Joint Legislative Committee on Emergency Management
Assembly Committee on Emergency Management
Senate Committee on Governmental Organization

Joint Informational Hearing

Seismic Resilience in California's Building Stock and Multi-Hazard Mitigation

Tuesday, May 14, 2024
1021 O Street, Room 1100
1:30pm

BACKGROUND

Summary:
This background paper describes some of the planning, preparedness, resilience, and mitigation strategies present at all levels of California government, if and when the next significant seismic event, along with potential secondary hazards, occurs, resulting in critical disruptions to essential services such as power, water, and housing. It describes the risk landscape, provides an overview of building standards and retrofits with an emphasis on post-seismic functional recovery, addresses the potential for mitigation projects to make communities resilient to multiple hazards, and discusses state and regional mitigation initiatives aimed at shoring up seismic safety and multi-hazard system resiliency.

Policy Considerations for the Legislature

- What is California's strategy for safeguarding existing buildings? How can the state create programs to retrofit and protect critical facilities that don't yet have mandates, such as first responder facilities, non-acute care facilities, grocery supply chains, etc.? How can policymakers protect and fund the existing retrofit programs in a harsh fiscal climate?

- How quickly should California be able to bounce back from a major catastrophe? How can policymakers advance the functional recovery standards of the state's critical infrastructure, lifelines, and buildings to speed re-occupation and resumption of services?

- How is California encouraging local communities to adopt hazard-resilient building codes and to engage in recovery-based planning and mitigation?

- What is California's building codes strategy? How can California be a leader in adopting the newest International Building Code and Building Seismic Safety Council's Provisions Update from the National Earthquake Hazards Reduction Program (NEHRP)?

- What guidance is California providing to local jurisdictions, businesses and infrastructure owners regarding statewide priorities for lifeline sustainment and support?

- What is California's mitigation investment strategy? How does the state measure the success of mitigation investments?

- How can we reimagine our hazard mitigation strategy to protect Californians from multiple and intersecting hazards?

Part 1: Earthquake Engineering, Building Codes, and Retrofits

According to seismologists and other experts, it is not seismic shaking but the collapse or failure of structures that kill the most people in an earthquake. Emergency managers and engineers have long emphasized that the nature of the built environment often determines the severity of a disaster no matter whether the inciting event is an earthquake, hurricane, flood, or fire. How buildings withstand seismic shaking, high winds, floodwaters, or falling embers may determine the number of casualties, how long the power is out, and how many millions or billions of dollars are needed to rebuild. The potential for hazards to become dangerous, disruptive, or costly often depends on where and how communities build.

In the Bay Area, there is a 72% chance of a 6.7 magnitude earthquake, a 51% chance of a 7.0 magnitude earthquake and a 20% chance of a 7.5 magnitude earthquake before the year 2043, according to the U.S. Geological Survey (USGS). The East Bay's Hayward Fault, which is believed capable of generating up to a magnitude 7.0 earthquake, has not produced a big quake since 1868 and is "due" for one, geologists say. The San Andreas Fault produced the estimated 7.9 magnitude earthquake of 1906 and could give San Francisco another huge shake again. In Southern California, there is a 93% chance of a 6.7 magnitude or larger earthquake somewhere in the region before 2043 and a 17% chance of a 7.7 magnitude or larger occuring on the Southern San Andreas Fault before 2043.

According to the Federal Emergency Management Agency (FEMA) and the California Office of Emergency Services (Cal OES), a 7.8 magnitude earthquake on the Southern San Andreas Fault could result in thousands of fatalities, injuries, hundreds to thousands of people trapped alive in collapsed structures, over 1 million buildings damaged and over 250,000 displaced households. Similarly, a catastrophic earthquake in the San Francisco Bay Area is expected to result in thousands of fatalities, injuries, as many as 10,000 commercial buildings with major structural damage and 152,000 households, or 411,000 people (the majority of the local workforce), could be temporarily or permanently displaced from their homes. These regions' supply chains, which serve some of the nation's most densely populated areas, will be degraded due to road, rail, air, and marine transportation system impacts. A severe earthquake will also affect water, power, and gas utilities and disrupt telecommunications and digital information transmission services - all of which will limit normal business operations.

Additionally, nearly one-third of the U.S. housing stock is considered to be at high risk of a natural disaster. Given that Americans are estimated to spend approximately 90% of their time indoors, individuals are most likely to experience a hazard inside of a building. Sarah Atkinson, the Hazard Resilience Policy Manager for the San Francisco Bay Area Planning and Urban Research Association (SPUR), wrote of the Bay Area in a recent article: "The Bay Area is already facing a housing crisis: Housing is unaffordable for low- and middle-income residents, housing development is not keeping up with demand, and in 2022 more than 30,000 people were unhoused. If a major earthquake were to hit, the region could face significant casualties and lose thousands of housing units. The lives of residents will be enormously disrupted, and it could take months to rebuild damaged housing and re-establish essential services."

In fact, it is estimated that San Francisco has 3,900 non-ductile, meaning brittle and inflexible, concrete buildings that have the same vulnerability as many of the structures in Turkey and Syria that collapsed during the recent 7.8 magnitude earthquake. Many of these are commercial. But, according to Brian Strong, the Chief Resilience Officer for San Francisco, much of the city's affordable housing stock is also made of concrete — and some of it is potentially non-ductile. In addition, some single-room occupancy units in the Tenderloin area and in Chinatown, as well as some homeless shelters, might be in the same situation.

The impacts of natural hazards are expected to increase during the useful lifetime of much existing and new U.S. property and infrastructure, placing an increasing burden on state and local governments, as well as individuals and businesses. For these reasons, FEMA, Cal OES, and the California Earthquake Authority (CEA) have long stressed the importance of hazard-resistant building codes and land use policy as a means to mitigate disaster losses.

Building Resilience: FEMA's Building Codes Policies

The built environment plays a critical role in determining the severity of a natural hazard's impact on a community. How many lives are lost, how long a recovery takes, and how many dollars would be needed if rebuilding often depends upon the structural integrity of the buildings struck by the tornado, hurricane, fire, earthquake, flood, or other natural disaster. For this reason, experts and agencies promoting hazard resiliency often focus on the development, adoption, and enforcement of hazard-resilient building codes and design standards.

In recent years, Congress has increasingly acknowledged how buildings and building codes may determine the expense and severity of a disaster and has authorized FEMA to utilize a range of policy tools that may promote a resilient built environment and enforcement of hazard-resistant building codes despite the limitations on federal authorities.

Under both long-standing and recently enacted statutory authorities, FEMA may provide funding to states and localities to adopt and enforce hazard-resilient building codes, require that federally funded reconstruction efforts adhere to recent hazard-resistant building codes, and restrict federal funding to rebuild in certain hazard-prone areas. FEMA has, in turn, recently taken a range of actions to promote the adoption and enforcement of hazard-resistant building codes across the country, and monitored the weakening or absence of building codes at the state and local level.

FEMA's authorities with respect to building codes have generated a number of policy discussions. Issues include how to develop hazard-resistant building codes in an age of climate change, and how to ensure that code requirements align with FEMA's goals to promote equitable disaster recovery and ensure the fair treatment of survivors.

Value of Building Codes

The role of inadequate building codes is a significant contributor to natural disaster losses. For example, although South Florida had one of the strongest building codes in the nation in 1992, a quarter of the $16 billion in insured losses from Hurricane Andrew were attributed to Dade County's failure to enforce its building code. Experts have also pointed out how hazard-resistant building codes reduce earthquake damage. In 2010, both Chile and Haiti were hit by major earthquakes. The magnitude 7 earthquake in Haiti killed an estimated 220,000 people, injured 300,000, and left 1.5 million homeless. The much stronger magnitude 8.8 earthquake in Chile killed less than 800 people, most due to the resulting tsunami, and caused relatively little structural damage. Some of the difference in outcomes might be attributable to variations in seismic and site characteristics, while much of the difference in casualties and structural damage has been attributed to the adoption and enforcement of strong building codes in Chile, in contrast to the virtually nonexistent and poorly enforced building codes in Haiti.

The National Institute of Building Sciences also emphasized the importance of building codes in a widely cited study which found that adopting the most recent building code could save $11 for every dollar invested in hazard-resistant codes and standards, and above-code design could save $4 for each dollar invested. The study also found that adopting the 2015 International Code Council building codes added about 1% in costs relative to 1990 standards.[1]

[1] National Institute of Building Sciences, Natural Hazard Mitigation Saves: 2019 Report, Washington, DC, 2019, pp. 37-39, https://www.nibs.org/files/pdfs/NIBS_MMC_MitigationSaves_2019.pdf.

Role of the International Code Council and Code-Development Organizations

In 1994, the three groups publishing model codes merged to form the International Code Council (ICC), which published the first International Building Code (IBC) in 1995. The ICC continues to develop and publish model codes and guides to building practices that are now adopted, adapted, and enforced at the state, territorial and local level. The ICC's "family" of I-Codes includes codes for different types of dwellings (e.g., residential, new, existing structures), and was most recently updated in 2021. The 2030 IBC update is expected to codify the new seismic standards that are due to be released next year by the National Earthquake Hazards Reduction Program (NEHRP) and the American Society of Civil Engineers (ASCE). The Earthquake Engineers Research Institute (EERI), a consortium of practitioners, researchers, and advocates iterates a number of policy recommendations for action California can take on building codes, which have been appended at the end of this document.

Federal Role

In the last decades of the twentieth century, the federal government, including FEMA, helped to develop and promote hazard-resistant building codes promulgated by the ICC and other code developing organizations like the ASCE. The federal government continues to collaborate with the ICC and similar organizations to help develop, revise, and promote hazard-resistant model

building codes. The ICC updates I-Codes on a three-year cycle and includes hearings and opportunities for public comment.

State and Local Roles

Most states and local jurisdictions adopt model codes that are created on a national or international level by standards-developing organizations like the ICC, and amend them where needed prior to adoption into state laws and local ordinances. Building codes are administered at a community level; the federal government cannot mandate the level of code enforcement in states or communities. Some states have adopted statewide building codes that apply to virtually every type of structure while others employ lesser degrees of regulation and code applicability. Statewide codes sometimes allow certain individual jurisdictions (e.g., cities or a particular class of counties) to deviate from the standard, weakening the model minimum code in response to objections based on the cost of compliance.

Building Codes Adoption and Enforcement Shortfalls

Nearly two-thirds of Americans live in communities that have not adopted the latest model building codes, and many jurisdictions do not consistently adopt and enforce them, leading to significant threats to public health and individual safety - particularly in the face of a hazard. According to FEMA, just 35% of localities across the country have adopted "modern building codes without weakening the natural hazard-resistant provisions."

Most inhabitants are unaware that they may live in substandard, vulnerable structures, which increases the risk of damage and casualty. Further, FEMA has found that a majority of areas with natural hazard risk in the United States have not adopted current versions of hazard-resistant building codes. In many regions, low-income or otherwise socially vulnerable households are more likely to live in areas of higher risk to natural hazards.

In addition, the U.S. Surgeon General has found that socially vulnerable populations, including individuals with low-incomes, identifying as racial or ethnic minorities, and those with disabilities, are more likely to live in substandard housing. Citing these risks, FEMA advocates for the adoption, strengthening, and enforcement of local building codes. Many jurisdictions particularly struggle to adopt and adequately enforce codes in the wake of a disaster. Local officials may face a large number of damaged structures and a high volume of permit applications, and there may be pressure on local officials to waive requirements that are perceived to hamper rapid reconstruction or "getting back to normal." The sudden, widespread increase in building activity, loss or displacement of workers, and other factors may lead to personnel shortfalls. For these reasons, some jurisdictions have established mutual aid agreements to allow building departments to augment staff in times of need. FEMA encourages and tracks such agreements.

Hazard-Resilient Buildings: Sustaining Occupancy and Function after a Natural Disaster

Natural disasters contributed to more than $2.2 trillion in total losses in the United States between 1980 and 2021. Policymakers are interested in reducing the losses due to buildings damaged or destroyed in disasters. One way to accomplish this and help communities recover more rapidly without disruptions or additional losses is to construct new buildings (or retrofit

existing buildings) that are hazard-resilient, meaning capable of being occupied and remaining functional during and/or immediately after a disaster.

Congress directed FEMA, the National Institute of Standards and Technology (NIST), and stakeholders to recommend ways to make buildings hazard-resilient, with the aim of reducing disaster losses and enhancing community resilience. Two reports, one submitted to Congress in 2018 and one in 2021, recommended that the federal government and stakeholders enhance hazard-resilient designs in model building codes and facilitate adoption and enforcement of these codes at the community level.

The recommendations in these reports encouraged more research and development in four areas to move toward more hazard-resilient buildings: (1) building design, (2) community planning, (3) economic and social feasibility, and (4) adoption of building codes. In addition, the reports recommended that the federal government lead development of a national framework to increase hazard-resilient building stock nationwide.

The primary way to affect building performance objectives is through building codes, which are adopted and enforced by state, local, tribal, and territorial governments). Currently, most **building codes require a habitable structure that protects people from injury or death and do not require occupancy or functionality soon after a disaster**.

2021 Congressional Recommended Options Report

In the 2018 reauthorization of the NEHRP; P.L. 115-307, 42 U.S.C. §7705b), Congress requested that NIST and FEMA jointly convene a panel of experts to assess and recommend options for improving the built environment and critical infrastructure to allow occupancy and function immediately after an earthquake. The agencies submitted to Congress a report entitled Recommended Options for Improving the Built Environment for Post-Earthquake Reoccupancy and Functional Recovery Time in 2021.

The seven recommendations in the report are as follows:

1. Develop a framework for post-earthquake re-occupancy and functional recovery objectives;
2. Design new buildings to meet recovery-based objectives;
3. Retrofit existing buildings to meet recovery-based objectives;
4. Design, upgrade, and maintain lifeline infrastructure systems to meet recovery-based objectives;
5. Develop and implement pre-disaster recovery planning focused on recovery-based objectives;
6. Provide education and outreach to enhance awareness and understanding of earthquake risk and recovery-based objectives; and
7. Facilitate access to financial resources needed to achieve recovery-based objectives.

Current vs. Future Standards

Historically, the focus of engineering and building codes has been to safeguard the lives of building occupants in an earthquake. This is referred to as a ‘life safety’ standard, and most of

the current building code is aimed at saving lives and preventing injury. Today, however, there is both the technical ability and the societal need to limit downtime and repair costs. While the state is in the throes of a housing crisis, any displacement of residents that can be avoided will be a boon. Economic harms will be reduced if businesses are quickly able to resume operations, and critical lifelines like transportation, communications, water, power, and access to safe nutrition can recover quickly from interruption. Facilities, such as hospitals and fire stations, also have a need to be functional immediately following an earthquake, in order to provide critical and life-saving services to the impacted population. Building techniques which allow a structure to retain or quickly regain usability and occupancy are referred to as 'functional recovery' standards.

Terminology: Re-occupancy and Functional Recovery

Hazard-resilient buildings are intended to maintain occupancy and functionality with minimal repairs during and after a natural disaster. The IO report stated that an immediate occupancy performance objective may enable buildings to remain functional or to experience interim loss of function for a limited time, while repairs may take place during occupancy and basic functioning. The FRT report defined **re-occupancy** as a post-earthquake performance state in which a building is maintained or restored to allow safe reentry for the purposes of providing shelter or protecting building contents. The time frame for re-occupancy may vary, and an acceptable time frame may depend on the building's occupancy levels and functions.

Functional recovery is a post-earthquake performance state in which the building is maintained or restored to safely and adequately support its basic intended functions. The functional recovery time is the amount of time it may take a building to recover certain basic functions after a disaster. The time may be specified in hours, days, weeks, or months, based on the hazard's intensity, the building's functions, occupancy levels, and other factors.

Small Premium for Big Payout

While functional recovery is not yet codified in state law, there are several building projects in California which have targeted better seismic performance that can be used as a proxy to begin considering the fiscal impacts of building to a higher standard. One study, put together by David Bonowitz, a structural engineer in San Francisco, found a 0-3% cost premium was incurred when new build projects increased their seismic design goals (see chart below). This is because many of the techniques used are not inherently more expensive to implement, they are simply a different set of choices builders can make in terms of materials and techniques. This preliminary look at performance-based design suggests that **adopting functional resilience building codes for new construction in California does not have to signify the state incurring significantly higher construction costs in an already expensive market.**

CASE STUDY PROJECTS

Building (Engr)	Use	FR objective / expectation	Features / criteria	Cost premium
181 Fremont (Arup)	Office high-rise	Within weeks of DE, immediate RO	RC core, first REDi	1 – 2%
Beaverton schools (SEFT)	Public school	RC IV performance, service as post-EQ shelter	RC IV (shelter), emergency generator	1 – 1.7% (relative to RC III)
UCSF Mission Hall (R&C)	University offices	Operational after 84th %ile Hayward	Enhanced criteria, concrete shear walls	0% by RFP
Casa Adelante (Mar)	Senior housing	1 day after 475-yr EQ, no tenant relocation	Rocking wall, dampers	0.24%
85 Bluxome (ZFA)	Private sector office	"Days to weeks" after "major EQ"	Zero lot lines, SidePlate MRF	Steel cost offset by add'l lease space
UCSF CVN (FE)	University research	60 days after M7 San Andreas (limited by liquefaction, utilities)	I = 1.25, 1.5% drift in M7	0.4% (80% offset by PT slab saving)
Oregon Treasury (KPFF)	Government offices	0 days after MCE_R (impeding factors unclear)	Base isolation, tailored nonstructural	None. High perf intended.
Stanford Biomed (R&C)	University research	26 days after 475-yr EQ	~RC III, element-specific R, I_p = 1.5	None. High perf intended.
Allenby Building (KPFF)	Government offices	0 days after 475-yr EQ	Low drift limits, amplified demand, post-EQ plan	None. High perf intended.

DAVID BONOWITZ, S.E.

Climate Change and Earthquake Vulnerability

At the recent USGS Northern California Earthquake Hazards Workshop, one session focused on the intersection of climate change and seismic vulnerability: https://earthquake.usgs.gov/contactus/menlo/seminars/1490. Speakers discussed how the secondary hazards of earthquakes are landscape processes that are also affected by climate change. For example:

1) **Liquefaction:** Liquefaction frequently occurs in low-lying areas near the coast, which will become wetter and more easily inundated by sea level rise. Increasing the water content of the ground will make it more susceptible to liquefaction when shaken.

2) **Landslides:** California weather is increasingly likely to behave in extremes as the climate changes. This leads to dry, hotter years that make wildfires more likely. Wildfires can strip hillslopes of the plants that help retain the soil. The other extreme are years that are much wetter than normal, which can destabilize sloped terrain. Both denuded and wet hillslopes are more prone to landslides when shaken.

3) **Fires following earthquakes:** Climate change can also increase the occurrence of strong prevailing winds like the Santa Ana's, which will increase the spread of fires ignited by earthquake damage. In drought years, dry conditions will also promote fire spread.

Climate change can also complicate seismic resilience by:

1) **Creating a high incidence of extreme temperatures** that make it harder to safely provide emergency shelter and meet needs when lifelines are already stressed or operating at a lower capacity due to earthquake damage; and

2) **Reducing the financial resilience of individuals and communities** through floods, storms, wind events, heat events, and fires that incur expensive damage and demand the use of the limited shared pot of disaster response funds.

As such, seismic resilience necessarily includes climate resilience. Conversely, seismic resilience can and should be integrated into projects, increasing the resilience of critical infrastructure and the built environment across the multiple hazards that threaten integrity. The California Department of Transportation (CalTrans) project to re-make State Route (SR) 37, a critical corridor in the North Bay Area region, is an example of multi-hazard mitigation. The roadbed will be raised to avoid sea level rise, and the surrounding wetlands will be restored to improve ecological function. The roadway will also be constructed to reduce congestion and be built to a high seismic safety standard in order to preserve the access SR 37 provides whenever a nearby fault awakens.

Similarly, the work utilities have done to underground power lines and microgrid their systems to be more resilient against wildfires also reduce risks in earthquake scenarios by preventing broken power lines from causing fires and making the provider more nimble with outages. Upgrades to municipal water pipes by the East Bay Municipal Utility District (EBMUD) protects human health by reducing exposure to old, unsafe pipe materials, preserves the water supply by minimizing underground leaks by removing corroded pipes, and makes the water supply more seismically resilient by replacing old, brittle pipe with flexible conduits that can withstand seismic motion.

The State Retrofit Program

More than 28 million Californians still live in areas of high seismic risk. While the State has some of the most modern and earthquake-resistant buildings in the world, it also contains thousands of buildings that are known to present a heightened earthquake risk of death, injury, and damage based on their age, structural system, size, and location.

In residential homes, there are a few common retrofit needs to reduce collapse risks incurred by older building methods. These include bracing and bolting raised foundations, securing houses better to their foundations and securing partitioned foundations to each other, and strengthening garages which support living space above them.

Other common seismic vulnerabilities to buildings at large include construction techniques that leave the vertical supports of structures vulnerable to collapse when shaken by seismic waves, such as in unreinforced masonry and non-ductile concrete.

Brace and Bolt

Many California homes built before 1980 feature raised foundations, wherein the main floor of the house is elevated a half story above the ground. Raised foundation houses are often 'craftsman style,' marked by having a handful of steps leading up to the front door and a crawl space beneath the house surrounded by a 'cripple wall.' While the building techniques used in this style are sufficient for supporting the weight of the house, raised foundations do not have good lateral strength and tend to collapse when shaken side-to-side, e.g. by an earthquake. Some houses are so insecurely connected to their foundations that they can slide right off. A simple fix is to "brace and bolt," essentially, screwing sheets of plywood between the supports to provide lateral support, and securing the house to the foundation so that both move together when shaken.

There are two programs that can help fund a homeowner's Brace + Bolt retrofit. CEA policyholders may be eligible for funding through the CEA Brace + Bolt (CEA BB) program. Everyone else, including CEA policyholders who do not meet the eligibility requirements for CEA BB, may be eligible for funding through the Earthquake Brace + Bolt (EBB) program that is run by the California Residential Mitigation Program (CRMP). EBB is open to California homeowners in select ZIP Codes. ZIP Codes chosen for program participation are ordered by the following two criteria:

1) Earthquake Hazard: Hazard was identified using the USGS earthquake hazard map for California.

2) Earthquake Vulnerability: Vulnerability was determined by identifying the percentage of pre-1940 houses in ZIP Codes in California (US Census Data). Older houses are more likely to require earthquake bracing and bolting.

Over time, and with additional funding, CRMP hopes to make all high hazard areas in California eligible for EBB grant funding.

Income-eligible homeowners may also qualify for a Supplemental Grant if their household income is $87,360 or less. When combined, these grants may be able to pay for up to 100 percent of a homeowner's retrofit, if they qualify. Grants are contingent upon meeting eligibility requirements and available funds.

Upon completion of a Brace and Bolt retrofit, earthquake insurance policyholders may also be eligible for a 25% discount on their policy premium.

Soft Story: Living Space Over Garages

Retrofits of single-family houses that have a living space over a garage, or "soft story," are needed because without reinforcement of the garage area, they are especially susceptible to collapse during an earthquake. A soft-story seismic retrofit strengthens the garage door and ground floor walls of the house so it can better withstand earthquake shaking.

Earthquake soft-story retrofits are performed in accordance with FEMA P-1100. The CCRMP offers an Earthquake Soft-Story (ESS) grant program to help fund a homeowner's seismic

retrofit. CRMP created ESS to provide California homeowners with grants of up to $13,000 to seismically retrofit their soft-story house to better withstand earthquakes.

A homeowner may be eligible to apply for an ESS grant if (among other criteria):

- They own and live in the house they would like to retrofit;
- The house is located in one of the ESS program areas, which are designated by ZIP Code
- The house was built before 2000;
- The house has a living space over the garage;
- The house is no more than two stories;
- The house is built on level ground or a slight slope;
- The house is wood-framed construction; and
- The homeowner has not already completed a soft-story retrofit.

Fortunately, in San Francisco at least, ninety percent of the soft-story buildings known to be vulnerable have been retrofitted, according to Brian Strong, the SF Resilience Officer.

Soft Story Multifamily Housing in California

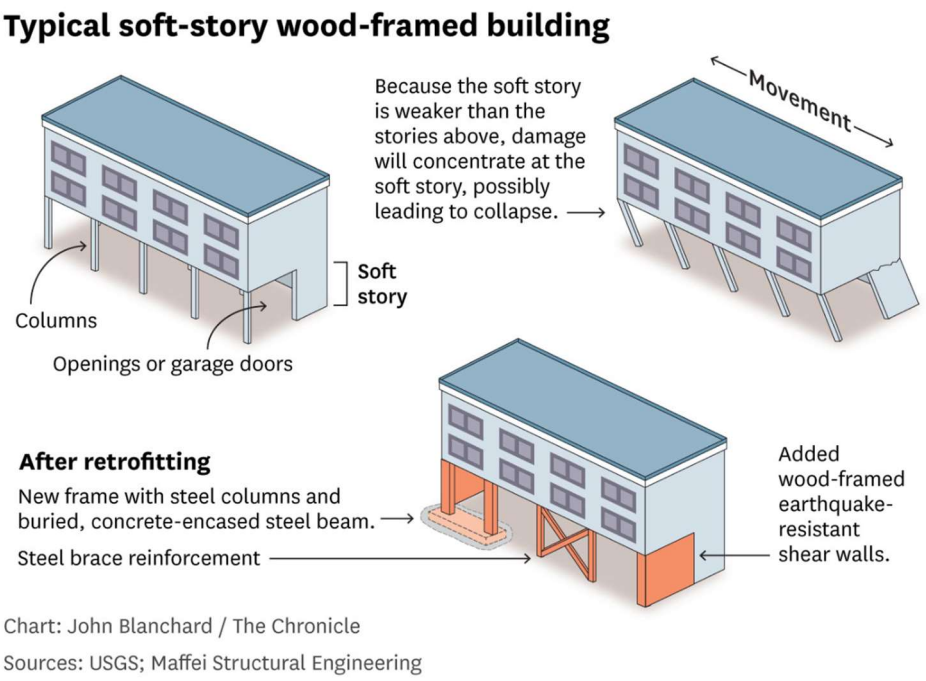
The Structural Engineers Association of California and California Seismic Safety Commission estimate there are as many as 100,000 soft-story apartment buildings, often located in small, disadvantaged communities that do not have the resources to correct these conditions. According to the U.S. Resiliency Council, as many as 2.5 million Californians may live in older, soft-story, multi-family housing at risk of collapse in earthquakes due to weak construction.

Recognizing this vulnerability, the California Legislature has consistently been supportive of establishing a multi-family soft story retrofit program to provide incentives to owners of vulnerable buildings. On May 26, 2022, the Assembly voted 75-0 (with three members not voting) in favor of AB 1721 (Rodriguez), which would have established a $250 million seismic retrofit program to be administered by the CEA.

Although this program, as envisioned in AB 1721, was included in the Budget Act of 2022-2023, only $15 million was appropriated. Unfortunately, due to the ongoing structural budget deficit, the previously approved $15 million for this program has been proposed for elimination as part of an overall effort to achieve budget solutions.

Last year, following the devastating earthquakes in Turkey and Syria, the Assembly Committee on Emergency Management held a hearing to assess California's preparedness for major earthquakes. Witnesses urged the Legislature to be mindful of the lessons from those devastating seismic events.

According to Chair Rodriguez, "the hearing made it clear that we need to adopt a real sense of urgency when it comes to preparing our communities and infrastructure for a catastrophic earthquake in California. Don't be fooled by those who would dismiss Turkey as a developing country with substandard building codes, or those who claim that an earthquake of such magnitude could not occur in California, or those who would dismiss the possibility of collapsed buildings. It would be a deadly mistake to underestimate the potential consequences of a major earthquake."



Unreinforced Masonry

An article in the San Francisco Chronicle discussed vulnerable building types in San Francisco shortly after the magnitude 7.8 and 7.5 earthquakes in Turkey and Syria. These included unreinforced masonry and non-ductile concrete buildings. Unreinforced masonry buildings are those made of brick, stone and concrete reinforced with little to no steel rebar. While such buildings are quite capable of holding up loads when subjected to gravity, they are prone to crumbling when subjected to seismic shaking, which involves side-to-side motion.
After the passage of a law in 1981, Los Angeles began a campaign to address its unreinforced masonry problem. By 2015, nearly all of the 8,000 buildings identified as unreinforced masonry had been retrofitted or demolished. After the 6.9 magnitude 1989 Loma Prieta earthquake, San Francisco also passed an ordinance requiring all unreinforced masonry buildings to be retrofitted. As of 2014, 95% have been retrofitted or demolished, according to the Structural Engineers Association of Northern California.

Non-ductile Concrete

A thornier problem to tackle is non-ductile concrete. Non-ductile concrete buildings feature brittle concrete columns, beams, walls and other points of connection. They lack sufficient steel reinforcement, making them more susceptible to buckling from back-and-forth shaking, said Megan Stringer, president of the Structural Engineers Association of Northern California. "Imagine if you were to take a straw, and you put it between your fingers and you push on it," Stringer said. "Eventually that straw bends in the middle." In a multistory building, non-ductile concrete construction can lead to a phenomenon seen in the Turkey-Syria earthquake known as "pancaking," where one floor drops onto the next in succession.

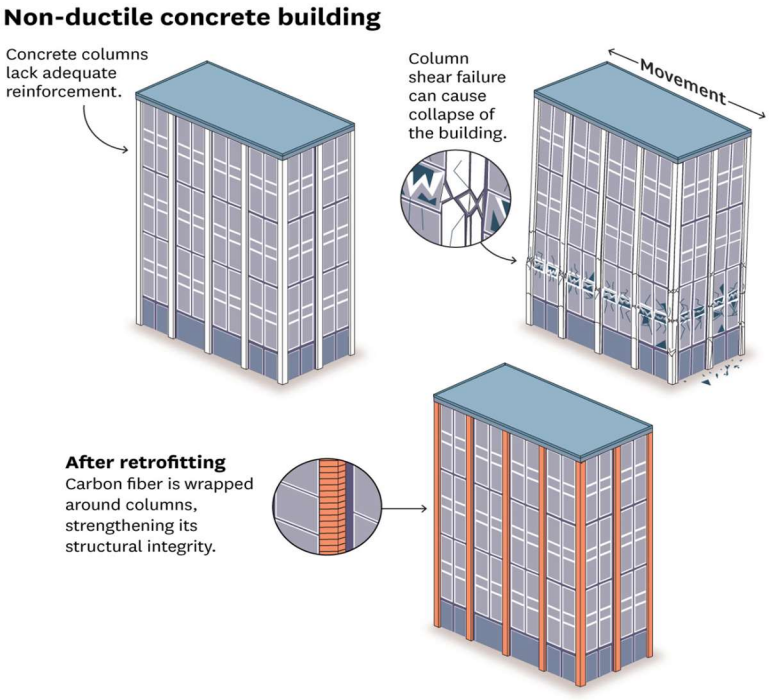
Some of the most vulnerable non-ductile concrete buildings in the Bay Area were built during the 1950s to 1980s, though "up until the year 2000, there were still aspects of concrete buildings

that were not sufficiently designed," said Joe Maffei, principal at Maffei Structural Engineering and a consultant to the city.

Non-ductile buildings are difficult to retrofit. For one, they are hard to identify. Whereas it is possible to look at a building and determine that it has a soft story, non-ductile concrete buildings require a structural engineer's assessment to verify, Maffei said. That is why San Francisco has only an estimate of the number, based on old insurance files and volunteers who walked around observing building types, and little confirmation about specific addresses that are affected.

Non-ductile concrete buildings also require more invasive, complicated retrofits than soft-story apartment buildings, Maffei said. Multiple floors might need to be retrofitted as opposed to the single floor for soft-stories, and more people living in non-ductile buildings might have to move elsewhere as the retrofits are completed — a process that could take months, added Atkinson of SPUR. Because concrete buildings vary so much in their design, costs also range from $40 per square foot to up to $200 per square foot, Maffei said.

"These buildings collapse all the time in earthquakes across the world, and it's very obvious to everyone that these are hazardous buildings," Atkinson said. "Yet not many cities have actually taken steps to move forward with retrofit mandates of these buildings." Certainly, in the Bay Area, no city has a mandate requiring that building owners do so. A few Southern California cities have ordinances requiring retrofits of non-ductile concrete structures, including Los Angeles, Santa Monica and West Hollywood.



Earthquake Insurance

Traditional insurance, including the insurance required to obtain a mortgage, does not cover damage from earthquakes (though some cover fires caused by earthquakes). Earthquake insurance is an optional policy that one buys separately. Earthquake policies can insure damage to dwellings, personal property, and temporary relocation expenses incurred when a residence becomes uninhabitable. In California, the CEA, a publicly-managed, mostly privately-funded entity, sells earthquake insurance through participating insurance companies. Two other companies with policy offerings in the state are GeoVera and Palomar.

According to the former CEO for the CEA, Glenn Pomeroy, just 13% of Californians have earthquake insurance. Partially, this is due to the cost barrier; for a $1 million dollar house with medium coverage in Berkeley, a homeowner would spend ~$4,500 a year *just* on earthquake insurance. Many simply hope they won't need it. Others think emergency response and relief programs will be sufficient. Unfortunately, this is a fallacy; Pomeroy stated. "A FEMA grant is limited to emergency repairs, and the maximum is about $33,000. So that's not going to rebuild anybody's home."

Part 2: Approaching Seismic Resilience from a Multi-hazard Perspective

California's mitigation investment strategy

Hazard mitigation is defined as any action taken to reduce or alleviate the loss of life, personal injury, and property damage that can result from a disaster. It involves long- and short-term actions implemented before, during and after disasters. Hazard mitigation activities include planning efforts, policy changes, programs, studies, improvement projects, and other steps to reduce the impacts of hazards. The federal Disaster Mitigation Act (DMA) of 2000 emphasizes planning for disasters before they occur. The DMA requires state and local governments to develop hazard mitigation plans as a condition for federal disaster grant assistance.

The responsibility for hazard mitigation lies with many, including private property owners, commercial interests, and local, state and federal governments. The DMA encourages cooperation among state and local authorities in pre-disaster planning. The planning network called for by the DMA helps local governments articulate accurate needs for mitigation, resulting in faster allocation of funding and more cost-effective risk-reduction projects. The DMA also promotes sustainability in hazard mitigation. To be sustainable, hazard mitigation needs to incorporate sound management of natural resources and address hazards and mitigation in the largest possible social and economic context.

California's primary hazard mitigation strategies are guided by the State Hazard Mitigation Plan (Plan). It provides an analysis of the State's historical and current hazards, specifies the State's hazard mitigation goals and objectives, and describes the State's hazard mitigation strategies and actions. The Plan reflects the State's commitment to a comprehensive overall mitigation strategy to reduce or eliminate potential risks and impacts of disasters, thereby promoting faster disaster post-recovery, reducing loss of life and property, and increasing resiliency. The Plan is updated on a five-year cycle and is essential for making California eligible to receive critical federal disaster relief and emergency assistance funds for disaster and hazard mitigation programs.

The hazard risk assessment within the Plan determines what hazards are of concern for the State and assesses the potential impacts of those hazards on California's people, property, and environment. The 2023 Risk Assessment was conducted using the best available data and science to incorporate future projections and equity considerations. It identifies hazards to which the State is susceptible; which areas and populations within the State are most vulnerable to these hazards; what these hazards can do to physical, social, environmental, and economic assets; and the subsequent cost of damage or cost that can be avoided through mitigation efforts.

The 2023 Plan profiles 34 hazards, divided into two categories as follows:

Natural Hazards of Interest:	**Other Hazards of Interest:**
1. Earthquake	1. Urban Structural Fire
2. Riverine, Stream, and Alluvial Flooding	2. Other Potential Causes of Long-Term Electrical Outage
3. Extreme Heat	3. Public Safety Power Shutoff (PSPS)
4. Extreme Cold or Freeze	4. Terrorism
5. Wildfire	5. Air Pollution
6. Severe Wind, Weather, and Storms	6. Energy Shortage
7. Sea-Level Rise, Coastal Flooding, and Erosion	7. Cyber Threats
8. Landslide, Debris Flow, and Other Mass Movements	8. Tree Mortality
9. Drought	9. Invasive and Nuisance Species
10. Tsunami and Seiche	10. Epidemic, Pandemic, and Vector-Borne Disease
11. Dam Failure	11. Civil Disorder
12. Levee Failure	12. Natural Gas Pipeline Hazards
13. Snow Avalanche	13. Hazardous Materials Release
14. Subsidence	14. Transportation Accidents Resulting in Explosions or Toxic Releases
15. Volcano	15. Well Stimulation and Hydraulic Fracturing
	16. Oil Spills

	17. Electromagnetic Pulse Attack
	18. Radiological Accidents
	19. Geomagnetic Storm (Space Weather)

The State Mitigation Planning Unit within Cal OES oversees the maintenance and implementation of the Plan. This includes tracking the progress of the action items detailed in the Plan, recording additional mitigation efforts taken by State partners, and analyzing how this mitigation work helps to achieve the goals stated in the Plan.

Mitigation Resources

Cal OES supports eligible California communities, state agencies and tribal nations in their efforts to mitigate the risk of natural hazards and their effects related to climate change through applying for funding in the FEMA Hazard Mitigation Assistance grant programs. Eligible entities submit applications for the Flood Mitigation Assistance (FMA) and Building Resilient Infrastructure and Communities (BRIC) programs every federal fiscal year they are available. BRIC and FMA are annual, nationally competitive grant programs that differ from the Hazard Mitigation Grant Program (HMGP), which is funded through a percentage of total cost for federally-declared disasters.

Cal OES provides special consideration for communities facing higher rates of social vulnerability and capacity restraints. FEMA included social vulnerability criteria into the 2023 FMA and BRIC programs, prioritizing communities that are considered disadvantaged using the federal Justice40 Initiative screening tools, the federal CDC social vulnerability index and new Community Disaster Resilience Zone designations. Cal OES indicates it received $1.3 billion in federal share for grants applications that aim to do the following:

- Mitigate current and future flood risk through nature-based solutions,
- Upgrade existing critical infrastructure, like drinking water systems, to withstand seismic and wildfire risks,
- Provide comprehensive analyses of flood risk for communities to evaluate alternatives and scope out the best option for future grant opportunities,
- Focus on building code development and compliance grants in the new “Building Code Plus-up” Allocation in BRIC, and,
- Help communities reduce the risk of sea level rise and flooding along the Pacific Coast.

According to the most recent information available from the 2022 Federal Fiscal Year, there were 29 applications for BRIC and FMA (amounting to a $663 million federal share) submitted to Cal OES.

Additionally, the Department of Water Resources notes that it continuously monitors federal programs for future funding opportunities and has been approved for funding from FEMA’s HMGP for the Lake Oroville State Recreation Area Fuels Reduction Project and the Castaic Dam Tower Debris Catchment and Lower Gate Seismic Infrastructure Retrofit Project.

FEMA's Safeguarding Tomorrow Revolving Loan Fund Program

FEMA's Safeguarding Tomorrow Revolving Loan Fund (RLF) complements the agency's Hazard Mitigation Assistance grant portfolio to support mitigation projects at the local government level and increase communities' resilience to natural hazards and climate change.

While FEMA's other Hazard Mitigation Assistance grant programs require states and federally recognized tribes to act as pass-through entities that route applicant requests to FEMA for review, the Safeguarding Tomorrow RLF empowers entities to make funding decisions and award loans directly. The revolving loan funds will help local governments reduce disaster risks for homeowners, businesses, nonprofit organizations and communities while fostering greater climate resilience.

For Fiscal Year 2024, FEMA has $150 million available for this program, with a minimum award of $5.1 million per recipient. Eligible activities include constructing or modifying natural or built infrastructure to improve resilience, reduce risk and increase pre-disaster mitigation. The application period closed on April 30, 2024.

Seismic-Related Multi-hazard Mitigation Projects: Examples

Southern California Edison (SCE) Retrofitting Project

Utilities perform seismic mitigation work to reduce severe damage or loss of electricity that could occur in the event of a significant earthquake. As part of its Seismic Resiliency Program, SCE recently completed retrofitting 50 of its largest bulk power transmission substations, including those closest to the San Andreas Fault. They are known as the "backbone" of SCE's electric grid and help provide electricity to about 15 million customers.

Project improvements included enhancing the anchoring of large transformers, replacing older equipment components with seismically tested ones, increasing the slack of conductors between equipment components and replacing porcelain bushings.

Due to the project's scale and complexity, SCE analyzed Southern California earthquakes that occurred in 1933, 1971, 1986, and 1994, to consider the potential for strong shaking, surface rupture, soil liquefaction and earthquake-induced landslides. These factors helped determine where seismic improvements needed to be made in SCE's 50,000 square mile service area.

SCE reports that it has invested more than $186 million in seismic grid resiliency improvements since 2016 to help safeguard energy infrastructure and minimize the potential disruption to the communities, and their respective economies, that are located in SCE's service area.

San Francisco Seawall Resiliency Project

The Port of San Francisco (Port) is undertaking an effort to rehabilitate a three-mile-long section of the San Francisco Seawall, with a focus on public safety and resiliency in connection with earthquake and sea level rise vulnerability. The seawall supports critical disaster response infrastructure, provides transportation for more than a half-million people every day, and helps support billions of dollars of commerce in the City each year. The aging seawall is highly susceptible to earthquake damage because it was built prior to the development of engineering

techniques that account for seismic risks and land liquefaction, thus putting at risk critical disaster response infrastructure and historic structures along the waterfront. The seawall is also vulnerable to climate change and a possible 66 inches in sea level rise by the year 2100, exposing critical transportation infrastructure, such as the Bay Area Rapid Transit tunnel, to flooding.

In 2015, the Port launched the Seawall Resiliency Project, a major City and Port effort to significantly improve earthquake safety and performance of the Seawall, provide near-term flood protection improvements, and plan for additional long-term resilience and adaptation of the waterfront. The Project is envisioned to take place in the following two phases:

- Phase I focuses on seismic improvements to address the most critical life safety and flood risks at isolated locations along the Seawall. Phase I is budgeted for $500 million in 2016 dollars, currently underway and scheduled to finish by the end of 2025.

- Phase II would begin after 2025 and would potentially replace the entire three miles of the Seawall with all necessary seismic and sea level rise adaptation measures. This phase is estimated at $2-5 billion in 2016 dollars and could take more than 20 years to complete.

State Route (SR) 37
As previously mentioned, the current SR 37 Project overseen by Caltrans is another example of a multi-pronged project in California. SR 37 traverses through Sonoma, Marin, and Solano counties in one of the Bay Area‘s largest remaining tidal marsh environments, known as the San Pablo Bay lands.

The low-lying 21-mile corridor is an important regional connection linking the east and west portions of the North Bay Area. It experiences significant travel delay due to the narrowing of the highway from four to two lanes and is also impacted by uneven subsidence and intermittent storm-related flooding in several areas. Significant portions are predicted to become permanently submerged by 2050 as sea levels rise and several sections of the corridor will experience increased flooding events leading up to 2050 if modifications are not made. The result would be additional traffic on distant roadways that are not equipped to handle it, economic loss, and reduced opportunity for community residents who commute from and to Marin and Sonoma counties.

To address these concerns, the SR 37 Flood Reduction Project aims to construct a causeway at an elevation of 35 feet to withstand storm surges and address projected sea level rise while improving mobility and safety along the route. In its Environmental Impact Report for the Project, Caltrans notes that the project area is in a seismically active region, although not in an earthquake fault zone, and on soil with the potential to experience lateral spreading or liquefaction, which occur when ground shaking, such as from an earthquake, causes soil or sediment to become loose and liquid-like. Accordingly, Caltrans indicates the causeway structure will be designed using Caltrans’ Seismic Design Criteria, which prescribe the minimum seismic performance requirements and structural capabilities for highway bridges built in California.

Included in project management is a Chief Resilience Officer who acts as an in-house consultant helping entities apply a resilience lens to leverage their resources holistically, and plan their projects accordingly. This enables the entity to get the most "bang for its buck" on projects, potentially achieving multiple resilience goals with one project, such as building a flood barrier that also serves as a bike path, thus promoting healthy citizens and cohesive communities. Similarly, raising the roadbed creates an opportunity to restore the function and health of the surrounding wetlands, which provides ecological benefit and can also help diffuse storm damage using a nature-based solution. Preventatively improving the quality and durability of the roadway also preserves a valuable access and evacuation route in an emergency.

Appendix A: 2023-24 Session Legislation Relating to Earthquake and Seismic Resilience

AB 869 (Wood & Garcia) requires the Small and Rural Hospital Relief Program within the Department of Health Care Access and Information (HCAI) to give first priority to planning grants to single- and two-story general acute care hospitals (GACHs) that meet specified criteria. Creates an additional grant program for rural hospitals with a seismic safety compliance assessment to apply for grants to come into compliance with 2030 seismic safety requirements. Delays the requirement to meet those and other building standards for specified GACHs until January 1, 2035, and exempts a GACH with an assessment and with a certain estimated cost from those seismic safety standards if HCAI determines that the cost of design and construction for compliance results in a financial hardship for the hospital and certain funds are not available to assist with the cost of compliance. Establishes a similar program for financially distressed health care district hospitals. (Pending in the Senate Health Committee)

AB 1046 (Lowenthal, Chapter 825, Statutes of 2023) made a number of specified changes to the Alquist-Priolo Earthquake Fault Zoning Act.

AB 1471 (Pellerin, Chapter 304, Statutes of 2023) extends the deadline for O'Connor Hospital or Santa Clara Valley Medical Center's current plan for 2020 seismic compliance, and extends the dates for the hospital or medical center to report to the HCAI on their progress.

AB 1505 (Rodriguez) provides, as an exception to the Bagley-Keene Open Meeting Act, that nothing in the act prevents the California Earthquake Authority's governing board or advisory panel from holding closed sessions when addressing the development of rates, contracting strategy, or competitive strategy, if specified conditions are met. (Pending in the Senate Insurance Committee)

AB 1770 (Committee on Emergency Management) authorizes the Alfred E. Alquist Seismic Safety Commission to coordinate with the Department of Forestry and Fire Protection and the California Office of Emergency Services to take specified actions related to implementing and funding seismic mitigation activities and earthquake early warning technology. (Pending on the Senate Floor)

SB 528 (Rubio) clarifies confusing and outdated sections of the California Earthquake Authority's statute regarding potential assessments of the insurance industry, and consolidates a

Legislative reporting requirement. (Pending in the Assembly Insurance Committee)

SB 759 (Grove) would have extended the seismic safety deadline for hospitals to be capable of continued operations following an earthquake by ten years, to January 1, 2040, as specified. (Never heard in the Senate Health Committee)

SB 867 (Allen) the Drought, Flood, and Water Resilience, Wildfire and Forest Resilience, Coastal Resilience, Extreme Heath Mitigation, Biodiversity and Nature-Based Climate Solutions, Climate Smart Agriculture, Park Creation and Outdoor Access, and Clean Energy Bond Act of 2024 would authorize a $15.5 billion climate resilience bond to be placed before the voters at an unspecified election. (Pending in the Assembly Natural Resources Committee)

SB 1119 (Newman) would extend the dates by which four specified hospitals in California are required to comply with seismic safety standards. (Pending in the Senate Appropriations Committee)

SB 1382 (Glazer) prohibits the construction standards for a licensed community clinic from being more restrictive or comprehensive than comparable construction standards that are applied to clinics that are exempt from licensure, as specified. (Pending in the Senate Appropriations Committee)
SB 1432 (Caballero) provides for extensions of the January 1, 2030, deadline by which hospitals are required to be capable of continued operations following a major earthquake, as specified. (Pending in the Senate Appropriations Committee)

SB 1447 (Durazo) provides, for the Children's Hospital Los Angeles, extensions of the January 1, 2030, deadline by which hospitals are required to be capable of continued operations following a major earthquake, as specified. (Pending in the Senate Appropriations Committee)

ACR 112 (Rodriguez, Res. Chapter 171, Statutes of 2023) proclaimed September 2023 as California Emergency Preparedness Month.

ACR 151 (Calderon) supports the use of nonstructural seismic technologies. (Pending referral in the Assembly)

SCR 75 (Ochoa Bogh, Res. Chapter 8, Statutes of 2024) declared the month of September 2023 as California Emergency Preparedness Month.

Appendix B: 2024 EERI California Legislative Priorities and Actions

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Despite California's leadership on seismic safety, our cities remain at risk, threatened by collapse-prone older buildings, economic and social disruption, and stagnant recovery. The California Legislative Subcommittee of the Earthquake Engineering Research Institute (EERI) recommends the following eight actions the State can take now to improve community safety and resilience.

1. We must retrofit our existing vulnerable buildings. California still has thousands of buildings at risk of collapse or prolonged loss of function. Jurisdictions across California are adopting retrofit mandates to preserve housing, community services, and recovery-critical facilities. We applaud their proactive efforts and their leadership, but many other jurisdictions need help.

ACTION A: Establish and fund a State mitigation program for mitigation of recovery-critical non-residential buildings, similar to the "soft story" program established in 2022 (described in item 3). AB 1505 (Rodriguez) has already identified first responder facilities, care facilities, grocery supply chains and other facilities as priorities for grant funding, but there is no reason California, given its resources and its risk, should have to wait for Federal funding to solve our own problem.

ACTION B: Direct CalOES to provide funding to assist local school districts with retrofit projects. California produced a report on existing K-12 public-school buildings over 20 years ago (AB 300), but the State provided only a small fraction of the funding necessary to eliminate even severe collapse-prone conditions across the state (Prop 1D in 2006). Some districts have prioritized retrofit and replacement, but most have not, and many need assistance only the State can provide. At the very least, parents deserve to know the expected seismic safety of their local public-school facilities, which is not reported in School Accountability Report Cards.

2. We must adopt building codes that support rapid community recovery. Our current building code ensures that a new building is unlikely to collapse, but it does not mean the building will be usable after an earthquake. Our communities rely and thrive on basic services—schools, grocery stores, apartment buildings, and assisted living facilities. When these services are lost, even temporarily, their absence can delay recovery and permanently alter the fabric of a community. In 2021, the Legislature came close to requiring California to start the process of updating our code for functional recovery, but the bill (AB 1329, Nazarian) failed to make it to Governor Newsom's desk.

ACTION C: Direct the Building Standards Commission (BSC) to proactively adopt and enhance functional recovery provisions already approved for the 2024 International Building Code (IBC). The IBC has already adopted modest provisions to recognize the need for functional recovery in more buildings, but that national model code will not be effective in California until 2026. The BSC can proactively adopt those provisions as simple amendments now and can extend those provisions to suit California's needs.

ACTION D: Direct the Building Standards Commission to monitor the work of national code-development bodies and adapt their tentative provisions into the California Building Code on a faster schedule. The Building Seismic Safety Council's NEHRP Provisions Update Committee is currently developing comprehensive functional recovery provisions that could be codified in the 2030 International Building Code and, by normal adoption, the

2031 California Building Code (CBC). The draft provisions will be ready much sooner, and California would benefit from faster adoption timelines, perhaps in time for the 2025 CBC.

3. We must provide better earthquake performance with our new and existing housing. Housing is fundamental to earthquake recovery and to community resilience. Beyond safety, a significant percentage of the financial loss in earthquakes occurs in housing. Further, many of California's collapse-prone buildings provide naturally occurring affordable housing. As long as our codes set only minimum standards for design and retrofit, low-income and other vulnerable groups are especially at risk of housing loss. Given our statewide housing crisis, we can ill afford to lose the housing we do have – or the new housing we're trying to build quickly and cheaply – to an earthquake. A call for better housing design and proactive retrofitting is a special case of our call for retrofit funding and for functional recovery design (items 1 and 2 above).

ACTION E: Allocate $15 million in the 2024-25 State budget to the new "soft story" retrofit program for multifamily housing administered by the California Residential Mitigation Program under Government Code Section 8590.15 et seq. The program was created in 2022 anticipating $250 million in funding over ten years, but the 2023-24 budget gave it only $15 million for its first year. *Update: This funding has since been encumbered by the Governor due to the continued budget deficit. We would like to see this funding distributed to the California Residential Mitigation Program this year.*

ACTION F: Enhance support for the mitigation programs currently managed by the California Earthquake Authority (CEA). Expand the CEA's mitigation programs to include more communities and more vulnerable housing types such as manufactured (mobile) homes.

ACTION G: Direct the Building Standards Commission to require recovery-based design for new housing for low-income and other vulnerable tenants (e.g., assisted living, supportive housing, and senior housing).

4. We must uphold existing laws that require our healthcare facilities to be earthquake-ready. Hospitals play an essential life-saving role in post-earthquake response and recovery for their communities. The Alfred E. Alquist Hospital Facilities Seismic Safety Act (Alquist Act) of 1983, along with amendments such as SB 1953 (1994), require that acute care hospitals and supporting facilities remain operational immediately after an earthquake. Hospitals are to be retrofitted or replaced by 2030. While most of California's hospitals have complied, some have not. EERI supports proposals to assist certain small, rural hospitals for which compliance with SB 1953 is especially difficult, but otherwise, our current laws must be upheld so that critical hospital facilities are retrofitted by 2030.

ACTION H: Monitor proposed legislation that would negatively affect compliance with SB 1953. When such proposed legislation arises, consult with EERI about likely costs and benefits.