Item VIII

State of California
Seismic Safety Commission

# Memo

To: Seismic Safety Commission

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Subject: Draft Guide to Identify and Manage Seismic Risks of Buildings for Local Governments

Attached for your review and comment is the March version of the 14-page guide along with an updated draft appendix that contains minor edits reflecting prior comments from Commissioners, along with new images and captions. The appendix has not yet been edited professionally, which is planned.

**Staff Recommendation**

The staff recommends that Commissioners provide comments on the attached draft at the May hearing and be prepared to discuss next steps on engaging other stakeholders in future refinements of the draft.

Item VIII

# Guide to Identify & Manage Seismic Risks of Buildings for Local Governments

**Presentation Draft Version 1.7**

**March 16, 2016**

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# Overview

California has some of the most modern and earthquake-resistant buildings in the world. However, most of our older buildings could be damaged by severe shaking in a major earthquake, and some of them could partially or completely collapse. Many Californians live, work, go to school, shop and worship in these buildings. “Collapse risk” buildings present the greatest risk of death and injury from earthquakes. They can also cause fires, damage and disrupt surrounding properties, and threaten neighborhoods and public rights of way. Together, these social and economic disruptions may amount to hundreds of billions of dollars after the largest foreseeable earthquakes. Mitigation of this risk is an expensive project, but much cheaper than the costs of collapse.

The California Seismic Safety Commission considers these buildings a top priority in seismic risk mitigation efforts across the state. Given sufficient time, effort and luck, many collapse risk buildings can be retrofitted or replaced before they cause harm in the next damaging earthquake. The Commission encourages a long-term outlook and commitment, because even under the best conditions it will take generations to achieve the ultimate goal of an earthquake-resilient society.

Every jurisdiction has an obligation to determine its degree of exposure to risk from building collapses in earthquakes, but there is more than one way for a jurisdiction to handle the threat. This guidebook presents a broad four-step process, with many different options, to help local governments identify and reduce the risks presented by these buildings. It also summarizes California’s relevant laws and regulations. Along the way, it presents examples of successful approaches that have been taken by different California cities to address collapse risk buildings. Because each jurisdiction faces its own unique circumstances, each summary section of this guide is expanded in the Appendixes.

The advice in the Appendixes can be considered a toolbox from which local governments can draw and adapt to their community’s unique circumstances. Checklists, success stories, financial incentives, and references for more detailed information might prove useful to local governments when designing initiatives to manage collapse risks.

The California Seismic Safety Commission has drawn from the experiences of hundreds of local governments to generate this Guide and Appendixes. Your feedback is welcome and essential for the Commission to make periodic improvements and corrections. Please send your comments to feedback@stateseismic.com

See **Appendix 1** for more detail on this topic.

## What Are Collapse Risk Buildings?

No building is without any risk of collapse during a very strong earthquake, but some have much greater risk than others. Buildings may be vulnerable to collapse because they were:

- Not constructed to comply with codes and standards, or
- Constructed before earthquake resistance was required in the 1930s, or
- Built to codes that were later found to be inadequate, or
- Poorly maintained or improperly altered, repaired or retrofitted.

Experience in California near active earthquake faults has shown that the following types of buildings generally pose exceptionally high risks of collapse:

- Pre-1940s unreinforced masonry, primarily brick, buildings
- Pre-1980s concrete frame buildings
- Pre-1980s buildings with soft or open lower stories, unbraced crawl space walls below first floors, or irregular shapes, including those on steep hillsides
- Pre-2000s buildings with precast concrete tilt-up walls or masonry walls, and precast concrete parking structures.

Other types of buildings pose risks that are significant, but generally lower or harder to identify:

- Pre-2000s steel buildings
- Buildings of all ages that are inadequately constructed, repaired or maintained
- Buildings on sites subject to fault displacement, landslides, or soil liquefaction

Smaller, residential buildings, such as those with up to two stories and four units or less, and various specific building components have their own sets of vulnerabilities, but they present a relatively low risk of death and injury and are not considered further here.

In setting priorities among their collapse risk buildings, jurisdictions may choose from three basic approaches. The first focuses on the specific building category that poses the greatest risk. The second addresses vulnerable buildings in order of their size. The third prioritizes buildings by their importance. Many jurisdictions combine two or more of these in a hybrid approach.

See **Appendix 2** for more detail on this topic.

## The Most Effective Methods of Managing Collapse Risk Buildings

The best defense against building collapse during earthquakes is strong standards and professional practices. Ensuring that building construction and alterations are properly designed by licensed professionals, using plan reviews and inspections by qualified regulators, is the most effective way for governments to identify and reduce the risks of collapse.

Nearly all of this responsibility falls upon local governments. They review construction plans, issue building permits and inspect construction for most buildings, including local essential service facilities such as fire and police facilities. State agencies check plans for and inspect public schools, hospitals and other essential services buildings. Federal agencies regulate building safety for federal buildings and support research to improve building standards. Regulatory permits are required from all appropriate agencies for new buildings as well as alterations and seismic retrofits of existing buildings.

See **Appendix 3** for more detail on this topic.

## Who Is Responsible?

The responsibility for collapse risk buildings is generally well defined, but not always widely understood. For effective cooperation, building owners and regulators need to be aware of each other's obligations and concerns.

Building owners are responsible for ensuring their buildings are safe and are responsible for disclosing a building's vulnerabilities to occupants. Regulators leave certain matters to the discretion of building owners (tenant alterations, minor repairs and so on) that may affect the collapse risk of buildings. Owners are not obliged by law to go beyond the ordinary care exercised by a reasonable person; however, there are many extra options that prudent owners can take in their own self-interest. These include:

- Arranging for professional seismic evaluations and retrofits where warranted
- Storing construction records securely
- Creating a Building Occupancy Resumption Plan to ease disruption after a disaster; and
- Obtaining earthquake insurance.

Government agencies can also set examples of prudence in managing buildings.

Because decisions made by building owners usually affect others, many circumstances associated with buildings may involve government regulators in their role of ensuring public safety. For example:

- A building at risk of collapse may endanger neighboring structures and rights of way, blocking emergency response efforts.
- Owners might not inform building occupants—or not even know—about the vulnerable condition of their buildings.
- The public may assume that the existence of regulations ensures the safety of a building even if its owners are negligent.
- Local government policies aimed at population growth, preservation, redevelopment or revitalization of neighborhoods may affect the public's exposure to seismic risks in ways that should be considered during decision-making.

These circumstances tend to accumulate with time, increasing levels of risk, unless they are addressed through proactive intervention by regulators and effective action by policy-makers.

The public is a stakeholder in questions of collapse risk buildings. Collapsed buildings cause major disruptions that affect the whole community. Retrofitting policies should focus on speeding improvements, reducing their costs, and minimizing their disruption to all parties: owners, occupants and surrounding neighborhoods. The best initiatives go beyond technical feasibility by respecting owners' knowledge and experience, selecting cost-effective alternatives, and demonstrating that local governments are serious about ensuring their success.

Because California's jurisdictions vary so greatly, a uniform statewide approach is not optimal. In deciding the appropriate levels of investment in retrofit programs and the urgency with which to pursue them, local governments have difficult choices to make in balancing the risks against their resources. Internal factors within government affect these choices, such as the confidence of leadership, funding priorities, relationships with other stakeholders, staff costs and expertise, and time horizons. Governments should acknowledge these factors as they work to best ensure safe buildings.

See **Appendix 4** for more detail on this topic.

## Nexus for Public/Private Partnerships to Manage Collapse Risks

Most buildings are privately owned, but their risk of collapse affects occupants as well as the public. Both building owners and government agencies therefore have a stake in managing earthquake risks. It is in everyone's best interests for governments and building owners to collaborate in identifying vulnerable buildings and improving their earthquake resistance. After several decades of witnessing such collaborations, the Seismic Safety Commission has observed that fostering active dialogues, mutual understanding, and commitment are key to helping these efforts succeed.

See **Appendix 5** for more detail on this topic.

# Four Steps to Managing Collapse Risk Buildings

There are many options for governments to manage the risk presented by buildings that are prone to collapse. They range from passive approaches that may gradually reduce collapse risk for some buildings over decades to active approaches that require seismic evaluations and retrofits within a few years. This guidebook summarizes knowledge gained from monitoring hundreds of local government efforts.

The public often assumes, incorrectly, that government agencies require existing buildings to be earthquake resistant. Many people are surprised to learn that some earthquake safety regulations only apply to existing buildings when they undergo major alterations, additions, or repairs.

Owners may not know or may be reluctant to find out about the earthquake resistance of their buildings. As a result, many buildings have never been seismically evaluated or upgraded. Pre-1930s buildings were likely constructed without considering earthquake resistance since California's building codes did not include earthquake safety requirements until 1933.

There may be only a few key opportunities to address the collapse risk of a building during its useful life, such as major alterations or changes in use. These opportunities set the baseline pace for risk reduction in a jurisdiction. In dealing with collapse risk buildings, policymakers should

*Success Story*

### St. Helena's Unreinforced Masonry Building Program

St. Helena has 33 buildings in its inventory, and the owners have retrofitted all of them. The city provided numerous incentives including building permit fee waivers, creation of a historic district to take advantage of a 20% federal tax credit, use of the state's Mills Act to preserve facades and reduce costs, and a streamlined design review process.

decide whether to speed up this pace and how much to do so. This section outlines ways to organize that decision-making process.

When buildings are sold, the California Seismic Safety Commission's *Commercial Property Owner's Guide to Earthquake Safety* and the *Homeowner's Guide to Earthquake Safety* encourage or require sellers to disclose typical earthquake weaknesses to buyers. When major buildings are refinanced, lenders and insurers may require seismic evaluations as a precondition. When buildings undergo major alterations, additions or repairs, local governments may require seismic evaluations or retrofits when issuing construction permits.

If a community relies on building owners to manage their own risks, conscientious owners who have long-term interests in their community and are aware of earthquake risks may eventually replace or retrofit their vulnerable buildings when they find it convenient. But risk reduction progress is expensive and will typically be slow and uneven. In the meantime, those who occupy collapse risk buildings and rely on streets and sidewalks nearby are exposed to their risks while facing the prospect of years of disruption after a major earthquake.

In the face of this situation, three public policy questions warrant consideration by governments, building owners and the public:

1) How effective are our current policies regarding earthquake safety?

2) How many years will these policies take to significantly reduce collapse risks in our community?

3) What alternative policies might we consider?

Communities assume that their government officials will take initiatives in long-term planning and place earthquake safety priorities into context with other competing priorities. And California has many examples of government agencies that have undertaken earthquake risk management initiatives.

Here are the four necessary steps of a successful initiative to manage earthquake risks associated with buildings most likely to collapse.

*Success Story*

### Fremont's Soft Story Apartment Building Program

In 2007, Fremont required owners of 30 apartment complexes to retrofit. The city designed its ordinance to result in no occupants being relocated from their units during construction. Fremont also reimbursed owners for all plan check and permit fees once the retrofits were completed. Owners could apply for time extensions due to financial hardship. Fremont demonstrated remarkable success, albeit for a relatively small portion of its apartment building stock.

## Step 1: Create Opportunities for Education, Dialogue, and Public/ Private Participation in Decisions about Buildings

Before anything else, governments should make a commitment to ensure sound decision-making. The right process will avoid surprises and minimize delays, complaints and lawsuits after a course of action has been set. Considering issues deliberately, incrementally and from a variety of perspectives is a proven, effective management technique.

It is important at the start for departments within local governments to work together to generate effective changes. At the right time, a lead agency should be named to communicate issues in a timely manner to the public. Messages can be crafted that evoke confidence in carrying out risk reduction rather than provoke anxiety and fatalism.

Along with the private sector, government building officials, emergency managers, city councils, and boards of supervisors should actively engage and inform the public about the issues related to collapse risk buildings and the alternatives for managing their risks.

Stakeholders should be kept informed about who makes decisions, when, and how they can participate and influence policymaking. Building owners should be informed about the variety of seismic upgrade options available to building design professionals. Stakeholders can respond well to specific approaches pitched to their interests and allies.

See **Appendix 6** for more detail about this topic.

*Success Story*

### San Diego's Downtown Parapet Bracing Program

The City of San Diego includes parapet bracing as a key part of their downtown redevelopment effort. In light of their somewhat lower risk than in other parts of California, they considered the risks posed by other vulnerable aspects of brick buildings to be too costly to address. Bracing was accomplished with historic preservation in mind so that the aesthetics of the brickwork was not adversely impacted by the installation of new wall anchors.

## Step 2: Estimate the Size and Nature of Collapse Risk

Buildings offer different levels of collapse risk, depending on their construction type, age, and occupancy. Inventories of buildings thus can provide detailed insights into a community's vulnerability. A jurisdiction can make a useful beginning with indirect surveys based on agency records, online street views, Sanborn maps, other archives and similar resources. There are several more robust approaches that can be considered as part of

**Step 3**. Agencies may benefit from comparing efforts in other similar communities that have conducted such studies.

Learning basic information about the ages, occupancies, sizes, locations, and states of repair of the buildings in the jurisdiction will help quantify the potential for deaths, injuries, downtime, economic and social losses from damaging earthquakes. Reviewing long-term plans for economic improvement, historic preservation, transportation, and redevelopment will help identify opportunities and constraints for reducing earthquake risks while accomplishing other objectives. Inventories will also help identify buildings that have already been retrofitted or replaced and the rate at which changes are already taking place.

Even if no further steps are contemplated, community leaders, emergency managers, and building officials will gain a better sense of what to expect and how to respond to future earthquakes.

**Appendix 7** has much more detail on this topic.

## Step 3: Develop and Consider Options for Identifying and Mitigating Collapse Risks

In this section we present seven options to manage collapse risks. These range from implementing existing regulations to enacting mandatory retrofit programs. They are ranked below from lowest to highest according to their difficulty to implement and their potential for resistance from building owners. **Appendix 8** treats each of these options in more detail.

### Option 1: Rely on Attrition and Current Triggers for Alterations in the Building Code

Older buildings are periodically replaced by newer, typically more earthquake-resistant buildings as communities grow. This attrition typically occurs at rates of less than 2 percent of the building stock per year. Most California jurisdictions rely on attrition as a risk reduction strategy. It offers owners the most discretion, is the least confrontational, is market-driven, and is consistent with the policies of neighboring jurisdictions. However, most jurisdictions are not making use of the information coming in from attrition-related activity.

Chapter 34 of the California Building Code requires owners to consider seismic safety in existing buildings when major alterations, additions, and repairs are contemplated. However, these regulations tend to discourage owners because they can cause

uncertainties and triggered costs like fire safety and accessibility upgrades. The cumulative effects of prior alterations are required to be considered when altering or constructing additions to existing buildings. Voluntary seismic improvements are encouraged by the building code, which allows owners discretion when proposing improvements.

State laws require disclosures of typical earthquake weaknesses at the time of sale for certain dwellings and encourage disclosures for certain commercial buildings. These disclosures can trigger voluntary retrofits.

This option is consistent with policies in most jurisdictions except for unreinforced masonry buildings in regions of high seismicity. A community's building official will have more information and a sense of how effectively and at what rate attrition and voluntary seismic improvements are taking place.

## Option 2: Develop Reliable, Detailed Inventories of Collapse Risk Buildings

Any risk reduction program that goes beyond attrition will require detailed inventories as a foundation. Starting from information gathered in **Step 2**, these inventories can rely on:

- Samplings of buildings to infer characteristics of a larger inventory
- Records of building permits for past seismic evaluations as well as triggered and voluntary seismic retrofits
- Online street views and other geographic information systems
- Sanborn maps that depict construction types
- Building permit and tax assessor data
- Archives of architectural, civil, and structural engineering firms
- Redevelopment plans or transportation corridor studies
- Maps of liquefaction zones and areas with landslide potential
- Registers of historical buildings and surveys of historic districts
- Adopted versions of the building code in effect when buildings were constructed or retrofitted

*Success Story*

### Los Angeles's Unreinforced Masonry Building Retrofit Program

The City of Los Angeles spent over a decade requiring owners to retrofit or replace over 8000 unreinforced masonry buildings. At the time of the Northridge earthquake in 1994, over 6000 had been retrofitted and 2000 replaced. Fortunately, no one was killed in these buildings during the earthquake. While not all retrofits were entirely successful and lives could have been lost if the earthquake had occurred at another time of the day, the city's recovery efforts were accelerated by reduced damage and disruption in these buildings.

These can help determine construction types, sizes, heights, and occupancy classifications and overall vulnerability to earthquakes. Software is available that can help analyze building inventories and make preliminary estimates of possible earthquake losses. **Appendix 8** presents this option as an eight-step checklist.

## Option 3: Develop Seismic Performance Options

Governments and other stakeholders can consider a variety of alternatives for describing how buildings can be expected to perform in earthquakes. These seismic performance objectives, which are issued separately for structural and nonstructural parts of buildings, can then be used for retrofits or replacements.

The process of considering seismic performance objectives will enable a dialogue in the community about acceptable levels of risk, recovery costs, and durations of social and economic interruption. Discussions can highlight the differences between the expected performance of newer buildings compared with the performance of existing buildings.

Typical structural performance descriptions or objectives are:

- **Not Considered or Unknown**
- **Immediately Dangerous** – and not safe to occupy
- **Significant Collapse Risk** – considered safe enough to occupy
- **Collapse Prevention** – with little or no margin of safety
- **Life Safety** – with larger margins of safety beyond collapse although buildings may not be occupiable after damaging earthquakes
- **Immediate Occupancy** – although not necessarily operational due to damage to building contents, nonstructural systems, or lifelines

Typical performance objectives for nonstructural portions of buildings such as equipment, electrical, plumbing and ventilation systems, ceilings, partitions, and cladding are:

- **Not Considered or Unknown**
- **Life Safety** – to avoid death and injury, but not necessarily keep systems in place

*Success Story*

### San Luis Obispo's Downtown Revitalization Program

The City of San Luis Obispo requires that all of its 126 unreinforced masonry buildings be retrofitted by 2017. The city provided free downtown parking for contractors, $5000 incentives for each owner that retrofits, grants for up to $25,000 for some owners, and permit fee waivers. Most importantly, the downtown business community is experiencing a major revitalization with enhanced foot traffic, retail and restaurant activity partly as a result of the improvements.

- **Position Retention** – to keep systems in place during shaking, but not necessarily operational
- **Operational**

Detailed advice about seismic performance options is in the Appendices.

## Option 4: Undertake Seismic Screenings

Selective screening of collapse risk buildings will be informative for setting priorities for other options and aiding public understanding of the risks. This option doesn't necessarily involve formal quality assurance or public disclosure of screening results.

Two standard techniques for screenings are available:

- *Rapid Visual Screening of Buildings for Potential Seismic Hazards* (FEMA 154, a national guideline) is a simple procedure that can be accomplished with smartphones from the sidewalk and no access to interiors.
- *Seismic Evaluation and Retrofit of Existing Buildings – Tier 1 Seismic Screening* (from ASCE 41-13, a national standard) is a somewhat more in-depth procedure that can be accomplished in less than a day for most buildings with interior access.

The results of these screening techniques can be incorporated into community-specific vulnerability databases for more reliable loss estimates for large cities and counties. Loss estimates can also help generate what-if scenarios for an expected range of earthquakes as well as annualized losses based on screening data unique to each community.

## Option 5: Require Seismic Evaluations and Ratings of Buildings

More stringent ASCE 41-13 Tier 2 or 3 evaluations of buildings that have a particular type of exceptionally high risk construction will provide comprehensive insights into vulnerabilities. These are typically done for buildings that face retrofits. This information can help scope retrofit costs and disruptions to occupants and neighbors. The results of ASCE 41 evaluations can also be used to generate safety ratings and compare them with the performance provided by standards for new construction.

A number of jurisdictions have opted to subsidize owners' costs of these evaluations.

## Option 6: Encourage Voluntary Retrofits or Replacements

Communities can take steps to accelerate the baseline rate of attrition through programs that make retrofits or replacements more attractive to building owners. The success of these programs will be influenced by:

- Real estate market conditions including property values, rents, and vacancy rates
- Frequencies of changes in occupancy
- Code-based triggers of seismic evaluations and retrofits including those for alterations, additions, or repairs
- Changes in stakeholder awareness when ratings and disclosures become known pursuant to previous options
- Ordinances that require owner notification of exceptionally high risk buildings and specify seismic performance objectives
- Redevelopment and intensification of properties
- Incentives such as reducing building permit fees, or reduction of disincentives such as waiving parking requirements

An important part of such programs is asking owners to commit to a self-defined time frame for action. It may be more politically acceptable and less confrontational to start a voluntary retrofit program first, but typically a large percentage of owners will not retrofit or replace their buildings until they are required to do so.

*Success Story*

San Francisco's Earthquake Safety Implementation Program

San Francisco engaged its citizens in collaborative ways to develop a Community Action Plan for Seismic Safety to reduce vulnerabilities with priorities tailored to the City's unique building stock and socio-economic conditions. The plan's recommendations are now being managed through a new 30-year Earthquake Safety Implementation Program. First steps include addressing the most vulnerable soft story apartment buildings. Next in line are older private schools and with plans to address non-ductile concrete buildings later.

## Option 7: Require Retrofits or Replacements

Mandatory retrofit ordinances will generally require retrofits by owners within time frames of multiple years. Ordinances will typically include:

- Notification of owners of exceptionally high risk buildings near active earthquake faults
- Minimum seismic performance objectives and retrofit requirements
- Financial incentives and removal of disincentives
- Procedures for regulators to record certificates of collapse risk and compliance on property deeds
- Ways to ensure effective enforcement of evaluations, retrofits or replacements within prescribed time frames
- Procedures to accommodate changing economic conditions, respond to unexpected construction costs and delays, and allow time for buildings to be sold to others more willing to retrofit
- Guidelines for preserving qualified historical resources

- Language specifying demolition and replacement of high risk buildings as a last resort when retrofit alternatives are infeasible
- Requirements to monitor and report progress to policymakers

California jurisdictions have enacted successful ordinances of this type for unreinforced masonry structures. In extending them to other building types, flexibility and creativity are essential for success. Communities considering this option should closely study existing programs in this state and elsewhere.

## Step 4: Other Key Management Considerations

Only rarely can collapse risk buildings be dealt with in isolation. Other issues always complicate the process of seismic risk reduction, but the specifics are unique to each jurisdiction. To help avoid unforeseen difficulties, the following issues should be evaluated as part of the planning checklist for each of the three previous steps.

- Hazards arise from nearby active faults, including the extent and expected rate of occurrence of damaging ground motions, landslides, liquefaction, tsunamis, and other geological effects. The exact mixture of these hazards is unique to each community.
- Fire protection needs, electrical and communications networks, and infrastructure of regional significance each require special attention.
- Earthquakes induce major secondary effects such as water damage, nonstructural damage and damage to building contents.
- Costs are always significant. It is imperative to balance them against realistic estimates of benefits, affordability and the time needed to reduce collapse risks effectively.
- Financial, zoning and use incentives can make a significant difference in helping owners invest in building safety.
- Seismic safety objectives should mesh with other planning, zoning, economic, social development, and historic preservation initiatives.
- Seismic retrofits can trigger other requirements such as disabled access compliance, fire resistance and repairs that can substantially increase project costs and discourage building owners from taking action.
- The community's tax base will be affected, both by altering the building stock and by damaging earthquakes.
- Post-earthquake recovery times, and the extent to which they might be reduced by pre-earthquake risk reduction, should be carefully considered.

A final challenge to communities is reconciling the human and geological timescales. Damaging earthquakes may occur at any time and cannot be predicted. But they are relatively rare, so communities may have the advantage of many years, possibly decades, before the next one. But retrofits and replacements of collapse risk buildings are quite costly, so they can't be readily accomplished in the short term. Therefore, adopting a long-term perspective is typically sound practice. These are the essential elements:

- Building safety regulatory oversight by well-trained and qualified professional inspectors and plan reviewers, who are generally licensed or certified, to ensure that new buildings are earthquake resistant and every opportunity is taken to effectively reduce the risks posed by older buildings
- Preparedness, public education, and emergency management measures including barricading, stabilization and having repair ordinances in place to address the anticipated risks that damaged buildings can pose
- Management by metrics, using periodic progress reports to keep the public and policymakers abreast of the size and nature of the collapse risks posed by buildings, what has been done about them over time, how soon will such risks be significantly reduced to manageable levels, and how the rate of retrofit and replacement progress compares with the expected rate of occurrence of future earthquakes
- Incorporation of retrofit and replacement initiatives into a community's multi-hazard mitigation plans and coordination with other long-term planning and growth objectives
- Periodically reevaluating progress and revising priorities and strategies, especially after damaging earthquakes

# Appendices for Guide to Identify & Manage Collapse Risk Buildings for Local Governments

## Part 1: Introduction and How to Use this Guide

California's 14 million buildings are some of the most modern and earthquake resilient in the world. Over 95 percent of the state's buildings are not expected to collapse in severe earthquake shaking. Risk management practices and regulations are available to manage and reduce these risks. It is in everyone's best interests to understand these measures that help ensure earthquake resilience, their effectiveness, and their limitations. There are many alternative approaches that can enhance the safety and reliability of buildings and quicken recovery after future disasters.

A few buildings – perhaps two to five percent of California's building stock - are prone to collapse in earthquakes and could become tragic experiences that kill or injure potentially hundreds of occupants, passersby and others in adjacent buildings. They don't merely pose losses to victims and building owners, but will cause substantial social and economic disruption and draw worldwide scrutiny about why the collapses happened, who is responsible for the risks, what measures were taken to manage them prior to the collapses, and what will be done about similar buildings.

California epitomizes ***Earthquake Country***. The odds are over 90 percent that a major earthquake will strike California within the next 30 years. Moderate but damaging earthquakes will strike more frequently. Earthquakes that impact smaller communities may create only localized, regional economic disruptions. But major metropolitan earthquakes can cause thousands of casualties and long-term, statewide economic losses.

The significant risks to life stem primarily from a few existing buildings that are vulnerable to earthquakes in regions with active faults. Many of these buildings can be identified, retrofitted or replaced before they cause harm.

This guide is intended to assist government officials and building owners in managing the seismic risks posed by commercial, multi-family residential, institutional and industrial buildings. This guidebook summarizes California's laws and regulations, and presents step-by-step approaches in Part 6:

- Step One is developing a decision-making process that includes effective

communication and stakeholder participation.

- Step Two is identifying buildings that are prone to collapse and characterizing their potential consequences.
- Step Three is developing options for managing the risks.
- Step Four includes other considerations for implementing effective management strategies.

The Commission encourages users to adopt a long-term outlook with multi-decade commitments since this is a large, costly concern that will challenge Californians for generations to come.

Each jurisdiction and building owner faces risks and priorities that differ from others in California, so readers are encouraged to use the table of contents and index to find potentially relevant topics and skip over others that are lower priority or do not apply.

## Part 2: Common Types of Buildings at Risk of Collapse in Damaging Earthquakes

Buildings may be vulnerable to earthquakes because they were:

- Not constructed to comply with codes and standards; or
- Constructed before earthquake resistance was expressly required in the 1930's when California began to require local governments to regulate buildings for earthquake safety after the 1933 Long Beach earthquake; or
- Built to codes that were later found to be inadequate; or
- Improperly altered, repaired or poorly maintained.

These buildings may have compromised earthquake resistance. Some buildings can be exceptions to the types described in this guide, and will be typically harder to identify and systematically inventory. For example, buildings may have parts that are not well connected that can create falling risks. Seismic inventories and evaluations can identify many, but not all risks.

Buildings that collapse can cause fires, property damage, and disruption to surrounding neighborhoods and streets. Californians routinely live, work, go to school, shop, and worship in some of these buildings.

See Part G in Additional References on Page ___ for common characteristics of buildings posing the greatest risks of collapse.

**Figure _. Compton Junior High School in the 1933 Long Beach Earthquake.**

## Part 3: The Most Effective Methods of Managing Collapse Risk Buildings

Regulation that ensures new construction is not prone to collapse is our best defense against earthquakes. New buildings as well as alterations to old buildings must be:

- Properly designed by licensed professionals;
- Built with approved permits by licensed contractors; and
- Checked with thorough plan reviews and inspections by qualified regulators.

California's primary lines of defense are its building departments and their regulatory effectiveness. Rigorous enforcement of design and construction relies on a comprehensive set of standards in the *California Building Code* (CBSC 2013). This code is updated every three years to include new requirements based on testing, research and development, and observations from past earthquakes. More stringent requirements apply to buildings with essential services or large occupancies and those closest to active earthquake faults. (OES 2013)

| Level of Government | Which Buildings They Regulate |
|---|---|
| Local | Over 90% of all buildings |
| State | State-owned buildings, mobile homes, public schools, public universities, essential services buildings, hospitals |
| Federal | Federally-owned buildings, nuclear power plants |

Regulators are responsible for prohibiting unlawful construction by reviewing plans and conducting inspections. Other key stakeholders in the building industry, particularly building owners and contractors, should report and discourage unlawful construction in their projects and the work of competitors.

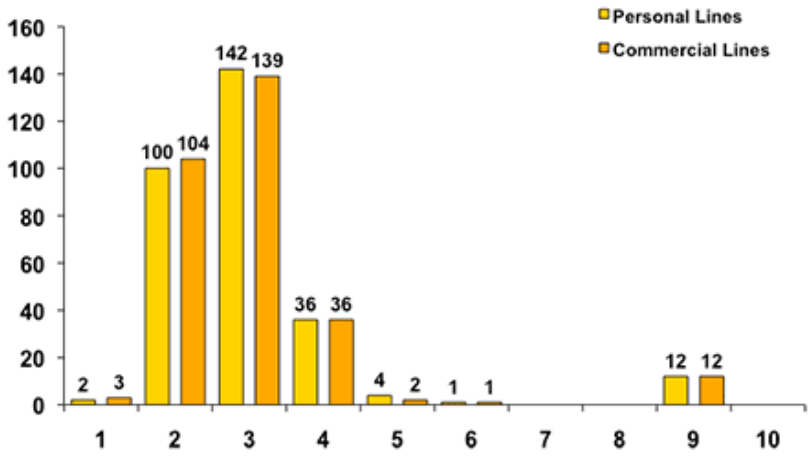



**Figure _. California's building departments are ranked by the Insurance Services Office (1=best, 10=worst).**

Most of California's seismic vulnerability comes from older buildings that were constructed long before our latest codes came into effect. The four alternatives below have been employed by state and local jurisdictions, often tailored to the unique circumstances and priorities for reducing collapse risks identified by policymakers:

*Alternative 1 for Prioritizing Collapse Risk Building Initiatives – By Types of Buildings*

This most common alternative is to focus on types of building construction that are considered most vulnerable to earthquakes. Based on performance in past earthquakes, the *Commercial Property Owners Guide to Earthquake Safety* (SSC 2006) lists the following types of buildings that have characteristics vulnerable to severe shaking in approximate order of their risks to life:

1. **Unreinforced masonry buildings (URM's, mainly brick or stone) that were built primarily before the 1940's.**

2. **Non-ductile concrete buildings that lack sufficient reinforcing steel and were built before the 1980's.**

4. **Precast (tiltup) buildings with reinforced concrete walls that are pooly anchored to roofs that were built primarily before 1995. Some reinforced masonry buildings similarly.**

3. **Apartment buildings with lower stories that have soft or open fronts for parking that were built primarily before the 1980's.**

- Other Buildings with unusual shapes (irregular configurations) that were built primarily before the 1990's.
- Steel frame buildings that were built primarily before 1995.
- Shorter buildings of all ages that are adjacent to and within the fall zone of taller, vulnerable buildings.

The *Homeowner's Guide to Earthquake Safety* (SSC 2005) also lists common vulnerabilities in smaller, residential dwellings. These generally pose widespread economic losses but lower risks to life and injury than larger buildings. These smaller dwellings are beyond the scope of this Guide:

- <u>Wood frame homes:</u>
  - Built primarily before the 1960's on crawl space walls that may not be braced or bolted to their foundations.
  - Built on unreinforced masonry or pier and post foundations before the 1940's.
  - Built on steep hillsides primarily before the 1990's.
  - With unbraced rooms over garages built before the 1980's.

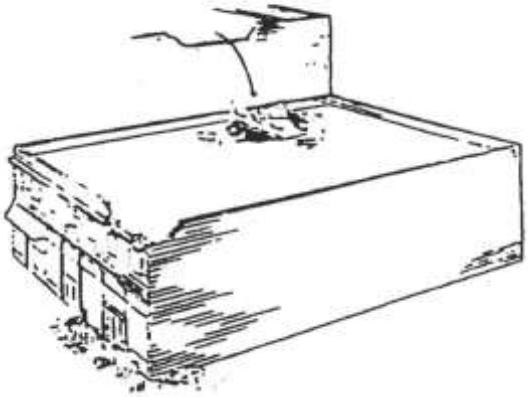
- <u>Mobile homes</u> installed before 1995 that rely on under-floor supports of concrete or steel piers or unreinforced masonry blocks are prone to fall off them.

This is not an exhaustive list of vulnerable building types, but it captures the predominantly poor performers observed after past earthquakes in California and in similar regions around the world.

Governments considering this primary alternative of focusing on one or more vulnerable building types should be aware that other buildings with construction types not listed above and that are difficult to inventory can also pose substantial risks. The other alternatives below can help identify some of the additional risks that might not be captured by alternative 1.

*Alternative 2 for Prioritizing Collapse Risk Building Initiatives – By Parts of Buildings*

The second-most common approach focuses on vulnerable parts of buildings, many of which are called nonstructural components. They include:



2. **Unbraced parapets or tops of walls.**

1. **Chimneys that can fall through roofs or onto critical surroundings.**

3. **Cladding not properly attached.**

4. **Unbraced water heaters.**

Other common vulnerabilities that are costly contributors to building damage are

- Sprinklers
- Partitions
- Signage
- Mechanical and electrical equipment including light fixtures and unbraced water heaters.

If not properly attached, they can fall or break in earthquakes and cause casualties, flooding, fires and other property losses.

*Alternative 3 for Prioritizing Collapse Risk Building Initiatives – By Essential Buildings*

A third alternative is to identify and prioritize mitigation of collapse risk buildings that are most likely to create widespread secondary impacts such as social disruption, fire conflagrations, hazardous materials releases, or disruptions to surrounding neighborhoods and streets. Schools, hospitals, and other essential services buildings such as fire and police stations, and major industrial facilities are typically the focus of this strategy.

**Figure _. San Fernando Veterans Hospital Collapse in 1971.**

*Alternative 4 for Prioritizing Collapse Risk Building Initiatives – By Evaluations & Ratings*

Since it can be difficult to pre-identify some of the vulnerabilities in the building stock, instead of focusing on only known collapse risk building types, a fourth alternative is to encourage or require seismic evaluations and resilience ratings for all major buildings with targeted occupancies or for those larger than a prescribed size or number of stories regardless of building type.

**Figure _.Building Performance Rating Placard by the U.S. Resiliency Council.**

## Part 4: Who are Responsible for Collapse Risk Buildings?

### Building Owners

Common Law, in effect throughout the history of the U.S., states that building owners are principally responsible for ensuring and maintaining the safety of their buildings:

> "Common law requires that an owner exercise the ordinary care that a reasonable person would use under the circumstances. Building owners are required to have the premises in a reasonably safe condition for the customer, and to warn the customer of any unsafe condition which the owner knows about or should, using ordinary care, know about." (Allen, 2013)

In 2010, the State's Second Appellate Court, ruled to affirm this Common Law, upholding a lower court's decision by finding that building owners were negligent notwithstanding the 2018 compliance date adopted in the City of Paso Robles' mandatory retrofit ordinance for URM buildings (Court of Appeals, Div. 6, 2010).

In addition, the California Building Code requires owners to maintain buildings, structures and their parts in a safe and sanitary condition (Section 3401.2, CBSC, 2013).

See also Part 6, Reference Material, Section C regarding other liability considerations.

Prudent owners should become aware of and actively manage the seismic risks associated with their buildings.

**Figure _. Collapse of the Acorn Clock Tower Building in Paso Robles after the 2003 San Simeon Earthquake**

Each owner should consider the following steps:

- Obtain and archive a complete set of construction plans as well as those for major alterations and seismic evaluations, including specifications, and design calculations for their building. Retain copies of all plans and permit records that were approved by the government authority having jurisdiction. Store the information in a fire- and flood-safe,

offsite location that can be quickly accessed by two or more designated facility management personnel after disasters.

- Periodically hire a design professional to conduct a seismic evaluation of the building to identify and prioritize vulnerable aspects of structural systems, nonstructural systems, contents, and nearby risks. Evaluations older than 15 years should be updated.
- Identify seismic performance objectives for the building. Develop budgets and timelines for retrofits and maintenance of building systems that will help ensure that they meet performance expectations.
- Incorporate the reduction of unacceptable seismic vulnerabilities into long-term capital outlay planning for the building.
- Consider obtaining earthquake insurance.
- Create a Building Occupancy Resumption Program to enable rapid evaluations of damage by design professionals familiar with the building after disasters to shorten disruptions and recovery times.
- Communicate seismic risks and management practices to building occupants.
- Periodically revisit progress toward acceptable levels of risk.
- Disclose earthquake vulnerabilities to prospective buyers consistent with the *Commercial Property Owner's Guide to Earthquake Safety* and the *Homeowner's Guide to Earthquake Safety.*

If an owner is unable to invest in managing building risk, they should consider selling or replacing their building.

Government agencies that own buildings can set good examples for private owners by actively managing their own buildings in this way.

Key factors that often limit or discourage owners from actively managing the collapse risk posed by their buildings are:

1) Higher priorities for the use of limited funds for capital outlays;
2) A lack of awareness or discounting of seismic risks;
3) Fear and anxiety about earthquakes;
4) Feelings of helplessness and fatalism about earthquake risk;
5) Distrust of or lack of confidence in the building industry and regulatory agencies about their ability to ensure a safe built

**Figure _. Collapse of a brick building on Bluxome Street San Francisco after the 1989 Loma Prieta Earthquake**

environment; (Joffe, et al, 2013)

6) High costs associated with conducting seismic evaluations and alternatives such as retrofitting or replacing buildings; and
7) Short time horizons of investors after which financial involvement in particular buildings will be liquidated.

**Government Regulators**

While government agencies have key roles in regulating construction, many changes take place in buildings without direct government intervention. Minor or unpermitted work, owner/tenant alterations, installations of equipment and unregulated contents often occur and at times can adversely affect building safety. Governments can – and often do - leave the managing of collapse risk posed by buildings to the discretion of building owners and tenants, and thus owners are principally responsible for building safety. Option1 on page__ summarizes how that can be done effectively and how mitigation progress can be monitored when relying on this option.

Commonly occurring circumstances associated with existing buildings raise challenges for the appropriate role of government regulators in ensuring the public's safety and welfare:

- Collapsing buildings can fall onto sidewalks, streets, and adjacent lower buildings placing those at risk directly within the public right of way. For example, a tall building that is severely damaged in an earthquake can force the closure of multiple city blocks around its perimeter until it is stabilized. Impacts of collapse or even the possibility of smaller amounts of debris falling from buildings can cause severe, direct impacts to neighborhoods as well as indirect impacts to the overall well-being and security of a community, including its economy, standard of living, and vibrancy. When collapse occurs, rights of way are often disrupted. Emergency responders and recovery efforts in the vicinity can be impeded.
- Owners don't always know if their buildings are vulnerable to collapse or don't warn the public about vulnerable conditions.
- Owners often defer maintenance and don't typically evaluate seismic risk. Lack of maintenance tends to accumulate and, in the absence of proactive intervention, can increase risks to life, economic and social welfare.
- The rates of attrition reducing seismic risk in old buildings are typically slow. Alterations to

**Figure _. Collapse of the Alexandria Building after the 2014 South Napa Earthquake.**

older buildings and replacements over time can gradually change the risks posed by older buildings when regulations are effectively enforced and owners make conscientious choices about earthquake risk.

- The public is largely unaware which buildings are at risk of collapse. Yet the public has a right to know so that they can make informed decisions about occupancy and earthquake risk. Local governments have key roles in informing the public.
- Owners, regulators and policy-makers should be informed regarding buildings that present acceptable levels of risk, potentially vulnerable conditions that are safe enough to occupy, as well as buildings and their surroundings that are so unsafe that they should not be occupied.
- While local jurisdictions have the authority to regulate the safety of new construction, as well as alterations, additions, and repairs to existing buildings, the public often incorrectly assumes that such regulations are foolproof and always ensure safe buildings. What the public doesn't know is that many buildings pose risks that are not known or vary depending on the type, extent and age of construction as well as prior alterations, additions, or repairs.
- Local government decisions regarding neighborhood revitalization, redevelopment, historic preservation, and intensification of building usage can alter or perpetuate the public's exposure to seismic risk in both positive and negative ways. Informed, transparent, and visionary public policy decisions will include consideration of seismic safety.

State and federal laws typically transfer the role of ensuring building safety to local governments, with a few notable exceptions enacted in state laws for mobile homes, public schools, hospitals and other essential services buildings.

The public has multiple options. The choices for effectively managing earthquake risk are often complicated and can be quite costly, even onerous. Options are not often cost-effective to owners' when only their direct costs and benefits are considered. When the public's interests are considered that extend beyond owners, including the community-wide interests of other stakeholders, then policy-makers can more effectively compare alternatives:

- Potential for saving lives.
- Reducing the cost of injuries.
- Reducing delays in recovery and business interruption in the neighborhood.
- Accounting for the time value of funds invested in improving buildings.
- Historic and cultural preservation.
- Consideration of other direct and indirect social and economic impacts including loss of tourism, tax revenue after damaging earthquakes.

Buildings that collapse are horrendous experiences causing major disruptions to communities after earthquakes. It can take days to extricate victims and months to determine the causes of collapse and clear debris. In contrast, resilient communities that avoid collapse can recover quickly after disasters and minimize long-term adverse effects.

Another major consideration affecting seismic risk is California's population that has increased its building stock dramatically. See Figure 1.

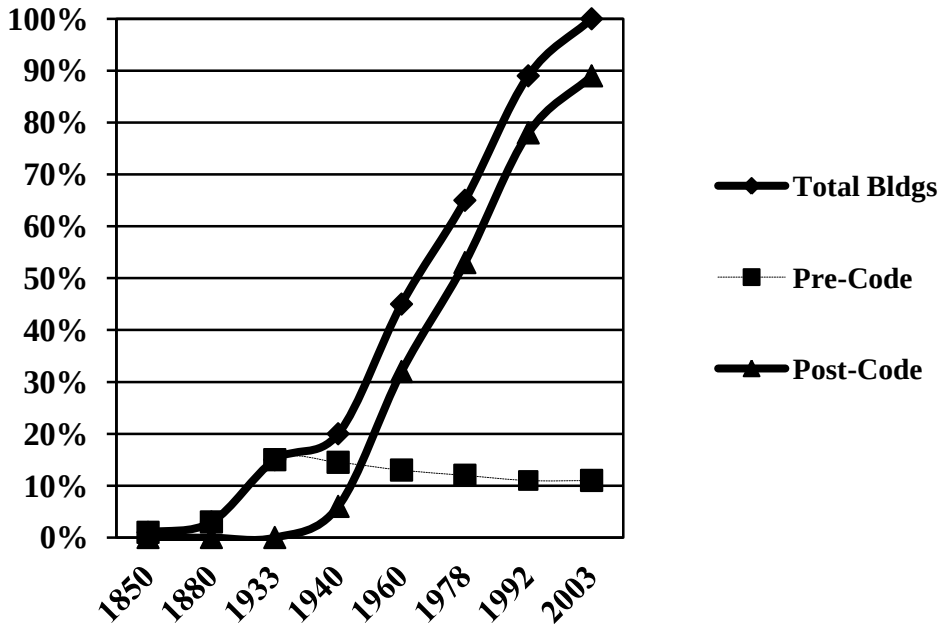



**Figure 1.** The Growth of California's Building Stock from 1850 to the Present. **(**Update this figure**)**

As a result of population growth, California's building stock is relatively young and more earthquake-resistant compared to many other regions of the world. Approximately 90 percent of the state's growth has occurred since most local governments began to require earthquake resistance in building construction in the 1930's. California population and building stock has grown over twenty percent since the Northridge earthquake. California's growth continues to be robust, so strategies should capitalize on market forces and population growth to help reduce seismic risk.

It is important for local government agencies to work together in developing and enforcing appropriate seismic risk management priorities and regulations with a focus on speeding the improvements, reducing costs, and minimizing disruption to owners, occupants and surrounding neighborhoods.

Successful seismic risk management initiatives depend on:

- Knowledge and experience of building owners, contractors, and design professionals selecting the most cost-effective alternatives for the future built environment.
- Technical and economic feasibility.
- Meaningful incentives and other supportive government policies (SSC 87-02).
- Effective regulation of construction through plan reviews and inspections.

Local governments can measure the rates of investment devoted to building retrofits or replacements. Understanding the percentages of vulnerable buildings that are gradually replaced or retrofitted annually will give communities a tool to gage the adequacy of current seismic risk policies and whether or not adopting other approaches will speed up or hinder progress. Since the public demands safe buildings and values seismic retrofits and replacements, governments should measure and periodically report progress on those efforts.

Communities in regions of high seismicity are encouraged to explore three classes of difficult choices:

a) Do nothing more than existing policies;

b) Make smaller, initial investments in earthquake risk management and information outreach that rely primarily on passive, market-driven approaches. These may result in potentially higher casualties, social and economic disruption, slower recovery after future earthquakes, as well as higher post-earthquake costs compared to c) below; or

c) Make larger, more assertive risk management investments to further reduce vulnerabilities and future casualties, minimize social and economic disruption, and quicken recovery after future earthquakes.

Key factors that often limit or discourage local governments from actively managing the collapse risk posed by buildings in their jurisdictions are:

1) Higher priorities for the use of limited funds and time on policy-setting agendas;
2) A lack of awareness of the risks;
3) Fear and anxiety about earthquakes;
4) Feelings of helplessness and fatalism about earthquake risk;
5) Distrust or lack of confidence by policymakers in the building industry and regulatory agencies about their ability to ensure a safe built environment; (Joffe, et al, 2013)
6) High costs associated with conducting inventories, seismic evaluations and scoping out alternatives such as retrofitting or replacing buildings; and
7) Short time horizons within which government policymakers and key staff exercise responsibility for making decisions that may or may not influence long-term risks such as earthquakes.

The choices for how to ensure safe buildings are best left to each building owner and government to tailor to their unique circumstances, including the economics, social conditions, investment priorities, exposures and tolerances to risk, as well as other priorities and demands on limited resources that they face. Risks, social and economic conditions vary greatly across the state, so uniform, statewide approaches are typically not optimal.

## Part 5: Nexus for Public/Private Partnerships to Manage Collapse Risks

Most buildings are privately-owned, but if they were to collapse, they would adversely impact public spaces and neighboring buildings around their perimeters, create demands on government emergency and recovery services, disrupting social and economic activities. So both building owners and government agencies have major stakes in managing earthquake risks. Building owners stand to lose property values while governments lose tax revenues after earthquakes. It is in everyone's best interests for governments and building owners to collaborate in identifying vulnerable buildings, improve their earthquake resistance or replace them.

The Seismic Safety Commission has observed efforts to address collapse risk by building owners and local governments across the state for the past several decades. Progress appears to be greatest when active dialogues, mutual understanding, commitment and collaboration are fostered between private owners and governments. Governments can play a critical role of informing the public, encouraging talk about risk reduction and easing efforts by building owners. Collaboration to identify risk reduction priorities, funding mechanisms, time frames for accomplishing retrofits and replacements, financial incentives and removal of disincentives are most effective when they reflect the collective interests of stakeholders. See page ___ for a discussion about incorporating seismic risk into multi-hazard resilience initiativess.

## Part 6: Four Steps to Managing Collapse Risk Buildings

There are a variety of ways to approach this issue. The Commission recommends that local governments become familiar with common options and with what other jurisdictions have already learned in identifying and reducing collapse risks. This guidebook summarizes information from the Seismic Safety Commission's monitoring of useful approaches and experiences of hundreds of local government efforts since the 1970's.

### Step One: Create Opportunities for Education, Dialogue, and Public/Private Participation in Decisions about Buildings

Helping the public to learn about earthquakes, temper their fears, overcome the sense of helplessness and recognize how they can take steps to ensure that buildings are safer and more resilient will benefit the community. The city council or board of supervisors should direct staff to:

- Consult with the city's or county's attorney for advice on due process and notifications to ensure timely and appropriate public participation in developing risk management alternatives to address collapse risk buildings.
- Actively inform the public about the issues and the alternatives to be considered the can include public notices for initial discussions on the agendas of Councils, Boards, and Commissions that have responsibilities in the matter.
- Listen and provide responses to community views.

- Place priority on ensuring due process that allows for ample opportunities to review and comment so that stakeholders are kept informed about how and when decisions will be refined and adopted. This will help eliminate surprises and ensure timely input.
- Consider creating a task force involving community leaders to help develop and guide deliberations.
- If an interest emerges to explore alternatives in greater detail, local governments can appoint a coordinator or staff point person to solicit opinions and obtain background information in a timely manner.
- Minimize delays, complaints and lawsuits by engaging in dialogues with the public that allow for multiple opportunities to solicit and consider differing points of view and options.
- Deal with policy and financing challenges arising from the dialogue .
- In the end, local political leaders must be involved since decisions will require commitments of time and resources, balancing community goals and priorities, and choosing from controversial alternatives.

Consideration of the issues deliberately, incrementally and from a variety of perspectives is a proven, effective management technique. Several departments and divisions within local governments have stakes in collapse risk buildings and will need to work together to generate effective changes. These include the building and planning department, community, finance, and economic development authorities, the fire department, emergency management, legal counsel, historical preservation commissions, public works, and parks and recreation departments. If initial dialogue finds merit to consider alternatives, a lead government agency should be designated to reach out to more stakeholders and coordinate the communication campaign and decision process.

Elements of effective communication campaigns include a description of the risks, the alternatives that owners and government agencies should consider to manage the risks, past retrofits and building replacements that highlight success stories, and the opportunities for public participation in the discussion.

Efforts should be made to address the public's natural fears and anxieties about earthquakes, to counterbalance fatalism and promote participatory and community-based approaches that will be effective for minimizing losses and speeding recovery after future earthquakes. Confidence-

building messages to the public emphasizing that risks posed by vulnerable buildings can be effectively managed are preferable compared to anxiety-provoking messages that evoke denial and inaction (Joffe, et al, 2013).

Initial attempts at reaching out to stakeholders may primarily engage the most adversely impacted who may focus on opposing the costs that could be imposed on building owners. Local engineers and architects will also likely be among the first to show an interest. So governments should plan to make extraordinary efforts to create multiple communication opportunities by engaging other stakeholders that may experience indirect costs and benefits from risk management decisions. Neighborhood groups, business improvement associations, and other entities such as non-governmental organizations, like the Chambers of Commerce, Rotary, and Lions Clubs, and other charitable and business groups should be engaged in such dialogues.

Part 5's Reference Materials (Page __) have links to resources to help governments apply principles of effective risk communication.

**Step Two: Estimate the Size and Nature of Collapse Risks**

Hazards that are directly caused by earthquakes include severe ground shaking, landslides, liquefaction, lateral spreading of soils, tsunamis in the ocean and bays, seiches in lakes and reservoirs, and fault rupture. Other triggered hazards include fire following earthquakes, dam and levee failures. Losses from severe ground shaking causing building collapse tend to dominate the losses from other types of hazards in the absence of major conflagrations. Earthquakes are unlike most other hazards since they can occur with no warning or at best only seconds of warning.

*Causes of Building Vulnerability to Earthquake Damage*

Compared to other earthquake vulnerabilities, buildings pose the largest risks to life, injury, property, and economic welfare. California has approximately 14 million buildings, with an average of 2.7 occupants per building. Approximately 95 percent are low-rise (one to three stories), 5 percent are medium-rise (four to seven stories), and 0.03 percent are high-rise buildings (eight or more stories). Observations after earthquakes indicate that building safety is often compromised by poor quality in design and construction, inadequate maintenance, lack of code enforcement at the time of original construction, as well as improper alterations to buildings. (OES 2013)

Approximately 13 percent of California's buildings were constructed before 1933, when explicit requirements for earthquakes first began to be incorporated into building codes and the state first required local governments to create building departments and issue permits. Pre-1933 brick buildings pose well-known collapse risks. (OES 2013)

A somewhat less common cause of damage is the poor performance of older buildings constructed to earlier seismic codes. About 18 percent of California's buildings were constructed before 1940, when the first significant strong motion recording was made in El Centro. About 40

percent of the state's buildings were constructed before the Structural Engineers Association of California's first statewide consensus on recommended earthquake provisions were published in 1960. About 60 percent were built before the mid- to late-1970s, when significant improvements to lateral force requirements began to be enforced throughout the state. California did not require uniform adoption of the same edition of building codes in every jurisdiction until the early 1990s. Thus, code requirements and enforcement varied from region to region. Well over half of all existing buildings in California are built to earlier standards that, in some cases, can result in extensive damage or otherwise inadequate earthquake performance. (OES 2013)

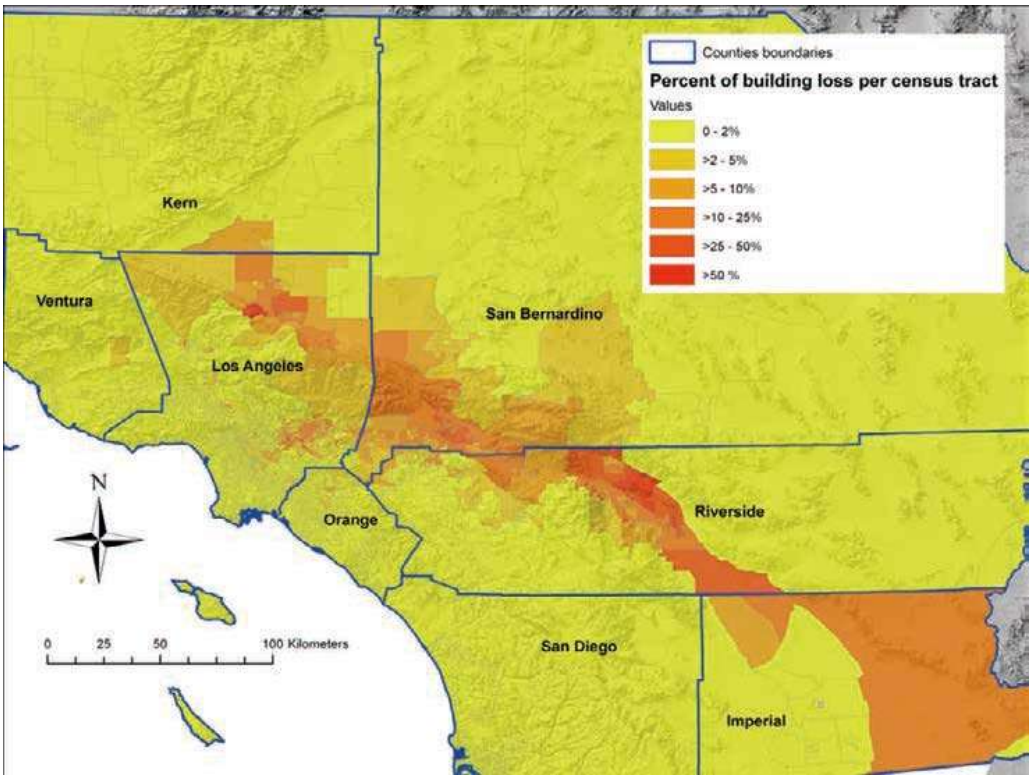



**Figure __. Loss Estimation from the 2008 Southern California Shake-Out Scenario**

Fortunately, the vast majority of buildings in California are inherently earthquake-resistant, in large part because of the predominance of wood frame construction. However, a small but significant percentage, perhaps on the order of two percent of all buildings, pose collapse risks that can conceivably be identified by systematic inventories and seismic evaluations.

*Techniques for Estimating the Number of Vulnerable Buildings*

Accurate data collection and how data are transmitted to the public are two of the most important steps in a successful program; government staff should ensure that procedures are transparent and data are beyond reproach. Rough estimations that include identifying the neighborhoods with concentrations of collapse risk buildings without necessarily listing individual addresses can help governments take first steps to identify priorities and begin to evaluate potential losses, costs and benefits of risk management alternatives. Estimates of the number, size, story heights,

occupancy, socio-economic conditions including rental rates, can be generated using a variety of indirect and direct techniques including (Anagnos 2012):

- Windshield and sidewalk surveys;
- Online maps, streetviews can depict building heights, shapes and proximity to neighboring buildings and public rights of way, which can be used to evaluate falling risks from adjacent collapse risk buildings;
- Consultations with Building Officials, their staffs and their permit records;
- Old Sanborn maps that depict building construction types;
- Tax assessor data;
- Various sources of information and databases on the internet and at libraries;
- Archives of Architectural, Civil, and Structural Engineering firms;
- Loss estimation programs;
- Building stock sampling, characterization and databases that can be used to infer building stocks elsewhere;
- Building Occupancy Resumption Program data;
- Transportation Corridor studies;
- Redevelopment studies;
- Historical Building Registers and Historic District surveys, and;
- Rapid visual screenings

A somewhat more detailed approach than indirect estimation is available in *Rapid Visual Screening of Buildings for Potential Seismic Hazards* (FEMA P-154, 2015). It relies on civil or structural engineers to conduct field surveys to fill out one-page forms that generates a basic score for each building to help classify them into common types and determine if more detailed evaluations are warranted. The amount of information collected with FEMA 154 is substantially less detailed than compared to ASCE 41 Tier 1 Evaluations described in Option Four below (Page ___).

*Using Earthquake Scenarios to Describe the Risk to a Community*

Recently-developed scenarios can be used to describe the effects of major earthquakes striking metropolitan regions. The 2008 Southern California Shakeout Scenario (USGS 2008) describes anticipated losses from a major earthquake on the Southern San Andreas Fault. A 2006 scenario

describes losses from a repeat of the 1906 earthquake (2006 EERI). It is reasonable to estimate the increase in losses by multiplying the scenario's losses by ratios reflecting population and cost of living increases since these scenarios were developed.

These regional scenarios lack sufficient detail to allow individual jurisdictions or subregions to define their specific losses, so the scenarios can be supplemented with more detailed loss estimates for smaller study areas as described in the next section.

*Techniques to Estimate Earthquake Shaking Losses from Collapse Risk Buildings*

A low-cost, Federally-funded computer program called HAZUS (2014) can be used to generate aggregate loss estimates for a group of buildings within a region. The program contains default vulnerability data for common building types. It also allows users to input custom building location and vulnerability estimates and subject them to either probabilistic ground motions or scenario earthquakes. The results can include the numbers and types of casualties, dollar losses, and volumes of debris that would be generated by scenario earthquakes.

Jurisdictions have used HAZUS and other similar loss estimation tools to conduct what-if scenarios to judge how much and how soon retrofits or replacements would reduce aggregate losses.

Since the HAZUS input information is simplified and limited, the results of HAZUS are not reliable for nor intended to judge the adequacy of individual buildings, but the results are quite suitable for estimating aggregate, region-wide losses from many buildings.

Rough estimates of the number and sizes of collapse risk buildings pose significant limitations. For example, without a more detailed building-by-building inventory, it is difficult to guess the percentage of collapse risk buildings that have been previously retrofitted. So input into HAZUS loss modeling may not be reliable or quotable in a public hearing. But nevertheless, such attempts at initially estimating the size and nature of the building stock are effective, low-cost ways to develop a feel for the challenges that may lie ahead.

If a jurisdiction chooses to release rough estimates to the public, descriptions of the limitations and uncertainties associated with the estimation should be included in the release and emphasized. Publishing ranges of estimates can also be an effective way to characterize the uncertainty.

Emergency managers, fire officials and other first responders can also use these estimates to conduct table-top disaster response exercises.

Whether a jurisdiction decides to take no further action as in Option One below or to explore more assertive alternatives such as those in Options Two through Seven, having access to rough estimates of collapse risk buildings numbers and sizes is a critical first step to effectively manage them.

**Step Three: Develop and Consider Up to Seven Options for Mitigating Collapse Risks**

*Option One: Rely on Attrition and Current Triggers for Alterations, Additions, Repairs in the Building Code*

This option reflects the current practice in nearly all jurisdictions. Collapse risk buildings are occasionally identified and retrofitted or replaced voluntarily. Two of the most commonplace triggers for these actions are: 1) Disclosures of earthquake vulnerabilities at the time of sale and; 2) major repairs, alterations or additions, the latter at times triggered by requirements in the California Building Code.

The *Commercial Property Owner's Guide to Earthquake Safety* summarizes state laws that encourage buyers to promptly disclose typical earthquake weaknesses to sellers. Similar laws requiring disclosure for residential dwellings are summarized in the *Homeowner's Guide to Earthquake Safety.* Realtors are motivated to minimize their liability by making these guides available to their clients and encouraging buyers to comply with prudent disclosure practices.

As a result of disclosure practices, market prices for buildings are often adjusted downward to reflect the costs of seismic retrofits. So owners sometimes consider retrofitting or replacing buildings before they sell, or offering the building as is. Similarly, buyers who receive earthquake vulnerability disclosure information before they close real estate transactions can make more informed decisions. Buyers can choose to reduce their offering prices or retrofit before they move in to newly purchased buildings.

Chapter 34 and Parts 8 and 10 of the California Building Code (CBC) have requirements for existing buildings when undergoing voluntary additions, alterations, repairs and/or retrofits. Owners who apply for building permits for minor changes to the building are typically not required to consider seismic vulnerability as long as the building will be made no more unsafe. However, major changes to buildings as defined in Chapter 34 will trigger such considerations. Limits on increases to the weights of buildings, reductions in strength, and the extent of damage being repaired are defined in the code. Many owners limit proposed alterations to fall below such triggers. However, recent code changes require consideration of the cumulative effects of all major alterations and additions since original construction. These requirements have the effect of discouraging owners to alter, repair, or add on to buildings. They can also encourage unpermitted, illegal construction.

**Fremont's Soft-Story Residential Buildings Retrofit Ordinance**

Fremont justified its ordinance in 2007 by noting that the city is near the Hayward Fault that can cause a major earthquake. The California Building Code did not contain provisions for such retrofits, so Fremont adopted a local amendment invoking geologic reasons for its ordinance requiring retrofits.

Local governments are authorized to amend the California Building Code for geologic reasons that include earthquake risk provided they report such amendments to the Building Standards Commission (Health and Safety Code Section 18941). This is one mechanism that local governments can use when exercising their regulatory authority to more proactively manage and reduce collapse risk.

Voluntary seismic retrofits can be undertaken with limited performance objectives, or without any explicit objectives, as long as the buildings are no less safe than they were before the retrofits. Some retrofits might focus on improving nonstructural systems or portions of buildings. Other retrofits might address only structural systems.

**Figure __. Reroofing should trigger reevaluations of parapet bracing at tops of walls.**

Seismic retrofit projects are often included in projects that include other objectives such as modernization, so many jurisdictions do not currently maintain a record of which projects include seismic work and what, if any, was the performance objective for the seismic improvements.

The primary advantages of this option are that it offers owners the most discretion, and is the least confrontational, completely market-driven and generally more consistent with the policies of neighboring jurisdictions.

The main disadvantage of this option is that most jurisdictions are not currently monitoring and periodically reporting on incremental seismic evaluation and retrofit progress that has been occasionally occurring at the time of sale or by permits pursuant to the triggers in Chapter 34 of the CBC. Nor are jurisdictions necessarily capable of retrieving documentation for all prior alterations and additions to existing buildings. So to maximize the effectiveness of this option, jurisdictions should consider enhancing their accounting practices so that basic information

about voluntary or triggered seismic retrofits and cumulative alterations and additions can be tracked and periodically reported. Tracking such progress can help policymakers determine if a market-driven approach to seismic risk management is generating an adequate pace of investments. After several years of data are collected, building departments can report to policymakers about annual progress on major voluntary retrofits as well as the pace of smaller alterations and additions that are accumulating. Such refined data about a jurisdiction's building stock can also inform more detailed inventories described in Option Two and improve the reliability of future earthquake loss estimates.

Whatever path that jurisdictions take, it is critical that the process be transparent and the public is aware of and provided opportunities to participate in deliberations before policies such as those for tracking progress are implemented. By monitoring and reporting on seismic evaluation, retrofit and alteration progress, jurisdictions will be communicating to the public that it values seismic safety and is encouraging the market to make improvements, albeit gradually, to address the risks of collapse and increase resiliency.

**Arcata's Unreinforced Masonry Building**

Arcata inventoried their city and found one unreinforced masonry building in its jurisdiction. The building had undergone a major renovation in 1977, and, as a condition for the renovation, the City required a seismic retrofit, so there was no need for the city to enact a formal ordinance requiring the retrofit.

Even if other options described below introduce more assertive approaches to address the most vulnerable building types, this option applies to all building types regardless of their vulnerabilities and, over decades, can significantly reduce risks in all building types. Population growth can drive building replacements, particularly if buildings that are vulnerable to collapse are targeted for replacement.

Political and fiscal support for building code enforcement capabilities such as civil service and consultant personnel qualifications, training, continuing education, licensure, and credentialing are also critically important to ensure that this option is effective. (See page ____)

*Option Two: Develop Reliable, Detailed Inventories of Collapse Risk Buildings*

Local governments will find that, without a detailed inventory of pre-defined classes of collapse risk buildings, it is difficult to monitor seismic retrofit and replacement progress or take advantage of merging seismic programs with other efforts such as redevelopment, green building initiatives, flood or fire prevention programs. Jurisdictions might be aware of a few buildings that were fully or partially retrofitted or demolished and replaced over prior years, but records may not be complete or systematically maintained. So a detailed inventory is critical to knowing how big the risk is, where such buildings are primarily located, and how much progress has been made to date. In other words, monitor and manage this risk using progress metrics (See page ___).

Surveying buildings to identify those prone to collapse involves eight tasks:

**Task One**: Office Planning

**Task Two**: Field Survey and Reports

**Task Three**: Office Research and Verification

**Task Four**: Contacting Building Owners

**Task Five**: Revising the Draft Inventory

**Task Six**: Publishing the Inventory

**Task Seven**: Analyzing the Findings

**Task Eight**: Periodically Refining the Inventory

During **office planning**, samples of existing records including street views, aerial photography, footprint maps, Sanborn maps, building permits, and construction plans are identified and located (See Step 2 on Page ___). The state of thoroughness and reliability of current office and archived records should be determined. Local building officials should work with inspectors to identify neighborhoods where particular classes of collapse risk buildings predominate.

Next, a **field survey** is done, beginning in those neighborhoods. As part of the field survey, a brief report of basic data can be generated for each potential collapse risk building that is tentatively identified, and a preliminary inventory may be compiled.

Then, personnel will **verify** the field survey findings using office resources and, if warranted, follow-up site visits. Additional buildings may be identified and added to or removed from the list.

The jurisdiction should then **contact owners** of the potential collapse risk buildings to notify them that their buildings are on a preliminary list. If they do not agree that their buildings are prone to collapse, or if they have information on prior seismic evaluations or retrofits, they may respond with pertinent information.

The owners' responses should be carefully reviewed and the inventory of potentially vulnerable buildings **revised** and eventually **published** first as a draft and then, after an opportunity for public comment, as a final version of the inventory.

The list of likely collapse risk buildings can then be **analyzed** to determine community impacts before beginning to select risk management options.

In future years, building departments should plan to periodically **update and refine** the inventory as it is likely additional buildings that were overlooked will occasionally come to the departments' attention. Department personnel should be trained and on the lookout for the

common characteristics of such buildings when future construction projects may bring them to their attention.

The process described above might be modified by the jurisdiction. For instance, if office information is already available, comprehensive, and current, it may make sense to conduct more detailed office research before making a field survey. Exhibit A includes a suggested checklist of tasks to identify collapse risk buildings.

**Exhibit A - Checklist for Inventorying, Seismic Evaluations & Retrofits**

**<u>Option One</u>**: **Rely on Attrition and Current Triggers** for Alterations, Additions, Repairs in the Building Code

a) Audit Building Department Personnel Qualifications, Licensure, Certifications, and Continuing Education.

b) Develop a tracking system to record when additions, alterations, repairs, seismic evaluations, seismic retrofits, demolitions, or replacements of collapse risk buildings occur that includes listing the seismic performance objectives for retrofits.

c) Periodically report to policymakers on mitigation progress, expressed as the sum of retrofitted and demolished or replaced buildings divided by the inventory or estimates of the number of collapse risk buildings in the jurisdiction.

d) Periodically advise policymakers that the rate of progress will substantially reduce the collapse risk in ___ years based on current rates of mitigation progress.

**<u>Option Two</u>**: **Develop Reliable, Detailed Inventories of Collapse Risk Buildings**

**Task One: Office Planning**

a) Identify possible office resources.

b) Determine which available resources are most useful, complete, and current.

c) Have inspectors, plan review engineers, and others meet to discuss which neighborhoods are most likely to have collapse risk buildings.

d) List buildings thought to be a collapse risk type.

e) Develop a sample Building Survey Form for use.

**Task Two: Field Survey and Report**

a) Develop procedures and estimate hours for a field survey

b) Train survey personnel.

c) Proceeding block by block, examine buildings in neighborhoods expected to have collapse risk buildings.

d) Proceeding block by block, create a preliminary list of collapse risk buildings. If in doubt, put questionable buildings on the preliminary list.

e) For each building on the list, fill out the Building Survey Form.

**Exhibit A - Checklist for Inventorying, Seismic Evaluations & Retrofits Continued**

f) Compile and refine a draft list of collapse risk buildings from multiple neighborhoods.

g) Create a folder in a database for each collapse risk building on the list.

h) Add a copy of each Building Survey Form to the folder.

**Task Three: Office Research and Verification**

a) Develop procedures and estimate hours for office verification of the draft list of collapse risk buildings.

b) Review local building codes and ordinances to determine the dates that seismic design requirements were first enforced for the collapse risk building types. Consider that some buildings in more recently-annexed areas of the jurisdiction may have been built to different editions of the code than other buildings. Determine the dates that seismic design requirements were first enforced for the collapse risk building types.

c) Review existing building permit files, construction plans, specifications, calculations, and seismic evaluations to refine the list of collapse risk buildings, and to add buildings not initially observed in the field. Start the process by reviewing documents and mapping resources that are the most useful, current, and complete.

d) For each building listed in the field survey, confirm whether or not it should remain on the draft inventory of collapse risk buildings.

e) Depict collapse risk building locations on a map.

f) Sort buildings by address and assessor's parcel number.

g) Fill out the rest of the Building Survey Form.

h) Revisit buildings in the field for follow-up investigations, if warranted.

**Task Four: Contacting Building Owners**

a) Draft a form letter to be sent to building owners.

b) Ask legal counsel to review the draft form letter.

c) Send out certified letters to each owner of collapse risk buildings.

d) Add a copy of the sent letter to the folder for each building in a database.

e) Receive responses from owners.

**Exhibit A - Checklist for Inventorying, Seismic Evaluations & Retrofits Continued**

**Task Five: Revising the Draft Inventory**

a) Review owners' responses. If warranted, remove or add buildings from the draft inventory of collapse risk buildings.

b) Conduct follow-up investigations to confirm the revised information.

**Task Six: Publishing the Draft and Operational Inventory**

a) Establish a reasonable timeframe and notification procedure for public input including provisions for updating the inventory upon receipt of public input.

b) Develop a statement to be released with the draft inventory that describes its limitations, the potential for errors and omissions and opportunities for the public to help correct and refine the record.

c) Coordinate release of the draft inventory with education and public outreach efforts to encourage public awareness.

d) Issue an operational inventory with a proviso that the jurisdiction reserves the right to periodically amend the inventory as new information becomes available.

**Task Seven: Analyzing the Findings**

a) Sort and categorize the buildings by age, size, number of stories, number of occupants, occupancy types, retrofit status, historic versus non-historic.

b) Map the buildings to enable consideration of adjacency risks and effects on concentrations of buildings with similar vulnerabilities.

c) Merge the refined inventory data into a loss estimation program like HAZUS and develop new estimates of property and casualty losses.

d) Report on analysis findings periodically to policymakers and the public.

**Task Eight: Periodically Refining the Inventory**

a) Train building department personnel to keep on the alert for changes in collapse risk building status (i.e. those retrofitted, demolished or replaced) and to detect additional buildings that may not have been identified in the initial survey efforts.

b) If new buildings are added to the inventory, provide their owners comparable time frames in which to respond to inquiries and participate in policy deliberations.

c) Plan to periodically summarize adjustments to the inventory and the status of buildings for the benefit of policymakers and the public.

**Exhibit A - Checklist for Inventorying, Seismic Evaluations & Retrofits Continued**

**Task Nine: Considering the Circumstances**

a) Determine how to comply with the California Environmental Quality Act (CEQA) and coordinate CEQA requirements in developing the mitigation program.

b) Review existing policies and socio-economic circumstances of the neighborhoods that could be affected by a collapse risk building mitigation program:

   i. How are collapse risk buildings distributed or clustered? Are busy streets, sidewalks and other public rights of way exposed to risks adjacent to collapse risk buildings?

   ii. Determine the nature of the occupancy types in collapse risk buildings. Does the population within and around buildings vary during the day or seasonally?

   iii. Determine the patterns of building neglect such as lack of maintenance by owners.

   iv. Consider future planning and redevelopment characteristics in the jurisdiction and how seismic risks can be incorporated into priorities for those plans.

   v. Determine the locations and extent of historic districts in neighborhoods with collapse risk buildings. How would historical resources be impacted by their severe damage or collapse?

   vi. Where are collapse risk buildings located relative to commercial, industrial, tourism, residential, and institutional centers?

c) Review these and other seismic risk issues:

   i. Do some neighborhoods have a greater potential for severe ground shaking because of soft soil conditions than others with stiffer soils or rock?

   ii. Are areas with collapse risk buildings at risk of soil liquefaction?

   iii. Are areas prone to lateral spreading of soils?

   iv. Are areas prone to landslides?

   v. Are areas prone to tsunamis from the ocean, seiches in lakes, or dam indundation?

**Task Ten: Selecting the Specific Requirements of the Voluntary or Mandatory Program**

a) Draft options and detailed provisions of a retrofit program considering whether or not to include:

   i. Specific design criteria for seismic evaluations and retrofits including performance objectives.

ii. Draft timetables for conformance.

iii. Deed restrictions to inform potential buyers that a building is a collapse risk. Provisions for revising or removing the deed restrictions once buildings have been retrofitted to meet a defined performance objective.

iv. Financial incentives and removal of disincentives.

v. Procedures to ensure effective enforcement of the program. The provisions should include an appeals procedure for owners who have difficult, unusual or unforeseen problems with compliance.

vi. Provisions for monitoring progress, reporting to policymakers and making adjustments downstream.

b) Evaluate the proposed retrofit program by addressing the following questions:

i. Does it address important buildings such as schools, police, fire and other critical government and institutional facilities in a timely manner?

ii. Does it address buildings of certain occupancies in a rational and equitable order?

iii. Does it consider impacts on and accommodate housing needs?

iv. Does it make sense with current and future redevelopment plans for the jurisdiction?

v. Does it adequately balance competing goals of preserving historical characteristics and safety?

vi. Does it make sense when environmental risks are considered?

vii. Does it make sense when land-use and growth patterns are considered?

c) Estimate costs and durations of disruptions for building owners.

d) Estimate costs to the jurisdiction for managing the program and to address collapse risks of government-owned and leased buildings.

e) Formalize a draft of the proposed retrofit program and alternatives.

f) Have the draft reviewed by other departments with stakes in its outcome.

g) Hold public hearings, as well as informational and outreach meetings.

h) Revise the draft proposed program to reflect persuasive public comments received.

**Exhibit A - Checklist for Inventorying, Seismic Evaluations & Retrofits Continued**

i) Prepare written information to provide to owners of collapse risk buildings and others potentially affected by the program.

j) Ensure that the final proposal and supporting documentation including notifications, disclosure provisions, compliance orders, noncompliance orders, and progress monitoring provisions are reviewed by legal counsel.

k) Inform stakeholders and jurisdiction policymakers of all details of the proposed program.

l) Present the final proposal to policymakers for their consideration and action.

m) Plan for additional public outreach at periodic intervals throughout the duration of the program, not just during initial phases.

n) Facilitate interaction with property owners, design professionals, contractors, and lenders to help connect owners with qualified professionals with experience in managing collapse risk buildings.

**Task Eleven: Notifying Building Owners and the Public and Implementing the Program**

a) Send out a letter to each owner of collapse risk buildings. See Exhibit B.

b) File a copy of each letter sent in a database folder for each building.

c) Assign staff to answer questions from the public.

d) Provide information to owners and others.

e) Provide multiple changes and options to remove unintended buildings from the program and clearly explain the type of buildings intended to be included in the scope of the program.

f) Ask owners to respond to the Building Official with information about past alterations or retrofits, if any.

g) Consider holding an Earthquake Retrofit Fair to encourage vendors, contractors, financiers, and design professionals to share information with owners about retrofit designs, financing, and construction alternatives (San Francisco, ESIP 2016)

**Task Twelve: Periodic Monitoring and Reporting on Progress**

a) Develop and issue by certified mail compliance orders for owners.

b) Log in seismic evaluations and retrofit plans and permit applications.

**Exhibit A - Checklist for Inventorying, Seismic Evaluations & Retrofits Continued**

c) Review evaluations, and plans calculations using qualified, licensed plan review engineers.

d) Issue permits.

e) Monitor list of collapse risk buildings for compliance.

f) Carry out enforcement procedures in cases of non-compliance.

g) Inspect retrofit, demolition, and replacement construction.

h) Maintain records including inspection and testing reports.

i) Issue compliance and completion notices.

j) Compile and present annual progress reports to policymakers for their reviews, comments and reconsideration of the provisions of the program in light of progress.

k) Make recommendations to policymakers for adjustments to the program that will improve its effectiveness.

l) Coordinate with the local real estate community to create clear disclosure requirements for collapse risk properties at the time of sale.

*Task One: Office Planning*

Figure __ is a list of possible office resources. Once all available office resources have been identified and sampled, local officials can decide which ones have the most useful information. Next, they should meet with inspectors who will have a good idea which areas of the jurisdiction have the majority of collapse risk building types. These may be the areas to be first visited in the field survey.

| | |
|---|---|
| Online Overhead and Oblique Street Views | Sanborn Maps |
| Online Maps of Building Footprints | Online Aerial Photography Maps |
| GIS, Planning & Zoning Maps | Fire Zone Maps |
| Assessor's Parcel/Block Maps | Building Department Permit Files |
| Historical Building Surveys | Building Department Plan Archives |
| Redevelopment Agency Records | Fire Department Records |
| Previous codes and Ordinances | Utility Company Plans |
| Public Works Agency Records | Special District Records |

**Figure ___ <u>Typical Office Resources for Identifying Buildings</u>**

*Task Two: Field Survey and Report*

The purpose of the field survey is to create a list of addresses of collapse risk building types. Survey personnel will inspect neighborhoods where hazardous buildings are expected and will walk the streets and alleys of these areas looking at each building. It is critical for local government personnel to articulate and clarify the intent of the field survey to ensure the public's understanding. Policy scoping studies are very different from hard data collection. Policy scoping data can differ considerably from future, more complete inventories.

Building Officials in consultation with experienced engineer plan reviewers should develop a summary of how to identify types of collapse risk buildings, their common characteristics, architectural eras, and decorative finishes, and where to typically find them. With that summary, field surveyors can make one of the following determinations:

- The building is **definitely a type commonly considered a collapse risk:** In this case, its address is added to the list and a Building Survey Form is filled out.

- The building is **definitely not a type commonly considered a collapse risk:** In this case, the building is not added to the list and a form is not filled out.
- It is **not certain whether the building is a collapse risk type**: In this case, the building's address will be added to the list and the Building Survey Form will be filled in as completely as possible.

The survey should probably be a very rapid visual investigation, primarily of the exterior of the buildings. In some cases, access to the buildings' interiors will be necessary to determine if a building is of a collapse risk construction type. Survey teams should proceed methodically, block by block. Field procedures will vary depending on the number of collapse risk buildings anticipated. Before the survey is begun, personnel should thoroughly understand its objectives. Some building inspectors and most engineer plan reviewers will have adequate background to conduct the survey. If less experienced personnel are used, they may need special training. The level of detail sought should be appropriate to the goals of the anticipated type of mitigation option.

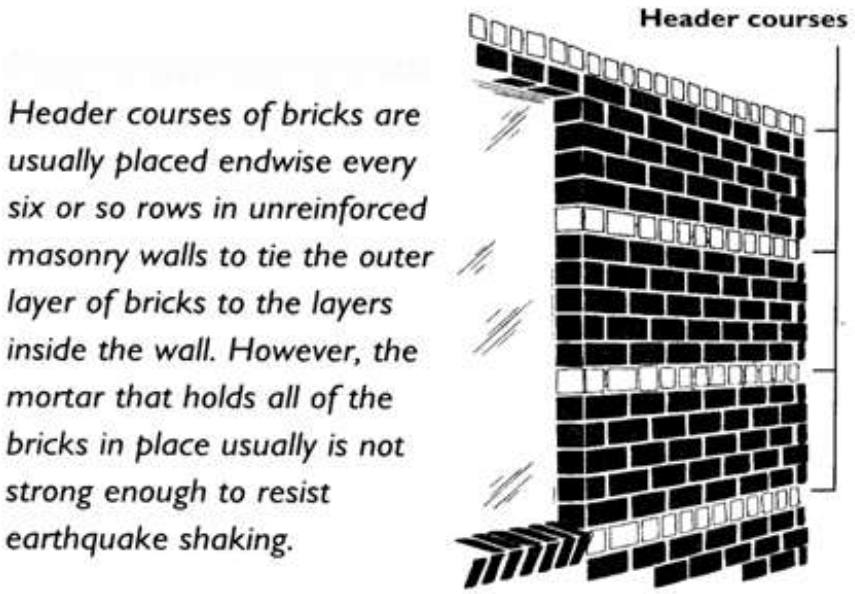



**Figure __. Some building types are easy to reliably identify from the street or sidewalk such as unreinforced masonry buildings**

Plaster, veneer and other building finishes often cover the structural system of buildings. Looking at the alley sides of buildings or peering between closely spaced buildings may reveal unfinished surfaces. Knowing typical characteristics of collapse risk building types will help personnel conduct the field survey more reliably.

After completing the field survey, compile the list of addresses of collapse risk buildings. It may also be valuable to create a digital map depicting the locations of the buildings. It is important that the jurisdiction maintains organized databases. Folders should be set up for each building, sortable by address, assessor's parcel number, neighborhood, historical status, occupancy type, or other identifying characteristics. A Building Survey Form should be included in each folder. A summary file with lists of confirmed and uncertain collapse risk buildings should also be maintained.

*Task Three: Office Verification*

The purpose of this Task is to review existing documents in city files to verify if the buildings identified in the field survey are really collapse risk building types. See Figure ___ for resources to be used in this effort. Once a collapse risk building type is identified, its date of construction is a key factor in determining which code it may have complied with and whether it is a candidate. A jurisdiction's individual code adoption history can indicate cutoff dates after which construction of certain types of collapse risk buildings was no longer allowed. Buildings constructed before the cutoff date should be added to the list unless such buildings were subsequently retrofitted as determined by a search of building permits and construction plan archives.

If a building is already on a list of national, state, or local historical resources, it has been reviewed for architectural importance, but possibly not for seismic vulnerability. Information about structural and nonstructural systems and other pertinent data about historical buildings should be reviewed. Nationally-registered surveys of historical buildings or districts will contain detailed information.

**Figure __. Maps of Historic Districts and information about individual buildings in the district are excellent resources to help identify vulnerable building types**

Early zoning maps can depict older areas of commercial development. County assessor's records may include information on buildings' construction materials, dates of construction, or uses. Sanborn Maps, produced for fire insurance companies beginning in the late nineteenth century, can help date buildings. A sample Sanborn Map is shown in Figure ___, depicting the site plans, the numbers of stories, construction types, and other information.

After finishing the office verification, survey personnel may need to return to the field to revisit certain buildings. In some cases, it still may not be certain whether a building is a collapse risk type. When in doubt, the building should be designated on the list and the owner should be asked for information.

It is important that the jurisdiction continue to maintain organized files. The completed Building Survey Forms should be kept in folders or a database after the field survey and office verification.

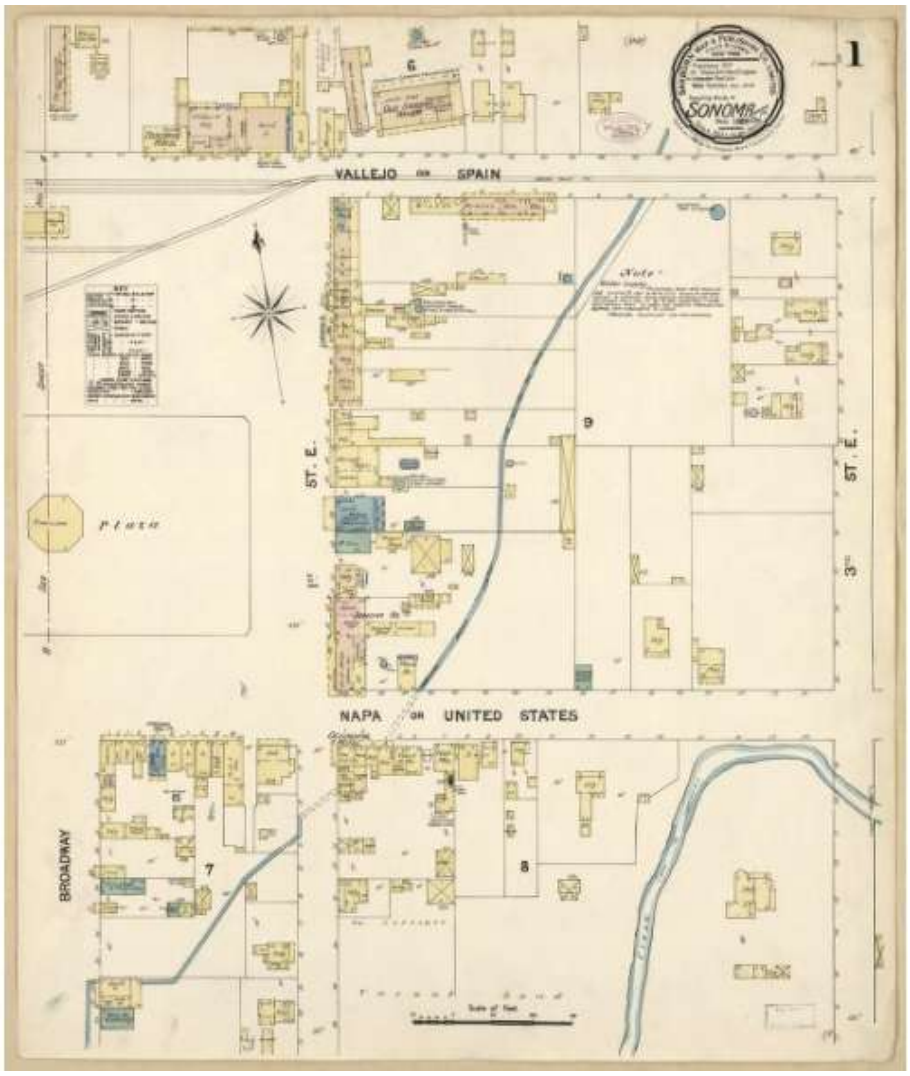



**Figure __. Sanborn maps can be used to identify construction type, age, and footprints.**

*Task Four: Contacting Building Owners*

The Building Official should contact owners of each likely collapse risk building type by emails or letters. Exhibit B includes a sample letter that can be used or adapted. The letters should inform the owners that the jurisdiction may be considering options to manage or reduce the risks of collapse, and it should ask owners to help verify the construction types and retrofit status of their buildings within a reasonable timeframe. A copy of the letter should be included in the building's folder in the database. Not all buildings initially listed as a collapse risk type will turn out to be included in the final inventory. Owners may be able to provide evidence that a building has been retrofitted, is capable of meeting an earthquake performance objective, or is of a type of construction that is outside the scope of the jurisdiction's inventory.

*Task Five: Revising the Draft Inventory*

All information from building owners should be carefully reviewed. If warranted, the local official may then decide to remove certain buildings from the draft inventory.

*Task Six: Publishing the Draft and Operational Inventories*

Once a draft inventory has been completed and vetted with input from owners, it should be made publically available and a reasonable amount of time should be granted to encourage public review and comment. This may generate additional information particularly from neighbors, construction contractors, and design professionals that can lead to further refinements in the inventory. An operational inventory should then be released with a proviso that the jurisdiction expects to make further refinements to the inventory if additional information becomes available. This information should be readily accessible online and updated periodically by responsible parties. After the jurisdiction allows for a reasonable amount of time for owner and public input, perhaps six months to a year, a final inventory can be published. Experience from past, established programs indicates that keeping up-to-date information for public access is a major asset for effectively monitoring progress and measuring the reliability and success of the risk reduction efforts.

**Exhibit B - Sample Form Letter to Building Owners**

<Date>

<Owner Name>
<Owner Address>
Re: Property Located at: <Address of Collapse Risk Building>

Dear <Mr. Ms.  >:

Widespread concerns over earthquake safety caused the City/County of <Jurisdiction Name> to create a draft inventory of collapse risk buildings. Our survey results indicate that your building is likely a <collapse risk building type> that is expected to perform poorly in future damaging earthquakes and pose significant risks to occupants, nearby buildings and/or adjacent public spaces.

The state, through its multi-hazard mitigation plans, encourages local governments to enact risk management programs to identify and significantly reduce the risks posed by collapse risk buildings. The City/County of <Jurisdiction Name> is in the process of developing a <seismic evaluation/disclosure/retrofit program> that may require <_____>. It is expected that a proposed <program/ordinance> will be presented for public review and comment on <date(s)>. Before such a <program/ordinance> goes into effect you and other members of the public will have opportunities to participate in public hearings before formal action is taken on this proposal.

The City/County of <Jurisdiction Name> has compiled a draft inventory of approximately <_____ > collapse risk buildings. The building referenced above is tentatively on the draft inventory. Before this draft inventory of <_____> collapse risk buildings is finalized, the <name of agency> wants to be sure that the inventory is accurate. If you believe that your building is not a <collapse risk building type> or that the building has already been evaluated, retrofitted or is planned to be replaced or otherwise determined not to pose significant risks, please check the appropriate box on the attached form, and return it to our office within two weeks. Please include information to support your opinion.

Sincerely,

<Building Official Name>
<Building Official Title>
<Building Official Name>
<Building Official Title>
<Building Department Address>

**Exhibit C - Sample Form Letter from Building Owners to Building Official**

<Date mailed or emailed>

Dear <Building Official Name>:

My property at <Address of Collapse Risk Building>

☐ is not a <collapse risk building type>.

☐ has been seismically evaluated that demonstrates compliance with a minimum seismic performance objective of <  >.

☐ has been seismically retrofitted to provide a seismic performance objective of <  >. The date of retrofit completion was _____.

Comments and supporting material are ☐ attached / ☐ not attached.

<Owner Name>
<Owner Address>

*Task Seven: Analyzing the Findings*

The final list of collapse risk buildings should be summarized and analyzed. There may be some benefit in categorizing these structures in terms of total number, type of use, occupancy, whether they are essential for emergency response, social and economic recovery and other criteria. This information about the vulnerability of a portion of the building stock will be of interest to agencies and non-profits responsible for emergency services and recovery after earthquakes.

Detailed earthquake loss estimation can be performed using inventory data to generate a much more nuanced and reliable sense of the potential impacts and casualties from future earthquakes. With refined information from the inventory including specific building vulnerabilities and locations, occupancy exposed to the collapse risk, variations in the uses of buildings depending on the time of day, loss estimations can characterize the risk of casualties in much greater detail than estimations which rely on default assumptions with HAZUS.

All of the summary information will help in the next phase of work: considering options for a risk management program.

*Task Eight: Periodically Refining the Inventory*

Jurisdictions, particularly where large numbers of buildings have been inventoried, should plan for and recognize that inventory processes are generally not perfect. New information can emerge in the months and years ahead that could alter the status of buildings on the inventory. When owners of newly discovered vulnerable buildings are notified much later than other owners, they should be granted a reasonable time in which to take actions consistent with that required for other owners.

CITY OF [redacted]

INVENTORY OF POTENTIALLY HAZARDOUS BUILDINGS

The following list represents those structures defined as potentially hazardous in accordance with the provisions of A.B. 547. The structures identified herein are those of unreinforced masonry construction known to have been constructed prior to 1933 and not subsequently strengthened to an acceptable level.

| Building Address | Current use | Daily Occupant Load* |
|---|---|---|
| 6737 [redacted] Ave. | Vacant | 30 |
| 6751 [redacted] Ave. (et al.) | Retail/service | 17 |
| 7028 [redacted] Ave. | Retail/service (currently vacant) | 44 |

**Figure __. Publishing an inventory of collapse risk buildings is an iterative process warranting periodic re-evaluation and amendments.**

*Option Three: Develop Seismic Performance Options*

Both owners and jurisdictions have the option to consider a variety of seismic performance objectives. A performance objective can be described as an expected performance level for a building that is responding to defined earthquake ground motions. Both performance levels and the severity of the ground motion can be varied to generate a suite of options, some basic, others enhanced, and still others that are more limited in scope. State and national building codes and referenced national standards allow for the following alternatives listed in rough order of increasing cost:

- Limited Objectives.
- Partial Retrofit Objectives.
- Reduced Performance Objectives.
- Basic Performance Objective for Existing Buildings.
- Objectives Similar to that Required for New Buildings.
- Enhanced Objectives.

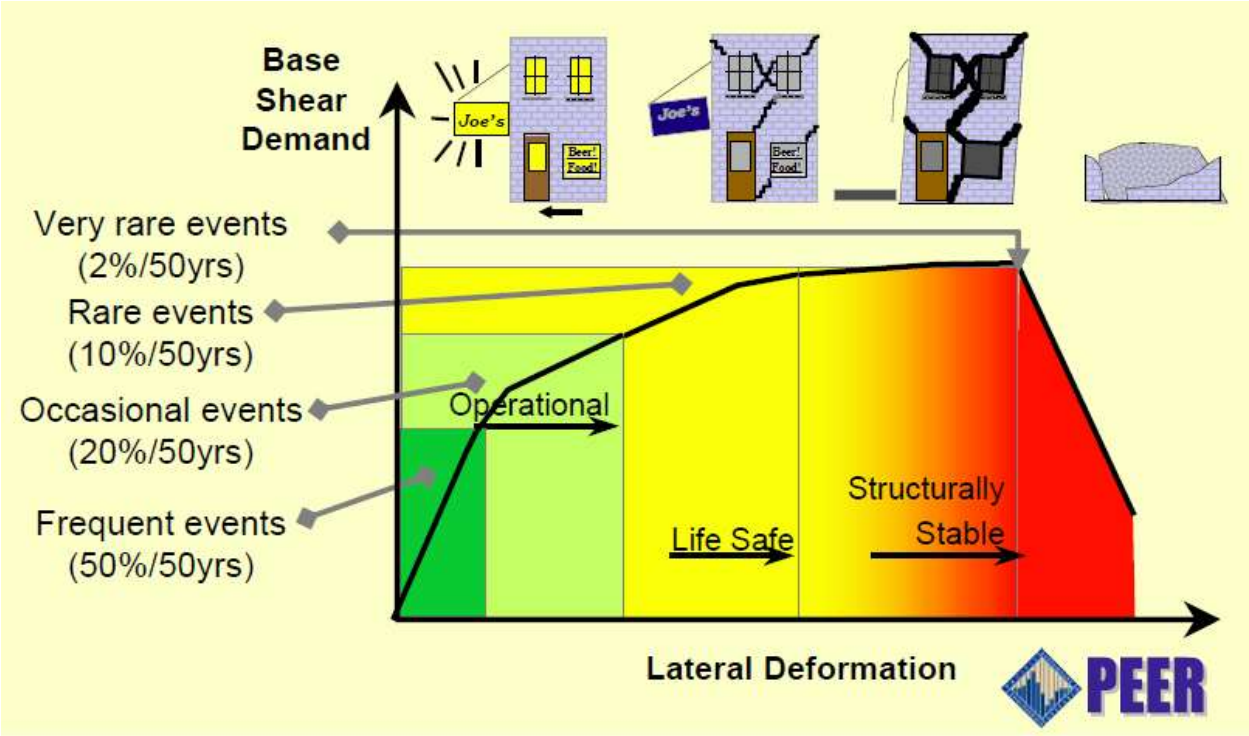



**Figure __. Owners and policymakers need to talk about and decide which performance objective is minimally acceptable for buildings.**

Performance choices can also focus on addressing only the vulnerability of structural systems, or only nonstructural systems, or both. Common structural performance levels are in order of increasing cost and performance:

- **Not Considered**.
- **Collapse Prevention**, which may still pose significant risks to life
- **Life Safety**, which offers an additional margin of performance beyond collapse prevention.
- **Immediate Occupancy**, where functionality above and beyond life safety typically depends on nonstructural systems and building contents

The implication is that buildings meeting a life safety performance level may not necessarily be immediately occupiable after a selected ground motion occurs.

Common nonstructural performance levels are in order of increasing cost and performance:

- **Not Considered**.
- **Life Safety**: Building components may dislodge during earthquakes but won't generally pose significant risks to life or injury
- **Position Retention**: Building components are unlikely to be dislodged but may still be damaged and not fully functioning.
- **Operational**: Structural and nonstructural systems and building contents are expected to fully function after earthquakes.

The severity of earthquake ground motions selected from a range of mean return periods and probabilities of exceedence in order of increasing costs and performance:

| Mean Return Periods for Ground Motions | | Probability of Exceeding Ground Motions |
|---|---|---|
| **Very Frequent** | **43 Years** | 50% probability of exceedence in 30 years |
| **Frequent** | **72 Years** | 50% probability of exceedence in 50 years |
| **Less Frequent** | **224 Years** | 20% probability of exceedence in 50 years |
| **Pre-2000 Building Code** | **475 Years** | 10% probability of exceedence in 50 years |
| **Rare** | **975 Years** | 5% probability of exceedence in 50 years |
| **Maximum Considered** | **2475 Years** | 2% probability of exceedence in 50 years |

A jurisdiction's conversations with stakeholders should include consideration of these options as well as expected future losses, retrofit costs and benefits associated with each. Note that partial retrofits have been observed to have mixed and comparatively less reliable performance than complete retrofits, so retrofit designs that address the complete performance of the building are preferable in terms of safety, resilience, and reliability. It is generally not feasible or economically viable to retrofit existing buildings such that their performance is similar to that required for new buildings, so often owners and jurisdictions are faced with selecting lower

performance objectives. Replacement of vulnerable buildings can often be more cost effective than retrofits.

For example, most unreinforced masonry (URM) building retrofits typically focused on collapse prevention as a structural performance level for a relatively moderate and short duration of ground motions. And only some of the nonstructural risks such as parapet bracing were typically addressed in these retrofits. As a result, many URM buildings will likely be severely damaged and unrepairable after future severe ground shaking. Risks to life will be significantly reduced but not eliminated when compared to the performance of unretrofitted URM buildings.

Similar choices and tradeoffs in light of costs and benefits are expected to influence the selection of performance objectives for other types of collapse risk buildings, in large part because of high costs and disruptions to occupants associated with common retrofit practices.

Before selecting performance objectives for one building or an entire inventory, it is good practice to obtain a more detailed understanding of the deficiencies posed by vulnerable buildings. Seismic Evaluations described in Options Four and Five below address this need.

**Figure __. Free publications from the Federal Emergency Management Agency FEMA can be use of screen building stocks. (FEMA 154)**

*Option Four: Undertake Seismic Screenings*

The most recent tool intended for rapid screening is FEMA 154 *Rapid Visual Screening of Buildings for Potential Seismic Hazards.* A considerably more detailed and costly evaluation protocol is contained in the national standard titled *Seismic Evaluation and Retrofit of Existing Buildings,* ASCE 41-13 (ASCE 2013). Its Tier 1 Screening relies on civil or structural engineers

determining building types, visit buildings, investigating as-built conditions, and, if available, reviewing plans, to fill out a checklist that identifies potential deficiencies common to the building type. Screenings of a sample subset of an inventory of collapse risk buildings will be informative for setting priorities for other options and understanding the risks to the public.

One drawback of conducting rapid screenings or evaluations is that they are not entirely reliable and the actual performance of buildings can depend on other factors not identified in the screenings. In addition, this option provides no consistent way of disclosing the results of the screenings to the public. Quality assurance of such screenings can be problematic and may lead to a loss of confidence by the public if such results were made widely available. This drawback is more specifically addressed in Option Five below.

Project: _____ Location: _____

Completed by: _____ Date: _____

**16.12LS LIFE SAFETY STRUCTURAL CHECKLIST FOR BUILDING TYPES PC1: PRECAST OR TILT-UP CONCRETE SHEAR WALLS WITH FLEXIBLE DIAPHRAGMS AND PC1A: PRECAST OR TILT-UP CONCRETE SHEAR WALLS WITH STIFF DIAPHRAGMS**

**Low Seismicity**

**Connections**

C NC N/A U WALL ANCHORAGE. Exterior concrete or masonry walls that are dependent on the diaphragm for lateral support are anchored for out-of-plane forces at each diaphragm level with steel anchors, reinforcing dowels, or straps that are developed into the diaphragm. Connections shall have adequate strength to resist the connection force calculated in the Quick Check procedure of Section 4.5.3.7. (Commentary: Sec. A.5.1.1. Tier 2: Sec. 5.7.1.1)

**Moderate Seismicity: Complete the Following Items in Addition to the Items for Low Seismicity.**

**Seismic-Force-Resisting System**

C NC N/A U REDUNDANCY: The number of lines of shear walls in each principal direction is greater than or equal to 2. (Commentary: Sec. A.3.2.1.1. Tier 2: Sec. 5.5.1.1)

C NC N/A U WALL SHEAR STRESS CHECK: The shear stress in the precast panels, calculated using the Quick Check procedure of Section 4.5.3.3, is less than the greater of 100 lb/in.$^2$ or $2\sqrt{f'_c}$. (Commentary: Sec. A.3.2.3.1. Tier 2: Sec. 5.5.3.1.1)

C NC N/A U REINFORCING STEEL: The ratio of reinforcing steel area to gross concrete area is not less than 0.0012 in the vertical direction and 0.0020 in the horizontal direction. (Commentary: Sec. A.3.2.3.2. Tier 2: Sec. 5.5.3.1.3)

C NC N/A U WALL THICKNESS: Thicknesses of bearing walls shall not be less than 1/40 the unsupported height or length, whichever is shorter, nor less than 4 in. (Commentary: Sec. A.3.2.3.5. Tier 2: Sec. 5.5.3.1.2)

**Figure __. Checklists in national standards can be used to identify critical vulnerabilities in buildings. C means "Compliant". NC means "Non-Compliant". U means "Unknown".**

*Option Five: Require Seismic Evaluations and Ratings of Buildings*

Beyond Tier 1 screenings, ASCE 41-13 also encourages deficiency-based retrofits for simple buildings using somewhat more detailed Tier 2 evaluations. Complex buildings such as those with irregular configurations, unusual performance objectives may require Tier 3 evaluations so they may not be suitable candidates for Tier 2. Either of these tiers will provide preliminary and conceptual bases for scoping retrofit costs and disruptions to occupants.

Detailed evaluations for a sampling or subset of an inventory of collapse risk buildings could be used to generate more reliable estimates of the performance of similar unretrofitted buildings as well as likely scopes and costs of their retrofits.

Once Tier 1, 2 or 3 evaluations are completed, buildings can be rated using criteria developed by the U.S. Resiliency Council (USRC 2013). Its five-star Certificate of Resilient Engineering (CoRE) rating system is a consistent way to measure and communicate risk and expected building resilience. A five star building is expected to be life safe and have repairable losses of less than 5 percent of the building's replacement value, and be immediately occupiable and fully functional after repairs are completed in under 72 hours after shaking with a return period of 475 years occurs. In contrast, a one star building is a collapse risk. Such ratings could be posted at the entrances to buildings, either voluntarily by owners or as a requirement of the jurisdiction to effectively communicate risks to the public.

There are significant costs associated with assigning USRC CoRE ratings to buildings including training and accreditation for engineers, as well as peer reviews for quality assurance, and an appeals process.

USRC CoRE ratings coupled with detailed seismic evaluations are effective and defendable ways to convey results to the public in an effective simple and consistent manner. Such disclosures may alter the use of buildings by occupants who become aware of risks and place significant pressures on owners to address risks in a timely manner. Vacancy rates may increase or commercial activity may decrease as a result of people choosing to use safer buildings elsewhere. However, evaluations and ratings alone will not significantly reduce collapse risks in the short term. Options Six and Seven below address this shortcoming by describing measures to further encourage voluntary retrofits or require mandatory retrofits and replacements.

*Option Six: Encourage Voluntary Seismic Retrofits or Replacements*

After identifying an inventory of collapse risk buildings, jurisdictions can consider alternatives to reducing their risks. The most viable approaches will depend on each jurisdiction's risk perception, social and economic circumstances, historical preservation objectives, and other factors. A voluntary retrofit or replacement program will be less confrontational and objectionable than a mandatory retrofit or replacement program. But in all respects except the timeline for retrofitting or replacements, voluntary programs are similar to mandatory programs. Four Tasks are generally used to implement a retrofit or replacement program:

*Task Nine: Considering the Circumstances*

Reviews of other laws, policies, plans and socio-economic circumstances are warranted before developing the specifics of an earthquake risk reduction program. For example, the California Environmental Quality Act must be applied when such a program would create adverse impacts on historical buildings to ensure that a variety of alternatives are considered. A jurisdiction's growth projections, historical preservation policies and priorities, development and economic revitalization plans should be consulted. If opportunities arise, changes can be suggested to such plans to address or encourage consideration of seismic safety. Some jurisdictions also face significant vulnerabilities from tsunami and seiche inundation, flooding, landslides, liquefaction, or subsidence. Many of these can be exacerbated or triggered by earthquakes, so they also warrant consideration.

*Task Ten: Selecting Specific Requirements of the Retrofit/Replacement Program*

Voluntary retrofit or replacement programs in the past have included some or all of the following components:

- Notification of the owners and other stakeholders. See Task 11 below.
- Minimum seismic performance objectives for both evaluations and retrofits.
- Financial incentives and removal of disincentives.
- Required seismic evaluations of collapse risk buildings within prescribed time frames.
- Time frames when owners report back to the jurisdiction describing their intentions to carry out retrofits voluntarily.
- Appeals provisions.
- Periodic monitoring of progress and reports to policymakers. See Task 12.

> The purpose of Palo Alto's voluntary strengthening program was twofold, it: "1) revealed the extent of seismic hazards present and enabled owners to gauge the costs and disruption that repairs would involve, and 2) provided an incentive to building owners, where potentially hazardous conditions are revealed, to correct them in a timely fashion." (CSSC 1990-05)

*Task Eleven: Notifying Building Owners and the Public and Implementing the Program*

Some cities and counties have used an effective strategy of publishing a draft inventory of buildings to notify the public and engage stakeholders before implementing a program. Maintaining complete or nearly complete contact information for stakeholders that could be impacted by a proposed program will help ensure they have an opportunity to participate in the development and implementation of the program. Six months to a year may be appropriate for this task. See also Step 1 on page ___. Other stakeholders such as Chambers of Commerce, Business Improvement Districts, Neighborhood Watch Groups, and Neighborhood Emergency Response Teams should also be contacted and kept abreast of steps toward implementing the program.

*Task Twelve: Periodically Monitoring and Reporting on Progress*

Some jurisdictions have found it politically viable and less confrontational to initiate a voluntary retrofit program first. But invariably, there will likely remain a large percentage of owners who will not retrofit or replace their buildings until they are required to do so. It will take several years before the results of a voluntary program begin to take quantifiable effect. The public discourse should explore the likely extent to which owners will voluntarily commit to reducing their buildings' risks and to what degree will financial incentives or removal of disincentives help stimulate their progress.

Stakeholders should also discuss and periodically re-assess the pace of compliance. If a voluntary retrofit program is being considered, owners should be asked to commit to self-determined timeframes, so that policymakers can evaluate progress and compare it to more or less stringent alternatives. Similarly, the pace of retrofits or replacements in mandatory programs can be monitored since political, social and economic conditions are likely to change over time. Judging the adequacy of the pace of retrofits or replacements should take into consideration the risk of damaging earthquakes occurring before the program is fully effective. (See the Management by Metrics Section on page ___)

*Option Seven: Consider Requiring Seismic Retrofits or Replacements*

Mandatory seismic retrofit programs should contain many of the characteristics of voluntary programs as delineated in Exhibit A along with a time schedule for owners to comply with evaluations, retrofits, or demolitions and replacements.

Mandatory Retrofit or Replacement Programs in the past have generally included the following components:

- Procedures to ensure notification of the owners and stakeholders. See Task 11.
- Minimum seismic performance objectives for both evaluations and retrofits.
- Recording of a certificate of collapse risk on the deed of the property that can be removed after a retrofit or replacement is completed.
- Financial incentives and removal of disincentives.
- Required seismic evaluations, retrofits or replacements of collapse risk buildings within prescribed time frames.
- Procedures to ensure effective enforcement of the program including demolition as a last resort.
- An appeals process to address disputes and provide relief in the event of hardships.
- Provisions for monitoring progress including the frequency of periodic progress reports to policymakers. See Task 12.

Considerable discretion should be granted in ordinances to building officials for administering and extending timelines for compliance, since this has proven to be an appropriate and necessary

practice. It enables building officials to speed up or slow down retrofit progress to respond to varying circumstances, economic conditions, and to avoid shortages of qualified contractors to carry out the work. Jurisdictions should plan to stagger timelines for compliance with mandatory retrofits and so that owners don't all wait to the eleventh hour to try to hire retrofit designers and contractors at one time. It is best to spread out a program over several years, perhaps a decade in larger jurisdictions, to maintain manageable levels of design, construction disruption and enforcement activity over time. It is more important to complete retrofit work thoroughly than to rush to meet arbitrary deadlines and, as a consequence, skimp on quality of construction or thoroughness in enforcement of retrofit safety.

**Figure __. Retrofits often involve scaffolding, work in cramped spaces and many safety precautions and inspections.**

**Step 4: Other Key Management Considerations**

*Benefits and Pitfalls of Typical Approaches*

Many adaptable lessons can be drawn from past efforts to manage earthquake risk. The most important ones are:

a) ***One size does not fit all*** **-** No single approach to managing risk has been suitable to the wide variety of seismic risks, social and economic circumstances within California's 482 cities and 58 counties.

b) ***Look around*** **-** Local governments are encouraged to learn from similar communities that have pioneered past efforts and then tailor and adapt from their experiences.

c) ***There are limits -*** Voluntary retrofit programs can work if communities require seismic evaluations, have vibrant economic conditions and sufficient incentives and progress monitoring measures in place, but they can create inequitable conditions where some owners cooperate and others don't.

d) ***Devil's in the Details -*** Mandatory retrofit programs can be confrontational and unenforceable unless there is economic viability and manageable time frames for compliance.

e) ***Be flexible -*** Extending deadlines for mandatory retrofits produces better results than forcing owners to abandon buildings or cut corners on retrofits simply to meet unrealistic deadlines. Staggering and adjusting deadlines for compliance based on actual experience in the community produces better results than setting arbitrary deadlines and forcing compliance regardless of the side effects.

f) ***Ill-conceived efforts can backfire -*** Programs such as simply notifying owners that their buildings are prone to collapse are typically ineffective and can have slower mitigation rates than relying only on natural attrition from additions, alterations, repairs, and sales that can trigger voluntary retrofits.

g) ***Beware of simplistic fixes -*** Programs that have relied primarily on placarding collapse-risk buildings to warn the public have been difficult to enforce over time and have generally been ineffective.

h) ***Don't bank completely on the unknown –*** For example, programs that rely on seismic ratings of buildings have little or no track record yet for motivating owners to retrofit or replace vulnerable buildings.

i) ***History is a compelling motivator -*** Regions of California that have experienced damaging earthquakes nearby tend to manage earthquake risk more assertively than regions that have not experienced damaging earthquakes in recent history.

j) ***Gestures can be motivational even without much substance -*** Financial incentives have been generally too small to provide meaningful motivations for building owners to retrofit sooner. However, the discussions that can lead to local governments committing to financial incentives can be useful as a tool to engage stakeholders, convey the commitment and priorities of policymakers and encourage cooperation.

k) ***General interests can't be met with one solution –*** The needs of individual owners and neighborhood economic conditions vary greatly, so many jurisdictions can help by developing a suite of financial incentives and the removal of disincentives that best suit the jurisdiction's needs. Uniform statewide solutions tend to be inflexible or inadequately funded to be effective for a large number of owners. See Items l and m below.

l) ***Special interests are often the focus*** **–** But some financial incentives are only available to a narrow pool of eligible building owners (such as Federal Tax Credits for Nationally-Registered Historical Buildings).

m) ***Avoid too many strings*** **-** Eligibility conditions and red tape required to apply for some financial incentives have at times created so many restrictions that owners have opted out of applying. Management costs incurred by local governments to administer some incentive programs have disproportionately cost more than the benefits accrued. Tax laws or market conditions can change rendering financial incentives inflexible or underused if they are unable to be updated.

*Hazards Vary for Each Jurisdiction and over Time*

California's earthquake hazards vary greatly from region to region depending on proximity to known, active faults. On one extreme, the Triple Junction region near Cape Mendocino where the Pacific, North American and Juan de Fuca Plates intersect is one of the most active regions in the U.S. In contrast, parts of eastern California are relatively stable with quite modest hazards. This is one reason why advocating for uniform seismic risk management policies is generally not appropriate for statewide adoption. Regulations across the state currently vary consistent with known variations in hazards.

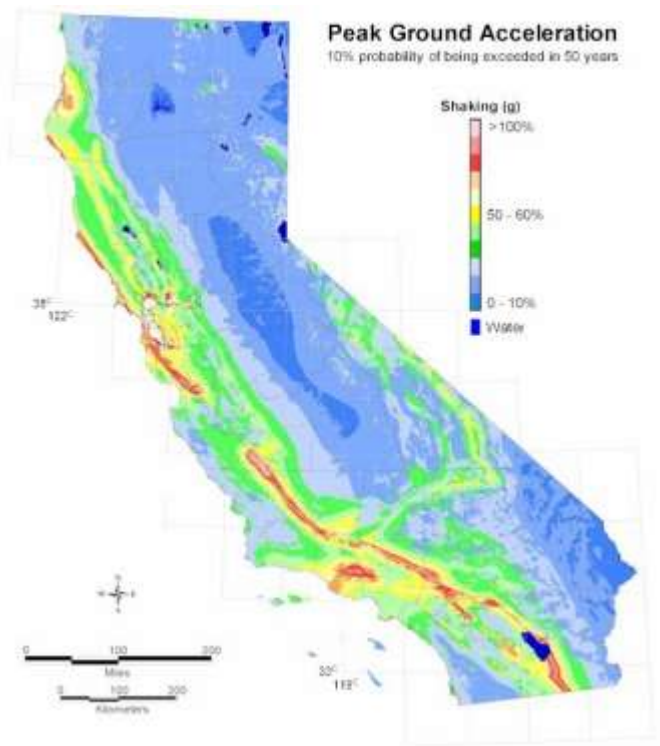



**Figure __. Seismic hazard varies greatly across California depending on distances from active faults and soil conditions.**

In addition, some regions recently experienced damaging earthquakes and are now in a period of relative quiescence as stress rebuilds within the earth's crust before future earthquakes occur. So the absence of earthquakes in recent decades may not be a reliable indication of actual hazards. Also, recent small to moderate earthquakes may not be reliable indicators of future earthquakes that can be much larger, somewhat closer, and more damaging. Just because your city or county may have "survived" past earthquakes, that is not necessarily an indication of future losses.

Furthermore, many California earthquakes in the past half century have occurred at relatively fortunate times of the day when people were less exposed to casualties from falling buildings. No two earthquakes will necessarily be alike. Perhaps parts of California have been lucky in this respect.

*Major, Secondary Effects*

*Impacts with Regional, National or International Significance*

The implications associated with loss of functions or collapse of buildings that house assets with regional, national or international significance should warrant higher priority consideration than other buildings.

For example, in small jurisdictions, vulnerable buildings whose damage could disrupt traffic flow along major transportation arteries can justify contingency planning. Are detours around such buildings to maintain traffic flow feasible? Could hard barriers be feasibly installed during repairs or demolition to maintain traffic flow?

In large jurisdictions, it can be prudent to evaluate concentrations of multiple assets within a few blocks of development. Their co-location risks should be considered in the event that one or more buildings that are severely damaged or collapsed could indirectly disrupt entire neighborhoods and regional economies. Multi-agency table-top exercises that address traffic flow considerations or ad hoc Task Forces to characterize the risks of tall buildings and envision "Red Zones" that define plausible extents of collapse are two potentially useful ways to pre-identify and pre-plan for vulnerabilities and impediments that could inhibit safety and recovery. Economic impact studies could also help postulate the range of indirect effects of such impacts and identify risk management alternatives to speed recovery.

*Fire Following Earthquakes and Fire Protection Needs*

Recent earthquake scenarios (USGS HayWired, 2015) (USGS Shakeout, 2005) as well as many older scenarios have identified the potential for conflagrations following earthquakes to generate far greater losses than shaking-related damage. Major variables are how much wind is blowing once fires start and how easily fire is likely to spread to adjacent buildings. Other studies referenced in these scenarios suggest that the number of fires will greatly exceed local and regional fire fighting resources, thus requiring mutual aid from other regions and states.

However, mutual aid from distant regions and other states can take many hours to arrive when they may be needed the most, leaving fires to spread unabated or victims trapped in collapses.

**Figure __. Fires following earthquakes will likely spread faster in buildings damaged during shaking.**

Shaking damage can compromise a building's fire resistance and enable the spread of fire as demonstrated by recent tests on a shaking table. (UC San Diego BNCS 2012)

Risk managers for jurisdictions can generate shaking loss models (HAZUS 2014) and fire spread models to help characterize this risk and evaluate the relative effectiveness of various risk reduction alternatives.

*Water Damage*

Damage to functions, nonstructural systems, and building contents from broken sprinkler systems, toppled water heaters, and flooding from other piping has the potential to rival shaking-related losses in many buildings. Recent enhancements in building code requirements for newer buildings are expected to help reduce future losses, but the vulnerability of older buildings to post-earthquake water damage persists. Retrofits for sprinkler systems, water heater and pipe bracing can be accomplished through periodic, routine maintenance programs that significantly reduce this risk. Training occupants to quickly identify and shut off water sources can also help minimize losses.

*Nonstructural Losses and Building Contents Losses*

The vast majority of buildings are not expected to collapse, but typically nonstructural systems (ceilings, external cladding, windows, mechanical and electrical equipment, and partitions) will result in greater costs and disruption to functions than compared to losses from structural systems. Post-1980 buildings are expected to have more earthquake-resistant nonstructural systems than older buildings because of enhanced requirements in buildings codes and standards since then. (See page __)

**Figure __. Ceilings that move during earthquakes can shear sprinkler heads off causing water damage.**

*Façade Risks and Maintenance Programs*

Facades of existing buildings are subject to weathering and deterioration. They can benefit from periodic inspections to ensure that cladding, windows, and ornamentation are: 1) adequately connected to structures; 2) to identify corrosion and other signs of maintenance needs; and 3) reduce their risk of falling in earthquakes. Well-maintained facades will help reduce deaths and injuries on sidewalks and public rights of way as well as reduce disruptions to adjacent buildings and roadways. Some jurisdictions, redevelopment and business improvement districts, and historic buildings with Mills Act agreements have or are planning to implement façade maintenance programs that encourage or require building owners to more actively and consistently manage this risk.

*Electrical and Communication Networks, Infrastructure Vulnerability*

Functions in buildings depend on external infrastructure that includes electricity, gas, water and telecommunication. The failure of one or more of these can disrupt functions triggering indirect losses (including social, economic, and unemployment effects) that can be several times larger than direct losses from shaking. Major utilities generally have implemented earthquake risk reduction programs. But many smaller utilities have chronically underinvested in such efforts.

Internal damage to nonstructural and structural systems of buildings that are the responsibility of building owners and beyond the control of utilities can also interrupt electrical, telecommunication, and other utilities. Seismic evaluations and retrofits should include consideration of these effects.

*Social Implications of Risk Management Alternatives – Social Vulnerability from Collapse Risk Buildings*

The most vulnerable population groups including the elderly, poor, disabled, and non-english speaking, experience disproportionate losses in disasters. These groups often occupy low-income housing that tends to be more vulnerable than other housing. The need for emergency shelters and interim housing after future earthquakes will be dominated by these vulnerable populations. Government-subsidized housing to help replace damaged housing is expected to dramatically increase to possibly over a hundred thousand housing units, and could last for many years after some major metropolitan earthquakes. (ABAG, *Shaken Awake*, 1996, *Preventing the Nightmare*, 1999)

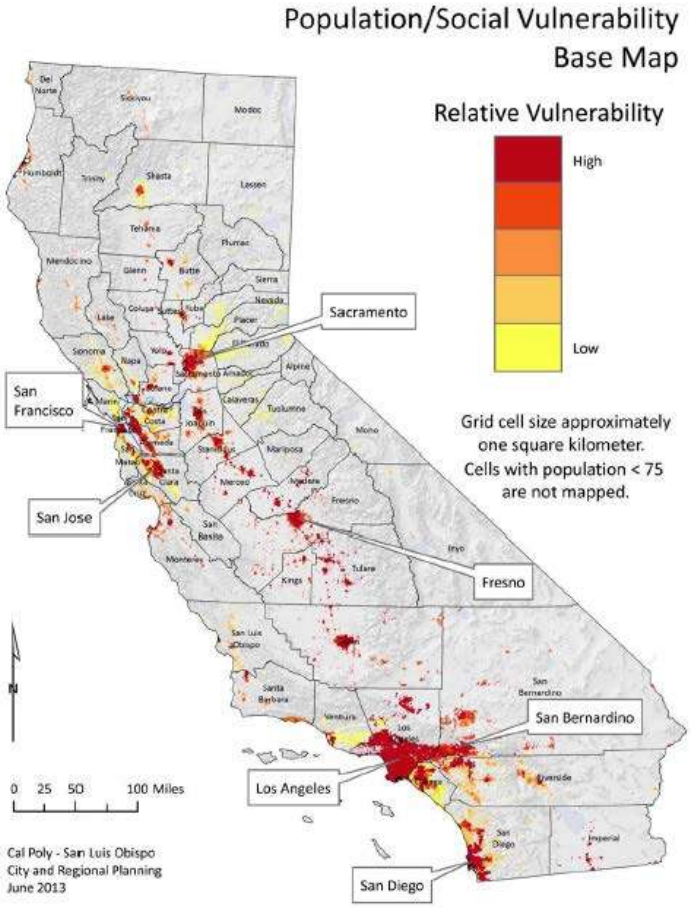



**Figure _ Social vulnerability in the Coastal and Southern Inland Empire regions correlates with high earthquake hazards (Multi-hazard Mitigation Plan 2013)**

The state's Multi-hazard Mitigation Plan (OES 2013) summarizes social vulnerability by census tracts based on 2005-7 American Community Survey data combined with the 2000 Census data for tracts with population densities greater than 75 people per square kilometer. The map in Figure __ showing social vulnerability in areas at high risk to earthquakes hazards suggests that the greatest concentrations are in Southern California and the San Francisco Bay Regions. Local governments are encouraged to conduct similar studies of social vulnerability as the basis for their local multi-hazard mitigation plans. The statewide map lacks sufficient detail to distinguish those sub-regions in metropolitan areas from other less vulnerable regions. However, local studies using a similar approach, particularly with more detailed information about the inventories of collapse risk buildings, their locations and occupancy types can generate considerable insights. Such information was compiled for San Francisco and Ventura regarding URM buildings in environmental impact reports (San Francisco 1990) (Ventura 1991).

*Financial Implications of Risk Management Alternatives*

For most building owners, seismic retrofits pose new expenses without clear opportunities for increased revenues to pay for them. Rental rates are often set by the market irrespective of whether individual buildings are retrofitted. Older buildings often house marginal occupants or are only partially occupied, so in many cases they may have already exceeded their economic life. Retrofitting or replacing the buildings whether for seismic or other reasons can eliminate the small businesses that occupy them, causing economic problems such as loss of jobs in the segments of society perhaps least able to bear them. Moreover, many older buildings possess architectural and character-defining features that lend charm, historical significance, and distinct identities to communities. Adaptive reuse and modernization of buildings can maintain and enhance the positive qualities that they possess (SSC 87-020). (See Page __ for Historical Buildings)

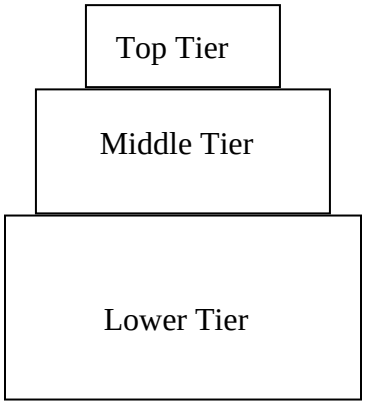



**Figure _ - The Wedding Cake of Building Types**

Neighborhoods and their individual buildings typically fall into one of three tiers of economic vitality:

- The **Top Tier** consists of buildings that retained consistent growth in equity, command high rents and are fully occupied. These are excellent candidates for seismic retrofits and adaptive reuse since owners typically have the ability to refinance and generate funds to pay for improvements.
- The **Middle Tier** consists of buildings being used for more marginal businesses or as housing for low-income people that are already being rented at or near the prevailing rates in their area. Financing for seismic retrofits for these buildings is much more difficult. Such buildings often have been owned by a single family for a long period, and the owners don't have the funds or inclination to spend money on them. Even if they are upgraded and modernized, the buildings cannot command much, if any, more rent since rents are determined by market conditions in the neighborhoods in which they are located. Financial institutions can be unwilling to make construction loans for seismic retrofits without clear revenue sources. Banks will loan on the middle tier if they can be confident that projects will be completed on time and within budget, and the revenue streams and the owner's other assets are reliable so that their equity is protected from default. They can be marginal candidates for seismic retrofits or good candidates for replacements depending on a wide variety of factors.
- The **Lower Tier** consists of buildings that have long exceeded their economic life. They are often vacant or partially vacant and no longer generate sufficient revenues. Owners are banking on the value of the land, more than the building itself, or hoping that speculators will take them off their hands. (SSC 87-02) Gradual demolition by neglect and blight is commonplace. These properties are primarily candidates for replacement since they often require much greater investments than merely seismic retrofits to restore them to the Middle Tier. Such investments are generally not cost-effective.

Mandatory seismic retrofit ordinances that don't provide adequate time for owners to comply can leave many owners with untenable choices. They can make the improvements with private financing and try to pay for them by increasing rents, or they can try to disinvest and sell the properties to others who may be willing to invest in retrofits. Some owners will milk their buildings for all they are worth until ordered to vacate, then, through demolition by neglect, hope to convert the sites to other and more economical uses. (SSC 87-02)

Darwin's Principle of Evolution - survival of the fittest - applies to buildings. Owners, governments, and other stakeholders should adopt realistic expectations when managing the building stock. It is realistic to assume that the use of top and middle tier and perhaps a few lower tier buildings can be extended or adapted. However, many lower tier buildings should probably be replaced unless sustainable financial mechanisms can be found. Consider that thousands of demolitions of severely damaged buildings after future metropolitan earthquakes are expected. So policies that gradually replace vulnerable, under-used buildings over decades can be a preferable alternative compared to policies that expect all lower tier buildings to remain in use for generations to come.

Seismic risk management approaches including incentives, compliance time frames and expectations can be tailored to each tier since their circumstances and financial and social needs are so different.

**Figure __. Retrofits can be part of a façade improvement effort.**

*Ranges of Current Retrofit Costs for Building Owners and Occupants**

Costs per square foot of floor area for seismic retrofits vary widely, depending on a host of factors:

- Size of the building since smaller buildings will typically experience higher retrofit costs per square feet of floor area than bigger buildings.
- Number of stories.
- Building shape and regularity of configuration, since irregular buildings will generally experience higher retrofit costs compared to buildings with simple shapes.
- Quality of the original building design and construction.
- State of repair and deferred maintenance of the building.
- Skill and experience of the retrofit design professionals.
- Skill and experience of the retrofit contractors and their personnel.
- Location of the building and proximity to other buildings that may constrain the retrofit
- Local wage rates and how the retrofit is financed. Some sources require the use of more costly labor.
- Whether building owners can manage any of the design or construction coordination themselves.
- The seismic performance objective or standard that the retrofit is expected to meet.
- Whether innovative technologies are used for the retrofit.

- Whether other improvements such as modernizing the building's access, energy consumption, mechanical or electrical systems should be done at the same time as the seismic retrofit (SSC 87-02).

The Seismic Safety Commission does not maintain a database of current retrofit costs. The Federal Emergency Management Agency sponsored the last known effort to provide a cost database using an inventory of retrofits conducted primarily in the 1980's and 1990's (FEMA 156/7, 1995, FEMA Cost Estimator 2013). However, seismic retrofit standards and retrofit approaches and costs have changed significantly since then, so those costs may no longer be reliable. Nevertheless, these outdated cost databases provide a sense of the high variability of retrofit costs and the factors that contribute.

Experiences with government retrofit programs suggest that retrofits are often less than half the total value of typical modernization projects.  (Reference UC and CSU Seismic Review Board, 2004?)

Local governments are encouraged to track and share with other jurisdictions and the Seismic Safety Commission their permit valuations for such work and, where possible, segregate out the cost of bare-bones seismic retrofits from other unrelated alteration costs. This information, particularly the variations and trends in costs, are critical for judging the cost-effectiveness and life-cycle costs of seismic retrofits.

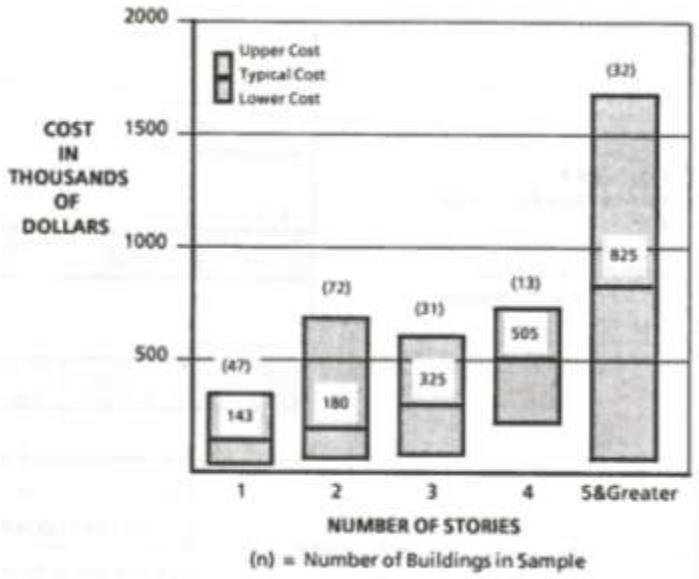



**Figure _ Retrofit costs are known to vary greatly. Federal cost databases were last updated in 1994 (FEMA 156).**

*Ranges of Current Costs to Local Governments*

Some vulnerable building types are relatively easy to identify and inventory. For example, unreinforced masonry buildings and soft story apartments can typically be identified and

inventoried by sidewalk and alleyway surveys in well under an hour per building. Unretrofitted, unreinforced masonry buildings almost always pose collapse risks or serious parapet falling risks. In contrast, many soft story apartments may have irregular lateral force resisting systems that can protect against collapse. In this case, more detailed seismic evaluations of apartments could find them to be earthquake resistant and removed from final inventories of collapse risk buildings.

Other types of buildings such as reinforced concrete are far more difficult to quickly and reliably identify as risk to collapse since architectural finishes may obscure the structural system. Many were built in accordance with some earthquake resistance requirements, and most have concrete walls that can enhance resistance compared to buildings without walls. Upon further scrutiny beyond simple sidewalk surveys, detailed seismic evaluations that include reviews of original construction plans will likely indicate that many, perhaps most smaller concrete buildings do not pose significant collapse risks.

As a result, the costs to identify and inventory buildings depends greatly on the types and numbers of buildings to be addressed. Only when such buildings are few in number will building code enforcement agencies be capable of absorbing inventorying costs within existing budgets. In most other cases, agencies will require additional funds to conduct systematic inventories and review seismic evaluations. Local building departments should anticipate long, perhaps five- to twenty-five year durations for internal program management when estimating staffing needs.

Local governments are encouraged to track their costs and share this intelligence with other similar jurisdictions and the Seismic Safety Commission.

**Figure __. Retrofits often include adding new connections of walls to roofs.**

*Benefit-Cost Comparisons*

A few local governments have conducted benefit-cost studies for unreinforced masonry buildings (San Francisco 1990) (Ventura City 1991). These can inform considerations for future benefit cost studies since they articulate alternatives and offer advice on how to account for variability in losses including such effects as earthquakes occurring at different times of the day when occupancy and sidewalk usages differ.

A 2005 benefit-cost study by the National Multi-hazard Mitigation Council (MMC 2005) called "Natural Hazard Mitigation Saves" suggested that overall, each dollar spent on multi-hazard mitigation provides the nation about $4 in future benefits with typical benefit cost ratios for earthquake mitigation in the range of 1.5 to 1. However, that study's interest rate used to compute the present value of future benefits was called into question by the Congressional Budget Office (CBO 2007). If the CBO's adjustments to MMC's report are considered, benefit cost ratios for some past earthquake mitigation projects are less than 1.0 and were thus not necessarily cost effective unless other, indirect and qualitative benefits are considered.

There are no recent benefit-cost comparisons that account for recent changes in current seismic evaluation and retrofit codes and standards.

*Model Ordinances and Other Approaches Adopted by Local Governments*

Some agencies have already adopted programs that can serve as models for other jurisdictions. Most performance objectives for seismic retrofits are considerably lower than that required for new construction due to high costs. They may intend to significantly reduce risks to life, but not necessarily or entirely eliminate the risks. Typical seismic retrofit objectives do not attempt to limit property damage or ensure repairability of damaged buildings after earthquakes. State law authorizes local governments to adopt retrofit standards that do not fully comply with requirements for new buildings (Health and Safety Code 19160 *et seq*). This law also provides certain liability immunities to local governments. (See Resource Materials page __)

The Seismic Safety Commission monitors and keeps a database of local government retrofit programs. Local governments are encouraged to contact the Commission to get information about what similar agencies have accomplished or are proposing elsewhere in California. There have been many lessons learned from prior efforts, so the Commission provides a clearinghouse of information to help facilitate risk management practices by taking advantage of the experiences gained by others.

**Local Government Immunity from Liability**

No city, city & county, or county, or any employee of any such entity, shall be liable for damages for injury to persons or property, resulting from an earthquake or otherwise, on the basis of any assessment or evaluation performed, any ordinance adopted, or any other action taken pursuant to this article, or on the basis of failure to take any action authorized by this article. (19167 Health & Safety Code)

In the past, the Seismic Safety Commission has encouraged statewide organizations such as the California Building Officials, the California Council of the American Institute of Architects, and the Structural Engineers Association of California to work together to develop recommended model ordinances. These documents can improve enforceability and consistency by encouraging jurisdictions that adopt them to take advantage of vetted and consensus experience from other members of the organizations. At present, a model ordinance only exists for unreinforced masonry buildings (CSSC 2006). As the needs and consensus arise, the development of other model ordinances may be pursued.

Six case studies are also provided in Part 8, Additional Reference Material, page __.

*Incentives and Reduction of Disincentives*

Following is a list of earthquake risk reduction incentives and the cities that have adopted them. Each city should be contacted for more information (EERI-NC, 2006): The Seismic Safety Commission maintains information on each local government in the high seismic regions of California and can direct inquiries into various alternatives for incentive management.

- **Waiver of Permit Fee for Seismic Retrofit**: Albany, Berkeley, Fremont, Livermore, Los Gatos, Morgan Hill, Oakley, San Rafael, Sonoma, St. Helena.
- **Permit Fee Reductions**: Pittsburg, San Leandro, St. Helena.
- **Local Tax Breaks**: St. Helena's Mills Act, Redwood City's Mills Act.
- **State Tax Breaks:** Taxes reduced for earthquake strengthening when applicable forms are submitted prior to retrofitting. Contact your County Assessor's Office.
- **Federal Tax Breaks:** 20% federal tax credit for seismic retrofits of historical buildings on the National Register, limited to work that is certified by the National Park Service and the State Historical Preservation Officer in the State Department of Parks and Recreation.
- **Federal Mitigation Incentives:** The Disaster Mitigation Act of 2000 (DMA2000) allows for enhanced eligibility for post-disaster mitigation funds for those jurisdictions that have effective mitigation programs established prior to disasters.
- **Grants**: Brentwood, Colma, Emeryville, Morgan Hill, Napa, Pinole, St. Helena, Windsor,
- **General Obligation Bonds:** San Francisco. These can be used for retrofitting privately-owned buildings when the local jurisdiction declares such work is in the public's interests.

- **Other More Unique or Less Used Incentives**:
  - Dixon – $3 per square foot of floor area for URM retrofits
  - Fremont – low interest loans for redevelopment area Napa's redevelopment funds for retrofit designs
  - Palo Alto – allowances for additions waivers
  - Los Gatos – parking waivers
  - San Leandro – special assessment district loan program
  - San Mateo – storefront improvement loans and grants

- Santa Clara – 3% interest, 5 year loans for engineering analysis
- Sonoma – grants for retrofit designs
- Vacaville – 3% interest, 25 year redevelopment loans
- Vallejo – Up to $40,000 per building from Community Development Block Grants
- Berkeley's Transfer Tax is a unique example of a large, effective incentive that enabled Berkeley to achieve more than three times the number of retrofitted homes of adjacent cities. However, it will only apply to jurisdictions that also levy transfer taxes like Berkeley when buildings are sold.
- Property Assessed Clean Energy (PACE) financing: Offered by AllianceNRG through a non-profit organization California Statewide Communities Development Authority's OpenPACE program. Note however that only one seismic retrofit project has been financed so far by this program that is available at the owners' discretion in 59 cities and 11 counties as of February 2016.

*Adaptability and Sustainability of Incentives*

The adaptability of incentives used by other jurisdictions depends greatly upon the similarity of economic and real estate conditions, the owner's willingness to pay depending on the size and effectiveness of the incentive, and current competing lending rates or other alternatives available in the market.

**St. Helena's Unreinforced Masonry Building Program Incentives**

St. Helena has 33 buildings in its inventory, and the owners have retrofitted all of them. The city provided numerous incentives including building permit fee waivers, creation of a historic district to take advantage of a 20% federal tax credit, use of the state's Mills Act to preserve facades and reduce costs, and a streamlined design review process.

Tax laws have changed dramatically over the years, rendering many earlier attempts at incentives, such as the Marks Historical Bond Act and some types of special assessment districts such as Mello-Roos, either non-applicable or less feasible.

Some incentives are not readily adaptable to other jurisdictions unless tax laws are similar, which is the case for Berkeley's Transfer Tax since most other jurisdictions don't have a transfer tax and creating new taxes coupled with offsetting incentives would require a two-thirds vote of the electorate. Many incentives have a limited life or effectiveness. For example, special assessment districts may be created once and not allow for additional participants at later dates. Some below market-rate loans may become unattractive with changes in the market or for owners unable to take on additional loans.

As a result, governments should periodically review existing incentives and options for new or revised incentives since conditions change with time and the economy as well as changes in local, state, and federal laws. (EERI-NC, 2006) Two out of date publications summarize financial incentives and their limitations (EERI 1998) (ABAG 1992).

*Life cycle Returns on Investments as Incentives*

Some building owners have conducted life-cycle studies to estimate the potential returns on their investments if they were to voluntarily retrofit their buildings. For example, in Southern California, earthquake insurance is available for some retrofitted tiltup buildings. One construction company provided anecdotal examples suggesting that retrofits of tilt-up buildings can generate returns on investments primarily in the form of reduced insurance premiums within 2 to 5 years. ***(**Add reference or delete this statement? ___**)***

Other vulnerable building types for which earthquake insurance is readily available or affordable may benefit from potential net savings in avoided business interruption, life loss, injuries, or property losses by taking into account the infrequency of earthquakes and the time value of money. (See page ___ about benefit cost studies)

**Figure __. New braces are a common retrofit strategy.**

*Market-Driven Incentives to Attract Tenants and Obtain Loans*

Some proponents of seismic retrofits have adopted a strategy that safer buildings will be more competitive in the rental market, perhaps resulting in lower vacancy rates, commanding higher rents. Visible indicators of seismic retrofits such as prominent walls or diagonal braces in storefronts have been architecturally emphasized in some building modernization projects suggesting that they provide attractions to owners and potential tenants. On the other hand, there is little evidence that owners have been able to reliably charge higher rents for retrofitted buildings. Anecdotal observations suggest that most rents are set by the market and not greatly influenced by individual building safety or perceptions of safety.

Probable Maximum Loss (PML) estimates are generally required by lenders of commercial mortgages. Some lenders will not issue mortgages if PML's exceed 20% of replacement value. Seismic retrofits will substantially reduce PML's and enable some owners to get access to market-rate loans. However, PML's are often overly simplistic, inaccurate or inconsistent indicators of building risk. And retrofits with low performance objectives may only address life loss, but still pose substantial risks to business interruption and loss of property value after damaging earthquakes. Consider using a more comprehensive rating system as an alternative to PML's such as the USRC's CoRE rating system. (See page ___)

## Additional Strategies & Other Management Considerations

*Including Seismic Objectives in Other Planning, Zoning and Development Initiatives*

Since earthquake risk management is typically not a community's highest priority until damaging earthquakes occur, local governments are encouraged to include seismic issues when developing and implementing other initiatives. Pre-Earthquake Planning for Post-Earthquake Rebuilding (Spangle, 1986) has been used as a technique to visualize the nature and extent of future losses and to identify opportunities that will influence changes to seismic resilience more gradually through change spurred by other planning, revitalization, growth inducing, zonation and historic preservation initiatives.

**Economic Development:** It is best to include considerations of seismic risk when making decisions about enhancing a community's economic vitality. Communities should avoid overdependence on vulnerable buildings unless reinvestment plans include seismic evaluations and retrofits where needed.

**Urban Revitalization and Reducing Social Vulnerability:** Streetscape and façade improvements on buildings may be poor investments unless their collapse risks are also addressed. Repairing single-room occupancy apartments for low-income residents should also include retrofits. However, there are several examples of past California earthquakes that have destroyed earlier redevelopment investments. Earthquakes damaged previously-renovated portions of Whittier in 1987, Santa Cruz in 1989, and Paso Robles in 2003.

**Figure __. Downtown Whittier relied on a Redevelopment District prior to the 1987 earthquake, but no funds were allocated to seismic retrofits. Much of its investments were lost due to damage.**

**Transportation Management, Smart Growth, and Green Growth:** Intensifying new developments or investments in older buildings near transit hubs and population centers should avoid over-reliance on collapse risk buildings. Growth priorities should target the replacement or adaptive reuse of lower and middle tier buildings at risk of collapse. Resilience in new construction and retrofits should be promoted since the greenest, smartest buildings are earthquake-resilient.

**Influencing Adaptive Reuse and New Investments in Urban Areas with Zoning Incentives:** Encouraging owners to intensify or change the uses of their buildings can be accomplished with parking waivers, building height allowance transfers to other owners, easing nighttime use

restrictions, allowing certain occupancies as well as other types of zoning changes. Seismic evaluations and, if warranted, retrofits should be considered as a condition for eligibility for these incentives.

**Efforts to reduce fire, flood, climate change, and terrorism risks:** Land use planning decisions should incorporate seismic considerations along with the management of other natural hazards.

*Other Requirements that can be Triggered by Retrofits*

The California Building Code contains specific triggers for additional work beyond seismic retrofits including abatement of asbestos, improving disabled access, adding fire sprinklers, carbon monoxide detection and other life safety requirements. Generally most owners will include modernization and other improvements in conjunction with seismic retrofits. It can be more cost-effective to make several kinds of improvements to buildings when undergoing seismic retrofits. The costs associated with complying with other non-seismic requirements can often exceed the seismic-only costs of a retrofit.

*Investment and Tax Losses due to Earthquakes*

Many jurisdictions have commonly invested millions of dollars in prior redevelopment projects by foregoing property tax increments or providing subsidies or other incentives in efforts to finance renovations and attract investors. Investments that can be at risk if collapses were to occur in older neighborhoods are often a combination of public and private assets. Individual owners, business improvement districts, chambers of commerce and communities as a whole should consider alternatives for how to best protect prior and future investments from earthquake losses. Future tax revenue projections depend on assumptions that buildings will continue to function and owners will be paying property taxes. However, these assumptions often do not reflect the vulnerability of those assets, but financial contingency planning by local governments should include the potential for loss of tax revenues after earthquakes.

*Earthquake Insurance as a Tool to Transfer Liability*

As of 2015, only about 8.5 percent (CDI, 2015) of all commercial property in California is insured for earthquake losses. Generally premiums are affordable for building classes that have a good record of performance in past earthquakes. In contrast, unreinforced masonry buildings are typically uninsurable. Local governments are sometimes self-insured or participate in a pool of insurance with other governments. Building owners are encouraged to periodically explore insurance alternatives including how much of an impact seismic retrofits will have in reducing future losses and premiums. Some insurance companies offer incentives to owners to evaluate buildings and reduce their risks.

*Management by Metrics*

Since the issues raised by collapse risk buildings are typically not going to be resolved in a short time frame, risk managers and policymakers should consider adopting a system of metrics, periodic monitoring, and benchmark goals to periodically address the following questions:

***How big is the threat posed by collapse risk buildings?*** Questions about the size and nature of the threat can be addressed by developing estimates or more detailed inventories of classes of known vulnerable building types, as well as retrofit and replacement cost estimates, and loss estimates for earthquake scenarios or probabilistic studies.

***What are we currently doing to address the threat and how many years will current policies take to reduce the threat to acceptable levels?*** Questions about how effective our current policies are and how many years it will take can be addressed by developing a detailed inventory of buildings (Option Two on Page __) and monitoring individual building retrofit and replacement progress over several decades including information about the range of seismic performance objectives for the retrofits. Overall progress can be reported as a mitigation ratio, namely the sum of retrofitted plus replaced buildings divided by the number of inventoried buildings in a jurisdiction's vulnerability class. Mitigation ratios have been published for unreinforced masonry buildings. The statewide average was 70 percent of the buildings retrofitted or replaced in regions of high seismicity when last surveyed in 2006 (CSSC 2006).

**A Common Risk Reduction Metric to Measure Progress:**

$$\textbf{Mitigation Rate (\%)} = \frac{\textbf{(\# Buildings Retrofitted + \# Buildings Demolished)(100\%)}}{\textbf{(\# Collapse Risk Buildings in Inventory)}}$$

Option One (Page __) relies on current triggers for voluntary retrofits and replacements and will likely reduce collapse risks at a relatively slow pace over several generations, ranging from 50 to 250 years depending upon market conditions and how often buildings are sold and renovated. Gradual investments in maintaining and upgrading buildings will vary over time. Major repairs, alterations and additions should trigger retrofits or replacements.

Each jurisdiction can determine the current annualized rate of mitigation by monitoring progress over several years. This can be reported as an incremental increase in the mitigation ratio or an annualized rate of mitigation expressed as a percentage of retrofit and replacement progress per year. Option One ranges from perhaps from 0.2 to 2 percent of the buildings per year.

With this information, policymakers and stakeholders can compare the rate of progress with the expected rate of future earthquakes to generate a sense of how many damaging earthquakes might be experienced before the great majority of a class of collapse risk building types is reduced or eliminated.

Progress can then be monitored and compared with other jurisdictions or other building types. If a jurisdiction determines that Option One will provide an acceptable rate of investment in managing this risk, a jurisdiction could decide to take no further action, except perhaps to monitor and report on progress periodically. If Option One is determined to leave a community vulnerable to damaging earthquakes and unacceptable losses for too long, other Options and corresponding expected mitigation rates can be estimated. Options Four, Five and Six that require seismic evaluations can generate more specific information about the extent and severity of the collapse risks and prompt more owners to voluntarily take steps to reduce them.

Option Seven that requires seismic retrofits will produce the fastest progress and yet will generally still require multi-year implementation periods, so progress monitoring is a useful tool with all options. Mandatory retrofit and replacement programs that allow for varying the rate of compliance in response to local economic and social conditions have been used by local governments over the past several decades. In a few cases, mandatory programs have been enacted but for a variety of reasons later became stalled due to local political influences or economic conditions. Maintaining the monitoring and reporting on mitigation progress can be prudent if the public and its electorate value risk reduction and meeting resilience goals.

***How does our progress compare with neighboring jurisdictions and the statewide average?***
Every five years, local governments are required to update progress on multi-hazard mitigation plan initiatives to the CA Office of Emergency Services. Progress on retrofits and replacements of collapse risk buildings should routinely be included in such updates. In a similar fashion, OES should compile aggregate statewide progress updates every five years for the state's Multi-hazard Mitigation Plan depicting regional variations and averages once initiatives of a common nature and building type begin to be systematically reported by multiple local governments.

For example, notification-only programs for URM buildings generated mitigation rates of 0.65 percent per year for a total of 13 percent retrofitted or replaced over two decades. Voluntary strengthening programs for URM buildings generated mitigation rates of 1.2 percent per year for a total of 24 percent retrofitted or replaced over two decades. In contrast, URM mandatory strengthening programs generated mitigation rates of 4.3 percent per year over four decades for a total of 87 percent retrofitted or replaced. Curiously, local governments that chose not to adopt a URM program have higher mitigation rates than governments with ineffective programs. In many of these cases, planned redevelopment initiatives and other voluntary efforts were underway at the time those governments decided not to adopt more proactive measures such as mandatory strengthening (CSSC 2006) (OES 2013)

| URM Program Type | Annualized Mitigation Rate | Cumulative Mitigation Rate After 20 years |
|---|---|---|
| No Program Adopted | 1.5% | 31% |
| Notification of Owners Only | 0.6% | 13% |
| Voluntary Retrofit | | from 39 programs |
| Without Incentives | 1.1% | 23% |
| With Incentives | 1.3% | 26% |
| Other Program Types | 1.3% | 26% |
| Mandatory Retrofit | 4.3% | 87% from 134 programs - some more than 40 years old |

The actual rates above can also be compared with recommended rates in California's model mandatory retrofit ordinance (SSC 1995-05 and periodically thereafter updated)

| | |
|---|---|
| Low-Risk Bldgs | 14.3% |
| High-Risk Bldgs | 33.3% |

The experience with URM buildings also demonstrates that such decisions are best left up to each local government rather than dictating uniform acceptable levels of risk statewide. Local governments are best suited to determine the public's tolerance for risk, to account for local economic and social circumstances, and set goals and priorities for managing collapse risk. It also shows that after over 40 years of effort, many unretrofitted buildings remain, approximately 4000 out of the 26,000 inventoried.

However, consider with caution the potential for misleading conclusions that this management by metrics approach can generate. For example achieving an "apples-to-apples" comparison may be difficult when earthquake risk or socio-economic makeup between neighboring jurisdictions may vary greatly. A more prudent approach can be achieved by comparing the difference between an optimal state of progress as defined by policymakers and the current state. Exceeding the capabilities of neighboring jurisdictions can provide a false sense of accomplishment relative to each jurisdiction's individual situation.

***Does our jurisdiction have a management team in place with appropriate professional licensure, training and continuing education to effectively implement policies?*** Surveys of Building Department staff that have periodically been conducted by the California Building Officials can be used to benchmark salary structures, staffing ratios based on population and

permit valuation, and training budgets to ensure an effective team with adequate resources is managing earthquake risk. Section ___.

*Preservation of Historical Buildings*

Retrofitting historical buildings while preserving their character-defining features will improve the likelihood that they can be repaired after damaging earthquakes. The California Historical Building Code provides acceptable alternatives to evaluation and retrofit codes and standards that are intended for non-historic buildings. The code includes an objective to prevent partial or total structural collapse such that the overall risk of life-threatening injury as a result of structural collapse is low. It is intended to promote sustainability, provide cost-effective approaches to preservation, and to provide for reasonable safety. Past records of appeals to the State Historical Building Safety Board can also provide examples of how difficult retrofit decisions were resolved in the past. (SHBC 2016)

**Figure __. Retrofits can protect character-defining features of our historic resources.**

Historical buildings that are damaged in earthquakes cannot by law be construed as imminent threats requiring rapid demolitions if the risks posed by the damage or archaic building system can be addressed by shoring, stabilization, barricades or temporary fences. (CBHC 2016)

*Limitations of Retrofit Reliability – They are not Earthquake "Proof"*

Most complete seismic retrofits are expected to significantly reduce the risks to life of the public exposed to collapse risk buildings. Partial retrofits may only reduce some of the risks and the remainder of the unretrofitted building can perform as poorly as unretrofitted buildings. Older retrofits, particularly those for unreinforced masonry buildings, were completed long before performance-based earthquake engineering and will likely not have addressed the potential for loss of building functions. Owners and jurisdictions should consult with structural engineers to gain an understanding about the limitations of retrofit performance and the cost tradeoffs for achieving higher or more reliable performance. Owners should also take steps to inform building occupants so that they too can make informed risk management decisions about the future use of buildings.

*Emergency Preparedness, Public Awareness and Education*

Building owners should develop emergency response plans that incorporate known vulnerabilities that have been identified by seismic evaluations. Such plans should be periodically tested by table-top exercises. Annual ShakeOut exercises on the Second Thursday of each October to practice drop, cover and hold on responses can be excellent opportunities to familiarize key building personnel and occupants with emergency response procedures and known building vulnerabilities.

Local governments should also maintain and periodically exercise their emergency response and recovery plans. Procedures for responding to severely damaged and collapsed buildings are key to ensuring a safe and rapid recovery. With specific inventories and locations of buildings that are prone to collapse, emergency plans can incorporate realistic estimates of deaths and injuries, disruption, and dollar losses and compare emergency resources with anticipated demands.

Ensuring that all building occupants are trained to drop, cover and hold on could save many lives even in buildings that pose collapse risks. It is typically much safer for occupants to stay inside buildings under sturdy furniture than to attempt to leave buildings during shaking. Assigning trained coordinators for each floor to help occupants respond effectively can help create a culture that values safety, reduces casualties and speeds recovery.

*Post-Earthquake Recovery*

*Post-earthquake Safety Assessment Program*

The State of California has trained over 6,000 building inspectors and volunteers to conduct safety assessments following disasters and assign red (unsafe), yellow (restricted use), or green (inspected) placards on damaged buildings. After damaging earthquakes in major metropolitan areas, safety assessments can take weeks to months and can be expedited by owners who arrange for BORP agreements with their jurisdiction before earthquake occur (see page _). Buildings with red placards are not necessarily repairable or required to be demolished. Green buildings may also be damaged to the extent that they are later found not to be repairable. Such decisions must rely on more detailed seismic evaluations and repair considerations that are the primary responsibility of owners and their design professionals. Neighboring buildings that are placarded red or yellow may adversely impact the use of green or undamaged buildings in the vicinity. So owners should not just be concerned about the seismic vulnerability of their own buildings, but also others in their neighborhood.

*Building Occupancy Resumption Program*

Owners should consider creating a Building Occupancy Resumption Plan (BORP 2016) in cooperation with their city (or county in unincorporated areas) to accelerate post-earthquake seismic evaluations, and repairs after future damaging earthquakes. BORP encourages owners to hire Structural Engineers to conduct seismic evaluations between earthquakes, BORP owners

maintain relationships with their consultants who have first-hand knowledge of each building's characteristics and seismic vulnerability, so that they can be engaged without delay to conduct safety assessments, evaluate damage and generate repair plans after future earthquakes.

*Evaluation, Stabilization, and Repair of Damaged Buildings*

Despite best intentions, some of California's buildings, even some retrofitted ones, may not survive future damaging earthquakes. Labeling retrofitted buildings resilient can be an exaggeration. In many cases, prior retrofits may be capable of resisting only one moderate earthquake with a short-duration of severe shaking. Damaged buildings may then pose much greater risks in aftershocks unless they are stabilized and extensively repaired. Hundreds of local governments throughout California have significant concentrations of collapse risk buildings that could place extraordinary demands on government staff and owners during emergency response and recovery. The California Building Officials has developed "Interim Guidance for Barricading, Cordoning, Emergency Evaluations and Stabilization of Buildings with Substantial Damage in Disasters" (CALBO, 2013).

**Figure _ Hard barriers such as containerized cargo units can be quickly installed to keep damaged buildings from falling onto streets in aftershocks.**

When major metropolitan regions are damaged by earthquakes and aftershock sequences, the Governor's Office of Emergency Services expects local governments to request mutual aid from undamaged jurisdictions elsewhere in the country. OES also manages a building Safety Assessment Program that relies on volunteers from the private sector as well as mutual aid from other government agencies to evaluate and placard damaged buildings and ensure occupants do not enter unsafe areas. OES calls for the creation of Strike Teams to address special needs associated with each of the following sectors: essential services facilities, hazardous materials, tall and mid-rise buildings, housing, low-rise buildings, schools, infrastructure, as well as

geotechnical/geological teams for landslides, liquefaction, lateral spreading and foundation settlement. In particular, the demands of assessing, barricading, and stabilizing damaged buildings, particularly tall and mid-rise buildings will far exceed the response capabilities of local government staffs.

Government agencies are encouraged to periodically conduct table-top exercises to understand and anticipate response to damage that will be unique to their communities. Such exercises offer ways that agencies such as fire, police, public works, and social services can become familiar with their response roles as they relate to vulnerable building inventories, locations and occupancies. Advanced preparations, dialogue and relationships improved through these exercises will help facilitate communication and speed response and recovery in the event of actual disasters.

After major damaging earthquakes, local governments should anticipate dramatic impacts on the built environment, including collapses and potentially hundreds of buildings requiring major stabilization, repairs, demolitions and replacements.

*Managing Aftershock Risks*

Most earthquake sequences include many more than one damaging ground motion. Some vulnerable building types may perform adequately during one small earthquake, but accumulated damage after multiple earthquakes can reduce a building's strength, expose occupants to additional hazards, and can cause delays before decisions about the repair or demolition of buildings can be made. Aftershocks have at times been larger or more damaging than foreshocks. Many owners can mistakenly believe that since their building survived the last earthquake in their region, they expect it to survive intact in future earthquakes. But no two earthquakes or aftershocks are alike, so past performance is not necessarily an indication of future performance. Comprehensive seismic evaluations that consider the potential for losses from aftershocks can be informative risk management tools. Owners should also be prepared to stabilize their damaged buildings and protect occupants and surroundings from the potential for additional falling risks in aftershocks (See page ___).

**Figure __. Severely damaged, tall buildings can force the closure of entire city blocks until they are stabilized or demolished. This building took 5 months to demolish.**

Earthquakes with a rich aftershock sequence can greatly discourage interest in reinvesting in damaged communities and other more discretionary activities such as tourism at least until aftershocks subside. In some cases aftershock sequences can last for many years. Aftershocks can also adversely affect the public's perception about the effectiveness of regulatory efforts to ensure safety. So jurisdictions should become familiar with managing these potential long-term impacts.

*Identifying Recovery Priorities and Avoiding Long-Term Catastrophic Effects*

If owners obtain basic information about the vulnerability of their buildings and infrastructure, they can begin to visualize recovery priorities and take steps to minimize the prospect of long-term catastrophes. Similarly, jurisdictions can do the same for key neighborhoods. Options include: 1) Retrofits to reduce risks or; 2) Replacements with new, earthquake-resistant construction between earthquakes; and 3) Repairs after future earthquakes. Consideration should include the owners' abilities to pay and survive disruptions associated with each option as well as a community's overall expectation of supporting recovery and risk reduction efforts.

*Building Department Personnel Qualifications and Training*

Building department staffs are typically qualified and experienced in the regulation of new construction, remodels and, with varying skills, seismic alterations to existing buildings. Seismic evaluations and retrofits encompass specialties and rely on building materials and systems that are unfamiliar to many building department staff members. It is in the best interests of local governments to support education and training programs for building department staff to ensure effective monitoring and regulation of seismic evaluations and retrofits. Training is essential for familiarity with the provisions of Chapter 34, as well as Parts 8 and 10 of the California Existing Building Code and inspection and testing protocols that can apply to existing buildings.

A shortcoming of some past seismic retrofits has been inadequate and uninformed design and construction resulting in some disappointing performance in past earthquakes. Rigorous plan reviews of retrofit designs as well as thorough inspections during construction by regulatory authorities will help minimize poor quality and improve performance.

An example of the critical role that building department personnel have in seismic design and evaluation is water heater installations and replacements. Water heater braces and gas piping can easily be installed incorrectly. Training building inspectors to be capable of identifying properly installed gas piping and water heater bracing to prevent their toppling will minimize fire and water damage in future earthquakes.

*Monitoring Progress, Maintaining Inventories, Sharing Progress with the State*

In adopting a long-term perspective, local governments should plan for and budget periodic efforts to monitor and report seismic evaluation, retrofit and replacement progress to policymakers. Local multi-hazard mitigation plan updates provided to OES every five years should ideally include such progress summaries. OES should consider supporting consistent reporting protocols so that it can more readily compile and interpret statewide progress. The reporting protocols for URM buildings can be readily adapted to other types of buildings with the principal metric being the “mitigation rate” which is the number of retrofitted plus

demolished buildings divided by the number of inventoried collapse-risk buildings of a particular type. In turn, the state updates its Multi-hazard Mitigation Plan every five years and can report on and compare regional, incremental progress.

*Long-term Perspectives and Commitments*

Experience has shown that progress should be measured in decades not years to effectively track seismic retrofit and replacement initiatives involving private and public buildings.

For example, it took California 44 years, from 1933 to1977, to complete the first cycle of seismic retrofits and replacements of public schools, for grades K to 14. Now some school districts are embarking on a second generation of retrofits of early Field Act buildings and prior retrofits.

**Figure _.. Retrofits often involve challenging construction in cramped spaces.**

The Hospital Seismic Retrofit Program started in 1995 and is expecting completion 35 years later in 2030. A decade prior to 1995 included several surveys and seismic evaluations of hospitals.

In 20 years, from 1986 to 2006, 55 percent of the unreinforced masonry buildings that were inventoried by 283 local governments were retrofitted, and 15 percent were demolished.

Retrofit programs at the University of California have been underway since the 1970's and since the 1990's at the California State University campuses.

By no means will these programs be able to declare 100 percent completion, since managing seismic risks tends to be an ongoing, iterative endeavor. Drawing from the public school experience, many earlier retrofits should periodically be reevaluated and, if warranted, re-retrofitted or replaced.

Building owners and local governments should adopt similar perspectives for other types of collapse risk buildings. While there are significant risks that earthquakes will occur in the interim before all retrofits can be completed, that risk should be balanced with the limitations of financing major investments, to spread out the costs over time and avoid placing too great a short-term burden on owners and the design and construction industry that have limited resources.

**Figure__. This retrofit project in Eureka took over 25 years to finance and complete. It relied on Federal tax credits for historical buildings and a loan from the City's Community Development Block Grant.**

*Reevaluating Progress Periodically, Especially after Future Earthquakes*

By investing in mitigation progress monitoring, policymakers can periodically revisit and reevaluate each community's pace and overall adequacy as well as gaps and other shortcomings of their initiatives. Comparisons with progress in nearby jurisdictions and statewide can also be made. In this vein, monitoring and reporting conveys to the public that jurisdictions recognize the importance and value of seismic risk management.

The public will typically expect reconsideration of progress and critiques of how retrofitted buildings actually perform after future damaging earthquakes. If government staffs invest in maintaining inventories and records of progress, they can readily summarize the size and nature of the concerns associated with particular types of collapse risk buildings, what has been done about them so far, how much they cost, and what remains to be done at the current pace of progress, and how long will the current phase of retrofitting and replacing will take.

In contrast, post-earthquake recovery phases are not optimal times to identify collapse risk buildings and determine which buildings were retrofitted. So local governments should implement programs and document seismic risks and prior retrofits between earthquakes so that they are prepared to provide timely and accurate information about aspects that are fundamental to the safety of buildings after future earthquakes.

Reconsideration of past risk reduction policies will occur after future damaging earthquakes, both those directly affecting jurisdictions as well significant earthquakes elsewhere in the world. Local government staffs should anticipate this and be prepared to reevaluate policies without delay.

Many local governments in California have experienced changes in priorities. Since 1975, the Seismic Safety Commission has maintained records of such deliberations by local governments and the State Legislature. Local governments are encouraged to consult with the Commission if locally maintained records don't extend back to 1975.

*Incorporating Collapse Risk Building Management into a Community's Multi-hazard Resilience Initiatives*

***Making Cities Resilient*** Campaigns are underway and growing in popularity across the world. They were advocated in the latest Sendai Framework for Disaster Risk Reduction and have been encouraged by the Federal Department of Homeland Security and the Governor's Office of Emergency Services. It makes sense to include building seismic risk management as a major subset within an overall, multi-hazard resilience program. Societal expectations for resilience can often exceed the capabilities of the built environment. So there is considerable risk that the public could assume unrealistic expectations for resilience when that is often not a realistic objective for many existing buildings in damaging earthquakes. Yet it is prudent to include earthquake considerations in resilience efforts. The focus of resilience programs is on enhancing the reliability and continuity of functions after disasters and measuring performance across multiple scales. One strategy calls for adopting ten essentials to improve resilience (  ):

**Essential Step 1: Organize for Disaster Resilience:** See Part 3 of this Appendix on page ___.

**Essential Step 2: Identify, Understand and Use Current and Future Risk Scenarios:** See Step 2 of this Appendix on page ___.

**Essential Step 3: Strengthen Financial Capacity for Resilience:** See Other Management Considerations on page ___.

**Essential Step 4: Pursue Resilient Urban Development and Design:** See Step Option One on page ___.

**Essential Step 5: Safeguard Natural Buffers to Enhance Ecosystems' Protective Functions:** This is an appropriate objective to apply to tsunami risk management

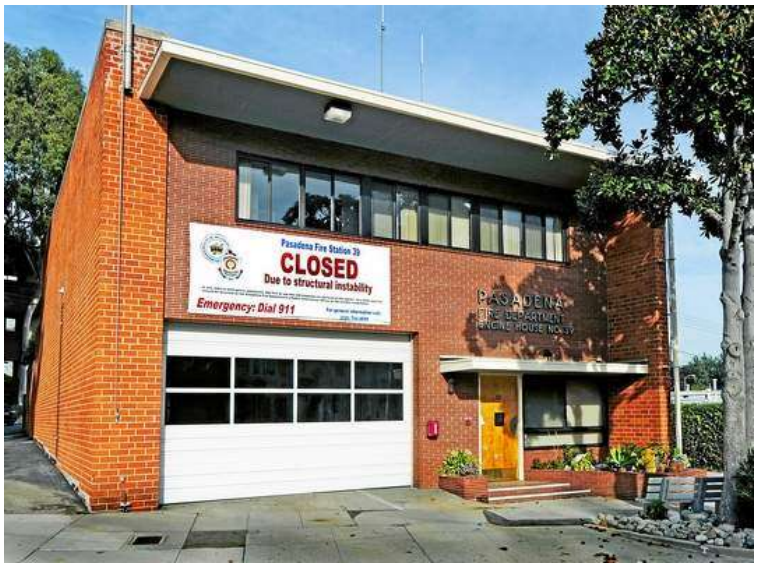
**Essential Step 6: Strengthen Institutional Capacity for Resilience:** See Building Department Qualifications and Training on page ___.

**Essential Step 7: Understand and Strengthen Societal Capacity for Resilience:** See Other Management Considerations on page ___.

**Essential Step 8: Increase Infrastructure Resilience:** Insofar that much of California's infrastructure relies on buildings that house or impinge upon infrastructure not to collapse and to function, this guide is a key part of such an effort.

**Essential Step 9: Ensure Effective Disaster Response:** See Post-earthquake Recovery on page ___.

**Essential Step 10: Expedite Recovery and Build Back Better** See Post-earthquake Recovery on page ___.




**Retrofits can trigger building closures…**

**…but disruption after earthquakes can be reduced by retrofits.**

## Part 6: Reference Material

### Applicable State Laws – These can be searched at www.legislature.ca.gov

Business and Professions Code 10147 *et seq* "Seismic Safety Commission publishes Commercial Property Owner's Guide to Earthquake Safety"

Education Code 17280 and 81130 *et seq* "Field Act for Public School Construction"

Health and Safety Code 16000 *et seq* "Essential Services Building Seismic Safety Act"

Health and Safety Code 18950 *et seq* "State Historical Building Code"

Health and Safety Code 19000 *et seq* "Riley Act requiring Local Governments to Issue Permits and Regulate New Construction"

Health and Safety Code 17320 *et seq* "Private Schools Building Safety Act of 1986"

Health and Safety Code 19160 *et seq* "Earthquake Hazardous Building Reconstruction"

Government Code 8870 *et seq* "California Earthquake Hazards Reduction Act of 1986"

Government Code 8875 *et seq* "Unreinforced Masonry Building Law"

Government Code 8876.1 *et seq* "Enabling Legislation for the Pacific Earthquake Engineering Research Center at UC"

Government Code 8893.1 *et seq* "Eligibility for State Assistance Programs for Earthquake Repairs"

Government Code 8893.2 *et seq* "Commercial Property Owner's Guide to Earthquake Safety"

Government Code 8894 *et seq* "Buildings enclosing more than 20,000 Square Feet of Concrete or Reinforced Masonry Column or Wall Construction Seismic Retrofit Standards"

Health and Safety Code 55000 *et seq* "Seismic Safety Rehabilitation Loans"

Constitution, Article 13A, Section 2 "Property Tax Exclusion for Seismic Retrofits"

Public Resources Code 2621 *et seq* "Alquist-Priolo Earthquake Fault Zoning Act"

Public Resources Code 2624 *et seq* "Seismic Hazard Mapping Act, Disclosure to buyers of property"

Public Resources Code 2700 *et seq* "Strong Motion Instrumentation Program"

### Liability Considerations for Building Owners, Governments, Contractors and Design Professionals

> "The question of tort liability for building owners is determined on a case-by-case basis by a judge or jury based on the following standard: Did the owner or operator of the building (that is, the person or entity having control over the facility) act as a reasonable person would have to prevent the harm? Many factors might be considered, including actual or imputed knowledge of the risk, the cost to mitigate the risk, the expected degree of harm, timing of corrective

> actions, alternatives available to the owner or operator of the building, and the ability of occupants or others impacted by the collapse to avoid the harm." (San Francisco, January 2014)

Local and state governments have immunity from liability unless they are found to be grossly negligent in carrying out their regulatory duties. However, such immunity does not extend to public or private owners of buildings. (Reference Government Code Section 818) While immunity may generally offer some protection to government staff, agencies could nevertheless face years of criminal and civil trials while documenting and defending past regulatory decisions that may or may not have been significant over the life of a building that collapses. Recovery after earthquakes will be significantly delayed by criminal and civil investigations that will be undertaken to determine the causes of the collapses and responsible parties. The costs of legal defenses are typically borne by owners and government agencies and are not necessarily recoverable.

Contractors and design professionals may also be found liable for actions or inaction associated with a building that has collapsed. It can take years to conduct a defense or negotiate a mutually agreeable settlement with those who have been harmed.

The public has a right to know about the vulnerability of the buildings they occupy or are exposed to and owners have a duty to disclose those vulnerabilities. (CSSC Right to Know, 1992)

**Risk Communication Guidance – to be completed – Fuad Sweiss has been asked to contribute text for this section.**

**Statewide Incentives**

***Federal Tax Credits:*** The Federal Government offers tax credits of up to 10 percent of a seismic retrofit construction cost for pre-1936 non-residential, non-historic buildings and up to 20 percent for historic buildings that are listed on the National Historic Register pursuant to the 1986 Tax Reform Act. For more information: www.nps.gov/tps/tax-incentives.htm

***Mills Act Agreements*:** These are contracts with minimum 10-year terms that are individually negotiated between local governments and owners of historic buildings. Generally, in exchange for property tax relief, owners agree to restore, maintain, and protect their buildings in accordance with specified historic preservation standards and other conditions. Local jurisdictions typically commit to periodic inspections to ensure adherence to the contract. Local governments can also impose penalties for failure to protect the buildings. Contracts are transferable to new owners when a property is sold. Over 90 local governments have Mills Act participants: ohp.parks.ca.gov/pages/1074/files/Mills%20Act%20Contacts%20List.pdf

For more information: ohp.parks.ca.gov/?page_id=21412 Or call Ms. Shannon Lauchner, Mills Act Certified Local Government Coordinator at the state Office of Historic Preservation: 916-445-7013 Shannon.Lauchner@parks.ca.gov

**Figure __. Federal tax credits were used to retrofit this theater in a Los Angeles Hotel.**

***Property Tax Exclusions for Seismic Retrofits:*** Some seismic retrofits can be excluded from property tax assessments. Owners who are contemplating seismic retrofits can notify their county tax assessor prior to, or within 30 days of, completing a seismic retrofit project. Documents supporting claims for property tax exclusions must be filed within six months after completion of the retrofits. The local building department that issues a permit for retrofit construction must report the cost of the retrofit portion of the projects to the county tax assessor. The State Board of

Equalization has more information and a claim form BOE-64 *Claim for Seismic Safety Construction Exclusion from Assessment at* *http://www.boe.ca.gov/proptaxes/pdf/lta10036.pdf*

**Retrofit Codes, Standards, and Guidelines for Reducing Collapse**

A small percentage of older buildings have been strengthened or "retrofitted" to improve their resistance to earthquake shaking. Observations after recent earthquakes suggest that retrofitted buildings on the whole perform noticeably better than similar buildings that have not been retrofitted (ATC31, 1992, SSC 94-06, and WJE 1994). But in many cases, their performance has been mixed.

California has adopted, with some amendments, a national standard, ASCE 41-06, *Seismic Rehabilitation of Existing Buildings*, as a retrofit regulation for acute care hospitals, public schools and state-owned buildings. California has also adopted retrofit regulations for hospitals, unreinforced masonry (URM) buildings, and wood dwellings (see Chapter 34 of the 2013 CBC and the CEBC (CBSC 2013). The CBC generally allows retrofits of any nature provided that they make existing buildings no less safe. These regulations and the 2012 International Existing Building Code are available for use at the discretion of all state and local regulatory agencies. They include a compilation of seismic evaluation and retrofit provisions for unreinforced masonry, tilt-up, wood-frame dwellings, and older concrete buildings. The California Historical Building Code contains alternative requirements for evaluating, rehabilitating, and altering historical buildings (CBSC 2013).

The latest national standards for building seismic evaluations and retrofits are published by the American Society of Civil Engineers as ASCE/SEI 41-13, *Seismic Evaluation and Retrofit of Existing Buildings* (ASCE 2013). They become enforceable in California in 2017.

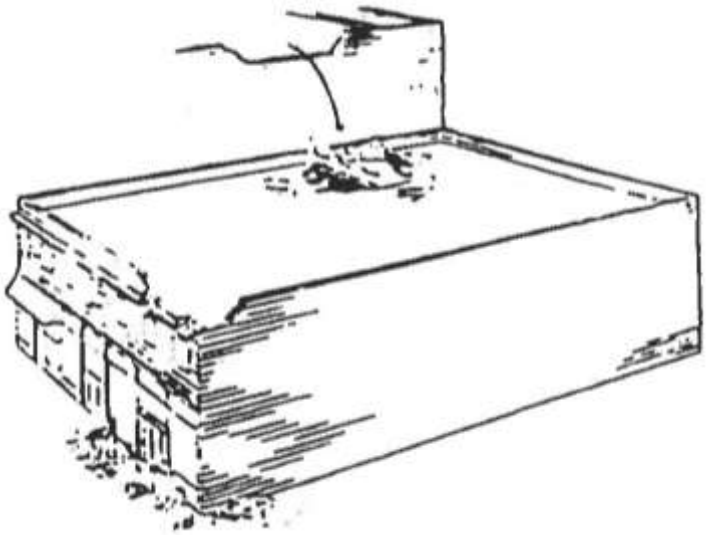
Mitigation measures for residual ground displacements that can occur during earthquakes (e.g, landslides, liquefaction, lateral spreading and settlement of soils) include strengthening foundations, locating new facilities to avoid sites with the potential for large displacements during earthquakes, and modifying soils below foundations. In addition to the above standard, the *Guidelines for Evaluating and Mitigating Seismic Hazards in CA*, (Special Publication 117A, CGS 2008) can help address foundation-related risks.

**Common Characteristics of the Buildings Posing the Greatest Risks of Collapse**

***Unreinforced Masonry (URM) Buildings*** have six types of vulnerability:

- Unbraced tops of walls, called parapets, can fall onto sidewalks, streets, alleys and adjacent, lower buildings.
- Walls that are not well-connected to roofs and floors can separate and fall outward
- Masonry walls that have little or no reinforcing steel inside, have low strength and in some cases have deteriorated mortar and can quickly degrade in severe shaking.

- Ground floors with open fronts, lacking solid walls can allow excessive movements in buildings causing damage and collapse.
- Incomplete or inadequate seismic retrofits or additional deterioration that has occurred since they were retrofitted can result in life-threatening damage during earthquakes.
- Perhaps 5 percent of URM buildings in California are mid-rise (4 to 10 stories) and may have steel or concrete frames with masonry walls infilling the frames that can separate and fall away from the frames.



A 1986 state law requires local governments in high seismic regions to inventory URM buildings, establish risk management programs, and report progress to the Seismic Safety Commission. When last surveyed in 2006, 70 percent of the 26,000 URM buildings that were inventoried by 283 local governments in the regions of California closest to active earthquake faults had been retrofitted or demolished. About 7,800 inventoried buildings remained unretrofitted in these regions (SSC 2006). Buildings in regions of moderate seismicity have typically not been inventoried. These buildings were commonly used as fire-resistive construction in low- to mid-rise commercial and industrial neighborhoods of California from the early 1800's to the early 1930's until the Riley Act in 1933 prohibited their construction (Health and Safety Code 19100, 1939). These buildings are relatively easy to identify and nearly all of the unretrofitted ones pose significant risks to life.

***Non-ductile Concrete Buildings*** have four areas of vulnerability:

- Columns, beams and joints lack sufficient reinforcing steel to effectively confine their concrete.
- Concrete walls are too few in number, have too many openings or otherwise lack strength and stiffness.
- Weak floors and roofs, large openings in floors and roofs, and inadequate connections to walls can exist.

- Irregular building shapes or discontinuities can aggravate other vulnerabilities.

**Figure __. Collapse of the Pyne Gould Building in Christchurch in 2011 killed 18 people. It was non-ductile-concrete and partially retrofitted before the earthquake.**

Only a small and unknown percentage of the 12,000 to 15,000 older concrete buildings that were built from the early 1900's to the late 1970's have been retrofitted (CA-OES 2013).

Detailed seismic evaluations can identify the relatively small fraction of these buildings that clearly pose collapse risks. However, low-cost seismic evaluations could also designate nearly all older concrete buildings as collapse risks, when more costly, sophisticated analytical techniques and actual earthquake performance would suggest that most are not. Research and development efforts are underway to improve and lower costs of seismic evaluation techniques for non-ductile concrete buildings (ATC 78, 2014)(PEER 2013).

***Precast Concrete Buildings*** (i.e. tilt-ups) have two areas of vulnerability:

- Connections of the walls to roofs and floors are weak and can fail causing roofs and floors to fall down or walls to fall outward.
- Connections between segments of precast walls can be weak.

There may be upwards of 57,000 pre-1976 tilt-up buildings and similar weak wall to roof connections can exist in an unknown number of older reinforced masonry buildings (CA-OES 2013). Seven local governments have completed mandatory tilt-up retrofit programs as of 2015.

***Soft-Story, Multi-unit Residential Wood Frame Building***s have the following vulnerabilities:

- Irregular configurations with open fronts typically at the ground floor to accommodate parking below living units.
- Soft (flexible) or weak wall configurations that cause buildings to move excessively during earthquakes.

These buildings number the low tens of thousands statewide and were built prior to the 1990's. About 15 local governments have conducted inventories and two require retrofits. A 2005 state law encourages local governments to address the risks posed by these buildings. The law refers to a Seismic Safety Commission recommendation in 2007 for starting mitigation programs by 2020, but that recommendation is currently out of date and was replaced by a 2013 loss reduction plan that did not include such milestones (SSC 2013).

***Steel Frame Buildings*** have the following vulnerabilities:

- Brittle, welded connections between steel beams and columns can crack during earthquakes.
- Diagonal braces can fail prematurely in severe shaking.

An unknown number of these were built from the 1940's to the mid 1990's.

**Figure __. Reinforced masonry buildings such as this can have poor wall-to-roof connections that fail similarly to concrete tiltup wall buildings. 1992 Landers Earthquake.**

**Reducing Losses from Non-Structural Systems and Building Contents**

California did not begin to regulate the earthquake safety of non-structural systems in buildings, such as water heaters, ceilings, light fixtures, and heating equipment, until the 1970s. Buildings

built before the 1970s and newer buildings that were not properly regulated and that have unbraced systems can be made safer with retrofits or replacement projects. The California Building Code (CBC) contains seismic requirements for nonstructural parts of buildings. FEMA offers guidelines for the evaluation and retrofit of building contents and non-structural building systems (FEMA E-74, 2013). Nonstructural retrofits can significantly reduce the risks of injuries and business interruption from earthquakes and are often feasible at low costs and minimal disruption to occupants during construction.

Cal OES offers guidelines for evaluating and retrofitting nonstructural falling hazards common in schools (OES 2011). The *Commercial Property Owner's Guide to Earthquake Safety* also contains recommendations on how to identify and retrofit contents and non-structural systems that are vulnerable to earthquakes. Water heater bracing kits that were certified for use by the State Architect are available at most hardware stores. The State Architect also offers strapping instructions online. (DSA 2012)

Bracing can prevent fires and serious water damage caused by toppled water heaters. State law requires all replacement water heaters to be braced and all existing residential water heaters to be braced upon the sale of homes (Health and Safety Code 19210, 1992).

Building contents are typically not regulated by government agencies for earthquake safety except those on upper shelves of racks above 12 feet high or that contain hazardous materials. (FEMA 460, 2005)

**Local Government Case Studies:**

**Saint Helena's Financial Incentives**: Recognizing that its old brick and stone buildings along Main Street, Highway 29, are critical to the city's tourism and cultural identity, Saint Helena:

1) Waived building permit fees for seismic retrofits;
2) Established Mills Act agreements (see page __) with owners to help preserve historical facades in exchange for reductions in property taxes;
3) Encouraged the use of Federal Tax Credits for retrofit work on Nationally Registered historic buildings (see page __);
4) Allowed for building permit renewal extensions to give owners more time to finance the retrofits;
5) Streamlined the design review process; and
6) Provided small grants to fund architectural and engineering services to those owners who had financial difficulties to help pay for retrofits.

While funds invested by the City in these incentives were relatively small compared to the investments in retrofits by the owners, the lengthy discussions that led up to the City Council enacting these incentives and the government's clear expression of commitment to helping building owners with this effort sent a strong message of priorities and a desire to collaborate in reducing earthquake risk. After 12 years of investments and retrofit efforts, 33 unreinforced masonry buildings were eventually retrofitted.

**Fremont's Soft Story Apartment Building Program:** In 1999, Fremont's building department inventoried its soft story apartments and its city council ordered notices sent to 30 owners of soft story apartments that their buildings were vulnerable to collapse. The city also established a goal of voluntary retrofits within a year. However, only two owners voluntarily retrofitted. In light of the lack of progress in 2007, Fremont amended its ordinance and required retrofits of the remaining 28 buildings within 5 years. The city allowed owners to apply for deadline extensions by demonstrating financial hardships. The city also waived plan review and building permit fees as long as owners met the timetables in the ordinance. As of September 2014, reportedly 80 percent of the buildings had been retrofitted (www.mercurynews.com/business/ci_26449983/thousands-bay-area-apartment-houses-need-quake-fix )

A copy of Fremont's ordinance is available at:

http://www.fremont.gov/377/Earthquake-Hazard-Reduction-Ordinances

**Los Angeles' Unreinforced Masonry Building Retrofit Program:** The City of Los Angeles had more unreinforced masonry buildings than any other local government in California, but they represented just 1.3 percent of the city's stock of 700,000 buildings back in the 1970's (Spangle 1990). It inventoried 9,211 buildings and adopted two programs, one in 1981 for buildings with load-bearing walls and another in 1993 for non-load bearing infill masonry wall

buildings with steel or concrete frames. When the M6.8 Northridge Earthquake struck in 1994, over 6,000 of the buildings had been retrofit and approximately 2,000 had been demolished or replaced. Fortunately, no one was killed by falling masonry from the buildings, in part, because the earthquake occurred early in the morning. However, had the earthquake occurred at another time of day, lives could have been lost from the partial collapse of retrofitted buildings. The retrofit efforts clearly demonstrated that such buildings are not necessarily earthquake-proof, but that they significantly reduced losses and accelerated recovery compared to nearby unreinforced masonry buildings that were not retrofitted.

The City considered financial incentives, but "enactment of Proposition 13 virtually eliminated the possibility of substantial assistance from the city. New initiatives were not forthcoming from either the federal or state government. Public funding programs were being cut; not expanded. However, in the end, the City Council acted on the ordinance without resolving the issue of financial assistance to owners or tenants." (Spangle 1990) Nevertheless, the City's Community Development Department later funded 27 retrofits using $29 million in federal Community Development Block Grants. Los Angeles used $32 million in redevelopment funds to offset seismic retrofit costs for 50 URM buildings. Two seismic retrofit projects were funded by tax exempt revenue bonds authorized by the state legislature in 1984. The City attempted to enact a bond program in 1989, but it just missed getting the required two-thirds vote of its electorate. (Spangle 1990) Some owners took advantage of a state law that exempts seismic retrofits from property tax increases (see page __). Owners of URM buildings took advantage of Federal tax credits (see page __). Out of the roughly $1.7 billion spent on retrofits and replacements in Los Angeles, less than 10 percent came from government finances.

**Figure __. Soft story apartment building with a retrofit underway.**

The City has a form of rent control and approved rent increases for seismic retrofits that averaged an increase of $64 per month in 1988. The City also required owners to provide tenants

relocation assistance of up to $5,000 per unit when seismic retrofits required tenants to move out. Most of the remaining costs for seismic retrofits were paid by owners of buildings.

**San Luis Obispo's Downtown Revitalization Program:** San Luis Obispo's downtown had 126 unreinforced masonry buildings. Progress on their 11-year old retrofit program was slow at the time the M6.5 San Simeon earthquake occurred in 2003. After the earthquake, the City Council shortened the deadline for strengthening from 2018 to 2012. The City's Economic Development department established a Seismic Task Force that included building owners, small business owners who typically rent space from owners and city staff to encourage a dialogue on how to best manage the seismic retrofit effort and minimize impacts to the fragile economy downtown while encouraging revitalization. The Task Force worked for three years to develop a program that "balanced the need for strengthening with the cost to property owners" (Clark 2010). The program included no-cost building permits, waiving of sewer and water costs during construction, favorable retrofit contractor parking fees, as well as small grants to fund portions of the work. After seven years of monitoring progress, the City reconvened the Task Force to revise the compliance deadlines and financial incentives. A new fee structure was established for building permits and construction parking. No additional grants were provided. Placards warning the public of potential risks to life in the event of earthquakes were added to the ordinance. Penalties for non-compliance including fines, administrative citations and injuctive relief were also included. The main message to building owners from the City Council was to "get it done" (Clark 2010). The City streamlined entitled reviews for façade changes to historic buildings. A Seismic Coordinator was assigned to provide individual support to each retrofit project, improve communication and keep the public abreast of progress, while highlighting successful efforts by individual owners. Time extensions for compliance were granted in 2010. Completion of the retrofits is anticipated in 2016. The City learned that the proximity of deadlines is key to motivating owners to retrofit. The City's Seismic Coordinator serving as an internal advocate and catalyst was also a key factor. Lastly, a few willing building owners set good examples to get other owners to join them and commit to investing in building retrofits. Progress varied over the years in large part as a reflection of local economic conditions, so it may be best to allow deadlines to be adjusted over time to prevent undue hardships and sustain economic revitalization. (Clark 2010)

**San Francisco's Earthquake Safety Implementation Program:** The City and County of San Francisco has long placed a premium on and benefits from its stakeholder feedback for their earthquake risk management programs. In the 1980's and 90's, it's Seismic Investigation and Hazards Survey Advisory (SIHSAC) Committee helped set priorities for unreinforced masonry buildings. In 1998, the City launched a new effort called the Community Action Plan for Seismic Safety (CAPSS) that was funded using $1 million from the state-mandated fees collected by San Francisco for the Strong Motion Instrumentation Program. Many volunteers also helped develop the plan over nine years, San Francisco's Department of Building Inspection developed and proposed in 2010 a thirty-year Earthquake Safety Implementation Program (ESIP) to carry out the recommendations of CAPSS. A key part of the ESIP is the City's Earthquake Safety

Working Group that provides public policy advice and feedback from stakeholders. First steps for the Program include reducing the collapse risks from the City's most vulnerable soft story apartment buildings. Next in line are older private schools, chimneys, and non-ductile concrete buildings. As the program ramps up, additional working groups are being formed: 1) Facade Maintenance Working Group; 2) Neighborhood Support Center Working Group; 3) Private Schools Earthquake Safety Working Group. This allows the City to focus volunteer time commitments on limited efforts and expands the number and diversity of participants.

**San Diego's Down Parapet Bracing Program:** The City of San Diego was not contemplated by the State Legislature to be included in the scope of the State's Unreinforced Masonry Building Law (Section 8875, Government Code) when it was enacted in 1986. That Law was limited to regions of high seismicity and San Diego was thought to be located west of California's region of principal active earthquake faults. However, in the late 1980's more studies of the Rose Canyon Fault became available and elevated the expected seismicity in San Diego. City Council members, the Building Department, and local engineers began to consider the implications of damaging earthquakes occurring along the Rose Canyon Fault and identified the collapse of unreinforced masonry walls in older portions of San Diego as one of the City's greatest risks. So San Diego developed a scaled-down, partial retrofit program for bracing the tops of walls known as parapets on older brick and stone buildings. While not as comprehensive as complete retrofits that are commonly mandated by local governments in regions of higher seismicity, San Diego's parapet bracing program can serve as a model for other jurisdictions that do not have effective programs throughout California. Bracing was accomplished with historic preservation in mind so that the aesthetics of the brickwork and ornamentation was not adversely impacted by the installation of new wall anchors. Risks posed by other vulnerable aspects of the masonry were judged not to be cost effective to address because of lower seismic hazards and correspondingly lower benefits likely to be achieved compared to higher seismicity regions of California. Much of the work was funded by a redevelopment investment program in the downtown area. 728 buildings were inventoried, and, as of 2006, 218 had parapets braced for partial retrofits, 144 had been demolished, and 24 were fully retrofitted to comply with state standards in the California Existing Building Code (SSC 2006).

**Recommended Model Ordinances – To be completed**

Seismic Safety Commission's Model Ordinance for Unreinforced Masonry Building Retrofits – Update and insert here

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