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STRUCTURAL HAZARD MITIGATION POLICY: LOCAL GOVERNMENT IMPLEMENTATION CONSIDERATIONS

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SUMMARY

California has a recorded history of damaging earthquakes, dating from 1769. There is a consensus among the scientific community that a catastrophic earthquake will occur in a heavily urbanized region of the State within the next 30 years. There is also a consensus among the engineering community that unreinforced masonry (URM) buildings pose the greatest danger to life safety and are the most vulnerable to ground shaking. This paper will describe the efforts being undertaken at the state and local government level to implement hazard abatement programs for URM, and identify the associated socio-economic impacts.

THE EARTHQUAKE THREAT IN CALIFORNIA

The written history of earthquakes in California is relatively short when compared with that of other areas in the world such as China, Japan and the Soviet Union, indicating that 101 earthquakes over M6 have occurred in California since it became a state in 1849.

As the boundary between the Pacific and North American Plate, it is estimated that the onset of movement on the San Andreas fault system occurred 15-20 million years ago. The fault extends for approximately 700 miles through the state of California from Cape Mendocino to the Gulf of California, and underlies the San Francisco Bay Region and the Los Angeles Basin. In 1906 as much as 20 feet of strain was released in a M8.3 earthquake near San Francisco which caused massive destruction over a large area.

The San Andreas fault itself accounts for only about 60% of the strain build-up between the Pacific and North American plates. The remaining 40% is taken up by the other active faults associated with the San Andreas system. (See Figure 1) The consensus among the scientific community in California is that there is greater than a 50% probability that a catastrophic earthquake will occur in both of the heavily urbanized region of the State within the next 30 years.

The threat to life and property from earthquakes is a result of having built our cities in close proximity to what we know are active earthquake faults, and in many cases in areas where soils are of poor quality or comprised of uncompacted fills. In addition many of our recent damaging earthquakes have occurred on faults previously not known to be active.

The greatest threat to life safety from moderate and larger earthquakes is posed by structures which are not adequately designed or constructed to withstand strong earthquake forces. Unreinforced masonry buildings in particular have performed poorly in every damaging California

earthquake and it is generally agreed that they pose the foremost threat to life and are the most vulnerable to ground shaking.

CALIFORNIA'S RESPONSE TO THE EARTHQUAKE HAZARD

In response to the earthquake threat, California has undertaken many measures to address hazards and to prepare its population for emergencies. This paper will address only those programs that have had an effect on structural hazard mitigation for buildings.

Although the 1906 earthquake which destroyed much of San Francisco stimulated the first lateral force design requirements in California, little was done during the reconstruction process to prevent destruction from future events. Houses of unreinforced brick were, in many cases, constructed from the debris of collapsed buildings. In the aftermath of the 1925 Santa Barbara earthquake (M6.3), however, the first real seismic requirements were introduced into a building code. The California seismic provisions were first adopted by the International Conference of Building Officials in 1927, but were not mandatory for use by local governments.

It was not until after the 1933 Long Beach earthquake (M6.3) severely damaged unreinforced masonry buildings in southern California that a major effort was undertaken to make our cities seismically safe. The State enacted the Riley Act mandating municipalities to adopt earthquake codes, and incorporated the 1927 Uniform Building Code as the minimum standard. This code in essence outlawed the construction of unreinforced masonry buildings in California. In addition, because a large number of schools were severely damaged in the Long Beach earthquake, the State also enacted the Field Act which mandates that all public school buildings meet special seismic safety requirements. Since the law's passage, almost all public schools built in California under Field Act standards have performed well in earthquakes.

The 1971 San Fernando earthquake (M6.4) prompted renewed attention to earthquake safety. Severe damage and life loss occurred as a result of the collapse of pre-1933 masonry hospital buildings. Three other hospitals near the epicenter were also severely damaged and had to be evacuated, even though they had been designed with earthquake resistant features. The Hospital Act of 1972 was passed to ensure the design and construction of all new hospitals to standards adequate to resist earthquake shaking and to provide continuity of services. The San Fernando earthquake was the first test of many newer construction types. Significant problems were encountered with non ductile concrete frame, tilt-up concrete, and buildings with discontinuous shear walls and soft first stories. However, the greatest damage and loss of life was suffered from the failure of unreinforced masonry buildings.

In 1986, Governor George Deukmejian signed landmark legislation to address California's earthquake hazard. Senate Bill 548 set as a goal the elimination of seismic hazards by the year 2000. This goal can be met only if aggressive programs are implemented to eliminate hazardous buildings. The program strongly emphasizes the need to minimize the hazards associated with the vulnerability of existing development.

In July 1986, Senate Bill 547 (the URM Law) was signed by the Governor. This legislation requires cities and counties in Seismic Zone 4 to inventory unreinforced masonry buildings and adopt hazardous building mitigation programs to strengthen, raze, or otherwise reduce hazards associated with occupancy of such buildings.

THE UNREINFORCED MASONRY (URM) BUILDING HAZARD MITIGATION PROGRAM

Prior to passage of the State URM Law in 1986, some California jurisdictions, most notably Long Beach, Santa Rosa, Los Angeles, and Palo Alto, had enacted local ordinances to address their URM problem. These programs have had a significant impact on reducing hazards in their communities. However, it is estimated that as many as 50,000 URM structures remain in use in

California at the present time. It is the State's desire, through the 1986 URM Law, to begin the process of mitigating the earthquake hazard posed by these remaining buildings.

Under the law, all local jurisdictions in California's Seismic Zone 4 must do the following by January 1, 1990:

1. Identify all URM buildings that are potentially hazardous and include the current uses and daily occupant loads in an inventory.
2. Develop and implement a mitigation program to reduce the hazard.
3. Submit information regarding the inventory and mitigation program to both the local jurisdiction legislative body and to the California Seismic Safety Commission.

The law defines potentially hazardous buildings as "any building constructed prior to the adoption of local building codes requiring earthquake resistant design and constructed of unreinforced masonry wall construction". Earthquake resistant design was required as early as 1933 in some jurisdictions and as late as the mid-1950's in others. The law covers all types of URM buildings, including:

- buildings with unreinforced brick, concrete block, terra cotta (hollow clay tile), adobe, or stone bearing walls;
- steel frame buildings with interior or exterior infill walls, interior partitions, or shaft walls of URM (usually brick or hollow clay tile);
- concrete frame buildings with interior or exterior infill walls, interior partitions or shaft walls of URM.

Structures exempt from the law include warehouses or similar structures not used for human habitation except for buildings storing emergency services equipment or supplies; residential buildings of five or fewer living units; and, buildings owned by the state or the federal government. Historic properties recognized as such by a local, state or federal authority are technically exempt from the identification portion of the law because they are already on a list or register. However, if these buildings are found to be hazardous, they should be included in the mitigation program.

The technical knowledge currently exists to enable all jurisdictions to proceed with a hazardous building abatement program, not only for URM, but for other known hazardous building types as well. However, as local governments proceed with the development and implementation of these abatement programs, it is clear that technical solutions are not enough. What appeared initially as simply a problem of engineering the strengthening of URM's, is in fact a problem defined by social and economic considerations resulting from a severe housing shortage in California cities.

SOCIO-ECONOMIC CONSIDERATIONS FOR LOCAL GOVERNMENT IMPLEMENTATION

The wording of the URM law allows a great deal of flexibility and discretion to the jurisdiction in developing a mitigation program. Each municipality can develop a mitigation program that fits the specific needs of its community. Socio-economic considerations can generally be grouped by issues related to: standard of safety; displacement/relocation of tenants; preservation of historic buildings; and costs. Each of these issue areas is discussed briefly below.

Standard of Safety:

The question of how much seismic strengthening should be required to ensure life safety may be the most difficult question for policy makers to answer. Although most engineers would agree that bolting (anchoring) the floors and walls together provides a significant margin of safety for a

minimal cost, that standard is still far below those required for new construction.

Most of the existing URM buildings are located in the oldest parts of our cities, and tend to be those buildings in the poorest condition as a result of their age. The costs of strengthening these buildings to current code would be prohibitive. However, minimum retrofit, while saving lives, may not save the building from total destruction in the next earthquake. It leaves us with a question. Is the goal of the retrofit program to reduce loss of life and injury to occupants and passerbys, or to make improvements substantial enough to ensure that the buildings themselves will survive the earthquake with minimal damage.

The incremental increase in life safety through additional strengthening must also be weighed against the costs of achieving that increase. Although it is not possible to put a monetary value on a human life, developing cost-benefit analyses of various seismic retrofit options is a prerequisite to deciding on a mitigation ordinance.

Displacement\relocation of tenants:

The temporary and permanent displacement of residents remains as a public policy issue which challenges our ability to design humane seismic hazard mitigation programs. Displacement can result from three causes:

- temporary displacement for a few months while seismic retrofit takes place
- permanent displacement due to rent increases
- loss of housing units or buildings due to demolition or change in use

It is very difficult to do seismic rehabilitation work with tenants in place. In some cases, remedial work can be accomplished without displacing residents. However, both the length of time required to accomplish the work and the costs are generally increased.

In developing the mitigation program, serious consideration must be given to providing temporary or permanent relocation resources to both residential tenants and business tenants. Rents for URM buildings tend to be the lowest available in our communities, because of their age and condition. It may be difficult or even impossible to find replacement housing and commercial space at a comparable price.

In areas where hazard mitigation programs are currently underway or completed, experience indicates that building owners who are required to seismically upgrade their property take the opportunity to make other improvements as well. The costs incurred by the property owner in rehabilitating the building are frequently passed on to residents or future tenants through increased rents. If care is not taken, the financial impacts of a mitigation program could have an adverse affect on a community's low-cost housing stock.

In the situation where a property owner cannot secure financing to make the required improvements, the options are limited. The property may be sold to another party or a development corporation, who may in turn significantly change the use and character of the building. The other alternative, which may be equally detrimental to the objective of preserving low-cost housing is demolition of the building. The challenge then is to conserve scarce housing resources and at the same time act responsibly to achieve an adequate level of life safety.

Historic properties:

Many URM buildings possess architectural and historic values that lend charm and character to their communities. These buildings, although exempt from the inventory requirements of the URM Law, can be extremely hazardous and should be incorporated into the mitigation program. Repairs to properties that have achieved historic status through either local, state or federal authority, are

often governed by a special building preservation code, and as such will require special consideration in the program.

Old community structures that may or may not be registered are frequently very closely tied with the social fabric of the surrounding neighborhood. Emotional opposition to changes or proposed demolition can be expected from the community.

Costs:

Hazard mitigation programs can be costly undertakings, particularly in a jurisdiction having large numbers of URM buildings. There currently are few financial incentives or financing options available to government, property owners, or tenants in carrying out the desired programs.

From a local government standpoint, program costs can be expected to be incurred in carrying out the inventory, developing the program, and implementing the program. Additional staff must be hired and trained in identifying hazardous buildings, and in providing inspection services.

Property owners currently bear the burden of the costs of engineering studies on their buildings to determine the extent of seismic retrofit required. In addition, it is generally the responsibility of the owner to secure the loans necessary to carry out the work. As discussed previously, the primary option for cost recovery on the part of the owner is through an increase in rents to tenants.

It is clear that the burden of hazard mitigation programs must be borne by all segments of our population, not only by those who own or use the buildings in question. For a hazard mitigation program to be successful, strategies for financing must be developed hand in hand with the abatement ordinance.

THE SAN FRANCISCO CASE STUDY

Many California jurisdictions are in the process of addressing their hazardous building problem. The City of San Francisco has been working for several years on a program to develop a URM building retrofit ordinance. The following is a brief summary of the steps that have been taken to date.

By amendment to the San Francisco Municipal Code in 1980, the Seismic Investigation and Hazard Survey Advisory Committee (SIHSAC) was established to recommend legislation to improve structural resistance and to minimize risks associated with earthquakes. In 1981, the Committee recommended that the City approach the problem of older URM buildings through the adoption of an ordinance, and further recommended that an accurate census of older URM buildings be conducted as a first step in the process.

The census (inventory) was conducted by the Bureau of Building Inspection of the San Francisco Department of Public Works from 1985 through 1987. The total building stock of the City is 155,000. Of these, approximately 2100 are URM buildings. Over half of those buildings were constructed in the six years following the 1906 San Francisco earthquake. Most of the URM buildings are low-rise structures of four stories or less.

The single largest use of URM's in the City is commercial, followed by residential apartments. Within the City's URM's are 11,000 apartments, 10,500 hotel residential units, and 5500 tourist hotel units. It is these buildings, with the highest occupancy loads that are of greatest concern to the City of San Francisco. Most of the buildings are clustered in three general areas, each with a unique community identity. The city has recognized that buildings in neighborhoods such as Chinatown, the Tenderloin, and the Bush Street Corridor are a valuable and irreplaceable resource of low-income housing. As a result of the URM census, the City commissioned a study to investigate a range of seismic upgrading measures and their associated costs, to determine the

impact of a retrofit program on the property owners and tenants in these areas, and to make recommendations for a policy that would improve the life safety of the existing residential building stock while maintaining that stock as low-income housing. The study recommended the following approach for implementation of a seismic upgrading ordinance:

- that the City enact a seismic rehabilitation ordinance that requires owners to complete a basic minimum upgrade as appropriate for each building;
- that the ordinance contain provisions to discourage demolition of buildings unless replacement housing is provided;
- that the City develop a 20-year program for phased implementation of seismic upgrading;
- that the City take an active role in the upgrading process by obtaining housing for temporary relocation of tenants;
- that buildings be cited for upgrading on a block-by-block basis, so that tenants and owners can make plans accordingly;
- that the City match the number of buildings cited for upgrade per year to the ability of all parties to engineer, construct, finance and inspect units;

The Mayor then requested that a city-wide Task Force be created with a goal to mitigate the URM threat to public safety and welfare by developing a package of ordinances. The Task Force is currently meeting to develop policy options. A community input and review process has also been established through the Community Advisory Committee (CAC). The CAC is divided into three subcommittees to address the areas of technical, socio-economic and financial issues.

Although the City of San Francisco is anxious to enact an ordinance to mitigate its existing URM hazard, it recognizes that in order for the program to be effective, a very arduous process must be undertaken. It is hoped that the City will have a package of ordinances finalized in the coming year.

CONCLUSIONS

The problems raised by URMs are not easy for any local government to address. However, it is clear that jurisdictions will move ahead with hazardous building mitigation programs. There is an obvious benefit and need for seismic retrofit programs, but they must be well thought out.

In the long run, there's no question that requiring seismic rehabilitation of unreinforced masonry buildings is a social good, improving a city's housing stock and benefiting the community. But in the short run, rehabilitation programs can create hardships for both owners and tenants, and ways to ameliorate these should be identified and implemented. If a damaging earthquake comes before such programs are completed, there will be substantial loss of life and injuries. However, if enough time remains before the next major earthquake for local mitigation programs to be implemented, countless lives will be saved.

California communities have come a long way in recognizing earthquake hazards, but there remains much to do. The statewide unreinforced masonry building hazard mitigation program is an ambitious one, and represents the first such effort in the United States.