PART II: URBAN EARTHQUAKE SAFETY

CHAPTER 3
THE URBAN ENVIRONMENT

INTRODUCTION

The occurrence of a major earthquake on or near an urban site can lead to severe economic consequences and to risks to the life safety of inhabitants of the area. The possible extent of such earthquake effects is demonstrated by recent planning scenarios indicating that a single great earthquake in California could cause $20 to $40 billion worth of property damage and could kill or injure several tens of thousands of people.

Past urban earthquakes, in particular the Mexico City earthquake of 1985 reinforce the need for the redevelopment process to include and analyze the full range of decisions associated with developing safe environments.

The characteristics for such a seismically safe urban environment seem to coincide with those of a well-planned area. This includes the protection of essential urban systems through building codes and land-use planning. These areas need to be explored and evaluated as a means for achieving both a viable urban system and one that is seismically safe, an invaluable goal at a time of limited resources. This chapter reviews such issues and explores them in terms of earthquake safety.

URBAN SYSTEMS

Urban systems are a vital component of earthquake mitigation planning. Certain community facilities and operations must be depended upon in an earthquake to provide critical public services such as rescue, fire suppression and medical assistance. In fact, the need for these services have increased up to 1000 percent in past earthquakes determining that local authorities will often find themselves exceedingly taxed to perform the critical services expected in the aftermath of an earthquake.

Whole communities can be disabled for weeks if the necessary infrastructure is damaged. Urban systems are defined to include: (1) communications systems; (2) power systems; (3) water systems; and (4) transportation systems. These systems collectively provide the essential functions of supply, disposal, transportation, and communication required by an urban community.

Lifeline earthquake engineering is a relatively new field triggered by the 1971 San Fernando, California, earthquake which caused dramatic damage to the community's lifeline systems within a fairly small geographic area. Spurred by recent earthquakes in urban environments throughout the world, seismic design of critical facilities has been receiving increasing attention from local officials, governmental agencies and the public. Current seismic building code provisions require increased seismic design for these facilities and some states, California in particular, have separate design and construction approval programs (at least for schools and hospitals). However, there is limited earthquake design guidance which addresses the continued operation of these facilities and systems.

BUILDING CODES

A building code is intended to ensure that a building is so located, designed and constructed that, if it is subjected to natural or man-made destructive forces, it will present no particular threat to the life, health and welfare of its occupants or the general public. In addition, a code is intended to ensure uniform minimum standards of health and safety with reasonable economy and to obviate the need for expensive and difficult studies for every building project, large or small.

Codes are based on knowledge, derived from experience, laboratory testing and theoretical research and analysis. Codes refer to standards. Standards are defined as acceptable design and construction practices developed by those with expert knowledge but are not law unless incorporated by reference within a code. Standards provide for levels of design, manufacturing, and construction that are often embodied in codes and may also be voluntarily utilized by designers to specify the quality of materials and components of construction.

Building codes do not explain how to design and construct a building; they provide the criteria and standards to which a building must be designed, but assume that the user is a professional who is knowledgeable about the nature of the hazard in general and is experienced in building design.

Building codes reflect the fundamental duty of government to protect people and property from harm, within the concept of *police power*, the right of all states to protect the general health, safety and welfare through appropriate legislation. In the United States, building codes generally are an expression of the police power of government, which the U.S. Constitution has reserved for the states. Most states have delegated this function in whole or in part to their political subdivisions (cities, counties, towns, and other special districts). Therefore, the building code system is predominantly an aspect of local *home rule*, and has evolved with different traditions and to different degrees in various localities and regions. To this day, there are parts of the country where building is unregulated, in deference to the perceived right of the property owner to build as one wishes on one's own land.

Once a jurisdiction decides that it should have a building code, there are three common options available:

- The jurisdiction may develop its own code.
- The jurisdiction may adopt one of the three available model codes in its entirety.
- The jurisdiction may use one of the model codes as a foundation upon which to develop its own code by making modifications (large or small) that reflect local concerns and conditions.

Purpose of Building Codes

The purposes of building codes are set forth directly in the code or operative legal documents of a jurisdiction making them minimum legal criteria that can establish both criminal and civil liability for noncompliance. The purposes of building codes generally are to:

- Prevent or minimize bodily injury or death to the public.
- Prevent structural failures and collapse with attendant death and injuries to the public.
- Prevent or minimize the incidence of fire damage and spread both for individual structures and the community as a whole.
- Prevent or minimize deterioration and damage to property from the elements.
- Prevent or minimize *overcrowding* and creation of deteriorated community conditions.
- Protect the public welfare as this concept is further defined in local community and/or state law.

From these basic purposes, the concept of public welfare in the U.S. has been expanded by the courts significantly during the last few decades. Present building codes often include detailed provisions for other safety objectives (for example, accessibility for the disable historic preservation, energy conservation and noise control). Some broader environmental concerns (for example air and water pollution), economic development issues, and aesthetic considerations also have found their way into some building regulations under an expanded concept of public welfare.

Participants in the Building Code Process

Enforcement of the building code system for the majority of construction activity emanates from local jurisdictions that issue building permits and perform inspections for code conformance. Separate from these local regulatory jurisdictions are a number and variety of local special districts; for example, schools and utilities. The enabling legislation that forms these special districts often makes them autonomous authorities and exempts them from local regulatory controls. They usually develop their own building regulations, which may cross local jurisdictional boundaries.

States, in response to either lack of uniformity in or the absence of local building codes, have enacted parallel sets of statewide minimum regulations for selected building types. These statewide regulations reflect a multitude of formats and legislative backgrounds and often serve as a screening device for state lending, insurance and other funding programs and mechanisms.

States also typically have agencies that construct, regulate and maintain state-owned and -operated facilities (for example, universities, correctional facilities, hospitals). These agencies also are exempt from local regulations for their programs and buildings.

Although states have the authority to write their own building code, as a practical matter they usually adopt some form of the model code in current general use in the region, incorporating additions and amendments to reflect specific concerns and conditions.

Like the states, the federal government is exempt from the home rule concept of U.S. building codes. Although the trend is for the federal government to use existing national codes and standards whenever possible, federal programs have developed extensive in-house building requirements to address their own proprietary design and construction interests.

In many cases, federal agencies have developed or adopted building regulations as direct qualifying standards for federal funding of private sector construction or for indirect funding through redevelopment and other subsidy programs.

At present there are four US organizations that produce model sets of basic building codes.

- The Building Officials and Code Administrators International (BOCA) produces the National Code series.
- The International Conference of Building Officials (ICBO) produces the Uniform Code series.
- The Southern Building Code Congress International (SBCCI) produces the Standard Code series.
- The Council of American Building Officials (CABO) composed of the three above model code organizations produces the *One-and Two-Family Dwelling Code*.

These organizations publish code documents (building, mechanical, plumbing, fire, gas, etc.) and provide a variety of other educational and support services necessary to make the local jurisdictional system work on an effective constitutional and technical basis.

These model code organizations have regional bases although there are instances where local jurisdictions within one state use different model codes. BOCA focuses on the Northeast and Midwest; ICBO focuses on the West and Midwest; and SBCCI on the South and Southeast.

In addition, the National Fire Protection Association (NFPA) produces nationally used electrical and fire protection codes. Several of these documents (for example, the National Electrical Code, the Life Safety Code, and the Sprinkler Code) are adopted by state and local jurisdictions. One major conflict arises from these process in that the NFPA codes and standards are enforced by the local safety departments through fire marshals while the building codes are enforced by the local building departments through building inspectors.

Professional societies of architects and engineers, trade associations of product manufacturers, and nongovernment standards writing organizations have a long-standing tradition of active interest in the building code system. They have developed, through consensus processes, material and manufacturing standards, testing procedures, and design criteria for almost every material, product, component and system used in buildings. Some of these organizations have developed seismic standards for specific products and components within their special interests. Materials developed by these organizations are often directly incorporated into model codes or are referenced within the model code thereby becoming a legal requirement.

Building Code Adoption Procedures

The adoption of building codes by states may take a variety of forms. The two most common are total pre-emption, in which the state develops or adopts regulations that must be enforced by the local jurisdiction, or partial pre-emption, in which the state regulations are minimum standards and the local jurisdictions may adopt equal or more restrictive regulations.

In states that have mandatory statewide building regulations (approximately half of the states) proposed new rules are usually submitted as amendments to existing regulations. When the proposed rules are included in a model code forming the basis of the state code, they may be adopted very simply as a routine update to the model code on an annual basis or upon publication of a new edition of the model code.

In states that do not regulate buildings on a state-wide basis, an initiative must be generated through the introduction of a bill in the state legislature. If passed and signed by the state executive branch the provisions become state law and the responsibility for enforcement is placed in a state agency.

For local jurisdictions which already adopt one of the model codes, new provisions are introduced as part of that code's periodic revision and adoption process.

For those local jurisdictions with a locally written code in effect or no code at all, new provisions must be processed as adoption ordinances. Once adopted by the local authority the new provisions are usually set forth as a local ordinance and a local agency is selected for implementation and enforcement. Local procedures must then be reviewed and revised to reflect the new ordinance.

Seismic Building Code Provisions

As with building codes in general, the principal purpose of seismic building code provisions is to ensure public safety, health, and welfare insofar as they are affected by building design and construction. Because of the many variables concerning the nature, extent, and frequency of earthquake forces, measures essential to ensure total safety from earthquake would be prohibitively expensive. Thus, seismic codes usually reflect some degree of compromise. Seismic codes generally have the following objectives.

- Structures should resist minor earthquakes without damage.

- Structures should resist moderate earthquakes without structural damage but some nonstructural damage may occur.

- Structures should resist major earthquakes without collapse but some structural as well as nonstructural damage may occur.

It is important to understand that damage may occur in even a very well designed building if it is subjected to the effects of a severe earthquake.

Seismic codes establish minimum standards for providing a simple and uniform method by which the nature of the ground motion for any location can be assessed and the forces on a building determined with enough accuracy to ensure a safe yet economical design. A seismic code must also provide for approximate uniformity of results over the whole range of building types so that no one group is discriminated against. Since seismic codes have the force of law, provisions must be unambiguous and clear so that building inspectors can uniformly and efficiently enforce the code.

Seismic Provisions in Model Building Codes

Although seismic codes have been around internationally since 1908, even the famous earthquake in 1906 in San Francisco did not result in a U.S. seismic code. Not until 1927, following the 1925 Santa Barbara earthquake was a set of seismic provisions published in the United States. And not until 1933, following the 1933 Long Beach earthquake were such provisions made mandatory in California's Field Act which regulated school buildings. Soon after, however, California established a mandatory seismic design coefficient; this measure was the first statewide requirement for earthquake resistant design within the United States.

At the present time all four model codes contain earthquake provisions although local jurisdictions can still (and many do) choose not to adopt the seismic provisions as part of their adoption of a model building code.

The Uniform Building Code developed by ICBO first contained a seismic provision in 1927. However not until 1935 did the UBC contain seismic provisions similar to those enacted by the State of California and City of Los Angeles.

In 1960, the Structural Engineers Association of California (SEAOC) prepared lateral force provisions for the design of buildings. SEAOC published the *Bluebook*, which was the first seismic code whereby reasonably comprehensive seismic design provisions are incorporated together in one code type document.

ICBO adopted these lateral force provisions into the Uniform Building Code which marked the beginning of modern concepts of seismic design in building codes. The lateral force provisions of the UBC became the standard for many building codes throughout the world.

In 1988 the UBC expressed quantitative values for building configuration issues, previous UBC codes had dealt with issues concerning the shape, set-backs, and other configuration elements in a non-numerical way.

An important parallel development, since 1978, has been the development of the NEHRP (National Earthquake Hazards Reduction Program) Recommended Provisions. This programs develops and updates a source document for seismic code development that reflects the latest knowledge on seismic design and construction, with emphasis on national applicability.

The changes in the 1988 and current editions of the UBC reflect the NEHRP Provisions.

In 1989, the Building Officials and Code Administrators International (BOCA) formed a committee to review and study the 1988 edition of the NEHRP Provisions. Based on recommendations from this committee, during the 1991 annual meeting BOCA adopted new seismic provisions for the National Building Code reflecting the majority of the Provisions.

The Southern Building Code Congress International (SBCCI) also acted to approve similar seismic provisions for the Standard Building Code during its 1991 annual meeting.

Thus, in essence all three model codes now reflect one basic source document on seismic design, the NEHRP Recommended Provisions.

The NEHRP Recommended Seismic Provisions

In 1977, the U.S. Congress passed the Earthquake Hazards Reduction Act of 1977 (P.L. 95-124) (see also Chapter 4). As part of this act the National Earthquake Hazards Reduction Program (NEHRP) was created in 1978. During the same year, FEMA was created as an independent agency to coordinate all emergency management functions at the federal level.

The emergence of FEMA as the agency responsible for implementation of P.L. 95-124 and the NEHRP required the establishment of a mechanism for obtaining broad public and private consensus on both recommended improved building design and construction regulatory provisions and the means to be used in their promulgation.

For this purpose, the Building Seismic Safety Council (BSSC) was established in 1979 under the auspices of the National Institute of Building Sciences (NIBS) as an entirely new type of instrument for dealing with the complex regulatory, technical, social, and economic issues involved in developing and promulgating building earthquake hazard mitigation regulatory provisions that are national in scope.

In 1985, the NEHRP Recommended Provisions were published by BSSC. Since then, a number of documents have been developed and published to support and complement the NEHRP Recommended Provisions.

The objective of the NEHRP Recommended Provisions is to present the minimum requirements to provide reasonable and prudent life safety for building occupants. For most buildings designed and constructed according to the Provisions, it is expected that structural damage from even a major earthquake would likely be repairable. However, this would depend upon a number of factors including the type, materials, and details of construction used.

The need for continuing revisions of the Provisions had been anticipated since the onset of the BSSC program and the effort to update the 1985 edition began in 1986. In 1988 and 1991, new editions of the Recommended Provisions were published. In 1992, the effort to update the 1991 edition of the Recommended Provisions was underway with the final review and balloting of the document scheduled for 1993 with publication of the new NEHRP Recommended Provisions planned for 1994.

The NEHRP Guidelines for the Seismic Rehabilitation of Buildings

In 1991, BSSC through NIBS entered into a cooperative agreement with FEMA for a comprehensive program leading to the development of a set of nationally applicable guidelines for the seismic rehabilitation of existing buildings.

The guidelines document produced as a result of this project is expected to serve as a primary resource on the seismic rehabilitation of buildings for the use of model code and standards writing organizations, state and local building regulatory programs, design professionals, and educators.

The major objectives of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings project are to:

- o Develop a set of technically sound, nationally applicable guidelines (with commentary) for the seismic rehabilitation of buildings,
- o Develop building community consensus regarding the guidelines, and
- o Develop the basis of a plan for stimulating wide-spread acceptance and application of the guidelines.

In essence, the guidelines will present minimum design/construction criteria for reducing the likelihood of death or injury as a result of earthquakes (other performance goals will be addressed as appropriate) and will reflect accepted building technology, procedures, and practices. The basic intent is to generate a set of procedures that, insofar as possible, can be implemented effectively, efficiently, and at reasonable cost and that incur minimum dislocation of building occupants. The guidelines will be developed to reflect both state-of-the-art technical information and information provided by project activities undertaken to study the social, economic and legal implications of implementation of the procedures being developed, capture relevant research, develop credible cost data on application of the procedures, and examine unresolved issues and problems from related seismic rehabilitation efforts.

LAND-USE REGULATIONS

Land-use planning is the broad planning process which encompasses zoning ordinances, subdivision regulations, and master planning. Regulating urban development has been a common practice in the U.S. for many years. Regulatory tools have been used traditionally by local governments to influence the configuration of urban settlements. During the early 1900s cities experienced the need for government intervention to regulate critical issues concerning public health. With the advancement of industrialization, cities were confronted with unprecedented population densities, inadequate locations of factories, noxious industries, and the lack of sewer systems. In 1916, a group of New York City merchants joined forces with city planning officials in an effort to protect the Fifth Avenue shopping district from encroachment of emerging factories. As a result of this movement, the city adopted what is known as the first formal comprehensive zoning ordinance in the U.S.

Several factors contributed to the adoption of zoning ordinances nationwide. In 1921, an Advisory Committee on Zoning was appointed within the Department of Commerce. Three years later, this Committee issued the Standard State Zoning Enabling Act, a model upon which a great deal of State zoning legislation is still based. In 1926 the U.S. Supreme Court, in the case of Village of Euclid versus Ambler Realty Co., upheld the constitutionally of zoning as a reasonable exercise of local government's power. This decision granted local governments with a police power. Since then, zoning ordinances have spread rapidly. By the end of 1930 more than 1000 cities had adopted zoning ordinances.

Early attempts to regulate the land through subdivision regulations took place during the 19th century in an effort to control the layout and construction of streets. Land subdivisions gained acceptability in 1928 when the Department of Commerce issued the Standard City Planning Enabling Act which set up the legal basis for these regulations. However, the depression put a halt to the adoption of most subdivision regulations. By 1934, only 269 municipal planning commissions in 29 States were empowered to regulate land subdivisions. However today, subdivision regulations are widely used throughout the U.S.

Comprehensive planning encompasses a set of development strategies oriented to enhance and/or improve the social and economic fabric of a particular community. Many names have been given to comprehensive planning, including, master planning, general planning, development planning, or community planning. The first city to develop and adopt a comprehensive plan was Cincinnati Ohio, in 1925. Before that time, comprehensive planning was reduced basically to zoning ordinances. Today, comprehensive planning is an indispensable tool for professionals in the planning field.

Land-Use Planning and Earthquake Safety

Land-use planning as a tool to mitigate earthquake potential damage is carried out only by a few states of which California has been the leader. The California State Legislature (1971) which requires that a seismic safety element must be part of all local general plans and the Alquist-Priolo Special Studies Zones Act (1972) which restricts development near or over the surface traces of active faults constitute an important legal framework for including seismic safety within the planning process. More recent efforts include the creation of the Southern California Earthquake Preparedness Project which is currently making use of scientific information to develop prototypical local emergency plans.

Typically, zoning ordinances control the type of development to be built in a particular area of a community and divide a municipality or county into districts. Within each of these districts a uniform set of ordinances specifies the permitted uses, such as the size of lots; densities; building setbacks; and lot coverage requirements. Ordinances addressing natural hazards can minimize the impacts of earthquakes by reducing the amount of development in hazardous areas or requiring stringent mitigation measures than can reduce the risks to the natural and built environment to reasonable levels. In addition, zoning ordinances can require submission of geologic information when projects are located in areas vulnerable to earthquakes and can advocate creative development designed to avoid unsafe locations.

While conventional zoning normally applies to individual lots, subdivision regulations govern the process by which those lots are created out of larger tracts of land. Subdivision regulations seek to assure that plats are appropriately related to its own site, as well as, to its surroundings. Subdivisions can play a critical step in the reduction of natural hazards. An approved subdivision is required before existing property can legally be divided into parcels for sale, lease, and financing. During this process, problems related to natural hazards can be more easily averted and studied, and specific-site mitigation provisions can be required as a precondition to project approval. In parcels suspected vulnerable to earthquake related hazards, subdivision regulations can require the preparation of soil engineering and geotechnical reports to be submitted with applications for land subdivisions.

A third element of land-use planning is comprehensive planning. This type of regulation is normally used to encourage certain types of development, incentives, allocation of resources, and capital improvement programs oriented to improve the social and economic welfare of the community. Under this framework, master planning can include geological and environmental-hazard related information and data based on vulnerability studies and risk assessments. Such information can be used to reduce potential losses of lives, and properties; damage to schools, dams, public buildings, and churches. In addition, it can set standards to direct development and/or endorse the prohibition of urban development in hazardous areas.

A comprehensive approach to earthquake safety can be developed using this framework of regulatory tools, namely, zoning ordinances, subdivision regulations, and master planing. The master plan can set an umbrella for the development of the community and can enforce policies which essentially prevent development on hazardous lands. The site development or zoning ordinance enacted to implement the general plan, can require a detailed report on soil, geologic conditions, grading specifications, drainage calculations, and landscape plans. The subdivision regulation, which regulates the conditions and procedures under which land may be subdivided, can require that such subdivisions be in conformity with the general plan and zoning ordinances before it can be approved.

WATER SYSTEMS

The major U.S. experience with extensive damage to water systems occurred in 1906 when the San Francisco earthquake caused the near-complete failure of the water distribution system. Essentially no water was available to fight fires immediately after the earthquakes, which resulted in the conflagration of some 490 city blocks, partial damage to 32 more, all resulting in the destruction of homes for nearly 200,000 people.

Significant, although less catastrophic, damage occurred during the 1971 San Fernando earthquake. Damage included numerous water and sewer pipeline breaks; cracking of storage tank roofs, shells, and piping; fracturing of well casings and piping; and ground failure with associated damage to reservoirs and water treatment facilities. Water supply contamination was caused by sewer damage.

With increased population density in urban environments and the well documented aging and corrosion of their water and sewage systems the almost certain potential exists for the wide spread failure of water distribution systems in future major earthquakes affecting our country's cities.

Earthquake damage to water systems has three principal effects. First, potable water supplies to domestic and essential users may be lost or contaminated. Second, water for firefighting can be lost or disrupted. Third, water supplies to industrial facilities may be cut off. Damage to sewage systems can result in loss of collection capabilities, blocked flow, or loss of pumps, causing the overflow of sewage from manholes and broken pipes and the presence of raw sewage in the streets with the associated health problems, an especially hazardous condition for high urban densities.

The success of an existing water or sewage system following an earthquake depends on many operational factors that are difficult to quantify. Many items contribute to the overall operation of the water distribution system. Of critical importance in the ability to isolate severely leaking portions of the water system so that reservoir capacity is not wasted. Identification and upgrading of critical system components forms another important goal in a hazards mitigation program. Specific examples include anchoring equipment; replacing critical pipe segments that are badly deteriorated; repairing or replacing inoperable valves; strengthening pump mounting and their lines; restraining pipe joints; and upgrading tanks.

Retrofitting and upgrading of most buried facilities is extremely expensive. Urban systems are barely able to keep up with routine maintenance and increased demand caused by urban growth. Historically, it has been difficult to secure adequate funding to upgrade major portions of water distribution or sewage collection systems for earthquake preparedness. Capital funds for new construction commonly have been easier to obtain than funds for upgrading for seismic safety alone. Thus a relatively straightforward, though gradual, method of improving earthquake response is to ensure that all new construction is capable of withstanding the anticipated seismic hazard.

TRANSPORTATION SYSTEMS

Transportation systems such as highway, railroad, rapid transit, port, and airport systems consist of different structural components (e.g. bridges, tunnels, embankments, buildings) that have been damaged during past earthquakes due to ground shaking, fault rupture, liquefaction, and other soil failures. Extensive damage to transportation systems would hamper: (1) the rate at which goods, medical supplies, and other forms of aid could reach the affected area; (2) the ability of police, fire, and medical services to respond to and remove people from affected areas; and (3) long-term and short-term recovery processes for the affected area. Post-earthquake reliability levels for these systems are considered to be comparable to the reliability levels expected for water supply, sewage, electrical, and natural gas systems.

Recent research on the seismic vulnerability of transportation systems have emphasized the seismic design and retrofit of highway bridges as a direct result of the damage sustained to highway bridges during the

1971 San Fernando, California earthquake. The result of this research was the adoption in 1983 by the American Association of State Highway and Transportation Officials (AASHTO) of the *Guide Specifications for Seismic Design of Highway Bridges*. Prior to 1971, seismic design criteria that specifically addressed the seismic vulnerability of transportation components had not been developed in the United States.

However, accepted seismic design requirements have not been developed for other common modes of transportation such as railroads, rapid transit systems, port facilities, and airports and hence considerable differences exist in seismic design requirements and practice.

Railroad system components consist of bridges, tunnels, track, embankments, building facilities, train cars, and communication/switching/power systems. Although railroad systems suffer damage similar to that of highways during an earthquake, the operations are more severely impaired by ground movement than highways.

Airports are unique among the various transportation systems in that they are typically a composite of many structure types (e.g., buildings, bridge-type elevated roadways, rail systems within tunnels between terminals, and pavements). Most airport elements are similar to other transportation systems, however, airport buildings differ from conventional buildings in that they have a multitude of vital post-earthquake functions that include: (1) life safety protection of airport occupants; (2) control of aircraft traffic for bringing supplies into and evacuating injured people from affected areas; and (3) aircraft repair and maintenance. Despite this, there has been virtually no engineering research directed toward the development of comprehensive seismic design and evaluation criteria for critical airport buildings.

It is customary to include seismic factors in the design of port structures in accordance with local building codes. It is not customary, however, to include seismic hazards in the process of overall port development and regional transport planning, so as to provide a comprehensive framework for decisions in the event of a major earthquake. Recent earthquakes have caused major damage to port facilities including the 1985 Chile and 1985 Mexico earthquakes which damaged the ports of Valparaiso, San Antonio and Lazaro Cardenas. They indicate that a systematic approach is imperative for the planning of port development as a distinct form of facility design, taking into account earthquake considerations as an integral part of the process.

POWER SYSTEMS

Not only are power systems necessary for a community's orderly return to normalcy after an earthquake, they are highly capital intensive and can present the utility with an unacceptable financial loss should a significant failure occur. Therefore, in addition to the potential direct impact on the utility should a significant failure occur in a power system, there is potential for an even greater impact on the community.

Although utility systems generally have performed well when exposed to seismic loading, localized urban areas have remained unserviced for extended periods of time after major earthquakes. This is because failures of power system components were usually caused by failures of nonpower system elements located in close proximity to power system components in the crowded urban environment.

Several issues can be identified which place the power system as a critical lifeline. Power is, of course, essential for the short and long-term functioning of the community. Lead time for the purchase of a large number of replacement equipment and components can be several months and major power system components can be very expensive. While the vast majority of power system components may survive without damage the failure of a few individual critical components can operationally shut down or disrupt the entire system.

Even with this *weak link* scenario there are no comprehensive system performance models that can be used to determine a power utility system's overall seismic risk. Nor are there any large-scale testing facilities in place that test electrical components and assemblages for the benefit of the utility industry.

Possibly the most vulnerable *weak link* in the power lifeline is high-voltage substation equipment containing ceramic components. While evidence continues to mount demonstrating the vulnerability of this equipment, there is little information on this damage or its mitigation. Of particular importance is the significant damage reported from moderate earthquakes in California where seismically strengthened equipment is used and good seismic design and construction practices are common. The eastern United States is particularly vulnerable since higher voltage, more seismically sensitive equipment is used in the eastern U.S. with limited seismic strengthening.

The public is more than simply inconvenienced by a widespread power outage that could be expected in an urban earthquake. Since even the most routine banking transaction requires availability of computer information processing, and therefore electric power, people would soon discover that they could not withdraw cash from their bank accounts. Retail stores would be unable to process even cash purchases. Credit verification of purchases would be prevented. The impact of power loss on residential, retail, and wholesale refrigeration facilities would be dramatic. Commercial and residential areas would lose all appliance services, lighting, television, air conditioning, and sometimes heating.

The loss of Mexico City's electric power system during the 1985 earthquake serves to demonstrate that the consequences of immediate and sustained power loss may be so significant as to justify even the most elemental program of power lifeline mitigation. The relatively recent rise of private corporate emergency management and planning should be an indicator of the corporate consumer's growing fear of the consequences of a disaster, including that of power loss.

COMMUNICATION SYSTEMS

The continued operation and serviceability of communication systems following an earthquake is essential to implement emergency operations. The regulated communication public utilities have for years designed the installation of their equipment and plant for continued operation in emergencies, sometimes including earthquakes. To maintain continued service the utilities have provided standby emergency power generators, redundancy of equipment, system bypasses, equipment reinforcing, equipment bracing, and have attempted to avoid hazardous geologic conditions.

Mexico City provided in its 1985 earthquake an example of disaster-hampered telecommunications that should stir earnest concern in the United States. There are many U.S. parallels to the communication problems faced in this disaster.

Present telecommunications facilities vary across the U.S. in their protection from earthquakes. Most are not designed for the accelerations that would be expected to damage and disrupt the sensitive equipment housed in them. Only in California have the many years of experience and damaging earthquakes resulted in significant retrofitting of communications equipment and facilities.

However, even in California where telephone exchange facilities, buildings which house telephone exchange equipment, are designed and constructed to the latest seismic building provisions, the support system buildings which house support functions including maintenance and supply are designed to meet only the current building code with no special considerations as essential facilities. To compound this problem many of the support functions are located in leased buildings which were designed using local codes with no consideration of the essential function of the tenant. Outside plant facilities including poles, cables, lines and underground systems usually have limited seismic considerations, however their performance during past earthquakes has been good.

For communications systems to continue operating, the facility that houses the equipment must remain in operation during and following an earthquake. These facilities typically have tall story heights and heavy floor loading. Communications systems have suffered extensive damage in past earthquakes to facilities and equipment. One of the problems is that equipment manufacturers have typically ignored seismic forces in the design of equipment, leaving it to the utility to add earthquake anchoring and bracing to provide seismic protection.

Electronic switching equipment is being used in place of the old electro-mechanical switching gear. Both deflection and vibration can cause these systems to malfunction, since the printed circuit boards can be cracked, causing open circuits on the boards. Since this failure is very difficult and costly to locate and repair structural deflections become critical for these building and should be kept to a minimum.

Equipment in communications facilities are typically installed on raised floors. Unfortunately, equipment manufacturers do not typically provide bracing or anchoring features to be used for a secure installation.

It is common in high earthquake risk areas throughout the country that communication system equipment is inadequately or improperly secured to resist lateral and vertical earthquake forces. With new system equipment proliferating and changing almost daily, the problem of adequate design of restraint in any standard way is increasingly difficult.

CHAPTER 4
FEDERAL EARTHQUAKE PROGRAMS

INTRODUCTION

In spite of the fact that most states and other cities exposed to earthquake risk in the U.S., there is no national requirement aimed toward mitigating damage from this natural hazard. What presently exists is legislation that promotes --in a direct or indirect manner-- the introduction of earthquake safety through different federal programs. In general, seismic safety policies are embedded in federal constitutional mandates aimed at protecting the health, safety, and welfare of the residents of the United States.

This limitation poses a significant problem, especially for the urban environment. As mentioned earlier in this report, there are, throughout the U. S., large numbers of older and unreinforced masonry buildings which are considered potential hazards in case of earthquake. Increasingly, urban neighborhoods are becoming affected by poverty, spreading blight, and abandonment while many central business districts in older cities are continuing to shrink in size and original ethnic shopping areas disappear due to an economy that can not longer support them. At the same time, maintenance of old structures are becoming more difficult as the user base recedes and self raised revenues depart from old neighborhoods to new suburbia. The City of Los Angeles has identified approximately 8,000 unreinforced masonry buildings (few other cities or counties have systematically surveyed their inventories of older structures). It has been estimated that a 6.0 magnitude earthquake could cause as many as 7,000 deaths and 26,000 injuries due to the failure of these older buildings in Los Angeles (Ayner and Mann, 1986).

Typically the barrier of any initiative oriented at promoting seismic safety policies and programs is cost. This situation has become more critical as many programs that could be used to promote earthquake safety are currently constrained by lack of funding. Even in post-disaster events such as the 1989 Loma Prieta earthquake which attracted presidential and massive media attention, the flows of federal funding were limited in comparison to the magnitude of the event (as of June, 1990 assistance for public facilities totals slightly over $106 million for the State of California). (California Preservation Foundation, 1990)

The purpose of this chapter is to review a number of federal programs which constitute a national framework and current funding source for earthquake safety programs.

EARTHQUAKE HAZARDS REDUCTION ACT OF 1977

The purpose of the Earthquake Hazards Reduction Act of 1977 (Public Law 95-124) (also see Chapter 3) is to reduce the risks to life and property from future earthquakes in the U.S. through the establishment and maintenance of an effective National Earthquake Hazards Reduction Program. In addition to ensuring the seismic safety of new building construction, one of the objectives of the act is *"the development of methods for rehabilitation, and utilization of man-made works so as to effectively resist the hazards imposed by earthquakes."* In addition the act stresses the development and promulgation of specifications, buildings standards, design criteria and construction practices to achieve appropriate earthquake resistance for new and existing structures.

The National Earthquake Hazards Reduction Program was established in 1980 through amendments to the Earthquake Hazards Reduction Act of 1977. This program is coordinated by the Federal Emergency Management Agency (FEMA) with the assistance and cooperation of the National Science Foundation (NSF), the U.S. Geological Survey (USGS), and the National Institute of Standards and Technology (NIST).

This Act has been amended extensively. As written today, the Act requires the adoption, not later than December 1, 1994, of standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government. An Advisory Committee has been established to aid the agencies involved in planning and implementing the program. Funding for complying with their programs has been assigned on a yearly basis and by agency. The Act also mandates that a report should be issued to Congress describing how the standards adopted can be applied with respect to buildings for which federal financial assistance has been obtained through grants, loans, financing guarantees or loans or mortgage insurance programs. There are numerous positive consequences that can be derived from the new amendments of this act.

THE STAFFORD ACT OF 1988

The Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 100-707), commonly known as the Stafford Act, is one of the most important pieces of legislation for earthquake safety. Through this act, federal agencies, operating under their own statutory authorities are able to provide assistance in case of a disaster. If the situation is beyond the capabilities of local and State forces a major disaster or an emergency can be declared. The Stafford Act allows the President, following a petition of the Governor of the affected State, to make contributions to state, local governments, non-profit organizations, and individuals for the repair, restoration, reconstruction, or replacement of damaged properties and/or public facilities; associated expenses incurred by local agencies; and relocation assistance, emergency public transportation, debris clearance, and loans to cover substantial losses of local tax revenues. Also this assistance can be extended to individuals who own or operate a private nonprofit facility damaged or destroyed by a major disaster.

FEMA is the primary agency to respond and administer programs in the immediate aftermath of a disaster as authorized by two separate Executive Orders (12148 and 12673). One of the most important features of the Stafford Act is that it triggers other Federal disaster programs. Sections 404, 406, 409, and 417 of this Act establish potential sources of funding for rehabilitation from different public institutions.[5] Measures that can be allowed under this program are identified following a natural disaster and should be cost-effective in terms of reducing the risk of future damage, as well as hardship, loss, or suffering in areas affected by major disasters.

Section 404 establishes a Hazard Mitigation Grant Program under which a range of multihazard mitigation measures --including, at least theoretically, seismic strengthening --are eligible under certain conditions in a declared disaster area. Section 404 establishes that in case of a disaster federal funds will be available on a 75 percent cost-share basis , and up to 15 percent of the total contribution of funding available for mitigation (combination of public assistance and individual assistance).[6]

To qualify for this program, seismic strengthening in buildings damaged or undamaged by the disaster have to be included in a mitigation plan submitted by the State. This programs has been used extensively for multi-hazard mitigation activities. During the Great Floods of 1993, $95.8 million were available for nine states through the Hazard Mitigation Grant Program.

Section 405 specifically identifies retrofitting activities as eligible projects that can be undertaken through the Stafford Act. As part of the national objective which underwrites the need to increase community welfare, both, buildings that have and those that have not been damaged by a natural hazards can qualify for federal assistance.

Section 406 (contribution for repair, restoration, and replacement of damaged facilities) stipulates that contributions can be made to state or local governments for the repair, restoration, reconstruction, or

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[5] Sections 406 and 409 were published in final form on August 30, 1990, in Part II of the *Federal Register* (44 CFR Part 206, Subpart N and M, respectively).

[6] These percentages reflect modifications made to the Stafford Act on November 19, 1993.

replacement of a public facility which has been damaged or destroyed by a major disaster. Seismic strengthening of damaged buildings could be fully covered by federal funds.

Section 409 stipulates that the States and/or local governments must take actions to mitigate those hazards that affect a particular disaster prone area using, when necessary, provisions such as land-use and adequate construction practices.

Section 417 stipulates the authorization of loans to any local government which has suffered a substantial loss of tax and other revenues as a result of a major disaster. This section stipulates that loans will be available for those agencies that require financial assistance in order to perform their governmental functions and that such loans should not reduce in any manner grants or other assistance stipulated by the Stafford Act.

As of this writing, the financial incentives offered by the Hazard Mitigation Grant Program have not been used for seismic strengthening of public or private buildings. The State of California, however, is now reviewing about 1,000 potential projects under the mitigation grant program as a result of the Loma Prieta earthquake, and some of them may include seismic strengthening. (Building Technology Inc., 1990)

The Stafford Act encompasses many forms of federal assistance which can either increase the flows of income into the affected community or free individual income that can be used in post-disaster reconstruction and rehabilitation programs. For instance after a disaster a number of loans are also available for state and local governments, small businesses, farmers and disaster victims in general. Also a temporary housing program is available through FEMA and/or designated state agencies. Such programs provide transient accommodations for disaster victims (i.e., hotels, motels, government-owned mobile homes, and tents) and finance temporary emergency repairs.

In addition, under the Stafford Act, the Internal Revenue Service provides counseling and assistance in the form of income tax refunds to disaster victims who file income tax returns for the year of the disaster occurrence, or any of the three previous years (these earlier returns may be amended to receive an immediate tax refund for non-insured casualty losses to homes, personal property, business or farming/ranching operations). Losses are only deductible to the extent they exceed 10 percent of the adjusted gross income. Benefits may also result from filing amended state income tax returns. Also, county assessors may provide information on possible property tax relief.

EXECUTIVE ORDER 12699, SEISMIC SAFETY OF FEDERAL AND FEDERALLY ASSISTED OR REGULATED NEW BUILDING CONSTRUCTION

Executive Order 12699 signed on January 5, 1990 calls for Federal agencies to "...reduce risks to the lives of persons who would be affected by earthquake failures of federally assisted or regulated buildings, and to protect public investments, all in a cost-effective manner."

Each federal agency was made responsible for developing and implementing its own seismic safety program commensurate with its specific program responsibilities. The Interagency Committee on Seismic Safety in Construction (ICSSC) was charged with the responsibility of developing applicable standards for new building construction. To support the use of seismic codes and standards which are substantially equivalent to the *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings*, several actions have been taken to support the implementation of the Executive Order. The main purpose of this committee is to develop one Federal Seismic Risk Assessment Methodology for adoption by all agencies that may be affected by the Executive Order. All applicable statutory requirements are expected to be finalized by 1994.

Funding for assuring appropriate consideration of seismic safety elements in new construction can be obtained from grants or loans, or guaranteeing the financing through loans or mortgage insurance programs. Three years are given for the full implementation of this Executive Order. In spite the fact that this order will have an important impact on earthquake safety, it is important to indicate that the order does not affect federally-owned existing buildings.

NEHRP REAUTHORIZATION ACT OF 1990

The National Earthquake Hazard Reduction Program Reauthorization Act was signed on November 16, 1990, and, in part, impacts on existing buildings by requiring the following:

> *The President shall adopt, not later than December 1, 1994, standards for assessing and enhancing the seismic safety of existing buildings constructed for or leased by the Federal Government which were designed and constructed without adequate seismic design and construction standards. Such standards shall be developed by the ICSSC.*

To satisfy this legislation, ICSSC has developed a standard to assess the seismic safety of existing buildings, and FEMA has developed methodologies for screening and analyzing, and then strengthening and retrofitting existing buildings to resist probable earthquake forces.

THE NATIONAL AFFORDABLE HOUSING ACT OF 1990

As mentioned in Chapter 2, HUD, under different mandates, has established programs that promote both rehabilitation and earthquake safety. Through section 947 of the National Affordable Housing Act of 1990 (P.L. 101-625) seismic safety standards are required for all existing properties assisted under HUD programs. This program increases the coverage of the Executive Order by affecting also existing buildings and allows that local building codes can be deferred in order to meet sound seismic safety standards. (HUD, 1992)

In addition, section 947 of the National Affordable Housing Act requires that a seismic risk assessment should be conducted for all properties assisted under HUD programs and seismic safety standards developed for such properties.

Under this framework, HUD has initiated an earthquake risk assessment study for several urban centers with the collaboration of USGS. A Building Classification System has been developed which allows the ranking of vulnerability by building type. The level of accuracy for this inventory will be based on the level of need and the time and resources available. Intensity maps will be used to estimate the degree of hazard. These maps will be combined with population densities and aggregate dollar values of HUD-assisted properties to designate urban areas with the highest risk. However, it is anticipated that a comprehensive seismic risk assessment for a larger inventory of HUD-assisted existing buildings vulnerable to high-intensity earthquakes will probably take several years and continuous funding. Additionally, residential construction identified under assistance programs will need to be examined to develop a database inventory of all affected existing buildings. In many cases insitu investigations and inspection will need to be conducted to validate the inventories. (Fuller, 1992)

In spite of the fact that the enforcement of adequate seismic resistance codes in HUD-assisted properties is in an early beginning, great benefits can be anticipated from this project in the future. During field work in Memphis, it was determined that the Memphis Housing Authority and the Community Development Commission do not enforce seismic safety measures during rehabilitation of residential structures, and no guidance is provided in terms of earthquakes risks and loss reduction (see Memphis case study).

ENVIRONMENTAL IMPACT ASSESSMENTS

The National Environmental Policy Act of 1969 (NEPA) provides an important framework for earthquake safety. NEPA requires that an environmental impact statement be prepared for proposed legislation and other federal actions that may significantly affect the quality of the human environment. When preparing environmental impact statements, federal agencies must do so concurrently and integrated with environmental impact analyses and all other related surveys and studies required by federal acts, environmental review laws and executive orders. In addition, the leading federal agency must notify and request comments from all other federal agencies, state and local governments and private interest groups that have jurisdiction by law or special expertise with respect to any environmental issue involved when creating an environmental impact statement. The review of each proposed action and legislation on an individual basis by experts on all levels (federal, state, local and individual) allows for a number of opportunities to enhance seismic safety.

Earthquake safety measures can be incorporated into environmental impact statements if required directly or by a connected prerequisite action. For instance a seismically unsafe area could have impacts on the surrounding natural and built environment in the event of an earthquake. Structures that contain, use or produce potentially hazardous substances that might pollute the surrounding environment in case of an earthquake and thus, infringe upon the Clean Air Act, the Endangered Species Act, the Wilderness Act, natural resource requirements, state or local requirements can be required to incorporate earthquake safety measures within the overall project.

Also the instability of soils could increase the potential for ground failures such as landslides, erosion, liquefaction or subsidence in the event of an earthquake. In this case and again depending on the specifics, EPA, USGS, FEMA, state and local agencies could have or could create legislation that would ensure seismic considerations in the environmental impact statement. Specific requirements established in an environmental impact statement by an agency are enforced by that agency or by the lead agency. The lead agency is specifically responsible for incorporating appropriate conditions in grants, permits or other approvals.

Since environmental issues are capitalizing on the public's attention and securing an increasing portion of federal funded programs, it is in the best interest of seismic safety to search for common ground between natural disasters and environmental programs in order to identify avenues through which funding assigned to environmental projects can serve to mitigate natural hazards when planning and implementing capital investment projects. For example preserving the margins of San Francisco Bay for ecological and environmental reasons is consistent with seismic safety objectives. Many local governments are using environmental parameters as part of their normal regulations. For instance, Santa Cruz County has developed a series of matrices which assign a score to sites that have slope and erosion potential; seismic and landslide hazards; fire susceptibility; groundwater; and proximity to important wildlife habitants. In the state of Washington, King County requires specific detailed setbacks and buffer requirements for several key environmental areas, including steep slopes and landslide hazard areas.

OTHER FEDERAL INCENTIVES

Through federal tax incentives, grants and loans, the federal government can fund earthquake safety programs. These types of incentives have acquired a particular importance since the reduction of federal assisted programs in urban centers have created great constraints on local government budgets for the replacement of obsolete urban systems.

Typically **federal tax credits** have been used over recent decades to promote private activities which support federal or state policies. They have been used to encourage energy conservation, solar energy development, historic preservation, and affordable housing. Federal tax credits have been one of the most important incentives for the rehabilitation of older structures.[7] Tax credit programs enable taxpayers to credit some percentage of allowable expenditures against their tax liability. They have been very successful in generating development, such as the revitalization of the historic district in Charleston, South Carolina.

In spite of the opportunities offered by tax credits in the past their advantages can be limited at present since tax credits for the rehabilitation of older and historical structures have been reduced over the recent past. In 1986 the Tax Reform Act was passed and many tax incentives and rehabilitation moneys which could have been used for urban programs were severely affected. The Rehabilitation Credit (section 47) established a 20 percent tax credit for the substantial rehabilitation of historic buildings for commercial, industrial and rental residential purposes, and a 10 percent tax credit for the substantial rehabilitation for nonresidential purposes of buildings built before 1936.

The 10 percent tax credit is not available for the rehabilitations of certified historic structures, and owners that have properties within registered historic districts and who wish to elect this credit must obtain certification that their buildings are not historic[8]. (U.S. Department of Interior, 1990) Prior to 1986, the Tax Equity and Fiscal Responsibility Act of 1982 and the Tax Reform Act of 1984, provided a 25 percent Investment Tax Credit for the substantial rehabilitation of historic commercial, industrial, and rental residential buildings.

Federal tax deductions can also be used to promote earthquake provisions. The IRS views building improvements as capital investments and are subject to depreciation for tax purposes. Recent discussions in the field of asbestos abatement have suggested that abatement expenditures may be viewed by IRS as maintenance, in which case they are fully deductible in the tax year in which they are incurred. This has provided an opportunity for the same argument in terms of earthquake safety, especially seismic strengthening. Retrofitting could be written into the tax code by legislation, and possibly, by regulation, thus allowing seismic strengthening to become fully deductible for property owners and/or developers. (Building Technology Inc., 1990) However, as this report is written, there is no evidence that this approach has been applied to earthquake safety programs.

Federal grants can be allocated to the states or their subdivisions in accordance with formulas prescribed by law or administrative regulation for activities of a continuing nature not confined to a specific project. The states, in turn, may use these funds in the form of grants or in the form of other assistance programs to promote an activity at the local government level.

Project grant monies can be allocated for fixed or known periods and in accordance with specific services or products. Grants are the only way (except by regulation) to generate activities which may be desirable, but do not result in a near term economic return or value increase. The disadvantage of grants compared to other forms of assistance is that once expended, the resource is exhausted and there is little opportunity for leveraging the funds.

Financial assistance from the federal government can be provided directly to individuals, private firms, and other private institutions to encourage or subsidize a particular activity by conditioning the receipt of the

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[7] It is important to point out that the rehabilitation of historic buildings is not necessarily the same as the seismic retrofit of older buildings. Certified rehabilitation is defined in the Internal Revenue Code as *"any rehabilitation of a certified historic structure which the Secretary of the Interior has certified as being consistent with the historic character of such property or the district in which such property is located."* Seismic retrofitting of older non-historic structures is not explicitly included.

[8] The National Historic Preservation Act was enacted in 1966 creating he National Register of Historic Places. This register contains all the National Historic Landmarks, the historic areas of the National Park Service and a very large number of historic buildings. The fact that properties are included in the National Register allows them to qualify for an IRS tax break for easement donations and for rehabilitation credits However, the impact of such credit has been diminished with the implementation of the 1986 Tax Reforms

assistance on a particular performance by the recipient; such is the case of the section 404 Hazard Mitigation Programs sponsored by FEMA under the Stafford Act.

Incentives for seismic strengthening could take the form of *project grants* or *direct payments for specified use*. *Formula grants* could be used for seismic strengthening voluntarily, or seismic strengthening would be required under certain conditions of their use, if federal legislation mandated it.

Federal direct loans can be provided through federal monies for a specific period of time, with a reasonable expectation of repayment. Such loans may or may not require the payment of interest. Loans of this type are defined in the Catalog of Federal Domestic Assistance.

Direct loans can be an effective way for federal, state and local governments to promote an activities of wide social benefit but of marginal economic benefit. A disadvantage of loans is that there may be administrative costs, sometimes substantial, for managing the loan. Recent programs have reduced these costs by having the loan administered by a commercial lender.

Another type of loan assistance defined by the Catalog of Federal Domestic Assistance is the loan guarantee. Government guarantee of commercial loans makes credit available to borrowers who do not meet the credit requirements of commercial lenders.

The advantage of this form of assistance is that it involves no up-front outlay of government resources. Through this type of loan the federal government can make arrangements to indemnify a lender against part or all of any defaults by those responsible for the repayment of loans. Such loans have been found to be especially useful in the case of building rehabilitation, where construction financing is difficult to secure, but where permanent financing is available upon completion of the work. A particular advantage of this type of loans is that the waiting period for the loan is usually reduced.

The Guaranty Loan Program provided by the **Small Business Administration** (SBA), is one of the most important programs to owners of seismically hazardous buildings. Typically after a disaster federal assistance is *layered*. SBA loans are the first type assistance offered to disaster victims. Households and businesses experiencing damage can receive assistance which can become a critical agent in the reconstruction of private property. The majority of these loans are usually directed at homeowners. Loans are made by private lenders with a percentage of the loan amount (up to a maximum of $750,000) guaranteed by the SBA. Loans are dependent upon the use of the loan proceeds.

One year after the Loma Prieta earthquake, a total of 14,000 residential loans valued over $492 million had been approved by SBA for residential properties. (California Preservation Foundation, 1990) Interest rates on SBA loans range from prime rate plus 2.25 percent to prime rate plus 2.75 percent, depending on the terms of the loan. The limitations of this programs are in relation to the collateral. Sufficient assets have to be pledged as collateral. Also loans do not set minimum loans amounts; although most loans are above $50,000.

In spite of the fact that large urban programs are practically non-existent, a number of HUD programs can still have a substantial impact on urban redevelopment programs. These programs can be used in direct or indirect ways to finance earthquake safety programs. The objectives of the *CDBG* programs are primarily oriented toward low- and moderate-income communities for the prevention or elimination of slums and blight. They aim at impacting neighborhood revitalization, economic development, and the provision of improved community facilities and services (see chapter 2). Through *CDBG* programs more discretion is given to local governments in spending federal assistance monies in their distressed areas. Compared with grants-in-aid, the

CDBG programs have given state and local officials broader authority to set priorities and determine the use of funds. It is the discretionary aspect of the legislation that is particularly important for earthquake safety.

CDBG can be used for substantial rehabilitation and retrofitting programs (see annexes 1 and 2). For instance, Los Angeles and Salt Lake City have extensively used *CDBG* funds for retrofit activities. Santa Rosa and (more recently), Santa Cruz used *CDBG* funds for reconstruction activities after the earthquakes which devastated large portions of the downtown areas in both cities (see case studies). The City of Upland, California has designed a seismic retrofit program for substandard commercial buildings in the downtown area. A portion of the program is being financed by *CBDG* funds. The city developed a program description which accomplished HUD's national objectives with respect to slum and blight. The City of Inglewood has developed a program that introduces reimbursements to property owners performing retrofit repairs. The city funds this programs with *CDBG* monies.

Another important source of funding under this category are those under the *108 Loans and Loan Guarantee Program*. Through the *108 program*, communities may apply to receive guaranteed loans that can be used to finance the removal of debris, repair, rehabilitation or demolition of buildings on public land, and the installation of public improvements.

In addition, through the Community Development Act of 1974 a new leased-housing program was created, titled *Section 8*. This program intended to correct deficiencies of both the Model Cities and the Urban Renewal Programs (see chapter 2). *Section 8* became the major housing program of the 1970s and early 1980s. *Section 8* assistance, either in the form of *Certificates* or *Vouchers* supplements the rent for low income renters in private rental units. Under *Section 8*, low- and moderate income families pay up to 30 percent of their income for rent while HUD pays the difference between that amount and the market rent. (Jacobs, 1986)

In many ways, *Section 8* can be an important tool for earthquake safety. Traditionally *Section 8* certificates and Vouchers have been used for post-disaster assistance. The program directs that following the President's declaration of a national disaster under the Stafford Act assistance must be provided for individuals and families whose housing has been damaged or destroyed as a result of the disaster. Under this program HUD evaluates the natural hazards to which any permanent replacement housing is exposed and takes appropriate action to mitigate such hazards. Budget authority for assistance under the moderate rehabilitation program is also authorized to be increased in any fiscal year in which a major disaster is declared by the President under the Stafford Act. This mortgage or rental payment assistance has been used in the past. In addition, *Section 8* may allow rent subsidies to be *attached* to particular rental buildings in exchange for the owners' commitment to *certain safety* standards. Thus, HUD can work through local public housing agencies to encourage the use of seismic safety standards in areas prone to earthquakes. However, in spite of favorable attributes of *Section 8* in terms of earthquake safety, it is important to point out that funding from this program to undertake major rehabilitation work has currently elapsed.

In addition HUD has recently created the *HOME* program which supplements *CDBG* programs. Both *CDBG* and *HOME* funds are allocated at the local government's discretion within broad federal guidelines. *HOME* is not a categorical program which requires a specific housing activity. Eligible activities include tenant-based rental assistance, assistance to first-time home-buyers and existing homeowners, property acquisition, new construction, reconstruction, moderate or substantial rehabilitation, site improvements, demolition, relocation expenses and other related activities, all of them associated with the development of non-luxury housing programs. Funding from this program can be used for earthquake safety mitigation measures, as long as local governments determine that such activities are priority issues within their communities.

Finally, the *Urban Development Action Grant* (*UDAG*) program, enacted through the Community Reinvestment Act of 1977 can support earthquake safety activities in urban areas. Through this programs, federal grants are made available to local governments on a competitive basis. Local governments use these funds to make loans to private developers and companies to implement economic development projects. The major objectives of this program are to assist distressed and older declining cities economically stagnant neighborhoods, and areas of extensive poverty and unemployment. Substantial federal assistance for rehabilitation has been authorized through *UDAG* programs for downtown commercial projects. For Instance Kansas City has been extensively relying on the *UDAG* program for the rehabilitation of older buildings. (Building Technology, 1990)

Private loans can be granted under the Community Reinvestment Act of 1977. Private lenders can be required or induced (within limits) to make funds available as an incentive for action that would otherwise not take place in the existing market. This was one approach taken by the federal government in the Community Reinvestment Act of 1977. Such inducement may or may not be combined with a government loan guarantee program. This private source of funds is theoretically easier to secure if used for purposes that ultimately create value which, however marginal, will be viewed by the private lender as collateral.

The reverse is the case where private lenders condition the loan on certain actions being taken by the borrower. This is frequently the case in financing the purchase of a building, or in its refinancing, where the condition is the mitigation of a potential hazard. One example is termite inspection and mitigation, where the lender's concern is protection of the collateral. Another more recent example is asbestos removal or mitigation, where the lender's concern is potential liability. No data was found that show that this approach is being used for earthquake safety.