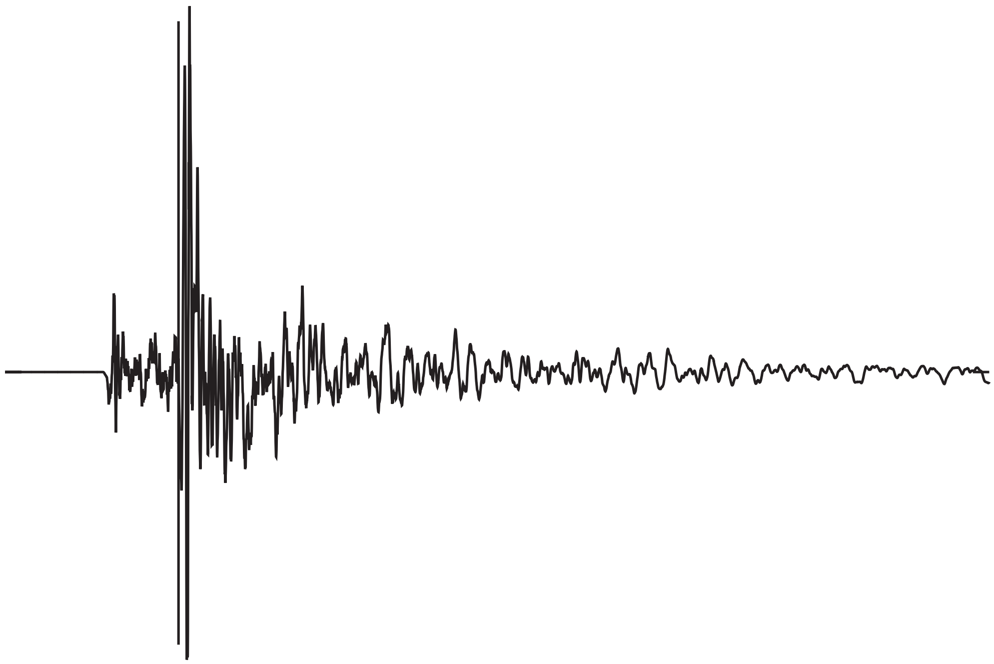
Resilience by Design



Resilience by Design

My Fellow Angelenos:

As Mayor, I have no greater responsibility than the public safety of Los Angeles. And here in our city, it's not a question of if the so-called "Big One" will hit. It's a matter of when. So we cannot afford to be complacent. The known risks – to life, property and our overall economy – are too great.

Los Angeles has always been an epicenter of seismic risk. Now, the action steps in this report will make our city a nation-leading epicenter of seismic preparedness, resilience, and safety.

This package of action steps represents a tectonic shift of how earthquake policy is made in Los Angeles. To this point, earthquake policy has more often than not been developed in the immediate aftermath of a major earthquake. And even then, momentum quickly died out, leaving grave vulnerabilities behind. Today, Los Angeles is addressing our greatest earthquake vulnerabilities proactively and strategically.

I have set a clear agenda for my Administration – to get City Hall "back to basics" and to focus City government on our core responsibilities. Unfortunately, here in earthquake country, those responsibilities have been put to the wayside for far too long. That's why I appointed renowned seismologist Dr. Lucy Jones as my Science Advisor for Seismic Safety. Through an unprecedented partnership with the U.S. Geological Survey, she has spent the last year studying our vulnerabilities; convening stakeholders and experts from academia, industry, business, government and our communities; and developing this action plan.

The outcome of this extensive process, which also incorporates cutting edge research and lessons learned from past earthquakes, is that we are focusing on three major sectors: fortifying our buildings, fortifying our water system and fortifying our telecommunications networks. Tied together, these actions will strengthen resilience in our city for decades to come.

These action steps are designed to be best-in-class and achievable. This is not intended to simply be the latest "blue ribbon commission" report that sits on a shelf. It's designed so that government, property owners, and commercial and residential tenants can come together to strengthen Los Angeles against a known and major threat to life, property, and our economy.

This report represents a full year of work by dozens of people under the leadership of Dr. Jones. It is with the deepest gratitude to them that I present "Resilience by Design."

Sincerely,

ERIC GARCETTI

Mayor

Executive Summary

Resilience by Design presents the recommendations of the Mayoral Seismic Safety Task Force, the members of which are listed in the Acknowledgements Section of this document. These recommendations address the city's greatest vulnerabilities from earthquakes with significant and attainable solutions to:

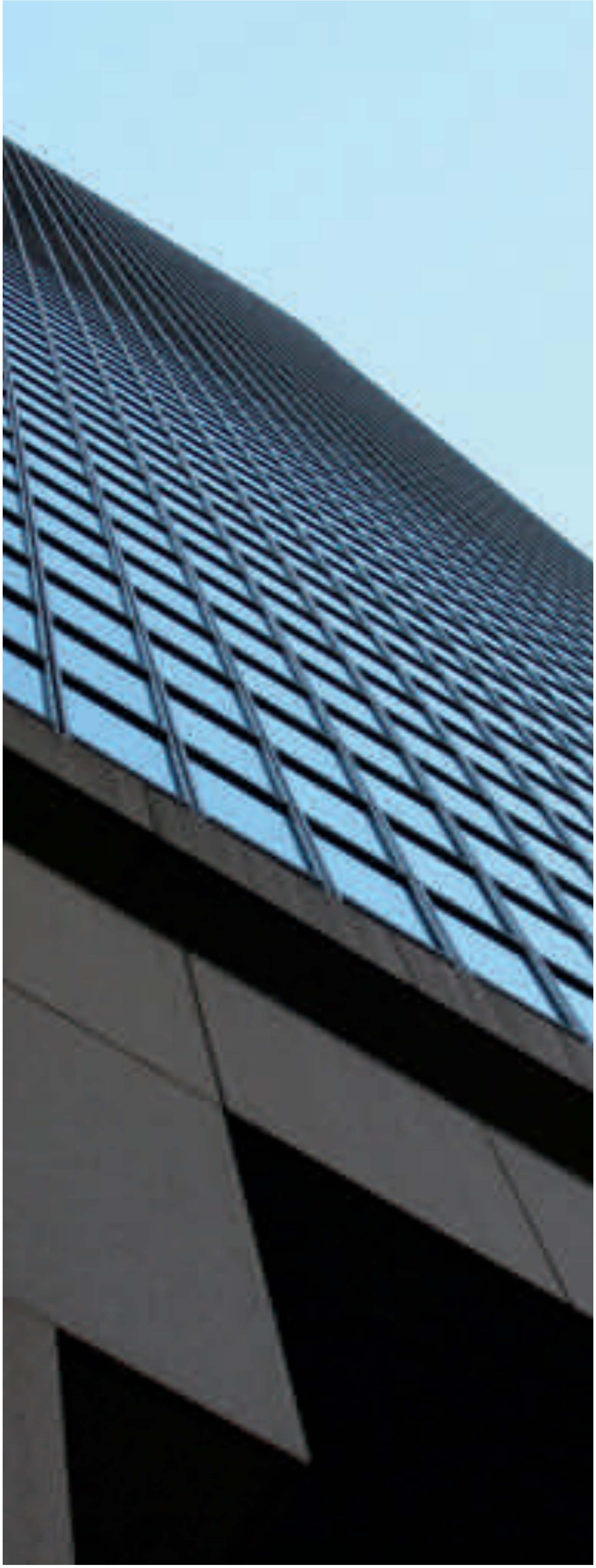
- Protect the lives of our residents
- Improve the capacity of the City to respond to earthquakes
- Prepare the City to recover quickly from earthquakes
- Protect the economy of the City and all of Southern California.

The Mayoral Seismic Task Force evaluated four areas of seismic vulnerability, namely:

- Pre-1980 "non-ductile reinforced concrete" buildings
- Pre-1980 "soft-first-story" buildings
- Water system infrastructure (including impact on firefighting capability)
- Telecommunications infrastructure

Strengthen Our Buildings

The most obvious threat from earthquakes is physical damage to vulnerable buildings. Soft story and concrete buildings built before the implementation of Los Angeles' 1976 revision of the building code pose a significant risk to life in strong earthquake shaking.




Strengthen Our Buildings

Assess And Retrofit Pre-1980 Soft Story And Concrete Buildings

This report recommends that these buildings be assessed and retrofitted as necessary:

Soft Story

Soft story buildings are wood frame buildings where the first floor has large openings, for example tuck-under parking, garage doors, and retail display windows. This Report recommends that building owners be required to, within one year of passage of the implementing legislation, submit to the City documentation establishing that an acceptable retrofit has already been conducted, or that a retrofit is required. It is further recommended that retrofitting be required so that first floors are strengthened to the same capacity as second floors within five years.

Concrete

"Non-ductile reinforced concrete" buildings (most concrete buildings built before the implementation of the 1976 code) are at higher risk of collapse, because some parts of the building such as columns and frame connectors are too brittle and break in strong shaking. The weight of the concrete makes them particularly deadly when they fail.This Report recommends that building owners be required to, within five years of passage of the implementing legislation, submit to the City documentation establishing that an acceptable retrofit has already been conducted, or that a retrofit is required. It is further recommended that retrofitting be mandated within 25 years to either the Basic Safety Objective of the American Society of Civil Engineers (ASCE) standard 41 or to the equivalent standard if other approaches are approved.

Strengthen Our Buildings

Implement a Seismic Safety Rating System

Our building code is designed around a life-safety requirement that mandates construction that ensures a low probability of collapse in the worst earthquake. The code is not designed, however, to make it so buildings, while still standing, are also likely to remain usable after an earthquake. This report recommends a voluntary rating system to encourage building owners to invest in the resilience of their buildings so that they not only stay standing after an earthquake, but so that they also remain functional.

Create a Back To Business Program

In the aftermath of a major earthquake, it is important that our business community is able to rebound as quickly as possible to minimize negative economic impacts and to provide residents access to important goods and services. Following a major earthquake, however, the City's ability to certify buildings as safe for use will be hampered by city services being focused on emergency response and by high demand on our cadre of building inspectors. Deploying inspectors from outside of the city through mutual aid agreements is time consuming.

This report recommends that the City develop a "Back to Business" program to rapidly supplement the capacity of the city's building inspection force in the event of a major earthquake.

Mandatory Retrofit of Buildings that are Excessively Damaged in Earthquakes

Mandate retrofitting of buildings that incur excessive damage in a low level of earthquake shaking.

Fortify our Water System

The water system is the utility most vulnerable to earthquake damage, and that damage could be the largest cause of economic disruption following an earthquake. Portions of the system are more than a century old and vulnerable to many types of damage. Lack of water would impede recovery and the long-term loss of a water supply could lead to business failure and even mass evacuation. Developing a more resilient water system is imperative for the future of Los Angeles.

Fortify our Water System

This report recommends the following actions:

Develop an Alternative Water System For Firefighting

Create a resilient, redundant alternative water system for firefighting by using reclaimed water, pressurized seawater, seismic resilient pipes and other methods.

Fortify the Los Angeles Aqueduct

Los Angeles is dependent on imported water that is transported across the San Andreas Fault in aqueducts. Therefore, mitigation alternatives for the Los Angeles Aqueduct crossing the San Andreas Fault should be identified and implemented.

Fortify Other Aqueducts

The city is dependent on several other aqueducts that are the responsibility of outside agencies with whom we must cooperate to ensure our water supply. The City should create a Seismic Resilience Water Supply Task Force with the DWP, California MWD, and the DWR, in an effort to create a collaborative and regional approach to protecting the resiliency of our water supply.

Fortify Water Storage

DWP dams must be maintained at a level that ensures a reliable water supply and public safety in the event of an earthquake.

Increase Local Water Sources

Increased use of local water reduces the risk posed by reliance on water imported via fault-crossing aqueducts. Initiatives to improve local water supplies through storm water capture, water conservation, water recycling, and San Fernando Valley Groundwater Basin contamination remediation provide the best possible protection and should be supported as fundamental earthquake resilience measures.

Create a Seismic Resilient Pipe Network

The water distribution pipes that carry water to our homes are vulnerable to failure during earthquakes, and large earthquakes that cause shaking over wide geographic areas can cause hundreds or thousands of simultaneous pipe breaks. DWP should commit to a future water system that utilizes seismically resilient pipes. The long-term goal should be to do this across the City. Due the complexity of the water system and the cost of pipe replacement, this will be a long-term project that begins in strategically critical areas serving essential facilities and firefighting needs.

Implement a Resilience by Design Program at DWP

L.A.'s power and water infrastructure is incredibly complex and susceptible to earthquake damage. The City should establish a Resilience by Design Program within the DWP, covering both the power and water systems, with resources and authority to keep an institutional emphasis on seismic resilience as a core function of the agency.

Develop a Statewide Seismic Resilience Bond Measure

Developing a strong resilience effort in a timely manner requires an investment greater than currently available budget allocations. The City should work with local, regional, and state partners to develop a seismic resilience bond measure to help fortify our water infrastructure and make other critical investments.

Enhance Reliable Telecommunications

Modern society and economic activity are dependent on telecommunications, including cell phones and Internet access. The Northridge earthquake occurred prior to these services being widely available, so we do not have direct experience with their vulnerabilities. We can, however, use the experiences in other countries and in other disasters to inform the efforts needed to protect vital communications systems.

Telecommunications

This report recommends initiatives to:

Maintain Internet Access After Earthquakes

To mitigate service impacts after an earthquake, the City should partner with service providers to remove barriers to bandwith and Internet access during emergencies. Under these agreements, service providers would, during declared disasters, share bandwidth and allow free temporary Wi-Fi access in public locations.

Protect the Power System at Fault Crossings

Our cellular network is vulnerable to power outages caused by earthquakes, and our electric grid is at high risk caused by powerlines that cross the San Andreas Fault. The City should create a Southern California Utility Resiliency Consortium to develop solutions for cascading failures in the interacting utilities as they cross the San Andreas fault. The lifelines belong to many different entities, public and private, that will need to cooperate to find solutions to the problems.

Create a Citywide Backup Internet System

Develop a solar-powered Citywide Wi-Fi to provide residents with a way to access the Internet at a time when the primary system is disrupted. This low power system could also serve as way to maintain communication through email and texting should electrical system failures cause other communications systems to fail.

Fortify Cellular Towers

Cellular towers are designed and constructed to life-safety standards, meaning that they are designed to be unlikely to collapse, but not necessarily be functional following an earthquake. The City should amend its building code to require new freestanding cellular communication towers to be built with an Importance Factor of 1.5. Existing towers would not be affected.

Advancement of Earthquake Early Warning

The City of Los Angeles and the U.S. Geological Survey have agreed to begin implementation of early warning in Southern California with projects with the Los Angeles Fire Department and the Los Angeles Unified School District. This partnership will allow the early warning development to eventually create a better system for all of California and other states. The City should work with Congressional representatives to ensure a robust Earthquake Early Warning system.

"Plans are worthless, but planning is everything. There is a very great distinction because when you are planning for an emergency you must start with this one thing: the very definition of 'emergency' is that it is unexpected, therefore it is not going to happen the way you are planning."

President Dwight D. Eisenhower, 1957

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Acknowledgements

This Report is the result of the work of many people, whose talents, skills, and expertise collaboratively developed this document. For many months they worked together to improve the resilience of Los Angeles. We are indebted to them all.

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Hollywood Chamber of Commerce
Hollywood Property Owners Alliance
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US Resiliency Council (USRC)
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Introduction

From a seismological standpoint, Northridge was not a big earthquake. The 1994 magnitude 6.7 earthquake occurred on a 10-mile long fault, lasted 7 seconds, and caused strong shaking (Intensity VIII and IX) in about 20% of the City of Los Angeles (USGS and SCEC, 1994). Similar to the 1906 San Francisco earthquake, future earthquakes generated by the San Andreas Fault are expected to be a magnitude 7.8 or higher, last about two minutes, and cause the same level of strong shaking over thousands of square miles (Jones et al, 2008). To be ready for our seismic future, it is critical that the City of Los Angeles set a higher standard than having recovered effectively from the Northridge earthquake.

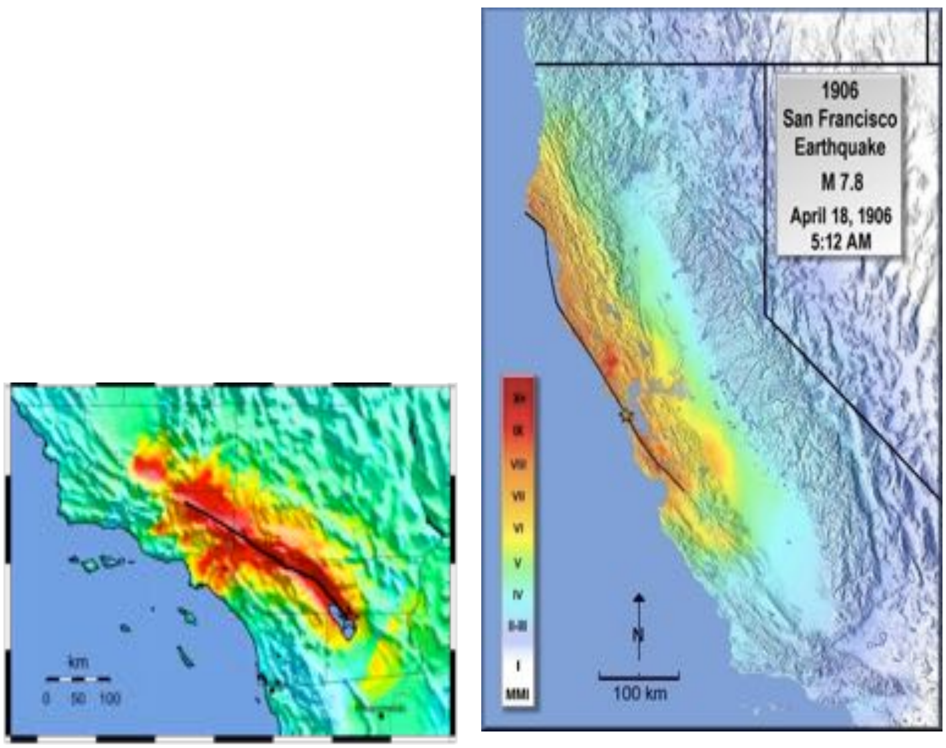

Figure 1.1. Maps of the intensity of earthquake shaking in the 1906 San Francisco magnitude 7.8 earthquake, the 1994 magnitude 6.7 earthquake, and predicted for a magnitude 7.8 earthquake on the southern San Andreas Fault. All maps are at the same scale.

According to Swiss Re, one of the world's largest reinsurance companies, Los Angeles faces one of the greatest risks of catastrophic loss from earthquakes of any city in the world, eclipsed only by Tokyo, Jakarta, and Manila (Swiss Re, 2013).

Policies, if not considered carefully, can design for disaster (Mileti, 1999. But, when thoughtfully developed, they can design for resilience. While the City of Los Angeles has been working on a number of fronts to increase its resilience to the effects of earthquakes, much more work remains to be done.

Earlier this year, Los Angeles Mayor Eric Garcetti appointed Dr. Lucy Jones of the United States Geological Survey (USGS) as his Science Advisor for Seismic Safety. This was enabled through a Technical Assistance Agreement with USGS. In addition, Mayor Garcetti organized: (1) experts in his office in the areas of resilience, emergency management, law, infrastructure, housing, building safety, communications, and sustainability; (2) a Technical Task Force that included leaders of the structural engineering community in California and subject matter experts from Los Angeles Department of Building and Safety; (3) subject matter experts on water systems within the Los Angeles Department of Water and Power; and (4) a Communications Task Force that included leaders in the Communications industry. Collectively, these experts constitute the Seismic Safety Task Force that prepared this Report.

The Seismic Safety Task Force provided critical information which supported the development of recommendations to address vulnerabilities with significant and attainable solutions. Overall, the recommendations aim to:

- Protect the lives of our residents during earthquakes;
- Improve the capacity of the City to respond to earthquakes;
- Prepare the City to recover quickly after earthquakes; and
- Protect the economy of the City and all of Southern California.

This Report's approach to evaluating the severity of the risk relies on the ShakeOut Scenario (Jones et al., 2008). The ShakeOut scenario was created by a multidisciplinary team convened by the Multi-Hazards Demonstration Project of the USGS. The Shakeout team included the California Geological Survey, Federal Emergency Management Agency ("FEMA"), Southern California Earthquake Center, and nearly 200 other partners in government, academia, emergency response, and industry, working to understand the impacts of a very large earthquake on the complicated social and economic interactions that sustain Southern California society.

The Shakeout Scenario considers the impacts of a probable magnitude 7.8 earthquake on the southern San Andreas Fault. It is not the worst earthquake possible. A full assessment of earthquake risk requires a probabilistic approach that accounts for the full range of faults, earthquakes, and likelihoods. The ShakeOut Scenario considers the impact of a single event that is large enough and likely enough to create a catastrophe in our lifetimes. The ShakeOut Scenario is not predicting, and does not need to predict, whether this particular earthquake will actually occur. The benefit of examining the consequences and far-reaching impacts of one such event, however, can help us prepare for other such events.

The magnitude 7.8 ShakeOut Scenario earthquake estimates approximately 1,800 deaths and $213 billion of economic losses across Southern California, consisting of: $47.7 billion due to shaking damage; $65 billion due to fire damage; $96.2 billion due to business interruption costs; and $4.3 billion due to traffic delays. The most significant triggered hazards in this scenario are landslides, utility disruptions caused by fault offsets, and fire. The Shakeout Scenario identified five major areas of loss in Southern California:

1. Older buildings that were built to earlier building code standards;
2. Non-structural elements and building contents that are generally unregulated;
3. Infrastructure crossings at the San Andreas Fault;
4. Business interruption from damaged infrastructure, including telecommunications, and especially water systems; and
5. Fire following the earthquake.

From this assessment, the Seismic Safety Task Force determined the most critical areas that could be addressed through policies developed by the City of Los Angeles, and which would have the greatest impact on the four goals of life-safety, emergency response, recovery, and economic resilience. Thus, the scope of this Report is directed at four specific areas of seismic vulnerability:

1. Pre-1980 "soft-first-story" buildings;
2. Pre-1980 "non-ductile reinforced concrete" buildings;
3. Water system infrastructure (including impact on firefighting capability); and
4. Communications infrastructure.

Using this approach, the Seismic Safety Task Force presents this Report, and seeks to spark the development of a culture in Los Angeles of creating “Resilience by Design.”

Why now? The risk to our economy

People fear earthquakes because they threaten our lives. Of all natural disasters, earthquakes have caused the greatest amount of fatalities in the world: 86,000 people died in the 2005 Pakistan 7.6 magnitude earthquake; 88,000 people died in the 2008 China 7.9 magnitude earthquake; and the more than 200,000 people died in the 2010 Haiti 7.0 earthquake (EERI, 2006; USGS, 2014c; USGS, 2011).

Almost all earthquake deaths result from the failure of human construction. Through the application of stronger building code requirements in Los Angeles, we have reduced much of the risk to our lives. Most of the risk we now face comes from the harsh reality that no building code in the world is retroactive. A building is only as good as the code that was in place when it was built. Neither concrete nor soft-first-story buildings can be constructed in Los Angeles today, but thousands of these buildings remain in existence around the City because they were built at a time when the building code permitted their construction. The collapse of the new Olive View Hospital in the 1971 San Fernando earthquake illustrated the inadequacies of the existing codes for reinforced concrete buildings, yet un-retrofitted structures continue to stand across Los Angeles. The 1994 Northridge earthquake revealed problems with soft-first-story construction, notably the collapse of the Northridge Meadows Apartments. According to the Public Policy Institute of California (2006), Los Angeles lost 49,000 housing units in the Northridge earthquake, two-thirds of which were in soft-first-story buildings. Again, the failure of these buildings did not make the thousands of soft-first-story buildings disappear (Xia, 2014). The larger ShakeOut Scenario of a southern San Andreas Fault earthquake predicts the collapse of 1,500 buildings, most of which would be concrete and soft-first-story buildings, causing almost 700 fatalities and thousands of other casualties (Jones et al., 2008).

To put these figures in context, the 700 fatalities reflected in the Shakeout Scenario are less than the number of people who will die in traffic accidents in Los Angeles over a three-year period (Los Angeles County Department of Public Health, 2011).

The relative risk that earthquakes pose to our economy, however, is much greater. The USGS and FEMA analyzed all of the faults across the nation and determined the expected loss from all of them. In that analysis, Los Angeles County alone represents one quarter of the expected losses of the whole country, an average of $1.5 billion per year (FEMA, 2008).

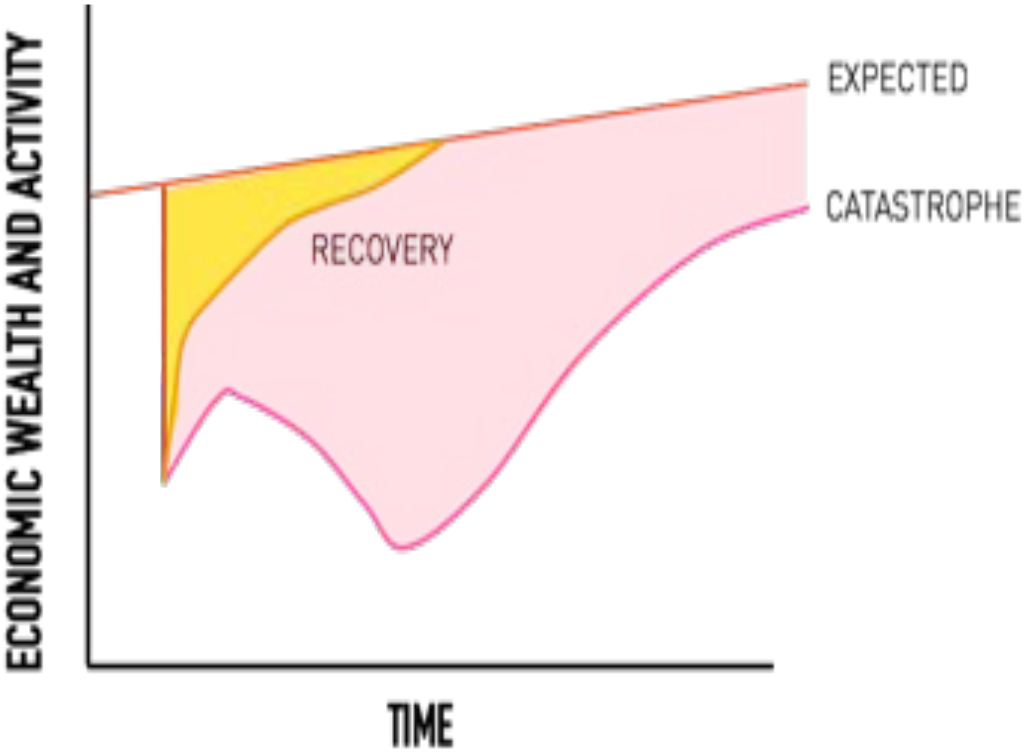

Figure 1-2. A schematic of the impact of a disaster on a regional economy, from Perry et al. (2008).

When the biggest earthquakes occur, with potentially hundreds of years of annualized loss happening at once, we face a catastrophic depression of our regional economy. When a damaging earthquake strikes there is an immediate drop in economic activity (see Figure 1-2). If infrastructure comes back into service without a long delay, the recovery will be quicker and the regional economy may return to its expected level within a few years. In great earthquakes, economic activity may not recover for several decades, resulting in economic catastrophe. In some cases, the economy remains functional but has a permanent long-term reduction compared to the pre-event levels. In the greatest extreme, the economic activity never recovers but continues to decline, disabling a safe and equitable lifestyle for city residents (Davis, 2012).

Hurricane Katrina stands as one of the most destructive natural disasters that the United States has weathered to date. After its initial landfall on August 25, 2005, and then again in Louisiana on August 29, 2005, the hurricane caused over 1,800 deaths. The vast majority of these fatalities occurred in Louisiana, particularly concentrated in New Orleans. In addition to these deaths, the hurricane caused an estimated $108 billion in direct damages in both Louisiana and Mississippi. Thousands of homes and businesses were destroyed, with debris from these ruined buildings remaining on the ground years after the storm waters had receded (Knabb et al., 2005).

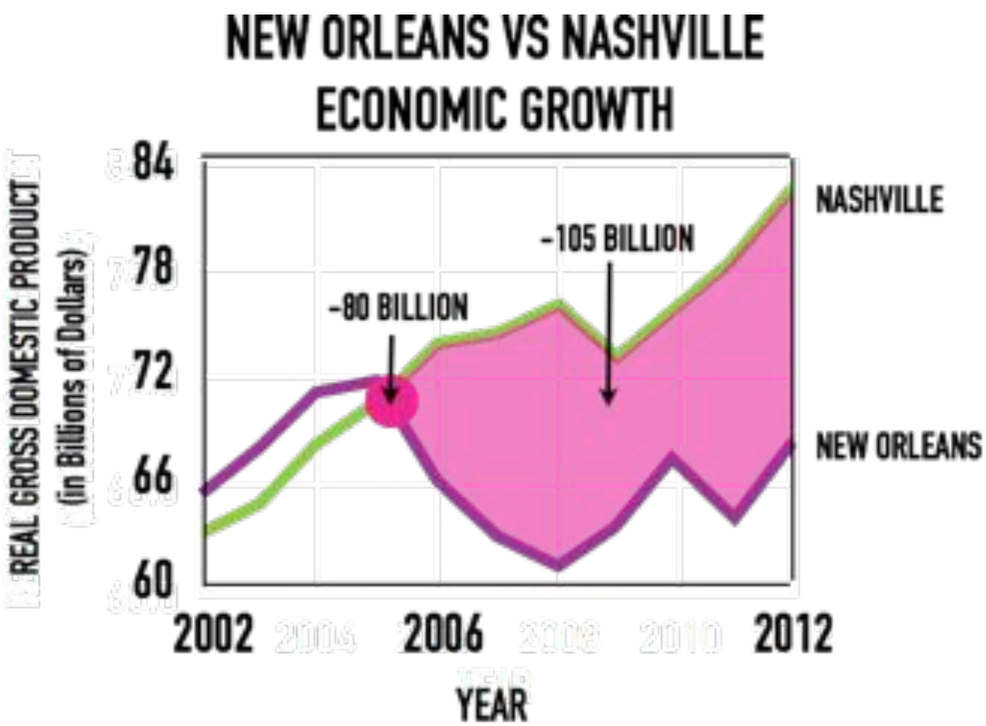

Figure 1-3. The Gross Domestic Product of the Nashville, TN and New Orleans, LA metropolitan area per year. Data Source: U.S. Bureau of Economic Analysis, Google Data

Yet even with all of this direct damage, one of the most chilling effects of the storm was how it severely reduced the long-term population in affected areas. From July of 2005 to June of 2006, 237,000 people migrated away from Louisiana (Olshanksy, 2006). By 2014, census data showed that only 100,000 of those people had returned (Corey, 2011). New Orleans maintained a unique and precious culture prior to Hurricane Katrina, and has struggled to recover to pre-Katrina conditions with a sizeable portion of its population still, perhaps even permanently, displaced. Should an earthquake cause comparable levels of devastation in Los Angeles, a similar migration pattern could occur. Losses would not be limited to those directly caused by the earthquake.

A similar long-term depression faced San Francisco after the great San Andreas earthquake of 1906. The economic disruption from the earthquake immediately reduced United States GNP by 1.5 to 1.8%. Most of the loss was covered by British insurance companies. The capital outflow prompted the Bank of England to raise interest rates and discriminate against American requests for loans. British bank policy pushed the United States into a recession and set the stage for the 1907 financial crisis. In 1905, San Francisco was the sixth largest city in the United States with a population of 400,000 (USGS, 2014a). Over the next two decades, as other American cities grew several fold, San Francisco initially dropped in population and later experienced only limited growth (Odell, 2004). The New Orleans and San Francisco examples demonstrate that building resilience is key to preventing negative long-term impacts.

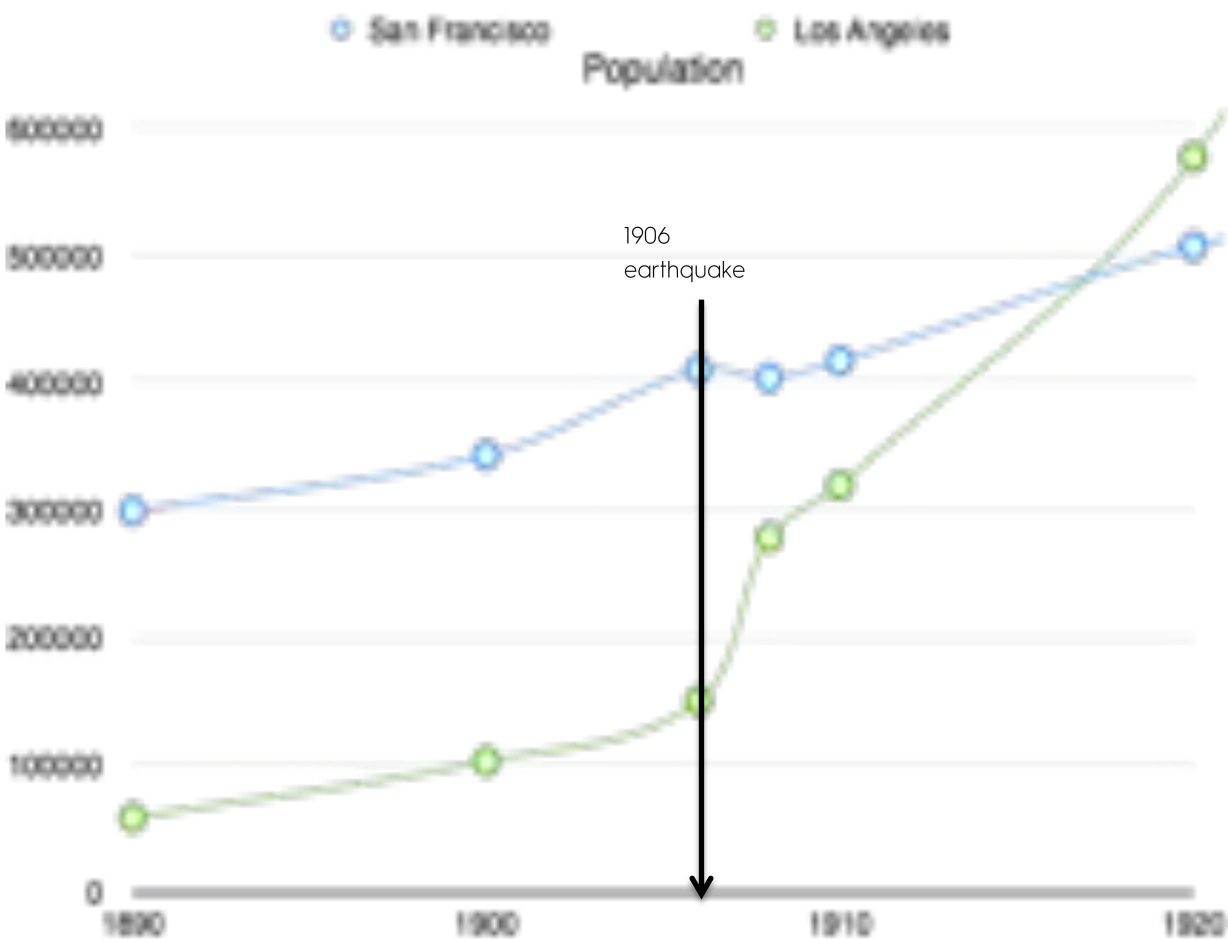

Figure 1-4. The population of the Cities of San Francisco and Los Angeles (U.S. Census Data). The population of Los Angles grew fivefold in the decade after the 1906 earthquake struck San Francisco.

For Los Angeles, the second most populous city in the United States, with a gross domestic product (GDP) of nearly $81 billion (Bureau of Economic Analysis, 2013), and home to the largest container and cargo port in the United States, the economic consequences from a large earthquake would be devastating and could generate unforeseeable rippling effects beyond City boundaries. A large earthquake affecting the City of Los Angeles impacts Los Angeles County, California and the entire nation.

In the wake of the major disasters that have taken place in recent years, the demand for a new proactive science-based approach toward resilience has surfaced. The first step is a thorough understanding of the vulnerabilities and the potential for single points of failure. This has already been done for large Southern California earthquakes through the work completed in the ShakeOut Scenario. The next step is to develop approaches that could reduce the vulnerabilities and the potential for catastrophic collapse.

This Resilience by Design Report is the beginning of that effort. The Report outlines recommendations for cultivating resilience in the City's soft-first-story and concrete building stock, and the region's water system and telecommunications network. Within a large city like Los Angeles, this is a complex task. Thus, the goal of this Report, and its set of recommendations, is not to eliminate all hazards or threats. Rather, it is to mitigate key known hazards and their cascading effects, with the ultimate goal of protecting the economic viability of the City of Los Angeles. Thus, Los Angeles can evolve into a City that creates its Resilience by Design.

References

Benfer, N. A., & Coffman, J. L. (1974). San Fernando, California, Earthquake of February 9, 1971. (Vols. 1A, 1B). Washington: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration.

Bureau of Economic Analysis, U.S. Department of Commerce. (2013, September 17). Economic Growth Widespread Across Metropolitan Areas in 2012. Retrieved from http://www.bea.gov/newsreleases/regional/gdp_metro/2013/pdf/gdp_metro0913.pdf

Corey, C. M., & Deitch, E. A. (2011). Factors Affecting Business Recovery Immediately after Hurricane Katrina. Journal of Contingencies and Crisis Management, 19, 169-181. Retrieved July 16, 2014, from the Wiley Online Library Database.

Davis, C. A., (2012, January 12). Lifeline System Serviceability and Megacity Disaster Resilience:

Multihazard Impacts in Coastal Regions. Retrieved from seminar proceedings on Large Scale Combined Geotechnical Hazards in Coastal Urban Areas, Kyoto University, Japan, Uji Obaku Campus.

Earthquake Engineering Research Institute (EERI). (2006, February). The Kashmir Earthquake of October 8, 2005: Impacts in Pakistan. Retrieved from https://www.eeri.org/lfe/pdf/kashmir_eeri_2nd_report.pdf

Federal Emergency Management Agency. (2008). HAZUS MH Estimated Annualized Earthquake Losses for the United States. Retrieved from http://www.fema.gov/media-library-data/20130726-1627-20490-0934/fema366b.pdf

Field, E.H., Biasi, G.P., Bird, P., Dawson, T.E., Felzer, K.R., Jackson, D.D., Johnson, K.M., Jordan, T.H., Madden, C., Michael, A.J., Milner, K.R., Page, M.T., Parsons, T., Powers, P.M., Shaw, B.E., Thatcher, W.R., Weldon, R.J., II, and Zeng, Y., 2013, Uniform California earthquake rupture forecast, version 3 (UCERF3)—The time-independent model: U.S. Geological Survey Open-File Report 2013–1165, 97 p., California Geological Survey Special Report 228, and Southern California Earthquake Center Publication 1792, http://pubs.usgs.gov/of/2013/1165/.

Jones, L. M., Bernknopf, R., Cox, D., Goltz, J., Hudnut, K., Mileti, D., Perry, S., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., & Wein, A. (2008). The ShakeOut Scenario: U.S. Geological Survey Open-File Report 2008-1150 and California Geological Survey Preliminary Report 25. Retrieved from http://pubs.usgs.gov/of/2008/1150/

Knabb, R., Rhome, J., & Brown, D. (2005). Tropical Cyclone Report Hurricane Katrina 23-30 August 2005. National Hurricane Center. (2005, December 20). Retrieved August 14, 2014, from National Hurricane Center.

Los Angeles County Department of Public Health. (2011). Mortality In Los Angeles County 2011. Retrieved from http://publichealth.lacounty.gov/dca/data/documents/mortalityrpt11.pdf

Mileti, Dennis. (1999). Disaster by Design: A Reassessment of Natural Hazards in the United States. Washington, D.C.: Joseph Henry Press.

Olshansky, R. (2006). Planning After Hurricane Katrina. Journal of the American Planning Association, 72, 147-153. Retrieved July 14, 2014, from the Taylor and Francis Online Database

Odell, K. A. & Weidenmier, M.D. (2004, December 4). Real Shock, Monetary Aftershock: The 1906 San Francisco Earthquake And The Panic Of 1907. Journal of Economic History, 6, 1002-1027.

Perry, S., D. Cox, L. Jones, R. Bernknopf, J. Goltz, K. Hudnut, D. Mileti, D. Ponti, K. Porter, M. Reichle, H. Seligson, K. Shoaf, J. Treiman, , and A. Wein, 2008, The ShakeOut Earthquake Scenario; a story that southern Californians are writing: U.S. Geological Survey Circular 1324 and California Geological Survey Special Report 207, 16 p. [http://pubs.usgs.gov/circ/1324/].

Philibosian, B., Fumal, T., and Weldon, R. (2011). San Andreas Fault Earthquake Chronology and Lake Cahuilla History at Coachella, California. Bulletin of the Seismological Society of America, 101 (1). pp. 13-38. ISSN 0037-1106

Public Policy Institute of California - Northridge Earthquake- Just the Facts, April 2006, http://www.ppic.org/content/pubs/jtf/JTF_NorthridgeJTF.pdf

Swiss Re. (2013). Mind the Risk, A global ranking of cities under threat from natural disasters. Retrieved from http://media.swissre.com/documents/Swiss_Re_Mind_the_risk.pdf

U.S. Geological Survey. (2011). Earthquake Information for 2010. Retrieved from http://earthquake.usgs.gov/earthquakes/eqarchives/year/2010/

U.S. Geological Survey. (2014a). Casualties and damage after the 1906 Earthquake. Retrieved from http://earthquake.usgs.gov/regional/nca/1906/18april/casualties.php

U.S. Geological Survey. (2014b). 1857 Fort Tejon Earthquake. Retrieved from http://earthquake.usgs.gov/research/parkfield/1857.php

U.S. Geological Survey. (2014c). Magnitude 7.9 - Eastern Sichuan, China. Retrieved from http://earthquake.usgs.gov/earthquakes/eqinthenews/2008/us2008ryan/#summary.

U.S. Geological Survey and the Southern California Earthquake Center. (1994, October 21). The Magnitude 6.7 Northridge, California, Earthquake of 17 January 1994. Science. 266, 389-397.

Xia, Rosanna. (2014). L.A. to list Structures that could be at risk in quake. Los Angeles Times. Retrieved from http://www.latimes.com/local/la-me-earthquake-inspections-20140529-story.html

Strengthen Our Buildings

Overview

The most obvious threat from earthquakes is physical damage to vulnerable buildings. Buildings can be built to withstand strong earthquake shaking, but because of the increased costs associated with such enhancements, most are not. Many people believe that the modern building code ensures that our buildings will not be severely damaged in earthquakes. The current building code, however, was designed to maximize life-safety (Liel et al., 2010), and not to minimize building damage. This standard means that while buildings are designed to remain standing and protect occupants from collapse, they are not designed to remain usable after strong earthquakes. A strong earthquake in Los Angeles would cause some buildings to collapse, but would leave many more standing but unusable, which would close businesses, deny residents access to goods and services, and devastate our economy.

Further, building codes are not retroactive. This means that building code changes do not trigger automatic retrofits of buildings built to earlier codes. Earthquakes often trigger building code changes after shaking exposes weaknesses in types of buildings or construction techniques. But this only results in future buildings reflecting the lessons learned; existing buildings remain in their vulnerable state.

In the recent history of Los Angeles, the strongest earthquake shaking has been experienced in the northern parts of the San Fernando Valley in 1971 and 1994 (USGS, 2014). The result is that many buildings located in other parts of the City have not experienced the impact of strong earthquake shaking, and remain largely "untested." Thus, these buildings may have hidden vulnerabilities that might only be discovered in the next large earthquake.

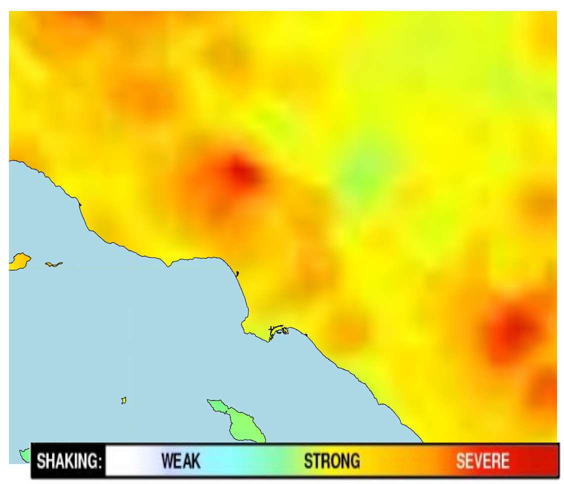

Figure 2-1. Historic intensity Map. The maximum level of shaking (described by the Modified Mercalli Intensity scale) recorded in southern California in any earthquake in the 20th Century. (Figure from D. Wald, USGS 2014)

In order to address the issues posed by these building vulnerabilities and to further the efforts of this Report, Mayor Garcetti convened a Technical Task Force that met throughout 2014. The Task Force included leaders of the structural engineering community in California, and subject matter experts from the Los Angeles Department of Building and Safety. The Task Force discussed these vulnerabilities, evaluated the types of buildings that pose the greatest risk, and developed recommended approaches to fixing these issues.

The Scope of the Problem

The 1994 Northridge earthquake demonstrates the scale of the problem. The fault in the Northridge earthquake was about 10 miles long, resulting in the strongest shaking occurring mostly in the western part of the San Fernando Valley. This equates to approximately 20% of the area of the City (USGS 2014). Further, the highest levels of shaking were in the Santa Susanna Mountains (the dark red areas illustrated in Figure 2-2).

In spite of this, more than 130,000 buildings required inspection due to earthquake damage. The total number of buildings in Los Angeles was estimated to be 1.2 million, so approximately 11% of all buildings in Los Angeles were affected by this earthquake.

It is important to note that Northridge was not a large earthquake by geologic standards. In contrast to the fault that produced the Northridge earthquake, which was only 10 miles long, it is estimated that the part of the fault that will move in a San Andreas earthquake will be 200 miles or longer. In a San Andreas earthquake, intense shaking could take place across much of Southern California (Jones et al., 2008).

The financial consequences of the estimated building losses in a San Andreas earthquake are dramatic, with about $38 billion in direct losses to buildings (Jones et al., 2008). These losses can grow exponentially as a result of businesses in both the damaged buildings and their neighboring buildings being unable to open.

This scenario has played out in other earthquakes around the globe. For example, in the 2011 Christchurch, New Zealand earthquake, only two buildings collapsed but 70% of the buildings in the Central Business District (CBD) were damaged and were too dangerous to occupy (LawNews, 2014). However, all of the buildings in the CBD were closed because of the possibility that an aftershock would cause a damaged building to collapse into the street or onto a neighboring building. Thus, in addition to damage from a weak building impacting that building's owner and tenants, weak buildings also impact neighboring buildings and their tenants, workers, and customers. In addition, damaged buildings that are not removed can lead to blight that reduces the property values for everyone in the City. Thus, when considering the impact of seismic safety measures, it is important to consider the impact on the whole community and not just the individual building owner.

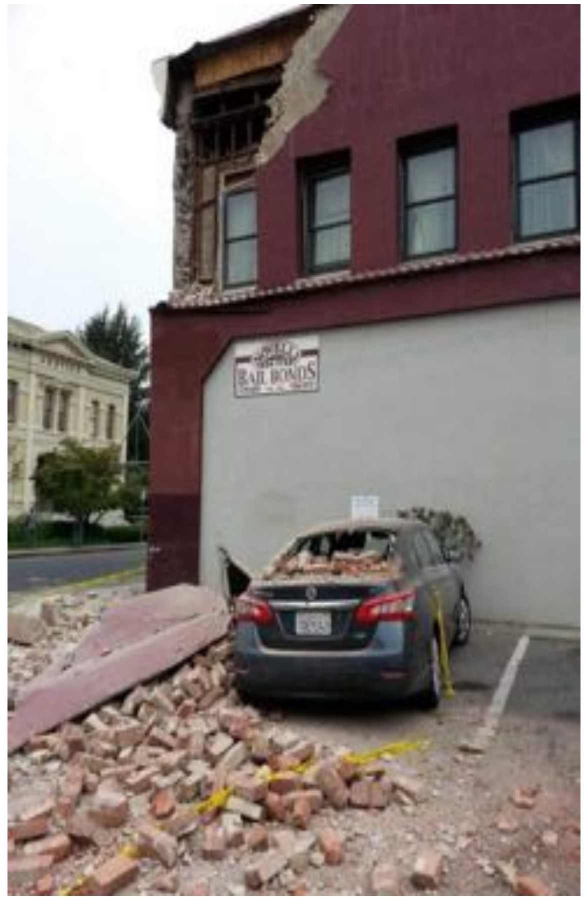

Figure 2-4. Damage to an unretrofitted URM building in the 2014 South Napa earthquake. Adjacent buildings were temporarily closed until this building could be secured. Photo: J. Maffei

Seismic Resilience in the Building Code

Despite the number of earthquakes in California, there have been challenges to developing a seismically resilient building code. Historically, significant code changes have only been made following large-scale earthquakes. For example, the first building code to have a seismic design provision was the 1927 Uniform Building Code (UBC), which was developed after the damage from the 1925 Santa Barbara earthquake (FEMA, 1998), but even then it was only included as an appendix to the main building code. It was not until 1961 that seismic design provisions moved from an appendix to the main body of the UBC (FEMA, 1998) and it was not until 1989 that all California jurisdictions were required to use the most recent edition of the UBC.

The worst buildings in earthquakes are unreinforced masonry buildings (URMs), which are buildings where walls of either brick or stone held together with mortar support the roofs. Damage to brick buildings in the magnitude 6.4 1933 Long Beach earthquake led to a recommendation against building URMs in the most seismically active areas (Green, 2011).

Figure 2-3. Damage to an unreinforced masonry building in the 1933 Long Beach earthquake. Source: USGS

Yet, even the clear danger these buildings pose in an earthquake was not sufficient impetus to eliminate these buildings through legislative action. While new URM buildings are no longer constructed, older buildings built to earlier building codes remained. Thus, during subsequent earthquakes, such as the magnitude 7.5 1952 Kern County earthquake and the magnitude 6.7 1971 San Fernando earthquake, their predictable collapse continued to be responsible for the loss of life.

Los Angeles led the way in reducing the vulnerability of these URM buildings with the first-ever mandatory retrofit ordinance in 1981 (City of Los Angeles, 1981). Inspired by this example, the State of California passed an ordinance in 1986 requiring all local jurisdictions to catalog their URMs and develop a retrofitting program (California Legislature, 1986), that could be either mandatory or voluntary.

The California Seismic Safety Commission has monitored the progress of all the voluntary and mandatory URM retrofitting programs. As a result, the URM program offers an opportunity to compare the effectiveness of different types of retrofitting programs, and whether mandatory or voluntary programs can be successful. Mandatory programs were adopted by 134 jurisdictions, while 126 jurisdictions chose voluntary or notification programs.

Under mandatory retrofit programs, 87% of URMs have either been retrofitted or demolished. Under voluntary programs, only 22% of URMs have been retrofitted or demolished (California Seismic Safety Commission, 2006). In the City of Los Angeles, which has the longest-running mandatory URM retrofit program, over 99% of URMs have been retrofitted or demolished. Thus, mandatory programs have a higher rate of successfully eliminating dangerous buildings.

Soft-First-Story Buildings

Issue

Soft-first-story buildings have large open sections on the first floor, such as garages, tuck-under parking spaces, or large windows that create an unusually flexible or weak first story. They therefore do not have the resistance to an earthquake's shear (sideways) motions that is needed to hold up the upper floors. Because the damage to a soft-first-story building is concentrated in the lowest level, the first floor collapses and the rest of the building "pancakes" onto the first floor. This results in the complete destruction of the building and the potential for significant loss of life (FEMA, 2012a).

Figure 2-5. The Northridge Meadows Apartments after the January 17, 1994 Northridge earthquake. Source: Los Angeles Times

In Southern California, many soft-first-story buildings are apartment complexes with tuck- under parking. This type of building was built extensively beginning in the 1960s, in light of the growing need for parking spaces. This structure type includes the Northridge Meadows apartment building that collapsed during the 1994 earthquake and killed 16 people. In addition to apartment complexes, soft first stories can also be found in other types of residential and commercial or industrial buildings.

Background

The 1994 Northridge earthquake demonstrated the weaknesses in soft-first-story buildings and the impact such structures have on the City following an earthquake. Similar to the Northridge Meadows apartment complex mentioned previously, two-thirds of the 49,000 housing units made uninhabitable by the Northridge earthquake were structures with soft first stories, making soft-first-story buildings the most damaged type of building from that earthquake (California Seismic Safety Commission, 1995). In total, about 200 soft-first-story buildings suffered severe damage or complete collapse (FEMA, 2012b).

The economic impact of these losses went well beyond the loss of the buildings. Tenants, homeowners, and business owners all struggled with the effects of the earthquake. Soft-first-story buildings housed many low-income residents with fewer options for recovery, leaving many displaced from their homes and seeking shelter. It is noteworthy that the only years in which Los Angeles has experienced a decrease in population are 1971-1972 and 1994-1995, which are the two years after our two largest earthquakes (U.S. Census data).

Currently, there are more than 29,000 wood-frame apartment buildings with five or more units built prior to 1978 (the year that California adopted the 1976 Uniform Building Code) in the City of Los Angeles, and nearly 16,000 of these are estimated to be soft-first-story buildings. All of them are subject to the rent-stabilization ordinance. The loss of these rent-stabilized buildings in a big earthquake would eliminate a large amount of affordable housing in Los Angeles.

Fortunately, the engineering problem with soft-first-story buildings is easily understood. The remedy to the structural problem is straightforward and can be performed without considerable disruption to a building's residents.

Recommendation

Mandatory Retrofit of Soft-First-Story Buildings. Implementation of a City ordinance requiring mandatory retrofit of soft-first-story buildings. The Seismic Safety Task Force proposes the draft ordinance that is presented in Appendix A.

The main features of this proposed solution include:

- The retrofit will be mandatory for all soft-first-story buildings except for single-family homes and residences with three or fewer units.
- The Los Angeles Department of Building and Safety (DBS) will identify the buildings covered by this ordinance and will notify those building owners.
- Retrofitting will address the first floor structural deficiency.
- Retrofitting of these buildings will be completed within five years after passage of the ordinance.

Non-Ductile Reinforced Concrete

Issue

Non-ductile reinforced concrete buildings are among the deadliest buildings in earthquakes around the world. California faced this problem with the collapse of the Olive View Hospital in the 1971 San Fernando earthquake, which exposed the deficiencies of these types of buildings and led to significant changes in the building code that prevented their future construction. However, older concrete buildings with these problems still exist across the City.

Older non-ductile reinforced concrete buildings are currently used as apartment complexes, schools, hospitals, office buildings, warehouses and more. Thousands of people in Los Angeles live and work within these structures every day (Anagnos et al., 2012). Significant damage to this type of building could not only present immediate safety concerns following a major earthquake, but could cause long-term or even permanent disruption to a community. Repairing damage or demolishing unsafe buildings, with the resulting loss of tenant space and the closure of businesses, are costs that can cripple the economy. The loss of historic buildings and landmarks could also change the character of Los Angeles.

Network for Earthquake Engineering Simulation (NEES) data estimates that Los Angeles has over 1,400 non-ductile reinforced concrete buildings, many of which could be at risk for collapse in future earthquakes (Anagnos et al., 2012). The ShakeOut Scenario estimates that if the San Andreas earthquake happens on a weekday morning, almost 8,000 people will be in commercial concrete buildings that suffer partial or total collapse (Jones et al., 2008). Non-ductile reinforced concrete buildings, therefore, pose a significant threat to the life safety, business continuity, and economic resilience of the Los Angeles region.

Figure 2-7. The Kaiser Permanente Office Building, a non-ductile concrete building that suffered partial collapse in the January 17, 1994 Northridge earthquake.

Background

Concrete buildings are a major contributor to earthquake losses around the world. In California, those constructed to building code standards earlier than the code improvements in 1976 are at particular risk for collapse and pose significant life-safety hazards.

While ductile materials and appropriate connections and detailing have the ability to plastically deform or bend in order to absorb high amounts of energy before failure, brittle materials and detailing do not. Non-ductile reinforced concrete buildings are brittle, and they have a limited capacity to absorb the energy of strong ground shaking past their limited elastic range, increasing the likelihood of collapse and mortality for inhabitants.

Concrete building damage has been the cause of significant losses in past California earthquakes. The Olive View Hospital, the San Fernando Valley Juvenile Hall, Camp Karl Holton Juvenile Facilities, several hospitals, and the Sheraton-Universal Hotel were heavily damaged or partially collapsed (Benfer, 1974) in the 1971 San Fernando earthquake. The 1994 Northridge earthquake caused failures in older, non-ductile concrete-frame structures, including Saint John's Hospital, John F. Kennedy Senior

High School, Champaign Tower, a Holiday Inn, and a Kaiser Permanente Office Building (EERI, 1995).

Similar failures have been seen globally. The collapse of two reinforced concrete structures in the 2011 Christchurch, New Zealand magnitude 6.3 earthquake caused 135 out of the 182 total fatalities (Kam, 2011).

In a strong earthquake here, we can expect that some concrete buildings will collapse but that many more will have to be torn down because they are unsafe due to damage.

Data from the California Office of Emergency Services, shown in the figure below, evidences the damage incurred by concrete buildings during the 1994 Northridge earthquake. A red tag indicates that a building experienced significant damage and was unsafe for habitation. A yellow tag identifies a building that experienced moderate damage, but that might have been available for use following repair. A green tag means the building was safe, although it might have incurred some slight damage.

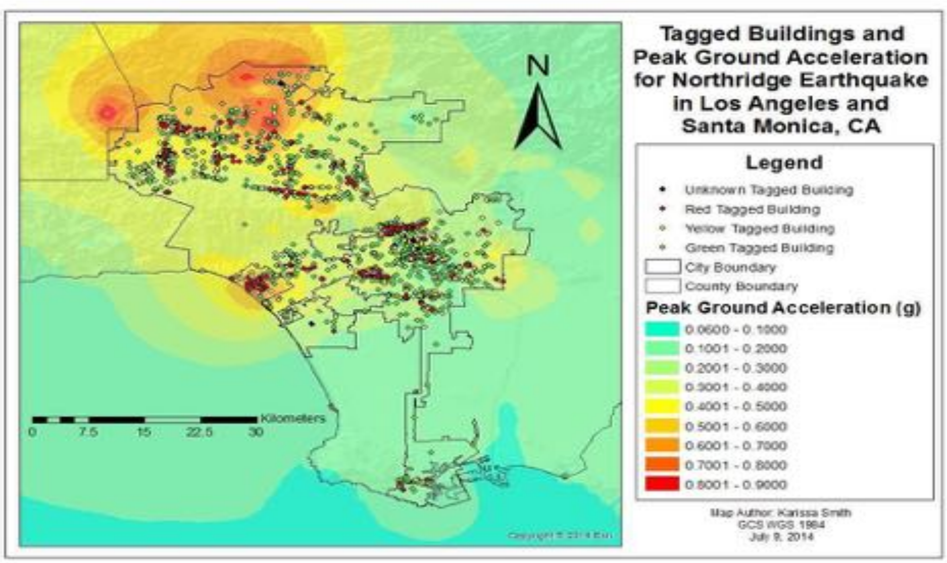

Figure 2-8. The figure above refers to concrete buildings. A relatively small portion of Los Angeles actually received strong shaking in the Northridge earthquake, where more than 30% of concrete buildings suffering significant damage.

In the areas of the City that experienced low levels of shaking, 18% of buildings inspected received a red or yellow tag. In areas of the City that experienced higher shaking levels, at least 30% of buildings were designated with red or yellow tags. And this was a region where the worst concrete buildings had already been damaged and removed in 1971.

That any buildings were damaged in areas with lower levels of shaking demonstrates that some buildings are particularly weak. One building might be more damaged than a neighboring building because a) its design makes it inherently weaker, b) the implementation of the design (actual techniques and materials in construction) was substandard, or c) the soils under that lot are particularly loose or otherwise amplify shaking from the earthquake. These circumstances will continue to exist in future earthquakes, so a building that incurs significantly more damage than its neighbors in an earthquake is expected to continue to perform poorly in subsequent earthquakes.

One way to address this is to require any building that is disproportionately damaged in low levels of seismic shaking to be retrofitted and seismically upgraded when the earthquake damage is repaired. Such an "Excessive Damage Ordinance," similar to one developed in San Francisco, can be an effective way to identify those buildings most at risk. While building evaluations by engineers generally succeed at identifying the buildings at risk, actual earthquake shaking is the best test of a building's strength.

Unlike other types of buildings, identifying the concrete buildings that are at risk poses challenges since a simple visual inspection does not reveal which buildings are at risk. The engineering community has developed an approach to identifying vulnerable concrete buildings. The American Society of Civil Engineers (ASCE) has developed ASCE 41, a document that describes the standards and process for assessing and retrofitting these types of buildings (Pekelnicky and Poland, 2012). A FEMA-funded research project currently underway by the Concrete Coalition, a collaboration of entities focused on assessing and mitigating the risk associated with dangerous non-ductile concrete buildings, is developing a more refined set of criteria to better identify the buildings that are the most likely to fail during an earthquake. The results of this study are expected by 2016.

The California Seismic Safety Commission recommended retrofit of concrete buildings in 1995, but no jurisdiction has adopted a mandatory retrofitting program (California Seismic Safety Commission, 1995). Similar to its approach to the URM issue, Los Angeles has the opportunity to be a leader in tackling the concrete building challenge and, if it does, will enhance its resilience as a City tremendously.

Recommendations

Mandatory Retrofit of Concrete Buildings. Mandate that concrete buildings designed prior to the enactment of the 1976 Uniform Building Code meet the Basic Safety Objective (BSO) in the ASCE 41. The Seismic Safety Task Force proposes the draft ordinance that is presented in Appendix B.

The main features of this proposed solution include:

- Mandatory retrofitting for all concrete buildings designed to a building code prior to the 1976 Uniform Building Code.
- The minimum standard for retrofitting is the Basic Safety Objective in ASCE 41.
- Owners would have five years after enactment to complete an evaluation with a structural engineer to determine what if any retrofitting they will need to complete. After certification of this evaluation by the Department of Building and Safety, the building owner will then submit a retrofitting plan.
- Owners would have 25 years to complete the retrofit work.
- The retrofitting process, include the evaluation, the submission of plans, and the actual retrofitting will be complete within 30 years.

Mandatory Retrofit of Buildings that are Excessively Damaged in Earthquakes. Mandate retrofitting of buildings that incur excessive damage in a low level of earthquake shaking (less than 40%g on the USGS ShakeMap).

Back To Business Program

Issue

Recovery from a major earthquake, and the resiliency of Los Angeles, will depend upon our collective ability to ensure that the business community is able to rebound quickly and return to a normal level of functionality. If this can be achieved, residents will be more likely to return to their jobs and will be less likely to leave or abandon the City. In the event of a major catastrophic earthquake, the City will be required to focus on essential core services in order to ensure the safety of its four million inhabitants. Further, the City's cadre of Building Inspectors may be stretched thin and it could take days for mutual aid inspectors to be activated, mobilized, and ready to work. In the biggest events, hundreds of other jurisdictions will be competing for the available volunteer inspectors.

Background

The inspection of the City's hundreds of thousands of buildings can be facilitated by the development of a program where the City pre-certifies private emergency inspectors, who are licensed engineers, to be automatically deputized upon Declaration of an Emergency. These pre-certified engineers, who will work in collaboration with the City's Department of Building and Safety, can assist businesses in inspecting specific pre-identified buildings. The resulting benefit will be that many businesses will no longer need to wait for a City inspector or mutual aid inspector to arrive. The City's resiliency efforts would be enhanced by enabling people to get back to work quickly, and enabling local businesses to support the community with needed supplies and commerce.

Such a program is not without precedent, and the need for such a program is illustrated by evaluating large-scale earthquakes in California. Statistics from the 1989 Loma Prieta earthquake, the 1994 Northridge earthquake, and other large-scale earthquakes demonstrate that such events can overwhelm the capabilities of a City, and stretch all of its resources. In the two weeks following the Northridge earthquake, there were an average of 176 volunteer building inspectors each day assisting in the City's effort to assess building safety. (Barnes, 2014).

After the 1989 Loma Prieta earthquake, San Francisco created a program to permit a building owner to retain a qualified engineer who would be available to inspect the building following a major earthquake and would, therefore, allow City officials to address other post-earthquake community needs. Furthermore, the City of Glendale and a major film studio there established a program allowing for pre-qualified engineers to inspect its buildings.

While there are mutual aid programs available to assist any jurisdiction with post-earthquake inspections, the need following a catastrophic earthquake will be great. For example, the State's Safety Assessment Program (SAP) includes a mutual aid agreement to deputize trained engineers and architects as SAP Inspectors. This program can be a tremendous resource for local jurisdictions following a major earthquake. Unfortunately, it can take several days to request the aid, organize the inspectors, arrange for their transportation into an affected area, organize the assignments, and then, finally, start inspecting. Many jurisdictions will also be vying for their services following a major earthquake. Incorporating a cadre of private building inspectors, who work in cooperation with City officials, can improve the resiliency of the City and its business community.

Recommendation

Adoption of a Back to Business Program: Adopt a "Back to Business Program" to supplement the capacity of the City's building inspection force in the event of a major earthquake. The Seismic Safety Task Force's proposal is presented in Appendix C.

The main features of this proposed solution include:

- Private emergency inspectors will be pre-certified by the Los Angeles Department of Building and Safety and will be retained by participating building owners.
- The certified inspectors will respond to and inspect the building.
- The certified inspectors will work with the Department of Building and Safety to evaluate the inspection. The Department of Building and Safety will review the recommended posting and issue the official Building and Safety Placard on the building.

Rating System

Issue

Buildings in any City are built under a variety of building codes, depending on what code was in effect at the time the building was designed and constructed. Some buildings have been retrofitted or otherwise structurally enhanced over the years and some have not. The result is that absent the assistance of an evaluation by a structural engineer, the average building owner, prospective building purchasers, tenants, residents, or other members of the public do not have a clear understanding of a building's seismic strength. Moreover, current code only requires life-safety and many people are unaware that code-compliant buildings may very well be a complete financial loss.

Background

The United States Resiliency Council (USRC) is a nonprofit organization, formed by structural engineers in California, which has developed a consensus approach to rating the seismic resilience of buildings. The result is a methodology that can be utilized to rate buildings that will ensure that reliable and consistent information is available to the general public about the seismic resiliency of buildings. This rating system has the following characteristics (U.S. Resiliency Council, 2014):

- It is a voluntary rating system;
- It rates buildings from one star (poor) to five stars (excellent);
- A three star building is a building designed and constructed to the current building code. Buildings constructed to a higher standard have the opportunity to obtain the higher star ratings; and
- Buildings that obtain a lower star rating can increase the number of stars received through the retrofitting of the building.

Thus, the rating system is designed to encourage the construction of buildings that exceed the minimum standards articulated in the current building code, which would be more likely to be able to be utilized following a catastrophic earthquake. Further, sharing the information about the seismic strength of existing buildings should enhance the market's desire for stronger and more resilient buildings.

Specifically, the USRC rating system ranges from one star (loss of life is probable in the building) to five stars (expected to be usable after the largest probable earthquake). In order to determine the exact rating of any building, an engineer must complete a building evaluation. An average person, however, can estimate a building's rating by knowing:

(1) The type of construction (stucco-wood frame, concrete, steel, etc.);

(2) The date of construction; and

(3) Whether the building has been retrofitted.

The following table offers a comparison of the USRC ratings with general types of building construction. The dates provided refer to years in which the Los Angeles building code was revised. In 1989, the State of California passed legislation that required all jurisdictions to use the most recent version of the Uniform Building Code (before 1997) or International Building Code (after 1997). Before 1989, different cities may have adopted the Uniform Building Code at different times.

Table 1 General Range of Safety Star Rating – City of Los Angeles

Type of construction	Date of construction			
	Before 1935	1935-1976	1976-1997	After 1997
Wood frame buildings, with or without stucco	2 or 3 stars. Early houses not bolted to their foundation or with cripple walls could be 1 star.		3 or 4 stars. Assuming wood sheathed shear walls and cripple walls.	3 or 4 stars.
Unreinforced masonry (brick)	Not built after 1935. All such buildings in the City of Los Angeles known to the Building Department have been retrofitted. This reduces loss of life but will not preserve the function of the building - 1 or 2 stars.			
Concrete	1 star unless retrofitted or assessed as safe by a structural engineer, then 2 stars		2 or 3 stars	3 or 4 stars
Steel	N/A	2 to 3 stars	2 to 3 stars	3 or 4 stars
Public safety facilities	1 or 2 stars	1 to 3 stars if retrofitted	2 to 4 stars	4 stars
Hospitals	Because of state regulations, existing hospital buildings built before 1976 and still in use should achieve 2 to 3 stars. Hospitals built between 1976 and the mid 2000's before the more common use of advanced technologies such as base isolation may achieve 3-4 stars. Hospitals built within the past decade are expected to achieve 4 or more stars.			
Base Isolated Buildings	Base isolation technology is able to provide a 5 star rating. It was first implemented in California in 1985. It has been used in the design of new buildings and the retrofit of existing buildings including Los Angeles City Hall.			

Recommendation

Voluntary Ratings of Buildings. Adoption and implementation of a voluntary rating system, utilizing the system designed by the United States Resiliency Council. The Seismic Safety Task Force's proposal is presented in Appendix D.

The main features of this proposed solution include:

- Adoption of the USRC system.
- Dissemination of information about the rating system to the public about how the rating systems work, and how they can use the information.
- Rating of City-owned buildings.

References

American Legal Publishing Corporation. (1998). Los Angeles Municipal Code: Chapter IX Building Regulations: Article 1 Buildings: Voluntary Earthquake Hazard Reduction in Existing Wood Frame Residential Buildings with Soft, Weak, or Open Front Walls. Retrieved from: http://www.amlegal.com/nxt/gateway.dll/California/lamc/municipalcode/chapterixbuildingregulations/article1buildingsbuildingcode?f=templates$fn=altmain-nf.htm$q=[field%20folio-destination-name:%27C9A1D93%27]$x=Advanced#JD_C9A1D93

Anagnos, T., Comerio, M., Goulet, C., May, P., Greene, M., McCormick, D., & Bonowitz, D.. (2012). Developing Regional Building Inventories: Lessons from the Field. Earthquake Spetra, V. 28, n.4, p. 1305-1329.

Association of Bay Area Governments. (2014). Speeding Up Post-Disaster Business Building Reoccupancy. Retrieved from: http://www.abag.ca.gov/bayarea/eqmaps/business/BORP.html

Applied Technology Council. (2009). ATC 52-3: Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings. Retrieved September 16, 2014 from http://www.sfgsa.org/modules/showdocument.aspx?documentid=9756

Barnes, James, Lead Statewide Safety Assessment Program Coordinator, California Governor's Office of Emergency Services, interview November 2014.

Benfer, N. A., & Coffman, J. L. (1974). San Fernando, California, Earthquake of February 9, 1971. (Vols. 1A, 1B). Washington: U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration.

California Legislature. "The URM Law," Section 8875 et seq., Government Code, California Statutes of 1986,

U.S. Geological Survey. (2007, February 1). CISN ShakeMap for Northridge Earthquake. Retrieved September 15, 2014 from http://earthquake.usgs.gov/earthquakes/shakemap/sc/shake/Northridge/

California Seismic Safety Commission (2007). The Field Act and Public School Construction: A 2007 Perspective. Seismic Safety Commission. Retrieved September 15, 2014, from http://www.seismic.ca.gov/pub/CSSC_2007-03_Field_Act_Report.pdf

California Seismic Safety Commission. (1995). Northridge Earthquake Turning Loss to Gain. Retrieved from http://www.seismic.ca.gov/pub/cssc95-01/cssc5-01b-toc.pdf.

California Seismic Safety Commission. (2006). Status of the Unreinforced Masonry Building Law: 2006 Progress Report to the Legislature, Seismic Safety Commission SSC Report 2006-04. Retrieved September 15, 2014 from http://www.seismic.ca.gov/pub/CSSC%202006%20URM%20Report%20Final.pdf

City & County of San Francisco, Department of Building Inspection. (2014). BORP Guidelines for Engineers. Retrieved from http://sfdbi.org/borp-guidelines-engineers

City of Glendale. (2014). 20 Years after Northridge Earthquake Be: Ready with Glendale's Back to Business Program. Retrieved from http://www.glendaleca.gov/Home/Components/News/News/8/2129?arch=1

City of Los Angeles, "Division 88 - Earthquake Hazard Reduction in Existing Buildings," February 13, 1981

Earthquake Engineering Research Institute. (1995). Earthquake Spectra: Northridge Earthquake of January 17, 1994 Reconnaissance Report.

FEMA. (1998). Promoting the adoption and enforcement of seismic building codes: A guidebook for state earthquake and mitigation managers: Appendix A: History and Principles of Seismic Design, FEMA-313. Retrieved from http://www.fema.gov/media-library/assets/documents/564

Federal Emergency Management Agency. (2012a). FEMA P-807: Guidelines for Seismic Retrofit of Weak-Story Wood-Framed Buildings. Retrieved from http://www.iitk.ac.in/nicee/wcee/article/WCEE2012_5431.pdf

Federal Emergency Management Agency. (2012b) Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings.

Green, M. (2011). Building Codes for Existing and Historic Buildings. Published by John Wiley and Sons, http://www.wiley.com, 264 pages.

Jones, L. M., Bernknopf, R., Cox, D., Goltz, J., Hudnut, K., Mileti, D., Perry, S., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., & Wein, A. (2008). The ShakeOut Scenario: U.S. Geological Survey Open-File Report 2008-1150 and California Geological Survey Preliminary Report 25. Retrieved from http://pubs.usgs.gov/of/2008/1150/

Kam, W. Y., Pampanin, S., & Elwood, K. (2011). Seismic Performance of Reinforced Concrete Buildings in the 22 February Christchurch (Lyttelton) Earthquake. Retrieved from http://www.nzsee.org.nz/db/SpecialIssue/44(4)0239.pdf.

LawNews. (2014, February 7). Christchurch courts receive international award for actions during Christchurch earthquakes. Auckland District Law Society. Retrieved September 15, 2014 from http://www.adls.org.nz/for-the-profession/news-and-opinion/2014/2/7/christchurch-courts-receive-international-award-for-actions-during-christchurch-earthquakes/

Liel, A., Haselton, C., & Deierlein, G. (2010, July 15). Using Collapse Risk to Inform Seismic Safety Decisions: California's Existing Reinforced Concrete Structures. ASCE, 137(4), 492-502.

Pekelnicky, T., & Poland, C., (2012). ASCE 41-13: Seismic Evaluation and Retrofit of Existing Buildings. Retrieved from: http://www.nehrp.gov/pdf/ACEHRNov2012_ASCE41b.pdf.

City and County of San Francisco. (2013). Ordinance 45-13. Retrieved September 16, 2014 from http://www.sfgsa.org/modules/showdocument.aspx?documentid=10136

San Francisco Department of Building Inspection. (2011). Building Occupancy Resumption Program. Retrieved from http://sfdbi.org/sites/sfdbi.org/files/migrated/FileCenter/Documents/Permit_Review_Services/BORP_Program.pdf

Sankin, Aaron. (2013). San Francisco Earthquake Safety Questioned As Report Lists Nearly 3,000 Potentially Dangerous Buildings. Retrieved from http://www.huffingtonpost.com/2013/01/14/san-francisco-earthquake-safety_n_2475044.html.

U.S. Resiliency Council. (2014). A Standard to Measure Risk and Resilience. Retrieved from: http://www.usrc.org/index.html.

U.S. Geological Survey, 2014, ShakeMap Southern California Archive, Retrieved from: http://earthquake.usgs.gov/earthquakes/shakemap/list.php?y=2014&n=sc

Fortify our Water System

The water system is the utility most vulnerable to earthquake damage, and that damage could be the largest cause of economic disruption following an earthquake. (Jones et al., 2008). Protecting our water system from catastrophic failure in a major earthquake is essential for our economic future.

The Los Angeles Department of Water and Power (DWP) owns and operates the water system within the City of Los Angeles. Created over 100 years ago, the system supplies water to millions of people and businesses. The principal sources of water supply are from the Los Angeles Aqueduct System, local groundwater, and bulk water transmission from the Colorado River and California Aqueducts overseen by the Metropolitan Water District of Southern California (MWD) (LADWP, 2010a).

Providing water to Los Angeles is a complex endeavor. In fact, DWP considers five separate categories for its service program:

1. Water delivery - does something come out of the tap?
2. Water quality - is the water clear, clean and safe to drink?
3. Water quantity - does everyone get all the water they need?
4. Fire protection - does the Fire Department get what they need?
5. Functionality - is all of the water system in good working order?

The goal of a seismically resilient water system is to limit the loss of each of these services in a disaster and restore them as rapidly as possible while protecting property, life safety, and regional social and economic stability. Earthquakes can disrupt these services in many ways. Currently, according to DWP, the City of Los Angeles receives approximately 88% of its water from outside the region, and all of that imported water has to cross the San Andreas Fault. Earthquakes can damage the aqueducts and pipelines that carry our water and the reservoirs in which we store water. The pipes that distribute water to residences and businesses constitute some of the oldest infrastructure in the City. Hidden from view, old pipes that need replacement or repair can easily be ignored until they break. Further, power is needed for pumps. If the water pressure is too low, contaminants enter the system and the water is no longer potable. Many water lines run near sewer lines and contemporaneous breaking of both increases the risk of contamination issues.

The impact of the Northridge earthquake on the water system, and the restoration of water service following the earthquake, is depicted in Figure 3-1. The graph illustrates the earthquake's impact on each of DWP's five service categories and the length of time it took each service category to return to normal levels. Following the

Northridge earthquake, total water delivery service immediately dropped, with 22% of customers receiving no water. An estimated 850,000 people were affected. The most significant water delivery impacts were above the fault that caused the earthquake in the highly residential San Fernando Valley. The water delivery service was restored to 100% after about 7 days, quantity and fire services between 8.5 to 9 days, and quality service at 12 days after the earthquake. Total water system repair costs for this event reached $41 million (Davis et al., 2012).

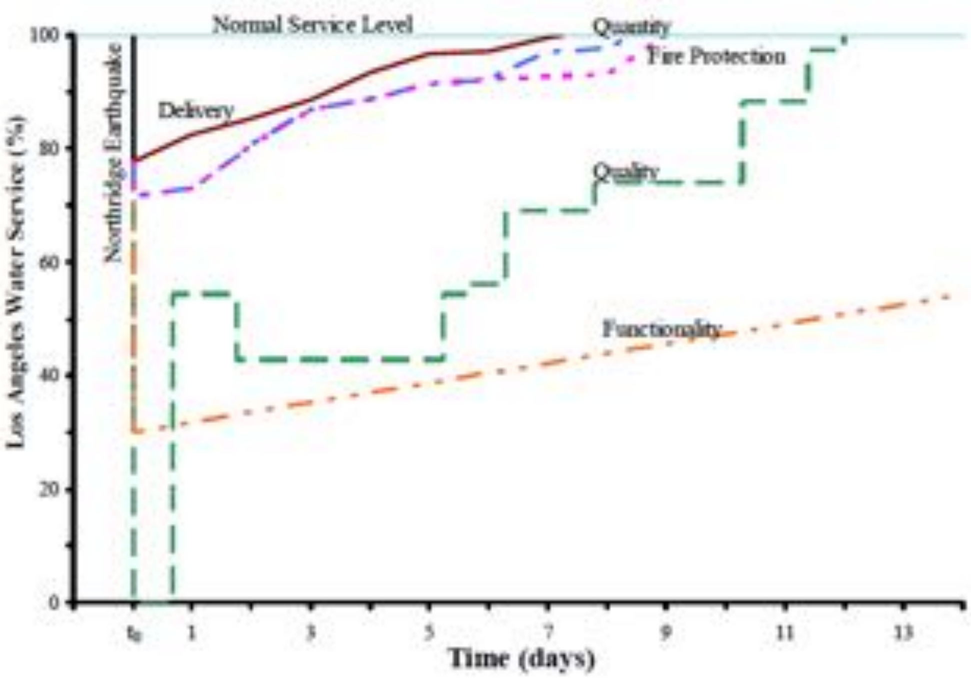

Figure 3-1. Los Angeles Water System service restorations following the 1994 Northridge earthquake (Davis et al, 2012).

A quantitative measure of the functionality of the system (including all aspects working correctly and not depending on temporary measures) initially dropped to about 34%. In total, it took approximately 9 years to restore the complete functionality of the water system to pre-Northridge conditions.

The Northridge earthquake was relatively small, compared to the potential for large-magnitude earthquakes in Southern California. As mentioned earlier, a San Andreas Fault earthquake could rupture a section of fault 200 miles long or more, making it 15 times as long as the Northridge earthquake. Figure 3-2 shows the results of the water system's performance to the Shakeout Scenario's magnitude 7.8 earthquake. Under this simulation, water delivery, quantity of water delivered, and fire protection services are expected to drop to about 20% of normal (Davis, 2010a). Water loss alone is estimated to cause about $50 billion of business disruption.

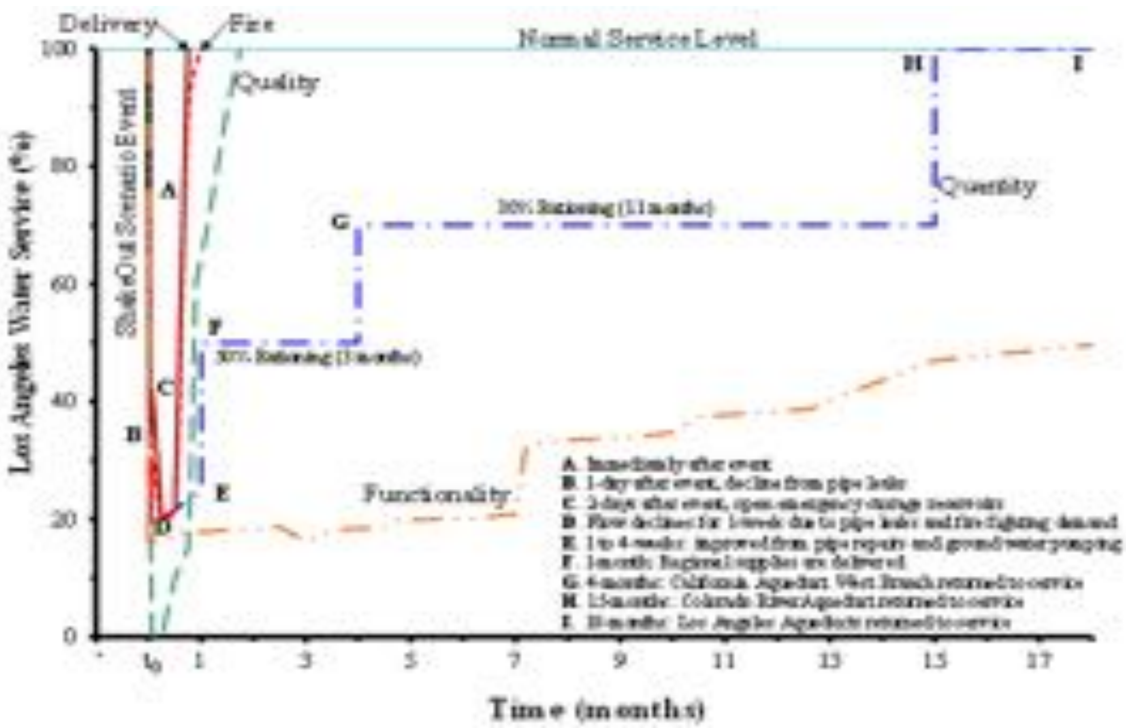

Figure 3-2.The expected times for water service restoration after a magnitude 7.8 ShakeOut scenario earthquake.

The projected disruption of service shown in Figure 3-2 is 15 months of inadequate water supply, which would greatly undermine the resilience of Los Angeles.

In addition to service and direct economic loss, damage to water pipe infrastructure would impair the City's ability to fight fires, with the risk of exponential increases in the losses if the fires cannot be controlled. In several cases, large urban earthquakes have spawned super-conflagrations where the damage caused by fires eclipsed the direct losses from the earthquake.

Firefighting Water Supply

Issue

It is estimated that at least 1,600 fires will be triggered by a San Andreas earthquake. Damage to the water system will make fighting these fires more difficult and raise the possibility of catastrophic conflagrations (Jones et al., 2008).

Background

Fire following earthquakes has caused the largest losses in many notable earthquakes, for example the 1923 magnitude 7.9 Great Kanto earthquake that sparked subsequent fires that destroyed Tokyo and much of Yokohama, and killed more than 140,000 people (Hammer, 2011). The 129 fires in Tokyo included 30 chemical fires (Kobayashi, 1984), and the Yokohama fires destroyed more than half of the city's buildings or 381,000 out of 694,000 (James, 2002).

In reaction to the fire damage following the 1906 magnitude 7.8 San Francisco earthquake, that city created a backup system of underground cisterns and pipes for firefighting (USGS, 2012). The backup firefighting system is powered by gravity from two water tanks located on top of the city's biggest hills, Twin Peaks and Nob Hill. The Twin Peaks Reservoir holds over 10.5 million gallons, allowing enough water pressure to put out large fires. This system, called the Auxiliary Water Supply System, is augmented by fireboats that pump water from the Bay. While the system fell into disrepair, it was restored just before the 1989 Loma Prieta earthquake by order of then-Mayor Feinstein (Van Dyke, 2004).

In the 1994 Northridge earthquake, damage to water system infrastructure rendered firefighters unable to draw water from hydrants in large parts of the San Fernando Valley (Davis et al., 2012). Instead, they used swimming pools as alternative sources of water and used water-dropping helicopters to drop more than 15,000 gallons of water on structure fires. Fire-related incidents constituted one-third of the calls for assistance within the first 27 hours after the earthquake (Beall, 1997).

The recent magnitude 6.0 South Napa earthquake on August 23, 2014 further demonstrated the vulnerability of the water system on which our firefighters depend. More than 150 water main breaks were reported, leaving firefighters with inadequate resources to initially fight six major fires that broke out following the earthquake (Wetzstein, 2014). Water pipe failures in county buildings caused more damage than the shaking itself, and could lead to future complications if the water damage causes mold (Carter, 2014).

A recent engineering study exploring the adequacy of the water supply for firefighting purposes following earthquakes in California (Scawthorn, 2010) found several areas of concern, including:

- Many water agencies view providing potable water following earthquakes as a higher priority than firefighting;
- Water agency system vulnerabilities are not well understood by fire agencies, although water and fire agencies both generally believe most municipal water supply systems are unreliable in a major earthquake;
- Fire and water agency liaison is generally not very good, and is often somewhat indirect and solely through larger enterprise-wide coordination meetings; and
- Emergency firefighting water supply is not a priority focus.

Recommendations

Alternative Water System. LAFD and LADWP should develop a resilient and alternative water system for firefighting purposes. This system should include:

- Use of the reclaimed water system as a second water supply by developing a purple pipe system to bring reclaimed water for non-potable use that will provide a water supply for firefighting. The purple pipes should be seismic resilient pipes.
- Use of pressurized seawater in areas close to sea level. A network of pumps and pipes could deliver seawater to fight fires. This system would need backup power for the pumps and seismic resistant pipes.
- Prioritized installation of seismic resilient pipes in parts of the water system critical to supplying fire hydrants, and at distances consistent with the Fire Department's ability to relay water in a disaster.
- Identification of alternative water supply sources useful for firefighting throughout the City. In addition to swimming pools, alternative water sources may include local ponds, lakes, special connections added at existing reservoirs, the Los Angeles River, creeks, storm drains, ocean water, ground water, or cisterns.

- DWP and LAFD should prepare a preliminary plan for the Mayor to consider by July 2015. An effective and robust plan could take years to develop, and additional years of implementation will be needed. Nevertheless, it is important that both departments work toward achieving these goals, under the direction of the Mayor.

Water Imported Across the San Andreas Fault

Issue

Water supplies are at risk because the aqueducts bringing outside water to Los Angeles cross the San Andreas Fault. Without retrofitting, the aqueducts will be broken by the fault's movement in the earthquake.

Background

Los Angeles currently imports 88% of its water supply from the Eastern Sierras, Colorado River, and Sacramento-San Joaquin Rivers Delta (Bay Delta). The imported water comes to Los Angeles through three aqueduct systems: the Los Angeles Aqueducts operated by the LADWP, the Colorado River Aqueduct operated by MWD, and the California Aqueduct providing water through the East and West Branches, operated by the California Department of Water Resources (DWR) (LADWP, 2010a).

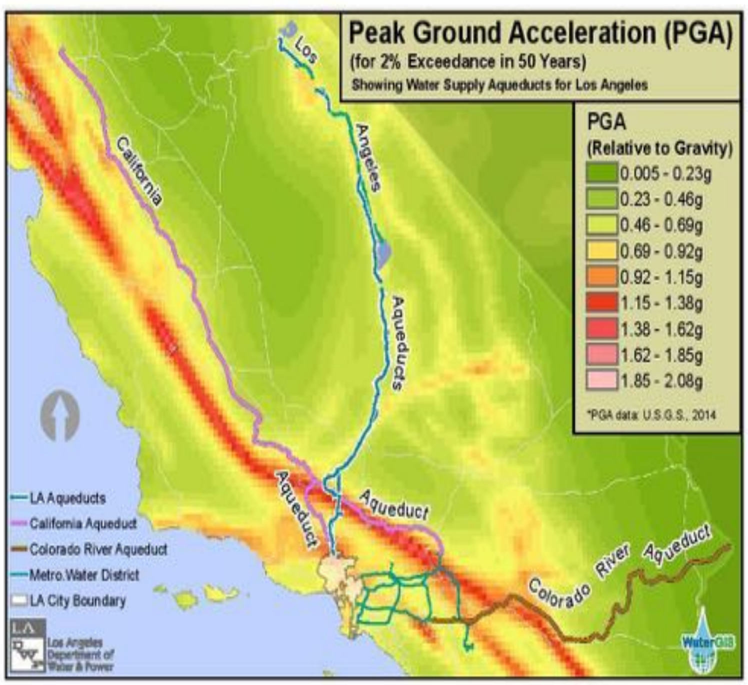

Figure 3-3. Map of California showing the location of the major aqueducts that bring water to Los Angeles and the most probable location of future earthquake shaking. The highest accelerations are expected near the largest faults so the darkest red is along the San Andreas fault.

All three systems cross the San Andreas Fault. The Los Angeles Aqueduct, Colorado River Aqueduct, and California Aqueduct, cross the San Andreas Fault zone a total of 32 times and will likely be simultaneously damaged in a single earthquake event resulting in the inability to import water to Los Angeles for many months (Jones et al, 2008). The Los Angeles Aqueduct is the only aqueduct that crosses the San Andreas only once (Jones et al., 2008).

Most of us think of earthquakes as the shaking we experience. But what causes an earthquake is the movement along a fault that produces the shaking as one of its effects. The movement at the fault creates a permanent offset at the fault, such as the offsets illustrated in Figure 3-4. Any structure built across the fault will be damaged by the fault displacement (or pulled apart). The ShakeOut Scenario projects that the areas along the San Andreas Fault will move an estimated 10-40 feet, destroying roads, pipelines, and aqueducts that cross the fault unless they are engineered to accommodate the offset.

Figure 3-4. Three examples of fault crossing damage. The railway was bent when the fault in the 1999 Izmet, Turkey earthquake moved sideways (lower part of the picture to the left) about 7 ft. The dam was damaged when the 1999 Chi Taiwan earthquake moved (right side up) about 25 ft. The fence was broken when the 1906 San Francisco earthquake moved 5 ft.

The City of Los Angeles, as well as all of Southern California, is highly dependent on water imported through the three aqueduct systems. A preliminary review of potential damage to these three major aqueducts in response to the ShakeOut earthquake scenario indicates repairs to restore flow into all of the aqueducts will likely take more than a year (Davis, 2010).

There is an inadequate backup water system available to provide water to Southern California through the one-year aqueduct reconstruction period. Emergency water supplies are stored for use following an earthquake. These supplies are stored at the Stone Canyon, Hollywood, and Encino Reservoirs where large water volumes are stored primarily for emergency purposes. Back-up water sources are also available through connections with other water distribution agencies. Additionally, MWD constructed the large Diamond Valley Reservoir and some local groundwater banks for emergency water storage, some of which can be made available to the City of Los Angeles. Despite these efforts, local water storage is estimated by MWD to last approximately 6 months, and even then only with significant rationing.

Recommendations

Protect the Los Angeles Aqueduct. Identify mitigation alternatives for the Los Angeles Aqueduct crossing the San Andreas Fault.

Current infrastructure in fault crossings, like the 5-mile long, 9-foot wide Elizabeth Tunnel, should be improved to create a system that can survive an offset when the San Andreas fault ruptures. DWP should be credited for already working on this program, and its plan should include:

- Coordination with the USGS in developing the plan to engineer the Elizabeth Tunnel fault crossing for the expected largest offset that could result from a San Andreas Fault earthquake.
- Continued work with the USGS to place instrumentation along the Elizabeth Tunnel alignment allowing near real-time intelligence to be obtained after fault movement in the San Andreas Zone.
- A preliminary plan to reduce the risk of failure and increase the probability of being able to provide some level of service following a San Andreas earthquake impacting the Elizabeth Tunnel should be presented to the Mayor by July 2015.

Protect the Other Aqueducts. Create a Seismic Resilience Water Supply Task Force with the DWP, California MWD, and the DWR, in an effort to create a collaborative and regional approach to protecting the resilience of our water supply. While the water problem is widely recognized, the agencies have not convened to find solutions.

Protect Water Storage. Ensure that DWP dams are maintained in a safe and reliable manner to both ensure a reliable water supply and to ensure public safety in the event of an earthquake. As part of this effort:

- Detailed estimates for the total volume of emergency storage water, in coordination with local ground water supplies, that is expected to be required following a San Andreas earthquake and current volumes available must be made;
- DWP should regularly evaluate the seismic safety of its dams, implementing risk-based methodologies incorporating the probabilities of events and consequences; and
- Inundation maps should be updated regularly and used to inform emergency action plans prepared for each reservoir.

Develop Local Water Supplies

Issue

The contamination of the groundwater in the San Fernando Basin increases our dependence on imported water, and thus our vulnerability to damage to the aqueduct systems.

Background

Local sources of water in the Los Angeles region are unavailable because of contamination. The San Fernando Valley Groundwater basin, prior to the discovery of contamination, provided drinking water to more than 800,000 local residents. In 1980, concentrations of chlorinated volatile organic compounds, including trichloroethylene (TCE) and perchloroethylene (PCE), were found to be above Federal Maximum Contaminant Levels and State Action Levels in a number of City production wells in the basin. Those solvents were widely used in a number of industries including aerospace and defense manufacturing, machinery degreasing, dry cleaning, and metal plating. Some contaminants currently affecting the basin can be traced as far back as the 1940s, when chemical waste disposal was unregulated throughout the Valley (EPA, 2013).

Historically, Los Angeles derived a significant percentage of its water supply from local wells. A groundwater monitoring program conducted from 1981 to 1987 revealed that over 50% of the water being produced by wells in the eastern portion of the San Fernando Basin was contaminated. The shutdown of these wells resulted in a substantial loss of drinking water, and the City turning to more expensive sources for water.

Recommendation

Develop Local Water. In the 2010 Urban Water Management Plan (UWMP), DWP set goals for developing local water supplies through storm water capture, water conservation, and water recycling. The 2010 UWMP addresses the need to remediate the San Fernando Basin and ensure extracted water meets safe drinking water regulations. This plan should be aggressively pursued.

This is particularly important because:

- A healthy San Fernando Basin also sets a foundation for implementing recycled water and storm water capture projects.

- Local water supply development will enable DWP to reduce reliance on imported water and cut purchases from MWD in half by 2024. The City previously sought to achieve this goal by 2035, but accelerated it due to Executive Directive 5 issued by Mayor Garcetti.
- Local supply development will enhance water availability in emergencies.
- Resilience will be improved with continued implementation of the local water supply program and San Fernando Basin remediation program.

Seismic Resilient Pipes

Issue

The water distribution pipes that carry water to our homes often fail in earthquakes. During large earthquakes, much larger areas suffer strong shaking, leading to hundreds or thousands of simultaneous pipe breaks. The ShakeOut Scenario estimated that it could take 6 months to completely repair all of the damaged pipes in Southern California (Jones et al., 2008).

Background

Official construction of the first water system in Los Angeles started in 1908, joining new infrastructure with the City's acquisition of existing pipes. Pipes used in the Los Angeles water system, and in many water systems throughout the United States, are up to 120-years-old. More than 7,000 miles of water pipe currently run underneath the City, and more than 266 miles of that pipe system were built before 1915.

Figure 3-5. Geyser from a broken water main in the 1994 Northridge earthquake.

The current pipe system is vulnerable to seismic shaking; even shaking from small earthquakes can cause damage. During the magnitude 5.1 La Habra earthquake in March of 2014, the City of Fullerton reported 13 water line breaks, including three ruptures under city streets (Los Angeles Times, 2014). Larger earthquakes cause strong shaking over a larger area and for a longer time, resulting in a larger number of pipes breaking. The City of Christchurch, New Zealand experienced widespread damage to its water system in the February 2011 magnitude 6.3 event, disrupting service to most locations, which contributed to economic disruption. The larger the earthquake, the more likely the number of water main breaks will exceed the capacity of a water agency to manage the damage.

The consequences of broken pipes extend beyond the lack of water and include substantial damage caused by the water. The July 29, 2014 water main break near the UCLA campus, where a Y-shaped section of a pipe burst creating a sinkhole in Sunset Boulevard and flooding the area with 20 million gallons of water in 3.5 hours (Ramallo, 2014), is a small example of the extensive water damage that could follow a large earthquake. The break, attributed to the deterioration of the 83-year-old pipe, caused flood damage to at least 400 cars in a nearby parking garage as well as to numerous buildings on the UCLA campus (Blume, 2014). In the event of a very large earthquake, hundreds of similar breaks could occur throughout the City due to the outdated pipe system.

Recent advances in water pipe technology have shown that it is possible to have a resilient water distribution system. For example, earthquake resistant ductile iron pipes (ERDIP), which are currently manufactured in Japan, are designed for flexibility by accommodating strain and rotation while also preventing pull-out at pipe joints. This design relieves the impact of earthquake-induced forces and prevents breakage in a seismic event. This technology has been incorporated into the buried water infrastructure in Japan over the past 40 years. In numerous earthquakes, including the 1995 Kobe earthquake, the 2004 and 2007 Niigata earthquakes, and the 2011 Great East Japan magnitude 9.0 earthquake, the pipe has repeatedly proven effective with no documented damages or leaks (Davis et al., 2013).

Christchurch, New Zealand has utilized High Density Polyethylene (HDPE) pipe to replace old brittle pipes in liquefaction zones. The HDPE has proven its ability to handle large seismic ground movements in several recent earthquakes near Christchurch (O'Rourke, 2014). Other pipes have also shown their capacity to be adequately designed to withstand earthquake forces.

DWP is currently constructing the second of five planned installations of ERDIP as part of a pilot project to investigate its use for improving the infrastructure network. The first completed ERDIP project consisted of laying 1,750 feet of ductile iron pipe along Contour Drive and was very successful. The second installation is underway on Reseda Boulevard as of November 2014 (Davis et al., 2013).

Recommendation

Seismic Resilient Pipe Network. DWP should commit to a future water system with a seismically resilient pipe network. The long-term goal should be to do this across the City. Due the complexity of the water system and the cost of pipe replacement, this will be a long-term project to replace pipes, beginning in strategically critical areas serving essential facilities and firefighting needs.

- The replacements should be prioritized to maximize the resilience of the system to the earthquakes that will happen before the retrofit program is completed.
- DWP should develop and present to the Mayor a timeline and proposal that will identify the time required to complete this program at different budget

levels.

- As part of this project, the City needs to develop the most cost-efficient supply of seismic resistant pipes.

Seismic Resilience Plan

Issue

DWP's water system is one of the most complex infrastructure systems ever constructed. Many parts of it are susceptible to earthquake damage, but the water provided through the system is critical to resilience and to maintaining the economic viability of Los Angeles following an earthquake.

The challenge with the water system is that it is evolving, and has shifting needs. New discoveries about its vulnerability are identified following each earthquake. Significantly, the water system is also dependent on electric power to maintain its functionality.

Background

The DWP has undertaken numerous priority seismic mitigation projects in the past and several seismic improvement projects are currently part of the Capital Improvement Program (CIP). For example, a number of resilience activities were incorporated at the Headworks Reservoir (currently in construction), such as:

- Physical modeling and computer simulations of seismic motions.
- Development of a new methodology to evaluate liquefaction potential for on-site soils containing gravels and cobbles, and implementation of foundation improvements.
- Special seismic designs for inlet and outlet pipes were incorporated.
- Seismic instrumentation to measure actual performance in earthquakes.

Fig. 3-6. An aerial photograph of the Headworks Reservoir during construction.

These and other resilience aspects

of the design and construction were undertaken to ensure limited damage during an earthquake, and to allow rapid restoration if damage does occur. DWP could benefit from the further development of resilience planning in all projects.

Many high priority seismic mitigation projects at DWP have been completed over the past 40 years, including addressing vulnerable buildings, pump stations, chlorination stations, tanks, dams, and other facilities (LADWP, 2010b). Much of the effort has been directed at the performance of individual facilities, and has been led by individuals with a strong commitment to seismic resilience. When those individuals have retired or left DWP, their individual efforts were not always maintained because resilience has not yet been fully institutionalized within DWP.

Maintaining the functionality of the water system requires a functioning electrical system. Pumps and computer controls both need an electrical system like most of the infrastructure systems serving the City. The only time in the City's history that the entire City of Los Angeles lost power was following the Northridge earthquake. Power was restored within 24 hours through an extraordinary effort by DWP (Shinozuka et al., 2003). A repeat of this type of rapid response cannot be assumed in larger earthquakes, which will impact larger sections of the City. In addition, in a San Andreas Fault earthquake, the natural gas supply lines could be broken by the fault offset. When it breaks, its proximity to petroleum product pipelines that would also rupture could trigger a large explosion and fire (Jones et al., 2008). As most of the in-basin electrical generation uses natural gas, this vulnerability raises the possibility of many weeks without electricity.

<u>Recommendation</u>

DWP Resilience by Design Program. Establish a Resilience by Design Program at the highest level of DWP, covering both the power and water systems to promote an institutional emphasis on seismic resilience as a core function of DWP. To be successful the program should:

- Be given the resources and authority to instill the importance of making resilient thinking and activities a standard of practice at DWP;
- Develop a work environment in which groups throughout the organization can fully understand how the water and power systems may perform in numerous possible earthquake scenarios, the interdependency of these two systems, and the core technical capabilities necessary to accomplish a successful Program.
- Include outside experts in the Resilience by Design Program who are selected by the Mayor, and include an earthquake scientist, an expert in water systems seismic resilience, an expert in power system seismic resilience, and

representatives of both the water and power systems.

- Assign a resilience manager to coordinate these efforts with senior management, as well as with other City departments, external agencies, and communities within Los Angeles. Resilience management covers topics related to pre-event planning, mitigation alternatives, emergency response, post-earthquake recovery and reconstruction.

Seismic Resilience Initiative

Issue

Developing a strong resilience effort in a timely manner requires an investment greater than currently available budget allocations. Absent significant capital investment to address existing and developing seismic issues, the regional economy could collapse following a major earthquake.

Background

There is a significant cost to implementing many of the proposed recommendations suggested in this Report. Using seismic resistant piping may increase the total cost of a project by 10-20%. The estimated cost to clean local aquifers is approximately $1 billion. Other expenses to government will include strengthening the Elizabeth Tunnel, working with the region on other San Andreas Fault crossings, and developing purple piping and other alternatives to aid effective firefighting.

Not only is the safety and security of our region at stake, but the economic viability of the region is at risk. A strong capital investment in these core projects will build resilience in our communities for generations.

Recommendation

Seismic Resilience Bond Measure. Work with local, regional, and state partners to develop a seismic resilience bond measure to allow for necessary investments in the seismic safety of our region.

References

Beall, K. (1997, June 1). Thirteenth Meeting of the UNJR Panel on Fire Research and Safety, March 13-20, 1996. National Institute of Standards and Technology, 2. Retrieved August 15, 2014.

Blume, H. (2014, August 3). Sunset Boulevard reopens after water-main break. Los Angeles Times. Retrieved August 7, 2014 from http://www.latimes.com/local/la-me-ucla-cleanup-20140804-story.html.

Carter, L. (2014, August 28). Napa quake damage rises to $362 million. The Press Democrat. Retrieved September 5, 2014 from http://www.pressdemocrat.com/home/2613337-181/napa-quake-damage-rises-to#page=1

Davis, C.A., (2010) Los Angeles water supply impacts from a M7.8 San Andreas Fault earthquake scenario, Journal of Water Supply: Research and Technology—AQUA, 59.6–7, pp 408-417.

Davis, C. A., O'Rourke, T. D., Adams, M. L., & Rho, M. A. (2012). Case Study: Los Angeles Water Services Restoration Following the 1994 Northridge Earthquake. 15th World Conference on Earthquake Engineering, paper No. 364, Lisbon, Portugal, September 24-28 2012.

Davis, C.A., Castruita, J., Williams, G., Saddler, K., Sufi, S., Zaldivar, L., & Land, D. (2013). Los Angeles Pilot Project using Japanese Earthquake Resistant Joint Ductile Iron Pipe. Proc.of 8th US-Japan Taiwan Workshop on Water System Seismic Practices, AWWARF/JWWA, Oakland, CA, Aug. 21-23, Session 5.

Department of Labor. (2011, December). A changing landscape: The impact of the earthquakes on Christchurch workplaces. Labour & Immigration Research Centre. Retrieved August 7, 2014 from http://www.dol.govt.nz/publications/research/earthquakes-impact-in-christchurch-workplaces/earthquake-impact-in-christchruch.pdf

EPA. (2013, December 23). Pacific Southwest, Region 9: Superfund: San Fernando Valley (area 2 Glendale). Retrieved September 19, 2014 from http://yosemite.epa.gov/r9/sfund/r9sfdocw.nsf/ViewByEPAID/CAD980894901

Hammer, J. (2011, May). The Great Japan Earthquake of 1923. The Smithsonian Magazine. Retrieved August 7, 2014 from http://www.smithsonianmag.com/history/the-great-japan-earthquake-of-1923-1764539/?no-ist.

James, C. (2002, October 8). The 1923 Tokyo Earthquake and Fire. Retrieved August 7, 2014 from http://nisee.berkeley.edu/kanto/tokyo1923.pdf

Jones, L. M., Bernknopf, R., Cox, D., Goltz, J., Hudnut, K., Mileti, D., Perry, S., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., & Wein, A. (2008). The ShakeOut Scenario: U.S. Geological Survey Open-File Report 2008-1150 and California Geological Survey Preliminary Report 25. Retrieved from http://pubs.usgs.gov/of/2008/1150/

Kobayashi, M. Urban Post-Earthquake Fires in Japan, 8th World Conference on Earthquake Engineering, San Francisco, 1984. Retrieved September 2, 2014 from http://www.iitk.ac.in/nicee/wcee/article/8_vol7_785.pdf

LADWP. (2010a). Urban Water Management Plan. Los Angeles Department of Water and Power. Retrieved September 16, 2014, from http://www.water.ca.gov/urbanwatermanagement/2010uwmps/Los Angeles Department of Water and Power/LADWP UWMP_2010_LowRes.pdf

LADWP. (2010b). Water System Ten-Year Capital Improvement Program For the Fiscal Years 2010-2019. Los Angeles Department of Water and Power. Retrieved September 16, 2014, from http://www.ladifferentiated.com/wp-content/uploads/2011/02/DWP_Water_System_10Y_Capital_Improvement_Program.pdf

Los Angeles Times. (2014, March 31). Hundreds of aftershocks from 5.1 earthquake. Los Angeles Times. Retrieved August 7, 2014 from http://articles.latimes.com/2014/mar/31/local/la-me-ln-hundreds-of-aftershocks-from-51-earthquake-20140330

Melero, M. (2014, July 30). UCLA Water Main Break by the Numbers. NBC Los Angeles. Retrieved August 7, 2014 from http://www.nbclosangeles.com/news/local/UCLA-Water-Main-Break-Highlights--269141431.html.

O'Rourke, T., Jeon, S., Toprak, S., Cubrinovski, M., Hughes, M., Van Ballegooy, S., & Bouziou, D. (2014). Earthquake Response of Underground Pipeline Networks in Christchurch, NZ. Earthquake Spectra, 30(1), 183-204.

Ramallo, J. (2014, July 30). Westwood / Sunset Water Trunk Line Break Update Wednesday -10:30 pm. LADWP News. Retrieved from http://www.LADWPnews.com/go/doc/1475/2215593/.

Scawthorn, C., (2011). Water supply in regard to fire following earthquake, PEER Report 2011/08, Pacific Earthquake Engineering Research Center, 123 pp..

Shinozuka, M., Chang, S., Cheng, T., Feng, M., O'Rourke, T., Saadeghvaziri, M., Shi, P. (2003). Resilience of Integrated Power and Water Systems. In Seismic Evaluation and Retrofit of Lifeline Systems, MCEER, 65-86. Retrieved September 16, 2014 from http://mceer.buffalo.edu/publications/resaccom/04-sp01/06_shino.pdf

U. S. Geological Survey. (2012, July 23). The Great 1906 San Francisco Earthquake. Retrieved September 16, 2014 from http://earthquake.usgs.gov/regional/nca/1906/18april/index.php

Van Dyke, S. (2004, June 7) San Francisco Fire Department Water Supply System. Virtual Museum of the City of San Francisco. Retrieved August 7, 2014 from http://www.sfmuseum.org/quake/awss2.html

Verdin, T., Leff, L., Thanawala, S., & Bonnell, C. (2014, August 24). Napa earthquake is area's strongest in 25 years: Injuries, damage reported after quake. KCRA. Retrieved September 5, 2014 from http://www.kcra.com/news/usgs-60-earthquake-shakes-northern-california/27703718#!bQbJfp

Wetzstein, J., Todorov, K., & Yune, H. (2014, August 24). Shattered property, bruised lives. Napa Valley Register. Retrieved September 5, 2014 from http://napavalleyregister.com/news/local/shattered-property-bruised-lives/article_1af7d38c-2d23-532d-a9da-b2c5c9e3def4.html

Enhance Reliable Telecommunications

The 1994 magnitude 6.7 Northridge earthquake occurred at the dawn of the Internet era, before the release of Mosaic (the first Internet browser), the formation of the World Wide Web (World Wide Web Consortium, 2014), and before cellular devices were in popular use. Twenty years later, the Internet and cellular communication have become integral to society (Pew Research Center, 2014a) and 90 percent of all adults in the United States now own a mobile phone (Pew Research Center, 2014b). Telecommunications have become a critical part of society's infrastructure, necessary for all high-functioning urban settings, including the City of Los Angeles.

The rise of the Internet has moved telecommunications from an amenity to a critical lifeline of our society and economy. Modern society assumes that information and the ability to communicate information will always be available and the lack of information could impede both the regional economy and the well-being of residents

Telecommunication technologies can help people ensure the safety of loved ones, collect emergency or disaster related information, and call for help, but a large earthquake is likely to cause significant disruption to these services (Jones et al., 2008). Moreover, any longer-term disruption of these services will impede recovery, amplifying economic losses.

Analysis of communication systems in disasters (Kwasinski, 2010) has shown that one cannot treat each asset in isolation, but must rather look at the communication system as a system of systems and analyze how they work together. In previous disasters, the cause of system failures has been, in order of frequency:

- Overloaded capacity from too many calls;
- Loss of power;
- Failure of local power generation (backup systems at individual sites); and
- Damage to equipment and tower at local sites.

This section examines vulnerabilities of telecommunication networks and provides recommendations for improvements, with the goal of restoring and maintaining economic vitality after a severe earthquake.

In order to address the issues posed by the vulnerabilities in the communications system, and to further the efforts of this Report, Mayor Garcetti convened a Communications Task Force that met multiple times in 2014. The Task Force included leaders in private industry and government. The Task Force discussed these vulnerabilities and recommended approaches to fixing these issues.

Coverage and Bandwidth

Issue

Historically, telephone services are overwhelmed by high demand immediately after an earthquake. The disaster increases the need for communication and the system is not designed for simultaneous high usage. Any reduction in capabilities that result from earthquake damage will compound the communication problem.

Background

Telecommunication networks consist of multiple components. One of the most basic is a cell or node. A cell is composed of a telecommunication structure that is either affixed or freestanding, a communication shelter that houses ground equipment, and an area surrounding the site that provides the cellular service known as coverage (Stuber, 2002). Cells provide a specified range of coverage per unit and come in various sizes:

- Macrocells, which service just over half a mile to twelve miles, are primarily used in rural settings; and
- Microcells, which service less than a mile in range, are primarily used in urban areas (Stuber, 2002).

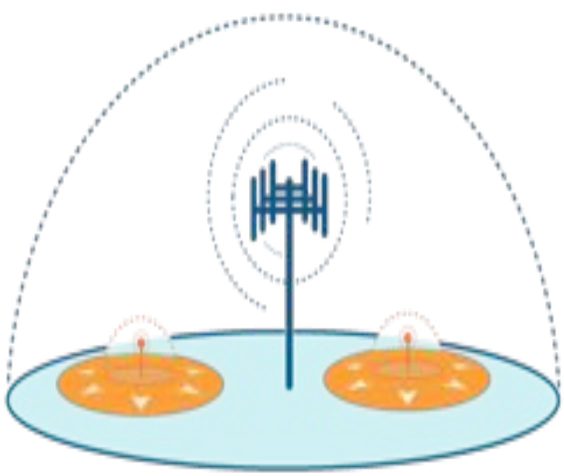

Figure 4-1. Macrocell coverage is indicated in blue, while microcell coverage is featured in orange. Source: Qualcomm.

Microcells predominate in urban areas, such as the City of Los Angeles, because they can increase user capacity with smaller cell sites, maintain reliability of those cells, and use less power at each site (Ohaneme et al., 2012). The Federal Communications Commission (FCC) allocates a certain range of frequencies to each private service provider, such as AT&T, Verizon, Sprint, or T-Mobile. Each provider can distribute their range of frequencies in a manner that is suitable for their operation (Federal Communications Commission, 2014).

Particularly in urban areas, accessible locations determine how wireless providers use their respective frequency allotments. Wireless providers do not usually own telecommunication structures outright, and instead lease tower space for their equipment. Providers maintain their own cells, which transmit and receive specific frequencies, and reassign a set of frequencies from their allotted bandwidth to cells in other areas that are not in close proximity (Stuber, 2002).

Each cell can only handle a limited amount of voice and data based on the FCC and provider allotted bandwidth (Sirbu, 1992). Therefore, when one frequency becomes overloaded, due to a spike in use or damaged tower or equipment, as can be the case in an earthquake, providers may open bandwidth on another frequency to accommodate excess traffic.

Recommendation

Partnerships with Service Providers. The City should enter into a Memorandum of Understanding (MOU) with cellular service providers to maximize access to telecommunication coverage in a disaster. A sample of this MOU is attached as Appendix E.

Prior to the release of this Report, the City began work to develop Memoranda of Understanding with wireless cellular providers, which will provide that during declared disasters:

The wireless cellular providers will:

- Share bandwidth, allowing users to access bandwidth available from other providers; and

- For those providers offering Wi-Fi-service, allow free temporary Wi-Fi access in public locations to reduce congestion.

The City will:

- Facilitate access and other requirements for rapid repair of damaged facilities after an earthquake; and

- Educate the public about effective communication strategies, such as texting instead of calling, to reduce bandwidth usage and congestion during a disaster.

Power for Communications Towers

Issue

A large earthquake will physically damage the electrical transmission system and cause many cell sites to lose power (Jones et al., 2008). The duration of the power outage may exceed the backup power at cell sites, further exacerbating communication problems.

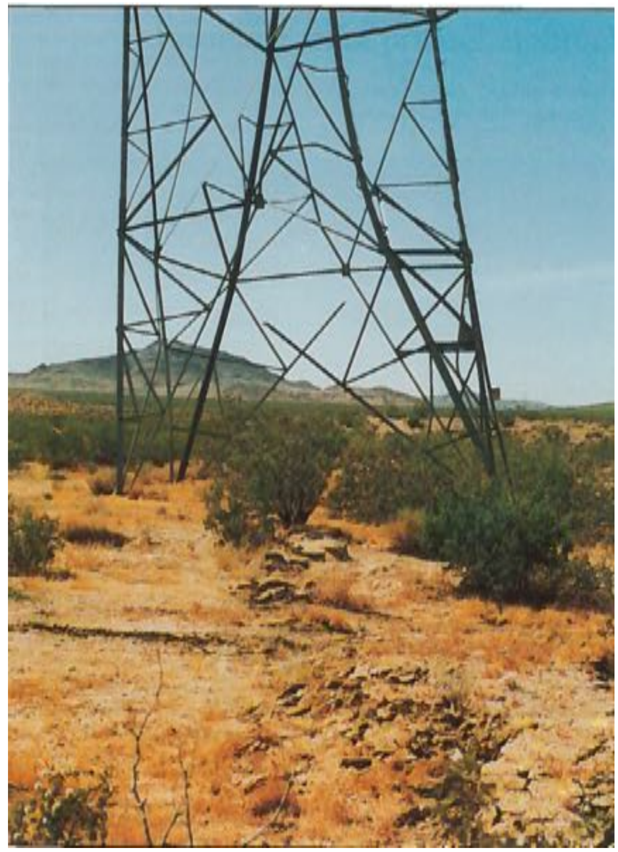

Figure 4-2. Powerline tower severely damaged by offset on the Emerson Fault in the 1992 magnitude 7.3 Landers earthquake. The fault moved the left side of the tower 11 feet to the right of the right side of the tower. Photo by California Geological Survey.

Background

The electric grid provides the primary source of power to telecommunication facilities, leaving them dependent on grid operability and vulnerable to even distant electric interruption. After a disaster, large sections of the power grid can be shut down for repair or as a precautionary measure to ensure additional damage is not sustained through disconnected live wires (Walsh, 2012). Loss of power has caused substantial disruption of telecommunications for days to weeks in Hurricane Katrina (Kwasinski, 2010), the Tohoku, Japan earthquake (Carafano, 2011), and Superstorm Sandy (Kwasinski, 2013).

As an example, approximately two million New Yorkers lost power following Hurricane Sandy (New York City Mayor's Office, 2013). According to U.S. Department of Energy (DOE) data, and an analysis performed by the Associated Press and Ventyx, power was out in parts of the New York region for 13 days (Fahey, 2012). In New York City, an average of 25% of cell sites in the affected area lost service directly due to power loss (Kwasinski, 2013).

Power restoration can be a lengthy and complex process, involving coordination between government agencies and private sector businesses. To further complicate matters for the City of Los Angeles, the City's power supply is contingent upon numerous entities and is not exclusively under the control of the City's Department of Water and Power.

Several of the State's major transmission lines are owned by Southern California Edison and overseen by the California Independent System Operator (ISO), which is an independent grid operator responsible for more than 26,000 miles of power lines and a significant wholesale power market. These lines cross the San Andreas Fault at locations that are likely to have very large offsets; the fault at these locations is likely to move a greater distance than there is slack in the lines. Their capacity is so large that their failure has the potential to bring down the power grid across Southern California and beyond. Furthermore, the major natural gas supply line crosses two petroleum product pipelines at the San Andreas in Cajon Pass. A large explosion and fire is likely to occur if all three pipelines break simultaneously (Jones et al., 2008). A disruption in the natural gas supply will make it difficult to maintain electrical service, since local generating plants operate on natural gas and transmission lines cross the San Andreas Fault.

Even if transmission lines across the San Andreas are unaffected, outages can occur on a more local level. To protect against such outages, telecommunication providers install backup power at cell towers, including the use of backup batteries and generators.

Because cell transmitters require air conditioning to function correctly, they have a large power draw and, therefore, batteries only provide four to eight hours of backup power. Some critical facilities use a generator that can provide 48 hours of backup power. Generators along with their air conditioning units require more space to house this equipment, which is not always practical in urban environments such as Los Angeles. Furthermore, the cell site power requirements are so large that solar power is not a reasonable option at this stage. Keeping cell tower generators running beyond two days will require transportation to the cell sites in order to bring the needed fuel and repair crews needed, but this could be challenging following a major earthquake.

Recommendation

Wi-Fi Alternative. Develop solar-powered Citywide Wi-Fi to provide a telecommunications alternative that uses less power and will allow Internet access in a time when the cell system is disrupted.

The City has proposed to develop the Los Angeles Community Broadband Network (LACBN) (City of Los Angeles Information Technology Agency, 2014), to ensure that all residents and businesses have Internet access with high speed capability in the City of Los Angeles (City of Los Angeles Information Technology Agency, 2014). This project will add to the resilience of Los Angeles because:

- Wi-Fi transmitters use much less power than a cell phone transmitter, especially because the latter requires air conditioning at the ground facility;
- If the City Wi-Fi system is designed with solar-powered transmitters, Internet connections and backup power, these Wi-Fi connections would provide an alternative communication option for the City's residents;
- A resilient network would provide free temporary Wi-Fi access immediately following a disaster in public locations such as schools, parks and recreation centers; and
- Citywide Wi-Fi reduces dependency on the electric grid for the City of Los Angeles.

Protect the Power System at Fault Crossings. Create a Southern California Utility Resilience Task Force to develop solutions to the potential for cascading failures in the interacting utilities as they cross the San Andreas Fault. This project will add to the resilience of Los Angeles because:

- Los Angeles is part of the regional Southern California community that will collectively be impacted by any earthquake;
- The utilities are interconnected in their ability to make their communities resilient, but they belong to many different entities, public and private, that will need to cooperate to find solutions to the problems; and
- This issue is the collective responsibility of State and local leaders, and they are in the best position to look for approaches to protect and prepare for the predictable damage that will happen at the fault crossings.

Physical Infrastructure

Issue

Cellular towers are designed and constructed to life-safety standards, meaning that they are designed to be unlikely to collapse, but need not be functional following an earthquake. Interruptions due to physical damage can create lengthy delays in response and recovery. Debris, downed bridges, and other hazards further create complications for repairing this infrastructure in a timely manner particularly following a catastrophic event.

Background

Cellular towers consist of freestanding towers and towers affixed to buildings. The type of structure depends on several factors including availability of electric power, electromagnetic interferences, wind exposure, topography, aviation routes and requirements, transportation networks, and local zoning ordinances.

In urban areas like Los Angeles, there is limited open space for freestanding towers, which requires that more than half of telecommunication structures are affixed to buildings. Older buildings, which are more likely to collapse, often house the cell phone towers.

Telecommunications can be easily lost if a building experiences serious damage. In the 2011 Haiti earthquake, an estimated 3,000,000 Haitians were suddenly without cell phone service because of the widespread building damage (Gould et al, 2011).

Thus, freestanding telecommunication structures become critical in maintaining cell phone service following an earthquake. They vary in height from 50 to 200 feet, depending on structural specifications and coverage capability, with four types of design (guyed towers, lattice towers, stealth towers, and monopoles) (Harris, 2011). Monopoles, simple poles of concrete or steel, are the most common type used by private service providers within the City of Los Angeles.

The basic strength requirement depends on local conditions and includes various load sources such as wind, ice, and seismic activity (Telecommunications Industry Association, 2009). The seismic strength to which telecommunication structures are built depends on several factors, including intended use and occupancy (American Society of Civil Engineers, 2002). For earthquakes, the building code uses the National Seismic Hazard Maps to determine what level of ground shaking has at least a 10% chance of occurring in 50 years. Given those loads, the towers are designed to prevent collapse and preserve the safety of people. For the less likely but possible earthquake (called the maximum credible earthquake), the structure should not suffer complete collapse, but enough damage to hinder its ability to perform is expected.

For some structures, such as fire stations and emergency operation centers, public policy has determined that the structure should be strong enough to do more than just remain standing, but to remain functional following an earthquake. This design goal is accomplished by using an importance factor, a strength multiplier that reflects the need to keep the most critical structures functioning after an earthquake. Towers used for critical public safety communications and other public safety buildings are given an Importance Factor of 1.5, but most private towers have an importance factor of 1.0.

Figure 4-3. Telecommunications tower in Tokyo, damaged in the 2011 Tohoku magnitude 9 earthquake.

The experience in small to moderate earthquakes is not a good model for understanding the behavior of cell towers in the largest earthquakes because the resonant frequency of a tall tower is low. This means that the seismic energy most likely to damage the tower is from the low frequency waves that are only generated by the largest earthquakes.

Looking at other countries where very large earthquakes have occurred, we see not just the collapse of the cell phone system in Haiti, but also the loss of 2,300 towers in the earthquake in China in 2008 (New York Times, 2008).

This is a helpful comparison because the Chinese Building Code has similarities to International Building Code, in that: 1) design criteria for the shaking from earthquakes with 10% and 2% exceedance probabilities in 50 years (in other words, that there is a 2% probability of an earthquake of this magnitude occurring in 50 years) (You and Zhao, 2013); 2) the equivalent of the Importance Factor is "Seismic Fortification Categories" with Category A buildings (critical facilities) required to build to at least one unit with higher seismic intensity, which is approximately 50% greater strength; and 3) mobile communications facilities are in general Category C, which is the same as an Importance Factor of 1.0 (Tang, 2009). Therefore, based on the Chinese example, we can expect cell towers currently built to the importance factor of 1.0 to not be resilient when a large-scale earthquake strikes.

Retrofitting existing towers to a higher seismic standard can be expensive, with costs estimated to be as expensive as a new tower. According to the Los Angeles Bureau of Engineering, building new towers to a higher standard is much more practical, resulting in an additional cost of 10-20%.

Recommendation

Stronger Cell Towers. The City should amend its building code to require new freestanding cellular communication towers to be built with an Importance Factor of 1.5. Existing towers would not be affected.

Earthquake Early Warning

Issue

The California Integrated Seismic Network has a prototype system to rapidly detect seismic waves as an earthquake happens, calculate the maximum expected shaking, and send alerts to surrounding communities before damaging shaking arrives. This system is referred to as Earthquake Early Warning or "EEW" (USGS, 2014). This information could be used to reduce losses in an earthquake, but because of limited funding, the current system is still in development and has occasional false alarms. Nevertheless, this system could be of great benefit to Los Angeles in building seismic resilience.

Background

Earthquakes do not happen at epicenters. They begin at hypocenters, but the seismic slip happens over a surface and every point on that surface radiates energy. The size of that surface determines the magnitude of the earthquake. In the largest earthquakes, strong shaking can be tens to even hundreds of miles from the epicenter, because it is still near the fault.

Technology can detect earthquakes and provide an alert that is sent to some areas before strong shaking arrives. An EEW system seeks to identify and characterize an earthquake a few seconds after it begins, calculate the likely intensity of ground shaking that will result, and deliver warnings to people likely to experience the shaking. This can be done by detecting the P-waves, the first energy to radiate from an earthquake that rarely causes damage, and using that to estimate the location and the magnitude of the earthquake. Next, the anticipated ground shaking across the affected region is estimated and a warning is generated. This method can provide warnings before the later and stronger S-wave arrives in a region.

EEW in California could range from a few seconds to a few tens of seconds, depending on the distance to the epicenter of the earthquake. For a very large earthquake like those expected on the San Andreas Fault, the warning time could be much longer because the affected area is much larger.

The ShakeAlert EEW system has been developed for the West Coast by scientists of the USGS, Caltech, and U.C. Berkeley. The ShakeAlert system has been sending live alerts to test users since January 2012. In Southern California, the Los Angeles-Long Beach Urban Areas Security Initiative (UASI) supported the development of the network by funding the addition of 125 stations to the Southern California portion of the network, resulting in Southern California being the first region in the United States with a density of stations that can support EEW. However, the system needs continued development to ensure more robust information is available before being publicly accessible.

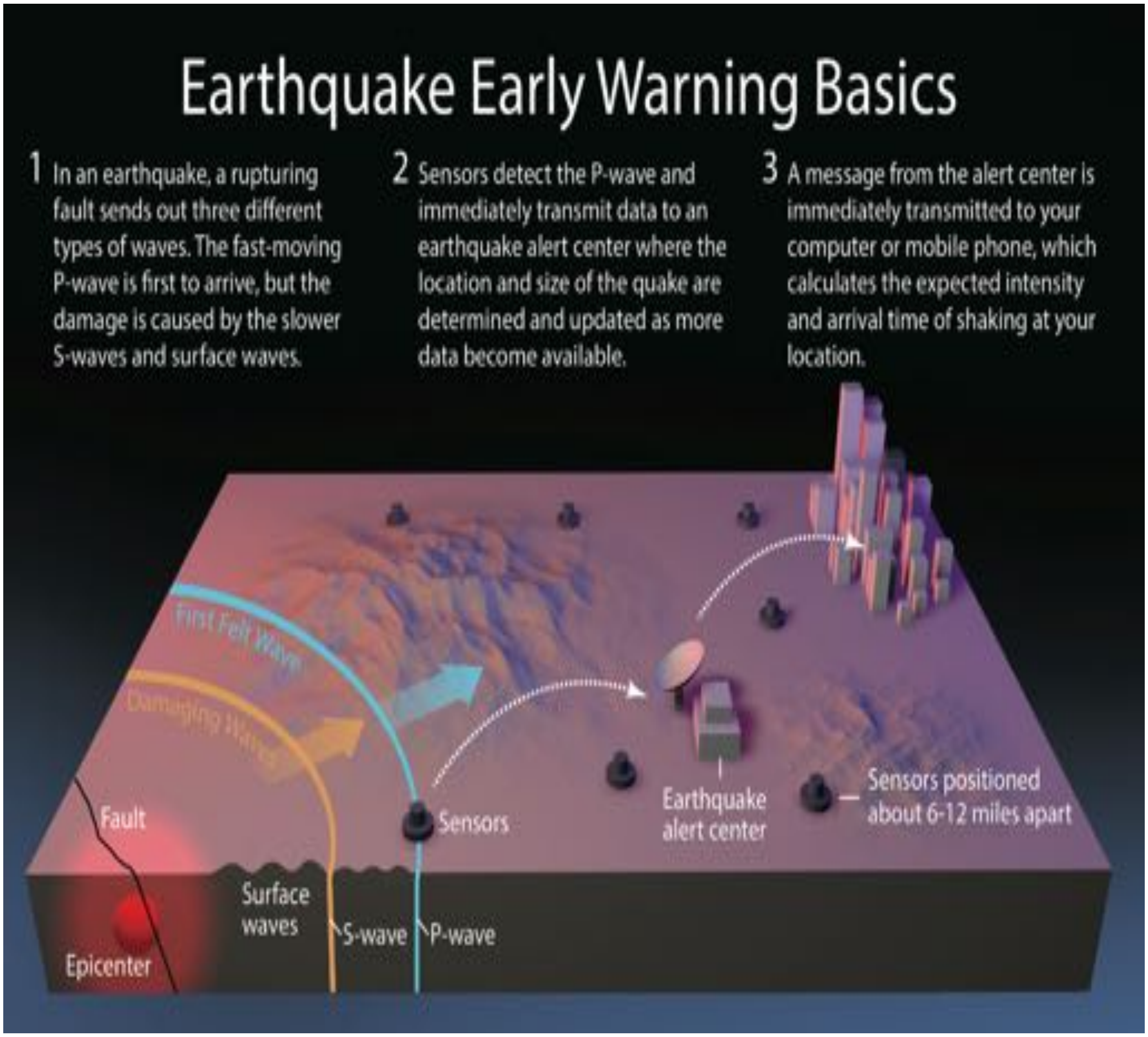

Figure 4-4. Illustration of how Earthquake Early Warning works. (Source: USGS; Credit: Staff, Orange County Register)

Recommendation

Advancement of Earthquake Early Warning. The City of Los Angeles and the USGS should begin to implement Early Earthquake Warning in Southern California. They should work together to convert the prototype into a fully functional and robust EEW system. This should include developing an expanded EEW program within the Los Angeles Fire Department and the Los Angeles Unified School District, so that the warning signal can be used to open fire station doors and signal to school children to "Drop, Cover, Hold On."

In addition, the City of Los Angeles should work with Congressional Representatives to support a robust Earthquake Early Warning system in California.

References

American Society of Civil Engineers. (2002). Minimum Design Loads for Buildings and Other Structures. Retrieved from https://law.resource.org/puv/us/cfr/ibr/003/asce.7.2002.pdf

California Building Standards Commission. (2013). California Building Code, Title 24. Retrieved from www.ecodes.biz/ecodes_support/free_resources/2013California/13Building/PDFs/Chapter%2031%20-%20Special%20Construction.pdf.

Carafano, J. J. (2011). The Great Eastern Japan Earthquake. The Heritage Foundation. Retrieved from http://report.heritage.org/sr0094.

City of Los Angeles Information Technology Agency. (2014). Request for Information (RFI): LA Community Broadband Network (LACBN) Initiative. Retrieved from: http://ita.lacity.org/ForResidents/CommunityBroadband/LACBNProject/index.htm.

Fahey, J. (2012, November 16). Power Outage Time After Sandy Not Extraordinary. Associated Press. Retrieved from http://bigstory.ap.org/article/power-outage-time-after-sandy-not-extraordinary.

Federal Communications Commission. (2014). Radio Spectrum Allocation. Retrieved from http://www.fcc.gov/encyclopedia/radio-spectrum-allocation.

Gould, Nathan, Barry J. Goodno, Phillip L. Gould, and Philip Caldwell (2011) Effects of the January 2010 Haitian Earthquake on Selected Equipment and the Implications for the Seismic Design of Critical Non-Structural Components Required for Post-Earthquake Recovery Operations in Developing Countries. Structures Congress 2011: pp. 2275-2284. doi: 10.1061/41171(401)197.

Harris, Michael. (2011). How Cell Towers Work. Union Site Management. Retrieved from http://www.unisonsite.com/pdf/resource-center/How%20Towers%20Work.pdf.

Jones, L. M., Bernknopf, R., Cox, D., Goltz, J., Hudnut, K., Mileti, D., Perry, S., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., & Wein, A. (2008). The ShakeOut Scenario: U.S. Geological Survey Open-File Report 2008-1150 and California Geological Survey Preliminary Report 25. Retrieved from http://pubs.usgs.gov/of/2008/1150/.

Kwasinski, A. (2010) Analysis of Vulnerabilities of Telecommunication Systems to Natural Disasters, 2010 IEEE Systems Conference, pp. 359-364, San Diego, CA, USA, April 5-8, 2010. http://dx.doi.org/10.1109/SYSTEMS.2010.5482356.

Kwasinski, A., & Tang, A. K. (2012). Telecommunications Performance in the M-9.0 Offshore East Coast of Japan Earthquake and Tsunami, March 11, 2011. Proceedings of the International Symposium on Engineering Lessons Learned from the 2011 Great East Japan Earthquake, Tokyo, Japan, 1514-1525. Retrieved from http://nisee.berkeley.edu/elibrary/Text/2012041210.

Kwasinski, A. (2013). Lessons from Field Damage Assessments about Communication Networks Power Supply and Infrastructure Performance during Natural Disaster with a focus on Hurricane Sandy. The University of Texas at Austin. Retrieved from http://users.ece.utexas.edu/~kwasinski/1569715143%20Kwasinski%20paper%20FCC-NR2013%20submitted.pdf.

New York City Mayor's Office. (2013). Hurricane Sandy After Action Report: Report and Recommendations. Retrieved from http://www.nyc.gov/html/recovery/downloads/pdf/sandy_aar_5.2.13.pdf.

New York Times. (2008). Powerful Quake Ravages China, Killing Thousands, Retrieved from http://www.nytimes.com/2008/05/13/world/asia/13china.html?pagewanted=all&_r=1&.

Ohanami, C., Onoh, G., Ifeagwu, E., & Eneh, I. (2012). Improving Channel Capacity of Cellular System Using Cell Splitting. International Journal of Scientific & Engineering Research. Retrieved from http://www.ijser.org/researchpaper%5CIMPROVING-CHANNEL-CAPACITY-OF-A-CELLULAR-SYSTEM-USING-CELL-SPLITTING.pdf.

Pew Research Center. (2014A). Internet Use Over Time. Retrieved from http://www.pewinternet.org/data-trend/internet-use/internet-use-over-time/.

Pew Research Center. (2014B). Mobile Technology Fact Sheet. Retrieved from http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/.

Sirbu, M. A. (1992). Technology and Infrastructure. Retrieved from http://www.cs.cmu.edu/afs/andrew/usr9/sirbu/www/pubs/ipaper_ToC.html.

Stuber, G. L. (2002). Principles of Mobile Communication, Second Edition. New York: Kluwer Academic Publishers. Retrieved from http://www.eletrica.ufpr.br/graduacao/e-books/Principles%20of%20Mobile%20Communication.pdf.

Tang, A. (2008). The ShakeOut Scenario Supplemental Study: Telecommunications. U.S. Geological Survey. Retrieved from http://books.google.com/books?id=sVYE6M3urJQC&pg=PA10&lpg=PA10&dq=shakeout+congestion&source=bl&ots=mIKLsq-NI-&sig=47Mu1EdlyGQpI1fuzp2I5-bMTno&hl=en&sa=X&ei=a6nOU9XbIY-JogSEroKYDw&ved=0CCAQ6AEwAQ#v=onepage&q=shakeout%20 congestion &f=false

Tang, A. (2009). TCLEE 2009: Lifeline Earthquake Engineering in a Multihazard Environment: pp. 1-9 Telecommunications Performance—May 2008, Wenchuan, Sichuan Earthquake, (doi: 10.1061/41050(357)132).

Telecommunications Industry Association. (2009). TIA-222-G: Structural Standard for Antenna Supporting Structures and Antennas.

U.S. Geological Survey. (1996). USGS Response to an Urban Earthquake Northridge '94. Retrieved from http://pubs.usgs.gov/of/1996/ofr-96-0263/.

United States Geological Survey. (2014d). Earthquake Early Warning. Retrieved from http://www.shakealert.org.

United States Geological Survey. (2014E). ShakeCast. Earthquake Hazards Program. Retrieved from http://earthquake.usgs.gov/research/software/shakecast/.

Walsh, B. (2012). Hurricane Sandy Will Put a Rickety Power Grid to the Test. TIME. Retrieved from http://science.time.com/2012/10/30/hurricane-sandy-will-put-a-rickety-power-grid-to-the-test/.

World Wide Web Consortium. (2014). A Little History of the World Wide Web. Retrieved from: http://www.w3.org/History.html.

You Hongbing and Zhao Fengxin, (2013). A Comparison of Domestic and Foreign Seismic Fortification Standards for Electrical Equipment, Earthquake Research in China, Volume 27, Number 4, 2013.

List of Recommendations

Strengthen Our Buildings

Mandatory Retrofit of Soft-First-Story Buildings. Mandate retrofit of soft-first-story buildings to make the first floor as strong as the second.

Mandatory Retrofit of Concrete Buildings. Mandate that concrete buildings designed prior to the enactment of the 1976 Uniform Building Code meet the Basic Safety Objective (BSO) in the AFSCME 41.

Mandatory Retrofit of Buildings that are Excessively Damaged in Earthquakes. Mandate retrofitting of buildings that incur excessive damage in a low level of earthquake shaking (less than 40%g on the USGS ShakeMap).

Adoption of a Back to Business Program: Adopt a "Back to Business Program" to supplement the capacity of the City's building inspection force in the event of a major earthquake.

Voluntary Ratings of Buildings. Adoption and implementation of a voluntary rating system, utilizing the system designed by the United States Resiliency Council.

Fortify Our Water System

Alternative Water System. LAFD and LADWP should develop a resilient and alternative water system for firefighting purposes.

Protect the Los Angeles Aqueduct. Identify mitigation alternatives for the Los Angeles Aqueduct crossing the San Andreas Fault.

Protect the Other Aqueducts. Create a Seismic Resilience Water Supply Task Force with the DWP, California MWD, and the DWR, in an effort to create a collaborative and regional approach to protecting the resilience of our water supply.

Protect Water Storage. Ensure that DWP dams are maintained in a safe and reliable manner to both ensure a reliable water supply and to ensure public safety in the event of an earthquake.

Develop Local Water. The 2010 Urban Water Management Plan (UWMP) to develop local water supplies through storm water capture, water conservation, and water recycling should be actively pursued.

Seismic Resilient Pipe Network. DWP should commit to a future water system with a seismically resilient pipe network.

LADWP Resilience by Design Program. Establish a Resilience by Design Program at the highest level of DWP, covering both the power and water systems to promote an institutional emphasis on seismic resilience as a core function of DWP.

Seismic Resilience Bond Measure. Work with local, regional, and state partners to develop a seismic resilience bond measure to allow for necessary investments in the seismic safety of our region.

Enhance Reliable Telecommunications

Partnerships with Service Providers. The City should enter into a Memorandum of Understanding (MOU) with cellular service providers to maximize access to telecommunication coverage in a disaster.

Wi-Fi Alternative. Develop solar-powered Citywide Wi-Fi to provide a telecommunications alternative that uses less power and will allow Internet access in a time when the cell system is disrupted.

Protect the Power System at Fault Crossings. Create a Southern California Utility Resilience Task Force to develop solutions to the potential for cascading failures in the interacting utilities as they cross the San Andreas Fault.

Stronger Cell Towers. The City should amend its building code to require new freestanding cellular communication towers to be built with an Importance Factor of 1.5. Existing towers would not be affected.

Advancement of Earthquake Early Warning. The City of Los Angeles and the USGS should begin to implement Early Earthquake Warning in Southern California. In addition, the City of Los Angeles should work with Congressional Representatives to support a robust Earthquake Early Warning system in California.

Summary of Potential Resilience Incentives

During the course of this project, the Seismic Safety Task Force discussed a number of programs that could be adopted in order to ensure the successful implementation of the recommendations. We recognize that these suggested programs require thorough analysis and discussion by the Mayor, the City Council, and the Los Angeles community prior to adoption. We also recognize that these programs were beyond the scope of the Task Force to fully analyze and recommend. Nevertheless, we offer these suggestions as a way to begin the discussion on the incentive programs that will be needed. These programs can include:

- Providing access to private lending sources based on the PACE financing program for soft-first story retrofits.
- Waiving fees required by the Department of Building and Safety and the Department of City Planning for permits and variances associated with mandatory retrofit work.
- Allowing a reduction of up to 20% in required parking for the necessary loss of parking associated with soft-first-story retrofits.
- Establishing a 5-year exemption from Business Tax for businesses that move into newly retrofitted buildings.
- Establishing a policy by which, if in the rare instance that a building must be demolished, an owner demolishes and replaces a concrete building determined to require retrofit, the new building may be built with the same entitlements.
- Offering a business tax credit or exemption for those retrofitting and/or those who build a structure above the minimum code requirements.
- Working with State to determine feasibility of easing CEQA requirements for projects associated with concrete building retrofit work.
- Working with the Los Angeles City Council, partner Cities, and State legislators to develop a resilience bond measure to assist in expediting the funding available for the replacement of key water and communications infrastructure,

and other appropriate resilience projects.

- Reviewing provisions under the rent stabilization ordinance addressing cost sharing between landlords and tenants to determine if these provisions require adjustment to protect low-income tenants.

Appendix A

MANDATORY EARTHQUAKE HAZARD REDUCTION IN EXISTING WOOD FRAME BUILDINGS WITH SOFT, WEAK OR OPEN WALLS

Ordinance No. ____, Effective_____

I. PURPOSE

The purpose of this Ordinance is to promote the public welfare and safety by reducing the risk of death or injury that may result from the effects of earthquakes on existing wood-frame buildings with soft, weak or open walls. In the Northridge Earthquake, many multi-story wood frame buildings with tuck under parking performed poorly and collapsed. These types of buildings were shown to be vulnerable to loss of human life, personal injury and property damage during past earthquakes. Common deficiencies of this building type have been identified to be soft, weak or open walls. This Ordinance creates minimum standards to mitigate hazards from these deficiencies. When fully followed, these minimum standards will improve the performance of these buildings but will not necessarily prevent all earthquake-related damage.

II. SCOPE

The provisions of this Ordinance shall apply to all existing commercial and residential buildings of wood frame construction, except residential buildings with 3 units or less, having all the following:

1. Two or more stories,

2. Determined by the Department to have been built and issued a Certificate of Occupancy before January 1, 1980, and

3. Ground floor portion of the wood frame structure contains parking or other similar open floor space that causes soft, weak or open wall lines.

III. DEFINITIONS

The following definitions shall apply for the purposes of this Ordinance:

CRIPPLE WALL is a wood-framed stud wall extending from the top of the foundation wall to the underside of the lowest floor framing of the building.

GROUND FLOOR is any floor within the wood frame portion of a building whose elevation is immediately accessible from an adjacent grade by vehicles or pedestrians. The ground floor portion of the structure does not include any level that is completely below adjacent grades.

OPEN WALL LINE is an exterior wall line with vertical elements of the lateral force resisting system which requires tributary seismic forces to be resisted by diaphragm rotation or excessive cantilever beyond parallel lines of shear walls. Diaphragms that cantilever more than twenty-five percent of the distance between lines of lateral force resisting elements from which the diaphragm cantilevers shall be considered excessive. Exterior exit balconies of six feet or less in width shall not be considered excessive cantilevers.

RETROFIT is an improvement of the lateral force resisting system by alteration of existing structural elements or addition of new structural elements.

SINGLE FAMILY DWELLING is any building which contains living facilities, including provisions for sleeping, eating, cooking and sanitation, as required by this code, for not more than one family.

SOFT WALL LINE is a wall line whose lateral stiffness is less than required by story drift limitations or deformation compatibility requirements of this Ordinance. In lieu of analysis, this may be defined as a wall line in a story where the story stiffness is less than 70 percent of the story above for the direction under consideration.

STORY is as defined in the building code, including any basement or underfloor space of a building with cripple walls exceeding four feet in height.

STORY STRENGTH is the total strength of all seismic resisting elements sharing the same story shear in the direction under consideration.

WALL LINE is any length of a wall along a principal axis of the building used to provide resistance to lateral loads.

WEAK WALL LINE is a wall line in a story where the story strength is less than 80 percent of the story above in the direction under consideration.

IV. COMPLIANCE REQUIREMENTS

Priority designation. Buildings within the scope of this Ordinance shall be recognized with the

priority designation as follows:

I. Residential Buildings with 16 units or more.

II. Buildings with 3 stories or more (other than buildings under Priority I).

III. All others

The owner of each building within the scope of this Ordinance shall cause a structural analysis to be made of the building by a civil or structural engineer or architect licensed by the state of California, and if the building does not meet the minimum earthquake standards specified in this Ordinance, the building shall be structurally altered to conform to such standards or be demolished within the time limits stated in this Ordinance.

Service of order. When the Department determines that a building is within the scope of this Ordinance, the Department shall issue an order to the owner of the building with the minimum time period for service of such orders. The minimum time period for the service of such orders shall be measured from the order effective date.

Buildings not served an order to comply with this Ordinance shall not invalidate any proceedings hereunder as to any other person duly served or relieve any such person from any duty or obligation imposed by this Ordinance.

This Ordinance does not require existing electrical, plumbing, mechanical or fire systems to be altered unless they constitute a hazard to life or property.

Unless expressly stated herein, this Ordinance is not intended to amend, repeal, or supersede provisions of the Los Angeles Municipal Code. In any specific section or case where there is a conflict within or between or among provisions, the most restrictive which prescribes and establishes the higher standard of safety or public benefit shall prevail and control.

Time limit.

A. The owner of a building within the scope of this Ordinance shall comply with the requirements set forth above by submitting to the Department for review and approval within one (1) year after the service of the order:

1. A structural analysis and plans which shall demonstrate the building, as is, meets the minimum requirements of this Ordinance, or

2. A structural analysis and plans for the proposed structural alteration of the building necessary to comply with the minimum requirements of this Ordinance, or

3. Plans for the demolition of the building.

B. Obtain all necessary permits, within two (2) years after receipt of the order, for rehabilitation or demolition.

C. All construction or demolition work under all necessary permits shall be completed within four (4) years after receipt of the order.

Appeal from order. The owner or person in charge or control of the building may appeal the Department's initial determination that the building is within the scope of this Ordinance to the Board of Building and Safety Commissioners. Such appeal shall be filed with the Board within 60 days from the service date of the order. Any such appeal shall be decided by the Board no later than 60 days after the date that the appeal is filed. Such appeal shall be made in writing upon appropriate forms provided therefor by the Department, and the grounds thereof shall be stated clearly and concisely.

Appeals or requests for slight modifications from any other determinations, orders or actions by the Department pursuant to this Ordinance shall be made in accordance with the procedures established in Section 98.0403.2 of the Los Angeles Municipal Code.

Recordation. At the time that the Department serves the aforementioned order, the Department shall file with the Office of the County Recorder a certificate stating that the subject building is within the scope of this Ordinance. The certificate shall also state that the owner thereof has been ordered to structurally analyze and to structurally alter or demolish the building when the Department determines the building is not in compliance with this Ordinance.

If the building is either demolished, found not to be within the scope of this Ordinance, or is structurally capable of resisting minimum seismic forces required by this Ordinance as a result of structural alterations or an analysis, the Department shall file with the Office of the County Recorder a certificate terminating the status of the subject building as being classified within the scope of this Ordinance.

Enforcement and penalty. If the owner or other person in charge or control of the subject building fails to comply with any order issued by the Department pursuant to this Ordinance within any of the time limits, the Department may order that the entire building or a portion thereof be vacated and that the building or a portion thereof remain vacated until such order has been complied with. If compliance with such order has not been accomplished within 90 days after the date the building has been ordered vacated or such additional time as may have been granted by the Board, the Superintendent may order its demolition in accordance with the provisions of Section 8903 of Building Code.

Notwithstanding any other provision of this Code to the contrary, it shall be unlawful for any person, firm, or corporation to maintain, use, or occupy any building within the scope of this division which does not meet the minimum earthquake standards specified in this division.

Any person who violates, causes or permits another person to violate this provision is guilty of a misdemeanor. Any person includes an owner, lessor, sublessor, manager or person in control of a building subject to this ordinance. This term shall not include any person who is merely a tenant or other individual occupying any dwelling unit, efficiency dwelling unit, guest room or suite in a building. The legal owner of a building is that person, firm, corporation, partnership or other entity whose name or title appears on the record with the Office of the County Recorder, as well as all successors or assignees of these persons.

EXCEPTION: This section shall not apply to any building on which work is proceeding in compliance with any extensions of time granted by the Department; or any action, order or determination made by the Department in the implementation of this ordinance

Occupant and tenant advisory. The property owner shall advise all current and prospective residential occupants and non-residential tenants of the building in a method and written format approved by the Housing and Community Investment Department.

Historical buildings. Qualified historical buildings shall comply with requirements of the California Historical Building Code established under Part 8, Title 24 of the California Code Regulations.

V. ENGINEERING ANALYSIS

Scope of analysis. This Ordinance requires the alteration, repair, replacement or addition of structural elements and their connections to meet the strength and stiffness requirements herein. The lateral-load-path analysis shall include the resisting elements and connections from the wood diaphragm immediately above any weak or open wall lines to the foundation. Stories above the weak wall line shall be considered in the analysis but need not be modified.

Design base shear and design parameters. The design base shear in a given direction shall be 0.20 W, where W is the tributary mass of the structure above the soft story and W shall be as defined in ASCE 7 Section 12.14.8.1.

Lateral Vertical Systems. Strengthening systems with concrete walls or masonry walls, or steel braced frame shall be not be permitted.

Horizontal Structural Irregularities in buildings with 3 or more stories. Structures with 3 or more stories having horizontal structural irregularities of either type 2, 3, 4, or 5 listed in ASCE 7 Table 12.3-1, shall be designated to meet the additional requirements of those sections referenced in the table 12.3-1 for the entire story with weak or open wall lines.

Alternate analysis, base shear and design parameters. The Department may approve alternate design methodologies that improve the whole first story seismic performance that are equivalent to the life safety objectives in this ordinance.

Additional anchorage requirements for buildings on hillsides. Where any portion of a building within the scope of this Ordinance is constructed on or into a slope steeper than one unit vertical in three units horizontal (33-percent slope), the lateral-force-resisting system shall be analyzed for the effects of concentrated lateral forces at and below the base level diaphragm shall also be analyzed for the effects of concentrated lateral loads caused at the building base from the hillside conditions and comply with the provisions of Chapter 94 of the Los Angeles Building Code.

Story drift limitations. The calculated story drift for each retrofitted story shall not exceed the allowable deformation compatible with all vertical load-resisting elements and 0.025 times the story height. The calculated story drift shall not be reduced by the effects of horizontal diaphragm stiffness but shall be increased when these effects produce rotation. Drift calculations shall be in accordance with ASCE 7-10 requirements.

Pole structures. The effects of rotation and soil stiffness shall be included in the calculated story drift where lateral loads are resisted by vertical elements whose required depth of embedment is determined by pole formulas. The coefficient of subgrade reaction used in deflection calculations shall be based on an approved geotechnical investigation conducted in accordance with approved geotechnical engineering reports.

P-Delta effect. The requirements of the Los Angeles Building Code shall apply, except as modified herein. All structural framing elements and their connections not required by the design to be part of the lateral force resisting system shall be designed and/or detailed to be adequate to maintain support of design dead plus live loads when subject to the expected deformations caused by seismic forces. The stress analysis of cantilever columns shall use a buckling factor of 2.1 for the direction normal to the axis of the beam.

Ties, continuity and collectors. All parts of the structure included in the scope of analysis shall be interconnected and the connection shall be capable of resisting the seismic force created by the parts being connected as required per the Los Angeles Building Code.

VI. REQUIRED INFORMATION ON PLANS

General. For existing and new construction, the plans and specifications shall be of sufficient clarity to indicate the nature, design methodology, and extent of the proposed work and to show in detail that it will conform to the provisions of this Ordinance and the Los Angeles Building Code.

Engineer's or architect's statement. The responsible engineer or architect shall provide the following statements on the approved plans:

1. "I am responsible for designing this building's seismic strengthening in compliance with the minimum regulations of the mandatory Wood Soft-Story Retrofit Ordinance (Ordinance No. _____)."

Appendix B

MANDATORY SEISMIC RETROFIT PROGRAM

NON DUCTILE CONCRETE BUILDINGS

OUTLINE

I. PURPOSE
II. SCOPE
III. DEFINITIONS
IV. COMPLIANCE REQUIREMENTS
V. ENGINEERING ANALYSIS
VI. FINANCING AND INCENTIVES

MANDATORY EARTHQUAKE HAZARD REDUCTION IN

EXISTING NON DUCTILE CONCRETE BUILDINGS

Ordinance No. ______, Effective ____

I. PURPOSE

The purpose of this Ordinance is to promote the public welfare and safety by reducing the risk of death or injury that may result from the effects of earthquakes on existing concrete buildings. In the Northridge Earthquake, the Great Hanshin Earthquake, Japan, the Mexico City earthquake, and Christchurch New Zealand Earthquake, many concrete buildings constructed prior to the 1976 Los Angeles City Building Code provisions, or similar era codes in other countries, performed poorly and collapsed causing loss of human life, personal injury, and property damage. The poor performance of these older concrete buildings is typically due to deficiencies in the lateral force resisting system (beams, columns, and joints) that render the building incapable of sustaining gravity loads when the building is subjected to earthquake induced lateral displacements. This Ordinance creates timelines and minimum standards to mitigate hazards from these deficiencies. When fully followed, these minimum standards will improve the performance of these buildings but will not necessarily prevent all earthquake-related damage.

II. SCOPE

The provisions of this Ordinance shall apply to all existing concrete buildings, except detached single family dwellings, having been determined by the Department to have been permitted before January 1, 1980.

III. DEFINITIONS

The following definitions shall apply for the purposes of this Ordinance:

CONCRETE BUILDING is a building having concrete floors and/or roofs, either with or without beams, supported by concrete walls and/or concrete columns, with or without masonry infills, and any combination thereof.

MASONRY INFILL is the unreinforced or reinforced masonry wall construction within a reinforced concrete frame.

RETROFIT an improvement of the structural system by alteration of existing structural elements or addition of new structural elements.

SINGLE FAMILY DWELLING is any building which contains living facilities, including provisions for sleeping, eating, cooking and sanitation, as required by this code, for not more than one family.

IV. COMPLIANCE REQUIREMENTS

Service of order. When the Department determines that a building is within the scope of this Ordinance, the Department shall issue an order to the owner of the building within the minimum time period for service of such orders.

The notice and order shall state the time limit stages the owner has to respond to the Department from the issuance date of the notice to the owner.

Buildings not served an order to comply with this Ordinance shall not invalidate any proceedings hereunder as to any other person duly served or relieve any such person from any duty or obligation imposed by this Ordinance.

This Ordinance does not require existing electrical, plumbing, mechanical or fire systems to be altered.

Recordation. At the time that the Department serves the aforementioned order, the Department shall file with the Office of the County Recorder a certificate stating that the subject building is within the scope of this Ordinance. The certificate shall also state that the owner thereof has been ordered to structurally analyze and to structurally alter or demolish the building when the Department determines the building is not in compliance with this Ordinance.

If the building is either demolished, found not to be within the scope of this Ordinance, or is structurally capable of resisting minimum seismic forces required by this Ordinance as a result of structural alterations or an analysis, the Department shall file with the Office of the County Recorder a certificate terminating the status of the subject building as being classified within the scope of this Ordinance.

Time limits.

A. The owner of a building within the scope of Ordinance shall comply with the requirements set forth above by submitting to the Department for review and approval within three years after the service of the order a completed checklist in the format and form provided by the Department.

B. For buildings within the scope of the ordinance, the owner shall provide within 5 years from the date of the original order, a detailed evaluation of the building documenting whether the building meets or exceeds the Engineering Analysis requirements of this ordinance. This detailed evaluation shall include either:

1. Proof showing that the building was previously retrofitted to all provision in Chapters 85 or 95 of the Los Angeles Building Code.

2. Proof showing that voluntarily retrofitted to the design criteria indicated in this ordinance.

3. A report summarizing structural analysis results that indicate that the existing building meets the structural requirement of the Ordinance.

4. A report summarizing structural analysis results and plans for the proposed structural alteration of the building necessary to comply with the minimum requirements of this Ordinance.

5. Plans for the demolition of the building.

C. Within 30 years from the date of the original notice order, demolition or retrofit of the building shall be complete.

D. All buildings within the scope of this Ordinance that did not receive an order from the Department shall not invalidate any proceedings hereunder as to any other person duly served or relieve any such person from any duty or obligation imposed by this Code to complete all demolition or retrofit work by July 1, 2040.

Appeal from order. The owner or person in charge or control of the building may appeal the Department's order that the building is within the scope of this Ordinance to the Board of Building and Safety Commissioners. Such appeal shall be filed with the Board within 60 days from the service date of the order. Such appeal shall be made in writing upon appropriate forms provided therefor by the Department, and the grounds thereof shall be stated clearly and concisely.

Appeals or requests for slight modifications from any other determinations, orders or actions by the Department pursuant to this Ordinance shall be made in accordance with the procedures established in Section 98.0403.2 of the Los Angeles Municipal Code.

Enforcement and penalty. If the owner or other person in charge or control of the subject building fails to comply with any order issued by the Department pursuant to this Ordinance within any of the time limits, the Department may order that the entire building or a portion thereof be vacated and that the building or a portion thereof remain vacated until such order has been complied with. If compliance with such order has not been accomplished within 90 days after the date the building has been ordered vacated or such additional time as may have been granted by the Board, the Superintendent may order its demolition in accordance with the provisions of Section 8903 of Building Code.

Unless expressly stated herein, this Ordinance is not intended to amend, repeal, or supersede provisions of the Los Angeles Municipal Code. In any specific section or case where there is a conflict within or between or among provisions, the most restrictive which prescribes and establishes the higher standard of safety or public benefit shall prevail and control.

Occupant and tenant advisory. The property owner shall advise all current and prospective residential occupants and non-residential tenants of the building in a method and written format approved by the Housing and Community Investment Department.

Historical buildings. Qualified historical buildings shall comply with requirements of the California Historical Building Code established under Part 8, Title 24 of the California Code Regulations.

V. ENGINEERING ANALYSIS

Scope of analysis. This Ordinance requires the alteration, repair, replacement or addition of structural elements and their connections to meet the following requirements:

Building Structural Analysis, Design and Evaluation. The building shall meet one of the following criteria:

1. Strength of the code conforming lateral resisting system shall meet or exceed seventy five percent (75%) of the base shear specified in the current Los Angeles Building Code seismic provisions. Elements not designated to be part of the lateral-force resisting system shall be retrofitted to be adequate for gravity load effects and seismic displacement due to the full (100%) of the design story drift specified in the current Los Angeles Building Code seismic provisions.

2. Meet or exceed the requirements specified for "Basic Safety Objective" using ground motions and procedures established by the Department based on ASCE 41.

3. Other methods approved by the Department, deemed to be equivalent to the approaches in 1. and 2.

VI. REQUIRED INFORMATION ON PLANS

General. For existing and new construction, the plans and specifications shall be of sufficient clarity to indicate the nature and extent of the proposed work and to show in detail that it will conform to the provisions of this Ordinance and the Los Angeles Building Code.

Engineer's or architect's statement. The responsible engineer or architect shall provide the following statements on the approved plans:

1. "I am responsible for designing this building's seismic strengthening in compliance with the minimum regulations of the mandatory non-ductile concrete retrofit Ordinance (Ordinance No. _____) using the design criteria of (75% of ASCE 7, ASCE 41). "

and when applicable:

2. "The Registered Deputy Inspector, required as a condition of the use of structural design stresses requiring continuous inspection, will be responsible to me as required by Section 1704 of the Los Angeles Building Code."

3. "Structural Observation will be performed in accordance with current Los Angeles Building Code."

VII. FINANCING AND INCENTIVES

Financing program. (?)

Green incentives. (?)

Non-conformance incentives. (?)

Parking reduction incentives. (?)

Appendix C

Summary of Back To Business Program

The adoption and establish of a program will require several steps by the City of Los Angeles:

1. Customize the program based on a template of an example program used by the City of Glendale. Customizations will include adjusting the program description to match the requirements of the City of Los Angeles, a review and customization of the individual building application information, the building owner's application and the requirements for certification of the designated inspectors.
2. By Administrative Action, the Superintendent of Buildings should add the B2B Program to the Department of Building and Safety procedures and assign a staff manager to oversee the program during initial building registrations, during annual program renewals and during the post-earthquake scenarios.
3. Establish all procedures for the review and approval of applications, for emergency contacts and for processing of annual reviews. Each building application should include the following information:
    a. Assignment of a specific pretrained & prequalified designated Inspector (a "B2B Inspector"), and back-ups for each building that will be pre-certified by Building and Safety to inspect the building in the event of a declared Emergency and act as liaison with the Building and Safety staff regarding inspection review and posting
    b. Emergency contact information for both the building owner and the designated inspectors
    c. Building Information: address, photos, description, floor plans, entrance locations, building uses, estimated building valuation, life safety systems, fire detection & suppression systems, potential falling hazards, hazardous materials
    d. Emergency Response information: emergency trigger information, access procedures, Inventory of available documents and equipment for the inspector's use
    e. Emergency Inspection Procedures:
        i. Inspection guidelines (ATC-20)
        ii. Detailed instructions (where to look for damage, how to look, what to look for, etc.),
        iii. Procedures following aftershocks
    f. Precertification of building
    g. Emergency B2B Inspector Authorization
    h. Annual Program Renewal information

4. Assign designated and dedicated Building and Safety Staff to respond automatically within 24 hours of the event or if requested earlier by the Building's B2B Inspector for all buildings enrolled in the program. The responding Building and Safety Staff will review the recommended posting and issue the official posting placard on the building.
5. Provide authority to the responding Building and Safety Staff to provide a Permit for Construction while on site based on the recommendations of the B2B Inspector.
6. Publicize and advertise the establishment of the Program to the public and promote through various business and community organizations.
7. Assign staff to maintain and administer the program including review of all submitted BORP Building Applications, review of all Annual Renewal certificates, and coordination of the communications between the B2B Inspectors and Building and Safety during those weeks after a damaging earthquake.

Long Term Goal: Improve the City's resilience by decreasing downtime with the improvement of the City's official response to a damaging earthquake by expanding the capacity of the Department of Building & Safety inspections through the establishment of a Building Occupancy Resumption Program.

1. Benefits to Building Owners:
   a. Insures occupants' safety reoccupying building
   b. Results in faster response for inspections
   c. Reduces chance of an overly "conservative" posting
   d. Will increase owner's control of building's re-occupancy
   e. Reduces chances of tenant displacement
   f. Reduces business interruption risks and costs
   g. Inspires Owner, Tenant & Employee confidence
2. Benefits to the City of Los Angeles:
   a. Insures Citizens' safety
   b. Keeps major "Clients" happy
   c. Reduces the number of buildings that City is responsible for inspecting
   d. Reduces business interruption costs for building Owners and therefore maintains strong tax base for City
   e. May result in proactive seismic retrofitting before the earthquake
   f. Increases City's resilience & should reduce overall community recovery time
   g. Increases citizens' confidence in City government

Appendix D

USRC Dimensions and Definitions

Safety, Repair Cost, and Functional Recovery

The performance of a building cannot be determined with certainty, even for a given level of earthquake shaking, and will also vary across possible earthquakes of different distances and strengths. The ratings below, when used for earthquake performance, correspond to the average performance given a single earthquake with ground shaking corresponding to that required for the design of a new building.

SAFETY

The SAFETY rating dimension reflects the expected state of the building in terms of exiting the building, injury and loss of life. A SAFETY rating in this context is an indicator of the risk of overall casualties, which includes both injuries of various types and seriousness and loss of life.

Safety Rating

★★★★★	Exit paths preserved and injuries unlikely Performance will likely result in conditions that do not cause injuries or blockage of exit paths.
★★★★	Major injuries unlikely Performance will likely result in conditions that limit the extent and severity of injuries.
★★★ ▪	Loss of life unlikely Performance will likely result in conditions that will not cause loss of life.
★★ ▪	Loss of life possible in isolated locations Performance will likely result in conditions at some locations within or adjacent to the building l major injuries and/or loss of life.
★ ▪	Loss of life probable throughout the building Performance will likely result in widespread conditions known to be associated with major injuri of life.
NE	Not Evaluated This dimension has not been evaluated .

REPAIR COST

The REPAIR COST rating dimension reflects an estimate of the cost to repair the building such that it can continue to be used as it was at the time the rating is issued. Repair cost is defined as a percentage of the building's overall replacement value, a common insurance concept measuring how much it would cost to construct a new building approximately the same as the one prior to the event. Repair cost includes the cost of damage to all of the structural, architectural and mechanical and electrical components of a building but does not include the cost of damage to the contents. Contents values may vary depending on occupancy at the time of the event. However content damage can be estimated once the contents are defined and this can be reported separately. Repair cost is determined without consideration of overall market conditions in effect following the event, such as post-event increases in local construction costs, and does not include such factors as business interruption associated with loss of use or occupancy restrictions, design fees, permit fees, historic preservation or mandatory upgrades triggered by building code regulations.

Repair Cost Rating

★★★★★ ▪	Within typical operating budget Performance will likely result in Repair Cost less than 5% of building replacement value.
★★★★	Within the typical insurance deductible Performance will likely result Repair Cost less than 10% of building replacement value.
★★★ ▪	Within industry scenario expected (SEL) loss Performance will likely result Repair Cost less than 20% of building replacement value.
★★ ▪	Repairable damage Performance will likely result Repair Cost less than 50% of building replacement value.
★ ▪	Substantial Damage Performance will likely result Repair Cost greater than 50% of building replacement value.
NE	Not Evaluated This dimension has not been evaluated.

FUNCTIONAL RECOVERY

The FUNCTIONAL RECOVERY dimension is an estimate of the time until a property owner or tenant is able to enter and use the building for its basic intended functions, assuming that external infrastructure (e.g., utilities, transportation) is available to permit access and provide basic services to the building. Back-up utility systems may be necessary to achieve four and five star performance goals if external utilities are not functional. A FUNCTIONAL RECOVERY rating represents a minimum timeframe to effect repairs and to remove major safety hazards and obstacles to occupancy and use. This rating does not address several other factors that can delay the time to regain function such as damage or post-event conditions associated with building contents or the condition of adjacent buildings.

unctional Recovery Rating

★★★★★ ▪	Within days. Performance will likely result in Functional recovery within hours to days.
★★★★	Within weeks Performance will likely result in Functional recovery that is delayed a week or more.
★★★ ▪	Within months Performance will likely result in Functional recovery that is delayed for at least one month.
★★ ▪	More than 6 months. Performance will likely result in Functional recovery that is delayed for at least six months.
★ ▪	More than one year Performance will likely result in Functional recovery that is delayed for least one year or more.
NE	Not Evaluated This dimension has not been evaluated.

The complexity and amount of time needed to restore a building to usable condition can increase quickly in relation to the degree of damage. Delays in design, financing, and construction may include time until arrival of special-order equipment or materials, increased prices and a lack of local design professionals or contractors available for hire in a community where many buildings have been damaged, and longer than usual permitting and inspection wait times. These factors can be estimated and reported separately, but the actual total time impact of these factors is highly uncertain and may even be different depending on who owns the building.

Appendix E

MEMORANDUM OF UNDERSTANDING

FOR THE CITY OF LOS ANGELES'

TELECOMMUNICATIONS RESILIENCE PARTNERSHIP

This MEMORANDUM OF UNDERSTANDING is made and entered into by and among the City of Los Angeles ("City"), through the Los Angeles Mayor's Office of Homeland Security and Public Safety, and the participating partners executing this agreement (the "Carriers"). This MOU memorializes the voluntary participation of the Carriers in partnership with the City to protect and restore telecommunications coverage for City residents and businesses in the event of a large scale emergency, including natural disasters, acts of terrorism, and other man-made disasters.

I. PURPOSE

The City mitigates, plans, prepares for, responds to, and aids in recovery from the effects of emergencies that threaten lives, property, and the environment. As the City's residents and businesses become more reliant upon wireless communications and remote access to information, the City recognizes the critical role that Carriers will play in ensuring continuity of coverage in the event of a natural or man-made disaster that impacts public and private communications infrastructure. It is anticipated that in a large scale earthquake, for example, between 100,000 and 200,000 addresses will lose phone and internet service.

The City and the Carriers intend to cooperate to carry out their respective responsibilities and plan and support joint initiatives with respect to disaster mitigation, preparedness, response, and recovery operations. The City and Carriers recognize that sharing certain information concerning emergency conditions, emergency response plans, and critical infrastructure impacts may maximize and expedite one another's restoration opportunities.

This MOU sets forth the terms by which the City and the Carriers will provide information, resources, services, personnel, as available, in order to strengthen the capacity to protect and expeditiously restore telecommunications coverage for City residents and businesses. Under this MOU, the City and the Carriers intend to develop specific action plans addressing particular aspects of emergency response operations.

II. RESPONSIBILITIES

A. The City will, as resources and information are available, and as is appropriate, undertake the following responsibilities:

1. The City shall coordinate with the Carriers for assistance during emergencies and disasters. Additionally, the City shall aid the Carriers in their efforts to retain telecommunication coverage in the City after a large emergency or disaster.

2. The City will provide notification of emergency conditions that may affect the Carriers' interests, enabling Carriers to better monitor disaster events. This will include naming a designee for the Carriers' representatives during disasters.

3. As deemed appropriate and reasonable, the City may facilitate access to critical infrastructure sites to enable Carriers to restore telecommunication coverage after a large emergency or disaster. This may include the assistance of law enforcement escorts, prioritization of road clearance and debris removal, and assistance providing temporary access to otherwise restricted locations.

4. The City, through its Emergency Management Department ("EMD"), will make training and exercises available on a regular basis to the Carriers' representatives to increase situational awareness during emergencies and disasters.

5. The City will share reports, policies, guidance manuals, brochures, videos, lessons learned, best practices and training resources as permitted.

6. The City will provide emergency operations center access for pre-designated representatives of the Carriers during emergencies. The City reserves the right to limit access to emergency operations centers based upon safety or security needs.

B. The Carriers will, as resources and information are available, and as is appropriate, undertake the following responsibilities:

1. The Carriers shall provide (or coordinate with EMD to develop) its communication strategy (with contractors, repair workers, vendors, etc.) to provide effective response and recovery in the event of an emergency.

2. Inventory

   a. Carriers shall develop and maintain a detailed inventory of equipment and resources which are required in the event of an emergency. City and Carriers will collaborate to ensure sufficient resources are available, as well as develop effective means of preventing theft or vandalism of critical assets.
   b. Carriers shall provide an updated inventory to the City annually.

3. Carriers shall identify critical facilities and vulnerabilities at each of their proprietary sites. Carriers shall identify areas recognized as single points of failure likely to require equipment immediately. Carriers shall provide a list or classification of proprietary sites (cell and switch sites) to the City in the order of importance and size to assist coordination with the City in the event of an emergency.

4. The Carriers shall appoint an individual with the authority to make critical decisions about the company after an Emergency Declaration. Said designee shall be the main point of contact to assist the City in its recovery efforts to restore telecommunication coverage to the City.

5. The Carriers shall provide the City with company emergency plans that are triggered by an Emergency Declaration and shall include the

following:

a. Protocol for initiation/activation of emergency plans.
b. Staffing of personnel with roles before, during, and after an emergency.
c. Repair strategy for continuity of services, equipment distribution, projected timelines for repair.
d. Backup power and fuel utilization plans.
e. Timelines for reconstruction, repair, and recovery based upon projected earthquake or other disaster impacts.

6. In the event of an emergency, Carriers will cooperate to temporarily share networks amongst one another, to the extent technologically feasible, such that customers' voice and data traffic may be securely carried on whatever network is compatible and more functional in their area, regardless of customers' particular networks or service agreements, and without incurring additional costs.

7. In the event of an emergency, Carriers will open Wifi networks, to the extent technologically feasible, for the purpose of providing temporary connections to the internet for secure public and private access to data and voice-over-Wi-Fi traffic.

III. PROTECTION OF CONFIDENTIAL AND PROPRIETARY INFORMATION

A. The Carriers may share information, both in writing and orally, essential to effect emergency response consistent with applicable laws and the need to protective sensitive proprietary information. This information shall be designated as "Confidential" and shall be protected by the City to the extent allowed by law and pursuant to the terms of a nondisclosure agreement, to be executed at a later date.

B. In no event shall the City disclose or require a Carrier to disclose information designated by a Carrier as Confidential without its prior written consent.

C. Confidential Information shared by Carriers, including emergency inventory, plans, and critical infrastructure data shall be securely stored in the City's

Public Critical Infrastructure Management System (PCIIMS). Access to such Confidential Information will be restricted to specified law enforcement personnel.

IV. TERM

This MOU shall remain in effect until such time as a party terminates their participation by providing notice, in writing, to the other parties of their intent to terminate.

V. POINTS OF CONTACT

The City and the Carriers will designate key people within their respective organizations to implement the MOU. The points of contacts will direct and coordinate partnership activities to ensure that mutual benefits and interests are served. The respective offices responsible for spearheading implementation are:

A. Los Angeles Mayor's Office

Eileen Decker

Deputy Mayor, Homeland Security & Public Safety

Office of Mayor Eric Garcetti

200 N. Spring Street, Room 303

Los Angeles, California 90012

(213) 978-0687

eileen.decker@lacity.org

B. Emergency Management Department

C. Sprint Corporation

D. Verizon Communications

E. T-Mobile US, Inc.

F. AT&T, Inc.

G. Time Warner Cable

VI. LIABILITY

A. Nothing in this MOU shall be construed as encroaching upon the sovereign rights, privileges, and immunities of any of the parties hereto in the conduct of inherently Municipal, State or Federal government operations. Further, nothing in this MOU is intended to conflict with current law, regulation, or the policies and directives of any of the parties. If any terms and conditions of this MOU are inconsistent with such authorities, the inconsistent term shall be deemed invalid, and the remaining terms and conditions of this MOU shall remain in full force and effect.

B. Each party will be responsible for its own actions in providing services under this MOU and shall not be liable for any civil liability that may arise from the furnishing of the services by any other party to this MOU. Participation in this MOU shall not impose any liability for claims upon any party to which it would not otherwise be subject under applicable law.

C. By entering into this MOU, the parties do not intend to create any obligations express or implied other than those set out herein. Further, this MOU shall not create any rights in any party other than the signatories to this MOU.

VII. OTHER PROVISIONS

A. This MOU creates neither a partnership nor a joint venture, and no party has the authority to bind another. This MOU is not intended to be enforceable in any court of law or dispute resolution forum.

B. The parties may use or display each other's name, emblem, or trademarks only in the case of particular projects and only with the prior written consent of the other party.

C. Any services, equipment or personnel provided to or by the City to accomplish the goals anticipated under this MOU are done so without expectation of reimbursement or the payment of fees related to the provision of such services, equipment or personnel.

D. Nothing herein is intended to create any rights or benefits, substantive or procedural, enforceable at law or in equity, against the City of Los Angeles, its agencies, departments, entities, officers, employees, or any other person.

E. This MOU imposes no financial obligation on the signatories. In the event that the City and any party wish to enter into a financial arrangement, said parties shall execute an agreement/contract stipulating the terms of said financial arrangement.

[THIS SECTION IS INTENTIONALLY LEFT BLANK]

IN WITNESS WHEREOF, each of the Participants have caused this MOU to be executed by their duly authorized representatives.

<table>
<tr>
<td>For: [Company Name]

By: ____________________

Name/Title: ______________
Date: __________________

[SEAL]</td>
<td>For: THE CITY OF LOS ANGELES
ERIC GARCETTI, Mayor

By ___________________________________

Eric Garcetti, Mayor

Homeland Security and

Public Safety, Mayor's Office

Date ___________________________________</td>
</tr>
<tr>
<td>For: [Company Name]

By: ____________________

Name/Title: ______________
Date: __________________

[SEAL]</td>
<td>For: [Company Name]

By: ____________________

Name/Title: ______________
Date: __________________

[SEAL]</td>
</tr>
</table>

For: [Company Name] By: ____________________ Name/Title: _______________ Date: ___________________ [SEAL]	For: [Company Name] By: ____________________ Name/Title: _______________ Date: ___________________ [SEAL]

Appendix F

U.S. RESILIENCY COUNCIL 35 VALLEY ROAD ATHERTON, CA 94027 WWW.USRC.ORG

Building on work of the Structural Engineers Association of Northern California that began in 2006, and the recommendations of a joint FEMA/Applied Technology Council Stakeholder's workshop held in March, 2011, Eric Von Berg, a Past President of the California Mortgage Bankers Association, proposed the formation of a non-profit organization to be the implementation organization for a rating system that would express the earthquake performance of buildings. Soon after, the US Resiliency Council® (USRC) was launched as a 501(c)3 nonprofit organization, with the mission of becoming the administrative vehicle for implementing a building performance rating system.

The USRC will play a similar role as the USGBC® has played in sustainable design. It will promote and implement a building rating system, and educate the public about hazards associated with buildings. Beginning with seismic hazard, the USER's vision is to become a nationally respected organization that considers a broad range of natural and man-made risks. The USRC does not develop the technical evaluation methodologies, but will implement the best systems developed by engineering and technical experts nationwide.

The USRC will credential engineers and other professionals who wish to rate buildings for their clients, and review rating evaluations for conformance to the technical methodologies. In this way, the ratings systems and procedures developed by the USRC will provide a level of technical credibility that can be relied upon by users. The USRC will also bring into leadership and advisory positions, stakeholder groups concerned about the safety and performance of buildings, ensuring that the implementation of the USRC rating systems are both fair and useful.

In Sept, 2013 the Founders began the process of raising initial start-up funding to enable the launch of the organization. By October, 2014 in excess of $500,000 has been committed over two years by Founding Members that include engineering companies, professional organizations, industry partners and individuals. In June, 2014 the first meeting of the Founding Members was held to develop the organizational structure and operational procedures of the USRC, with a goal to publicly launch the organization in early 2015.