ATC 52-2

Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco

A Community Action Plan for Seismic Safety

Applied Technology Council

Prepared for
San Francisco Department of Building Inspection
under the Community Action Plan for Seismic Safety (CAPSS) Project

Community Action Plan for Seismic Safety (CAPSS) Project

The Community Action Plan for Seismic Safety (CAPSS) project of the San Francisco Department of Building Inspection (DBI) was created to provide DBI and other City agencies and policymakers with a plan of action or policy road map to reduce earthquake risks in existing, privately-owned buildings that are regulated by the Department, and also to develop repair and rebuilding guidelines that will expedite recovery after an earthquake. Risk reduction activities will only be implemented and will only succeed if they make sense financially, culturally and politically, and are based on technically sound information. CAPSS engaged community leaders, earth scientists, social scientists, economists, tenants, building owners, and engineers to find out which mitigation approaches make sense in all of these ways and could, therefore, be good public policy.

The CAPSS project was carried out by the Applied Technology Council (ATC), a nonprofit organization founded to develop and promote state-of-the-art, user-friendly engineering resources and applications to mitigate the effects of natural and other hazards on the built environment. Early phases of the CAPSS project, which commenced in 2000, involved planning and conducting an initial earthquake impacts study. The final phase of work, which is described and documented in the report series, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco*, began in April of 2008 and was completed at the end of 2010.

This CAPSS Report, designated by the Applied Technology Council as the ATC-52-2 Report, recommends policies to reduce earthquake risk in privately owned buildings of all types. Several other CAPSS reports are also available in the series, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco*:

- *Potential Earthquake Impacts* (ATC-52-1 Report), which focuses on estimating impacts to the City's privately owned buildings in future earthquakes, and the companion *Technical Documentation* volume (ATC-52-1A Report), which contains descriptions of the technical analyses that were conducted to produce the earthquake impacts;
- *Earthquake Safety for Soft-Story Buildings* (ATC-52-3 Report), which describes the risk of one vulnerable building type and recommends policies to reduce that risk, and the companion *Documentation Appendices* volume (ATC-52-3A Report), which details the technical methods and data used to develop the policy recommendations and related analyses; and
- *Post-earthquake Repair and Retrofit Requirements* (ATC-52-4 Report), which recommends clarifications as to how owners should repair and strengthen their damaged buildings after an earthquake.

Many public and private organizations are working actively to improve the City's earthquake resilience. The CAPSS project participants cooperated with these organizations and considered these efforts while developing the materials in this report. Three ongoing projects outside of CAPSS but directly related to this effort are:

- *The Safety Element.* The City's Planning Department is currently revising the Safety Element of the General Plan, which lays out broad earthquake risk policies for the City.
- *The SPUR Resilient City Initiative*. San Francisco Planning and Urban Research (SPUR) published recommendations in February 2009 for how San Francisco can reduce impacts from major earthquakes. SPUR is currently developing recommendations on Emergency Response and Post-Earthquake Recovery.
- *Resilient SF.* San Francisco City government is leading a unique, internationally recognized, citywide initiative that encompasses the City's All Hazards Strategic Plan and seeks to use comprehensive advanced planning to accelerate post-disaster recovery. This work is coordinated by San Francisco's General Services Agency (GSA), the Department of Emergency Management (DEM) and Office of the Controller in collaboration with the Harvard Kennedy School of Government.

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A Community Action Plan for Seismic Safety

Prepared for the

DEPARTMENT OF BUILDING INSPECTION (DBI)
CITY AND COUNTY OF SAN FRANCISCO
under the Community Action Plan for Seismic Safety (CAPSS) Project

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PREFACE

Today, more than 5 years after the category 3 hurricane Katrina hit New Orleans, several thousand people still live in temporary housing and an estimated 25% of the city's population has not returned. The catastrophe of cascading consequences that Katrina wrought was devastating, even more so because the high storm surge and levee collapse accompanying the hurricane had been anticipated. In fact, the event, as played out, closely mirrored one of three Federal Emergency Management Agency (FEMA) "worst case" scenarios – that is, one of the three most catastrophic disasters expected to occur in the United States.

A major earthquake striking the San Francisco Bay Area was another of those three FEMA scenarios. Most Bay Area residents acknowledge the U. S. Geological Survey forecast that a major earthquake (magnitude 6.7+) is nearly twice as likely as not to strike the region in the next 30 years. Unlike hurricanes, most earthquakes strike without warning. However, while many people could and should have been evacuated in the several day warning window that New Orleans had, nothing could have been done to strengthen the levees in that time frame. The same is true in the Bay Area – even if the next earthquake was accurately predicted with a week's warning, the tens of thousands of seismically vulnerable buildings throughout the region would still be severely damaged or collapse. The resulting recovery would likely take years and potentially result in many residents leaving the region and many businesses closing permanently.

The purpose of the Community Action Plan for Seismic Safety (CAPSS) is to recommend specific actions that will reduce death, injury and damage in San Francisco from future earthquakes, thus allowing the City to quickly return to its pre-earthquake vitality. CAPSS has previously produced a series of unique reports, documenting the impacts that future earthquakes will likely have on San Francisco. The CAPSS project culminates with this call to action, which sets forth a series of recommended steps which the City can take to dramatically reduce the impacts of future earthquakes.

A study, however, never saved a life or prevented property damage – studies are only effective when their results and recommendations stimulate actions that mitigate the effects and consequences of future disasters. The CAPSS project team, together with the volunteer public advisory committee that represents tenants, landlords, small business owners, and other concerned citizens, have spent years investigating these issues and alternatives. They unanimously approve these recommendations. We know what to do, and how to do it. City government must now take action.

Will San Francisco be like New Orleans, aware of looming catastrophe but taking no action to prevent it? Or does San Francisco have the political will and courage to invest in its future, by retrofitting the many known seismically vulnerable building

types? Such investment will cost building owners in the short term, but will reap many benefits in the long-term both for the owners and the community at large when strengthened buildings continue to function as safe homes and sources of continued revenue in the aftermath of a major earthquake.

Inaction is inexcusable in light of the City's known vulnerability and the fact that most of these risks are avoidable. City government, especially the Mayor and the Board of Supervisors, are the linchpin for causing the essential evaluations and retrofits to take place to assure that, after the next big earthquake, San Francisco can recover quickly and maintain both its economic and cultural vibrancy.

Mary Lou Zoback
Advisory Committee Co-Chair

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Advisory Committee Co-Chair

MAYOR'S EXECUTIVE DIRECTIVE

On December 22, 2010, the Honorable Gavin Newsom, Mayor of San Francisco, issued Executive Order 10-02, Earthquake Safety Implementation Committee (ESIC), which directed the City Administrator to oversee the process of outreaching to interested parties around the City to building a broad coalition of supporters to implement the Community Action Plan for Seismic Safety (CAPSS) recommendations. The Executive Directive is provided verbatim on the following pages.

Office of the Mayor
City & County of San Francisco

Gavin Newsom

Executive Directive 10-02
Earthquake Safety Implementation Committee (ESIC)

December 22, 2010

ABOUT CAPSS
The Community Action Plan for Seismic Safety (CAPSS), run by the Department of Building Inspection, is a 9-year, $1 million effort to catalogue the specific seismic risks San Francisco faces as a result of damage to privately-owned property from future earthquakes, and suggestions on how to best mitigate this loss of life and property damage. The project ends on December 31, 2010, and CAPSS has completed reports describing the scope of vulnerability faced by San Francisco, and recommendations as to what steps the City can take to mitigate these risks.

THE CONSEQUENCES
USGS scientists have forecast 63% likelihood of one or more M6.7 or larger earthquakes striking the Bay Area in the next 30 years. Using GPS to measure strain accumulating along the San Andreas fault, scientists report that enough strain has re-accumulated along the Peninsula segment of the San Andreas already to produce a M7.2 earthquake. This event, which seismologists call the "expected" earthquake, would lead to an estimated 300 fatalities, 7,000 injuries requiring medical attention, 27,000 buildings being condemned, 2,700 additional buildings destroyed by fire, 85,000 housing units lost, and up to $30 billion in property damage.

All told, after shaking and fire, almost a fifth of the City's buildings would be uninhabitable or destroyed, including an estimated 11 million square feet that will burn. More detailed tables on casualties and building damage are attached to this Directive as Appendix A.

THE SOLUTIONS
The CAPSS reports present a very grim picture. But they also suggest policies and programs to mitigate as much damage and loss of life as possible. It all begins with requiring owners to evaluate the seismic performance of their buildings at the next sale or by a time-certain deadline. This citywide evaluation would be paired with updated code standards for all common building types in San Francisco, which would be mandatory by different deadlines for different specific retrofits.

CAPSS proposes a set of 17 recommendations to get buildings evaluated and retrofitted. A full outline of recommendations is attached to this Directive as Appendix B. Taken together, CAPSS's suggested policies will save lives and prevent billions of dollars in property damage. CAPSS details prioritized timetables for much of this seismic upgrading, a chart of which is attached as Appendix C.

NEXT STEPS
The scientific research is complete: San Francisco faces grave consequences when the next big earthquake hits. CAPSS provides us with actions we need to take to mitigate this damage. The next phase of the CAPSS program must include:

1) Raising the public's awareness of the consequences of future earthquakes and what we can do to prevent the resulting loss of life and property damage
2) Building a broad base of political will to enact government programs and mandates to get this work accomplished
3) Locating resources to assist with the retrofit of private structures

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Over the next several decades, billions of dollars must be spent on retrofitting privately owned buildings if we hope to prevent hundreds of deaths, thousands of injuries, and tens of billions of dollars of damage. Some of this money will come from private citizens paying to retrofit their own property. But some funding must be made available through government financing, either in the form of GO Bonds, special assessments, or some other instrument.

San Francisco needs a comprehensive program that links disparate interests together for a common cause. When the ground shakes and buildings fall, the damage and displacement of residents impacts the whole City. Loss of housing, tent camps, economic devastation, fires – these afflictions don't discriminate between neighborhoods or blocks.

Earthquake prevention requires citywide effort to achieve citywide benefit. In order to successfully educate the public on what must be done, the City must outreach to neighborhood councils, building owners, tenant associations, commercial builders, and dozens of other groups. Only with a citywide approach like this can we win support for the comprehensive interventions necessary to reduce the risks that San Francisco faces. Awareness breeds urgency. Urgency paves the way for solutions. The next phase of CAPSS must be widespread awareness, and knowledge of the relative risks posed by each building.

Directive Establishing ESIC Under the City Administrator

To that end, I am directing the City Administrator to oversee the process of outreaching to interested parties around the City to build a broad coalition of supporters to implement the CAPSS recommendations. The City Administration is currently tasked with post-disaster planning, coordination and recovery, and ESIC aligns with this existing responsibility. We have scientifically supported conclusions about how the next earthquake will impact San Francisco. We now need to implement.

This Directive establishes the Earthquake Safety Implementation Committee (ESIC), with the main objective being timely implementation of the 17 policy recommendations included in the CAPSS Task 4 report.

- Coordinating with DBI to create implementation plans and timelines for CAPSS's recommendations and tasking other departments with implementation assignments;
- Performing community outreach to build political support for a comprehensive, long-term earthquake mitigation strategy;
- Clarifying, through stakeholder meetings and further research, the costs associated with the CAPSS recommendations;
- Devising a variety of financial instruments to subsidize for the cost of implementing seismic mitigation activities on private property, through both the legislative process and public-private partnerships with the financial and mortgage sectors; and
- Building consensus around timelines for inspection and retrofit, taking into account CAPSS's recommended time frames and community feedback on feasibility and desire to perform the work.

The City Administrator should work closely with the following entities or their designees: the Controller, the Office of Public Finance, the Director of DBI, the President of the Building Inspection Commission, the Fire Chief, and the Director of the Department of Emergency Management. All other City departments and agencies are directed to cooperate with the City Administrator's requests for information, participation, and action pertaining to ESIC.

Gavin Newsom
Mayor

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Appendix A.
Casualty & Damage Estimates

Table 12 Estimated Injuries and Deaths in Four Scenario Earthquakes

Earthquake Scenario	Casualties			
	Severity 1: Injuries Needing First Aid	Severity 2: Injuries Needing Hospitalization	Severity 3: Life Threatening Injuries	Severity 4: Death
Hayward Fault, Magnitude 6.9	1,500 to 2,300	330 to 510	40 to 60	70 to 120
San Andreas Fault, Magnitude 6.5	1,800 to 3,600	390 to 740	40 to 60	80 to 120
San Andreas Fault, Magnitude 7.2	3,200 to 5,600	760 to 1,300	90 to 150	170 to 300
San Andreas Fault, Magnitude 7.9	6,500 to 10,600	1,800 to 3,000	220 to 450	420 to 880

Table 6 Estimated Damage States of Buildings Due to Shaking and Ground Failure in a Magnitude 7.2 Earthquake on the San Andreas Fault, by Building Use

Building Occupancy	Number of Buildings in Various States of Damage			
	Usable, Light Damage	Usable, Moderate Damage	Repairable, Cannot be Occupied	Not Repairable
Single-Family Houses	45,000	54,000	11,000	1,700
Two-Unit Residences	8,200	7,400	3,200	290
Three-or-More-Unit Residences	7,200	7,500	7,200	1,100
Other Residences	300	400	80	40
Commercial Buildings	1,600	2,400	630	290
Industrial Buildings	750	820	320	210
Other	330	280	60	30
Total	63,000	73,000	23,000	3,600

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Appendix B.
Community Action Plan for Seismic Safety – Recommended Actions to Reduce Earthquake Risk

1. Require evaluation of all wood frame residential buildings of three or more stories and five or more units, and retrofits of those that are vulnerable to earthquake damage. A Mayoral task force has drafted an ordinance to require retrofit of these buildings. The Board of Supervisors should pass it.

2. Inform the public of risks and ways to reduce risk. The City should conduct focused education and outreach campaigns aimed at building owners, tenants, realtors and others to improve their understanding of earthquake risk and measures to manage the risk, and to facilitate a market for retrofitting.

3. Adopt updated code standards. The City should adopt code standards for seismic evaluation and retrofit of all common building types in San Francisco.

4. Require all buildings to be evaluated for seismic risk. Owners of all buildings should evaluate the seismic performance of their buildings upon sale relative to DBI standards or, if no sale occurs, by a deadline established based on the building use and structural type. The results would be shared with tenants and prospective buyers and tenants, and be made a part of public City records.

5. Require retrofits of vulnerable buildings. Owners of vulnerable buildings should seismically retrofit their building for structural, fire, usability and falling hazards by specific deadlines, varying by building category.

6. Assist community service groups to reach earthquake resilience. The City should provide technical and financial assistance for important non-profits, medical clinics, daycare centers and similar groups to seismically retrofit their buildings or relocate to better buildings.

7. Establish clear responsibility for preparing for and reducing risk from earthquakes. The City should identify a single official in the Chief Administrator's Office, to be responsible for achieving earthquake resilience through mitigation, response and recovery.

8. Adopt improved post-earthquake repair standards. The City should enact updated post-earthquake repair and retrofit standards developed by CAPSS and expand this approach to other building types.

9. Offer incentives for retrofit of buildings. The City should enact a range of meaningful programs to help building owners afford retrofits.

10. Require gas shut-off valves on select buildings. The City should require owners of certain vulnerable buildings and buildings in Fire Department designated Post-Earthquake High Fire Hazard Areas to install automatic gas shutoff valves.

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11. Track evaluations and retrofits in a database system. The City should include information relating to seismic evaluations and retrofits in DBI's updated database system to allow tracking progress of mitigation activities and recording inventories, evaluation reports and retrofit information.

12. Provide technical assistance for building retrofits. The City should help residents and building professionals to evaluate and seismically retrofit buildings efficiently and in accordance with City codes.

13. Enact a façade ordinance, requiring periodic inspection of façades, parapets and decorative features fixed to building exteriors, and require repair of materials found to be falling hazards.

14. Promote development and implementation of effective ideas on earthquake risk reduction. The City should encourage efforts to improve knowledge relevant to San Francisco about building structural performance and effective ways to reduce earthquake risk.

15. Evaluate measures to reduce post-earthquake fires. Multiple City Departments should work together to evaluate and implement measures to reduce fire ignitions and spread, and improve fire suppression capacity following earthquakes.

16. Address the hazards from damage to furnishings, appliances and equipment and non-structural building elements. DBI should initiate a comprehensive program to encourage, and in some instances, require measures to reduce these hazards.

17. Periodically assess progress and implementation of these recommendations.

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18. Appendix C.
Proposed Timeframes for Seismic Retrofits

Table 5 **Recommended Timeframe* for Applying the Three-Step Strategy to Key Categories of Buildings**

Building Categories	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
Wood-frame residential buildings with three or more stories and five or more units**						
Concrete tilt-up buildings						
Residential buildings with three and four units						
Private K-12 schools and private universities						
Assisted living facilities						
Concrete residential buildings built before 1980						
Other types of residential buildings with more than five units						
Hotels and motels serving tourists						
Critical retail stores and suppliers						
Single family homes and two unit residences						
Concrete non-residential buildings built before 1980						
Houses of worship						
Preschools and daycare centers						
Buildings used by large audiences						
Historic buildings						
Large buildings with welded steel moment frames built before 1994						
Early retrofitted buildings						
All other building types						

*The mandatory evaluation or retrofit program would begin at the start of the period and be completed by the end of the period.

**See Table 3 for the detailed schedule proposed in the draft ordinance developed by the Mayoral Task Force.

Color key***:

Step 1: Facilitate a market in which earthquake performance is valued	
Step 2a: Nudge market by requiring evaluation upon sale	
Step 2b: Nudge market by requiring evaluation by a deadline	
Step 3: Implementation period to require retrofit by a deadline	

*** Note: all previous steps remain in effect after advancing to a higher step.

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REPORT SUMMARY

Earthquakes are in San Francisco's future. The consequences of those future earthquakes could be very different—worse or better—depending on the policy choices and actions City agencies and building owners take now.

The Community Action Plan for Seismic Safety (CAPSS) project studied four probable earthquakes that could strike the City and found that future earthquakes would damage many thousands of buildings to the point where they cannot be occupied. They would devastate the City's housing stock, and could have long-term implications on the City's affordability to middle- and low-income residents, who would be displaced for years. Hundreds of people could be killed and thousands could be injured. The City would lose irreplaceable historic buildings and rent-controlled apartments. The price tag of the earthquake damage would be many billion dollars. Property owners, the majority of whom do not carry earthquake insurance, would bear the brunt of these economic losses, but residential tenants and businesses would suffer as well. Many more details appear in a companion report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Potential Earthquake Impacts* (ATC, 2010a).

Demolition in the Marina District after the 1989 Loam Prieta earthquake. Photo credit: Courtesy of Earthquake Engineering Research Institute Mitigation Center, Oakland, California.

Much of the damage from future earthquakes is preventable. This report recommends measures building owners and the City can take to reduce risk to privately owned buildings[1]. It identifies steps to protect important community resources that currently face high risk from future earthquakes—affordable housing, private schools, and medical clinics, to name a few. Reducing the negative consequences of future earthquakes benefits all San Franciscans: building owners, businesses, residential tenants, and the City government. This report, recognizing the challenges building owners face to finance seismic retrofits, recommends that the City take steps to assist and empower most building owners to make improvements on their own schedule, prior to enacting mandates. Taking action before an earthquake strikes is far less costly than repairing damage after an earthquake, both in terms of the dollars required and the social impacts associated with housing losses, business closures, and damaged property.

This report proposes the following long-term objectives to guide mitigation actions and priorities:

After expected earthquakes:

1. Residents will be able to stay in their own homes;
2. Residents will quickly have access to important privately-run community services;
3. No building will collapse catastrophically;
4. Businesses and the economy will quickly return to functionality; and
5. The City's *sense of place* will be preserved.

This report identifies seventeen important actions that San Francisco's City government leaders should take now to reduce the consequences of future earthquakes. These recommendations were developed with advice from an advisory committee of a diverse group of San Francisco residents. The committee met over thirty times over two and a half years to guide the project.

Recommendation 1: Require evaluation of all wood-frame residential buildings of three or more stories and five or more units, and retrofit of those that are vulnerable to earthquake damage.

The moderate-sized 1989 Loma Prieta earthquake showed how vulnerable these buildings are to earthquakes. A Mayoral task force has proposed an ordinance to require evaluation and retrofit of these buildings. The Board of Supervisors should enact it.

Recommendation 2: Inform the public of risks and ways to reduce risk.

The City should conduct focused education and outreach campaigns aimed at building owners, tenants, realtors and others to improve their understanding of earthquake risk and measures to manage the risk, and to facilitate a market for retrofitting. On their own, education programs motivate only a limited number of people to take action. However, they are an essential part of making other risk reduction programs work.

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[1] It does not consider the risk to publicly owned buildings or infrastructure, though these risks are considerable. These risks are being addressed by other City programs.

A seismic retrofit in progress. Photo credit: Courtesy of Anderson Niswander Construction.

Recommendation 3: Adopt updated code standards for seismic evaluation and retrofit of all common buildings.

As the City moves forward with programs to encourage and require more retrofits of vulnerable buildings, it is critical for the San Francisco Department of Building Inspection (DBI) to adopt updated code standards applicable to all of the City's common building types that reflect both the City's earthquake resilience objectives and technical advances in structural engineering. It must be clear to building owners what building seismic performance is acceptable to the City, and what requirements of future mandates would be.

Recommendation 4: Require all buildings to be evaluated for seismic risk.

Building owners should evaluate the seismic performance of their buildings, upon sale, relative to standards adopted by the City. If no sale occurs, they should evaluate their buildings by a deadline established based on the building use and structural type. The result would be shared with tenants and prospective buyers and tenants, and be made a part of public City records. This information allows prospective buyers and tenants to consider seismic issues when making decisions about purchasing or renting space. It provides information needed to incorporate seismic issues in market

pricing of real estate. It would also provide owners with the information needed to decide whether to seismically retrofit vulnerable buildings.

Recommendation 5: Require retrofits of vulnerable buildings.

Owners of vulnerable buildings should be required to seismically retrofit their buildings for structural and fire hazards and building elements that affect usability, by specific deadlines, varying in time by building category. It is likely that most owners will not retrofit their buildings unless they are required to do so. Ultimately, to improve San Francisco's earthquake resilience, the City will need to require owners of vulnerable buildings to retrofit. Establishing deadlines for mandatory retrofits will show that the City recognizes the importance of this issue, allows the market to consider seismic safety in its pricing, and provides certainty for owners of vulnerable buildings to plan for the future.

Recommendation 6: Assist community service organizations to reach earthquake resilience.

The City should provide technical and financial assistance to important non-profit organizations, medical clinics, and similar organizations that meet the basic needs of many San Franciscans to seismically retrofit their buildings or relocate to better buildings. After an earthquake, vulnerable residents will need services from these groups more than ever. Many of these organizations occupy rented space and are not in control of building issues such as seismic safety concerns.

Recommendation 7: Establish clear responsibility within City government for preparing for and reducing risk from earthquakes.

The City should identify a single official within the Chief Administrative Officer's Office to be responsible for achieving earthquake resilience through mitigation, response and recovery. Implementing earthquake mitigation measures needs to become an ongoing concern of the City, with standing equal to other programs.

Recommendation 8: Adopt improved post-earthquake repair standards.

The City should enact the updated post-earthquake repair and retrofit standards developed by CAPSS and should expand this approach to other building types. In a companion report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Postearthquake Repair and Retrofit Requirements* (ATC, 2010c), CAPSS has clarified the technical requirements for post-earthquake building repair, to improve existing City policy and to improve the way this process builds the City's resilience over time.

Recommendation 9: Offer incentives for retrofit of buildings.

The City should enact a range of meaningful programs to help building owners afford retrofits. Owners ultimately are responsible for the earthquake performance of their buildings: they have the most to gain from improved performance, and the most to lose because of damage and liability. However, the City has an overriding interest in reducing the amount of damage that occurs to privately-owned buildings in future earthquakes. Therefore, it makes sense for the City to invest in encouraging building owners to make their buildings safer.

Recommendation 10: Require gas shut-off valves on select buildings.

The City should require owners of a limited number of vulnerable buildings and buildings in Fire Department designated Post-Earthquake High Fire Hazard Areas to

install automatic gas shutoff valves. In past earthquakes, gas leaks have played a significant role in fueling post-earthquake fires. Automatic gas shutoff valves, either triggered by shaking or excess flow, can play a role in reducing this fire risk.

Recommendation 11: Track evaluations and retrofits in a database system.

The City should include information relating to seismic evaluations and retrofits in DBI's updated database system to allow tracking progress of mitigation activities and recording inventories, evaluation reports and retrofit information.

Recommendation 12: Provide technical assistance for building retrofits.

The City should help residents and building professionals to evaluate and seismically retrofit buildings efficiently and in accordance with City codes. Training programs and other technical assistance can help make retrofitting easier and contribute to high-quality work.

Recommendation 13: Enact a façade ordinance.

An ordinance should require periodic inspection of façades, parapets and decorative features fixed to building exteriors, and require repair of materials found to be falling hazards. Parts of building façades can fall off and kill passers-by during earthquakes or at any time.

Recommendation 14: Promote development and implementation of effective ideas on earthquake risk reduction.

The City should encourage efforts to improve knowledge relevant to San Francisco about building performance and effective ways to reduce earthquake risk. Knowledge about earthquake risk reduction is developing rapidly from ongoing research, retrofitting experience, and studies following large, damaging earthquakes.

Recommendation 15: Evaluate measures to reduce post-earthquake fires.

Multiple City departments should work together to evaluate and implement measures to reduce fire ignitions and spread, and improve fire suppression capacity following earthquakes. Fires triggered by earthquakes pose a serious risk that transcends City departments.

Recommendation 16: Address the hazards from damage to building systems, appliances, equipment and non-structural building elements.

Damage to building systems, such as fallen ceilings and fixtures, broken pipes, and overturned equipment, cause serious problems in every earthquake, including deaths, greatly increased economic losses, and making buildings unusable. DBI should initiate a comprehensive program to encourage, and in some instances, require measures to reduce these hazards.

Recommendation 17: Periodically assess progress and implementation of these recommendations.

The preceding sixteen recommendations in this report call for significant new policies and programs to improve the earthquake resilience of San Francisco's building stock. The City should commission an assessment at least every five years to review progress and the consequences of the resulting program and to make recommendations for improving seismic programs.

This plan is a call to action to invest in the City's future. San Francisco will always have earthquakes in its future, but with foresight and effort, the consequences of

those earthquakes can be reduced so that the City can rebound quickly and maintain its unique character. San Francisco's leaders must act now. Improving San Francisco's earthquake resilience will take persistent effort and government intervention over several decades. However, as the recommended measures are implemented, the San Francisco community will weather earthquakes with fewer casualties and less damage, be able to more rapidly recover economically, and preserve for future generations the exciting, dynamic, culturally diverse, historic and livable city residents enjoy today. In a word, San Francisco would become more resilient.

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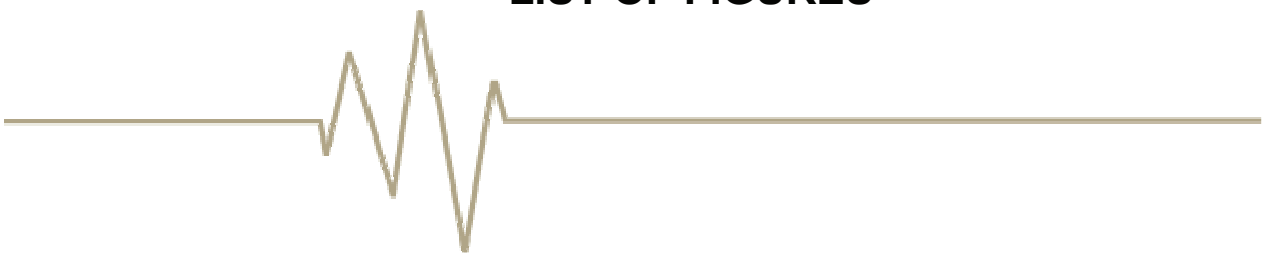

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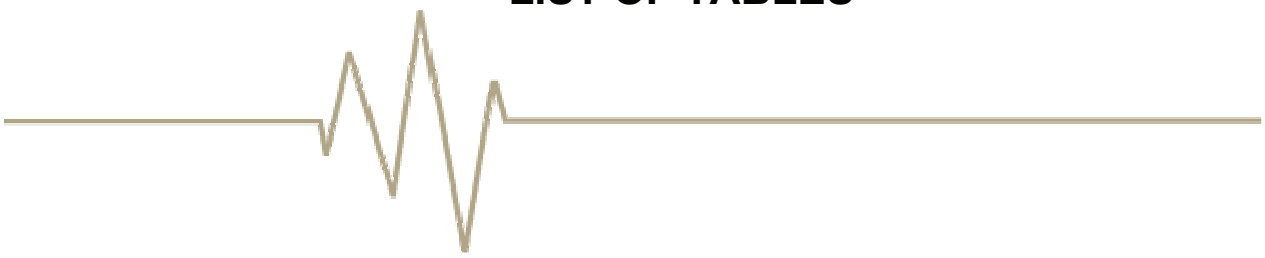

CHAPTER 1: INTRODUCTION

San Francisco faces a daunting earthquake threat given its proximity to active faults, buildings that are older than those in other Western cities, steep hillsides, areas with poor soils prone to liquefaction and amplification of shaking, and dense, wooden buildings with a susceptibility to fire. However, there are many things that can be done to minimize the consequences of future earthquakes and make San Francisco more earthquake resilient. Actions taken to improve buildings before earthquakes strike will reduce damage and casualties, speed recovery, lessen economic losses from business interruption, reduce housing and jobs losses, and protect community values and the unique character of the City. San Franciscans need to understand the risk from earthquakes and the steps they can take to improve the situation.

This report identifies measures that could be taken before earthquakes strike to reduce damage to privately-owned buildings. It recommends a comprehensive, long-term mitigation program to lead the City toward earthquake resilience and identifies steps needed to carry out the program. The program begins with building public awareness among specific groups of San Franciscans and builds over time to stronger measures to make the City's building stock more robust.

Earthquake risk creates a dilemma for building owners. Most owners understand that intense earthquakes would damage their buildings, and that the cost to repair their buildings and the income lost, while the building is repaired or replaced, can amount to significant losses. They also sense that they bear a duty to others who could be harmed by damage to their buildings and the ensuing disruption, but they are faced with uncertainty. The lack of community standards about the appropriate actions to take leads to misleading and inconsistent opinions about what needs to be done. Acting now appears to leave them open to requirements adopted later. If they retrofit their building now, will it comply with code requirements put in place in a few years? Will they need to re-do the work? Some owners, especially homeowners, have tried to improve their buildings without advice from qualified design professionals, but the lack of standards often leads them to overspend or carryout projects that might be ineffective. This report calls for measures to provide owners with the information and standards that would help them decide on the right course of action. It recommends giving owners of some types of vulnerable buildings about 20 years to voluntarily to protect their own interests before the City requires them to take action.

The course of action, however, cannot be only voluntary because too much is at stake. Therefore, this report recommends setting mandatory deadlines for buildings to be retrofitted. The report reiterates an earlier recommendation for a mandatory retrofit program addressing wood-frame buildings with five or more residential units and three or more stories[1]. A task force created by the Mayor drafted an ordinance to

[1] See companion CAPSS report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Earthquake Safety for Soft-Story Buildings* (ATC, 2009a).

implement this recommendation. Improving San Francisco's earthquake resilience will take persistent effort and government intervention over several decades. As the recommended measures are implemented, however, the San Francisco community would weather earthquakes with fewer casualties and less damage, be able to recover more rapidly and more economically, and preserve for future generations the exciting, dynamic, culturally diverse, historic and livable city residents enjoy today. In a word, San Francisco would become more resilient.

The recommended mitigation program is presented in the following chapters:

- Chapter 2 summarizes the likely impacts of future earthquakes in San Francisco as it exists today. These impacts are described in detail in the companion CAPSS report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Potential Earthquake Impacts* (ATC, 2010a).
- Chapter 3 recommends objectives to guide the City's mitigation activities.
- Chapter 4 recommends actions building owners and the City should take, and explains why these actions make sense for the City.
- Chapter 5 presents a worksheet so the City can prepare a plan of action for the next few years, 2011 to 2015, to launch the recommendations in this report.

This plan is a call to action to invest in the City's future. San Francisco will always have earthquakes in its future, but with the proper foresight and effort, those earthquakes do not need to be unmitigated disasters.

CHAPTER 2: SAN FRANCISCO'S EARTHQUAKE RISK

Future large earthquakes will have severe consequences to San Francisco if the City does not act to improve the seismic performance of its older buildings. These consequences are discussed exhaustively in a companion CAPSS report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Potential Earthquake Impacts* (ATC, 2010a), and they include deaths and injuries; damaged and destroyed buildings; loss of housing, particularly affordable and rent-controlled units; economic losses; job losses; businesses closures; reductions in City revenues at a time of increasing need; loss of historic resources; and increased difficulties for low and middle income residents.

Knowing the risk the City faces today is important because it defines the starting point for reducing those risks. The San Francisco community can compare where its risk is today with where it would like it to be, and identify the risks that are least acceptable. San Francisco can learn from New Orleans, where the risk of hurricane flooding was well known, but the importance of acting on that knowledge became widely accepted only after Hurricane Katrina struck.

This chapter briefly reviews selected impacts of four possible earthquakes that could strike the City, highlighting impacts that point towards mitigation priorities and steps the City could take to become more resilient. The earthquakes studied are magnitude 6.5, 7.2 and 7.9 earthquakes on the San Andreas fault at the City's western coast, and a magnitude 6.9 earthquake on the Hayward fault across the Bay. The CAPSS project analyzed the damage these earthquakes and fires ignited by the shaking could cause, and the impacts of that damage on various aspects of San Francisco. Selected findings are discussed below[2]. These findings are estimates, not predictions, and any number of circumstances could cause impacts after future earthquakes to be much lower or higher.

Loss of Life

Buildings damaged by earthquakes can kill people. Some loss of life may be unavoidable in large earthquakes, but measures can reduce the danger. In fact, San Francisco already has taken many steps to reduce casualties in earthquakes by enforcing building design and construction standards and requiring seismic retrofits of unreinforced masonry buildings and bracing of parapets. San Francisco can expect fewer casualties after a large earthquake than seen in less developed countries, but deaths are still expected and significant risk remains.

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[2] Detailed loss estimates are available in the report *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Potential Earthquake Impacts* (ATC, 2010a). A discussion of the technical methods behind the estimates appears in the companion CAPSS report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Potential Earthquake Impacts: Technical Documentation* (ATC, 2010b).

The study of four scenario earthquakes found the following[3]:

- Depending on the magnitude, location and time of day of an earthquake, deaths could range from 70 to nearly 1,000, and injuries requiring medical care could number from 1,900 to more than 14,000.
- Casualties could be much higher than these estimates if even one large, densely occupied office or apartment building collapses. There are some large, multi-story concrete buildings in the City built before 1980 that have the potential to collapse catastrophically and kill many people.

Specific types of buildings are most likely to cause casualties in future earthquakes. As shown in Figure 1, stiff and brittle concrete buildings built before the 1980's have the highest potential to cause casualties. Falling items, such as heavy shelves, plaster ceilings, or exterior veneer, even in buildings that are structurally robust, also can cause casualties. For example, studies following the 1999 Kocaeli earthquake near Istanbul found that nearly half of the casualties were caused by falling hazards[4]. Casualties caused by such damage are included in these estimates but are not reported separately.

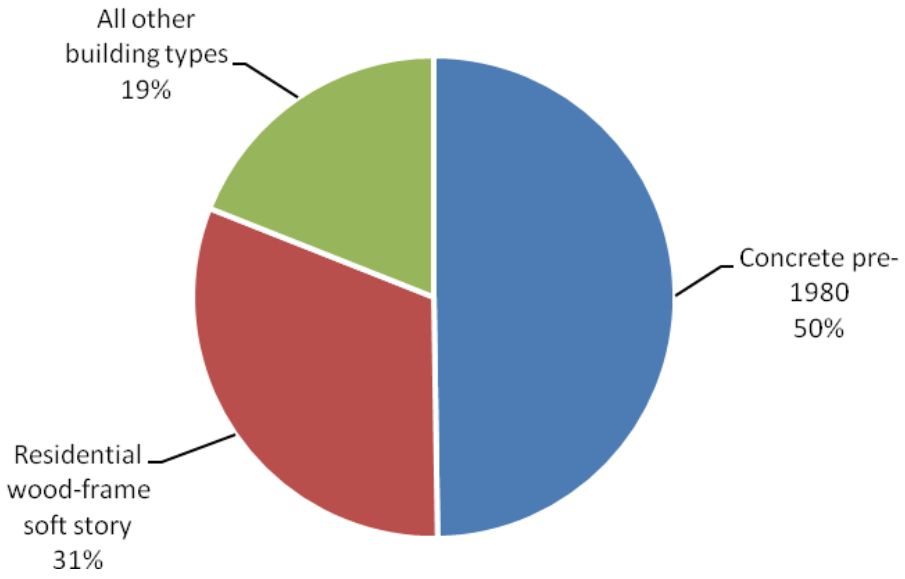


Figure 1 Estimated percent of deaths caused by various structure types in a Magnitude 7.2 San Andreas fault scenario, averaged over different times of day.

[3] These estimates only include casualties caused by building damage. They do not include casualties caused by infrastructure damage (e.g., collapse of overpasses) or casualties due to fires sparked by the earthquake.

[4] Petal, 2004.

Implications for Risk Mitigation Activities:

- Structural improvements to concrete buildings built before 1980 and residential wood-frame soft-story buildings would do the most to reduce expected casualties in future earthquakes.
- Casualties could be further reduced by making sure falling hazards are properly secured so that they do not fall on occupants during shaking. This is a relatively simple, low-cost effort.

Loss of Housing and Displaced Residents

Housing, which is a critical part of San Francisco's recovery from future earthquakes, will be hard hit. Damage will threaten the availability and affordability of housing and displace residents for years. The loss study found the following damage to housing after a magnitude 7.2 scenario earthquake on the San Andreas fault:

- 85,000 of the City's 330,000 housing units would not be safe to occupy due to damage caused by shaking. This is more than a quarter of the City's housing units.
- 11,000 of those damaged housing units would need to be demolished. It is likely that many of the lost units would be rent-controlled apartments, which, due to state law, could not be replaced by apartments covered by rent control.
- Fires that follow the earthquake could destroy more than 5,800 additional housing units.

Rebuilding is a slow process. After the Loma Prieta and Northridge earthquakes, both of which were much smaller in size than the earthquakes studied by this project, it took an average of two to three years before most heavily damaged residences were repaired or replaced. San Francisco can expect it will take much longer for its damaged and destroyed housing units to be usable after larger earthquakes.

Housing loss due to shaking damage is linked to particular types of structures. Figure 2 shows the types of structures responsible for unusable housing units after a Magnitude 7.2 San Andreas scenario earthquake.

Implications for Risk Mitigation Activities:

- Wood-frame residences with three or more units account for about two-thirds of the housing units that would not be usable after a Magnitude 7.2 San Andreas scenario earthquake. These structures are vulnerable largely because of weak or "soft-story" conditions. Retrofitting these types of structures would have a significant impact to improve post-earthquake housing availability. These retrofits are relatively straightforward and are less expensive than retrofits to other types of structures.
- Rebuilding after an earthquake will take a long time. There are steps City agencies and building owners can take prior to an earthquake to facilitate rapid and efficient repair and rebuilding, but reducing the amount of expected damage is the most effective way to speed post-earthquake recovery.

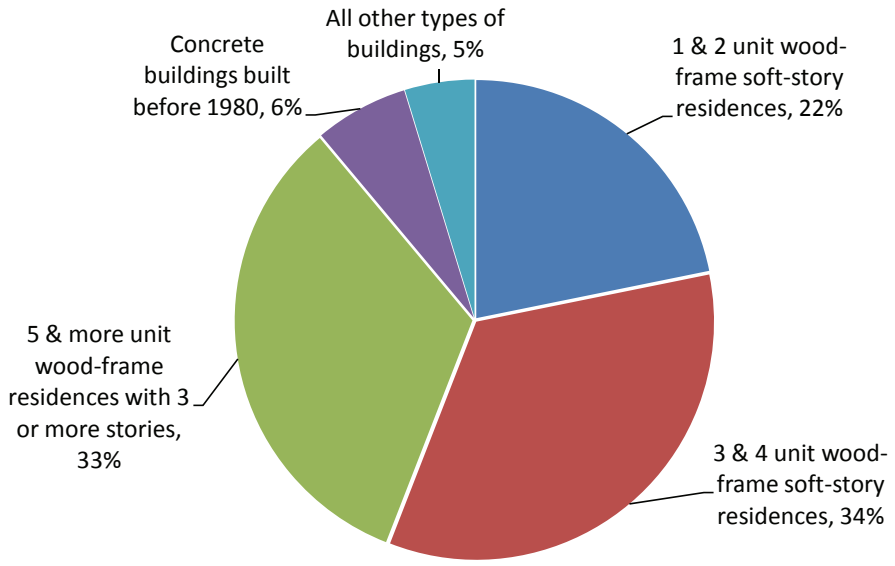


Figure 2 The estimated share of housing units that could not be occupied, by structural types, for a Magnitude 7.2 San Andreas scenario earthquake.

Economic and Business Impacts

The damage from earthquake shaking and fires sparked by the earthquake will be costly to households and businesses. Home and business owners will face an immediate need for funds to pay for repairs or to relocate. Businesses will fail and jobs will be lost. CAPSS found the following expected impacts:

- Damage to buildings due to shaking and fire could be valued at $17 to $54 billion[5], depending on which earthquake scenario occurs. These losses can be compared to the annual City budget of approximately $5 billion.
- Additional types of losses (such as damage to building contents and inventory, lost business income, lost wages, and relocation expenses) could add another $5 to $15 billion in losses, again varying by scenario earthquake.
- On top of the previously stated losses, reduced spending by businesses and workers could shrink the City's economy by more than two percent after a Magnitude 7.2 scenario earthquake, equivalent to or greater than the impacts of a recession.

In addition, a number of commercial and industrial buildings would be damaged. After the Magnitude 7.2 San Andreas fault scenario, it is estimated that more than 900 commercial buildings and 200 industrial buildings, out of a total of about 7,000 such buildings in the City, would not be safe for occupancy.

All of these impacts will affect the City's economy, businesses and jobs. The economy relies greatly on tourism and knowledge-based businesses. Many of the businesses and residents in San Francisco today do not need to be located here but

[5] All dollar figures are in 2009 dollars.

have chosen to be in San Francisco because of its urban amenities and attractiveness to creative workers. If those attractions change after an earthquake, these businesses could relocate and residents could move. The success of the City's tourism industry is directly linked to people wanting to visit San Francisco. Tourism will plummet after a major earthquake, and how quickly it rebounds is closely linked to how extensive the damage is and how quickly and how well the City as a whole recovers and rebuilds.

Damage to a Hotel in Nevada after an earthquake. Photo credit: Karl Steinbrugge, Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

San Francisco is privileged to have many small and local businesses; firms with 25 or fewer employees make up over 90 percent of the City's businesses. These face the highest failure risk after an earthquake. These businesses often have limited capital, depend entirely on revenues from one or few locations, carry limited insurance, and face difficulties repairing facilities, replacing damaged equipment and inventory, and weathering an economic downturn. Maintaining neighborhood business operations and speeding recovery are key to avoiding blighted neighborhoods. Vacant storefronts mean that both property values and neighborhood livability decline.

Certain businesses are critical to helping the City recover quickly and it is desirable to have them operational as soon as possible. San Franciscans need pharmacies, grocery stores, and similar retail establishments that provide the items required for daily living. Many of these important businesses may be located in weak buildings that would not be usable after a large earthquake.

Implications of Business And Economic Losses For Risk Mitigation Activities

- The cost of building damage and the economic ripple effects of this damage are daunting. The longer it takes to repair and rebuild the City, the more these losses will increase. Retrofitting buildings and reducing post-earthquake fire risk before

an earthquake would reduce these costs and keep the City's economy on stronger footing.

- Small and local businesses are particularly vulnerable to post-earthquake impacts. These businesses might be tenants in buildings with a limited ability to address seismic safety concerns and they may rely on nearby residents as customers. There are steps the City can take to minimize earthquake impacts to small and local businesses.
- There are particular retailers, such as large grocery stores and pharmacies, that are critical to the City's residents following earthquakes. The City has a particular interest in making sure these retailers can serve the community quickly after a disaster.

Impacts on Building Owners

Building owners stand to lose the most. Almost every building would be damaged by an intense earthquake to a degree that varies by building weaknesses, ground conditions, proximity to the fault and whether there are fires. Building owners bear the costs of repairs, as well as other costs, such as costs to relocate while damage is being repaired. Commercial owners lose income from rents. Existing lenders continue to expect payments. Owners' ability to repair their buildings depends on their ability to continue making payments on existing debt and to fund repairs from savings, liquidating other assets, or borrowing additional sums. Those without sufficient assets and with limited income might not qualify for additional loans. In contrast, retrofitting before earthquakes allows owners the opportunity to plan and finance measures to protect their assets and improve the chances that they will be able to afford repairs and recover quickly after future earthquakes.

Private building owners cannot rely on outside sources of funds to help them recover. FEMA's Individual and Households Program would cover some of the cost of minor repairs and temporary housing, but does not offer funds to cover the magnitude of costs that will face San Franciscans. Fewer than ten percent of San Franciscan homeowners carry earthquake insurance. The cost of insurance premiums is high relative to the coverage offered. Many argue that it is better to invest in retrofitting to reduce losses than to spend similar sums over time for insurance.

Implications for Mitigation Activities

- Owners should know the risks they face and measures they can take to manage the risks so they can make informed decisions;
- Building owners, by failing to address earthquake and fire risks, allow damage that jeopardizes adjoining buildings and entire neighborhoods.

Impacts on Vulnerable City Residents

Some privately-owned buildings that serve the City's most vulnerable populations may not be safe during or usable after future earthquakes. The following types of important services are often located in privately-owned buildings:

- Private schools—Kindergarten through grade 12 and colleges;
- Preschools and childcare centers;
- Assisted living facilities for the elderly or disabled;

- Medical offices and clinics, dialysis centers, medical suppliers;
- Nonprofits that serve vulnerable populations (e.g., meal delivery and public kitchens); and
- Single room occupancy hotels in older buildings.

: *A heavy ceiling panel that fell in a private school in the 1987 Whittier Narrows earthquake in southern California. Photo credit: Earthquake Engineering Research Institute Mitigation Center, Oakland, California.*

The buildings that house these services are no better than the general building stock and would suffer similar degrees of damage, if not more, in earthquakes. Many community serving organizations rent space in older buildings where rents are lower and near the population they serve. Some of these buildings might be unsafe. Extensive damage will interrupt critical support for those dependent on the services these organizations provide. Community service organizations have little leverage to cause owners to retrofit weak buildings.

Implications for Risk Mitigation Activities

- Organizations serving the City's most vulnerable residents may be located in buildings that will not be safe during or usable after future earthquakes. The City's elderly, disabled, children and poor will need the services these organizations provide in the aftermath of an earthquake. It makes sense for the City to help these organizations to become more resilient.

Loss of Community Character or "Sense of Place"

San Francisco's character could be defined in many ways, but surely it is partly captured by the distinctive flavor of the neighborhoods and the diversity of the City's residents. A major earthquake would affect both.

Earthquake damage and damage from fires sparked by earthquake shaking could destroy many buildings that define San Francisco's look and feel, including historic buildings. Demolished buildings would be replaced with buildings having modern construction materials that would look and function differently. Many of them would be larger, taking advantage of current height and density limits.

Earthquake damage to housing would have big impacts on the City's lowest income residents, senior citizens, people with fixed incomes and those with disabilities. Due to a variety of factors—including, but not limited to, few vacancies, expensive repairs, and loss of rent-controlled units—rents for apartments are likely to increase after an earthquake. Combined with short and medium term impacts on the City's businesses and job market, this could drive demographic changes that reduce San Francisco's socioeconomic diversity.

Implications for Risk Mitigation Activities

- Architecturally attractive private buildings, including historic buildings and districts, are at risk from earthquake and fire, and programs to limit building damage and earthquake-triggered fires would protect these irreplaceable resources.
- Risk reduction measures targeted at housing for low, middle and fixed income households would help keep San Francisco's population diverse.

Loss of City Government Revenue

Damage to privately owned buildings affects the City government's bottom line. An earthquake would reduce revenue at a time when increased funds would be needed because City-owned facilities would need repair and residents would need assistance to recover from the earthquake. The City can expect short and medium term declines in property tax, business tax, hotel room tax, sales tax, and other income sources. Federal funds will cover a fraction of the City government's rebuilding and recovery expenses, but none of its lost income.

Implications for Risk Mitigation Activities

- Limiting damage to privately owned buildings and the ensuing financial impacts would improve post-earthquake government revenues from property, sales and hotel taxes.

Conclusion

The analysis of four possible earthquakes to strike the City makes it clear that, as it is today, the City should expect a lot of damage from future earthquakes. As described above, wide ranging consequences will flow from that damage, causing recovery challenges for all residents, especially building owners. San Francisco will recover, but it could be forever changed by losing residents and businesses that relocate rather than wait for the City to recover. Taking steps to mitigate earthquake damage before the next earthquake strikes can avoid many of these consequences. In the following chapters, this report recommends a comprehensive program for the City to improve its earthquake resiliency.

CHAPTER 3: OBJECTIVES

Earthquakes are in San Francisco's future. The consequences of those future earthquakes could be very different—worse or better—depending on the policy choices and actions City agencies and building owners take now. It is up to San Franciscans to join in an informed and open process to decide what level and types of consequences they are willing to accept. San Franciscans should consider three fundamental questions: How many casualties are acceptable? How much damage and disruption are acceptable from shaking and fires sparked by that shaking? How quickly should the City return to a "new normal" after earthquakes? The citizens committee that advised the preparation of this study concluded that the expected casualties are too many, the damage and destruction too great, and the time to recover too long. Many of the attributes of the City that San Franciscans value are at risk. San Francisco, its neighborhoods and people, would be changed in regrettable ways by a large earthquake. This need not be the case.

Objectives are needed to guide the efforts to improve earthquake safety and post-disaster resiliency in San Francisco. This chapter recommends mitigation objectives, and the following chapters provide recommendations to meet the objectives.

Objectives are important because they shape the policies the City needs to pursue. The objectives indicate priorities for which categories of buildings should be evaluated first, and how quickly weak buildings should be strengthened. They guide development of the standards used for identifying unacceptably weak buildings and the measures needed to strengthen those buildings to achieve the desired performance. The objectives justify incentives that help building owners take actions that benefit the wider community.

This report proposes the following long-term objectives to guide mitigation actions and priorities:

After expected earthquakes[6]

1. Residents will be able to stay in their own homes.
2. Residents will quickly have access to important privately-run community services .

[6] The damage the City experiences in future earthquakes depends to a large extent on the intensity of earthquake shaking. Shaking intensity depends on a number of factors including the location of the fault where an earthquake occurs, magnitude of the earthquake, the manner that the fault rupture propagates, and the character of the ground underlying the City. The recommendations in this report are based on the intensity of shaking used by the building code for the design of new buildings. In its Resilient City report (SPUR, 2009), San Francisco Planning and Urban Research (SPUR) called this the "expected earthquake" because shaking of this intensity is likely to occur during the lifetime of the City's existing buildings.

3. No building will collapse catastrophically.
4. Businesses and the economy will quickly return to functionality.
5. The City's *sense of place* will be preserved.

These objectives are not new to the City. They respond to existing policies provided in the San Francisco General Plan. For over two decades, the City has clearly stated that earthquake safety, housing, neighborhood character and neighborhood-serving businesses are priorities (see sidebar on facing page for a discussion of how the objectives link to existing City policy). Additionally, the proposed objectives in this report also build on San Francisco Planning and Urban Research (SPUR) recommendations (see sidebar on page 14 for a discussion of how the objectives in this CAPSS report relate to proposed SPUR recommendations).

Meeting these objectives will require many San Franciscans to improve their buildings so that they experience less damage from earthquake shaking and resulting fires. It will require City government to develop new programs and rethink existing ones. There are many ways to structure objectives. This report proposes general objectives in terms of visualizing hopes for how the City will look after future large earthquakes. These objectives are long-term and ideal, and when pursued would result in a more earthquake-resilient San Francisco.

Looking at each of the proposed CAPSS objectives in more detail provides insights into why each is important:

1. Residents will be able to stay in their own homes.

Keeping San Franciscans in San Francisco after an earthquake is critical to the City's recovery. Residents will help revive their neighborhoods and the City's economy. It makes sense for owners to invest in, and the City government to encourage, making the existing housing stock robust, rather than coping with a major homelessness crisis, providing long-term temporary housing, and rebuilding a large part of the City's housing after an earthquake. Retrofitting residential buildings known to be vulnerable would save lives and money, and speed recovery.

2. Residents will quickly have access to important privately-run community services.

San Franciscans depend on numerous private entities for essential aspects of their daily lives. These entities range from non-profits that provide housing, food and care to disabled, elderly or low-income residents, to medical clinics and suppliers, to grocery stores and pharmacies, to daycare centers, schools and assisted living facilities. Residents need these services to be operational shortly after an earthquake. Many of the buildings that house these services need to be strengthened so they can withstand future earthquakes.

3. No building will collapse catastrophically.

Today, many buildings in the City used as residences and offices every day have the potential for dramatic and lethal collapses. These buildings can and must be made safer.

EXISTING CITY POLICY

The City articulates objectives in its General Plan, shaped by the 1986 Proposition M that established eight Priority Policies for the protection, preservation and enhancement of the economic, social, cultural and esthetic values that establish the desirable quality and unique character of the city. The objectives and priorities proposed in this report respond to five of these Priority Policies:

- That existing neighborhood-serving retail uses be preserved and enhanced and future opportunities for resident employment in and ownership of such businesses enhanced;
- That existing housing and neighborhood character be conserved and protected in order to preserve the cultural and economic diversity of our neighborhoods;
- That the City's supply of affordable housing be preserved and enhanced;
- That the City achieves the greatest possible preparedness to protect against injury and the loss of life in an earthquake; and
- That landmarks and historic buildings be preserved.

The Community Safety Element, an integral part of the General Plan, provides additional City policies. The City is currently updating the Community Safety Element. The 2007 draft Community Safety Element recognizes that existing hazardous structures have the greatest potential for loss of life and other serious impacts resulting from an earthquake and that the City should continue to explore ways to reduce this risk. It calls for more detailed plans.

The goals of the pending revisions to the Community Safety Element mirror those of this report. They call for protecting against injury and loss of life; reducing social, cultural and economic dislocations; and encouraging rapid recovery. Some of the many relevant objectives and policies in the Community Safety Element draft appear below:

Objective 1: Reduce Structural and Non-Structural Hazards to Life Safety and Minimize Property Damage Resulting from Future Disasters.

Policy 1.9—Complete remaining upgrades of the Unreinforced Masonry Building Seismic Hazard Reduction Program and the Parapet Safety Program.

Policy 1.10—Assess the risks presented by other types of concrete structures and reduce the risks to the extent possible.

Policy 1.11—Reduce the earthquake and fire risks posed by older small wood-frame residential buildings through easily accomplished hazard mitigation measures.

Policy 1.12—Explore incentives for private homeowners to upgrade their buildings.

Policy 1.14—Preserve, consistent with life safety considerations, the architectural character of buildings and structures important to the unique visual image of San Francisco, and increase the likelihood that architecturally and historically valuable structures will survive future earthquakes.

Objective 2: Be Prepared for the Onset of Disaster by Providing Public Education and Training About Earthquakes and Other Natural and Man-Made Disasters, by Readying the City's Infrastructure, and by Ensuring the Necessary Coordination is in Place for a Ready Response.

Policy 2.2—Encourage businesses and homeowners to evaluate their earthquake risks.

Objective 4. Assure the Sound, Equitable and Expedient Reconstruction of San Francisco Following a Major Disaster.

Policy 4.7—Develop and adopt a Repair and Reconstruction Ordinance, to facilitate the repair and reconstruction of buildings.

SAN FRANCISCO PLANNING AND URBAN RESEARCH (SPUR) RECOMMENDATIONS

In its Resilient City report (SPUR, 2009), SPUR recommended recovery targets for the City after an earthquake. SPUR's intent is for the City to require those improvements needed to assure a quick recovery—or the functional level needed for each phase of recovery. SPUR defined three phases of disaster response and recovery.

Phase 1, from one to seven days, is the period of initial emergency response and staging for reconstruction. Within this timeframe, SPUR proposes these recovery targets:

- Within 24 hours, hotels designated to house emergency response workers are safe and useable, shelters are open, and all occupied households are inspected by their occupants. Fewer than five percent of all dwelling units should be unsafe to occupy. Residents can shelter in place in superficially damaged buildings, even if utility services are not functioning.
- Within 72 hours, the initial recovery and reconstruction efforts will be focused on repairing residences and schools to a usable condition.

Phase 2, from 30 to 60 days, is the timeframe when housing is restored and ongoing social needs are met. Within this timeframe, SPUR proposes these recovery targets:

- Within 30 days, ninety percent of the neighborhood businesses are open and serving the workforce.
- Reconstruction efforts will be focused on repairing residences, schools and medical provider offices to a usable condition.

Phase 3, covering several years, is when long-term reconstruction is completed. Within this timeframe, SPUR proposes these recovery targets:

- All displaced households return home or are permanently relocated.
- Within four months, ninety-five percent of the community retail services are reopened.
- Within four months, fifty-percent of offices and workplaces are reopened.
- Within three years all business operations are restored to pre-earthquake levels.

SPUR also estimated the expected current status for selected uses following an expected earthquake. The target recovery times and current status applicable to private buildings are summarized in the following table.

Target States of Recovery for San Francisco's Buildings

Facilities	Phase 1 (Hours)			Phase 2 (Days)		Phase 3 (Months)		
	4	24	72	30	60	4	36	36+
95 percent of residents shelter in place							■	
Emergency Responder Housing			■					
Public Shelters						■		
Schools						■		
Medical provider offices							■	
90 percent of neighborhood retail businesses open								■
All residences repaired or relocated								■
95 percent of neighborhood retail businesses open								■
50 percent of offices and workplaces open								■
All businesses open								■

Legend

Desired Status	
Expected current status	■

Source: Adapted from SPUR, 2009.

4. **Businesses and the economy will quickly return to functionality.**

   The City's recovery depends on a functional economy. Particular businesses are especially vulnerable to earthquake impacts, such as small, local businesses and visitor serving businesses. If recovery is slow, many businesses would fail and others, such as knowledge-based businesses, could easily relocate to other communities. Retrofit of vulnerable buildings would help assure businesses stay afloat and in San Francisco after an earthquake.

5. **The City's *sense of place* will be preserved.**

   Keeping San Francisco diverse and maintaining its architectural character is important to preserving the City's soul. Retrofitting vulnerable buildings would prevent future earthquake damage from making the City unaffordable to low and middle income residents and maintain the cultural and architectural character of the neighborhoods. Many of the City's older historic buildings and cultural resources need to be preserved and protected.

The objectives and recommendations in this report are focused in a number of ways:

- This report was developed through a project of the Department of Building Inspection (DBI); therefore, its objectives and recommendations primarily focus on issues that are central to DBI's mission. Earthquakes, however, do not respect departmental boundaries. Therefore, this report also includes recommendations relevant to other City agencies.
- This report focuses on mitigation: steps taken before earthquakes strike to reduce their impacts. It does not focus on emergency response or preparedness planning, nor does it focus on post-earthquake recovery planning, which are all essential ingredients for achieving resilience. The lines among all these activities, however, are indistinct; recommendations in this report may contribute to other aspects of earthquake planning.
- This report focuses on reducing damage to privately owned buildings and the consequences that flow from that damage. It does not cover government buildings or infrastructure (roads, bridges, and water, sewer, gas, and electric utility systems), although the earthquake resilience of both is of major importance to the City.

The objectives recommended in this report cannot be achieved by the Department of Building Inspection acting alone, nor is requiring owners to strengthen weak buildings sufficient to achieve them. Achieving the recommended objectives requires actions by other City agencies and private partners joining in a long-term, comprehensive effort. The objectives build on and should be integrated within the policy fabric of the City as expressed in ordinances, the General Plan and its Community Safety Element, and through the policies carried out by the Planning Commission, Historic Building Commission, Fire Department, Rent Stabilization and Arbitration Board, and other bodies responsible for the stewardship and management of the resources at risk.

The objectives proposed in this report are ambitious. Reaching them will take decades of sustained effort. It will require using many approaches to tackle the City's risk. It will be an investment in the City's future, a recognition that the City does not want to pass all of the responsibility for earthquakes onto future generations. In the following chapters, this report recommends a long-term and comprehensive program of activities.

CHAPTER 4: RECOMMENDED ACTIONS: THE COMPREHENSIVE PROGRAM

San Franciscans have a choice: either absorb dramatic losses from future earthquakes and endure the painful and protracted recovery that follows, or undertake measures to reduce the losses and impacts from those earthquakes. Reaching the objectives proposed in the previous chapter will take thirty years of sustained effort by the City, its departments and residents. This chapter recommends the specific actions needed to pursue those objectives, in a comprehensive and phased effort.

Informed decision-making forms the basis of the comprehensive recommended program that follows. All San Franciscans, homeowners, business owners, tenants and officials, need to understand how earthquakes will affect them, and know measures they can take to reduce these impacts. Everyone should be empowered to make risk reduction decisions in their best interests, but not everyone will do so. Therefore, the recommended strategy proceeds through a series of activities, at first encouraging improvements to buildings, and later requiring such improvements to buildings when the larger community welfare is threatened.

This chapter is organized into three sections:

- **A Three-Step Strategy to Better Buildings**

  This section provides a discussion of the overall recommended three-step strategy the City should use to reach its earthquake mitigation objectives over the next thirty years. It begins with facilitating a market in which earthquake performance is valued. Next, building owners would be required to evaluate the seismic vulnerability of their buildings and share the findings with tenants and prospective buyers and tenants. Last, vulnerable buildings would be required to be retrofitted by set deadlines, which vary by category of building.

- **Specific Recommended Actions**

  This section recommends seventeen specific actions the City should take to carry out the three-step strategy to reduce earthquake risk. Together, these actions combine to form a comprehensive approach that addresses the recommended objectives. Many of the recommended actions contribute to meeting several or all of the objectives.

- **Building Categories and Retrofit Deadlines**

  This section recommends a scheme to categorize and prioritize the City's buildings based on both building structure type and use. It presents a recommended schedule for mandatory seismic retrofit of each vulnerable building category.

A Three-Step Strategy to Better Buildings

The recommendations in this report aim to use market forces and other mechanisms to drive actions to reduce earthquake risks. Public awareness and understanding is essential. Knowledge provides the information needed to give earthquake performance a financial value. Owners and occupants of buildings are empowered to make decisions in their own best interests when they know about the earthquake risk of the buildings they live in or use, understand how the risk affects them, and know what they can do about it. They can address earthquake vulnerability when buying, leasing, financing, insuring, repairing or renovating buildings. Currently, few owners or tenants have any knowledge about how the buildings they own or use are likely to perform in earthquakes, which may contribute to inaction. Misconceptions, both over and underestimating risk, abound.

Market forces have been working well to improve San Francisco's commercial building stock. Lenders and insurers for commercial buildings routinely require an analysis of the expected earthquake performance of a building before they will lend or insure. They generally require that expected building damage be less than 20 percent of the building replacement cost. The result is that the City's commercial building stock has undergone many upgrades over the years and is expected to fare significantly better than the City's housing stock in future earthquakes. Lenders and insurers generally do not have the same requirements for residential buildings and, for a variety of reasons, these industries are unlikely to enact such requirements anytime soon. Therefore, it makes sense for the City to step in and help build a market for seismically robust housing.

The goal of the strategy recommended by this report is to increase the number of seismic retrofits voluntarily conducted by owners of the most vulnerable buildings. As more retrofits are conducted, retrofitting techniques will improve, engineering and construction work will grow more efficient and less costly, and the community as a whole will begin to benefit from seismic remediation by building owners. However, experience with the unreinforced masonry law in San Francisco and other California communities indicates that many owners will not evaluate or retrofit their buildings until required to do so. Deadlines requiring evaluations and retrofitting of weak buildings are needed to give market forces a push, even though it may be appropriate to set some of these deadlines decades in the future. Requirements and deadlines show that earthquake risk is an issue the City government takes seriously; in contrast, a purely voluntary program suggests that this issue is not viewed as important. Deadlines for required action, based on the City's priorities and the capacity of the government and private sectors to do the work, are needed.

The City has a strong interest in making sure owners make informed decisions about their buildings and strengthen those that are most vulnerable. Unsafe and damage prone buildings threaten the safety of City residents, the viability of neighborhoods, the long-term affordability of the City's housing, the socio-economic diversity of the City, and the larger City economy. Individual building failures weaken the fabric of the entire community and can be economically ruinous for the owner, tenants and neighbors. Damaged buildings are prone to fire ignitions that could spread for blocks or consume entire neighborhoods. The cumulative impact of individual failures is devastating; conversely, the cumulative impact of individual retrofits will protect attributes that San Franciscans value.

This report recommends a three-step strategy to engage market forces to encourage structural retrofits, enact measures to reduce fire damage, and promote measures to reduce risk from falling hazards and non-structural elements. The strategy follows the following steps:

Step 1. Facilitate a market in which earthquake performance is valued;

Step 2. Nudge the market by requiring evaluation upon sale, or by a deadline; and

Step 3. Require retrofitting by a deadline.

By applying this three-step program in a phased manner, San Francisco would help buildings owners address their risk and take actions that benefit the broader community. Not all building categories need to pass through each phase. For example, the effort to strengthen weak unreinforced masonry buildings began with Step 3, in recognition of their lethal risk.

Each of the steps is described below:

- **Step 1: Facilitate a market in which earthquake performance is valued**

  Initially, the City would take steps to encourage building owners to have their buildings evaluated and retrofitted, if vulnerable. This involves the following types of activities:

  - Conducting focused education and outreach campaigns that present specific steps that particular types of building owners, tenants, business owners, construction professionals, and others can take to reduce earthquake impacts. Knowing how to reduce risk is a necessary first step to action (see Recommendation 2).
  - Adopting updated code standards for seismic evaluation and retrofit of all common building types in San Francisco. As the City moves forward with programs to encourage and require more retrofits of vulnerable buildings, it is critical for the Department of Building Inspection to adopt updated code standards that reflect both the City's earthquake resilience objectives and technical advances in structural engineering. It must be clear to building owners what building seismic performance is acceptable to the City, and what requirements of future mandates will be (see Recommendation 3).
  - Offering meaningful incentives to building owners who retrofit voluntarily. Owners ultimately are responsible for the earthquake performance of their buildings: they have the most to gain from improved performance, and the most to lose because of damage and liability. However, the City has a strong interest in reducing the amount of damage that occurs to privately-owned buildings in future earthquakes. Therefore, it makes sense for the City to incentivize building owners to make their buildings safer (see Recommendation 9).
  - Providing technical assistance to help residents and building professionals to evaluate and seismically retrofit buildings efficiently and in accordance with City codes. Technical assistance can range from developing standard plan sets to organizing technical training sessions (see Recommendation 12).

Many of these activities will require the Department of Building Inspection to work with other departments and private partners. During all stages, existing requirements to evaluate and retrofit buildings when expanding, changing use or repairing damage would remain in place.

- **Step 2: Nudge the market by requiring evaluation upon sale or by deadline**

  The second step (Recommendation 4) would require owners to complete an engineering evaluation, prior to selling buildings, that compares a building to the performance standards that DBI has adopted for each type of building. The findings of these evaluations would be shared with tenants and prospective buyers and tenants, and be made a part of public City records. The evaluations would identify structural weaknesses, fire ignition and spread risks, falling hazards that affect safety, vulnerable building elements that affect whether a building could be used after an earthquake, and ground failure hazards. These standards would specify whether it is likely that the occupants would be safe and be able to shelter-in-place following the expected earthquake. The evaluation should clearly identify buildings with dramatic weaknesses, or "killer buildings". A potential buyer could then decide on the building's value and, if it is purchased, whether to retrofit it or not. Buyers and sellers would negotiate sales prices and financing based in part on the findings of the seismic evaluations. The City would supplement this phase by requiring that certain categories of buildings, such as those that are infrequently sold, condominiums with multiple owners, and owners of many buildings, such as a university or institutional investor, to complete evaluations according to a schedule. This should include requiring larger buildings to participate in the City's Building Occupancy Resumption Program (BORP). BORP is a City program that allows building owners to engage an engineer before an earthquake to inspect their building for damage after an earthquake in order to expedite reoccupancy after an earthquake.

A seismic retrofit in progress. Photo credit: Anderson Niswander Construction.

- **Step 3: Require retrofitting by a deadline**

  The third, and last, step would require retrofitting vulnerable buildings by a deadline. This is the approach used to address unreinforced masonry buildings during the 1990's. This step ensures that owners of vulnerable buildings that threaten the broader community's welfare ultimately improve those buildings. Deadlines for mandatory retrofits show that the City believes this issue is serious, allows the market to consider seismic safety in its pricing, and provides certainty for owners of vulnerable buildings to plan for the future. The requirements of the earlier phases would remain in effect. This step is proposed in Recommendation 5.

This report recommends that the City apply the three-step strategy to key categories of buildings in the City in a phased manner, which is discussed further later in the report.

Recommended Actions

This section presents specific recommended policies to reduce San Francisco's earthquake risk. The seventeen key recommendations listed on the next two pages are needed to reduce vulnerability from earthquake shaking, falling hazards, ground failure and post-earthquake fire. Some of the recommended actions directly tackle the sources of risk; others are needed to sustain the City's mitigation efforts over the next few decades. Each of the seventeen recommendations is described in more detail in the pages that follow, including a discussion of why it is a good choice for San Francisco.

The recommendations are categorized by mitigation objective in Table 1, and by steps and other factors in the three-step recommended strategy in Table 2.

Recommended Actions to Reduce Earthquake Risk	Additional details
1. **Require evaluation of all wood-frame residential buildings of three or more stories and five or more units, and retrofit of those that are vulnerable to earthquake damage.** A Mayoral task force has proposed an ordinance to require evaluation and retrofit of these buildings. The Board of Supervisors should enact it.	page 26
2. **Inform the public of risks and ways to reduce risk.** The City should conduct focused education and outreach campaigns aimed at building owners, tenants, realtors and others to improve their understanding of earthquake risk and measures to manage the risk, and to facilitate a market for retrofitting.	page 28
3. **Adopt updated code standards.** The City should adopt code standards for seismic evaluation and retrofit of all common building types in San Francisco.	page 31
4. **Require all buildings to be evaluated for seismic risk.** Building owners should evaluate the seismic performance of their buildings upon sale relative to DBI standards or, if no sale occurs, by a deadline established based on the building use and structural type. The results would be shared with tenants and prospective buyers and tenants, and be made a part of public City records.	page 33
5. **Require retrofits of vulnerable buildings.** Owners of vulnerable buildings should seismically retrofit their building for structural and fire hazards and building elements that affect usability, by specific deadlines, varying by building category.	page 35
6. **Assist community service organizations to reach earthquake resilience.** The City should provide technical and financial assistance for important non-profit organizations, medical clinics, daycare centers and similar groups to seismically retrofit their buildings or relocate to better buildings.	page 37
7. **Establish clear responsibility within City government for preparing for and reducing risk from earthquakes.** The City should identify a single official in the Chief Administrator's Office to be responsible for achieving earthquake resilience through mitigation, response and recovery.	page 39
8. **Adopt improved post-earthquake repair standards.** The City should enact updated post-earthquake repair and retrofit standards developed by CAPSS and expand this approach to other building types.	page 40

Recommended Actions to Reduce Earthquake Risk	Additional details
9. **Offer incentives for retrofit of buildings.** The City should enact a range of meaningful programs to help building owners afford retrofits.	page 41
10. **Require gas shut-off valves on select buildings.** The City should require owners of certain vulnerable buildings and buildings in Fire Department designated Post-Earthquake High Fire Hazard Areas to install automatic gas shutoff valves.	page 45
11. **Track evaluations and retrofits in a database system.** The City should include information relating to seismic evaluations and retrofits in DBI's updated database system to allow tracking progress of mitigation activities and recording inventories, evaluation reports and retrofit information.	page 46
12. **Provide technical assistance for building retrofits.** The City should help residents and building professionals to evaluate and seismically retrofit buildings efficiently and in accordance with City codes.	page 47
13. **Enact a façade ordinance.** An ordinance should require periodic inspection of façades, parapets and decorative features fixed to building exteriors, and require repair of materials found to be falling hazards.	page 50
14. **Promote development and implementation of effective ideas on earthquake risk reduction.** The City should encourage efforts to improve knowledge relevant to San Francisco about building performance and effective ways to reduce earthquake risk.	page 51
15. **Evaluate measures to reduce post-earthquake fires.** Multiple City Departments should work together to evaluate and implement measures to reduce fire ignitions and spread, and improve fire suppression capacity following earthquakes.	page 53
16. **Address the hazards from damage to building systems, appliances, equipment and non-structural building elements.** DBI should initiate a comprehensive program to encourage, and in some instances, require measures to reduce these hazards.	page 55
17. **Periodically assess progress and implementation of these recommendations.**	page 56

Table 1 Recommended Actions Categorized By Mitigation Objective

Recommended Mitigation Actions	Objective				
	(1)	(2)	(3)	(4)	(5)
1. Require evaluation of all wood-frame residential buildings of three or more stories and five or more units, and retrofit of those that are vulnerable to earthquake damage.	X	X	X	X	X
2. Inform the public of risks and ways to reduce risk.	X	X	X	X	X
3. Adopt updated code standards.	X	X	X	X	X
4. Require all buildings to be evaluated for seismic risk.	X	X	X	X	X
5. Require retrofits of vulnerable buildings.	X	X	X	X	X
6. Assist community service organizations to reach earthquake resilience.		X		X	
7. Establish clear responsibility within City government for preparing for and reducing risk from earthquakes.	X	X	X	X	X
8. Adopt improved post-earthquake repair standards.	X	X	X	X	X
9. Offer incentives for retrofit of buildings.	X	X	X	X	X
10. Require gas shut-off valves on select buildings.	X	X		X	X
11. Track evaluations and retrofits in a database system.	X	X	X	X	X
12. Provide technical assistance for building retrofits.	X	X	X	X	X
13. Enact a façade ordinance.				X	X
14. Promote development and implementation of effective ideas on earthquake risk reduction.	X	X	X	X	X
15. Evaluate measures to reduce post-earthquake fires.	X	X		X	X
16. Address the hazards from damage to building systems, appliances, equipment and non-structural building elements.	X	X		X	
17. Periodically assess progress and implementation of these recommendations.	X	X	X	X	X

Mitigation objectives:

(1) Residents will be able to stay in their own homes
(2) Residents will quickly have access to important privately-run community services
(3) No building will collapse catastrophically
(4) Businesses and the economy will quickly return to functionality
(5) The City's sense of place will be preserved

Table 2 Recommended Mitigation Actions Categorized by Three-Step Strategy

Recommended Mitigation Actions	Step 1	Step 2	Step 3	Other
	Facilitate market for earthquake performance	Evaluation upon sale or by deadline	Retrofit by deadline	
1. Require evaluation of all wood-frame residential buildings of three or more stories and five or more units, and retrofit of those that are vulnerable to earthquake damage.		X	X	
2. Inform the public of risks and ways to reduce risk.	X			
3. Adopt updated code standards.	X	X	X	
4. Require all buildings to be evaluated for seismic risk.		X		
5. Require retrofits of vulnerable buildings.			X	
6. Assist community service organizations to reach earthquake resilience.				X
7. Establish clear responsibility within City government for preparing for and reducing risk from earthquakes.				X
8. Adopt improved post-earthquake repair standards.				X
9. Offer incentives for retrofit of buildings.	X			
10. Require gas shut-off valves on select buildings.				X
11. Track evaluations and retrofits in a database system.	X	X	X	
12. Provide technical assistance for building retrofits.	X	X	X	
13. Enact a façade ordinance.				X
14. Promote development and implementation of effective ideas on earthquake risk reduction.				X
15. Evaluate measures to reduce post-earthquake fires.				X
16. Address the hazards from damage to building systems, appliances, equipment and non-structural building elements.	X	X	X	
17. Periodically assess progress and implementation of these recommendations.				X

Recommendation 1: Require evaluation of all wood-frame residential buildings of three or more stories and five or more units, and retrofit of those that are vulnerable to earthquake damage. A Mayoral task force has proposed an ordinance to require evaluation and retrofit of these buildings. The Board of Supervisors should enact it.

San Francisco has about 4,400 wood-frame residential buildings with three or more stories and five or more units. Many of these buildings have a soft-story condition at the ground level, due to garage doors, store windows, or other conditions, that make these buildings extremely prone to damage in earthquakes. The 1989 Loma Prieta earthquake, a moderate sized and distant event, caused heavy damage to this building type.

A retrofit of a soft-story residence. Photo credit: Anderson Niswander Construction.

In a companion CAPSS report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco Earthquake Safety for Soft-Story* Buildings (ATC, 2009a), CAPSS analysis found that in likely, larger earthquakes these buildings would suffer a large amount of damage. Analysis of a sample of 2,800 of the worst of these buildings in a possible magnitude 7.2 San Andreas fault earthquake scenario found the following:

- Between 40 percent and 85 percent of these buildings would be red-tagged after post- earthquake inspection, meaning they would be posted with a red UNSAFE placard and could not be occupied. These red-tagged buildings contain from 12,000 to 25,000 residential units whose occupants would be displaced during the years required for repair.
- A quarter of these buildings could collapse (300 to 850 buildings), endangering ground floor occupants and causing permanent loss of rent-controlled housing and attractive, older buildings.

The project analyzed the effectiveness and costs of seismic retrofits for these buildings:

- Seismic retrofits would reduce the damage significantly. After retrofit, less than one percent of these buildings would collapse.
- Retrofits would likely cost between $60,000 to $130,000 per building. Residents of upper floors could remain in these buildings while the retrofits take place.

In early 2010, Mayor Newsom convened a task force of City officials and community stakeholders to develop a program to require mandatory retrofits of vulnerable wood-frame buildings with three or more stories and five or more residential units. This task force drafted an ordinance that is ready for the Board of Supervisors. The ordinance defines all aspects of the program, including code standards and timelines (see Table 3). Building owners would be required to, first, evaluate their buildings and then to retrofit them, if found vulnerable, within three to seven years. The Board of Supervisors should pass this ordinance.

Table 3 Proposed Implementation Schedule for Proposed Evaluation and Retrofit Program for Wood-frame Soft-Story Buildings with Three of More Stories and Five or More Residential Units (in years[a])

Compliance Tier[b]	Submission of Inventory and Analysis Form to DBI	Submittal of Permit Application with Plans for Seismic Strengthening	Completion of Work and Issuance of Certificate of Final Completion[c]
I	1	2	3
II	1	2	4
III	2	4	6
IV	2	5	7

[a] All time periods are in years measured from the date the ordinance becomes operative.

[b] The compliance tiers are the following:
Tier I: buildings containing a Group A, E, R-3.1 or R-4 occupancy on the soft-story level and buildings that are in a mapped liquefaction zone that is not covered under Tier IV.
Tier II: buildings containing 15 or more dwelling units, except for buildings that fall within the definition of another tier.
Tier III: all buildings not falling within the definition of another tier.
Tier IV: buildings located in lateral spreading areas as delineated in designated maps.

[c] Time limits and extensions are explained further in the draft ordinance. All work is to be completed by 2020, as recommended in California Health & Safety Code Section 19160(l).

Source: Draft Soft-Story Retrofit Building Code Ordinance, date 9/16/2010

Recommendation 2: Inform the public of risks and ways to reduce risk. The City should conduct focused education and outreach campaigns aimed at building owners, tenants, realtors and others to improve their understanding of earthquake risk and measures to manage the risk, and to facilitate a market for retrofitting.

The first step in the three-step strategy (see previous section) is to create a deeper understanding of earthquake risk and risk reduction measures, which will underpin a market for retrofitting. San Francisco residents, businesses and building owners need to know specifically what risks they face and what to do to reduce those risks. On their own, education programs motivate only a limited number of people to take action. However, they are an essential part of making other risk reduction programs work. When used in tandem with other programs aimed at reducing risk, education programs can lead to significant action.

Education and outreach campaigns need to be targeted at specific audiences and focused on particular building categories and topics to be effective. Programs should present specific steps that particular types of building owners, tenants, business owners, construction professionals, and others can take to reduce earthquake impacts. San Franciscans need to understand earthquake risk in personal terms. These campaigns need to be long-lasting and the messages frequent, and from multiple sources.

City departments can do some of this, and can get the ball rolling, but it is critical to coordinate with partners in the public and private sectors. Fire and earthquake insurance companies, utilities, contractors, and building materials stores could be particularly effective partners that also would benefit from better community understanding of these issues.

CAPSS recommends the following specific education and outreach programs for San Francisco:

a. Explain the need for and process to evaluate building seismic performance, including structural and fire hazards, and building elements that affect usability.

This report recommends requiring building owners to evaluate the seismic performance of their building upon sale or a scheduled deadline (Recommendation 4). Building owners and others that would be involved in this process (realtors, etc.) need to know what they need to do, and how to do it properly. They should also understand why evaluations are important and the goals behind requiring them.

b. Offer courses aimed at single-family homeowners about how to conduct small scale seismic retrofits.

Some single-family homes can improve their seismic safety through relatively simple and affordable steps. The City should develop a course for residents teaching them simple things they can do to upgrade their homes, as well as clarifying when they need to seek professional help.

c. Educate installers, building owners, and others about proper ways to brace water heaters.

Toppled water heaters have fueled earthquake-triggered fire in past earthquakes. State law and the City's building code currently require water heaters be strapped securely whenever they are replaced, or when buildings in the City are sold. However, it appears that many water heaters in San Francisco are strapped improperly, meaning they could still fall and fuel fires during an earthquake. A program to make sure water heater installers, building owners and others know the proper, safe ways to secure water heaters could make a big difference with small cost.

d. Educate residents about simple and cost-effective ways to make their homes safer and habitable following earthquakes by reducing falling hazards.

Damage to building systems, such as ceilings and fixtures, broken pipes, and upset equipment, cause serious problems in every earthquake, including deaths, increased economic losses, and making building space unusable. It is often simple and inexpensive to reduce the risk of casualties and damage from these hazards. The City should conduct an education campaign informing residents about specific steps they should take, and include details such as types of hardware to purchase and how to install it.

e. Develop a program in coordination with other City agencies to work with small businesses and important community service providers on measures they can take to reduce vulnerability to earthquakes.

Small businesses and important community services, such as non-profit organizations that serve the daily needs of the City's most vulnerable residents, are important to the City's recovery from future earthquakes. By reducing risk and planning in advance, these organizations can greatly improve their ability to stay afloat and continue to function after an earthquake. The City should encourage and help organizations to develop mitigation and recovery plans.

f. Encourage building materials stores, insurance companies and utility companies to supplement education campaigns.

Building materials stores, insurance companies and utility companies regularly contact building owners and managers, and could provide San Francisco specific information about reducing earthquake vulnerability and actions to take after earthquakes. These companies have a direct interest in reducing earthquake damage and post-earthquake fire, and should advise building owners accordingly. Multiple, consistent education messages from a variety of public and private entities are far more likely to lead to action than isolated messages only from government agencies.

g. Revise post-earthquake building inspection protocols and train inspectors and owners to identify buildings that can be occupied safely despite damage and loss of utilities.

After an earthquake, it benefits everyone to allow as many residents and businesses to remain in their buildings as possible, while ensuring safety during aftershocks. Displacing residents and businesses makes recovery more difficult. Inspectors who conduct post-earthquake safety tagging should be trained in

post-earthquake occupancy concerns particular to San Francisco. Many buildings will be inspected and evaluated by their occupants, which means that public information campaigns about this issue immediately after an earthquake will play an important role.

h. Train preservation engineers and architects knowledgeable about San Francisco's historic resources in post-earthquake safety tagging.

San Francisco's building stock is unique and beautiful. To ensure that it is protected, the City should make sure that engineers and architects are knowledgeable about preservation issues that are involved in post-earthquake building safety evaluations and tagging. The tagging process occurs immediately after an earthquake and influences repair and demolition decisions. Historic resource issues must be considered in these decisions. The City should conduct outreach to the preservation community to make sure that they are involved in this process.

Recommendation 3: Adopt updated code standards. The City should adopt code standards for seismic evaluation and retrofit of all common building types in San Francisco.

The Department of Building Inspection (DBI) should adopt building code standards to be used as a basis for determining vulnerability and seismic retrofitting requirements. As the City moves forward with programs to encourage and require more retrofits of vulnerable buildings, it is critical for DBI to adopt updated code standards that reflect both the City's earthquake resilience objectives and technical advances in structural engineering.

The City should define what performance it expects during earthquakes for all existing and new buildings, considering post-earthquake usability and safety. Retrofit standards should reflect these performance goals. Retrofit standards should relate to both a building's structure type and how it is used, because building use is a key factor in determining what level of damage in earthquakes is deemed acceptable by society. DBI should seek to adopt retrofit standards that take a practical, optimal approach. The standards should optimize performance improvements while minimizing intrusion into occupied spaces and the cost of retrofits. For some types of buildings, achieving "shelter-in-place" performance, or even reparability, might be unacceptably expensive or intrusive, making lower performance expectations reasonable.

During this process, the Department should develop a clear understanding of the performance expected from new buildings constructed to the current building code, and consider whether improvements are necessary. Superior performance is needed from new construction for the City to achieve its resilience objectives for housing and businesses.

The City also should define standards and procedures for engineering evaluations of seismic performance for all building types common in San Francisco**.** Recommendation 4 in this report recommends requiring building owners to evaluate the seismic vulnerability of their building upon sale or by a scheduled deadline. Before this can happen, DBI needs to adopt clear guidelines and technical standards for professionals to use for evaluations of structures of different types and for communicating the findings in meaningful and objective terms. For common building types, it would be ideal if inspectors could use a simple checklist approach that requires a minimum of complex calculations. DBI should also work to identify a scheme, such as a building rating scheme, to explain the findings of the structural evaluations to non-technical building owners and users in meaningful ways that can help them make decisions about buying, renting or retrofitting [7]. The information provided should be clear that buildings with identified vulnerabilities might perform better than buildings that have not yet been evaluated.

[7] As an example, the Structural Engineers Association of Northern California (SEAONC) is developing a scheme to assign stars to buildings, rating three characteristics: safety, repair cost, and time to reoccupy. After evaluation, buildings would be assigned from zero to five stars, indicating good or bad seismic characteristics (CAPSS, 2010). Another example is a proposed rating system for detached, single-family, wood-frame dwellings, developed for the City of Los Angeles (ATC, 2007), that assigns A, B, C, and D ratings that indicate expected losses should the design level earthquake occur. Other schemes may be available, as well.

CAPSS recommends the following general performance objectives for San Francisco code standards:

- Retrofit standards should result in most residential buildings being safe for use after earthquakes and during aftershocks (this performance level is generally referred to as "shelter-in-place"). Utilities (e.g., water, sewer, and power systems) may not be functional, which would influence whether occupants choose to remain in these buildings. San Francisco Planning and Urban Research (SPUR) has proposed a goal that 95 percent of San Franciscans should be able to shelter-in-place following a large, "expected" earthquake.
- Retrofit standards for buildings that cannot reasonably meet the shelter-in-place standard should result in buildings that can be repaired. Reparability protects San Francisco's communities, sense-of-place, historic resources and affordable housing.
- Retrofit standards for building types that cannot reasonably meet either the shelter-in-place or reparability standards, as a minimum, must prevent collapse and danger to occupants.

Regardless of the structural performance standard, all retrofit standards should also include measures to address the following issues: building elements such as stairs and elevators that affect the usability of buildings; other hazards that affect safety and occupiability, such as overhead piping, and equipment and furnishings; and fire ignition sources and conditions that could contribute to fire spread. Standards should require large buildings to address ground failure risks when undergoing retrofits; typically, addressing this risk for smaller buildings is prohibitively expensive.

DBI should specify benchmark code dates for all significant building structure types. Buildings constructed or retrofitted after these benchmark dates would be presumed to have adequate earthquake resistance to meet the City's performance objectives. For buildings constructed or retrofitted to earlier codes, standards designated by DBI would set the basic retrofit standard. Currently, DBI has one benchmark code date for all structure types—May 21, 1973—although it is clear that some building types constructed or retrofitted after that date have serious seismic vulnerabilities.

DBI should amend the building code to improve it as new information and standards become available. In particular, DBI should seek standards that reflect advances in structural engineering approaches and consider building flexibility in addition to strength. Some performance-based national standards are now referenced in building codes and are widely used here and abroad, such as ASCE 31 for evaluations (ASCE, 2003) and ASCE 41 for retrofits (ASCE, 2007). These standards have known limitations at this time, but should become increasingly practical for use in coming years. These "next generation" code standards potentially allow more effective retrofits at lower costs.

Recommendation 4: Require all buildings to be evaluated for seismic risk. Building owners should evaluate the seismic performance of their buildings upon sale relative to DBI standards or, if no sale occurs, by a deadline established based on the building use and structural type. The result would be shared with tenants and prospective buyers and tenants, and be made a part of public City records.

This is the second step in the three-step strategy. People who own and use buildings in San Francisco should know whether their building is likely to be safe during future earthquakes, and repairable and/or usable after those earthquakes. This information allows prospective buyers and users to consider seismic issues when making decisions about purchasing or renting space. It provides information needed to incorporate seismic issues in market pricing of real estate. It would also provide owners with the information needed to decide whether to seismically retrofit vulnerable buildings.

This requirement should be enacted only after DBI has adopted updated code standards for seismic evaluation and retrofits (Recommendation 3). The information provided should be objective and measured against the established standards. Building owners who choose to voluntarily retrofit to DBI standards after discovering, through an evaluation, that their building has seismic vulnerabilities, should be exempted from retrofit mandates for a period of 15 years.

Findings of the evaluation should be shared with existing tenants and prospective buyers and tenants and be available in public records. The findings should be included in the Report of Residential Building Record (3R report for residential buildings) provided to the buyer prior to the sale or exchange of any residential building older than one year. This evaluation should be conducted by licensed design professionals (engineers and architects), along with other inspections typically conducted by licensed personnel at the time of sale.

Evaluation results should be presented in a way that make it clear that evaluated buildings are not regarded as more vulnerable than buildings that have not yet been evaluated. Buildings not yet evaluated are potentially hazardous.

The evaluations should cover many aspects of building seismic risk, in addition to assessing whether a building's structure meets the adopted DBI retrofit standards:

- Evaluations should identify buildings with weaknesses that could lead to collapse and life loss.
- Evaluations should explicitly examine building materials for deterioration due to water intrusion or pest infestation and weakness in the attachment of cladding and decorative elements.
- Geotechnical evaluations should be conducted for large buildings located in areas designated as having a high potential for liquefaction-induced ground failure.
- Evaluations should identify fire ignition and spread risks, such as whether water heaters are properly secured; whether electrical wiring, gas piping, appliances and meters are properly installed; the presence of unauthorized perforations in firewalls; and whether a building is located in an area prone to conflagration

(defining these areas, designated as Post-Earthquake Fire Hazard Area, is discussed in Recommendation 10).

- Evaluations should identify issues that affect post-earthquake usability and safety. There are various "non-structural" aspects of buildings that affect the safety, usability and reparability of buildings. Damaged partition walls, equipment, furnishings, elevators and utilities can hurt people, ignite fires, or prevent occupancy and business resumption.

Deadlines for evaluations should be established for building types that sell rarely, or those divided into multiple parcels that sell at different times (e.g., condominiums), with priority given to buildings that may be unsafe. Owners of portfolios of many buildings, such as a university or institutional investor, could submit a program to DBI showing how their entire building stock will be addressed, reflecting their internal priorities and facility management needs, and be allowed flexibility within the City's deadlines by building type. Recommended building categories and associated deadlines appear in the next section, *Building Categories and Retrofit Deadlines*.

As part of this process, larger buildings could be required to participate in the Building Occupancy Resumption Program (BORP). BORP is a City program that allows building owners to engage an engineer before an earthquake to inspect their building for damage to expedite reoccupancy after an earthquake.

Recommendation 5: Require retrofits of vulnerable buildings. Owners of vulnerable buildings should seismically retrofit their building for structural, fire, usability and falling hazards by specific deadlines, varying by building category.

San Francisco is a City prone to earthquakes with an old and vulnerable stock of buildings. As discussed in other recommendations, the City needs to offer strong education and incentive programs and require seismic evaluations of buildings. All of these steps will encourage building owners to seismically retrofit voluntarily. However, it is likely that most owners will not retrofit their buildings unless they are required to do so. Ultimately, the City will need to require owners of vulnerable buildings to retrofit to improve San Francisco's earthquake resilience. This is the third, and last, step in the three-step strategy (see previous section), and was the approach used to address unreinforced masonry buildings during the 1990's.

A retrofitted multi-story, soft story building. Photo credit: William Godden, Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

Deadlines for mandatory retrofits show that the City recognizes the importance of this issue, allows the market to consider seismic safety in its pricing, and provides certainty for owners of vulnerable buildings to plan for the future. The City should define a number of building categories, based on building use and structural system, and set a series of staggered deadlines for requiring retrofits. Some of these deadlines should be soon; others should be decades away. Deadlines should be assigned to various building categories based on building risk, importance to community resilience, and feasibility and cost of retrofits. Again, owners of many buildings, such as a university or institutional investor, could submit a program to DBI showing how their entire building stock will be addressed, reflecting their

internal priorities and facility management needs, and be allowed flexibility within the City's deadlines by building type.

Recommended building categories and associated deadlines appear in the following section, *Building Categories and Deadlines*. Retrofits should address structural damage, fire risk, falling hazards, usability concerns and, for larger buildings, geotechnical concerns that were identified in evaluations (Recommendation 4).

Recommendation 6: Assist community service organizations to reach earthquake resilience. The City should provide technical and financial assistance for important non-profit organizations, medical clinics, daycare centers and similar organizations to seismically retrofit their buildings or relocate to better buildings.

San Francisco is fortunate to have many organizations that serve the daily needs of the City's most vulnerable residents—its poor, elderly, children, disabled, and non-native English speakers. After an earthquake, vulnerable residents will need services from these organizations more than ever. Many of these organizations occupy rented space and are not in control of building maintenance issues or seismic safety concerns. The City departments that work with these organizations should develop a program to assist them, technically and financially, to evaluate the seismic safety of the buildings they use and to retrofit vulnerable buildings or relocate to better buildings.

: *People standing in line for food and water after the 1994 southern California Northridge earthquake. Photo credit: Robert Eplett, Courtesy of Earthquake Engineering Research Institute Mitigation Center, Oakland, California.*

The City should provide special assistance to the following types of organizations:

- **Non-profit organizations providing important services to vulnerable populations**

  These providers serve the homeless, persons confined to their homes due to health or disabilities, persons with medical issues, the poor and others. Many City agencies use these organizations to deliver services. Tens of thousands of San Franciscans rely on these organizations for services that keep them alive.

- **Preschools and daycare centers**

  Children in preschool and daycare centers should be safe in earthquakes, just as their older siblings are in public schools. Moreover, parents rely on these facilities to care for their children while they work. San Francisco's recovery following earthquakes depends on people returning to work.

- **Clinics and facilities providing urgent and critical medical services**

  Neighborhood urgent care and psychological clinics, dialysis centers, medical suppliers, and hospital facilities not regulated by the State of California[8] provide critical services to San Franciscans. These services would be needed to treat the thousands of injuries that do not require hospitalization immediately after earthquakes, and in the days, weeks and months that follow.

- **Places of worship**

  Churches, temples, mosques and other religious buildings have large occupancies during services. Many provide critical services to the broader community. These buildings often have earthquake vulnerabilities due to their size, configuration, age and falling hazards. During earthquakes they pose serious threats to the safety of occupants, and the resulting damage would limit their ability to provide services to the community.

[8] A state law referred to as Senate Bill (SB) 1953 requires owners of acute care hospitals to evaluate their facilities and meet specified deadlines to retrofit or replace vulnerable facilities.

Recommendation 7: Establish clear responsibility within City government for preparing for and reducing risk from earthquakes. The City should identify a single official in the Chief Administrative Officer's Office to be responsible for achieving earthquake resilience through mitigation, response and recovery.

Implementing earthquake mitigation measures needs to become an ongoing concern of the City with standing equal to other programs. The earthquake programs within the City need to be institutionalized and responsibility for implementation clarified so that the long-term effort required will not wane as people retire and other issues emerge. It should be the responsibility of one high level official within the Chief Administrative Officer's office who has the authority to work with many departments and is accountable for achieving progress.

The official would monitor progress in carrying out the recommendations in this report within the responsible City agencies and would make public quarterly reports to the Disaster Council. Ideally, this function would be established in the City Charter.

Overseeing the interrelated yet autonomous departments responsible for earthquake mitigation, retrofit incentives, preparedness, response and recovery at the highest administrative level is necessary and the responsibilities should be explicitly described. The measures needed to improve the earthquake performance of the City are physical, involving private and government buildings and utilities, preparation of people and organizations, and many departments, commissions and boards (including the Departments of Building Inspection, Planning, Emergency Management, Public Works and Fire, and functions such as facilities management and capital planning). The office should seek appointment of a Mayoral task force to investigate a number of the recommended actions and to focus agencies on reducing and managing earthquake risk.

An early activity of this position should be to work with the staff revising the Community Safety Element in the General Plan to ensure that the recommendations of this report are incorporated.

The official should work with an advisory committee, which would meet periodically to review progress implementing the recommendations in this report and to advise on ways to improve the program. The preparation of the recommendations in this report benefited from an active and dedicated advisory committee. The insights and concerns of representatives of various interests and neighborhood groups provide valuable perspective and improve accountability for performance and progress.

This office would also support private sector efforts by providing on City staff an ombudsperson to help owners navigate through City requirements and programs relating to retrofitting. Navigating City requirements can be challenging. A dedicated staff person could help building owners and construction and design professionals meet all requirements relating to seismic safety and take advantage of all incentive programs. This ombudsperson office should have employees knowledgeable about programs and requirements across the many City departments that address these issues. An ombudsperson who reaches out to owners, provides training and instructions, and helps shepherd projects through the entire process could facilitate widespread retrofitting. The ombudsperson should understand both economic and technical issues and be supported administratively and not conflicted with other responsibilities.

Recommendation 8: Adopt improved post-earthquake repair standards. The City should enact updated post-earthquake repair and retrofit standards developed by CAPSS and expand this approach to other building types.

After an earthquake, some damaged buildings can be repaired to their pre-earthquake condition. Other damaged buildings need to incorporate seismic retrofits into their repairs, to ensure that they suffer less damage in future earthquakes. The City's current policy regarding which buildings need to retrofit, and which can only repair, needs improvement, as evidenced by problems experienced after the 1989 Loma Prieta earthquake. The City needs to have a post-earthquake repair and retrofit policy to receive certain types of post-disaster funding from the Federal Emergency Management Agency.

In a companion report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Postearthquake Repair and Retrofit Requirements* (ATC, 2010c), CAPSS has developed detailed, clarified technical recommendations to improve this policy and the way this process builds the City's resilience over time. The City should adopt these revised provisions.

The CAPSS recommendations cover 95 percent of the City's buildings. DBI should use this work as a model to develop detailed improvements for additional structure types identified in the CAPSS report.

A damaged building in the Marina District after the 1989 Loma Prieta earthquake. Photo credit: Courtesy of Earthquake Engineering Research Institute Mitigation Center, Oakland, California..

Recommendation 9: Offer incentives for retrofit of buildings. The City should enact a range of meaningful programs to help building owners afford retrofits.

Owners ultimately are responsible for the earthquake performance of their buildings: they have the most to gain from improved performance, and the most to lose because of damage and liability. Building owners benefit by retrofitting before earthquakes strike, but the upfront costs are significant and conflict with other expenditure priorities. While retrofitting results in a safer, more reliable building with its value better protected from earthquake damage, often there is no more useable space or operating efficiency achieved, and improved seismic safety may not be reflected in market values or rental incomes. However, the City has a strong interest in reducing the amount of damage that occurs to privately-owned buildings in future earthquakes. Less damage means a quicker and less costly recovery for the entire City, as well as reduced social dislocation. The consequences of cumulative damage to privately-owned buildings for neighborhoods, local businesses, historic character, and post-earthquake housing availability and affordability make private damage a public concern. Therefore, it makes sense for the City to invest in encouraging building owners to make their buildings safer.

It is imperative that agencies develop and offer meaningful incentives in the near future. Incentives are an important component of Step 1 of the three-step strategy (see previous section) to encourage owners to retrofit. While incentives will not lead to most buildings owners retrofitting their buildings, they could make the difference for some owners who are already inclined to retrofit and will combine with other programs to lead to more action. They also send a positive signal to building owners that the City does not expect them to solve this problem on their own.

Different incentives are meaningful for different owners, so the City should offer a variety of approaches. Incentives that would encourage and facilitate retrofitting in San Francisco are the following:

a. Amend the Planning Code and other City statutes and regulations to offer incentives to building owners who voluntarily conduct seismic retrofits, to allow changes to their buildings that would increase their value.

The City has the ability to offer a number of non-financial incentives that provide real value to building owners. These include allowing additional units or uses (density bonuses), encroachment into setbacks, increased floor/area ratios, relaxation of parking requirements, change in height limits, transfer of development rights, priority in the condominium conversion lottery, and others. These issues would allow building owners to make changes to their building to increase their value or income. While not costing the City anything in terms of dollars, these planning and zoning issues impact other values and can inspire strong feelings among City residents. The City should engage relevant departments, City residents and building owners to discuss which potential incentives provide meaningful motivation to building owners to retrofit, and whether their social costs outweigh the long-term social benefits that come from improved seismic performance. Existing policies protect values important to the City, such as housing affordability and density of uses. However, these values are threatened by inevitable earthquake damage far more than by changes made during retrofits. Incentives for earthquake retrofits would protect these values long-term, not erode them.

b. Allow owners to pass through the full costs of voluntary seismic retrofits that meet DBI code standards.

Rental housing is likely to bear the brunt of damage in future earthquakes, leading to long-term displacement of renters and permanent loss of affordable housing. Tenants benefit greatly from seismic retrofits that reduce these impacts and improve safety. The Board of Supervisors should change the rent ordinance to allow owners to pass through the full cost of retrofit measures undertaken voluntarily in accordance with the code standard. Procedures should protect tenants who would suffer undue hardships by spreading smaller rent increases over a longer period. Currently, building owners can only pass through 50 percent of the costs of voluntary retrofits for most buildings, but they can pass through all costs for mandated retrofits.

c. Maintain fee waivers and expedited review for voluntary seismic retrofits of vulnerable wood-frame residential buildings.

In 2009, San Francisco began offering expedited plan review and plan review fee waivers for owners who decide to retrofit vulnerable wood-frame residential buildings. Damage to wood-frame buildings will be responsible for most of the housing units that cannot be occupied after future large earthquakes. It makes sense to continue this modest program to encourage building owners to invest their own resources to retrofit these vulnerable buildings.

d. Adopt a policy that assures that those who voluntarily retrofit to appropriate standards would not be required to do more work for 15 years, even if standards change.

Owners who undertake retrofitting to the City's standards want some assurance that the City will not require additional retrofit measures as codes change and knowledge of earthquake performance advances. The City has a current policy that applies to both retrofitted unreinforced masonry buildings and wood-frame soft-story buildings, which should be extended to all types of buildings. Providing a 15-year period in which further retrofits would not be required would encourage owners to retrofit rather than wait, and assure lenders that additional funds would not be needed.

e. Publicize how to use the recently passed transfer tax rebate for seismic safety upgrades.

San Francisco voters passed Proposition N in November 2008. This allows up to a 1/3rd rebate of transfer tax upon sale to owners who invest in seismic retrofit measures. Few residents know about this rebate or how to use it. The City should publicize how to use this existing incentive.

f. Publicize and facilitate the process for building owners to make sure that seismic retrofit work is exempted from property reassessments.

This incentive has been state law for twenty years, but many owners do not know about it or how to apply for this credit when properties are reassessed after renovations. The City should clarify the process to ensure that seismic work is not considered in property reassessments after upgrades.

g. Change the Planning Code to prevent owners of buildings demolished after an earthquake from rebuilding to prior nonconforming conditions, unless the building was seismically retrofitted before the earthquake.

Currently, if a building is demolished following an earthquake, the owner can rebuild incorporating nonconforming conditions that existed in the building previously at that site (e.g., area, height, number of units, parking). This policy should be changed so that building owners have an incentive to retrofit.

San Francisco homes damaged in the 1906 earthquake. Photo credit: Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

h. Review, extend and document, as appropriate, historical resources both within designated historic districts, and individually, and conduct earthquake vulnerability assessments.

Owners of officially listed historical resources who invest in rehabilitation projects can qualify for federal income tax incentives. Because earthquakes threaten the preservation of irreplaceable historic resources, the City should encourage vulnerability assessments and measures to improve the earthquake performance of historical resources. The City also should seek funds to screen identified historical resources, and significant and contributory buildings located within designated historic districts, for earthquake vulnerability, and then work with building owners to encourage retrofitting. The term "Historical Resources" is defined by the California Environmental Quality Act and interpreted locally by the Planning Department.

i. Provide need-based loans for qualified retrofits.

Many owners lack the assets or cash flow to qualify for commercial loans to finance retrofitting. The City could help by offering conventional or deferred loans. The City could raise funds through the sale of a general obligation bond to lend funds needed to retrofit buildings that would be paid back on a schedule or when the building is sold or refinanced. This was the approach used to support retrofits of unreinforced masonry buildings. However, many people believe that loan program was ineffective due to the conditions owners needed to meet to use the funds. New loan programs should be designed with fewer restrictions so they provide true assistance to building owners. The City recently investigated creating a Mello-Roos "opt-in" district to provide funds for retrofit that would be repaid through property tax over a period of years. At the current time, this strategy is infeasible because mortgage lenders and mortgage investment agencies such as Freddie Mac and Fannie Mae believe these programs increase the risk of their debt securities. This approach may become a useful option in the future.

j. Advocate for federal and state incentives.

The City could advocate for federal and state incentives such as tax credits and depreciation schedules to reduce owners' costs and lessen federal and state costs following earthquakes and a retrofit loan insurance program to protect existing mortgages. The state also could require condominium associations to develop provisions for either repairing earthquake damage or for retrofitting vulnerabilities. Amendments to the federal Robert T. Stafford Disaster Relief and Emergency Assistance Act could provide resources to help the City carry out the recommendations in this report.

Recommendation 10: Require gas shut-off valves on select buildings. The City should require owners of certain vulnerable buildings and buildings in Fire Department designated Post-Earthquake High Fire Hazard Areas to install automatic gas shutoff valves.

In past earthquakes, gas leaks have played a significant role in fueling post-earthquake fires. Gas appliances can break away from connections and building damage can sever gas lines. San Francisco is a densely packed City with mostly wood frame, flammable buildings, making post-earthquake fire risk a serious concern.

Automatic gas shutoff valves, either triggered by shaking or excess flow, can play a role in reducing this fire risk. A limited number of buildings that are found through seismic evaluation to be particularly vulnerable should be required to install automatic gas shutoff valves. In addition, the Fire Department, working with DBI, should identify locations where fire risk is particularly high and where shut off valves would be required. These areas would be called Post-Earthquake High Fire Hazard Areas.

While gas shutoff valves reduce fire risk, they increase some social risks because it can take a long time to get all gas lines restarted after an earthquake. If shutoff valves were installed on all buildings, many residents in buildings with little damage could be left without heat, hot water, or cooking facilities for an extended period after an earthquake. This could be deadly to the City's large elderly and disabled populations, which is why this report only recommends shutoff valves for buildings most at risk of fueling fires. Requirements for shut off valves should be coordinated with social service agencies so that the needs of vulnerable persons are addressed.

Burned rubble in the Marina District after the 1989 Loma Prieta earthquake. Photo credit: Courtesy of Earthquake Engineering Research Institute Mitigation Center, Oakland, California.

Recommendation 11: Track evaluations and retrofits in a database system. The City should include information relating to seismic evaluations and retrofits in DBI's updated database system to allow tracking progress of mitigation activities, recording inventories, evaluation reports and retrofit information.

DBI's current database system does not include trackable information about seismic retrofits or vulnerability and cannot aggregate and manipulate information for evaluation and tracking citywide progress of mitigation programs.

DBI is in the process of installing an updated database system. This system should include a range of information to support earthquake risk reduction programs, such as the following:

- Information about building use;
- Whether and when buildings have undergone seismic retrofits, and to what standard a building was retrofitted;
- Building structural type and characteristics that affect vulnerability; and
- The findings of building seismic evaluations.

A seismic retrofit on the University of California, Berkeley, campus. Photo credit: William Godden, Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

Recommendation 12: Provide technical assistance for building retrofits. The City should help residents and building professionals to evaluate and seismically retrofit buildings efficiently and in accordance with City codes.

Training programs and other technical assistance can help make retrofitting easier and contribute to high-quality work. The following types of technical assistance activities would encourage retrofitting:

a. Develop standard plan sets for retrofits of typical San Francisco buildings.

Many of San Francisco's buildings are similar in design and construction. This means that similar seismic retrofit solutions should work for a number of buildings. DBI should develop standard plans sets for seismic retrofits of common and simple building types. Buildings that are similar to those in the plan set could use these plans for retrofit. Plan sets reduce design costs for retrofits and have been in use in the East Bay for cripple wall buildings (a building type that is not common in San Francisco) for several years.

b. Provide training for engineers and other licensed professionals in conducting building seismic evaluations.

The City should offer hands-on technical training for how to conduct building seismic evaluations (Recommendation 4). This type of training would help make sure that evaluations are competent.

c. Provide information on retrofit costs and effective technical approaches based on experience as the program progresses.

The City should monitor lessons learned when owners undertake retrofits, including effective retrofit design, construction techniques, costs, and innovative use of technology. The City can share these lessons with building owners, design professionals and contractors to help retrofit programs grow increasingly effective and efficient over time.

d. Provide training for design professionals and contractors in conducting seismic retrofits.

The City should provide training in how to conduct seismic retrofitting, particularly in how to use updated technical standards. This training could include an overview of innovative products and technologies developed for seismic retrofits. The City could post a list of those who have completed this training on its website, which would help consumers.

e. Develop additional building code standards, as needed, to reduce hazards and improve post-earthquake building usability, including bracing of mechanical and other heavy equipment and shelves, and elevator functionality.

Safety and post-earthquake usability are affected by the performance of contents, appliances, equipment, elevator functionality, functionality of HVAC (heating ventilation, and air conditioning) and utility systems, and other building elements not directly associated with a building's structural system. These elements can pose safety hazards during earthquakes, play a big role in whether

buildings can be used after an earthquake, and affect the scope of economic losses. The building code already includes some standards; however, DBI should develop additional technical standards for reducing the hazard from objects and systems not covered. These standards would be applied either as requirements or would guide voluntary efforts.

A store damaged in the 1989 Loma Prieta earthquake with damage that will delay occupancy. Photo credit: James Blacklock, Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

f. Conduct inventories of structural types and building uses of concern.

There are structure types in the City that are known to pose risks to the safety of residents, and building uses of special importance. However, the City has no inventory of exactly where these building are or how many there are. DBI should lead an effort to get a good inventory of the highest risk structure types and buildings with selected important uses in the City so programs to address the risk of these buildings can move forward.

Inventories are needed for the following types of structures:

- Concrete tilt up buildings;
- Concrete frame buildings constructed prior to 1980;
- Concrete and steel frame buildings with unreinforced masonry infill walls;
- Early retrofitted buildings; and
- Large welded steel moment frame buildings built before 1994.

Lists of owners responsible for buildings with the following uses are needed:

- Assisted living facilities;
- Social service providers;
- Daycare centers and preschools;
- Medical service providers;
- Critical retail services (e.g., grocery stores, pharmacies);
- Private schools and colleges; and
- Large institutions with control over many buildings.

Recommendation 13: Enact a façade ordinance. An ordinance should require periodic inspection of façades, parapets and decorative features fixed to building exteriors, and require repair of materials found to be falling hazards.

Parts of building façades can fall off and kill passers-by during earthquakes or at any time. Many cities have passed laws requiring regular inspection of façades and other building elements that could fall, and requiring maintenance of deficient conditions. San Francisco should have such an ordinance. San Francisco enacted measures in the 1970's to brace parapets and to prevent exterior building elements from falling on the sidewalks or adjacent buildings. These measures should be extended to address building façades and cladding vulnerable to falling, as many aging buildings have increased hazards due to corrosion and general deterioration.

Recommendation 14: Promote development and implementation of effective ideas on earthquake risk reduction. The City should encourage efforts to improve knowledge about building performance and effective ways to reduce earthquake risk that are relevant to San Francisco.

Knowledge about earthquake risk reduction is developing rapidly from ongoing research, retrofitting experience, and studies following large, damaging earthquakes. The City should keep abreast of new developments in structural, geotechnical and social science topics to make sure issues important to San Francisco are addressed and applied in San Francisco. As evidence that the City can influence research, the CAPSS project's work on wood-frame soft-story buildings has already resulted in a national effort in the technical community to define better standards and methods for retrofits of this type of structure.

The following activities would provide information helpful to San Francisco:

a. Plan data collection programs to follow the next damaging earthquake, focused on learning about issues of policy importance to San Francisco.

The City should plan now to make sure that important lessons relevant to San Francisco are learned from the next earthquake to strike the City or other communities with similar conditions. Earthquake damage is ephemeral, disappearing as residents repair and rebuild. Data collection programs, beyond standard post-earthquake building inspections, should be planned in advance. This will help the City be better prepared for the inevitable earthquakes that follow.

b. Support efforts to test and research innovative and low-cost retrofit concepts, such as bracing garage doors and adding ductility and energy absorption to brittle or weak building elements.

DBI should work with universities, companies and individuals developing innovative and potentially low-cost solutions for seismic retrofits. Encouraging such innovators to conduct demonstration projects, or to conduct seminars in San Francisco, can help move these technologies closer to reality and channel them in directions that make sense for San Francisco.

c. Support innovation needed to modernize and improve evaluation and retrofit standards.

Current building codes generally rely on analysis methods that are decades old. More modern methods, such as those developed for Performance Based Design, are increasingly becoming viable approaches for retrofits and building codes. DBI should work with the research community to help translate improved analysis methods into practical code standards that could be adopted by the City.

d. Reexamine the expected performance of previously retrofitted buildings.

San Francisco has pioneered efforts to improve the earthquake performance of its building stock. In the 1970's, the City required building owners to brace parapets and decorative elements, and began requiring retrofitting of vulnerable buildings when they were enlarged or renovated to change their use. In the 1990's, the City began its program to retrofit most unreinforced masonry

buildings. Since then, knowledge about retrofitting has changed in significant ways and some of the early retrofits might not provide the performance the owners and tenants expect, or that the City desires. The City should conduct a careful analysis of previous retrofits, especially the use of thin-wall steel tube braced frames. The City should report whether additional retrofits are needed to protect public safety and improve the City's resilience.

e. Study the hazard from masonry chimneys in San Francisco, and recommend necessary mitigation measures.

Masonry chimneys, mostly on small dwellings, often are unreinforced and prone to falling dangerously. San Francisco's fire chief was killed when a chimney fell during the 1906 earthquake. Unreinforced chimneys are not allowed by code and some cities encourage their removal. The extent of risk to San Franciscans needs further analysis and should be addressed when buildings are evaluated and retrofitted.

f. Support installation of instruments to measure building movement in earthquakes.

Records of building movements during earthquakes provide information that is useful when evaluating the extent of damage a building has experienced and its level of post-earthquake safety. The recordings also provide evidence to better understand how buildings respond when subjected to strong shaking.

g. Study the feasibility of administrative measures to mitigate against ground failures that affect multiple properties and cannot be completed by a single building owner.

Liquefaction and lateral spreading ground failures generally involve more than a single parcel, making it difficult for a single owner to address the hazard. Administrative arrangements, such as opt-in districts (geologic hazard abatement districts) can be used to fund and execute projects involving several owners, government agencies and utilities. Administrative measures will be needed when remediation technology (see recommendation below) advances to become useful.

h. Periodically review remediation technology and provide guidance to owners in potential liquefaction and lateral spreading zones when techniques become feasible.

Current research into soil remediation measures suitable for built-up areas shows some promise, but is not yet ready for widespread commercial application. The City should monitor progress periodically and consider administrative ways to use the technology when appropriate.

Recommendation 15: Evaluate measures to reduce post-earthquake fires. Multiple City Departments should work together to evaluate and implement measures to reduce fire ignitions and spread, and improve fire suppression capacity following earthquakes.

Fires triggered by earthquakes pose a serious risk. Strong efforts by multiple City departments are needed to reduce the number of ignitions that occur after future earthquakes and to limit fire spread to adjacent buildings. Issues that affect ignitions, fire spread, and fire suppression are the responsibility of a number of City departments, private owners, and entities outside of City control (e.g., Pacific Gas and Electric company and property insurers). The most sensible ways to manage post-earthquake fire risk should be determined through dialogue between all of these groups. Each of these groups should share what they know with other groups, to help everyone make good decisions for San Francisco.

Views of fires and displaced residents from the Presidio after the 1906 earthquake Photo credit: Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

A diverse group of City Departments and others should evaluate and consider implementing the following actions:

a. Improve water supply systems to cover those neighborhoods not served by the Auxiliary Water Supply System.

The Auxiliary Water Supply System provides a redundant water system for fighting fires after earthquakes and at other times, and incorporates many earthquake resistant features in its design. However, this system covers only the

northern and eastern City neighborhoods, those that were developed in the early part of the last century when the system was constructed. The City needs adequate, reliable water sources to fight post-earthquake fires in all neighborhoods. There are a number of options to improve the water supply in neighborhoods not served by the Auxiliary System, including expanding the City's Portable Water Supply System, which can be deployed wherever needed. This important issue needs to be addressed as soon as possible.

a. Expand the training and scope of Neighborhood Emergency Response Teams (NERT) to include fire suppression, fire reporting, assisting vulnerable residents, and assisting with neighborhood recovery.

The San Francisco Fire Department runs training programs for Neighborhood Emergency Response Teams (NERT) and has trained thousands of residents to help their neighborhoods after an emergency. NERT volunteers could be trained to help in new ways, including basic fire suppression, fire reporting, relighting pilot lights, and helping neighbors who are dependent on functioning utilities and others for the delivery of food, water, oxygen, medicine and health services. The City should examine how to take maximum advantage of the enthusiasm of NERT teams to help the City to respond to and recover from major earthquakes.

b. Increase accessibility of water shutoff valves on building fire sprinkler systems to control water loss from damaged sprinkler systems.

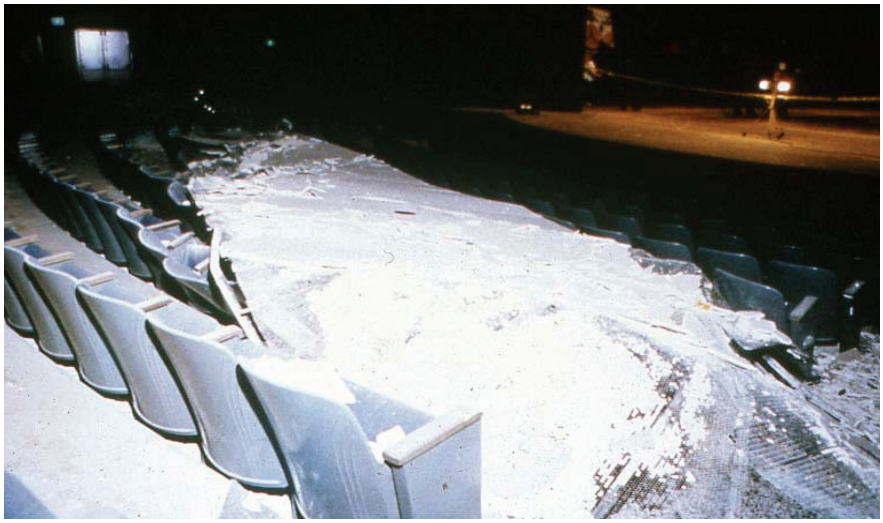
Damaged water sprinkler systems broken by earthquake shaking can contribute to loss of water needed to fight fires from the municipal water system, as well as seriously damage buildings by water inundation. The City should investigate whether making shutoff valves for these systems more accessible is a cost effective way to improve post-earthquake water availability and limit non-structural damage.

c. Study potential post-earthquake ignition risks and evaluate measures to reduce them.

There are a number of mechanisms that may reduce fire ignitions in earthquakes that warrant further investigation. These include using modern arc fault circuit interrupters to avoid electrical fires, using flexible connections for gas-fired appliances, and addressing the high pressure gas lines inside buildings. The City should convene a group to look at these and other ignition risks and recommend further action.

Recommendation 16: Address the hazards from damage to building systems, appliances and equipment and non-structural building elements. DBI should initiate a comprehensive program to encourage, and in some instances, require measures to reduce these hazards.

Damage to building systems, such as fallen ceilings and fixtures, broken pipes, and overturned equipment, cause serious problems in every earthquake, including deaths, greatly increased economic losses, and making buildings unusable. Building communications, electrical, plumbing and HVAC systems, elements such as stairs and elevators, furnishings, appliances and equipment, and retail inventories can be more valuable than the building structures. These elements greatly affect whether buildings can be used following earthquakes, the magnitude of losses, and the safety of inhabitants. Measures to reduce damage to these elements generally are not difficult, are affordable, and are readily achievable.



A heavy plaster ceiling that collapsed during the 1989 Loma Prieta earthquake. Photo credit: Consortium of Universities for Research in Earthquake Engineering, Courtesy of the National Information Service for Earthquake Engineering, University of California, Berkeley.

DBI should initiate a comprehensive program to encourage, and in some instances, require measures to reduce these hazards. It should include education and outreach activities focused on these issues (see Recommendation 2d) and development of relevant code standards (see Recommendation 12e). DBI should consider ways to improve enforcement of water heater installation standards.

This report recommends that falling hazards and other non-structural concerns be identified as part of mandatory evaluations (Recommendation 4) and be addressed prior to, or as part of, mandatory retrofits (Recommendation 5). For some building categories, the City might find that falling hazards and other non-structural concerns should be addressed before mandatory retrofit deadlines. For example, this report proposes that many building categories not be mandated to retrofit for more than two decades. In these cases, the City could require buildings to comply with non-structural standards by an earlier date.

Recommendation 17: Periodically assess progress and implementation of these recommendations.

The preceding sixteen recommendations in this report call for significant new policies and programs to improve the earthquake resilience of San Francisco's building stock. The City should commission an independent assessment at least every five years to review progress and consequences of the resulting program and to make recommendations for improving its effectiveness. The recommendations in this report are interrelated, and will be most effective if implemented as a complete program, instead of piece by piece. The assessment should look at what actions have been taken by the City and highlight important steps that may have been neglected. The assessment should also recommend adjustments based on lessons learned. Although these recommendations have been carefully selected, some of them may not work as intended when implemented. It is imperative that they be reviewed periodically to measure their effectiveness in reaching the City's objectives and to recommend changes to make them work better.

Building Categories and Retrofit Deadlines

Categories of Buildings

The City should divide the building stock into "categories," or groups of buildings defined by a building's use, its type of structural system, or both. This way of grouping buildings allows priorities to be set based on both the importance of buildings to the community and public safety. All buildings in a category would be moved through the three-step strategy—information, evaluation, and retrofit—as appropriate. The sequence in which building categories would be addressed would be assigned based on how important the type of building is to San Francisco's resilience (e.g., two important uses are rental housing and private schools) or the threat the building type poses for injuries and deaths (e.g., structural categories with known life safety risks include unreinforced masonry bearing wall buildings, concrete tilt-up buildings, and concrete frame buildings constructed before 1980).

Many buildings would be included in two categories, one because of their use and another because of the type of structure. The category with the first deadline would take precedence, but the retrofit standards should be the same. For example, if there is an assisted living facility located in a large concrete building constructed before 1980, the owner would be required to evaluate the building because it houses an assisted living facility, not because it is an older concrete building. When the program advances to the category of older concrete buildings, the seismic upgrade of this building would have been already completed.

The City could choose to prioritize within each category so that buildings with greater numbers of occupants, more important uses, located on weak soils, or with greater vulnerability, or a combination of these attributes, could be addressed first. These characteristics could be identified when an inventory of buildings in the category is prepared.

This report recommends twenty categories of buildings based on use, structure type or both. Each category is described below. Table 4 summarizes the categories and how they are comprised of both uses and building types.

The building categories are:

- **Wood-frame residential buildings with three or more stories and five or more units**

  There are about 4,400 buildings of this type, many with a soft-story condition at the ground level. A soft-story is significantly weaker or more flexible than the stories above it. The weakness at the ground level usually comes from large openings in perimeter walls, due to garage doors or store windows, and/or few interior partition walls. During strong earthquake shaking, the ground level walls cannot support the stiff and heavy mass of the stories above them as they move back and forth. The ground level walls could shift sideways until the building collapses, crushing the ground floor. This building type is expected to be responsible for about one-third of housing units that cannot be occupied after future earthquakes. Retrofits of this type of structure are relatively straightforward and inexpensive, compared to other structure types. The risk of this type of building and the benefits associated with retrofits are explored in detail in the companion CAPSS report *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Earthquake Safety for Soft-Story*

Buildings (ATC, 2009a). In response to this report, the Mayor formed a task force to create a program and to draft legislation to implement the report's recommendations (see Recommendation 1).

Table 4 Building Categories Summary

Building Category	Estimated Number of Buildings
Categories Based only on Structural Systems	
Concrete tilt-up buildings	200
Large buildings with welded steel moment frames built before 1994	Unknown
Early retrofitted buildings	Unknown
Categories Based on Structural System and Use	
Wood-frame residential buildings with three or more stories and five or more units	4,400
Concrete residential buildings built before 1980	Unknown
Other types of residential buildings with five or more units	Unknown
Concrete non-residential buildings built before 1980	Unknown
Categories Based Only on Building Use	
Residential buildings with three and four units	More than 6,000
Single-family homes and two-unit residences	112,000 single family, 20,000 two unit
Providers of important services to vulnerable populations	Unknown
Preschools and daycare centers	Unknown
Clinics and facilities providing medical services	Unknown
Private kindergarten through grade 12 (K-12) schools and private colleges	About 100 private K-12 schools, more than 20 private colleges and universities
Assisted Living facilities	Unknown
Houses of worship	Unknown
Hotels and motels	About 240
Critical retail stores and suppliers	About 30 large grocery stores and 100 pharmacies
Buildings used by large audiences	Unknown
Historic buildings, significant and contributory buildings in historic districts, and other resources that may be historic	Unknown

Sources: *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Potential Earthquake Im*pacts (ATC, 2010a), Housing Inspection Services.

- **Residential buildings with three and four units**

  There are an estimated 6,000 wood-frame residential buildings with three to four units. Many of these have a soft-story at the ground level. There also are a small number of unreinforced masonry buildings that were exempt from the earlier mandatory retrofit program, and a number of vulnerable buildings of various other structural types. These buildings are expected to be responsible for about one-third of residential units that cannot be occupied after a large earthquake (in addition to the third associated with larger wood-frame buildings, discussed above). A mandatory program addressing these buildings should begin as soon as progress on seismic upgrades to the five unit buildings progresses to the point that the program can be expanded, about five years from the present.

A reinforced concrete column undergoing retrofit. Photo credit: L. Thomas Tobin.

- **Concrete residential buildings built before 1980**

  Older reinforced concrete buildings are a serious risk for extensive damage and dramatic and deadly collapses during earthquakes. Such collapses have been responsible for many of the casualties in earthquakes around the world. There are older reinforced concrete buildings in San Francisco being used as apartment

buildings and residential hotels. Thousands of people live in these buildings and many would be killed or displaced by damage. Retrofit of these buildings is expensive, but is important due to the risks they pose to the City. It may make sense to retrofit these buildings to a "collapse prevention" standard, recognizing that, even after retrofit, many of them may not be habitable or repairable after an earthquake.

- **Other types of residential buildings with five or more units**

  This category includes all large residential buildings not constructed from wood or concrete that are found to be vulnerable through evaluation. This category includes diverse and vulnerable buildings, such as reinforced masonry and steel frame buildings with masonry infill walls. Mostly, these buildings are multi-unit; many of them have historic features. Many of these buildings provide housing for low income tenants and will be difficult to replace. It may be appropriate to retrofit some of these buildings to a "collapse prevention" standard.

- **Single family homes and two unit residences**

  This is by far the most common type of building in San Francisco, with an estimated 112,000 single-family homes and almost 20,000 two-unit residential buildings. Many of these buildings are vulnerable to earthquakes because of garages at the ground level, creating a weak or soft-story condition, as well as significant non-structural hazards that may prevent buildings from being occupied after earthquakes. There are a small number of unreinforced masonry buildings of this size that were exempted from the earlier mandatory program. DBI should develop prescriptive standards for typical buildings that would improve the likelihood that residents could shelter in place.

- **Providers of important services to vulnerable populations**

  These providers serve the homeless, persons with limited mobility, persons with significant medical and psychological issues, the poor and others. Many City agencies use these organizations to deliver services. Tens of thousands of San Franciscans rely on these organizations for services that keep them alive.

- **Preschools and daycare centers**

  Children in preschool and daycare centers should be as safe in earthquakes as are their older siblings in public schools. Parents rely on these facilities to care for their children while they work and to provide a satisfactory level of safety. San Francisco's recovery following earthquakes depends on people returning to work.

- **Clinics and facilities providing medical services**

  Neighborhood urgent care and other medical services, dialysis centers, medical suppliers, and hospital facilities not regulated by the State of California[9] provide critical services to San Franciscans. These services would be needed to treat the thousands of injuries that do not require hospitalization immediately after earthquakes, and in the days, weeks and months that follow.

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[9] State law gives the Office of Statewide Health Planning and Development authority over the design and construction of acute care hospital and skilled nursing facilities.

- **Private K-12 schools and private colleges**

  Most people assume that school buildings are safe, but most private schools are probably no safer than the general building stock. Many of San Francisco's private school buildings were constructed when building standards were much less stringent than today. Nearly one third of school children—more than 23,000—attend private schools in San Francisco, the highest rate in the entire state[10]. The City must ensure that all of San Francisco's children and other students attend school in buildings that meet standards equivalent to the standards for public schools[11].

- **Assisted Living facilities**

  The City's elderly and other disabled persons should be in facilities that are expected to be safe and functional after future earthquakes. Relocation after an earthquake would be hardest on these residents. The City must provide assistance to those facilities serving low-income residents.

- **Houses of worship**

  Churches, temples, mosques and other religious buildings have large occupancies during services, and often in times of emergency. Many provide critical services to the broader community. These buildings often have earthquake vulnerabilities due to their size, configuration, age and falling hazards. During earthquakes they pose serious threats to the safety of occupants, and the resulting damage would limit their ability to provide services to the community. Many of the most vulnerable houses of worship have limited resources, warranting long lead times before mandates to allow for planning.

- **Concrete non-residential buildings built before 1980**

  Like concrete residential buildings, older reinforced concrete buildings used for other purposes can experience dramatic and deadly collapses during earthquakes. Such collapses are responsible for many of the casualties in earthquakes around the world. There are many older reinforced concrete buildings in San Francisco being used as office buildings and warehouses. Thousands of people use these buildings daily. Retrofit of these buildings may be expensive, but is important due to the risks they pose to the City. It may make sense to retrofit these buildings to a "collapse prevention" standard, recognizing that, even after retrofit, many of them may not be repairable after an earthquake.

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[10] California Department of Education, 2009.

[11] The CAPSS project did not consider public schools, which serve about 55,000 students in San Francisco. Public schools built to state standards are among the most earthquake resistant buildings in California. However, like other buildings, some were constructed to older standards and some of the buildings constructed before the state standards were adopted in 1933 were retrofitted, but do not provide the performance expected from modern school buildings. In 2002, the Department of Conservation, Division of the State Architect, developed a list of public school buildings, *Seismic Safety Inventory of California Public Schools* (Department of General Services, 2002), to identify non wood-frame school buildings built before July 1, 1978 that should be evaluated because of their age and building type. There are 72 buildings belonging to the San Francisco Unified School District on this list.

- **Hotels and motels**

  Hotels and motels of all structural types must be safe during future earthquakes and readily reoccupiable. Hotels play a key role during post-earthquake recovery by housing emergency workers, including those brought to the City to restore utilities. They also provide potential temporary housing for displaced residents. Moreover, because tourism is a key part of the City's economy, improving the performance of visitor-serving buildings is critical for the City's earthquake recovery.

- **Critical retail stores and suppliers**

  Certain businesses are critical to helping the City recover quickly and it is desirable to have them operational as soon as possible. San Franciscans need pharmacies, grocery stores, and similar retail establishments that provide the items required for daily living. Some of these important businesses may be located in weak buildings that would not be usable after a large earthquake. Many of these businesses may rent the space they use, and retrofit timelines should allow time to renegotiate leases as part of this process.

- **Buildings used by large audiences**

  Theaters and other buildings that are used to gather many people need to be safe, considering hazards due to occupants due to damage to the building and falling hazards. Although many of these buildings are occupied only a few hours each week, when they are occupied there is the chance of a large number of casualties. A reasonable threshold for the size of buildings in this category is an occupant load of 300 persons.

- **Historic buildings, significant and contributory buildings in historic districts, and other resources that may be historic**

  Historic resource buildings should be repairable after future earthquakes so the City may maintain its heritage. This could include many older masonry buildings previously upgraded to standards only intended to reduce casualties, but not to assure reparability.

- **Concrete tilt-up buildings**

  These buildings have heavy precast concrete panels that are raised in place to form the building walls. If the walls are not adequately connected to each other and to the roof, they can separate when shaken by an earthquake, causing the roof and wall sections to collapse on the occupants and contents of the building. This structure type is often used for industrial purposes, but also may be used for grocery stores or other commercial purposes. There are an estimated 200 of these in San Francisco. These buildings are relatively simple and inexpensive to retrofit, compared to other structure types, and a number of communities have enacted retrofit programs for this type of building. Standards for retrofitting are readily available for adoption into the San Francisco Building Code.

- **Large buildings with welded steel moment frames built before 1994.**

  Many office buildings and workplaces were constructed with welded steel moment frames with details that were found vulnerable in the 1994 Northridge earthquake in southern California. Welding procedures and connection details were changed in 1994 to improve the performance of buildings built since then.

The connections used before 1994 can be damaged, resulting in buildings that cannot be used and might have to be razed. These large buildings should be retrofitted to reduce the chance of damage and increase the likelihood that the businesses they house will not be displaced and the buildings can be repaired and reoccupied quickly.

- **Early retrofitted buildings**

  Some retrofits conducted decades ago may be inadequate to meet public policy goals. These include early retrofits with thin-wall steel tube braced frames, those meeting very low standards, and those with partial retrofits not meeting an adopted standard. In these early retrofits, tube walls may be too thin, allowing buckling to occur, welded connections might be inadequate, or there may be other vulnerabilities.

- **All other buildings**

  There are other categories of vulnerable buildings and important building uses not included in this list. Buildings with mixed structural systems and parking structures are examples. The City should add additional categories as the need arises as part of the regular evaluation of mitigation programs (Recommendation 17).

Recommended Retrofit Deadlines for Building Categories

This report recommends that San Francisco's buildings go through a three-step strategy over thirty years to improve their seismic resilience—information, evaluation, and retrofit. The recommended timeframe for action for the key categories of buildings is depicted in Table 5.

The first step, providing information and incentives to inform and assist owners, should begin immediately for all building types and continue indefinitely (Recommendations 2, 3, 9, 11 and 12).

The second step (Recommendation 4), requiring evaluation upon sale, should begin for all building types within five years. The five-year timeframe allows the City time to adopt evaluation criteria and procedures and improved retrofit standards before the mandatory evaluations commence. However, after five years the City should establish deadlines and begin requiring evaluations.

The third and final step, mandatory retrofits, should begin immediately for wood-frame buildings with three or more stories and five or more residential units and concrete tilt-up buildings, and should conclude for all building categories in thirty years. This report recommends the City enact mandatory retrofit requirements for the following building categories in the following timeframe:

Ongoing

- Continue to strictly enforce retrofitting buildings as part of significant repairs, alterations, expansions, changes of use, and repair of damage above specified thresholds; and
- Enact retrofitting as a condition to converting multi-unit residential buildings to condominiums.

Begin to require retrofitting immediately and complete within ten years

- Wood-frame residential buildings with three or more stories and five or more units; and
- Concrete tilt-up buildings.

Begin to require retrofitting in five years and complete within fifteen years

- Residential buildings with three and four units;
- Private K-12 schools and private colleges; and
- Assisted Living facilities.

Begin to require retrofitting in ten years and complete within twenty years

- Concrete residential buildings built before 1980;
- Other types of residential buildings with five or more units;
- Hotels and motels ; and
- Critical retail stores and suppliers.

Begin to require retrofitting in twenty years and complete within thirty years

- Single family homes and two unit residences;
- Concrete non-residential buildings built before 1980;
- Houses of worship;
- Preschools and daycare centers;
- Buildings used by large audiences;
- Historic buildings, significant and contributory buildings in historic districts, and other resources that may be historic;
- Large buildings with welded steel moment frames built before 1994; and
- Early retrofitted buildings.

Other Categories

The following use-based building categories are very important to San Francisco's earthquake resilience. However, many of these organizations are nonprofit entities that do not own the buildings they occupy. This report recommends that the City assist these groups to evaluate and retrofit buildings where possible, or relocate, if necessary (Recommendation 6). However, buildings used for these purposes would trigger mandatory retrofit if they also fall under one of the other categories, such as a concrete building built before 1980.

Other categories:

- Non-profit organizations providing important services to vulnerable populations; and
- Clinics and facilities providing medical services.

Table 5 Recommended Timeframe* for Applying the Three-Step Strategy to Key Categories of Buildings

Building Categories	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
Wood-frame residential buildings with three or more stories and five or more units**						
Concrete tilt-up buildings						
Residential buildings with three and four units						
Private K-12 schools and private universities						
Assisted living facilities						
Concrete residential buildings built before 1980						
Other types of residential buildings with more than five units						
Hotels and motels serving tourists						
Critical retail stores and suppliers						
Single family homes and two unit residences						
Concrete non-residential buildings built before 1980						
Houses of worship						
Preschools and daycare centers						
Buildings used by large audiences						
Historic buildings						
Large buildings with welded steel moment frames built before 1994						
Early retrofitted buildings						
All other building types						

*The mandatory evaluation or retrofit program would begin at the start of the period and be completed by the end of the period.

**See Table 3 for the detailed schedule proposed in the draft ordinance developed by the Mayoral Task Force.

Color key*:**

Step 1: Facilitate a market in which earthquake performance is valued	
Step 2a: Nudge market by requiring evaluation upon sale	
Step 2b: Nudge market by requiring evaluation by a deadline	
Step 3: Implementation period to require retrofit by a deadline	

*** Note: all previous steps remain in effect after advancing to a higher step.

CHAPTER 5: GETTING STARTED: AN ACTION WORKSHEET FOR 2011 THROUGH 2015

This chapter outlines the actions needed to begin to implement the recommendations in this report over the next five years. It is intended to be used as a worksheet to plan detailed steps. Before completion of this period, the City should evaluate its progress, change the program based on what is learned and prepare a new action plan.

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
Getting Started				
Design a program with designated staff to carry out a sustained Existing Building Hazard Mitigation Program.				
Implementing the Recommended Actions				
Recommendation 1: Require evaluation of all wood-frame residential buildings of three or more stories and five or more units, and follow-up retrofit of those that are vulnerable to earthquake damage.				
• Contact known owners of the 4,400 buildings having five or more residential units and three or more stories to inform them of their potential vulnerability and the proposed mandatory program.				
• Adopt newly developed retrofit standards for large wood-frame soft-story residences, as revised by DBI.				
○ Draft				
○ Review				
○ Approve				
○ Adopt and implement				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Adopt procedures for evaluating this category of building, including report contents, forms, preparer qualifications, and a scheme to explain results to non-technical stakeholders.				
○ Draft				
○ Technical Review				
○ Community stakeholder review				
○ Approve				
• Submit ordinance to Board of Supervisors for approval.				
• Implement program				
Recommendation 2: Inform the public of risks and ways to reduce risk.				
• Develop a cross-departmental earthquake resilience education team.				
• Prioritize education and outreach activities to support other ongoing earthquake risk mitigation initiatives.				
a. Explain the need for and process to evaluate building seismic performance, including structural, fire, and non-structural hazards.				
• Work with organizations that represent building owners, Real Estate brokers and agents, property managers and residential tenants to design an effective outreach program.				
b. Offer courses aimed at single-family homeowners about how to conduct small scale seismic retrofits.				
• Develop materials that show typical retrofit details appropriate for residences in San Francisco, in non-technical language intended for homeowners.				
• Develop a strategy to distribute these materials and use them in training courses.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
c. Educate installers, building owners, and others about proper ways to brace water heaters.				
• Develop clear, non-technical information sheets with illustrations showing correct and incorrect ways to secure water heaters. One version should be aimed at installers. Another should be appropriate for building owners and realtors.				
• Develop a strategy to distribute these materials to all relevant parties when water heaters are installed or inspected.				
d. Educate residents about simple and cost-effective ways to make their homes safer and habitable following earthquakes by reducing non-structural hazards.				
• Develop materials aimed at residents that show, in simple and visual terms, steps they can take to reduce hazards in their home. Materials should be written for a non-technical, non-"handy" audience and should be explicit about hardware and tools required.				
• Develop a scheme to distribute these materials to residents.				
e. Develop a program in coordination with other City agencies to work with small businesses and important community service providers on measures they can take to reduce vulnerability to earthquakes.				
• Create a multi-departmental team to address earthquake risk issues relating to social service groups, small businesses, and vulnerable populations.				
• Work with groups such as the Red Cross and Collaborating Agencies Responding to Disaster (CARD) to develop a program to help social service groups with earthquake hazard mitigation.				
f. Encourage building materials stores, insurance companies and utility companies to supplement education campaigns.				
• Develop relationships with relevant private businesses to coordinate on communication and outreach programs.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Encourage private businesses to distribute City developed education materials, and to create their own complementary materials.				
g. Revise post-earthquake building inspection protocols and train inspectors and owners to identify buildings that can be occupied safely despite damage and loss of utilities.				
• Review and revise post-earthquake safety tagging procedures to make sure they reflect San Francisco's occupancy goals.				
• Create materials to train post-earthquake safety tagging inspectors in updated procedures.				
• Prepare video to show mutual aid inspectors at time of earthquake response.				
• Organize and hold training sessions.				
h. Train preservation engineers and architects knowledgeable about San Francisco's historic resources in post-earthquake safety tagging.				
• Develop post-earthquake standards for historic resources.				
• Reach out to the historic preservation community to encourage qualified people to participate in post-earthquake safety tagging training sessions.				
Recommendation 3: Adopt updated code standards.				
• Apply City adopted performance standards for existing and new buildings based on building structural system and use.				
• Amend the Building Code based on existing prescriptive standards for concrete tilt up buildings, as revised by DBI.				
○ Draft				
○ Review				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
○ Approve				
○ Adopt				
• Identify benchmark code dates. Buildings constructed in compliance with these benchmark codes would be deemed to have adequate seismic performance.				
○ Review				
○ Approve				
○ Amend Building Code				
• Develop standards to reduce fire ignition sources when buildings are retrofitted. These would be included in retrofits for all building types.				
• Incorporate standards to reduce falling hazards and other non-structural risks in retrofits of all building types (see Recommendation 12e).				
• Develop standards to address ground failure issues when larger buildings are retrofit.				
• Revise and adapt existing standards for additional types of building structural systems and uses, in consultation with professional associations such as the Structural Engineers Association of Northern California (SEAONC).				
• Encourage the Port of San Francisco and other jurisdictional entities to adopt the updated code standards in their jurisdictions.				
Recommendation 4: Require all buildings to be evaluated for seismic risk.				
• Adopt procedures for evaluating buildings including report contents, forms, preparer qualifications, and a scheme to explain results to non-technical stakeholders.				
○ Draft				
○ Technical Review				
○ Community stakeholder review				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
○ Approve				
• Adopt an ordinance requiring the seller of any building in San Francisco to have a building earthquake performance evaluation completed by a qualified design professional and to disclose the results to potential buyers and to provide the results to DBI as part of the public record.				
○ Draft				
○ Review				
○ Approve				
Recommendation 5: Require retrofits of vulnerable buildings.				
• Adopt an ordinance requiring owners of wood-frame buildings with three or more residential units to evaluate their buildings for earthquake vulnerability and to retrofit them, if found vulnerable, in conformity with the San Francisco Building Code. Owners of buildings with three or more stories and five or more residential units should comply by 12/31/17 (see Recommendation 1). Owners of buildings with three and four units should comply by 12/31/20.				
• Adopt an ordinance requiring owners of concrete tilt-up buildings built before 1980 to evaluate their building for earthquake vulnerability, and to retrofit those buildings that are found vulnerable.				
○ Prepare an inventory of concrete tilt-up buildings constructed before the bench mark code.				
• Amend the San Francisco Building Code to require all buildings to meet the *existing building earthquake standard* by December 31, 2039, with staggered deadlines for particular categories of buildings.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
Recommendation 6: Assist community service organizations to reach earthquake resilience.				
• Plan with a multi-departmental group (see Recommendation 2e) a program to assist social service groups to evaluate the vulnerability of their facilities and plan appropriate action.				
• Conduct outreach to social service groups about the program and need for earthquake evaluations.				
Recommendation 7. Establish clear responsibility within City government for preparing for and reducing risk from earthquakes.				
• Assign this responsibility for earthquake mitigation and recovery planning to one official and make it a permanent part of San Francisco's City structure.				
• Designate a single high-level official within the Chief Administrative Officer's Office to have responsibility for implementing a comprehensive Citywide coordinated effort to reduce the risk from earthquakes through mitigation.				
• Work to get CAPSS recommendations incorporated into the Community Safety Element of the General Plan.				
• Convene a Citizen's Advisory Committee to regularly advise on mitigation programs.				
• Establish an ombudsperson to assist building owners will all aspects of seismic retrofits.				
Recommendation 8: Adopt improved post-earthquake repair standards				
• Amend the San Francisco Building Code to incorporate the CAPSS recommendations for post-earthquake repair and retrofit.				
○ Draft amendments				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
○ Review				
○ Approve				
○ Amend Building Code				
• Support development of repair/retrofit guidance materials for the other building types recommended by CAPSS in companion report, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco, Post-Earthquake Repair and Retrofit Requirements*.				
○ Draft guidance				
○ Review				
○ Approve				
Recommendation 9: Offer incentives for retrofit of buildings.				
a. Amend the Planning Code and other City statutes and regulations to offer incentives to building owners who voluntarily conduct seismic retrofits to allow changes to their buildings that would increase their value.				
• Work with building owners and tenant organizations to identify meaningful and feasible incentives.				
• Amend the Planning and other codes to codify the incentives.				
b. Allow owners to pass-through the full costs of voluntary seismic retrofits that meet DBI code standards.				
• Convene a group of tenants, building owners and other stakeholders to discuss this issue.				
c. Maintain plan review fee waivers and expedited review for voluntary seismic retrofits of vulnerable wood-frame residential buildings.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
d. Adopt a policy that assures that those who voluntarily retrofit to appropriate standards would not be required to do further retrofit work for 15 years, even if standards change.				
• Draft policy				
• Review				
• Approve				
e. Publicize how to use the recently passed transfer tax rebate for seismic safety upgrades.				
• Work with the Assessor's Office to determine best procedures to use this incentive.				
• Develop a flyer explaining how to use this incentive and make it widely available.				
f. Publicize and facilitate the process for building owners to assure that seismic retrofit work is exempted from property reassessments.				
• Work with the Assessor's Office to determine best procedures to use this incentive.				
• Develop a flyer explaining how to use this incentive (possibly combine with flyer in Recommendation 9d) and make it widely available.				
g. Change the Planning Code to prevent owners of buildings demolished after an earthquake from rebuilding to prior nonconforming conditions, unless the building was seismically retrofitted before the earthquake.				
• Review the consequences of changing this policy (e.g., could neighborhood density be significantly reduced in some areas due to downzoning?).				
• Develop changes to the Planning Code.				
h. Review, extend and document as appropriate historical resources and conduct earthquake vulnerability assessments.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Develop a program to take maximum advantage of federal tax incentives to encourage retrofits of buildings identified as historical or contributing to historical districts.				
• Evaluate the earthquake vulnerability of all buildings and districts designated as historical under local, state and federal programs, recommend measures to enhance the post-earthquake reparability of these facilities and work with owners to implement these measures.				
i. Provide need-based loans for qualified retrofits.				
• Convene a group of representatives from relevant City departments and community stakeholders to review funding options for retrofits of private buildings, including loans, grants, opt-in assessment districts, and other possibilities, and to recommend best options.				
j. Advocate for federal and state incentives.				
• Encourage City officials to communicate with federal and state officials about the need for tax incentives to encourage seismic retrofitting and retrofit loan insurance.				
• Encourage City officials to communicate with state officials to communicate about state-level incentives for retrofitting, such as requiring homeowner and condominium associations to include in facility plans provisions for either repairing earthquake damage or for retrofitting vulnerabilities.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
Recommendation 10: Require gas shut-off valves on select buildings.				
• Create DBI and Fire Department team to identify neighborhoods highly vulnerable to post-earthquake fire spread due to building vulnerability and density, geological conditions and building combustibility, and presence of potential ignition sources. These areas will be called Post-Earthquake High Fire Hazard Areas.				
• Develop guidlines for the use of automatic gas shutoff valves, indicating types of valves for various building types and gas line configurations, in coordination with Pacific Gas and Electric (PG&E).				
• Develop an ordinance requiring buildings to install automatic gas shutoff valves prior to seismic retrofit if they are found by evaluation to be vulnerable (Recommendation 4), or if they are located in a Post-Earthquake High Fire Hazard Area.				
○ Draft policy				
○ Review				
○ Approve				
Recommendation 11: Track evaluations and retrofits in a database system.				
• Define database needs for earthquake mitigation programs, including data fields, and required search and analysis capabilities.				
• Work with team developing new database system to ensure mitigation database needs are incorporated.				
Recommendation 12: Provide technical assistance for building retrofits.				
a. Develop standard plan sets for retrofits of typical San Francisco buildings.				
b. Provide training for engineers and other licensed professionals in conducting building seismic evaluations.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Develop and conduct training sessions explaining how to conduct earthquake vulnerability evaluations, after evaluation protocols are developed (Recommendation 3). Explain evaluation requirements (Recommendation 4).				
c. Provide information on retrofit costs and effective technical approaches based on experience as the program progresses.				
• Develop a program to track retrofit lessons, including costs and effective techniques.				
• Develop a method to share these lessons with building owners.				
d. Provide training for design professionals and contractors in conducting seismic retrofits.				
• Develop programs, in coordination with outside groups, to train engineers to use newly adopted code standards for retrofits (Recommendation 3).				
e. Develop additional standards, as needed, to reduce non-structural hazards and improve post-earthquake building usability, including bracing of mechanical and other heavy equipment and shelves, and elevator functionality.				
• Develop code standards to reduce falling hazards and improve post-earthquake building functionality.				
○ Draft				
○ Review				
○ Approve				
f. Conduct inventories of structural types and building uses of concern.				
• Identify concrete tilt-up buildings.				
• Identify three and four unit residential buildings.				
• Identify K-12 private schools and private universities.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Identify assisted living facilities.				
• Identify and screen buildings designated historic or contributing to historic districts.				
• Identify critical stores and suppliers.				
• Identify concrete residential buildings built before 1980.				
• Identify providers of important services to vulnerable residents.				
• Identify preschools and day care centers.				
• Identify clinics and facilities providing urgent and critical medical services.				
Recommendation 13: Enact a façade ordinance				
• Draft				
• Review				
• Approve				
Recommendation 14: Promote development and implementation of effective ideas on earthquake risk reduction.				
a. Plan data collection programs to follow the next damaging earthquake, focused on learning about issues of policy importance to San Francisco.				
• Work with universities and professional organizations to identify the most useful data to collect after future earthquakes and how it could be collected most efficiently and with the largest public benefit.				
b. Support efforts to test and research innovative and low-cost retrofit concepts, such as bracing garage doors and adding ductility and energy absorption to brittle or weak building elements.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Invite speakers on innovative retrofit concepts to share their work with San Francisco audiences.				
• Work to support innovations relevant to San Francisco by providing advice and sharing data, as appropriate.				
c. Support innovation needed to modernize and improve evaluation and retrofit standards.				
• Communicate with professional organizations and others working to improve technical standards to make sure their work is practical for application in San Francisco.				
d. Reexamine the expected performance of previously retrofitted buildings.				
• Work with professional organizations to identify the expected performance of older retrofits.				
e. Study the hazard from masonry chimneys in San Francisco, and recommend necessary mitigation measures.				
• Review and adapt existing standards used in other communities for retrofit and repair of masonry chimneys.				
• Consider building code changes relating to masonry chimneys.				
f. Support installation of instruments to measure building movement in earthquakes.				
• Work with researchers to identify building types in San Francisco where seismic instruments would produce the most useful information.				
• Work with researchers and state and federal government institutions to get seismic instruments installed in a range of San Francisco building types.				
g. Study the feasibility of administrative measures to mitigate against ground failures that affect multiple properties and cannot be completed by a single building owner.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
• Convene a study group to examine administrative approaches to remediating liquefaction and lateral spreading risks, including reviewing what other communities are doing worldwide.				
h. Periodically review soil remediation technology and provide guidance to owners in potential liquefaction and lateral spreading zones when techniques become feasible.				
• Convene a study group to examine this issue and report to City officials.				
Recommendation 15: Evaluate measures to reduce post-earthquake fires.				
a. Improve water supply systems to cover those neighborhoods not served by the Auxiliary Water Supply System.				
• Develop a multi-departmental task force to review the need for expanding post-earthquake water for fire fighting and to evaluate options to do so.				
• Pursue the recommended strategy of the task force.				
b. Expand the training and scope of Neighborhood Emergency Response Teams (NERT) to include fire suppression, fire reporting, assisting vulnerable residents, and assisting with neighborhood recovery.				
• Encourage the Fire Department to work with NERT volunteers to examine whether those volunteers could do additional activities, including learning ways other communities are using NERT teams.				
c. Increase accessibility of water shutoff valves on building fire sprinkler systems to control building damage and water loss from damaged sprinkler systems.				
• Review the effectiveness of this strategy. If found to be effective, draft change in sprinkler system requirements.				

Action Required	Responsible Entities	Begin Date	End Date	Resources Required
d. Study potential post-earthquake ignition risks and evaluate measures to reduce them.				
• Convene a group to study ignition sources and possible ways to manage them.				
Recommendation 16: Address the hazards from damage to building systems, appliances, equipment and non-structural building elements.				
• Evaluate whether deadlines for mandatory remediation of non-structural safety and occupancy risks should precede deadlines for mandatory retrofits, which include such measures.				
• Consider ways to improve enforcement of water heater installation standards.				
Recommendation 17: Periodically assess progress and implementation of these recommendations.				
• Review the progress and accomplishments of the Existing Building Hazard Mitigation Program, new information regarding earthquake hazard and building vulnerability, and recommend how to improve San Francisco's earthquake resilience.				

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APPLIED TECHNOLOGY COUNCIL: AN OVERVIEW

The Applied Technology Council (ATC) is a nonprofit corporation founded to protect life and property through the advancement of science and engineering technology. With a focus on seismic engineering, and a growing involvement in wind and coastal engineering, ATC's mission is to develop state-of-the-art, user-friendly resources and engineering applications to mitigate the effects of natural and other hazards on the built environment.

ATC fulfills a unique role in funded information transfer by developing nonproprietary consensus opinions on structural engineering issues. ATC also identifies and encourages needed research and disseminates its technological developments through guidelines and manuals, seminars, workshops, forums, and electronic media, including its web site (www.ATCouncil.org) and other emerging technologies.

Key Publications

Since its inception in the early 1970s, the Applied Technology Council has developed numerous, highly respected, award-winning, technical reports that have dramatically influenced structural engineering practice. Of the more than 100 major publications offered by ATC and its Joint Venture partners, the following have had exceptional influence on earthquake engineering practice:

ATC-3-06, *Tentative Provisions for the Development of Seismic Regulations for Buildings*, funded by the National Science Foundation (NSF) and the National Bureau of Standards and completed in 1978, provides the technical basis for seismic provisions in the current *International Building Code* and other model U. S. seismic codes.

ATC-14, *Evaluating the Seismic Resistance of Existing Buildings*, funded by NSF and completed in 1987, provides the technical basis for the current American Society of Civil Engineers (ASCE) Standard 31, *Seismic Evaluation of Existing Buildings* (the national standard for seismic evaluation of buildings).

ATC-20, *Procedures for Postearthquake Safety Evaluation of Buildings*, funded by the California Office of Emergency Services and the California Office of Statewide Health Planning and Development, is the *de facto* national standard for determining if buildings can be safely occupied after damaging earthquakes. The document has been used to evaluate tens of thousands of buildings since its introduction two weeks before the 1989 Loma Prieta earthquake in Northern California.

ATC-40, *Seismic Evaluation and Retrofit of Concrete Buildings,* funded by the California Seismic Safety Commission and completed in 1996, won the Western States Seismic Policy Council' s "Overall Excellence and New Technology Award" in 1997.

FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Existing Buildings,* funded by the Federal Emergency Management Agency (FEMA) and completed in 1997 under the ATC-33 Project, provides the technical basis for the current American Society of Civil Engineers (ASCE) Standard 41, *Seismic Rehabilitation of Existing Buildings* (the national standard for seismic rehabilitation of buildings).

FEMA 306, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual*, **FEMA 307,** *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources*, and **FEMA 308**, *The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings*, funded by FEMA and completed in 1998 under the ATC-43 Project, provide nationally applicable consensus guidelines for the evaluation and repair of concrete and masonry wall buildings damaged by earthquakes.

FEMA 352, *Recommended Post-earthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings,* funded by FEMA and developed by the SAC Joint Venture, a partnership of the Structural Engineers Association of California, the Applied Technology Council, and California Universities for Research in Earthquake Engineering, provides nationally applicable consensus guidelines for the evaluation and repair of welded steel moment frame buildings damaged by earthquakes.

FEMA P646, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis*, funded by FEMA and completed in 2008 under the ATC-64 Project, provides state-of-the-art guidance for designing, locating and sizing structures to resist the effects of tsunamis and thereby provide safe evacuation refuge in affected coastal areas.

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With offices in California, Delaware, and Virginia, ATC's corporate personnel include an executive director, senior-level project managers and administrators, and technical and administrative support staff. The organization is guided by a distinguished Board of Directors comprised of representatives appointed by the American Society of Civil Engineers, the National Council of Structural Engineers Associations, the Structural Engineers Association of California, the Structural Engineers Association of New York, the Western Council of Structural Engineers Associations, and four at-large representatives.

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