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Special Report: California Earthquake Preparedness and Vulnerabilities

January 2017

Earthquakes are common occurrences in California – even more common than most residents realize. In 2014, California was host to nearly 200 earthquakes of Richter magnitude scale (magnitude) 3.0 and greater, following only Alaska and Oklahoma in number.ⁱ Southern California alone sees over 10,000 earthquakes annually, the vast majority of which are imperceptible to human senses.ⁱⁱ On December 31, 2016, the California Institute of Technology reported a “swarm” of more than 100 small earthquakes near the California-Mexico border that all occurred in just that single day.ⁱⁱⁱ According to the California Department of Conservation, “more than 70 percent of the state's population resides within 30 miles of a fault where high ground shaking could occur in the next 50 years.”^{iv} With such prevalence, earthquake preparedness should be in the minds of all Californians. However, it is human nature to neglect that which is not perceived as urgent. Since no one knows when the next big earthquake will strike, earthquake preparedness often falls to the wayside as other “more pressing” matters are attended to in homes, businesses, and governments throughout the state. This reactive approach has led some scientists to question whether California is truly ready for its next devastating seismic event.

An earthquake is unstoppable - a natural phenomenon that occurs when too much stress builds up between convergent tectonic plates under the Earth's surface.^v However, preparation can reduce the human death toll, economic impact, and recovery time for affected communities. California's strict building codes and other preemptive measures are part of the reason that, while the magnitude of earthquakes in the state have been large, the loss of life resulting from them is small compared to similar magnitude earthquakes elsewhere in the world.^{vi} To compare, California's deadliest seismic event was the infamous 7.8 magnitude San Francisco earthquake (and resulting fire) that left 3,000 dead in 1906; the deadliest earthquake in the world during modern history, however, was the 1976 7.8 magnitude earthquake in Tangshan, China that killed between 250,000 and 800,000 people.^{vii} In spite of the California's relatively advanced infrastructure standards and therefore low earthquake-related death counts, vulnerabilities still exist within the state and further improvements are essential in order to minimize public safety risk.

Even to this day, scientists are discovering new faults and updating predictions about the likelihood and severity of future earthquakes. In just October 2016, for example, a team of geologists from the U.S. Geological Survey (USGS) discovered that the Hayward Fault, which

runs under densely populated neighborhoods east of San Francisco, connects to a less active fault known as the Rodgers Creek Fault Line located beneath the San Pablo Bay.^{viii} As a result of the interconnectedness of these two faults, a simultaneous rupture is possible and could lead to a 7.4 magnitude quake. Such a quake in a highly populated area would likely result in “extensive damage and loss of life with global economic impact,” according to USGS.^{ix}

In light of these findings, scientists have attempted to use the new knowledge to inform public policy and positively affect public readiness for such an event. A USGS report entitled “The Shakeout Scenario” estimates the damage and loss of life from the most likely large earthquake to strike California next based on earthquake recurrence intervals and other geologic characteristics. The earthquake scenario analyzed was a 7.8 magnitude earthquake on the southernmost 200 miles of the San Andreas Fault. According to the study, this earthquake would likely produce shaking lasting nearly two minutes causing an estimated 2,000 deaths, 50,000 injuries, and \$200 billion in damage.^x Scientists authoring the study dubbed a seismic event of this intensity the “Big One.” For those familiar with the scientific field, the question about an earthquake of this magnitude occurring in California is not a matter of if it will happen, but when it will happen.

The ShakeOut Scenario was designed, not only to estimate the destruction caused by such a quake, but also to identify mitigating actions that can be taken preemptively. In order to best mitigate the risk of an earthquake, it is necessary to first develop an understanding of the state’s vulnerabilities. In doing so, earthquake preparedness takes on a new meaning; the definition expands from a reactive disaster relief mentality of canned food and bottled water to include proactive measures of risk reduction designs and safer building materials, for example.

California adopted this proactive mindset decades ago, but vulnerabilities remain. For example, mandatory earthquake retrofitting programs for buildings only exist in about half of California cities; the rest have voluntary programs.^{xi} Old buildings that have not been reinforced and retrofitted for safety present a public safety concerns across the state. In particular, the ShakeOut report notes that all non-reinforced masonry buildings within 15 miles of the San Andreas Fault would be completely leveled in the case of the “Big One.”^{xii}

The state’s aging water infrastructure presents a second vulnerability. Especially in Southern California, most water piping is still brittle.^{xiii} In the event of the Big One, the ShakeOut report expects that a “significant number of cities would be forced to lay down a completely new water system.” Aside from the exorbitant cost of such a project, the study estimates that the worst hit areas would not have water on tap for six months. If a major aqueduct is affected, as the ShakeOut Scenario study expects, that time frame could expand to up to 18 months.^{xiv}

In addition to losing water access for an extended time, residents will likely go for weeks without power. The state’s electrical grid remains vulnerable to earthquake damage, as well. Power companies, such as Southern California Edison (SCE), attempt to prepare for the worst with disaster plans and drills that would take effect in the event of a quake-induced outage. In addition to preparing employees for such an occurrence, the drills help identify areas for improvement in the relief plan. Even with such plans, Don Diagler of SCE said that “The bulk of the power

would start coming back on within 24 to 72 hours, but we could see some outages lasting up to two or three weeks.^{xv}

The state's transportation system could also be disrupted in the case of a quake. While the state has spent billions on seismic retrofitting of state freeways, many bridges and roads are owned locally and have not had access to funds to upgrade. The potential damage to roadways can exacerbate human death and injury as a result of the earthquake, as emergency personnel can be blocked from accessing areas in need.^{xvi}

Hospital resiliency and capacity are related vulnerabilities. While most hospital buildings are retrofitted or built to withstand a severe earthquake, the surge in patients immediately following such an incident presents a challenge. Many hospitals and emergency centers participate in the Great California Shake Out in preparation. Emergency Medical Services developed a program called, "50 in 15 minutes," which states that hospitals should be able to treat 50 patients within the 15 minutes following a major disaster event.^{xvii}

Earthquakes have the potential to spark other disastrous events such as fires and landslides. While landslides would only occur in certain geographic areas, fires are likely to result from any earthquake of high magnitude due to damaged gas piping or electrical lines.^{xviii} The consequences of these events could be exacerbated by the diversion of emergency personnel or inability to access affected areas due to roadway damage. For example, in the famous 1906 San Francisco earthquake, it is believed that more damage was caused by the resulting fire than from the earthquake itself.^{xix} Less likely but possible resulting vulnerabilities include flooding from damaged dams, escape of hazardous materials, soil liquefaction, and tsunamis.^{xx}

Knowing the vulnerabilities the state faces helps target the preparation necessary to minimize damage. From a policy perspective, the ShakeOut Scenario report found that the aggressive retrofitting efforts have succeeded in increasing the seismic resistance of buildings and roadways.^{xxi} However, there is still room for improvement in areas with many old buildings that would not be allowed under current building code standards.

A large area of improvement, which was identified in the ShakeOut Scenario, is to the fragile water system of the state. This applies particularly to Southern California, which relies heavily on water from the North and underground water infrastructure to meet demands. Investment in updating the aging and brittle piping of much of the state was found to potentially help the resilience of the area and subtract from the economic impact of a large seismic event.^{xxii}

Some preparation action can be done at the individual or business level. Non-structural elements and building contents that are unregulated provide a significant hazard and potential for economic loss. These are items in buildings such as heavy wall hangings, loose valuables sitting on shelves, and dressers and other furniture that could tip over. Even if a building remains largely undamaged, its contents can harm individuals inside the building when they shift or fall during a quake. The damage to the items themselves adds greatly to the economic loss caused by the earthquake. Building owners and residents can help mitigate this risk by anchoring furniture to walls, securing loose items on shelves with adhesive, and latching cabinet doors. Additionally, they can install nonstructural solutions such as cripple wall bracing, foundation bolting, and

reinforced chimneys to help protect the structure itself without major retrofitting. Individual dwellings and businesses should also be prepared with enough stored food, water, and emergency aid in the case of entrapment from building collapse.^{xxiii} While these actions may not be appropriate to legislate, they are often measures individuals do not perform without prompting. Education regarding earthquake safety measures could help minimize the damage to and improve the resiliency of families and businesses in the event of an earthquake.

Preparation is also needed amongst emergency response agencies. Groups including the Federal Emergency Management Agency (FEMA), California Emergency Management Agency (CalEMA), and volunteer organizations such as the American Red Cross will arrive at the scene as soon as possible to assist by setting up temporary shelters, bringing clean water and food, mental health services, and communicating the availability of resources to affected populations (often with great difficulty due to a loss of power).^{xxiv,xxv} Duplicative aid is wasteful and, in the event of an emergency where resources are thin, can cost lives. Therefore, coordination between and within agencies can help maximize the effect of aid. Most California emergency response teams, hospitals, and government agencies participate in the Great California Shake Out, which helps identify areas for improved coordination.^{xxvi} In the event of an earthquake, an organized and cooperative response has an incredible impact on the speed of community recovery and efficiency of resource use.

Policy makers aim to safeguard the public welfare. In the case of California, this means prioritizing earthquake readiness, even when it is not at the forefront of public attention. By doing so, California can be more prepared for the next severe earthquake than it has been for any other in its history.

ⁱ https://earthquake.usgs.gov/learn/topics/megaqk_facts_fantasy.php

ⁱⁱ <https://earthquake.usgs.gov/learn/facts.php>

ⁱⁱⁱ <http://abc7.com/science/swarm-of-100-small-earthquakes-hits-near-california-mexico-border/1681002/>

^{iv} <http://www.conservation.ca.gov/index/Earthquakes>

^v <https://seismo.berkeley.edu/outreach/faq.html>

^{vi} <http://content.time.com/time/nation/article/0,8599,1858700,00.html>

^{vii} https://earthquake.usgs.gov/learn/topics/megaqk_facts_fantasy.php

^{viii} <http://advances.sciencemag.org/content/2/10/e1601441.full>

^{ix} Ibid.

^x <https://pubs.usgs.gov/of/2008/1150/of2008-1150small.pdf>

^{xi} <http://www.sgvtribune.com/general-news/20160317/these-are-californias-5-biggest-vulnerabilities-from-a-major-earthquake>

^{xii} <https://pubs.usgs.gov/of/2008/1150/of2008-1150small.pdf>

^{xiii} <http://www.sgvtribune.com/general-news/20160317/these-are-californias-5-biggest-vulnerabilities-from-a-major-earthquake>

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- ^{xviii} <https://pubs.usgs.gov/of/2008/1150/of2008-1150small.pdf>
- ^{xix} <https://earthquake.usgs.gov/learn/facts.php>
- ^{xx} <https://pubs.usgs.gov/of/2008/1150/of2008-1150small.pdf>
- ^{xxi} Ibid.
- ^{xxii} Ibid.
- ^{xxiii} https://www.fema.gov/media-library-data/1408632135401-3d0521fa59d0dd4016e82f08fe7f3732/PrepareAthon_EARTHQUAKES_HTG_FINAL_508.pdf
- ^{xxiv} <https://www.fema.gov/about-agency>
- ^{xxv} [http://www.caloes.ca.gov/PlanningPreparednessSite/Documents/00%20SEP%207-01-09%20covrev%20\(12\).pdf](http://www.caloes.ca.gov/PlanningPreparednessSite/Documents/00%20SEP%207-01-09%20covrev%20(12).pdf)
- ^{xxvi} <http://www.shakeout.org/california/resources/>