GROUP REPORT
&
ABSTRACTS

Group 4

"Response--Damage Assessment"
Study Team

GROUP 4 REPORT
"RESPONSE--DAMAGE ASSESSMENT" STUDY TEAM

Co-Chairpersons: Toshikatsu Iwami and Laurence M. Kornfield

The following comments reflect the authors' views of the most significant areas of needed research and/or action following extensive discussion by this study team. Comments by the "Recovery and Reconstruction--Structure Assessment and Repair" team have been incorporated into this material.

Three categories encompass the major concerns of this team.

Policy and Procedural Concerns

While the response and recovery from a major earthquake at first often seems to be primarily a technical problem, this study group found the problems to be more related to the policies and procedures which govern the application of technology. There are broad opportunities for the U.S. and Japan to cooperate in addressing these problems.

Perhaps most essential to the public sector response to an urban earthquake is a clear determination of the goals and objectives of government response and the role of government in private sector recovery. The continuing conflicts between local, state and federal agencies over the U.S. Federal Emergency Management Agency's (FEMA) role in assisting the post-Loma Prieta recovery is an example of the confusion caused by ill-defined roles. An analysis of the approaches taken by various agencies, both in the U.S. and in Japan, would provide a valuable springboard for more in-depth policy studies.

Legal concerns, such as defining the authority of government to make inspections and take emergency action in private buildings are particularly difficult problems, particularly in Japan. So, too, are issues regarding immunity, liability and obligations of volunteer inspectors and other emergency workers. The entire panorama of Japanese post-earthquake decision-making seems to hinge on as-yet-unresolved legal concerns. The hesitancy in addressing these issues and the difficulty in gaining consensus in resolving related problems may stem from a deep-seated reluctance to articular the normally unwritten rules which define traditional Japanese personal interactions. One example of this is the concept of "obligation," or "*giri*," which might bind a volunteer inspector into some ongoing relationship with the owner of a property he/she has inspected.

The U.S. has much to offer in legal precedent regarding governmental rights and obligations, both in civil law and in municipal, state and other codes. Experiences from the 1989 Loma Prieta earthquake, both positive and negative, can be studied to determine what public/private decision-making processes were most effective in meeting the overall basic goals of assuring public safety and an orderly restoration of municipal functions.

Japan and the U.S. differ dramatically in the areas of liability for design and construction problems and in the types of insurance which designers and building owners might be expected to carry. The extreme contrast between the standard U.S. "legal" remedies versus the Japanese "taking personal and corporate responsibility" were one of the most startling revelations to the U S. members of this study team. Exploration of this topic and publishing material or case histories in U.S. professional journals could spark a major

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Members of Group 7 joined Group 4 on the second day of the workshop.
and their comments on Issues 3 and 4 are incorporated in the Group 4 report.

rethinking of issues of liability. Medium- and long-term post-earthquake recovery in both countries might be well served by a comprehensive review of how liability, insurance and government support to private reconstruction is assigned and effected.

In the post-earthquake period one of the primary concerns of most building owners is the rapid restoration of structures for use. Critical to this, but not yet developed in either the U.S. or Japan, are uniform, model codes which set standards for post-event repair and reconstruction. The standards developed by individual cities--usually developed hurriedly in the confused, post-event period--deviate widely and cause great confusion among building owners and design professionals.

Procedures for management of post-earthquake disasters can be standardized, avoiding the crisis-management form of decision making. Japan's advanced public works and utility infrastructure evaluation systems should be reviewed as models for the U.S. The complex information management needs of emergency response can be evaluated and standards set for collection and formatting of essential information; methods of integration of technical data into the administrative decision-making tree can be established before the actual emergency. Many individual pieces of such a program have been developed in the U.S but few or no integrated working models have been developed.

Technical Concerns

Willingness-To-Pay (WTP) for research and technical study as well as for the application of hazard mitigation and response technology is markedly different between Japan and the U.S. An exploration of the extent and fundamental reasons for this difference in WTP would be a topic of research which might change perceptions as to how to approach future basic research.

On a purely technical level, issues related to post-earthquake structural evaluation need further basic research. Perhaps most basic is a general analysis of building stock in a region and prediction of expected performance on these structures. Additional technical research needs to be undertaken in techniques for evaluating damage to foundations and underground structures. Another critical research need would explore the stability and strength of damaged materials and structures. This topic would include techniques for field analysis of residual capacity of damaged materials for both short-term, temporary use and for permanent repairs.

A technical, though not engineering, concern which warrants research is the relationship between earthquake hazard mitigation and market forces. One example of this is the insurance industry which has historically initiated codes for fire-safe buildings. Lenders almost universally demand that borrowers meet fire standards and provide fire insurance on structures providing their security. Insurers subsequently have higher rates for more dangerous buildings, lower rates for safer buildings and various incentives for making fire-safety improvements. In this case the market--the lenders, especially--push buildings toward a higher degree of fire safety.

In Japan, fire and earthquake are considered as one event; in the U.S. they are usually separated into two independent occurrences. A rigorous study of the links between fire and earthquakes might lead governmental agencies to more closely coordinate emergency response in these areas. The Loma Prieta earthquake highlighted the insurance complications resulting from an earthquake-caused fire when building owners carried only fire insurance. The linkage between earthquake and resulting fire was masterfully illuminated in the recent book *Denial of Disaster* about the 1906 Great San Francisco Earthquake.

Earthquake insurance as a general topic needs a careful review--insurance related questions seem endless. How can language and coverage be standardized? Should

government step in to require minimum earthquake insurance, such as was recently done by the State of California, if the marketplace doesn't require insurance? Is broad earthquake insurance coverage desirable based on the possible international financial impact of truly gigantic insured losses? The private sector should be encouraged to cooperate with academic and governmental institutions to undertake international research into these and related problems.

A critical research need is the very basic cross-disciplinary review of existing U.S. and Japanese technology focusing on how such technology can be applied to overall earthquake hazard mitigation and response. An example might be a consideration of the ideal integration of the exploding geographical information systems (GIS) technology into, say, the evaluation of safety and utility of designated emergency care centers in times of emergency.

Issues of Public Awareness, International Understanding and Cooperation

Neighborhood preparedness is acknowledged as critical to minimizing damage and injury in the event of a major urban earthquake. Japan has many excellent programs which can serve as models for generally underprepared U.S. cities. The effectiveness of technology of transfer in this area is a function of government's commitment to make emergency preparedness a priority, with adequate funding, a willingness to use preparedness models developed by other jurisdictions, access to those models, and the political fortitude to demand that the private sector cooperate in implementing emergency planning and drills.

As a positive program to increase public awareness and international cooperation, an International Disaster Preparedness Day is proposed with both live and tape-delayed cooperative exercises between the U.S. and Japan. This would ideally coordinate with the annual Great Kanto Earthquake preparedness exercises, perhaps in September 1993.

Although U.S./Japan relationships are extremely cordial, advanced understanding is difficult because of both language difficulties and a lack of cultural familiarity. Most Japanese researchers and managers have excellent skills in written English but few have matching oral skills. Comfort and fluency in spoken English usually come only with extended exposure to native English speakers, such as through foreign study. Shamefully few Americans have any Japanese language skills at all. Through a personal commitment to Japanese language study by U.S. researchers and managers and through opening doors to host medium- and long-term study visits in both the U.S. and Japan, some of these difficult communications barriers may be crossed.

To assist in cultural understanding in this field of earthquake hazard mitigation and response, a cultural "glossary" would be valuable. Such a book or paper would discuss issues that are possibly misunderstood in cross-cultural context, such as the concepts of "public nuisance," "small business," "emergency," "eminent domain," "debris," etc. A simple translation is not enough to understand the different cultural values given to these works or phrases.

Plans need to be developed to facilitate first-hand U.S./Japan management involvement during periods of actual response to urban earthquakes. Much more than follow-up study visits, real-time involvement in the operation of response will help bridge the chasm between theory and application. Although the language problems might prevent general mutual assistance, assistance in many areas of special interest should be arranged in advance.

Following an earthquake, international study groups need to be encouraged and hosted and a standard protocol for sharing research findings needs to be further developed. In Japan much research is done by private companies, the results of which are not generally shared with the international community. Much excellent Japanese work is neither indexed in English nor translated into English

As a final area of collaboration, an informal, quarterly international newsletter in this field could lead to major progress. This newsletter would notify the scientific and management community about current study projects, collaborative research opportunities, requests for information, scheduled earthquake drills, etc. Rather than publishing actual papers, such a newsletter would help glue together the community which has formed around the U.S./Japan Workshop on Urban Earthquake Hazard Reduction and, with diligence, could expand that community worldwide.

The challenges posed by an urban disaster such as a major earthquake are awesome. Only through continuing international cooperation, personal dedication, and governmental and private support can research and application continue to make the great strides such as have been seen over the past decade.

Further notes from this study group are included as an appendix to this paper.

APPENDIX

Report of 'Response--Damage Assessment' Study Team

Below are additional subjects which this study team found to be challenging in the areas of preparedness, response and restoration following a major urban earthquake. Each of these topics represents a need for further research and development of application strategies. Included are:

- Setting policies for evaluating and upgrading existing hazardous buildings
- Integration of public building inspection response with private insurance company building inspection response
- Training of technical support personnel, such as building inspectors, in nontechnical areas to be sensitive to and assist the confused and stressed public after an event
- Development of standard policies related to securing and maintaining vacant, abandoned buildings in the months following an event
- Development of a program to standardize "bulletin board" services for locating family and relatives and for leaving messages for both victims and responders
- Application of emerging technology to development of "intelligent" seismic monitoring systems
- Realistic assessments of usability of transportation systems following an event
- Planning for disposal of debris from extensively damaged structures
- Preparing policies for access to severely damaged buildings to remove records and goods
- Estimating direct losses in dollars/yen

- Estimating indirect losses, such as costs of response, reduction in tax revenues, business drop, etc.

- Assisting building owners in decision making in post-event period, particularly buildings with multiple owners or absentee or corporate owners

- Sharing the evaluations of privately hired structural evaluators with public agencies and the general public

- Expanding and supporting neighborhood response groups to plan for emergencies

- Standardizing emergency building evaluations systems with an eye to building utility and reoccupancy

- Analyzing the availability and utility of local resources in emergency situations, such as private gasoline supplies, taxicabs for emergency transport, local contractor skills and equipment, mediation assistance through local legal associations

- Expanding the protective net of earthquake insurance

- Developing standardized GIS database files with addressed-based format for on-line/real-time input of emergency evaluations

- Provision of multi-lingual, multi-cultural emergency information

- Integration of "safety-block" in City Planning to include "fire-breaks" between designated multi-block areas, and to provide designated safe gathering areas in these multi-block areas for public assistance and information

- Reviewing possibilities of building owners' "self-evaluation" of buildings versus public assistance to private property owners

- Consideration of how governments may be able to recoup their costs for response to emergency

- Evaluation of the applicability in U.S. of Japanese "peer review" system for structural evaluation of buildings

- Consideration of realistic limitations on construction in known extreme earthquake hazard areas

- Expansion of concept of "out-of-area" emergency voice-mail center to avoid tying up local lines and to utilize undamaged resources of other areas

- Arranging with telephone companies and other communications providers to exempt essential facility communications lines from standard emergency call restrictions

- Continuation of development of plans for building owners to undertake private, independent evaluations of buildings in accordance with public standards

- Installation of large loud-speakers and other public address equipment to allow communications with public during post-earthquake period
- Development of standard procedures for securing hazardous material areas
- Development of standard definitions for imminent hazards for the purpose of approving building demolitions
- Review of problems associated with time delays in switching from line power to emergency power when needed
- Evaluation of the many problems associated with elevators in earthquakes, including unnecessary shut-down, delays in reviev of elevator equipment, people trapped in elevators, need for a large number of outside-of-area mechanics to review smaller building equipment as part of government emergency response
- Standardization of reporting non-emergency problems for later, non-emergency follow-up
- Development of standardized system and format for providing rapid and complete building damage information to the public.

Working Group Abstracts

U.S. MUNICIPAL LAW AND PRACTICE-- EARTHQUAKE HAZARD REDUCTION

David Smith Fox

Attorneys for the municipality experiencing earthquake or other hazard trauma can be utilized in significant ways to assist in the emergency response.

Substantively and procedurally, attorneys should advise the decision makers and their teams responding in the field as to the standards and implementation of plans and strategy for handling the response.

A background understanding of ordinary code enforcement practices and remedies involves a basic application of public nuisance law and theory. The emergency event heightens the significance of these most profound and basic powers.

Emergency response assumes inspection functions followed by decision making and response services often fraught with time and social pressures. At no time should a life safety matter be considered legally too problematic for immediate advice of counsel or immediate response by the proper officials. Experience from the 1989 Loma Prieta earthquake will provide a basis for discussion.

In the context of the nature of the municipal and state laws governing emergency response, San Francisco earthquake officials could proceed competently in handling the emergency without loss of time. It has been later borne true that there have been little if no legal actions from these activities.

A careful understanding of governmental emergency powers and the due process rights of the public, owners, and tenants in tandem with unstinting common decency guided a massive effort. In short, emergency officials should get on with the job, utilize counsel in the ongoing planning and decision making, and even consider counsel a useful resource for sidetracking interference from those raising issues other than solution of the immediate problems.

The lessons of the recent cases in California defining the rights and responsibilities of government and individuals will be reviewed. Essentially, the municipality at all times will bare the burden of responsibility for proof of the very existence not only of the emergency but of the necessity that a governmental emergency action was necessary as to each particular property owner or user. From this responsibility, a spectrum of lessons can be learned. Emergency actions can be taken at any time, subject to the burden of proof that will live on forever until the close of potential court proceedings. A variety of options short of immediate emergency action are available and strategies can often overlap to accommodate the interplay of life-safety and social needs attendant to these emergencies. The bedrock U.S. notions of police power authority and due process will provide an ever-present backdrop to the discussion. The spectre of an inverse condemnation claim will be both distinguished and compared.

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OUTLINE FOR JOINT WORKSHOP RESPONSE--DAMAGE ASSESSMENT

Laurence M. Kornfield

The City and County of San Francisco has had a unique opportunity to apply and critically evaluate post-earthquake building assessment systems. Following the October 1989 Loma Prieta earthquake we conducted over 12,000 building damage assessments. The Bureau of Building Inspection has applied, critiqued and modified the ATC-20 program and developed a series of management procedures to improve the implementation of this post-earthquake evaluation process. We have developed procedures for coordinating the damage assessment process with the legal process of abating unsafe buildings.

Among the topics we wish to review with engineers and managers from U.S. and Japan are:

1. Social Impacts of Building Condition Assessments

The posting of a building as "Unsafe" or "Limited Entry" creates anxiety and hardship for tenants and the public. Reorienting damage assessment from "assessing structural damage" to "assuring public safety" plays an important part in fulfilling governments' role of assuring public safety and welfare. Specific issues include the training of damage assessment personnel to deal with the questions which people ask as a result of the posting of an assessment. Typical questions are:

- "How soon can I reopen my business in the building?"
- "What is the landlord's responsibility to repair the building?"
- "Am I allowed to go into the building to get my possessions?"
- "How can I get the posting of the building changed?"

Answering these and the hundred other questions related to implementation of the damage assessment and recover program is often more difficult than the structural inspection. Reassuring the public that there are clear, consistent policies requires special training of building assessment personnel as well as detailed postings, bulletins and public services messages.

2. Emergency Governmental Action to Demolish or Shore Buildings

The impact of using the emergency powers of government to order owners to take emergency action or to take direct action such as demolition and emergency shoring has long-term implications (witness the dramatic change in the character of San Cruz after demolitions). Japanese laws regarding emergency authority are dramatically different from typical U.S. laws, as are the cultural bases which, in the U.S., would permit a governmental agency to take action despite the opposition of a building owner.

San Francisco has developed an evaluation procedure for seriously damaged buildings which has resulted in delayed action whenever possible and which closely follows the Japanese system of allowing time to extensively confer and evaluate the options. The result of such delayed action is increased owner and public involvement and fewer contested emergency actions and lawsuits. Two major negative byproducts of this "slow" approach are the

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continuing presence of hazardous, damaged buildings which are extremely susceptible to further damage by aftershocks or other earthquakes. In addition, these buildings often pose the "attractive nuisance" problems related to abandoned buildings such as break-in and fire hazards.

3. Recordkeeping and Public Information in the Post-Earthquake Period

Following the Loma Prieta earthquake was an immediate demand by city officials and the public for "lists"--damaged buildings, demolished or to-be demolished buildings, etc. Access to the data collected continues to be critical throughout the entire recovery period. Integrated database management tools need to be developed and placed in emergency command centers. An ideal system would have:

- Direct clerical input into a local-area network database of information such as requests for inspection, dispatch of inspectors, inspection results. This would prevent multiple inspections and allow rapid access to information about any property.
- Ability to map damaged areas based on inspection results.
- Link to geo-base or other database for related information such as owner's name, building construction type, etc.
- Pre-formatted summary reports, press releases, information newsletters, etc., in a desk-top publishing format.

There are, of course, many other desirable features of such a system which would address the complexities of post-earthquake management.

4. Legal Aspects of Post-Earthquake Evaluation

Many of the legal issues involving post-earthquake response are of great interest to both U.S. and Japanese agencies. There are dramatic differences in the legal authority between U.S. and Japanese systems which have been an area of great interest to many of the Japanese visitors to San Francisco. Major legal issues involving the post-earthquake period include:

- Authority to gain access to buildings for evaluation
- Volunteer inspectors' jurisdiction and liability
- Required recordkeeping and public access to records
- Public sector role in tenant/landlord and related private disputes

5. Code Enforcement and Follow-Up in the Post-Earthquake Period

A critical link needs to be established between the emergency actions of structure evaluation and posting and requirements for follow-up action by government agencies. To be reviewed are local ordinances such as those requiring detailed inspections and repair as well as the structure of a follow-up program which allows for abatement action when owners abandon or fail to repair damaged buildings.

To make these follow-up programs work, original postings need to include information regarding the corrective actions that will be required. Abatement action needs to be coordinated with other city and state agencies, utilizing the tools available or developing new tools as needed. For instance, San Francisco has developed an aggressive program to put into receivership buildings which owners fail to repair. Other damaged buildings have been subject to emergency action to secure and guard. This city's experiences, both successful and unsuccessful, may assist other jurisdictions in implementing post-earthquake abatement programs.

LESSONS LEARNED FROM POST-EARTHQUAKE SAFETY EVALUATION OF DAMAGED BUILDINGS

Christopher Rojahn

Numerous lessons have been learned from post-earthquake safety evaluation of buildings following recent earthquakes in Coalinga, Whittier, and near San Francisco (Loma Prieta), California. These lessons relate primarily to (1) the disposition of damaged buildings, and (2) recently developed ATC-20 procedures for conducting safety evaluation of damaged buildings.

Critical Issues that have Emerged

Critical issues emerging in this topic area include the need for:

1. Standards for repair of earthquake damaged buildings
2. Guidelines for repair or removal of falling hazards
3. Guidelines for demolition of earthquake damaged buildings
4. Guidelines for evacuation of earthquake damaged buildings
5. Guidelines for salvage of personal belongings and business records/inventories.

Lessons Learned

Application of the ATC-20 procedures for post-earthquake safety evaluation of buildings on thousands of structures affected by the October 17, 1989, Loma Prieta earthquake provided a unique opportunity to critique the newly developed methodology. This experience suggested that the methodology could be improved in a variety of ways:

1. Revision of placards to distinguish limited access controlled by owners from limited access controlled by jurisdictions
2. Inclusion of additional technical information on strength and stability of degraded structural elements that would assist in making improved safety evaluation decisions
3. Inclusion of an initial "drive-by" survey to assist regional assignments of teams
4. Expanded information to assist in asbestos hazard recognition
5. Guidance on loss valuation estimation
6. More information to assist in dealing with victims

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7. Additional recommendations regarding the most appropriate composition of inspections teams, and

8. Recommended procedures for managing evaluation records.

Changes in Practice Resulting from Lessons Learned

The ATC-20 procedures for post-earthquake safety evaluation of buildings, which were developed and issued by ATC after the Coalinga and Whittier earthquakes, established standards for such evaluations in California. Lessons learned from application of the procedures suggested areas where improvements to both the methodology and its implementation could be made. The potential improvements are currently undergoing consideration in the ATC-20-2 National Science Foundation-sponsored project, "*Review and Revision of ATC-20 Procedures for Post-Earthquake Safety Evaluation of Buildings.*"

Issues Needing Attention

All of the merging critical issues identified above need attention. Following is a brief discussion of each.

1. Guidelines for Repair of Earthquake Damaged Buildings. The repair of structurally damaged buildings is a special subject of the general problem of retrofit of earthquake hazardous buildings, often involving special conditions and constraints. Communities affected by damaging earthquakes, such as Oakland, California, following the Loma Prieta earthquake, discovered that standards for repair, which presently do not exist, are critically needed for rapid and effective repair. Guidelines for the retrofit of undamaged buildings are scheduled for development, beginning in 1992 under sponsorship of the Federal Emergency Management Agency. Guidelines for the repair of damaged buildings are not yet scheduled or planned.

2. Guidelines for Repair or Removal of Falling Hazards. Leaning parapets and damaged cornices are life-safety threats that can be dealt with by first barricading and then removal or repair. Other falling hazards may require similar or special mitigation remedies. Guidelines are needed that identify potential hazards and provide generalized mitigation techniques. Photos and drawings to illustrate typical hazards should be included.

3. Guidelines for Demolition of Earthquake Damaged Buildings. Reasons cited for demolition of seriously damaged or collapsed buildings include eminent danger to public thoroughfare and eminent danger to an adjacent building or property. Too rapid a demolition response can result in building owner lawsuits, but too slow a response may endanger public or private property. Demolition problems, particularly acute after the Coalinga earthquake, followed all recent California earthquakes. Guidelines are needed that define when a city has the authority and responsibility for demolishing damaged buildings and how that demolition should proceed.

4. Guidelines for Evacuation of Earthquake Damaged Buildings. Crucial decisions regarding evacuation are dependent on the degree to which a building is unsafe: leaning buildings require immediate, rapid evacuation, whereas a wood-frame house off its foundation, without the possibility of further drop, does not (unless there is a gas leak). Guidelines for evacuating representative unsafe buildings are needed.

5. Guidelines for Salvage of Personal Belongings and Business Records/ Inventories. Often cities, such as San Francisco following the Loma Prieta earthquake, must respond to demands from building occupants and owners to salvage personal belongings, business records, and goods and merchandise from earthquake damaged buildings that have been posted unsafe. Different salvage conditions and decisions will apply, depending on whether a building is or is not in danger of eminent collapse. Guidelines are needed that define when and how salvage should proceed. Issues to be considered include the use of waivers and the opinion of the owner's engineer versus that of the local building department.

Recommended Additional Research

Most of the issues identified above can be addressed effectively without additional research, other than review and synthesis of existing research and other information. Additional research is needed, however, on strength and stability of degraded structural elements in order to provide technical information that would assist in making improved safety-evaluation decisions. This research need is particularly crucial in the case of reinforced concrete and reinforced masonry components and structures. Relationships between crack widths and patterns versus effective strength and stability need to be developed.

DAMAGE ASSESSMENT AND RECONSTRUCTION ARE ENGINEERS AND GOVERNMENT WORKING FOR OR AGAINST THAT GOAL?

Loring A. Wyllie, Jr.

Introduction

Prompt and accurate damage assessment by engineers and government inspectors is essential following damaging earthquakes so that the public is protected from potentially hazardous buildings and that buildings with minor damage can be quickly reoccupied. Buildings with damage need to be promptly repaired and possibly strengthened to respond to building regulations and to criteria that are logical and consistent with sound engineering judgment. Government actions and regulations need to be consistent with safety, engineering judgment and logic.

In recent California earthquakes, primarily Loma Prieta but also Whittier and Coalinga, the author has observed the process described above work well in many cases but fail in too many other instances. This paper will describe actual examples from these recent earthquakes to illustrate good and poor damage assessment and reconstruction in order to suggest recommendations for improved response following future earthquakes.

Damage Assessment Examples

1. A large commercial building owner had prescreened hundreds of buildings using ATC-14 evaluation procedures. Following the earthquake, the documentation was used to quickly assess building safety to keep business in operation.

2. Inexperienced engineers reviewed a historical building and recommended demolition because undamaged, archaic materials did not comply with the current building code for new construction.

3. A housing project which sustained considerable cracking in nonstructural finishes was vacated and may be demolished despite the design engineer's assurance that the buildings were safe for continued occupancy.

4 A government agency ordered demolition of damaged buildings without allowing the building owners to inspect their property or remove any contents.

5. FEMA, the U.S. agency that provides reconstruction funds to local governments, sometimes created bureaucratic delays and generated reconstruction estimates that differed by several factors from those dictated by sound engineering evaluation.

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Reconstruction Examples

1. A building owner of an unreinforced masonry building declined to repair minor damage as anticipated future government regulations may require significant seismic strengthening. The owner terminated leases and is now involved in litigation that will likely result in damages far exceeding the cost of the declined repairs.

2. An engineer advised the owner of a multistory building with one large crack in a wall that the building must be brought into compliance with current building codes. After spending over $10 million, the owner is suing the engineer for questionable advice.

3. An old building had a nonfunctional decorative tower damaged in an earthquake while the remainder of the building was undamaged. The engineer engaged reported the case to historic preservation groups which declared the tower historic. Considerable funds were then spent to repair and strengthen the nonfunctional tower whereas demolition would have been much more economical. The owner is also considering litigation for questionable, expensive advice.

4. A modern building sustained significant structural damage in an earthquake. The owner hired a competent engineer and contractor who completed design and construction of repairs in one week to reopen the building to normal functions.

5. While most building regulatory agencies have no requirements on repair of damaged buildings, one jurisdiction, without a consensus from the engineering community, adopted very restrictive regulations following an earthquake. It required buildings with relatively minor damage to be strengthened and modified to full compliance with requirements for new buildings. Many, many millions of dollars are being spent by building owners beyond what is appropriate for public safety to satisfy this regulation.

6. Caltrans, the State of California's Department of Transportation with authority over all major transportation routes, received awards and praise for their ingenuity in repairing and reopening the Bay Bridge one month after a span collapsed. They then demonstrated bureaucratic delays and the considerable problems with their designs by not being able to design nor repair nor replace damaged or collapsed freeway bridge structures. The result two years after Loma Prieta is routinely jammed freeways and bridges with unacceptable delays to the public, affecting commerce and business.

Conclusions and Recommendations

The above examples have illustrated the need for:

1. More engineers trained for damage assessment and reconstruction of earthquake-damaged buildings. Perhaps a registration or certification program is needed to prejudge competence in this area.

2. Second opinions by engineers, in essence peer review, of damage assessment and reconstruction decisions, should be encouraged and routinely performed following damaging earthquakes.

3. Guidelines need to be developed to create reasonable and appropriate regulations for historic structures damaged by earthquakes

4. Guidelines and draft building regulations need to be developed to govern repairs and required strengthening of buildings following earthquakes.

5. Common sense, good judgment and sound decisions need to prevail following damaging earthquakes to achieve the goal of proper damage assessment and appropriate reconstruction.