic Safety Commission).


October 11, 1977: Rigney elected second Chairman of California Seismic Safety Commission. Rigney then head of San Bernardino County’s Environmental Improvement Agency; becomes County’s Chief Administrative Officer about July 1980.

1/78: Site master plan delivered to County; $26.9M.

7/78: Process starts with draft EIR done in response to 10 acre master plan for the site; 6/20/78 - non-significant impact (no geological hazards mentioned).

10/17/79: Memo to Board of Supervisors for Earl Goodwin, CAO: The WVLJC “will be the largest construction project undertaken by the Country.” (no page number)

9/10/81: Robert J. Kuntz, President of the California Engineering Foundation, and Dr. Alexander G. Tarics of Reid & Tarics, a San Francisco engineering firm advocating use of base isolation technology, make a presentation to Seismic Safety Commission on base isolation. Some reluctance by some members to include it on the agenda; done under “Good of the Meeting” for public comments. CEF believed SSC not very supportive, but Rigney shows personal interest; stays after meeting with Olson to discuss concept further. Kuntz says it was this post-meeting that started the process of using base isolation in California (CEF conference remarks, 1/26-27/89)

1981-83: Follow-up by Rigney composed of several activities: meetings with base isolation consultants and researchers; tours to Malaysia for a technical conference as a featured speaker; trips by he and county elected officials to see applications in France and England (January 1983), and Malaysia and New Zealand (February 1983) with NSF financial support. Leads to decision to modify plans for new law and justice center building to use base isolation (design process already underway). Rigney stipulates that the building is a critical facility, and therefore it must be functional quickly after an earthquake, which introduced a major change in the criteria being considered by the engineers and basically forces consideration of non-traditional or minimum code designs. Delayed construction process because of time needed to redesign building (Nilson notes (p. 43) that "Base isolation was ‘grafted’ onto the original design."

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One result of Rigney's effectively developing political support for the building is noted by "The decision makers of the County, the Board of Supervisors, were intrigued by the idea of being the first in a new field and were inclined to try it if there was not a heavy financial impact and if the engineering community would support it." (Anatomy, p.2)

Through Rigney, Board champion became Supervisor Cal McElwain, who later supported a number of earthquake preparedness efforts. Nilson notes that "Cal McElwain returned from Europe an enthusiastic base isolation supporter. This support was crucial for three reasons. First, his prominence on the Board. Second, the Law and Justice Center was in his district. Third, he was part of the field trip that explored the issue in detail." (p. 37)

July 6, 1982: Metcalf & Eddy, the construction management firm for the County, issued its "Base Isolation Investigation" report to the County. It opened the door to the use of base isolation by noting:

"The Foothill Communities Law and Justice Center may be an ideal subject for Base Isolation. However, at this point in time a cost and schedule penalty will be experienced. The feasibility study will take an estimated three (3) months and require an additional fee. The delay may well increase fees and certainly any redesign for Base Isolation will require additional fees. If structural redesign which takes advantage of the Base Isolation techniques does not occur, the above additional expenses will not be offset. The time delay (doing the feasibility study and time for redesign) may impact on the construction budget. Changes in the economic environment may increase construction costs."

"The potential gain from using the Base Isolation methodology are: (a) the presently unquantifiable benefit of providing additional safety to persons and equipment within the building during an earthquake, (b) the opportunity for pioneering a new approach to seismic design of buildings. If properly monitored by scientists, this system would pave the way for more economical structural designs that significantly reduce damage to buildings contents as well as the building itself. If successful, Base Isolation could impact on the insurance industry which would ultimately profit most from an improved method of seismic design."

"It is our opinion that to determine the effectiveness of Base Isolation a feasible study using Base Isolation technique as applied to the Foothill Communities Law and Justice Center should be undertaken." (Base Isolation Investigation, July 6, 1982)

July 14, 1982: LeRoy Crandall and Associates, consulting geotechnical engineers, issued its report to Taylor & Gaines, the project's consulting structural engineers. It provided data about the estimated dynamic response of the soil deposits beneath the building site for three postulated design earthquakes.

July 29, 1982: Board approves grant request to NSF. Taylor & Gaines issues its interim "Base Isolation Feasibility Study" report to HMC Architects. It notes that the purpose was "to determine the applicability and potential design ramifications of utilizing the base isolation approach for seismic resistance for the proposed building structure." The report concluded that "the typical 'code' designed structure would not behave well in a moderate to strong seismic event. Laminated rubber base isolators installed at the base of the
building would soften the shock and allow it to ride with a more acceptable motion both for occupants and for contents," and that the feasibility study be continued.

**August 5, 1982:** LeRoy Crandall and Associates, submits a technical report to Metcalf & Eddy, Inc. about whether or not a perimeter drain is needed for the building because of a high ground water table. It is not recommended.

**August 9, 1982:** Minutes of the Board: CAO recommends that Board approve a $208,000 grant request to NSF "for special studies and to follow up on the program in the future." It also has money for knowledge transfer of a program to increase understanding of these (BI) techniques among building officials, community members and local decision makers.

**October 7, 1982:** Reid & Tarics Associates, base isolation engineering consultants, submits a technical report to Taylor & Gaines. This report supplies technical data on the design of the isolation system and the laminated elastomeric bearings.

**October 11, 1982:** LeRoy Crandall and Associates submits another report to Taylor & Gaines providing additional data requested by the Independent Review Panel formed by VSP Associates, Inc. on contract to the County.

**Late 1982 or early 1983:** HMC Architects submits (undated) final "Base Isolation Feasibility Study" to the County. It restated the purpose "Was to analyze the future building to determine if this method of construction would produce a structure that would meet the owner's requirements for performance in the event of a major earthquake." [p. 1, Executive Summary] Four different structural systems were designed and analyzed: 1) conventional "code" non-isolated moment frame, 2) conventional "code" non-isolated braced frame, 3) isolated moment frame, and 4) isolated braced frame. The study concluded that "the base-isolated braced frame structure would provide the best solution," and "we would recommend the base-isolation system utilizing a braced frame for the Foothill Communities Law & Justice Center." [p. 5, Executive Summary]

1983-85: Construction takes place; building dedicated; tours of researchers, officials and others take place all during construction phase and for early years thereafter. Rigney gives keynote talk at the dedication.

**March 28, 1983:** Board of Supervisors unanimously approves the use of base isolation. Decision implemented: design modified, expert panel formed and a second engineering firm retained to review design (independent review = insurance); NSF provides testing money for the bearings and travel support for officials; specifications prepared; vendors sought, etc. Rigney revises County contract with Engelkirk & Hart for a dynamic analysis of the FCLJC; approved. See Rigney's supporting memo of same date:

"In addition to the numerous design considerations which were reviewed and re-reviewed during the study, a Risk Analysis was completed which compared the expected damage to the conventionally-designed building to the Base Isolation-designed building. The analysis indicates that property damage from an expected earthquake would be reduced by $2,900,000 in 50 years, while the loss from a probable maximum earthquake would be reduced by $6,300,000 and the loss from a maximum foreseeable earthquake would be reduced by $9,650,000. The above
numbers are statistical averages. If the building were damaged beyond repair, the loss of course would be 100% plus demolition and inflation. The estimated extra construction cost for Base Isolation, which these numbers must be compared to, is $1,125,000. Additionally there will be contract adjustments for the various consultants and the County’s portion of the National Science Foundation grant."

December 5, 1983: Rigney recommends Board approve "in principle" County co-sponsorship of a conference on base Isolation with CEF. "The County has received requests from the California Engineering Foundation, University of California Berkeley, National Science Foundation, and others to utilize the Foothill Communities Law & Justice Center as a focal point for a conference on base isolation..."

July 29, 1985: Rigney signs agreement with California Division of Mines and Geology (CDMG) to install strong motion seismograph instruments (1st BI building in US to be instrumented).

November 25, 1985: Rigney recommends Board approve co-sponsorship of "Base Isolation Seminar" for February 12, 1986 and noted the SSC would meet there on February 13, 1986.

June 6, 1986: San Bernardino-Riverside branch and LA Section of American Society of Civil Engineers (ASCE) designated building to be "the Outstanding Civil Engineering Achievement of 1986 within our areas."

"Mr. Cornielle, representing the San Bernardino/Riverside Branch of the American Society of Civil Engineers, states his branch, in association with the Los Angeles section, has designated the Base Isolated County of San Bernadino’s Foothill Communities Law and Justice Center as their Regional Outstanding Civil Engineering Achievement Award for 1986. He states the basis for this award is ‘an engineering project that demonstrates the greatest engineering skills, and represents the greatest contribution to civil engineering progress and mankind.’ He states the project has also been nominated for the ASCE National Award and the Center will now compete with other projects across the State. The national award winner will be announced in late May or June, 1986. He requests the Board accept a bronze plaque from ASCE which states that the building has won The Greater Los Angeles Award for the Outstanding Civil Engineering Achievement for 1986."

June 13, 1986: San Bernardino County issues press release:

"The Law & Justice Center is the first U.S. building -- and the largest building in the world -- to use base isolation for protection of the building, its contents, and its occupants from danger of earthquakes..."

"Said County Administrative officer Robert Rigney, ‘Our major concerns for this building were increased protection of occupants and building contents and immediate operation of the building following an earthquake as an emergency response center. After extensive research on base isolation, we were convinced that this new technology was the answer we were looking for. And, recent data has confirmed that belief.’ Data received from the October 2, 1985 earthquake indicated that the acceleration of the top story of the Law & Justice Center was 25% less than that of the ground floor. Other local buildings tested during the
same earthquake showed a 2-5 times increase in acceleration on the top stories.

"Explained Rigney, 'This technology has been proven to be effective on the Law & Justice Center, but the ramifications of the technology are far-reaching. Already, there are activities underway to change the building code for hospitals in California to include the study of base isolation for new buildings. And, according to studies sponsored by the National Science Foundation, base isolation technology can be applied to existing buildings at a cost comparable to traditional methods of reinforcing existing buildings. Base isolation may have a very real impact not only on new buildings, but for many of the historically important buildings in California that would receive significant damage in the case of a severe earthquake."

March 20, 1986: Dedication of Foothill Communities Law and Justice Center.

October 31, 1988: Harry M. Mays (New CAO) recommends and Board approves a CEF proposal to have a seminar on January 26 & 27, 1989.

RESEARCH NOTES

Nilson comments in his paper (pp. 10-11) that "County Administrative Officer Robert Rigney is recognized by his Board and staff as an 'entrepreneurial executive'. He is also recognized as an international leader in seismic safety circles."

Arnold comments in his article (p. 66) that:

"The origins of this project are interesting, for the drive to innovate came not from the design team but from the building owner, a county bureaucracy. Some years ago, the chief administrative officer of San Bernardino County, Robert Rigney, gave the opening speech at a conference on base isolation in Malaysia. To his surprise, representation from the United States was small. The application of the idea all seemed to be taking place abroad. But the idea seemed to make sense. So on his return, Rigney set about exploring the use of such concepts in his own earthquake-prone county. A suitable building was found - the Foothills Communities Law and Justice Center - but schematic design was already complete and the design team had been selected for its expertise in conceiving innovative courtrooms and jails, not for structural innovation.

"The county went ahead anyway. A research grant was obtained from the National Science Foundation to pursue the concept; base isolation consultants were added; trips were made to New Zealand, France, England, and Malaysia; review committees were formed; the building department was satisfied; budgets were set and met; and the job was done. As Rigney has said, local governments are meant to be administrators, not innovators. Yet this project shows that a conservative bureaucracy can break new ground and participate with the research community, if the grounds for such decision making are carefully prepared in advance."
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1. Douglas C. Nilson, "A Participant Observational Study of Policy Making on the Decision to use Base Isolation in the County of San Bernardino's Law and Justice Center."

2. Robert B. Rigney, "System Selection From An Owner's View or the Anatomy of A Decision."


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Robert B. Rigney, Memorandum to the Board of Supervisors titled Foothill Communities Law and Justice Center-Base Isolation Feasibility Study, March 28, 1983.
APPENDIX 2: CHRONOLOGY

THE CITY AND COUNTY ADMINISTRATION BUILDING
SALT LAKE CITY, UTAH

Early history

Late 1880s: City and county officials began discussions of a joint City Hall and County Courthouse; Fall of 1889 decision made.

1890-94: Construction (unreinforced masonry); $800-900,000 cost.

March 12, 1934: Damaged by earthquake and removal of 5 statues.

Historically important: Originally city’s public square ("Emigration Square" and then "Washington Square"). Original construction greatly exceeded schedule and budget--opened in 1894. City was incorporated before Utah existed as a State; building housed Territorial and then first Utah Legislature.

Recent history

Early 1970’s: Modest study funded by City and County because of recurring problems and aging; however, "the building was woefully inadequate, seismically, and would require extensive modification" [1/p.2]

Mid-1970’s to early 1980’s: Some minor work funded by City and County ($200,000 each year by both governments) for incremental restoration, but "the continued deterioration of the building and the inescapable effects of inflation forced a reconsideration of this approach to the building’s restoration, and the City decided to have a comprehensive study made on the structure to determine whether the building should, or could, be restored and seismically retrofitted..." [1/p.2]

1974: Exterior restoration started on east entrance. In 1979 scaffolding was installed on the clocktower and some stabilization work was done on a pay-as-you-go basis.

1979: SLC changes form of government from a commission to a city council/elected mayor form. On agenda was continued joint funding of repairs to C&C building (two concerns = tower and exterior. Potential liability was important. First city council asked "What is the long term plan for this building?" There was none. Led to a joint committee formed between county and city; after two meetings, newspaper headline declared building to be torn down. Led Councilmember Fonnesbeck to notify Mayor Ted Wilson that unless the committee was restructured, he would not participate any more. Mayor also wrote county saying it was withdrawing from the committee unless it could be restructured. Meeting held with Bart Barker, Chairman of the SLC Commission, to discuss restructuring and suggestion that "we ought not to discuss the demolition of the building." [4/Fonnesbeck, p. 2] Agreement led to Request For Proposals to examine possibilities, and "We interviewed a number of people, we
looked at a number of sites, we took an opportunity to do a little bit of travelling to see what other companies had done, and Ehrenkrantz was selected." [p.3] Virtually no opposition at a public hearing; City Council voted 7-0 to go with restoration and provided funding for further studies. New members elected and requested another public hearing; some concern voiced, but council revote was 5-2, and "the City Council was on its way." [p.4].

1979: DePaulis elected to 4 year term on new City Council with Fonnesbeck. Term finished in 1984; chose not to run again; Ted Wilson, Mayor, and DePaulis "shared a lot of values." Recruited DePaulis to join City staff as Director of Public Works in December 1983 (after elections). C&C building was emerging as an issue, but preoccupied with 1983 and 1984 floods. Noted that "I worked with the City Council, with Mayor Wilson and with my Engineering Department going through the process of looking at how to restore this building...I was fortunate enough to travel with Mayor Wilson to Berkeley and to see the shaker table and begin to learn about retrofitting buildings, and all this process of base isolation..." [p.2]

1981: Bart Barker took office on SLC Commission (about 1 year after first city council took office). During 1982 budget deliberations he saw $200,000 request for county's contribution to repairs; he believed that at that rate "we would begin to fall behind in efforts to retard deterioration." [4]Barker, p. 1]. Met with Mayor Wilson and Councilmember Fonnesbeck and they formed a committee; letter from Mayor threatening to withdraw from it; Barker feared that "with the City withdrawing from the project, was that we could go from the point of falling behind a little bit each year to doing absolutely nothing." [p.1] Letter to Mayor Wilson asking him to reconsider; met, restructured committee. Soon after, SLC county does first public opinion poll of 50 questions on services: "A plurality of the citizens county-wide supported restoration over eliminating the facility. That came at a good time. The committee at that point was attempting to focus but seemed a bit nervous about whether they were pursuing the public will." [p.2]

February 18, 1991: Mayor DePaulis noted that the constant repairs and partial restoration, symbolized by the ever-present scaffolding became a "symbol of inaction" because it stayed too long.

1982: RFP issued; early 1983 contract awarded to Gustavson and Ehrenkrantz. Only 10% of county's employees in C&C building at time, but was where Salt Lake County Commission met. County therefore hired Ehrenkrantz to do a space needs study for the County; confirmed that its needs "far exceeded those that could be provided for in the City and County Building." Consultant's recommendation was that County should play a lesser role in C&C building: "It should be managed by one entity alone, which could manage it more efficiently than two; it should house mainly Salt Lake City government..." "Our final compromise was the County would lease about 1/5 of the building, which the County didn't need but was willing to lease to solve both entities' problems, and that the City should take over the project unilaterally and provide for the restoration in a way that would be sound, both financially and in management." [4]/Barker, p. 3]

October 28, 1983: Borah Peak, Idaho earthquake occurs; "Even though it was hundreds of miles from Salt Lake City...the City and County Building was dramatically affected." (because of long period ground motion and building was evacuated) [4]/lyons p.2]
1985: Max G. Peterson, SLC Engineer, attends conference in San Francisco Bay Area on seismic isolation. He "came away from the conference with the opinion that the City should seriously consider seismic isolation for the City/County Building." [4/p.1, Peterson's] Led to retention of engineering consultant to "determine the feasibility of using seismic isolation..." [p.1] "Seismic isolation was very attractive to us because it would allow most of the historic features of the building to remain in place." It also provided a greater degree of protection for the architectural features of the building, "and most importantly, the building could still be functional as a City office building after a major earthquake in the Salt Lake Valley." [p.2]

Peterson retains "prominent structural engineer" (Roland Sharpe) to provide second opinion. Wise decision because just after he was retained, newspaper editorial suggested that a second opinion would be a good idea to "protect the interests of the citizens." [p.2] Letter sent to paper informing it that this action already had been taken.

1983-84: This study recommended that the building be saved; "However, costs involved to seismically retrofit the building, using a conventional Uniform Building Code (UBC) approach, appeared to be prohibitively high." [1/p.3] "This type of solution is similar to what was done on the California State Capitol Building. The costs were so severe (for using the UBC approach) that they jeopardized even doing the (SLC) project, and alternate methods had to be found." [4/Bailey, p.3]

Referring to discussions about this time Terry Wright of Jacobsen Construction Company said that there "long and heated discussions about what to do with the building", and the final decision was to spend $19 million on restoration (of which $4 million was for seismic work), 30 months design time, and 25 months for construction. [3]

Late 1984: Ehrenkrantz and Beall study showed that field tests and reviews of original drawings done "to refine the structural study and explore ways of reducing the anticipated cost of seismic retrofit." Three methods of analysis were used: UBC, base isolation (BI), and ABK Method ("a relatively new methodology being tried in California for seismic hazard mitigation of existing unreinforced masonry buildings.") [1/p.3]

ABK method a minimal approach and less expensive to construct; goal is to reduce chance of collapse. BI method expensive, but savings accrue from not having to do massive interior strengthening; also saves historic fabric, capable of postearthquake functioning, and lower repair costs after earthquakes. UBC method well known, but meant massive disruption of historical interior and building may not be functional after earthquakes because emphasis is on life safety, not reducing property damage. [4/Lyons, pp.2-3] Lyons notes that "Minimization of property damage and the ability to function after an earthquake were major factors in the choice of a (base isolation) system." [4/Lyons, p.4] Costs for BI more than ABK, but less than UBC approach; this was added incentive given other project goals.

Since use of isolators not covered in the governing building code, variance sought and obtained from City's Board of Appeals. "Then it was merely an issue of following up with the media, with (City) Council and the Mayor to educate them as to why we made this choice and show them the benefits of it." [4/Lyons, p.5]
Findings presented to the Mayor and City Council (by now just a city building since county moved out and turned building over to the city). Simplified decision-making; now dealing with one governmental unit. Primary recommendation was to use Bl, although it would cost about $1 million more than ABK Method, but substantially less than UBC procedure.

**July 1985:** DePaulis appointed by City Council to be Mayor of SLC upon Wilson’s resignation; ran for election in fall of 1985, and DePaulis made the restoration of the building a plank in his platform; advised not to make it an issue because it was controversial, but he said "No! Choose me and the building, or vote for my opponent." [4/Opening Remarks, p.1] Apparently, floods and Idaho earthquake convinced him to look at all key public facilities, including building close to C&C Building that housed EOC, 911, etc. Led to setting of priorities for studies and allocating funds; retained engineers and started process. [2] He noted that seismic isolation provided a viable option that would "save more of the fabric of the building." [4/DePaulis, p. 3] and he said to the project engineers: "...don't look me in the eye and tell me that you are even going to attempt to bid on this building or do this building or work with this building unless you can bring me a project ahead of schedule and under budget." [4/DePaulis, p. 3]

**June 1986:** A "detailed analytical study" [1/p.4] completed for application of Bl technique. Some implications:

1. "As this job was truly unique, (first existing building in U.S. to use base isolation) with no real precedent, it was difficult to obtain a reliable cost estimate [for some kinds of work]." [1/p.7]

2. "It must be realized that the building is in greater seismic danger during the whole isolator installation process...An earthquake of any significant size during isolator installation could be catastrophic to the building." [1/p.9]

3. Finally, the difficulty of documentation and construction, and the complexity of engineering an isolated structure, make base isolation a technically challenging solution that should not be undertaken casually." [1/p.10]

At this time Forell\Elsesser Engineers of San Francisco was retained by E.W. Allen and Associates to develop a workable base isolation scheme.

**1986:** Bond issue passed by voters with project completion date of July 1989; building vacated end of 1986 for 2.5 years; DePaulis noted that in the referendum City had great difficulty explaining base isolation to the citizens. Project was done within the $30 million and ahead of schedule; built voters confidence. Completion of SLC building led to "Now we have to do more (fire stations, schools, etc.); public now willing to listen and are more inclined to support such efforts because of success of C&C Building restoration. [2] In 1987 the Board of Education commissioned a vulnerability study of SLC's schools

Fonnesbeck notes that bond issue ". . . was a vote of confidence for the building." (passed about 82%) "We went to the public with good costs that were liberal enough that we are currently (1988) under budget and feeling very good about that." [4/Fonnesbeck, p.4]
Following taken from Symposium proceedings [ref 4]:

**Phil Erickson’s introductions** [p.1]: “David Dee is the judge who refused to move out of the building and retired rather than relocate.” Norma Matheson, wife of former Utah governor, led restoration of old governor’s mansion (and moved into it), and “contributed much to the City & County Building restoration effort...” Henry Whiteside “most recently directed our successful fund-raising effort in the bond election in 1986.”

**Judge David Dee:** “The issue, essentially, for the Mayor of this city was the restoration of the City & County Building. His opponent was badly defeated. He took the position it should not be restored. The people in this community believe that the City & County Building in fact reflects their feeling about government and shows the feeling of solidarity behind anyone who is in support of that restoration.” [p.2]

"The City & County Building really...should be a court building. The big, open spaces are conducive to that kind of activity, more than office space. I’ve been unable, because of turf and a lot of other things, to convince the people who make the decisions that we ought to keep this building as a courthouse." [p.3]

**Norma Matheson:** (about preservation) "there was never any question in my mind about the fact that this truly is a landmark." [p.1] "...the successful campaign that was carried on by the City Administration and those interested in preservation also know is this: you’ve got to have public and private support. And often gaining the support from the public, always gaining support from the public, influences what the public official support is going to be." [p.1] "They had good support from people who were respected in the community and they knew that that was going to be an important factor in gaining public interest..."[p.2]

**Phil Erickson:** (public awareness campaign)

1. **Brochure:** 2 versions; 1 had blank last page and was not used; #2 included all City Council members’ names and other key figures; was a big success. Were expensive and were giving away a lot of them; led to a one sheet handout, which was “the first time that we began addressing some of it to the issue of base isolation. People were beginning to ask questions about it and so we developed a short question and answer format.” [p.1]

2. **Supper on the Porch**: Council still reluctant to financially support restoration, and County still balking "at any sort of cooperation financially." Four (4) days before considering request for ($2 million) for design phase Council members invited to the "porch" (scaffolding around the clocktower). All Council members attended and both mayors (Ted Wilson, outgoing, and Palmer DePaulis, Mayor elect). Event carried live by all three of the network TV stations. Key was the special mug which was given out; it showed the building with the scaffolding until filled with a hot liquid; then the heat made the scaffolding disappear. Used in TV and newspapers, and sold several thousand of them. Council started using the building on all of its correspondence. [pp.1-2]
3. **Christmas Card:** using old painting of the building, prepared the "City & County Building Christmas Card," which was mailed all over the country." [p.2]

4. **15 minute video:** Donated by the SLC Veterans Administration Hospital, and had been seen by thousands of school children. VA film crew "delighted to come down to the City & County Building because they are usually...filming how to treat arthritis or something." [p.2]

5. **Flyer and voter information brochure:** flyer about rehabilitation of the building linked to departure of Executive Director of the Utah Heritage Foundation. Went to all members of the Council before her going away party. Same photos and some language used in voters pamphlet that went all households in the city. [p.3]

6. **March 1987:** "Clocktower Illumination" ceremony: end of first phase of construction was the restored clocktower. Clocktower tee shirts "sold like hot cakes." At dusk, turned on the lights to illuminate the clock tower.

7. **City stationery:** about 1987 Mayor wanted to "make sure that the City & County Building be on every single piece of City correspondence" by ordering the phasing out of individual department logos. [p.3]

Alice Steiner, Wallace and Associates [4\Steiner]: noted that Heritage Foundation was frustrated about losing many battles over the demolition of old buildings in downtown SLC. C&C building became a rallying point: "...if you (city officials) didn’t support the saving of the City and County Building then it was pretty obvious that you couldn’t expect anyone else to save any other structure in the City." Confidence in Ehrenkrantz Group’s studies "...was a critical factor in the decision to go ahead." [p.1-2]

Thomas Godfrey, Chairperson, Salt Lake City Council noted that: "...one of the things that sold the building and the concept of base isolation to us was that the staff had really done its homework well and presented it well." [4/Godfrey, p. 1] Regarding 1983-84 Ehrenkrantz study: "If the Council had not asked for that study, they probably would have been better off, because many of our buildings are not seismically safe here. But because they had gone out and done the study, they were in turn responsible as far as insurance and life safety issues were concerned with doing something about it." [4/p.2] [4/p.2]
REFERENCES


2. Comments by Mayor Palmer DePaulis at the Annual Meeting of the Earthquake Engineering Research Institute, Salt Lake City, February 18, 1991.

3. Comments by Terry Wright at EERI meeting, above.

DESIGN-RELATED FINDINGS BASED ON ORAL HISTORY INTERVIEWS WITH EARTHQUAKE ENGINEERS
1.0 INTRODUCTION AND DISCLAIMERS

This paper, as requested by the CUREe-Kajima earthquake research program, comprises observations about seismic design based largely on an oral history interview program conducted primarily with older California earthquake engineers. (See Appendix A for recent listing of interviews conducted so far.) The interviews are being done as part of the Earthquake Engineering and Seismic Safety Oral History Project, of the Regional Oral History Office, Bancroft Library, University of California, Berkeley. In due course, the completed interview transcripts will be organized, indexed, and placed in the oral history depository in Bancroft Library.

The following disclaimers should be noted at the outset:

(1) The conclusions and opinions expressed should not be construed as necessarily representing those of the interviewer or of any individual interviewee.

(2) Oral history interview objectives are broad in scope and the time-span of their contemplated use is long-term. Like oral history as practiced in other fields, these interviews aim at capturing and recording permanently a wide range of first-hand information, recollections, and interpretations from individuals who were active participants in their fields of endeavor. (See Appendix B for selected references from a large literature on oral history.)

Most of the interviewees are distinguished structural engineers who have made highly significant contributions to development of the design professions, and to the growth of earthquake engineering in California. The best of them are uniquely creative individuals equivalent in stature and in skill to those who in Japan are called "National Treasures."

The interview material will provide a wealth of valuable data for future researchers and historians studying the development of earthquake engineering and seismic policy in California. The principal purpose of the interviews is not, however, to collect information on current design processes and procedures. Despite this caveat, the interviews do in fact have valuable and currently relevant design-related insights and findings. Many of the most important ones are briefly summarized here by the interviewer, who is also author of this paper.

2.0 PROFESSIONAL DEVELOPMENT OF EARTHQUAKE ENGINEERS

2.1 "Mentoring and Early "Indoctrination"

Many of the interviews strongly emphasize the importance of the early phases of an engineer’s career, including the value of close contact with skilled seismic designers. While not always using the term, many interviewees mention mentoring as a means of passing along earthquake and other engineering skills and judgments to younger engineers learning the ropes. (A simple dictionary definition of the term "mentor" is: A wise and trusted counselor or teacher.) This apparently was the principal way most of the best
earthquake engineers learned earthquake engineering. The relationship is considered very important to many who during their careers had been involved in both roles—first, when they were young, receiving advice and instruction from a senior person, and later themselves acting as mentors to younger colleagues.

The training given younger beginning practitioners by senior experienced colleagues is the principal way the former (1) learned the basics of seismic design, and (2) learned to place a high value on doing things properly to assure seismic resistance. Through the mentoring relationship, the younger engineers acquired not only a set of skills, but also a commitment and sense of dedication to an important cause. Both factors have been critical to the development of earthquake engineering and seismic safety policy in California.

The relationship usually occurred in fairly small engineering firms. Some interviewees seem doubtful that effective mentoring can be carried on in giant firms with many employees and large-volume practices that emphasize profits. If so, younger engineers today may not be benefitting in the way they were able to a quarter to half a century ago. This evaluation seems to underlie an acceptance by several of those interviewed that continuing education is a way of substituting for mentoring.

An integral part of the mentoring process considered important for earthquake engineering is a kind of "indoctrination" in early stages of career development: a focus of attention on seismic design as crucial to the design profession and to society in general. The process instills a sense of the importance of earthquake-resistant design, as well as an understanding of the kind of care and judgment required—more than just complying with the code. This includes some understanding of the background of the code, and of its limitations in achieving seismically resistant design. This kind of sophistication is typically not imparted by professional education alone.

2.2 Quality of Profession

There is concern that two major potential sources of earthquake design knowledge and judgment—(1) professional education, and (2) mentoring by older experienced colleagues—are not doing the job. Graduate education in engineering includes little about seismic design. As suggested above, the mentoring practiced in some of the larger design firms that now do much of the work may be much less effective than that in smaller and middle-sized firms in the forefront of earthquake engineering.

In any event, the professional competence of designers and quality of construction both show wide disparities between the best and the worst. Many unqualified persons are operating in the design field. Most engineers do not really understand either the performance of buildings during earthquakes, or the basis of the building code. A lot of substandard work is going on.

We could build better buildings than we typically do at present. More effective technology transfer via strengthened continuing education would help, along with better policing of professional practice, and tighter quality control, including organizational peer review, project peer review, and observation and inspection of construction. There is
review, project peer review, and observation and inspection of construction. There is justifiable concern with licensing, the examinations and evaluation of professional design practice.

3.0 INFLUENCES ON THE DESIGN AND CONSTRUCTION PROCESSES

3.1 Elite Participants And a Sense of History

The oral history interviewees comprise a rather select elite of the profession, self-chosen in a sense by their own beyond-the-call-of-duty participation and recognized contribution to the profession. They tend to have a sense of history in their interpretation of earthquake engineering and its development. They recognize that what is done is not done principally, or only, for the "next" earthquake, but to make California structures reasonably safe for the foreseeable future. Their time horizon stretches out indefinitely.

Consequently they have laid the foundations for what they believe ought to be done in the next 25, 50, 100 years. The building stock being constructed will last that long. Even in the early years of this century, leaders writing in the Bulletin of the Seismological Society of America were calling for (1) research on earthquakes and their effects on buildings, and (2) societal response to the earthquake threat. They long ago clearly saw the need for and the potential of a much safer building stock in California.

Although they remained voices in the wilderness for a quarter of a century, they in no way gave up hope. Only after the first third of the present century, however, was there enough accumulated information and concern to make a start, pushed along by earthquakes in 1923 (Tokyo), 1925 (Santa Barbara), and 1933 (Long Beach). When they did get going, the historic leaders (1) looked at the long-term, and (2) saw development of a code and design practice capable of dealing with seismic forces as essential to a design profession operating in earthquake country.

3.2 Seismic Code Developed by a Comparatively Sophisticated Elite

The elite of the profession pioneered in developing earthquake engineering practice and codes. Selected by a kind of extended peer review, the oral history interviewees not only are a source of historical information, but also of judgments and evaluations of the profession that carry considerable weight. Consequently there is merit in distilling their collective ideas on good design and good professional performance. They tend to be more perceptive, progressive, active and motivated than the average design practitioner. Hence their observations are of unusual value, both (1) their recollections of what happened and how, and (2) their interpretations of the progress, status and projected future of the discipline. Despite their success, however, they remain concerned about the adequacy of earthquake design and the skills of the profession generally.

They also have had a sense of history in understanding where the codes have came from. The process really began with influence of Tokyo earthquake of 1923, followed by the Santa Barbara earthquake of 1925. The leaders were and are very much aware of the long struggles it took to achieve even our present much improved but still unsatisfactory
level of earthquake-resistant design. Some of the principal long-term efforts they participated in included (1) obtaining public recognition of the importance of earthquake hazard and the potential of better design to reduce it, (2) developing methodologies and standards for the codes, and (3) learning lessons from successive earthquakes.

Some ten years of post-World-War II efforts went into developing the basis for a uniform seismic code for use in California. An initial northern California effort—which produced the document known as "Separate 66"—was followed by a statewide effort under the Structural Engineers Association of California that resulted in the SEAOC "Blue Book." These were big pro bono efforts by some of the best of the structural engineers. Again, it was an elite effort by structural engineers dedicated to seismic design and to the profession, who were much more sophisticated than the average designer.

3.3 Field Act’s Influence on Design and Construction

The older leaders observed the development of the "California practice" over the years, and especially the seminal influence of the Field Act—the remarkable 1933 law intended to assure the seismic safety of public schools. The oral history interviews help demonstrate how the Field Act had major influences far beyond its actual legal reach, setting examples of good design and construction that prompted improvements in general design and construction practice.

This is a continuing matter for both satisfaction and concern. The improved practice is not required, but is voluntary, and is not universally practiced, even in California and the west. Accordingly designers cannot necessarily depend on the best quality of construction work in carrying out a design. In that event, a valuable fall-back protection is a design providing extra strength or redundancy.

Quality of work is a greater cause for concern when considering design and construction in the midwestern and eastern parts of the United States. There are important interrelationship between design considerations and prevailing practices. For example, California engineers have acquired many detailing practices from years of designing for seismic forces. That level of detailing concern is not found throughout the nation. There are also many local differences, e.g., use of brick in the eastern U.S. Brick can be designed to resist earthquake forces, but the construction work takes great care.

3.4 Design Philosophy, Understanding and Judgment

Having seen earlier earthquake codes in the making, the older leaders were sensitive to how much the achievement of good performance depends on engineering judgment, in addition to following the code.

Use of Judgment. Many unspoken assumptions respecting practice underlie the codes. Probably the most important assumptions are (1) that good judgment will be used in basic designs and siting, (2) that a good deal of redundancy will be provided to supply an extra margin of safety, and (3) that the designer’s intent will be carried out in the construction work. Designers also need to be especially sensitive to site concerns, especially
geologic or foundation characteristics that could affect structural performance during earthquakes, and may require special design considerations.

More Than Just Complying With the Code. The seismic resistance of even modest-sized unexceptional buildings depends not only on following a recognized seismic code, but also on using a suitable firm site, construction with good workmanship, tying the structure together with reliable connections, including adequate bracing, designing in a little "redundant" strength, and providing a continuous load path for earthquake forces.

Obviously more is needed than simply following a seismic code. The code is an "intent" document, not a menu list or a cookbook, and has only a sketchy series of minimum requirements. The code's intent, which is to provide a safe building, may not be fully realized if engineers treat it as a checklist of seismic safety requirements and believe that compliance will assure a safe building.

Many are likely to do this, however, if they fail to understand either the basis of the code or the way buildings behave in earthquakes. Judgment is needed in weighing complex factors determining structural performance in earthquakes. This calls for understanding the code and the philosophy of good design, not just meeting the code requirements.

The Imperial County Building Failure. The failure of the code-complying Imperial County (El Centro) administrative services building in the 1979 earthquake is a good example of designers failing to understand the basic assumptions made by code-drafters in setting the code requirements. The code assumption was that the walls would go down to the floor. The designers, however, put in "legs" and a soft first story, without thinking of it as a dynamic system. They put in stub walls between the ground floor and the second floor, thus introducing high forces in places they had not been designed for. This was one of the principal sources of trouble, although there were also other contributing factors.

Ironically the site conditions and space available would have accommodated a highly resistant, less expensive, and altogether more satisfactory structure. The designers could have been designed such a building if they had been more sensitive to client needs as well as more seismically aware, and had communicated with each other better. Such a replacement building has in fact now been built.

Ethical and Social Responsibility. In still broader ways, the philosophical, ethical, and socially responsible side of good engineering practice shines through in the recollections and reflections of most of the oral history interviewees. They valued good judgment in weighing matters and distinguishing what is important or crucial from what is incidental or even trivial. Good judgment in evaluating the relative importance of things and in making decisions on priorities are central to the best professional practice.
3.5 The Significance of Strong Motion

There has been much difficulty in interpreting the significance and use of "peak acceleration" data. Peaks may represent quite narrow spikes of motion of very short duration, not as if the mass of a building is subjected to a constant acceleration of like amount. The significant indication of the severity of the shaking--the damaging capability--is not so much the peak itself, as the area under the curve or under the pulse.

On the other hand, there has been lack of general acceptance that ground motion can be very severe, compared to building code forces. Structures need to be able to absorb the energy of strong earthquake motion and respond without undue deformation or collapse. For this, ductility and redundancy are essential, along with tying a structure together firmly with tough connections.

3.6 Architect-Engineer Collaboration and the Cost of Good Design

For engineered buildings the goal is design by a structural engineer experienced in earthquake engineering, and able from the early phases of design to work in close collaboration with the architect. There are, however, concerns that structural systems are not decided on jointly, but dictated more and more by architects, leaving engineers only the job of making the system work. This may adversely affect the cost of achieving adequate seismic resistance.

Good seismic design need not, however, be costly:

"...if the architects are reasonable, good earthquake design can be done at very little, if any, extra cost over slipshod methods. For best results, an architect should work with his engineer from the start of early planning of a building. Few do this. The disposition of columns and walls, especially of the important first story, is vital to the effectiveness and the cost of earthquake resistance." (Blume oral history)

On the other hand, this same interviewee acknowledged that a really satisfactory accommodation is not always possible. Ethical and public-interest considerations may then prompt some firms to turn down jobs:

"...when you're dealing with vast expenditures of money, and owners, architects, planners, economists--the structural engineer is not the only man in the arena.... These are difficult decisions. The best way I've resolved them is to figure out what's best for the public interest, as well as I could....we've walked away from some jobs because we couldn't get what we considered a decent resolution."

3.7 Assumptions About the Construction Process, and Related Considerations

Earthquake safety also involves other assumptions about the process of converting designs into buildings, i.e., the construction process. The principal assumption is that designs will actually be carried out faithfully, as the designer intended. In the "real world" this requires a good deal of care throughout the processes, including double-checking and
triple-checking to see that things are done properly. On-the-job review by the structural engineer is an exception. Inspection by the building department for code compliance may not be adequate, and inspection by the owner is optional with the owner. (State law does require inspection of public schools and hospitals.)

Knowledge of the earthquake hazard appears to be the primary reason why California structural engineering and building regulations are superior to those in the Midwest and East. (See also "Field Act’s Influence....," above.) Midwestern practice shows little conception of what building regulations ought to do or how they ought to be enforced. Thus regulations may not be enforced, plan checks may not be made, and when they are it is alleged that they may not really amount to much. Neither the building departments nor the engineering practices were considered up to par.

The Uniform Building Code (UBC) is based on the work of California structural engineers, and particularly on the SEAOC "Blue Book." In recent work directed toward a national code, however, there has been a diminution in the influence of California structural engineers. The code requirements are being accommodated to the practices of other areas that have much less concern with earthquakes and have fewer restrictions on the use of some materials. The materials interests have a significant influence on codes, not always exercised for the public good. Those same interests appear to be influential in the move toward a national U.S. code. In short, there may be a real risk of watering down the code based on California practice and developed for the region of greatest seismic activity.

Other causes for concern include the following. (1) Fast-track construction is seen by some interviewees as potentially one of the worst things to come along. It risks proceeding past the point-of-no-return on designs that may later prove inadequate. Its laudable aim of speeding up construction processes may nevertheless compromise quality by forcing premature design judgments that leave loopholes for poor decisions later. (2) New building materials are constantly appearing on the market. This may involve increased working stresses, resulting in use of less material. Also the materials may be brittle, or combinations of materials may reduce ductility. (3) Precast concrete construction can have weak points, principally the joints and connections, which in earthquakes should be the strong points. It tends to be weaker than poured-in-place concrete. (4) Tilt-up construction can also have problems with joints. (5) The perceived backwardness of much of the construction industry means less assurance that a complex structural design will actually be fully followed in the field when a building is constructed.

3.8 Quality Control: Independent Review and Inspection

Assurance of quality—achieved by a variety of "quality controls"—is really essential to first-rate seismic design and construction. In fact, however, important quality control elements are often missing from design and construction processes.

Independent Peer Review. Independent peer review is one type of quality control. There are several forms of independent peer review. (1) The most familiar form is project peer review—review of individual projects. Such reviews are done by peer review committees made up of members who are well qualified technically, and who do have no personal, professional or monetary conflicts of interest, hence "independent." Project peer reviews
involve reexamination of the basic thinking and assumptions underlying design provisions for the seismic resistance in the design of major structures. The peer reviews may result in design changes to improve structural performance, or to achieve designer’s objectives more efficiently or economically.

Several interviewees strongly urged that designs of major structures ought to be independently peer reviewed to validate or raise questions about the principal design concepts, especially with respect to providing adequate seismic resistance, ductility and redundancy. (Note: a ductile building is one that can absorb earthquake energy without undue deformation and while maintaining its structural integrity. Redundancy is added or reserve strength that can help a structure withstand earthquake forces without undue damage, even when the primary system of structural resistance has begun to give.)

(2) Organizational peer review involves reviews of design-firm procedures, standards and criteria, and a sampling of design output. Peer reviewers comment on the adequacy of the firm’s internal quality controls and other procedures, recommending improvements as needed. Organizational peer reviews are encouraged by some insurance companies to improve performance and reduce liability claims.

Observation, Review and Inspection. Observation, review and inspection ought to figure in all significant construction as basic quality controls, but often do not. In observation or review of construction, the design professional makes periodic on-site visits to see that the work being done carries out the intent of the design. Many interviewees consider this lacking in current practice, and believe that designers should spend more time communicating with the contractor and in supervising the work. Insurance and liability concerns may, however, prompt designers to avoid such visits.

Inspection is a more detailed process of checking. Inspections ought to be done both (1) by qualified inspectors employed by the owner, for assurance that the details, and especially critical details, have been carried out properly and in accordance with the design, and (2) by qualified inspectors employed by the local municipal building regulation department, Primarily to see that the codes have been complied with.

This phase of quality control appears often to fall short in the execution. Many jobs do not receive inspection. Design professionals often do not make observation and review site visits. Owners often do not employ inspectors on their own. Inspectors may not be adequately up-to-date in state-of-the-practice. There are wide variations in building department practice, some being well qualified, but many appearing to be weak links in quality control.

One critic (not an interviewee) singled out four points where things may not go well in quality assurance: "First, the code can be misapplied in the design office. Second, plan checking quality differs between cities...and between various contractual plan checkers. Third...special inspection to verify the material and components....can be bad.... Fourth...[is] on-the-job inspection. Each of the four can have various levels of quality, and our administration does not assure any sort of uniformity." (Quoted in Scott article in Earthquake Spectra, v. 8, no. 1, February 1992)
3.9 Concern With Some Computer Influences

There is concern that reliance on designs based on computer programs and computation may be overshadowing judgment and intuition based on experience. Engineers need to understand the limitations of computer analysis, as well as to know how to use it. This is one reason why independent peer review of major project designs is seen as highly desirable. It is a check-point where potentially questionable design assumptions or errors may be spotted.

Several interviewees see computers as valuable tools, but not as replacements for earthquake engineering judgment. It is impossible to get a "feel" for building performance from looking at computer programs. One warned, "Don't believe your numbers." Computer answers should be checked by judgment. For major structures, it would be one aspect of independent review, to verify that the assumptions underlying the computer program are appropriate, and that the numbers obtained appear realistic.

4.0 PROFESSIONAL ORGANIZATION OF ENGINEERING FIRMS

Some of the best earthquake engineering work is done in relatively small firms, reflecting special abilities and dedication of the key individuals in the firm. The life histories of typical firms find some retaining their relatively small size and vitality for long periods. This depends on the dedication of goal-setting firm members and on vigorous recruitment of top-level new staff, usually recent engineering school graduates especially recommended to quality firms by faculty members.

The best firms also encourage participation in design profession organizational activities, post-earthquake investigations, and continuing education programs. Such participation not only taps critically important sources of information and learning, but also ensures invaluable cross-fertilization processes that build professional skills, attitudes, awareness and depth of understanding of the importance of the work being done.

Firms may develop in various directions. Some maintain good practices for long periods, and then gradually wither on the vine as principals age and younger people are not retained. Others experience long growth periods, becoming giants in the field, or being absorbed by merger and acquisition along the way. These developments can have highly varied outcomes, with firm members benefiting or losing financially, and with firm quality and performance depending on top-management policies, which today may be oriented more toward fiscal and stock market success than toward quality engineering.

Some oral histories have shown how merger, acquisition and growth to large size can have counterproductive effects. Large firms necessarily involve more formalities and overhead staff (accountants, attorneys, etc.) and result in less net time being spent on design. As noted earlier, the mentoring of younger staff members that has been a valuable feature of work in some of smaller and middle-sized firms in the forefront of earthquake design may not be practiced to the same extent in the larger design firms that now do much of the work.
5.0 CONCLUDING REMARKS

This is an impressionistic, subjective essay, based on the interviewer's participation in the oral history interviews and on his conclusions regarding principal points made that concern seismic design. It does not represent the results of a detailed analysis of the interview contents.

In addition, the interviewer has also drawn upon the results of work done in Year One of the CUREe-Kajima Research Project, on Topic Number 7, Multidisciplinary Strategies. This seemed appropriate because the original concept of the multidisciplinary strategies effort was itself based in part on what had been previously been learned from the oral history interviews. The two sources were mutually supportive, helping enrich and verify the results.

The author also used the Topic Number 7 material and the oral histories to prepare an article for publication in the professional journal of the Earthquake Engineering Research Institute. The article, entitled "Earthquake Engineering: Observations From California Experience," will appear in the Public Policy Theme Issue of Earthquake Spectra, vol. 8, no. 1, February 1992.

Finally, the interviewer wishes to emphasize that this brief essay does not begin to exhaust the wealth of material in the oral history interviews, which goes far beyond information relevant to seismic design. The histories contain autobiographical material on the interviewees, as well as their observations on the development of the design professions, earthquake engineering, seismic safety policy, and building codes. The histories include recollections and evaluations of the work of distinguished engineers and others whom the interviewees worked with during their professional careers. As suggested at the outset, this wealth of material will be archived in the depository for oral histories and available over future years and decades for analysis and interpretation by students of history, professional development, earthquake engineering, etc.
APPENDIX A: INTERVIEWEE LIST

Oral History Interviews on Earthquake Engineering (Eng), Field Act (FA), Geology (Geo), and Seismic Safety Commission (SSC)

(As of September 1991)

Alfred Alquist (SSC) 7/1/87, 7/8/87
Richard Andrews (SSC) 9/9/86, 4/7/87, 5/7/87
Steve Barnes (Eng) 2/8/87
John Blume (Eng) 3/24/87, 4/1/87, 7/2/87, 9/8/87, 10/22/87, 1/13/88
Bruce Bolt (SSC) 7/9/87, 9/25/87, 4/5/88, 2/14/89
David Brown, et al (FA) 2/4/91
Walter Brugger (Eng) 4/25/89
Vincent Bush (Eng) 3/28/89, 4/27/89
Alvaro Collin (Eng) 6/3/91
Henry Degenkolb (Eng) 14 interviews, January 1984, May 1986
Charles De Maria (Eng) 6/14/88, 7/19/88, 8/30/88
Robert Dewell (Eng) 1/13/87
Rodney Diridon (SSC) 5/21/87
Harold Engle, Jr. (Eng) 1/23/87
Leslie Graham (Eng) 4/19/89
John Hendricks (SSC) 4/13/87
Don·Hudson (Eng) 4/26/89, 10/11/89
Don Jephcott (Eng, FA) 2/27/89, 5/2/89
Carl Johnson (Eng) 11/29/88, 2/28/89
Roy Johnston (Eng) 11/29/90
Steve Larson (SSC) 1/6/87
George Mader (SSC) 10/16/86, 12/16/86, 3/27/87
Ralph McLean (Eng) 5/24/90, 7/20/90, 9/15/90, 11/26/90, 2/4/91
Frank McClure (Eng) 4/10/89, 9/10/91
### Oral History....(cont.)

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Language</th>
<th>Dates</th>
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<tbody>
<tr>
<td>Joseph Nicoletti</td>
<td>Eng</td>
<td>4/15/91 6/25/91</td>
</tr>
<tr>
<td>Svend Nielsen</td>
<td>Eng, FA</td>
<td>4/25/89</td>
</tr>
<tr>
<td>Gordon Oakeshott</td>
<td>Geo, Eng</td>
<td>1/17/86, 3/17/87</td>
</tr>
<tr>
<td>Ed O’Connor</td>
<td>Eng</td>
<td>8/21/87, 3/29/89</td>
</tr>
<tr>
<td>Robert Olson</td>
<td>SSC</td>
<td>7/14/86, 8/22/86, 12/1/86</td>
</tr>
<tr>
<td>Clarkson Pinkham</td>
<td>Eng</td>
<td>4/27/89, 2/9/90, 7/18/90</td>
</tr>
<tr>
<td>Michael Pregnoff</td>
<td>Eng</td>
<td>9/17/86, 10/15/86 (Full day)</td>
</tr>
<tr>
<td>Robert Rigney</td>
<td>SSC</td>
<td>7/29/87 (Half day)</td>
</tr>
<tr>
<td>John Rinne</td>
<td>Eng</td>
<td>10/14/86, 7/13/87, 10/19/87 7/19/88</td>
</tr>
<tr>
<td>Art Sedgwick</td>
<td>Eng</td>
<td>7/26/88, 4/18/89 (plus self-interview tapes dictated in 88-89)</td>
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<tr>
<td>Howard Schirmer</td>
<td>Eng</td>
<td>11/14/86</td>
</tr>
<tr>
<td>Roland Sharpe</td>
<td>Eng</td>
<td>5/24/89, 2/25/91, 3/18/91, 4/16/91, 5/30/91</td>
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<tr>
<td>Leon Stein</td>
<td>FA</td>
<td>3/30/89</td>
</tr>
<tr>
<td>John Steinbrugge</td>
<td>Eng, FA</td>
<td>4/25/89</td>
</tr>
<tr>
<td>Karl Steinbrugge</td>
<td>Eng, SSC</td>
<td>6/2/86, 6/27/87</td>
</tr>
<tr>
<td>James Stratta</td>
<td>Eng</td>
<td>3/25/91, 4/1/91, 4/15/91</td>
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<tr>
<td>Peter Stromberg</td>
<td>SSC</td>
<td>7/8/87</td>
</tr>
<tr>
<td>William Taylor</td>
<td>Eng</td>
<td>2/5/91</td>
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<tr>
<td>John &quot;Buzz&quot; Wright</td>
<td>Eng</td>
<td>12/3/86</td>
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</table>

**NOTE:** In addition to the oral history interviews noted above, in 1958 several hours of taped interviews were done with Henry Brunnier, San Francisco structural engineer. These reel-to-reel tapes recorded by interviewer Frank Killinger were transcribed in the late 1980s, and were reviewed, verified and corrected by former colleagues of Brunnier. The interviews contain extensive biographical material on Brunnier, who was one of the preeminent San Francisco structural engineers. He practiced here from his arrival in San Francisco immediately after the 1906 earthquake until the end of his life. The interviews do not, however, contain very much discussion of structural engineering practice or of the profession. Apparently one or more tapes of such discussion were made, but cannot now be located.
APPENDIX B: SELECTED REFERENCES ON ORAL HISTORY


Oral History Review. An annual published by the Oral History Association. (Note: The Oral History Association also publishes a Newsletter.)


A UNIFIED EARTHQUAKE HAZARD MITIGATION STRATEGY
1.0 INTRODUCTION

Kajima Corporation's report, "Long Road, Earthquake Hazard Mitigation," (1991) correctly notes that effective earthquake disaster prevention depends on actions by government, private firms, and the public (see Figure 1). A unified strategy for hazard mitigation means that each of these groups must understand earthquake risk information to be able to select useful countermeasures and to implement them.

A unified strategy must have two dimensions that are connected together: (1) the sectors of society (private citizens, private companies, government), and (2) the unifying categories of actions that need to be taken, including realistic risk assessments, determination of countermeasures, implementation of specific countermeasures, and the later improvement of them. This process must simultaneously involve the three groups as equal partners. Figure 2 is a simple way of showing these relationships. Each box in the matrix could be completed by entering the necessary information needed, actions to be taken, results of previous actions, or plans for the future.

As used in this report, mitigation is defined in its broadest sense. It means any actions taken to reduce the damaging impacts of expected future earthquakes. Typical actions may include limiting new development on poor ground areas or taking special geotechnical precautions to prevent damage, replacing or strengthening existing structures that are likely to perform poorly in the expected earthquakes, preparing and practicing emergency preparedness measures, developing plans for recovery and reconstruction that will not create new hazards, and others. Some of these are discussed in more detail later in the paper.

2.0 TECHNICAL AND SOCIAL INTERDEPENDENCIES

The economic and social well-being of large cities involve many complicated interdependencies between the technical and social elements of modern society. First, the well-being of a city depends on interdependence between public people, private companies, and governments. Second, the well-being of each of these entities depends on a complex network of technological elements, including lifelines, telecommunication systems, transportation systems, energy supplies, food supplies and the numerous other essential components of modern cities.

Major earthquakes may damage, destroy, or disrupt all of the essential components of modern cities and thereby greatly reduce the overall well-being of the city. Because of the critical interdependencies, damage to even a small part of the essential components of a city may have great impact on the overall functioning and well-being of a city. Therefore, in order for a unified mitigation strategy against earthquake hazards to be effective, the strategy must recognize and consider the many important interdependencies between both the sociological and the technological elements of a large modern city.
Present Earthquake Disaster Prevention System

Desirable Earthquake Disaster Prevention System
<table>
<thead>
<tr>
<th></th>
<th>PRIVATE CITIZENS</th>
<th>PRIVATE COMPANIES</th>
<th>GOVERNMENT</th>
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<tbody>
<tr>
<td>RISK ASSESSMENT</td>
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<td>DETERMINATION OF</td>
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<tr>
<td>COUNTERMEASURES</td>
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<td>IMPLEMENTATION OF</td>
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<td>COUNTERMEASURES</td>
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Figure 2

Unified Mitigation Strategy Concept
2.1 Sociological Interdependencies

The social interdependence between public people, private companies and government must be included in an effective unified mitigation strategy for reducing the negative impact of earthquakes. All of the essential functions of a modern city (production, commerce, and consumption) involve cooperative interactions between public people, private companies, and government. At present, with respect to earthquake hazard mitigation, each of these three entities have some interaction with the other two elements in planning and undertaking disaster mitigation actions. However, the total interdependence of these three entities must be adequately incorporated into a unified mitigation strategy.

2.2 Technological Interdependencies

Modern cities depend critically on a complex interdependent network of lifelines, telecommunications systems, transportation systems, energy supply systems, food supply systems, and others. In order for a city to function well and to protect the well-being of its occupants, all of these technologically-dependent systems must function not only individually, but also in coordination with each other. Earthquake damage to these critical systems may greatly impair the functioning of the whole city. Therefore, designing these systems to withstand the effects of earthquakes as much as possible, and planning to restore these systems as quickly as possible after an earthquake are essential parts of an effective earthquake hazard mitigation strategy.

With respect to these technological interdependencies, as well as with the sociological interdependencies discussed above, a cooperative partnership exists between public people, private companies and government. Therefore, an effective unified mitigation strategy for reducing earthquake hazards must also be a cooperative partnership which recognizes the sociological interdependencies as well as the technological interdependencies.

3.0 KNOWLEDGE TRANSFER AS A KEY ELEMENT

Effective earthquake hazard mitigation is partly a dynamic knowledge transfer process that involves all sectors. To be successful it requires continuing research and analysis by earth scientists (seismologists, geologists, engineers, social scientists, and others), the communication to and understanding of their findings to important governmental and private company decision-makers and to the public, and the conversion of the risk information into practical and effective mitigation measures by each of them. Figure 3 is from a study done by VSP Associates, Inc. for the Federal Emergency Management Agency. In a simple way, it shows how basic earth science information supports all mitigation efforts. Effective mitigation depends on each group taking specific actions within their responsibilities and spheres of authority so that danger is reduced throughout society. This is presented in Figure 4, which is based on Kajima’s concept.
PEOPLE & PROPERTY

USERS
Local, State, and Federal Agencies
Practicing Professionals, Private Organizations
Voluntary, Educational and Nonprofit Groups
The Public

MITIGATION AND PREPAREDNESS TECHNIQUES
Laws, regulations, codes, and standards
Emergency plans, tests, and exercises
Information dissemination and education
Siting, design, construction, and inspection practices

RESEARCH
Applied Earth Sciences,
Engineering, Architecture,
Social Sciences, Planning,
Others

THREAT
Basic
Earthquake
Information

THE EARTH

THE CONCEPT OF HAZARD REDUCTION

Figure 3
Risk Information

Reduced Earthquake Danger

Mitigation Measures

Implementation

Figure 4
4.0 HAZARD MITIGATION AS AN INNOVATION

Getting citizens, private companies, and governments to take hazard mitigation actions means that they must do something new or differently than they have in the past. These are the "users." Social scientists who are familiar with the study of innovation processes know that several steps are involved in getting the users to take specific actions to mitigate hazards. These are:

1. **Awareness of the problem:** The user becomes aware of the risk and technologies available to mitigate damages. Users usually want to solve the problem of reducing their risk. Their actions may be in response to new laws and regulations, public information, or technical information received from literature, consultants, scientists, and others. This awareness starts the process.

2. **Trigger for action:** Usually some event, such as the enactment of a new law, attendance at a scientific conference, technical meeting, or some other event, starts the search for effective mitigation techniques. Often, a leader is needed who initiates the process and becomes the person who promotes mitigation in the family, private company, or government agency.

3. **Search and planning:** The trigger event now mobilizes the people involved to search for information and technologies. Part of the search process is to clearly define the exact problem and the alternatives available to solve it. This is a critical stage, and it is both political and technical. Consensus has to be reached among those involved on the completeness and reliability of the technical information and what strategy to use for its implementation.

4. **Adoption:** This means making specific decisions to mitigate earthquake hazards. Leadership is important because money, staff time, consultants, and other resources have to be committed to implementing the mitigation strategy.

5. **Implementation:** Once the innovative mitigation strategy is adopted, the process required to complete the action must be managed. For major construction projects, for example, this process may take years. Therefore, support for and commitment to a new earthquake resistant design technique for a new building must be maintained long enough to get the building actually constructed.

6. **Transfer of experience:** Users of earthquake mitigation technologies do influence decisions by others to take similar actions. People who may be less interested see others taking action, and their willingness to do so increases. This second group might start the process by seeking information and setting up its own decision-making process.

5.0 KEY ELEMENTS OF INFORMATION

As noted earlier, successful mitigation depends on accurate and reliable information about the risk and the effectiveness of the mitigation strategies available to the user. Because of their importance, some of these are discussed below.
taken other measures. Some citizens have secured objects in their homes and joined community groups active in disaster prevention.

The methods for implementation vary among different societies. They depend on the cultural values; division of responsibilities between government, private companies and citizens; the mixture between regulation and voluntarism; organizational and institutional relationships, and others.

In California, for example, all levels of government are responsible for earthquake mitigation. Local governments adopt and enforce some measures directly. State government may require local governments to perform some functions under state direction. State government may take countermeasures directly. The national government may require the states to take some actions, and it also has complete responsibility for some of its own or regulated facilities within states.

6.0 CONCLUSION

The purpose of this brief paper has been to explore the elements of a unified earthquake hazard mitigation strategy. While more research and thinking needs to be done, it is clear that there is a way to organize a unified approach. Such an approach must connect the major elements of society (citizens, private companies, and government agencies) together through a mitigation process that begins with a risk assessment. This will lead to the determination of which are countermeasures are most effective, their implementation, and the making of later improvements. Further elaboration of the earthquake damage propagation model presented by Kajima Corporation in its Year Two report will be very helpful in defining effective mitigation actions.
APPENDIX 1

California at Risk

Reducing Earthquake Hazards
1987-1992

A report of the

California
Seismic Safety Commission
1900 K Street, Suite 100
Sacramento, CA 95814
916/322-4917

Report No. SSC 89-02
September 1, 1989
The heart of the program is the development and implementation of the initiatives, clearly stated actions and reachable goals to significantly improve California's earthquake safety by the year 2000.

When the program was developed, efforts were first focused on determining the actions the state itself must undertake to reduce earthquake hazards. Now, the steps essential for their implementation have been described, and the lead and supporting state agencies responsible for carrying out each initiative have been identified.

The initiative descriptions in Appendix A list the lead and supporting agencies responsible for the initiative's implementation. The “lead” agencies shown have the primary responsibility for the initiative; they work with the “support” agencies to assure effective, workable programs. The initiative descriptions also include time schedules showing the major milestone events that lead to the completed startup of the action. After each initiative is started, the lead and supporting agencies are to carry out the actions necessary to obtain the full impact of the improvements in seismic safety that are the object of the effort.

It must be strongly emphasized that the development of these initiatives has been a cooperative process shared by the Seismic Safety Commission and the agencies that are responsible for their implementation. This process brings together the multiple agencies and levels of government involved. The most important factor in success of the program is the participants' recognition that it will require their continuing efforts over a number of years to realize the seismic safety improvements that are being sought.

Six criteria have been used to evaluate each initiative:
1. Casualty reduction—the potential to save lives and prevent injuries.
2. Damage reduction—the potential to avoid property and economic losses.
3. Socioeconomic continuity—the potential to reduce economic disruption.
4. Social responsiveness—the degree to which the activity responds to and reflects social norms and values.
5. Opportunity—the relative ease with which the activity can be implemented and the degree to which the activity complements other activities (the opportunity to leverage resources of institutions, groups, industries, etc., through a relatively small investment).
6. Cost—the dollar cost associated with the activity.

Finally, each initiative has to meet a “common sense” test that is intended to reflect the degree to which the initiative would be considered by both decision-makers and the general public as being practical, sensible, and feasible.

This first five-year program emphasizes reducing the number of hazardous structures and strengthening the state's emergency response capabilities. These two areas were seen as having the greatest immediate potential for saving lives. The reduction of hazardous structures is an expensive process that has to be pursued vigorously if a significant number of such structures are to be retrofitted or removed by the end of the century.

Initiative Categories

Though they are interdependent and must be implemented as a group to achieve the program's goal of significantly reducing California's earthquake hazards, the initiatives have been divided into six categories that reflect the different areas in which actions are needed to prepare for an earthquake. In these areas two kinds of actions are described:

- Actions to increase life safety, which include reducing hazards before an event and improving the emergency responses necessary to save lives following the ground shaking.
• Actions to speed recovery from an earthquake. Problems of economic and social recovery can overwhelm a community or region and place impossible demands on state government unless pre-earthquake planning has provided guidelines. The loss of businesses damaged in an earthquake could cause a long-term economic slump, not only for the immediate region but for the entire state.

Detailed descriptions of the initiatives in each category, including their status and the agencies responsible for their implementation, appear in Appendix A.

Existing Development

The program identifies and strongly emphasizes the need to minimize the hazards associated with the vulnerability of existing development, defined as buildings and structures, to earthquakes. Existing development poses the principal threat to life safety. It includes some structures that were built before effective earthquake safety standards were established. There is also evidence some newer structures may also be potentially unsafe. Valuable beginnings have been made in starting to deal with these hazards, but the task of reducing the threat is not easy, nor will it be inexpensive to make these improvements to the building stock of California.

The problem lies in the large inventory of building stock in the state. Although we can expect some degree of "turnover" in this stock before the year 2000 (e.g., older buildings being demolished and replaced by newer, safer structures), unless measures are taken, many hazardous structures will still be in use at the turn of the century. Reducing the hazards of existing development is critical to meeting the goal of significantly reducing earthquake hazards by the year 2000.

The hazards represented by existing development have been grouped into three areas:

• Unsafe buildings and other structures;
• Hazardous nonstructural building components; and
• Hazards in the supporting infrastructure (e.g., utilities and transportation Facilities).

The hazards associated with each of these problem areas are: Unsafe Buildings. Collapse of buildings or portions of buildings are the most easily recognized threats to life safety during an earthquake. Equally important to life safety, however, is the continuation of operations of essential facilities that provide for the public's safety, security, and health. Reduction of building collapse potential and continued operation of these essential facilities form the basis for the definition of structural seismic hazards that are identified in the program.

A concern about collapse is directed toward buildings constructed of materials or using methods that have poor records of seismic performance. Included in this category are unreinforced masonry construction, older nonductile concrete structures, and other buildings designed prior to the introduction of seismic codes. Additionally, some modern buildings of unusual configuration or untested materials or construction methods may also be susceptible to earthquake damage.

Other buildings that house large numbers of people may require an independent review of building design and additional construction inspection based on life-safety considerations. As an example, although the 1933 Field Act requires the Office of the State Architect to review the design and construction of public K-12 schools and community colleges, neither private K-12 nor postsecondary education facilities are required to meet these statutory structural safety standards that have been in force since 1933. In addition, experience has shown that higher levels of design and more detailed construction inspection may be needed than those previously required.

Hospital structures and essential services facilities are especially important because of the vital function these facilities play in providing life safety support to the public in emergencies. For effective emergency response, hospitals, emergency operation centers, fire and police stations, and communication facilities must be functional after an earthquake. The problem that has been identified is that hospitals built prior to 1973 do not meet seismic safety standards that will enable them to remain in use after a disaster. Further, essential services facilities built before July 1, 1986, the date of the Essential Services Facilities Act, may not be adequately resistant to earthquakes and could become nonoperational at the very time they are most urgently needed.
Modern industry poses many problems. Hazardous materials such as industrial chemicals, pesticides, and flammable chemicals are processed and stored in structures and tanks that are potentially unsafe. Although there have been no significant problems with major hazardous spills in past earthquakes, the volume of such materials in the predicted earthquake zones has increased significantly in recent years, prompting increased concern about the earthquake resistance of processing and storage structures.

Occupants of residential structures, such as single family dwellings and mobile and manufactured homes, are relatively safe from personal injury during an earthquake, but the homes may be extensively damaged. Such damage can be reduced by the simple act of properly anchoring the structures to sturdy foundations. This kind of mitigation measure, if implemented, would reduce the large numbers of people requiring shelter and other forms of assistance following an earthquake.

To meet the goal of significantly reducing earthquake hazards described above by the end of the century, it is necessary to achieve the following objectives:

• Programs should be designed and implemented by state and local governments to accomplish the following: (1) inventory buildings that are potentially hazardous due to structural considerations (e.g., unreinforced masonry or other types of construction considered insufficiently resistant to shaking), (2) classify the buildings according to the degree of hazard, (3) develop mitigation strategies, and (4) implement measures to eliminate or reduce the life-safety hazard.

• Public schools and hospitals identified as hazardous should be retrofitted with seismic safety improvements. The steps noted above should be used to systematically reduce hazards in public schools and hospitals.

• Structures in which hazardous materials are commercially manufactured and/or stored should be strengthened and/or retrofitted to withstand earthquakes, so that hazardous materials and compounds are contained and not released into the environment.

Nonstructural Components. Buildings comprise more than just the structural framework that supports them. They include the many features, equipment, and contents that add value to a building, perform work and—in a major earthquake—can pose a serious threat to the people who live or work in such buildings. The Coalinga and Whittier Narrows earthquakes demonstrated the potential for damage from building contents associated with failure of nonstructural components.

This program puts a priority on reducing or eliminating incapacitating nonstructural earthquake damage in facilities needed for effective response. In hospitals, for example, serious damage to equipment and supplies can impair medical response during an emergency. The program encourages businesses and the public to anchor or otherwise provide for the security of nonstructural components and hazardous materials in the workplace for the protection of occupants.

To reduce these kinds of nonstructural hazards, the following objectives must be achieved:

• Facilities identified as essential for effective response to an earthquake must be strengthened and their equipment secured so they will continue to function after an earthquake.

• Training and information for building managers, safety directors, building engineers, and occupants of highrise buildings are needed to prepare these people to meet the emergency demands of a major earthquake.

Infrastructure. The utility systems that provide water, sewers, communications, electricity, and natural gas could suffer delivery service stoppages from earthquake damage. The need for an operating water supply was evident in the 1906 San Francisco earthquake, when uncontrollable fires caused great damage. If water, sewer, telephone, and electrical systems remain operational, or can be restored quickly, the difficulties of providing an effective emergency response to victims of an earthquake, and of recovery, will be greatly reduced. There is also danger of leakage and explosion from gas and petrochemical lines that do not withstand an earthquake plus dams, reservoirs, and transportation networks could suffer rupture causing damage from earthquakes. The intent of this program is to minimize damage to utilities
and transportation systems so they can be brought back into effective use promptly after an earthquake.

To ensure a reduction in hazards associated with existing infrastructure, the following objectives must be accomplished:

- Utility systems should be reviewed and, if necessary, their design and construction improved so they can withstand strong earthquake ground motion with minimal damage, and be brought back into operation quickly after a damaging earthquake.
- Dams, reservoirs, and transportation systems should be designed and maintained to withstand earthquake motion with minimum damage and risks to life safety.
- Public agencies and private owners must inspect their buildings to identify and correct potential falling hazards that threaten both occupants and the public passing by at the time of an earthquake.

**Emergency Planning and Response**

The inevitability of major earthquakes occurring in California, combined with the current inventory of hazardous buildings and other risks to life and safety, demands a high priority be placed on effective emergency planning and response to increase the number of lives saved and decrease property damage. The 1985 earthquake disaster in Mexico City, in which hundreds of people were trapped in the rubble, demonstrated just how important effective response is. The Armenian earthquake disaster demonstrated again the imperative requirement to effect rescue within 24 hours if victims are to survive. A major catastrophic earthquake will place demands on emergency responders that will exceed existing capabilities and resources. Steps must be taken to assure effective emergency response. The agencies responsible for initiatives in Category 2, Emergency Planning and Response, have been very successful in their implementation efforts.

Effective emergency response means that the capability has been established, and is being maintained, to provide such services as fire suppression, emergency medical care, emergency communications, evacuation and temporary shelter, search and heavy rescue, public information, and identification of buildings and other structures that earthquake damage has rendered hazardous.

Effective emergency planning requires that the agencies and personnel who provide these services are trained, equipped, organized, and prepared to deal with a major disaster and that emergency coordinators at all levels have detailed knowledge of how the response system operates and use this knowledge effectively.

It takes time to develop and implement a comprehensive emergency management system that ties together the response elements of local, state, and federal governments and volunteer and private sector resources. Recognizing this, the program emphasizes improvements in statewide emergency response capabilities and organization in both Emergency Planning and Emergency Response Systems:

**Emergency Planning.** Effective response depends upon the willingness and commitment to plan, and to spend time and resources on training and testing plans against future emergencies. The failure to make such investments could leave us in an unacceptably vulnerable condition. Some specific considerations relating to emergency planning are:

- **Emergency planning** is critical to effective earthquake response. The California Emergency Services Act requires the development of a State Emergency Plan and charges all counties and cities that establish disaster councils to adopt and publish emergency operations plans that assign emergency responsibilities.
- **Mutual aid,** described in the State Emergency Manual, is the mechanism by which local jurisdictions currently agree to provide mutual reinforcement of law enforcement and fire services when the effects of a disaster are greater than a single jurisdiction can handle. This concept needs to be extended beyond local police and fire protection to additional key services including emergency medical care, transportation, and public works so that all state and local public services can expand as required to achieve a more effective response after a major earthquake.
- **Trained personnel** are critical to an effective emergency response. In 1971, California established the California Specialized Training Institute (CSTI) to provide support to local governments in planning and preparation for disasters. CSTI conducts
training in emergency management, including response to earthquakes, floods, and hazardous material spills. This program provides the core around which the necessary additional emergency training effort must be built.

- Testing through use of realistic exercises must be conducted periodically to verify that emergency response planning works. Regular emergency response exercises help to determine whether mobilization of private-sector, local, state, and federal personnel and resources are capable of dealing with a major disaster. Such tests are expensive and can be easily postponed when resources are limited; however, commitments to conducting tests and exercises can be made.

This program proposes the following emergency planning objectives to reduce the loss of life associated with earthquakes:

- Meaningful emergency response plans should exist for state and local governments, state and local government agencies, special districts, private sector organizations, disaster relief agencies, and schools. Lead agency responsibilities must be identified for all emergency response functions.
- Regular emergency response exercises should be conducted to test and improve the effectiveness of state, local, and private-sector emergency response capabilities.
- A complete network of mutual aid agreements should be developed for critical functions required during earthquake emergencies, including fire, law enforcement, medical services, hazardous materials, engineering services, and heavy construction. There should be regionwide agreements covering major metropolitan areas.

Emergency Response Capability. Effective response to the devastation caused by major earthquakes requires planning, organizing, training, and providing support systems, facilities, and equipment so that emergency responders can perform their lifesaving duties. Without sufficient resources, response can become frustrating and haphazard at best, and may become dangerous at worst.

More specifically, emergency management systems are essential to effective disaster response. Poor communication and coordination among responders results in misunderstandings, delays, and duplication of effort. Analysis of the response to the Coalinga earthquake has suggested that improvements should be made in on-scene management and coordination of emergency medical care. Analysis of the Whittier Narrows earthquake repeats the same conclusions learned in Coalinga. A similar disaster in a major metropolitan area could create insurmountable problems.

Emergency Operation Centers (EOCs) must be effective and operational during earthquake response. The EOC is a centralized facility from which emergency operations can be directed and coordinated. To be effective, an EOC must provide adequate working space, be properly equipped and, most importantly, afford the capability to communicate with field units. The EOC must be capable of immediate operations, not left to be organized after an earthquake occurs and time is precious.

Urban search-and-rescue teams, trained and in place, are critical in earthquake disasters. Without such a capability, trapped victims will die from the lack of immediate attention to injuries, or from exposure. Special equipment and the safety and preparedness of rescuers is also vital.

Research on the great 1976 Tangshan, China earthquake showed that 99 percent of trapped victims rescued within the first half an hour after the shaking survived, compared to only a 36 percent survival rate of victims rescued on the third day. The Armenian earthquake in 1988 confirmed again that rescue during the first 24 hours is crucial if a victim is to have the greatest chance of survival. In a modern city, effective rescue requires the use of an organized program and approach in addition to immediate volunteers.

Communication systems must be in place and working during the emergency response effort. Currently, local emergency services organizations do not have adequate radio frequencies; there is no reliable intergovernmental communications system linking cities, counties, and state government emergency headquarters; and heavy use of multiple frequency bands further complicates interagency communications. The current communication system relies on ground-mounted towers and other facilities for telephone, radio, and microwave communications. Systems such as these
could suffer extensive damage in a major earthquake.

This program proposes the following emergency response objectives to reduce significantly the loss of life associated with earthquakes:

• A fully integrated emergency management system should be developed to support emergency response direction and control functions, including emergency operations centers for coordination of response efforts to regional disasters. Training courses should be developed and made mandatory for state personnel assigned essential earthquake emergency response functions.

• An integrated, statewide emergency communications system should be developed.

• The development of regional “search and rescue” capabilities, including a specialized urban heavy rescue program with ready access to specialized equipment, should be completed, and the system maintained and regularly exercised.

• Community-based, or neighborhood-based, volunteer emergency assistance programs should be established in metropolitan areas and coordinated with NVOAD (National Volunteer Organizations Active in Disaster) and the American Red Cross. Public safety personnel must be trained to manage these volunteers.

• Mutual aid agreements should be developed for all functions necessary for emergency response.

Future Development

Category 1 of this program deals with hazards associated with existing development. Category 3, Future Development, represents a different set of problems—with a different set of opportunities. This section discusses measures that can be taken to reduce hazards in new development when design decisions are being made and before money has been committed. If seismic safety requirements are considered during the planning, design, and construction of new development projects today, the extent of hazardous development in the year 2000 and beyond will be significantly reduced.

All buildings and other structures in California intended for high rates of human occupancy should be planned, designed, and built to the best current standards of earthquake resistance. This requires continuing improvements to keep pace with technical advances in site location, design, and construction practices, so that the structures are built to resist the damaging effects of earthquakes. Often building a safer structure will cost no more, and may even cost less. Improving current construction standards and processes for new development is clearly a reasonable approach for reducing future hazards.

For the purposes of this program, improvements associated with new development are grouped into the following areas:

• Planning, permitting and regulation of land use;

• Building codes and their enforcement; and

• Maintenance and use of current seismic safety information.

Planning and Regulation of Land Use.

Historically, the principal land use planning control in California has been exercised by the local governments (cities and counties) through general plans, subdivision and zoning regulations, and the permit process. The state establishes broad policies defining the exercise of land-use regulation. Land-use planning, as currently practiced, is intended to provide a rational arrangement of land uses in a community, taking all relevant factors into account—including seismic safety. The preparation of maps portraying the kinds and levels of earthquake risks, accompanied with geologic and technical information, can help guide community planning and land-use decisions.

Accurate hazard mapping and geotechnical assistance are fundamental in making prudent decisions about the location of new development and design requirements appropriate for a given development proposal. Hazard mapping includes the preparation of maps that realistically portray the relative levels of earthquake risks and indicate areas of potential earthquake-caused losses.

Each city and county in California prepares and adopts a general plan that addresses its long-range planning and development issues. One of the mandatory elements in a general plan is a safety element, which must consider such items as surface ruptures from faulting, ground shaking, ground failure, liquefaction, and seismically
induced sea waves. The safety element represents one of the best opportunities for promoting seismic safety before major development costs have been incurred.

All cities and counties are required to adopt subdivision regulations. It is important that land planned for development be carefully analyzed with respect to seismic hazards at the earliest possible stage to determine its suitability for a proposed subdivision. Currently, developers are required to record subdivision maps. Local jurisdictions, through ordinance, require physical improvements associated with the creation of lots. The disclosure of seismic risk to potential buyers, however, is not currently a requirement except in Special Studies Zones.

Zoning ordinances are the principal means of implementing the general plan. The zoning ordinances of local jurisdictions are required to conform to their adopted general plans. Therefore, since the safety element is a mandatory component in city and county general plans, zoning ordinances for cities and counties must be tailored to implement seismic safety policies. Cities and counties are, however, granted a high degree of control over local zoning matters, including the granting of variances from zoning ordinances.

The goal of significantly reducing earthquake hazards requires achieving the following objectives with respect to planning and land-use decisions:

- Preparation and statewide availability of geologic and seismic hazard maps that are sufficiently detailed to guide property owners and local governments.
- Amendment of all local general plans, taking into account the full range of seismic hazards and including measures to be taken to reduce seismic risks. Appropriate local ordinances should be enacted to reflect updated information on seismic hazards. Local land-use and subdivision regulations in high-risk areas should take into account the known extent of seismic hazards affecting proposed new development.

Building Codes. Building codes are designed to establish minimum safeguards for the construction of buildings, protect occupants from fire hazards or structural collapse, and prohibit unhealthy or unsanitary conditions. California uses the Uniform Building Code as a basis for establishing minimum statewide standards (embodied in Title 24 of the California Administrative Code). The authority to adopt building code provisions for certain types of occupancy has been delegated to local governments, which may establish more stringent provisions to meet local needs and preferences.

To be effective, codes must be well administered and enforced. Local building officials are responsible for reviewing and approving plans and inspecting construction of buildings intended for certain types of occupancy. A 1980 report by the International Conference of Building Officials on building departments and earthquake safety is believed to be still valid. It noted that some local building departments are ineffective in ensuring optimal structural seismic safety. Some of the problems noted were: (1) the large number of codes to be considered in the building inspection process; (2) the lack of support for seismic safety from local administrators; (3) shortages of staff and low salaries; and (4) the uneven levels of professional training and experience with seismic hazards.

This program is designed to achieve the following objectives with respect to building codes before the end of the century:

- Strengthen code enforcement by providing training and continuing education for local officials, and assuring the availability of structural engineers to review specific types of construction.
- Independent peer review of high-occupancy and other critical structures during both the design and construction phases.

Maintenance and Use of Current Seismic Safety Information. New information produced by research contributes to increased levels of earthquake resistance in new structures. Most recently constructed buildings have not been tested by an actual earthquake; consequently, the scientific evaluation of new construction technology is important. The transfer of research findings into codes or into practice of professionals designing new developments should be pursued.

Those involved in making design and construction decisions on local development—the design professionals, and construction and inspection personnel—need to stay current on "state-of-the-art" seismic safety considerations. Local building departments that lack the necessary
expertise should have access to the advice of special personnel with competence in earthquake-resistant construction.

Accomplishment of the following objectives will help ensure full use of all currently available seismic safety information:

- Local planning commissioners and government decision-makers should be made aware of how land-use planning decisions can affect earthquake safety.
- Continuing education training courses should be given for professionals involved in design, review, inspection, and construction of California structures.

Recovery

Recovery efforts include all of the activities necessary to stabilize a community and reestablish normal activity following an earthquake. Recovery issues begin emerging during the early emergency response activities, and the process of reconstruction may continue for decades. Past experience indicates that all too often recovery decisions are governed by immediate post-emergency needs, and available aid, programs, and funds are directed by widespread public pressure for a quick return to "normal." Such ad hoc approaches to recovery efforts do not provide safeguards against the long-term adverse effects of crisis decision-making on a community's future. Worse, the pressure to quickly reestablish normal circumstances can lead to the recreation of the same hazardous environment that existed before the disaster.

The California Earthquake Hazards Reduction Program emphasizes the need for greater advanced recovery planning. Communities can make many decisions about recovery priorities in advance, establish legal processes and authority, and assign responsibilities for recovery efforts. Effective recovery planning can help expedite reconstruction. Moreover, through advanced planning a community can better understand the need for outside resources and aid during the recovery phase and determine beforehand what it must do to get and use assistance. After a disaster, there are great pressures to rebuild immediately without adequately thinking through the long-term implications and effects on the community. Advance planning can make the recovery process more thoughtful, methodical, and effective.

Recovery of the private sector is critical after a devastating earthquake. Damaged or destroyed businesses mean economic loss and unemployment. Financial institutions that are unable to continue routine electronic transfers of funds because of earthquake damage will impact all types of business transactions, large and small, business and personal. Damage to utilities such as electricity, water, and telephone may limit production of those businesses and industries that could otherwise be functioning normally. Across a large metropolitan area these circumstances cannot be tolerated for long without significant social and economic distress. For these reasons, the functions and requirements of the private sector need to receive greater recognition and emphasis.

For discussion purposes, recovery needs have been grouped into pre-and post-earthquake categories:

Pre-earthquake Recovery Considerations. The need to plan for post-earthquake recovery during pre-earthquake time is not obvious at first. Recovery planning may become a sensitive matter because it appears to assume a degree of devastation that people hope will never occur. Recovery planning, however, must simply be based on a realistic recognition that extensive damage is a possibility for which a California community should be prepared.

Pre-earthquake considerations should recognize that development of recovery plans will expedite recovery and reconstruction efforts. These plans should be based on complete information about what a community can and should do to prepare for recovery including developing a process to expedite appropriate documentation and proper reporting to obtain federal funding, identifying potentially hazardous structures so damage projections can be made, and preparing guidelines for assessing damage.

Developing agreements with neighboring jurisdictions may help the impacted community receive prearranged help and services. This includes developing mutual-aid agreements to help provide long-term resources to aid the recovery efforts, and service agreements to obtain alternative sources of water, power, and other necessary services to aid in recovery after an earthquake.
Post-earthquake Recovery Considerations. Reestablishing government functions and operations is important to an impacted community so that reconstruction efforts can begin. The emphasis during the initial recovery phase should be on restoring those local government services critical to the health, welfare, and economic operations of the community. Local government has to develop the capability to deal with increased demand for services such as refuse disposal and building inspections.

Individuals requiring more than emergency treatment will need interim medical care. During the later recovery phase it can be determined what measures are to be taken to provide long-term care, including mental health and physical rehabilitation services.

It is essential to provide temporary housing for those individuals whose homes have been seriously damaged or destroyed. Such aid can include securing federal funds to rent hotel rooms, ensuring that mobile homes are available, and providing information on other housing options.

Removing and disposing of debris promptly is an important process during recovery. For example, roads need to be cleared quickly so that recovery efforts can proceed.

Providing information to disaster victims is a vital recovery function. It will help community members help themselves and contribute to the overall recovery efforts. The media should play an important role in keeping the community informed about recovery efforts. Recovery information will be important in providing information about the availability of disaster relief.

Damage assessment is necessary to secure federal funds and to plan for reconstruction. The community has to move quickly to identify areas of major damage and to assess overall damage levels to determine essential information that will guide recovery efforts.

Removing or restoring buildings the earthquake has rendered hazardous is important to the public health and safety. A structural engineer must assess a building's damage and its safety for occupancy, and make a determination as to whether the building can be restored. The removal or restoration of hazardous buildings may not need to occur immediately for such buildings can be posted “unsafe” and cordoned off to limit access while the final decisions are made about removal or possible restoration.

Earthquake recovery needs have received inadequate attention in California. Additional state and local efforts are needed to develop recovery plans that will facilitate rapid recovery and ensure safe reconstruction. To make significant recovery capability improvements, state and local governments need to pre-plan for local reconstruction authorities that will be responsible for planning, developing, and implementing recovery measures.

Education and Public Information

Earthquake education and public information are crucial to achieving improvements in earthquake safety. The Category 5 initiatives rest on the belief that properly educated citizens can save lives and reduce property damage by taking informed action before, during, and after earthquakes. Further, students educated about earthquake safety today will be better able to cope with them in the future. Moreover, providing earthquake education and information is a cost-effective approach to increasing earthquake safety, as money invested in teaching people how to make their own homes and workplaces safer can bring substantial dividends as they carry out these earthquake safety measures and encourage others to do the same.

Education and information are also critical in making earthquake awareness, planning, and hazard reduction a normal part of daily activities. When California’s government agencies, businesses, and individuals routinely include earthquake preparations in their business and personal planning, California will have gone a long way toward fulfilling the goals of reducing earthquake hazards significantly by the turn of the century.

Earthquake education, such as classroom study, general public information programs, outreach efforts, and materials for professional development, also supports and strengthens the other initiatives in this program. Education about emergency planning, for example, includes providing information to the public to prepare them for earthquakes as well as training professionals who will participate in disaster responses. Information on improved
building methods needs to reach those who plan, review, and build new structures.

Earthquake education and information needs fall into two general areas:

- The need to acquaint students, teachers, and school staffs with basic earthquake facts and encourage them to prepare for and respond correctly during an emergency.
- The need to educate the general public and special groups (such as businesses, local government officials, or neighborhood groups) in earthquake preparedness and mitigation measures that they should take.

**Education and School Preparedness.** California has long recognized a special obligation for the safety of the children in its schools. In 1933, after the devastating Long Beach earthquake, the Field Act mandated structural and procedural safeguards to assure safe public school buildings. More recently, legislation has been enacted to require school earthquake safety programs, improve the safety of new private school buildings, and create and disseminate classroom materials on earthquake safety in schools. But there is more to be done.

School earthquake curricula need to be expanded. Although seismic information is often provided in earth science classes, implementation of the California Earthquake Education Project (CALEEP) by the Lawrence Hall of Science at the University of California, Berkeley, which has created and disseminated earthquake preparedness materials under contract with the Seismic Safety Commission, has brought out the fact that earthquake science is often inadequately addressed in existing curricula, and has also indicated a need for improved teacher training in this area.

School emergency planning should be improved. Public and private elementary, middle, and high schools are required to have earthquake response programs, but there is no mechanism for assuring the quality of such programs or any requirement that universities and colleges have them.

**Information.** Informing the public about earthquakes is especially important since outside help may not be available immediately following a large or great earthquake in an urban area; response systems will be overloaded, and people will have to solve problems of food supply, refuse disposal, medical assistance, and debris removal for themselves for a time. Although notable improvements have been made in distributing earthquake information materials, most people have not yet prepared themselves, their businesses, or their families to solve these problems, so the programs needed must go beyond simply providing information, to encouraging its use. Local governments, too, must do much more to assure both that their own operations can be continued after an earthquake and that they can provide the assistance needed to the citizens of their communities.

An ongoing public information campaign anchored by an annual Earthquake Month can provide an effective focus for earthquake information programs. Many communities and groups have participated in the successful statewide Earthquake Month already held. These events featured activities including earthquake drills, school activities, and workshops; they received good media coverage and resulted in a broad distribution of earthquake information.

Regional earthquake preparedness projects can provide important benefits in addition to assisting local jurisdictions. The Southern California and Bay Area Regional Earthquake Preparedness Projects (SCEPP and BAREPP) have stimulated earthquake hazard mitigation and emergency planning in their respective geographic areas by working closely with many organizations and businesses as well as local governments. Other areas of the state could benefit greatly from similar projects.

Earthquake information is available from a wide variety of sources, but is often relatively inaccessible. SCEPP, BAREPP, the Red Cross, and many other organizations have published valuable earthquake information, but such information is not uniformly available to business or the general public.

The following seismic safety education and information objectives must be achieved to prepare Californians for earthquakes:

- All students, teachers, and staff should have the opportunity to learn basic earthquake facts and be trained to prepare for and respond correctly during an emergency.
- A permanent earthquake campaign, centering on an annual statewide Earthquake Month, should be established to
Inform the general public and special groups in earthquake preparedness and mitigation measures.

Research Each initiative in the first five categories depends upon scientific knowledge to be effective. Research is the basic ingredient that provides this knowledge. It is essential in understanding fundamental earthquake hazards and is the basis for developing effective strategies for reducing them. Greater understanding of the causes and effects of earthquakes will assist both public and private entities in carrying out their responsibilities. For example, comprehensive research on earth sciences, earthquake engineering, and behavioral science and public policy is needed to develop more reliable and cost-effective strategies for dealing with existing hazardous structures, design and construct safer buildings, make wiser policy decisions on earthquake-safety issues, and be better prepared for emergency response and recovery. Throughout this program, research efforts are needed to support the main initiatives and help identify opportunities for improvements in the program.

For these reasons, there is a powerful incentive to press ahead in filling the gaps in knowledge about earthquake causation, seismicity, resistant structural design, and hazard reduction. This broad scope of dependence requires a comprehensive research program with appropriate focus on the state's most critical seismic safety needs. Given the sporadic occurrences of earthquakes, a strong program must be supported over a long period of time.

For the purposes of the California Earthquake Hazards Reduction Program, earthquake research is separated into four major areas of understanding:

- Causes and nature of earthquakes;
- Geotechnical and structural response aspects;
- Social and economic effects of earthquakes; and
- Policies and strategies for reduction; long-term mitigation, preparedness, response, recovery, and reconstruction.

Causes and Nature of Earthquakes. Earthquakes are caused when the stresses within the earth's crust are relieved by sudden slippage along rupture surfaces known as faults. The rupture process generates waves that radiate from the fault source, affecting people and structures on the surface of the earth. Although the process is conceptually simple, the factors controlling its precise nature are not completely understood. Geological and seismological research is needed to understand where and when earthquakes will occur in the future and how strong the ground motions are likely to be, and to anticipate the probable effects on various types of construction. Specific areas requiring research are listed below:

- Evaluation of seismic potential. Research that contributes to understanding the location and timing of California earthquakes is vital to hazard-reduction efforts. Therefore, adequate modern seismographic networks are essential in California. Geological studies of faults identify those that have been active in the recent past, and can thus be expected to be the source of more earthquakes. Future research is needed on the properties of the many active faults in California to ascertain the size, location, and probability of potentially damaging earthquakes.

- Studies of surface faulting. Surface faulting can cause building damage, and may have catastrophic effects on critical structures such as dams and large buildings. Geological investigations of faults that have exhibited surface displacement in the recent geological past are needed to identify faults that may rupture in the future.

- Modeling of earthquake mechanisms. Investigations of the physics of deformation and failure along active faults are necessary in interpreting the character of past earthquakes and in forecasting the nature of future strong ground shaking. These insights are important in earthquake hazard reduction because they provide realistic ground motion parameters essential to calculating resulting structural damage and making predictions about future damage distributions.

- Estimation of ground shaking and secondary effects. Engineers must have knowledge of the local ground shaking that can be expected at specified distances from fault sources to evaluate the safety of existing structures and design new structures. Research is also needed on other damaging effects of earthquakes—landsliding, tectonic
subsidence, tsunamis, seiches, soil liquefaction, and differential settlement.

- **Earthquake prediction research.** Knowledge of the time, location, and size of future earthquakes, and estimates of the likelihood of occurrence, could save many lives and reduce the economic loss of business and industry. Although earthquake prediction research has not yet yielded results that give hope for reliable predictions in the near future, research in this important area should continue.

**Geological and Structural Hazards.** Reducing geological and structural hazards is the essence of seismic safety. Geological hazards include surface fault rupture, ground shaking, landsliding, soil liquefaction, tsunamis, seiches and tectonic subsidence. Structural hazards include damage to structural components that may lead to failure of the structural system and destruction of its contents, or lifeline failure and interruption of vital services. Specific areas requiring research are listed below.

  - **Seismic risk and siting research.** Problems associated with the siting of structures are becoming more important due to greater urbanization. Solving these problems will require identification of hazardous faults, characterization of ground motions, and evaluations of ground failure and threats from tsunamis and seiches.

  - **Measurement of ground motion and structural response.** Strong-motion earthquake records are an essential source of information to understand the response of structures to strong shaking. Ground and structural response measurements can be used for design and assessment purposes. Research is needed to correlate earthquake ground motion with structural damage in areas where damage approaches the point of failure of the structure.

  - **Analytical and experimental structural response studies.** Both experimental and analytical studies of building response are needed to guide improved earthquake-resistant design of structures. Many uncertainties are associated with the dynamic characteristics of a structural system. Research can help reduce the effect of these uncertainties by providing information on the probable performance of various combinations of characteristics.

- **Studies of nonstructural response.** Nonstructural components of buildings (e.g., partitions, infill walls, contents, electrical and mechanical equipment, furnishings, and exterior cladding) are also critical and can influence structural behavior. Research is needed to find ways to minimize the unwanted features of these components. This is particularly true for facilities that provide vital services, house dangerous materials, or are essential for emergency response and recovery.

- **Improvements in codes, standards, and practice.** Codes and standards establish basic minimums for the quality of design and construction. Codes should be revised periodically to take new research results and experience into account. Research implementation should emphasize transfer and use of existing knowledge and findings relating to seismically resistant design to ensure maximum use in practice.

**Social and Economic Effects of Earthquakes.** In studying social and economic effects of earthquakes, major concerns are the deaths and injuries caused, property damage, and disruptions of the local economic fabric of a community or region, as well as impacts on the national economy. The psychological response of individuals and families should also be considered. The extreme importance of social and economic effects emphasizes the need to learn more about ways to deal with earthquake-generated problems. Improved understanding of the social and economic effects of earthquakes can guide the formulation of policies and strategies for long-term mitigation, emergency planning and response, and recovery and reconstruction. Special areas requiring research are listed below.

  - **Studies of the awareness of and response to the earthquake hazard.** Research directed toward determining the awareness of and response to earthquake hazards on the part of government officials and the public is important. The results can improve the effectiveness of existing public policy, and help determine the need for new policies.

  - **Studies of health and safety impacts.** Research is needed to provide information on health and safety effects of earthquakes. This should include estimates of numbers of casualties, types of injuries, homeless and
unemployed, and businesses destroyed or disrupted.

- **Studies of social and economic disruption and recovery.** To reduce an earthquake's impact and deal effectively with recovery problems, it is necessary to identify and estimate the extent of the economic disruption resulting from an earthquake.

- **Studies of disaster services.** When a major earthquake affects a large area, many local jurisdictions will make simultaneous requests; aid must arrive quickly to be of value. Research is needed on the most effective methods of large-scale recovery operations and information.

- **Studies of liability and legal aspects.** While recent California legislation and legal research has helped clarify some issues of liability and legal responsibility, many important aspects of the law are still unclear. These issues should be studied from a broader public-policy and societal perspective.

**Policies and Strategies.** Policies and strategies for long-term mitigation, emergency planning, response, recovery, and reconstruction are crucial to earthquake safety because such strategies can help reduce existing hazards and avoid the creation of new ones. Policies on permissible land uses and codes (and standards) can guide decisions about the use and location of structures and can specify minimum requirements for earthquake resistance in their design, construction, and operation. The implementation of prudent policies and strategies will save lives and reduce economic dislocation in future earthquakes. Specific areas requiring research are listed below.

- **Studies of financial capability and fiscal and economic recovery problems.** A major damaging earthquake affecting an urban area is likely to cause billions of dollars in losses, most of which will be uninsured if present practices prevail. More research is needed into public policy questions posed by such a disaster.

- **Studies of land-use planning.** Research is needed to find ways in which land-use decisions can better take into consideration a thorough understanding of seismic hazards, including surface fault ruptures, ground shaking, soil-structure resonance, ground failure, and structural damage. Studies are needed to develop land-use policies whose adoption will significantly reduce future hazards to life and economic well-being.

- **Studies of public information and education.** Research on the use of information and education could provide an improved understanding of the level of knowledge possessed by different populations, the sources and quality of their knowledge, and the effectiveness of different information sources and educational techniques.

- **Studies of emergency response planning.** Research on policy formulation is needed, including applied research on ways of implementing new policies for improved emergency response.

- **Studies of mitigation programs.** Research is needed into ways to encourage government agencies and private companies to include hazard mitigation efforts in their regular activities. By the end of the century will require meeting the following research-related objectives:

  - The state should increase support for geological, seismological, and engineering research to provide information critical to understanding earthquakes and techniques to reduce earthquake hazards.

  - In preparing for major earthquakes, the state should support appropriate research in emergency planning, behavioral sciences, and public policy.

  - The state should work with federal agencies to increase the federal funding in California for seismological, engineering and policy research, and for earthquake hazard reduction measures. A strong federal emphasis on research and hazard reduction in California is appropriate because of the state's vulnerability to earthquake disasters.
KNOWLEDGE TRANSFER IN EARTHQUAKE HAZARD REDUCTION:
RECOMMENDATIONS FOR ACTION
This paper supplements the report from Year One of the Kajima-CUREe Research Project titled "Knowledge Transfer in Earthquake Hazard Reduction: A Challenge for Practitioners and Researchers" (February 1991). These recommendations are presented to help promote better knowledge transfer activities among people responsible for the design and construction of structures, and to improve the usefulness of research and the more rapid application of new knowledge. A fundamental principle is that the researchers and the practicing design and construction personnel must be linked together through a planned, organized, and managed process of mutual communication and learning.

The attached diagram has been adapted from work by the California Seismic Safety Commission. By improving the effectiveness of knowledge transfer processes it shows how hazard mitigation activities can reduce the impacts of earthquakes on society.

RECOMMENDATION 1. People making the earliest conceptual design and financial decisions about new buildings should be sure that their plans and decisions include assuring proper earthquake resistant design of new buildings. Design and construction involves many specialties throughout the process. Everyone needs to understand the particular role they play in assuring proper earthquake resistant construction. Among the most important are those people who make the early decisions on the location, configuration, size, function, and costs for new structures. It is more difficult to add earthquake engineering design into plans and specifications if the basic configuration and design are already completed.

RECOMMENDATION 2. Key managers in companies and professional and trade organizations should help improve the transfer of knowledge by seeing that one of their responsibilities is to encourage and support such activities. Managers can help link people working on various projects and in different specialties by holding problem-solving meetings, and sponsoring seminars on the results of new research and to define research needs and to evaluate progress. Also, managers can see that the results of research projects are prepared and summarized in language easy for practitioners to understand and use.

RECOMMENDATION 3. Practitioners should help design new research projects by defining questions they need answered. It is important that regular meetings between practitioners and researchers be held for this purpose so the practitioners have time to think about and discuss the nature of the problems they meet in designing and constructing new buildings. Then, researchers can interpret the practitioners' needs and design projects to find answers for them.

RECOMMENDATION 4. Researchers and practitioners should work together to plan the content and schedule of research projects. Timing is very important in knowledge transfer processes. Design and construction personnel are greatly controlled by the nature of the project and the construction schedule. Researchers work in less controlled settings and need more time to design, conduct, and validate their research. The scheduling of processes must account for these differences. Otherwise, the practitioner will be frustrated by not getting answers quickly enough to use on a project, and the researchers will be frustrated by not having enough time to do the necessary research.
RECOMMENDATION 5. Researchers should visit job sites periodically to observe the practical problems met in the actual design and construction of new structures. This field experience and the discussions with the construction personnel at the sites would help the researchers better understand the needs of the practitioners.

RECOMMENDATION 6. Practitioners and construction managers should visit research facilities. Tours and explanations of new or continuing research projects will help them understand what new information may be available soon. The practitioners also will learn about what kinds of support they can get from the research staffs and their laboratories and testing facilities.

RECOMMENDATION 7. Construction workers should be included in the knowledge transfer process. By using brief presentations and demonstrations at the job site, construction workers could be educated about the importance of properly constructing the building. This way, they could gain a greater understanding of why structures are designed in specified ways, and why it is important to give careful attention to details during the construction process.

RECOMMENDATION 8. Universities and professional training courses should include earthquake engineering subjects in their programs. When possible, such instruction should proceed from the fundamental to the more complex as the level of knowledge increases among those people being educated. Perhaps government agencies and large construction companies could finance special courses and training in proper earthquake engineering. University faculty members could also work for construction companies during leave times to learn more about the companies' needs for new knowledge and trained people.

RECOMMENDATION 9. Both practitioners and researchers should participate on teams that study damaging earthquakes. The practitioners will be interested in how structures performed and what can be done quickly to improve design and construction practices. The researchers will be looking for fundamental problems of design theory, strength of materials, and other more basic problems that will require analysis and testing. Both practitioners and researchers therefore have a great deal to contribute to improved earthquake resistant design.
Kajima-CUREe Project

Multidisciplinary Research on Socioeconomic Aspect and Earthquake Insurance

Final Project Report

Kaoru Mizukoshi
Masamitsu Miyamura
Yoshikatsu Miura
Toshirou Yamada
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Hiroshi Ishida

February 1992
WORKING PAPER

SOCIOECONOMIC LESSONS LEARNED FROM SELECTED JAPANESE EARTHQUAKES

SEEHM, Kajima Corporation

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1. Introduction and Objectives

This paper describes the major earthquake damage occurred in Japan since Great Kanto Earthquake in 1923, focusing on the interaction between damage and socioeconomic background.

As the major earthquakes, five earthquakes were selected, which are Kanto, Niigata, Tokachi-oki, Miyagiken-oki and Nihonkan-chubu earthquakes. The result will be reviewed and compared with the study by CUREe and pursue major socioeconomic factors or aspects affecting on earthquake damage.
### Destructive Earthquakes in Japan

<table>
<thead>
<tr>
<th>Earthquake</th>
<th>Date</th>
<th>Magnitude</th>
<th>Deaths</th>
<th>Injuries</th>
<th>Collapsed Houses</th>
<th>Burned Houses</th>
<th>Loss (Yen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kanto EQ</td>
<td>Sept. 1, 1923</td>
<td>7.9</td>
<td>142,807</td>
<td>103,733</td>
<td>128,266</td>
<td>447,128</td>
<td>—</td>
</tr>
<tr>
<td>Niigata EQ</td>
<td>June 16, 1964</td>
<td>7.5</td>
<td>26</td>
<td>447</td>
<td>1,960</td>
<td>290</td>
<td>300 billion</td>
</tr>
<tr>
<td>Tokachi-oki EQ</td>
<td>May 16, 1968</td>
<td>7.9</td>
<td>52</td>
<td>330</td>
<td>673</td>
<td>18</td>
<td>Over 40 billion</td>
</tr>
<tr>
<td>Miyagiken-oki EQ</td>
<td>June 12, 1978</td>
<td>7.4</td>
<td>28</td>
<td>1,325</td>
<td>1,183</td>
<td>0</td>
<td>270 billion</td>
</tr>
<tr>
<td>Nihonkai-chubu EQ</td>
<td>May 26, 1983</td>
<td>7.7</td>
<td>104</td>
<td>163</td>
<td>934</td>
<td>1</td>
<td>150 billion</td>
</tr>
</tbody>
</table>

**Epicenters of Destructive Earthquakes in Japan**
3.1 Kanto Earthquake

3.1.1 Supply of food

There were many victims that needed help and as it extended over a long period of time, difficulty was faced in supplying food. Although emergency measures were implemented, i.e. rice available from warehouses of up-town and rural communities were gathered, procurement from other prefectures and Korea, and release of government stock, still, partial starvation conditions befell, prices of groceries soared, and tormented by appearance of immoral rice merchants. Food rationing did not become organized although more than half a month passed.

3.1.2 Movement of evacuees

As of November 15th, two months and a half after the earthquake, the dispersal state of the victims are as shown in Fig.3.1.1. Considerable number of people moved to local districts dependent of relatives and friends, but the number of victims that remained in Tokyo Metropolis were approximately 1,500,000. Public parks and fire ruined schools overflowed with those that had lost their homes. The Tokyo City government built temporary barracks type shelters for the victims in more than 55 places. Fig.3.1.2. shows the change in the number of barracks occupants, which show increase with the peak at November and December when the weather turned cold. Tokyo City alone showed more than 85,000 people.

3.1.3 Social unrest

Unemployment due to the earthquake disaster was especially significant in the urban areas. The rate of unemployment in Tokyo and Yokohama hit 21% (fig.3.1.3). Robberies began to occur frequently in towns that escaped the fire, and corrupt merchants appeared taking advantage of the destitute of the victims. Many troubles occurred between the land owners and house owners and between the tenants and the house owners relevant to the ravaged property remains.
3.1.4 Finance and insurance

Banks allowed maximum accommodations (lowering of interest, expansion of loan limit, etc.) to loans for reconstruction. Also, the national government executed a basic revision of the policy in budgetary compilation for FY1924 and supplemented a reconstruction budget. At the time in Japan, there was no such a thing as earthquake insurance. Fire insurance exempted fires caused by earthquakes, however, in compliance with the demand from public opinion and administrative guidance, the insurance firms consented to partial payments. Provided that, from the total property insurance amount of 2,500 million yen (including 1,200 million from foreign firms), the resources available by the insurance companies were only about 200 million yen.

3.1.5 Prevention of epidemics and sanitation

Although there were partial breakout of dysentery and typhoid, they did not spread out widely. The Medical Department made public announcements calling attention to being careful with drinking water (boiling of water form wells, etc.). The Tokyo City office established temporary toilets and executed proper disposal of human sewage. The number of the dead bodies that the Honjo Ward Office handled reached 49,000 that includes people died from cyclonic fires, but only about 500 were identified, and the remaining majority were disposed by cremation without identity. Reports are found that the labor wage for disposing the dead bodies were 10 yen per day. Incidentally, the normal labor wages in those days were 1 to 2 yen per day.

3.1.6 Restoration of lifeline

Some newspaper articles are found reporting on restoration condition of water supply systems, however, perhaps due to use of wells in those days, serious water shortage condition is not reported. No news articles are found relevant to electrical power and gas.
Fig. 3.1.1 Dispersal State of the Victims from Tokyo Metropolis and Six Neighboring Prefectures
(at November 15th, 1923)
Fig. 3.1.2 Change in Number of Barracks Occupants
Fig. 3.1.3 Rate of Unemployment due to Earthquake Disaster

Rate of Unemployment (%)

- Tokyo Metro
- Tokyo City
- Kanagawa Pref.
- Yokohama City
- Chiba Pref.
- Saitama Pref.
- Shizuoka Pref.
- Yamanashi Pref.
- Ibaraki Pref.
3.2 Niigata Earthquake

(1) Outline and Characteristics of Damage

The Niigata Earthquake, needless to say, had a very large seismic intensity, however, its characteristics showed that the cause of disaster were due to the weak bearing soil and the evaluation technology regarding the supporting strength of the ground was still immature in those days. Reinforced concrete bearing wall structure apartment buildings, that were thought to be practically free from earthquake resistance problems, toppled over, and oil tanks of petrochemical companies that were built on weak ground in line with the storage programs promoted by the national government policy at the time, exploded and burst into flames in succession. Consequently, the fire spread to the general housing areas that resulted in great casualties. The presumption that such large earthquake occurrence is beyond imagination resulted in inadequate preparation which induced a far greater damage with the lifeline at the center.

The major damage are as follows:

Deaths : 14
Wounded : 40
House total collapse(burnt) : 3,018
Victims : 316,409
(2) Details of Damage

(a) Structures

Due to settlement and liquefaction of weak ground the wall bearing type apartment buildings fell down. Also, the tumbling of the Showa Great Bridge, bursting of the breakwaters, splitting of road and railway networks continued in succession. The happenings paralyzed the public transportation which was one of the reasons of delay in the recovery of the earthquake damage.

(b) Water supply

For the past water supply, asbestos pipes were used instead of cast iron pipes because their costs are more economical by about 1/4 in comparison, which resulted in the breakage of about 60% of the total supply line due to insufficient strength. And, because the water supply fixtures and implements were at the time under made-to-order manufacturing system (with no stocked items available), also became a significant reason in delay to recovery.

(c) Food supply

Lack of prior routine training regarding emergency food distribution system (against severe earthquake beyond imagination), confusion in transportation and communication systems, and tardy recovery in supply of electrical power and water, all led to shortage of supply and unfair distribution, which resulted in scenes of fierce excitement by some of the local inhabitants.

(d) Electrical power

There were some damage to electrical power generation facilities.
however, attention is directed to the fact that the destruction converged on the reinforced concrete power line poles, of which 43% of them were affected, which is about 4 times of that of the wooden ones. And yet, thanks to the prior mutual help exchange program with other power companies, only 4 days after the incident, almost 100% recovery was completed.

(e) Communication

Because economizing was the important factor in their selection, the communication cables were subjected to breakage one after another. This resulted in the great confusion in various areas to the systems of instructions and commands that was essential for recovery.

(f) Fires

At the time, Niigata City had been designated, by the national government, as the new industrial district, and many chemical firms advanced their plants on to the city reclaimed land. Also, too much reliance was placed on the Building Standard Law and Fire Fighting Standard Law of the time, and the city did not possess chemical fire fighting trucks. These factors led to the explosion and burning of oil tanks one after another, while their fire fighting was inefficient, that finally resulted in spreading to the general housing areas.
3.3 Tokachi-oki Earthquake

Weather Condition
*Due to continuous three day rainfall before earthquake, bearing capacity of soil became weak and many landslides were induced at mountain area.
*Since the earthquake occurred at the time of ebb tide, damage by Tsunami was very few.
*In general, since fire sources were very few, there were few fire damage, however, due to unusual cold weather compared with usual temperature in May, many stoves were still used and some of them were fallen down and induced several fire.

Soil Condition
*Many damage of wooden houses were seen at residential area at suburbs in Sapporo city. This is due to rapid expansion of urban development where many houses had been constructed on the ground with very soft volcano ash.
Such kind of soft soil condition also brought severe damage of water supply system.

Consciousness of Resident
*Most of the resident, even old people, lived in Aomori Prefecture have never experienced such severe ground shaking and few people imaged such a big earthquake hit Tohoku district. This made people so surprised and confused.
*Most of the fishingboats escaped to safety area, because fishermen worked at Hachinohe harber kept the lessons of Chile earthquakes in their mind.
*Two people at hospital were died due to heart attack.
*Governor went damaged area immediately to encourage suffered people and this behavior contribute to the early recovery of resident consciousness.
Damage of Buildings
*Old wooden school buildings suffered not so severe damage, while modern RC buildings such as city hall, high school buildings suffered severe damage. In Tohoku district, only a few number of RC buildings were constructed, such new type of buildings were started to be constructed recently.
*At the design stage, RC buildings were considered to be against the seismic level of Great Kanto Earthquake, however, in real condition, most RC buildings suffered severe damage.

Voluntary Activity
*Self-Defense Force started rescue activity immediately after the earthquake, such as Tsunami watching by helicopter, water supply by vehicle. As major activity, 100 people worked for repair of pipeline of water supply. 140 people rescued injuries barred by landslide.
*Many instant noodles, milk, blanket, underwares, food were provided from private companies.
*27 university student came to Aomori from Tokyo to assist rescue work.
*Independent rescue group of Tohoku Electric Power Company made a great contribution to recovery of stoppage of electric current. About 90% residence of Aomori pref. were recovered from stoppage of electric current by the rescue group.
*U.S. military force provided 2 water supply vehicles from Tokyo.

Social Influence
*After the earthquake, stoppage of water and electric current, lack of food, confusion and delay of information service are most important and urgent matter for resident.
*Damage of reservoir, pipeline were unexpectedly large.
*Well were so useful.
*In general, there were comparatively small damages of buildings or structures at urban area, while damage of landslides at mountain area which brought most of the death, bank break of railroad, collapse of wooden houses at farm area were so significant.
3.4 Miyagiken-oki Earthquake

(1) Casualty

Damage Twenty-seven people were killed by the 1978 Miyagiken-oki Earthquake. It was noticed then that about 60% of the dead were caused by collapse of block-built or stone-built fences and gateposts and that about 80% were over sixty years old or under twelve years old. On the other hand, statistics of injured people amounting to over ten thousand made it clear that most of them were due to scattered pieces of glass, fallen tiles and so on. Unfixed furniture was also one of the main causes of injury.

Background The cause of casualty may prove that modern buildings and houses are hardly to be collapsed because of progress of earthquake engineering, even if an earthquake occurs which could have easily changed past Japanese cities to ruins. However, at the same time it also became clear that even now there exists other dangerous elements in cities.

Lesson The 1978 Miyagiken-oki Earthquake convinced us of necessity of finding and mitigating factors which would injure people when a big earthquake occurs in modern cities. Now they are lying in dormant but increasing their danger. To add this, education of disaster prevention for people including old people and children is very important, as is proven by the fact that few fires occurred and none spread after the 1978 Mitogen-okay Earthquake. It is shown that weak people are concentrically sacrificed by destructive earthquakes.

(2) Building Damage

Damage Residential houses built on recently developed man-made land were remarkably damaged in the hillside or soft soil deposit area, while those built in the old part of Sendai were damaged very little. Reinforced concrete buildings were also damaged heavily on soft soil deposit. Especially, damage of high rise condominiums were paid attention to, because it was the first time for them to be damaged by a destructive earthquake in Japan.

Background In a word, the cause of this damage pattern is concentration of population to Sendai. Newcomers had to take up
their residence in the hillside or rice field area, where it was not appropriate to live very much, because there was no room to live in the old town. Earthquake motion tends to be stronger on the soft soil deposit and on the hillside than on the river terrace where the old town exist.

Lesson It is very important to prepare and review the microzonation map of rapidly expanding city like Sendai. Areas unsuitable to live like hillside and rice field may change to a resident district in a short period. Also, it is necessary to find out new types of buildings which have never experienced a strong earthquake motion and try to mitigate their damages. The high rise condominium was a new type building as of the 1978 Miyagiken-oki Earthquake.

(3) Lifeline Damage

Damage After the earthquake many kinds of lifelines, for example electric supply, water supply, gas supply, were shut off in wide area including Sendai. Electric supply for households was recovered completely in two days and a half, water supply in ten days, and gas supply in thirty-three days.

Background As population of Sendai increased, its infrastructures and many types of lifelines had been constructed for more convenient city life. When the earthquake occurred, lifelines had become indispensable to city people and thereby their damages had a big effect on city life.

Lesson Even if a certain future earthquake will not destroy a lot of buildings nor kill many people, it is clear that city people will not be satisfied with it. It is because they always require the convenience of city life although it is very frail in earthquake disaster. The Miyagiken-oki Earthquake was the first one that convinced people of the necessity of strong lifeline networks against big earthquakes.
3.5 Nihonkai Chubu Earthquake

3.5.1 General
- Distinctive features of the earthquake were Tsunami and Ground Damages due to soft soil and liquefaction.
- Most losses of human lives were caused by the tsunami after the earthquake.
- It attacked a blind spot on the side of the Sea of Japan where people didn't expect such a big earthquake.
- Damages concentrated on Oga and Noshiro area.
- People in the Sea of the Japan side have less recognition of the Tsunami disaster than those in the Pacific Ocean side where had been attacked by a lot of tsunamis.

3.5.2 Tsunami
- People had little understanding of 'Tsunami always came after earthquake' because they had no tsunami experience for 150 years.
- It was said for a long time that people should rather move to the seaside than the mountain side because landslide might occur when earthquake attacked.
- Tsunami came fast more than people expected.
- 20% of the fishing boats in Akita were destroyed.

3.5.3 Ground Damages
- Upheaval and subsidence of the ground by soil liquefaction caused damages upon housing, factories, roads, lifeline, harbour facilities, farmlands and etc.
- Almost 300 houses were destoryed in Noshiro.
- The function of the quay in Akita Harbour stopped for along period. Feed, cement industries and other users were largely affected.
- Many machines in those factories of woodworking, machine and metal industry stopped because of inclined and sunken foundations.
A lot of farm products was damaged by drying and flooding of field which was caused by soil liquefaction.

3.5.5 Countermeasure for Disaster Reduction
- Countermeasures for the tsunami in Akita were insufficient compared with other prefectures.
- The dike around the reclaimed land in Ohgata-mura clacked and drainage pump stopped by transformer breakdown. These were very important to shut out seawater from low level reclaimed land.
- Lifeline damages due to ground collapse spreaded over.

3.5.6 Fire
- Only 2 fires were observed. Resident's good understanding of "Fire comes after earthquake" was to be a reason.

3.5.7 Information and Communication
- Coast guards couldn't transmit the tsunami warning due to trouble with telephone system.
- Almost half of residents couldn't get tsunami warning in Oga area.

3.5.7 Lessons
- The Tohkai Earthquake predicted coming near future was so strongly watched that countermeasures of earthquake damage prevention for other district seemed to be despised.
- Houses shouldn't build closed by seaside.
- Construction of self protection organization against earthquake disaster would be very important.
- Wireress communication system should be built specially for local government.
- Those systems of Iwate and Shizuoka prefecture would be helpful to construct useful coutermeasure on earthquake disaster prevention.
- Lessons from past earthquakes should be enlightened to people repeatedly
4. Socioeconomic Damage Propagation Flow

In order to evaluate the past earthquake damage from socioeconomic aspect, damage propagation flows for 5 Japanese earthquakes were proposed and figured as shown in the figures at following pages. These flows describe the damage propagation process after the earthquake occurrence considering the visual or invisual social and economical background before and after earthquakes which might affect the damage pattern. Earthquake damage propagates and affects social activity in accordance with time and space interacting with society.

Comparison of the flow with same concept will provide useful and significant informations or suggestions for the prediction of future earthquake damage.
The Kanto Earthquake: Damage Propagation Flow

- Damage was extensive because the spread of fires was not prevented.
- Lack of accurate disaster-related information among the public led to misjudgments about appropriate action during evacuation and increased the number of those who died by fire.
- The baggage carried by evacuees became a reason of the fire spread, and hindered fire-fighting activities and blocked evacuation routes.
- Along with diffusion of public water supply services, water storages in individual house for fire prevention were decreased. The public water supply services were interrupted by the earthquake and were not available for fire fighting.
- There were shortages of food, shelter and clothing for the large number of evacuees. The public was uneasy, and many were victimized by profiteers and thieves.
- The normal flow of information was suspended. As a result, rumors spread which led to the murders of Korean resident.
- Inquiries concerning casualties was mounted, and various organizations, volunteers, and newspapers collected and distributed information on the safety of individuals.
Miyagi-ken Oki Earthquake (June 12, 1978 at 17:14, magnitude=7.4, Japanese scale=5 at Sendai)

- Damage to Filled Land and Buildings
  - Notable damage to filled land for housing (soft soils, hilly areas)
  - Damage to buildings and factories on soft soils
  - Damage to houses mainly limited to those on filled land (1377 houses levelled)
  - 163 damaged houses evacuated and intentionally destroyed
  - Relatively little damage since quake occurred after working hours

- Damage to Non-structural Members
  - Walls and gates fell (16 out of total of 27 deaths in Miyagi prefecture)
  - Damage to high-rise apartment buildings (non-structural members, overturned furnitures)
  - Casualties mainly the elderly and children (15 out of total 16 deaths)
  - Glass broken, furniture overturned

- Damage to Lifelines
  - Rail and road networks disrupted
  - Sewage discharged into rivers
  - Gas supply interrupted
  - Water supply interrupted
  - Electricity interrupted
  - Emergency food distributed to passengers on stranded longdistance trains

- Mental Effect
  - Worrying about Family's Safety
  - Rumor of another large earthquake impending

- Fiery
  - Few fires (total of 11 including two houses)
  - No spread of fires

- Difficulty of Urban Lifestyle
  - Difficulty of Industrial Activities

- Restoration
  - Complete recovery 1.5 days later
  - Complete recovery 11 days later
  - Complete recovery about 1 month later

Social Aspects of Damages

- Some fires broke out, but none of them spread. The reason was that people had already turned off gas because of the foreshock and that it was not winter when heating was necessary.
- Structural damage of buildings was slight due to advance of the earthquake engineering, but many people were injured with broken glass and overturned furnitures.
- High-rise apartment buildings suffered earthquake damage for the first time. It was very serious that doors could not be opened because of non-structural members' damage.
- Over a half of deaths were the elderly and children who were pressed under collapsed concrete-block walls and stony gateposts.
- Damage of houses and buildings on the filled lands in hilly and soft soil areas was remarkable. They had been developed with expansion of Sendai.
- This was the first earthquake that made Japanese people know that damage of lifelines were very serious in urban life.
- The earthquake occurred just after work, so that people started to go home by car simultaneously and it caused serious traffic jams in Sendai. In the result, the first-aid activities were paralyzed.
- False rumors and hoarding were observed but no panics was gotten up. It was because mass media were kept and damage of distribution mechanisms are very little.
Earthquake: May 16, 1968 at 9:48:53 a.m., epicenter offshore of Tokachi, Richter magnitude 7.9

- The many casualties due to landslides and landslips in mountainous areas led to considerable debate concerning evacuation plans and measures for coping with earthquakes.

- Fires were few thanks to lessons learned from the Niigata Earthquake and the fact that many among the public tried to extinguish fires.

- Regarding utility services, the electric supply was promptly restored due to a large extent to the efforts of the self-organized team from the electric power company.

- Extensive assistance was offered by private companies for food, funds, etc.

Tokachi-oki Earthquake; Damage Propagation Flow
Very few occurrences of tidal waves due to Otsu events.

Low population density.

Large-scale farming due to lack of preparedness.

Tidal waves peaked between 19:10 and 19:30.

Notable disaster human losses.

Damage concentrated on soft soil.

Main reason of house collapsed.

Few earth observations policies held.

Most citizens were not informed (survey shows).

Low tide embankment.

Submerged farmland.

Damage to fishing boats.

Fishing not possible for a long time.

Sudden acceleration.

Legislation for financial aid to sufferers of natural calamities.

Nihonkai Chubu Earthquake

Earthquake: May 26, 1983 at 0:01 p.m., epicenter 100 km offshore of Akita.

Social Aspects of Damage

There was very little preparation among the public because major earthquakes or tidal waves had never been experienced in living memory.

Measures for earthquakes and disaster prevention by public officials were insufficient.

Tidal wave warning system was inadequate. The warning was delayed reaching only some areas, resulting in numerous deaths due to the tidal wave.

The system for distributing information, which relied upon the telephone, experienced problems. Practice using more than one means of information distribution is necessary.

Houses and farmland were damaged over wide area by the liquefaction of soft sandy soils, making a great impact on the local economy.

The facility damage of key industry in Akita such as woods, metals, and machines accelerated the on-going recession.

The extensive failure of embankments on reclaimed land and the incapacitation of Akita seaport highlighted the importance of measures to prevent soil liquefaction damage to major facilities.

Rebuilding residences and farmland restoration were hindered by a lack of funds. The need for insurance was recognised.

Although it did not panic the extended interruption of water and gas supplies greatly affected daily life.

There are difficulties in applying various legislative disaster relief measures arising from the conditions under which they may be applied. The delay in applying such measures decreased their effects. On the other hand, a major disaster law was applied extensively according to the situation.
Earthquake Insurance in Japan

An outline of the earthquake insurance is given with the following heads:

1. Outline of Earthquake Insurance
2. History of Earthquake Insurance
3. Rating of Insurance Premium
4. Comparison of Earthquake Insurance in Japan and the U.S.
5. Problems to be solved

1. Outline of Earthquake Insurance

In Japan, under the fire insurance policy, the insurer is not liable for any loss caused by an earthquake, eruption or tidal wave, so that these damages are not lawfully covered. This is due to the characteristic of Japan's social structure; there are so many wooden houses that, in case of a great earthquake, the insurer should be obliged to bear an enormous liability. On the other hand, however, it is a fact that the need for earthquake insurance is keenly felt in Japan, an earthquake-prone country.

Earthquake insurance in Japan is now extending its boundaries to cope with the situation.

Coverage of "Earthquake Insurance"

* In cases where a building or household effects is/are damaged by an earthquake.
* In cases where a building or household effects is/are destroyed by fire caused by an earthquake.

* In cases where a building or household effects is/are destroyed or washed away by a tidal wave.

* In the case where a building or household effects is/are damaged or buried in the ground by lava or volcanic ashes caused by an eruption.

The earthquake insurance was revised on April 1, 1991, and covers the following losses: total, half, or partial loss of a building; and total, or half loss of household effects, according to the degree of the damage.

Although the upper bound of the coverage has been revised, the fact that earthquake insurance is a householder's insurance and its insurance premium should be set as low as possible is taken into consideration and the security of a minimum dwelling to serve for restoration from the calamity is intended. In view of this, the insurance companies have been managing the business with a basic principle of incurring "no loss and no profit," setting the bounds of the coverage to make possible payments for restoration to more people.
### Outline of Earthquake Insurance

<table>
<thead>
<tr>
<th>Items</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-matter of insurance</td>
<td>Dwelling houses (including joint-dwelling houses) and household effects</td>
</tr>
<tr>
<td>Contracting plan</td>
<td>Earthquake insurance cannot be contracted independently; it must be attached to a fire insurance contract (main contract)</td>
</tr>
<tr>
<td>Insurance amount</td>
<td>A choice is left to the applicant: within a range of 30-50% of the insurance amount of the main contract. (proviso: the maximum - ¥10,000,000 for building and ¥5,000,000 for household effects)</td>
</tr>
<tr>
<td>Cases where indemnity is paid, and payment of indemnity (Building)</td>
<td>In the case where the following loss or damage occurs due to fire, destruction, burying or washaway caused directly or indirectly by an earthquake, eruption or tidal wave an indemnity shall be paid.</td>
</tr>
<tr>
<td>Total loss</td>
<td>In cases where the loss to the main structure exceeds 50% of the current price, the total sum of the earthquake insurance amount shall be paid.</td>
</tr>
<tr>
<td>Half loss</td>
<td>In cases where the loss to the main structure is not more than 50% and not less than 20% of the current price, 50% of the earthquake insurance amount shall be paid.</td>
</tr>
<tr>
<td>Partial loss</td>
<td>In cases where the loss to the main structure is not more than 20% and not less than 3% of the current price, 5% of the earthquake insurance amount shall be paid.</td>
</tr>
<tr>
<td>(Household effects)</td>
<td></td>
</tr>
<tr>
<td>Total loss</td>
<td>In cases where the loss exceeds 80% of the current price, the total sum of the earthquake insurance amount shall be paid.</td>
</tr>
<tr>
<td>Loss not mounting to total loss</td>
<td>In cases where the loss occurs to household effects and the building containing them is damaged in more than a &quot;half loss&quot; state, 10% of the earthquake insurance amount shall be paid.</td>
</tr>
<tr>
<td>Items</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>In cases where the loss occurs to household effects and the building containing them is damaged in a &quot;partial loss&quot; state, 5% of the earthquake insurance amount shall be paid.</td>
<td></td>
</tr>
</tbody>
</table>

Note: The underlined parts are effective on and after April 1, 1991.
2. History of Earthquake Insurance

1875 Dr. Paul Mayet: "Of Insurance on Japanese Houses" (Nihon Hoken Ron)
A proposal of a government-managed compulsory insurance was made to the government (insurance for fire, earthquake, storm, flood and civil commotion).

Result: The report was submitted to Prime Minister Sanetomi Sanjo, with approval of Shigenobu Okuma, Hirobumi Ito and others, but ended in failure after three years' study meeting with opposition of Masayoshi Matsukata, the Home Minister.

1892 Nobi Earthquake occurs, Dr. Mayet published "On Disaster Relief" and demanded the enactment of the related laws but it was not realized.

Various opinions appear.

Dr. Shotaro Kajima;
Earthquake insurance should not be offered by a profit-making enterprise. The only solution is to make it compulsory and operated by the Government, (placing the earthquake disaster insurance under Government management).

Seiichi Shindo;
Since the earthquake insurance is strongly concerned with public welfare, it should be a Government-managed insurance, and at the same time, the fire insurance too, should be
managed by the Government. Then these two should be combined and be compulsory: (Of Earthquake Insurance)

Dr. Yoshikatsu Katayama;

It is not a good policy to place the earthquake insurance under Government Management. It is better to be under private management if its reinsurance is taken charge of by the Government. (Earthquake Insurance under Government management)

Dr. Sozaburo Mori;

He proposed that the fire, earthquake, war, tidal wave and flood insurances should be placed under private management and 80% of natural calamity risks except for fire risk should be reinsured by the Government. (Government Management of Fire Insurance)

Dr. Joji Matsumoto;

He proposed a reinsurance system by the Government (On Insurance Problems)

1923 Great Earthquake of 1923 occurs.

1926 The Government referred the earthquake insurance system to the Research Committee on Non-life Insurance Systems

Results: Since research in various fields by specialists are needed, it was resolved that a research organ should be established separately.
1934 A draft bill of the earthquake insurance law was prepared by the Insurance Department of the Ministry of Commerce and Industry.

Comments: The earthquake insurance shall be placed under Government management but it shall be compulsorily attached to the fire insurance managed by private insurance companies. The upper limit of insurance amount is 3,000 yen.

Results: The bill fell through and Japan rushed into World War II.

1944 The Wartime Special Non-Life Insurance Law was brought into effect; the first insurance to include the earthquake insurance in Japan.

Contents: The upper limit of the insurance amount is 50,000 yen, and the subject matter of insurance is the dwelling. The management is as a rule conducted by private companies but incomings and outgoings falls to the state.

Result: A year and nine months later, this law became void leaving a deficit of 140 million yen.

1948 After the Fukui Earthquake, Ministry of Finance drew up an earthquake insurance law.
Contents: Two kinds of earthquake insurances: one is a voluntary insurance, and the other is an earthquake insurance attached to a fire insurance, the subject matter of which includes the dwelling and household effective with the upper limit of the insurance amount being 20% of that of the fire insurance.

To establish a Government-financed Earthquake Insurance Fund for which private insurance companies stand proxy.

Results: Not realized

July, 1952

The Marine and Fire Insurance Association of Japan established the Special Committee on Windstorm, Flood and Earthquake Insurance, and set about making inquiries into earthquake insurance with the Fire and Marine Insurance Rating Association of Japan as the leader. The conclusion was reached that it would be impossible to realize the insurance without the reinsurance undertaken by the Government.

1956 Earthquake Insurance for Enterprises came into the market

Contents: It is undertaken under an extended coverage endorsement and needs reinsurance by the companies overseas such as in London.

1964 Niigata Earthquake occurs

The Committee on Finance in the House of Representatives made a supplementary resolution on the
establishment of an earthquake insurance system. Minister of Finance Kakuei Tanaka referred it to the Insurance Council. Based on the report, the Earthquake Insurance Law and the Special Accounts for Earthquake Reinsurance Law were presented, then, in May, 1966, they were promulgated and put in force.

June, 1966

The non-life insurance business circles brought the earthquake insurance to market.

Contents: The upper limit of the insurance amount: 30% of the main insurance amount, 2,400,000 yen for a building and 1,500,000 yen for household effects. The total sum of the payment is limited to 800 billion yen.

3. Rating of Earthquake Insurance Premium

1) Basic Conditions of Rate of Earthquake Insurance Premium

The rate of earthquake insurance premium (generally 1,000 yen, per annum premium) consists of "pure premium rate" appropriated for indemnity in the case where any loss is caused, and "loading rate" for meeting expenses to manage the business. However, this insurance is characteristic of a householder's insurance, so that it is managed with a principle of maintaining equilibrium between incomings and outgoings without including a certain profit rate, which is usually estimated in the premium rate in private insurance operations.
2) Basic Plan of Calculating Pure Premium Rate

Calculating the pure premium rate of earthquake insurance premium starts by grasping statistically the frequency of earthquakes causing damage and their scales. Actually, using the records of 347 cases of earthquakes which occurred during 1494 and 1976 listed in the "Chronicle of Damage Caused Earthquakes in and around Japan" in the "Chronological Table of Science" and, in addition, those of the earthquakes that occurred at a later period such as Izu Oshima Inshore Earthquake and Miyagiken Earthquake as data, the frequency and scale of the earthquakes in future are estimated. First, calculate technologically and statistically the estimated loss ratio (aggregate of insurance money/aggregate of insurance amount) for each type of subject matters classified by area and structure of building, then with this and the average frequency of each earthquake per annum as the base, calculate the pure premium rate.

3) Calculation of Degree of Loss in Earthquake Insurance

The outline of the process for the calculation of the degree of loss for abandonment of right in earthquake regarding insured matters is as follows;

* Calculation of Degree of Loss, Damage and Destruction by Fire to Wooden Building and Household Effects

Applying the formula of Dr. Kanai, with the magnitude and epicenter of the earthquake as the data, set the maximum seismic intensity on land surface in the hypothetic stricken area, and following the theory of Dr. Umemura, calculate the loss fixing on the areas as
'completely destroyed' or 'half destroyed' according to the proper periodic distribution of buildings and the periodicity of excellence of the ground.

* Rate of Destruction by Fire of Wooden Buildings

By using the relation between the rate of wooden buildings collapsed and that of outbreak of fire at the time of Great Earthquake of 1923 based on the research study of Dr. Kawasumi and Dr. Kishigami, find the figure of outbreak of fire in the urban area with the number of wooden buildings in the urban area and the above-mentioned rate of buildings collapsed as a basis.

Revision based on the difference in regions, periods, seasons and time as well as self fire fighting rate is made to the above figure and fix on a figure of average extensive fire per annum.

Basing upon this, find a rate of destruction by fire in the urban area, with reference to the rate of extensive fire density in the urban area, condition of density of buildings, and the degree of fire prevention and fire-resisting of the buildings.

5. Problems to be solved

1) A loss caused by an earthquake mounts up to an enormous sum, so that it cannot be borne only by the funds of the non-life insurance business circle. At present, the measure for this is limited to the excess of loss reinsurance by the Government.
2) Due to the complexity of earthquakes, it has become difficult to statistically grasp the average occurrence of earthquakes and the amount of the loss caused by them in a single year. Although what supports the insurance system is "the law of large numbers," it is unlikely to be applicable to the earthquake. With a nationwide study extending over a long period of time settled data within a certain range may be obtained, to deal with them on a private enterprise basis is difficult.

3) Although Japan is prone to earthquakes in all parts of the country, there exist regions that are prone to incur losses by earthquakes and those that are not. People who live in the regions where the risk of earthquakes can be keenly felt, an those in the regions where an earthquake swarm or premonitory symptoms of earthquakes occur are supposed to contract insurance. Therefore, regional or timesaving adverse selection occurs. To cope with the former, regional rates of premium for each prefecture classified according to the degree of regional risks are prepared. For the latter, it is provided that no insurance can be effected in the areas receiving warning for the Tokai Earthquake, after the warning announcement is made.

4) There are many problems to be solved such as the difficulties in measuring risks caused by earthquakes, in assessing damages and in reinsuring the original insurance overseas.
Comparison of Earthquake Insurance Systems

<table>
<thead>
<tr>
<th>Act</th>
<th>Japan</th>
<th>U.S.A.</th>
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<tbody>
<tr>
<td>Act respecting Earthquake Insurance (1964)</td>
<td>1965 Disaster Relief Act</td>
<td></td>
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<tr>
<td>The special public accounts act respecting Earthquake reinsurance (1966.5)</td>
<td>1985 Assembly Bill No. 2865 Act</td>
<td></td>
</tr>
<tr>
<td>Company Insurance(factory etc.) was established in 1956</td>
<td>1992 HR4480 Federal EQ Insurance &amp; Reinsurance Act</td>
<td></td>
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<tr>
<td></td>
<td>1992 HR4462 National EQ Insurance &amp; Reinsurance Act</td>
<td></td>
</tr>
<tr>
<td>Reinsurance refer to exceeded damages (1981) (a price ceiling of total payment)</td>
<td>EQ Project began its study of a possible federal role in earthquake in 1987.</td>
<td></td>
</tr>
<tr>
<td>0 85 billion yen</td>
<td>(Federal government contributed about $3 billion in Loma Prieta earthquake)</td>
<td></td>
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<tr>
<td>20 billion yen</td>
<td>Premiums in California totaled about $385 million (1990)</td>
<td></td>
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<tr>
<td>1500 billion yen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Insurance company (205.5 billion)</td>
<td></td>
<td></td>
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<tr>
<td>Government (1271.5 billion)</td>
<td></td>
<td></td>
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<tr>
<td>Fire caused by earthquake is managed by Earthquake Insurance (but 5% as a present of money in token of its sympathy, limit ; 3 million yen)</td>
<td>Fire caused by earthquake is managed by fire Insurance</td>
<td></td>
</tr>
<tr>
<td>Classification for calculation of an insurance bill and a price ceiling of insurance money</td>
<td>Structure (wooden,brick,steel,etc.) a hazard rating zones in California. When the fund exceeds specific dollar ($1 billion), money from the fund can be used to issue low-interest loans for retrofitting of residences.</td>
<td></td>
</tr>
<tr>
<td>Region (system of partition of land in 4 grades by prefecture)</td>
<td>100,000$ fundamentally, add 25,000$ optionally.</td>
<td></td>
</tr>
<tr>
<td>Structure (wooden or non-wooden)</td>
<td></td>
<td></td>
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<tr>
<td>Years of bldg.</td>
<td></td>
<td></td>
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<tr>
<td>Bldg. ; 10 million yen , Household effects ; 5 million yen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjuster</td>
<td>Independent adjuster is in existence</td>
<td></td>
</tr>
<tr>
<td>Under the insurance company Joint assessment system is contained</td>
<td>ATC20 is used in judgment of suffering</td>
<td></td>
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<tr>
<td>Broker system</td>
<td>He plays an important part as a representative protecting policyholders' interests</td>
<td></td>
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<tr>
<td>not exist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liability for request and Incidental percentage</td>
<td>If don't request within 60 days since an entry into a fire insurance, after that refuse an entry into an Earthquake Insurance (The veto right) about 20% (1990)</td>
<td></td>
</tr>
<tr>
<td>Fundamentally possible at anytime</td>
<td></td>
<td></td>
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<tr>
<td>Refuse an entry after a declaration of precaution at special regions</td>
<td></td>
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<tr>
<td>In the whole of Japan ; 8% In Tokyo ; 20%</td>
<td></td>
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<tr>
<td>Detail of Earthquake Insurance immunity</td>
<td></td>
<td></td>
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<tr>
<td>Others</td>
<td>The principle of non-loss &amp; non-profit</td>
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<tr>
<td>The principle of non-loss &amp; non-profit</td>
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<td></td>
<td>Oroville (1975)</td>
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<td></td>
<td>Santa Barbara (1978)</td>
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<td></td>
<td>Imperial Valley (1979)</td>
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<td></td>
<td>Coalinga (1983)</td>
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<td></td>
<td>Morgan Hill (1984)</td>
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<td></td>
<td>AS2865 (1985)</td>
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<tr>
<td></td>
<td>Southern California (1986)</td>
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<td></td>
<td>Whittier (1987)</td>
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<tr>
<td></td>
<td>Loma Prieta (1989)</td>
<td></td>
</tr>
</tbody>
</table>
(Reference)
1) [Economist], P133-139, Minichi-News Paper Co., July 7, 1975 (in Japanese)