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Life on the Pacific Rim: Should California Build Towards Seismic Resilience?

An ACEC California Infrastructure Discussion Paper

ACEC California
June 2018

ACEC
AMERICAN COUNCIL OF ENGINEERING COMPANIES
California

June 2018

Living in California means being able to access extraordinary and varied natural environments: from the spectacular coastal communities in San Diego and Los Angeles to the gorgeous mountain ranges of the High Sierras. However, California's unique landscape also includes the risk of natural disasters such as wildfires and earthquakes. In ACEC California's latest discussion paper, we examine the concept and challenges of achieving infrastructure resilience; specifically, whether California's infrastructure is or should be built with a focus on ensuring that structures and systems can quickly be restored to functionality following a large seismic event.

Experts believe that California will most likely experience its next massive seismic event in the near future. Given the state's history of large earthquakes, the government has appropriately prioritized seismic preparation through the lens of emergency response and the preservation of the life and health of California residents. Such efforts have included strengthening the state's building code and conducting mass public seismic preparation exercises to minimize the risk of injury and damage. The next challenge some policymakers, governments, and nonprofit organizations are examining is how California can continue its efforts on seismic preparedness to include creating more resilient structures and systems so that both community and wider economic disruption is minimized, and recovery becomes more efficient and less costly.

Already, the cities of San Francisco and Los Angeles are taking action to identify potentially vulnerable buildings and instituting different seismic retrofit programs to bring older buildings up to newer building code standards. However, more work needs to be done to examine and potentially resolve the barriers that exist to creating more seismic resilient communities.

It is always our aim to ensure our discussion papers are informative and engaging, and we hope *"Life on the Pacific Rim: Should California Build Towards Seismic Resilience*" contributes to the important policy discussions about how to build a better, more sustainable California for all its residents.

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LIFE ON THE PACIFIC RIM:

Should California Build Towards Seismic Resilience?

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California is called the "Golden State" for good reason. Its location on the West Coast draws tourists worldwide to its great natural beauty, and is a prominent source of its economic prosperity, with easy access to international trade partners across the ocean. However, life on the Pacific Rim can involve risk. Early Californian settlers quickly learned that lesson: the massive 7.9 magnitude Ft. Tejon earthquake of 1857 remains one of the largest recorded events along the San Andreas Fault.[1] Subsequent tremors have knocked over towns up and down the state, not to mention tremendous floods and catastrophic fires, yet Californians have endured and prospered. Indeed, California's 2.7 trillion-dollar economy — the fifth-largest on the globe if it were its own country[2] — sits atop some of the most volatile fault systems in the world.

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1 Southern California Earthquake Data Center, *Significant Earthquakes and Faults*, California Institute of Technology, accessed May 15, 2018, http://scedc.caltech.edu/significant/forttejon1857.html.

2 Associated Press, *California is now the world's fifth-largest economy, surpassing the United Kingdom*, LA Times, May 4, 2018.

Because of California's national and global economic prominence, it is understandable why many policy-makers, non-governmental organizations, and researchers are actively studying and debating how to create and sustain a resilient built environment that can help mitigate the effects of large seismic events. While there is no consensus definition of a resilient built environment, the American Society of Civil Engineers put forth the following definition in a 2015 paper to describe a resilient residential structure, "the capacity of a residential structure to absorb external stresses; retain function; reduce industrial risk; and help vulnerable people, organizations, and systems persist."[3] Additionally, the National Academy of Science's definition for a disaster-resilient community "is one in which its [buildings], through mitigation and pre-disaster preparation, develop the adaptive capacity to maintain important community functions and recover quickly when major disasters occur."[4]

The stakes for considering how to plan for and sustain a resilient built environment have never been higher. Nearly 70% of California's 40 million citizens live in an urban built environment, and the United States Geological Survey (USGS) determined there is a 70% probability California will experience an earthquake of 6.7 magnitude before 2030. The Hayward-Rogers Creek, San Andreas, and Calaveras Fault systems are at the highest risk of generating a quake, posing a threat to San Francisco, Oakland, and San Jose.[5]

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Investment in many structures in our built environment are not constructed to standards that can withstand the ground motion from an earthquake of 7.0 magnitude or higher.[6] At least $25 billion has been invested in earthquake countermeasures in the bay area region in the 30 years since the 1989 Loma Prieta earthquake,[7] but more remains to be done to protect life and property, and to speed the recovery of vital services when a calamitous quake strikes.

"Nearly 70% of California's 40 million citizens live in an urban built environment, and the United States Geological Survey determined there is a 70% probability California will experience an earthquake of 6.7 magnitude before 2030."

Already, large populous cities such as San Francisco and Los Angeles are recognizing the need to bring resilience to the forefront of community discussions. Both cities have already taken action to strengthen their cities' seismic resilience by enacting seismic ordinances for hazardous existing buildings. Such action is an example for other municipalities and the state legislature to follow so that public policy can be established, based on expert research, that improves the seismic resiliency of public infrastructure systems that affect the life and safety of the citizens of California before the next major earthquake hits.

Why build for seismic resiliency?

Casualties and property damage caused by major quakes are deeply troubling and understandably garner much of the public's attention regarding how to further California's seismic safety preparation. However, it is also important to consider how to protect or mitigate the damage to vital infrastructure systems, including energy, water, transportation, and telecommunications. Although building repair costs following a major tremor are enormous, total economic losses due to earthquake damage can be

staggering. Damage to nonstructural systems in buildings (water, electrical, sewer) result in extensive delays before buildings can be brought back into operation.[8] For example, the Cypress section of Interstate 880, a 1.6-mile stretch of elevated freeway in Oakland which collapsed during the Loma Prieta quake, took nine years and $1.2 billion to rebuild.[9] Ensuring the physical built environment, including nonstructural systems, can withstand a large seismic event and also recover essential services quickly is vital to avoiding extended disruptions of one of the largest economies in the world.

In recent years, policymakers and scientists have appropriately sharpened their focus on how to plan for mitigating the effects of large-scale seismic events on the built environment. But solutions are not easily had. The challenge of creating a seismically-resilient California with the ability to restore functional services quickly from a major quake is vast. Much of California was built before seismic safety was well-understood. Solutions require long-term commitment, planning, and a prioritization of financial resources across multiple levels of government.

The situation in California's largest city highlights a statewide phenomenon. According to Built: LA, 2.9 million buildings reside in the County of Los Angeles and their color-coded display shows the majority of those buildings were built prior to 1970.[10] In fact, thousands of buildings within the city have been identified as at a great risk of loss of life and property should a large seismic event strike in that region. Soft story buildings — a multi-story building with a ground floor remaining mostly open, used in many cases for parking — are exceedingly vulnerable to damage or destruction in a quake. Recognizing the risk, in 2015 Mayor Eric Garcetti pushed through some of the nation's most sweeping earthquake retrofit laws, requiring seismic fortification of pre-1978 wood-frame soft story buildings and pre-1977 non-ductile concrete structures.[11] Los Angeles has more than 13,500 soft story buildings, and a paltry 608 have completed the retrofit process. Approximately 4,000 are undergoing retrofit, leaving the seismic condition of roughly 9,000 of these highly-vulnerable buildings still unaddressed.[12] Another 1,500 or so older concrete buildings are also vulnerable as they are not equipped with enough steel reinforcing bars to hold the concrete together during an earthquake.[13]

Ground view of collapsed building and burned area. Beach and Divisadero, Marina District. [C.E. Meyer, U.S. Geological Survey]

Another densely-populated region with a history of seismic destruction, the San Francisco Bay Area, suffers from similar vulnerabilities. The U.S. Geological Survey, in its HayWired Earthquake Scenario report, estimated significant damage is likely to occur in the cities of Oakland and San Francisco in the event of a 7.0 earthquake centered along the Hayward Fault. The scenario suggests an earthquake of that magnitude would displace about 77,000 households — a number that more than doubles with anticipated utility

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outages and ensuing fires. The report, however, notes that more resilient buildings constructed to more stringent building codes could allow 95% of the citizens in the region to remain in their homes after a major quake.[14]

California's infrastructure: Is our built environment prepared for seismic events?

In California, significant policy developments in seismic preparedness tend to follow major catastrophes, as earthquakes drive home the unfortunate lessons of being unprepared. The Field Act, which guides the construction of public schools, was adopted after the Long Beach earthquake of 1933. One of the greatest advances in seismic safety came after the 1971 Sylmar quake in the San Fernando Valley: the adoption of stricter state and local building codes that account for seismicity. Los Angeles and other large cities also implemented their own building code requirements. Los Angeles officials concluded that their seismic retrofit requirements implemented after the 1971 quake proved to save lives during the 1987 Whittier quake, the 1991 Sierra Madre quake, and the 1992 Landers quake. Even in the 1994 Northridge quake, no deaths or injuries in the 37,000+ units in 1,300 retrofitted buildings were reported.[15]

In contrast to event-driven seismic policy, both state and local building codes are scrutinized and revised almost continuously for many reasons. State building codes are updated every three years and are subject to a lengthy and transparent public participation process throughout each code adoption cycle. State law also authorizes local government to enact local ordinances making amendments to the building standards in the California Building Standards Code.[16] This allows local jurisdictions along fault lines to develop and implement their own, more stringent seismic code standards. Stricter building standards have been adopted in several cities, as well as retrofit requirements for buildings built prior to the enactment of the National Earthquake Hazards Reduction Program in 1977.

These local and state efforts, while undertaken with great intentions, can, however, result in limitations regarding seismic resiliency:

Absence of adequate shear walls on the garage level exacerbated damage to this structure at the corner of Beach and Divisadero Streets, Marina District. [J.K. Nakata, U.S. Geological Survey]

1) **With the exception of 'essential facilities'** — hospitals and schools — the state building code does not contain a standard that determines the use and functionality of a building after a seismic event. The current code is designed to protect against the loss of life. Some have suggested that a stronger building code could help minimize recovery time, costs and mass displacement.

2) **There is no existing state mandate** to ensure most structures built prior to modernized code updates are brought up to new standards. California has only implemented a mandate to require hospitals built prior to more stringent seismic standards be upgraded or replaced to address seismic deficiencies.

California's rapid growth and development combined with the slow adaptation of our built environment to new building codes means that the overall trend of rising earthquake damages will continue. In fact, each of the two decades following adoption of the National Hazard Reduction Program saw new records set in California for quake damages. The 1989 Loma Prieta

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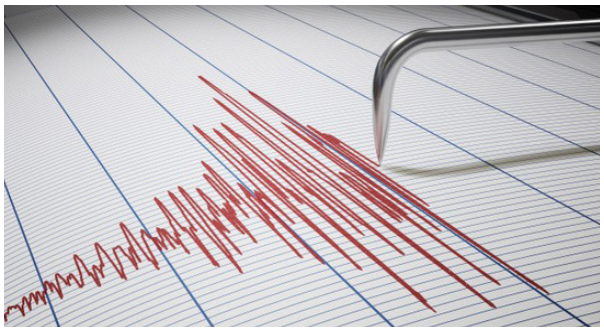
quake, broadcast to a national audience tuned in to Game 3 of the World Series, measured 6.9 on the Richter Scale, killed 63 people, and caused $6 billion in damages including the collapse of a portion of the Bay Bridge. Other structural damage included 16,000 housing units becoming uninhabitable, failure of highway systems, and bridge failures. The quake caused 1,200 leaks and breaks in water mains and service connections, 13 miles of gas-distribution lines had to be replaced, and five electrical substations were badly damaged.[17] At the time it was the most expensive natural disaster in US history. That record was broken a little over four years later by the 1994 Northridge quake, striking Southern California's San Fernando Valley at a magnitude 6.7. The Northridge quake claimed 57 lives and caused $20 billion in damages, including the collapse of major interstate freeways and overpasses all around the greater Los Angeles area.[18]

Policymakers and officials at the local, state, and national level are starting to discuss and research how to design communities that can nimbly and efficiently restore both public services and private commerce as quickly as possible after a major seismic event. While much progress has been made to ensure buildings remain standing — safeguarding life and allowing occupants to escape, policymakers are expanding their focus and asking the question: how can we make a community more resilient to ensure a stable, expeditious, less costly recovery?



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How should California prioritize seismic resilience?

Policymakers and seismologists are beginning to address California's seismic resilience limitations in key policy arenas. In the California State Legislature, Assembly member Adrin Nazarian, whose San Fernando Valley district experienced both the 1994 Northridge quake and the 1971 Sylmar quake among others, has proposed two bills in the 2017–2018 legislative session. Assembly Bill 1857 establishes a functional earthquake recovery working group comprised of certain state entities and members of the construction and insurance industries. The group would be charged with determining the criteria for "functional recovery" standards following a seismic event. The California Building Standards Commission would be authorized to propose the subsequent building standards to meet the new criteria.

Mr. Nazarian is also authoring AB 2681, which requires every local building department in the state to create an inventory of potentially vulnerable buildings within its jurisdictions and submit the inventory to the Office of Emergency Services (OES). OES would then be required to maintain a statewide inventory and require building owners to retain a licensed professional engineer to identify whether the building meets the definition of a potentially vulnerable building and, if so, complete the reporting form.

There are also multiple nongovernmental organizations partnering with local and state public agencies to study seismic resiliency and make policy recommendations for state and local governments to consider:

1) **The Seismic Resilience Initiative (SRI),** a working group comprised of local California Building Department leaders, practicing structural engineers, and the Los Angeles County Business Federation and Central Valley Business Federation (BizFed), was established in early 2017. The Initiative is led by the United States Resiliency Council and receives technical assistance from the California Seismic Safety Commission, California Office of Emergency Services, the California Department of Insurance, and the International Code Council. SRI's purpose is to educate the California public about seismic risks, and to promote statewide policy to identify buildings that present a heightened seismic risk of death, injury, and damage based on their age, structural system, size, and location.

2) **The US Resiliency Council (USRC),** an organization whose goal is to rate building performance in natural disasters, considers the performance of a building's structure, its mechanical, electrical and plumbing systems, and architectural components such as cladding, windows, partitions, and ceilings and identifies the expected impacts of an earthquake.[19] This provides an actionable blueprint of the areas of improvement needed to achieve seismic resiliency. USRC assigns ratings to buildings that meet or exceed modern code standards, providing valuable seismic resiliency information to all building stakeholders. Roseville City Hall in California has received the first ever Platinum rating handed out by USRC.[20]

3) **The National Institute for Science and Technology (NIST)** Methodology for Estimating Seismic retrofit costs report was developed because a nationwide standard approach to estimating retrofit costs did not exist. The NIST Methodology is useful in determining structural construction outlays, but the report warns their approach does not help with predictions of total costs as their focus solely on construction outlays ignores indirect costs, such as loss of productivity during a retrofit.[21]

> "Much of California was built before seismic safety was well-understood. Solutions require long-term commitment, planning, and a prioritization of financial resources across multiple levels of government"

Can we afford seismic resiliency?

Moving toward a resiliency model comes with a cost, and dialogue going forward must include a discussion of "who pays." As buildings are identified as "at risk," the onus of who should pay for retrofits remains fraught with controversy, as does the decision about whether retrofits undertaken are sufficient. The question also remains as to whether it is possible to create a mandatory program that accomplishes the needed retrofits to existing structures and brings new private family homes, commercial structures, and multifamily units safely to market in a way that is affordable to new homebuyers, renters, and property owners. The role and fiscal responsibility of taxpayers and commercial property owners will also need to be defined.

The high cost of housing in California cannot be overlooked. Today, only 31% of Californians can afford to buy a median-priced home ($540,000 as of April 2018, a figure that is substantially higher in quake-prone major cities such as San Francisco and Los Angeles). Rents are also among the highest in the nation. Whether homeowners and renters should bear the brunt of substantial retrofit costs, especially in areas close to fault lines, is an issue yet to be resolved. A lawsuit against the property

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owners of a Paso Robles building was won by the families of two women who died as a result of falling bricks set the precedent that liability for retrofits lies on the shoulders of property owners.[22] What remains unclear is how those costs may be absorbed. A significant increase in the cost of housing may not be economically viable for many Californians and their families.

A creative financing approach in San Francisco involving both public and private-sector partners may illuminate a path — albeit a complicated one — toward accelerated seismic improvements. The city has partnered with Alliance NRG/Counterpointe Sustainable Real Estate to help property owners retrofit soft story buildings. The financing is not considered a loan; rather, it is non-ad valorem assessment added to property taxes and backed by a municipal bond issuance. The assessment is collected as an additional line item on the owner's regular property tax bill.[23] A potential problem involves the perpetual battle between landlords and tenants over rent and rent control. While local rent ordinances allow property owners to pass through 100 percent of the seismic improvement cost to tenants, the property owner keeps any applicable federal/state rebates and/or tax credits for those improvements.[24] This potential solution remains both politically and financially difficult in a housing market nearly three times more expensive than any other city in the United States.[25] However, it is an illustrative example of the debate happening at the local level as many officials and policymakers are all too aware of the consequences should they choose to do nothing to address the problem of retrofits.

> "In California, significant policy developments in seismic preparedness tend to follow major catastrophes, as earthquakes drive home the unfortunate lessons of being unprepared."

Conclusion

Despite the many lives tragically lost due to significant natural disasters, Californians are a resilient people. They have survived floods, fires, mudslides, and major earthquakes, and always recovered. Prior generations built and re-built after destructive events, but at this place in history, advances in technology and engineering can better prepare our communities for seismic events and help mitigate the loss of life and property. They can help minimize both the enormous cost and economic loss of comprehensively rebuilding the whole of a community's built environment after a seismic event.

California's history of significant earthquakes offers many lessons about how the state's exposed infrastructure systems are in need of reinforcement; about how policymakers can better coordinate local and state mandates in a fiscally prudent manner; and about how analysis of the ever-shifting tectonic plates and fault lines can affect the built environment. As a result, experts are thinking critically about how to apply a broad, thoughtful vision to work towards a California with structurally and functionally resilient communities.

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Working toward resilience within financial and logistical constraints is perhaps as complex as the science guiding the policy discussions. Building towards seismic resilience will involve a long-term planning process and require the cohesive cooperation of multiple public agencies at both the local and state levels. However, based on scientific and historical data, a major earthquake is likely due in the near-term, and could potentially result in multiple casualties and increasingly higher costs to rebuild. In order to reduce both the loss of life, and the length of time and cost of recovery, proactive steps need to be taken now to improve our critical infrastructure systems and buildings. These proactive steps include continued discussion and policy debate, but with a deadline for implementation; because each day spent waiting is one day less to prepare for the next seismic event.

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