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Ensuring Resilience: Efforts to Retrofit Soft-Story Housing in California

Griffin Weizer
San Jose State University

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By
Griffin Weizer

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Professor Frances L. Edwards, Ph.D.
Adviser

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BACKGROUND

"Earthquake weather" is a term used to describe weather that is unusually warm, with people describing the term as an unusual "stillness" that creates a sense of impending doom before the start of an earthquake event (Nolte, 2019). October 17th, 1989 helped to popularize the myth of earthquake weather for many who underwent the tragic events of that day. At the time, many California Bay Area residents were a buzz about another historical event, Game 3 of the baseball World Series where the San Francisco Giants and Oakland Athletics were pitted against each other for baseball supremacy. By 5pm that evening, the game was only thirty minutes away, Bay Area residents were hurrying home from a day of work, and people around the country were starting to tune in at home to watch the game. At 5:04 a magnitude 6.9 earthquake rattled the Bay Area and became the only earthquake, at the time, to be broadcast live on television for the world to see (Kroichick, 2019). Seventeen seconds later, on a day that was supposed to be known as baseball history's "Battle of the Bay," the Bay Area had suffered the worst earthquake to hit the region since the infamous 1906 San Francisco Earthquake. The damage throughout the Bay Area was extensive: a section of the Bay Bridge's upper deck collapsed, killing one; 1.6 miles of the Cypress Structure roadway in Oakland collapsed killing 42; and fires raged in San Francisco's Marina district with the earthquake ultimately claiming the lives of 63 persons in total (Fagan, 2019).

The 1989 Loma Prieta Earthquake identified many of the structural flaws that were otherwise unnoticed in one of the more charming and ubiquitous San Francisco structures, the wood framed, soft-story building. While varied and unique, soft-story buildings derive their name from the nature of their ground floor, which is generally an open space, such as a garage, parking space, or a commercial space, with limited structural support for the floors above, which,

during the lateral movement of an earthquake, can prove to be structurally deficient (ABAG, 2016).

This deficiency was highlighted further in the 1994 magnitude 6.7 Northridge Earthquake with the collapse of the Northridge Meadows apartment complex, killing 16. Overall, the damage from the Northridge Earthquake was extensive, totaling more than $16 billion for wooden framed structures alone (Sutley, 2016). Since the 1989 Loma Prieta and 1994 Northridge earthquakes, there has been growing concern for the safety and resiliency of soft-story buildings in a major earthquake event throughout the state of California. In response, local governments from the San Francisco Bay Area to the greater Los Angeles area have adopted soft-story seismic retrofitting ordinances to address these public safety concerns. *The intention of this study was to determine what soft story housing retrofit ordinances have been offered by local governments in the State of California since the 1989 Loma Prieta earthquake, and to analyze the components and provisions therein to determine possible trends and best practices.*

Much of the current soft-story residential building inventory was constructed during the 1950s, 60s, and 70s. Then, as is the case now, soft-story structures were considered to be a novel and modern solution to land use issues facing growing urban areas (Baldridge, 2012). Soft-story buildings are common sights throughout the greater San Francisco Bay Area in areas such as San Francisco proper, Oakland, San Jose, as well as throughout Los Angeles County, particularly in the San Fernando Valley. Despite the large number of soft-story buildings throughout the state of California, as well as the state recognizing soft-story buildings as one of the most pressing building safety concerns, no state law has been enacted in order to mandate retrofitting these structures (Baldridge, 2012). Instead, local governments themselves have had to fill the gap in

state law in mitigating the risk that these buildings pose, resulting in a patchwork of retrofitting programs and efforts statewide.

While there are numerous soft-story buildings and retrofitting programs throughout the state of California, the science of retrofitting them has been standardized and refined. Typical soft-story retrofits fall into one of three categories: special moment frames, steel cantilever column systems, and plywood/steel shear walls. (Rodriguez, 2019). Steel moment frames are ideal for larger soft-story buildings and provide a combination of ductility and resilience, while simultaneously being one of the more expensive retrofitting methods (Rodriguez, 2019) (Rafezy, 2017). Cantilever column systems work by the addition of steel supports to replace the traditional wooden columns where appropriate (Rodriguez, 2019). Plywood and steel shear walls are an inexpensive retrofitting option, where the addition of reinforcement of existing shear walls provides additional resistance to lateral movement during an earthquake event, helping to prevent structural fractures (Rodriguez, 2019).

While architecturally soft story housing comes in many shapes and styles, a soft story housing development is generally uniformly defined as a wooden multi-story building where the ground floor is particularly soft, weak, and flexible, typically a result of being used as a garage, parking space, or as a commercial space with large storefront windows (ABAG, 2016). However, local governments throughout California have gone beyond that general definition to include more specific criteria. In the culmination of a nearly decade long project, the City of San Francisco in their Community Action Plan for Seismic Safety (CAPSS) went further by additionally defining soft-story buildings to be at least three stories, have a minimum of five residential units, and be built before 1973 (Day, 2009). Other jurisdictions have adopted similar definitions to San Francisco; however, many vary in establishing a historical cutoff date. The

City of Fremont and the City of Berkeley both establish a cutoff date of 1978 (City of Fremont, 2007) (City of Berkeley, 2014) while the City of Alameda includes housing built up to 1985 (City of Alameda, 2009). The City of Los Angeles goes further by establishing a historical cutoff date in 1995 as a direct response to the tragic 1994 Northridge earthquake (City of Los Angeles, 2015). Other cities, such as Oakland, have included in their definition of soft-story housing criteria regarding the number of stories and residential units, but make no mention of a historical cutoff (City of Oakland, 2019). This multitude of cutoff dates can be attributed to the fact that jurisdictions have over the years adopted a varying patchwork of building codes at different points in time. San Francisco, for instance, adopted a citywide soft story building code in 1973 which was soon followed up in 1978 when the State of California enacted a statewide building code (Day, 2009).

Stringent building codes are a necessity when earthquakes are the inconvenient reality of life of California -it is more so when an earthquake strikes the Golden State, not if. The United States Geological Survey estimates that the probability of a 6.7 magnitude earthquake striking the Bay Area by the year 2043 to be 72% (USGS, 2016). For an earthquake greater than 6.0, but less than 6.7, the probability increases to 100% by the year 2043 (USGS, 2016). Historically, the two most powerful earthquakes in recorded California history have been along the San Andreas fault, the 1857 7.9 Fort Tejon Earthquake, and the much more famous 1906 7.8 San Francisco Earthquake. Were a repeat of the 1906 San Francisco Earthquake to happen today, there would be an estimated $98,328,305,100 in building damage, with a potential range of deaths from 220 to 7,851 persons (Ghilarducci, 2018). In comparison, a 6.8 earthquake along the Southern Hayward fault, the most likely earthquake scenario (Baldridge, 2012), would have an estimated

building damage worth $15,168,660,800 and a potential range of deaths from 7 to 32 persons (Ghilarducci, 2018).

One of the worst natural disasters in world history, the 2010 Haiti Earthquake, MM 7.0, serves as a worst-case scenario. Compounding on its sheer intensity, the 2010 Haiti Earthquake was made more lethal from lax building codes and the equally lax enforcement of the codes that were in place (Bilham, 2010). As a result of these factors, losses and damages were estimated to be between $7-$14 billion dollars, over 316,000 people died, 300,000 were injured, and a further 1.3 million people were left homeless (Desroches, 2011). The 2010 Haiti Earthquake serves as a testament to the necessity of stringent building codes geared towards seismic safety as well as the necessity to mandate and enforce compliance.

Wooden soft-story buildings are not the only structure to undergo more rigorous scrutiny as deficiencies have become apparent in unreinforced masonry buildings and buildings constructed from non-ductile concrete. Unreinforced masonry buildings (URM) are generally defined as being constructed of earthly materials such as stone, brick, or concrete blocks without any reinforcing material integrated into the construction (Reitherman, 2009). These types of buildings were common throughout the United States until stricter building codes were adopted in 1934. This was in part a response to the 1933 Long Beach earthquake which rendered 54% of URM buildings with either significant wall damage or complete collapse (Reitherman, 2009). Currently, due to the seismically unstable nature of URM buildings, new construction is only allowed in areas with very low chances of earthquake activity with new URM buildings banned in active earthquake zones, particularly in the Western United States (Reitherman, 2009).

Furthermore in 1986, SB-547 required local governments to identify at risk URM buildings within their jurisdiction, and though it only mandated that local governments inform

property owners of the historic risk these structures create in earthquake conditions, and establish hazard mitigation programs, SB-547 did pave the way for greater regulation of these structures (Baldridge, 2012). Paso Robles adopted a retrofitting ordinance for URM buildings in 1992 mandating that such buildings be retrofitted by a deadline that was later extended to 2018. When the San Simeon Earthquake struck in 2003, the nine URM buildings that had undergone retrofitting survived the earthquake with little to no damage while some unretrofitted URM buildings were later demolished due to the severity of the damage sustained (Reitherman, 2009).

Another potential hazardous structural design, non-ductile concrete (NDC) buildings are defined as being particularly inflexible in such a way that NDC buildings are overly stiff and fracture under the stress of the earthquake which can lead to a loss of structural integrity (Prager, 2009). Modern concrete buildings built under newer building codes utilize specialized steel and other design considerations integrated within their construction that allows the building to be more flexible during an earthquake event, preventing the damage that would occur in an NDC building in similar circumstances. The need for more stringent building codes for concrete buildings became especially apparent in the 1971 magnitude 6.5 San Fernando Earthquake. During this event sections of the San Fernando Veterans Administration Hospital built with NDC in 1926 collapsed killing 44 people (Bartholomew, 2016). Following that disaster, the State of California began mandating that certain hospitals constructed with NDC be retrofitted to ensure resilience but has stopped short of mandating other possibly at-risk structures such as public schools or office buildings (Bernstein, 2005). While some local governments have instituted guidelines for voluntary retrofitting ordinances, only Los Angeles and Santa Monica have adopted mandatory retrofit programs in 2015 and 2017 respectively. Despite NDC buildings being at significant risk during extreme stress, property owners have resisted efforts to retrofit

buildings citing high costs and suggesting that the dangers of NDC buildings are overstated (Bernstein, 2005).

LITERATURE REVIEW

While ensuring that buildings are built with earthquakes in mind, as well as retrofitting existing buildings to increase seismic safety will help save lives and reduce property damage during an earthquake, they will also serve to help quicken disaster recovery. During the aftermath and reconstruction of New Orleans after Hurricane Katrina, among the top concerns for returning residents was the availability of housing, education facilities, and access to healthcare (SPUR, 2014). Four years after Hurricane Katrina hit, New Orleans had among the highest rates of homelessness in the nation, as well as over 65,000 registered abandoned buildings (Flaherty, 2009). This puts a tremendous strain on public and social services, effectively slowing the speed and quality of disaster recovery (USGAO, 2008). Thus, having buildings prepared for a seismic event ahead of time is crucial for disaster recovery (Business Civic Leadership Center, 2010). Furthermore, the works of Cutter et al. (2010) found that strong social, community capital, including such factors as religious, social networks, and citizen participation, was correlated with quality disaster recovery and resilience throughout FEMA region IV (2010). Such factors are heavily reliant on a community that can maintain a "sense of community [and] place attachment" (Cutter, 2010, page 9), highlighting the need for local governments to ensure that housing construction is in line with modern seismic safety standards.

The Loma Prieta and Northridge earthquakes illustrate the damage that a moderate to severe earthquake can cause to dense urban areas. Of the Loma Prieta earthquake, there was a considerable concentration of damage to low-income, multi-family, rental units. 60% of San Francisco's 115,000 damaged properties were rental units, additionally, 40% of these were considered affordable housing (Comerio, 1997). Similarly, the Northridge earthquake disproportionately affected multi-family apartment complexes and mobile homes, seriously

damaging 60,000 units out of more than 400,000 damaged, approximately 15%, many of which were in less modern structures typically occupied by lower-income groups and difficult to replace (Comerio, 1997)(Winslow, 1998).

Despite both being large dense urban areas, the problems and experiences which arose in the recovery efforts after the Loma Prieta and Northridge earthquakes are remarkably distinct. The combination of having a significant portion of the Bay Area's affordable housing stock damaged in need of repair along with incredibly low vacancy rates, especially for the area's moderate to very-low income categories, created a housing crisis (Comerio, 1997). This crisis was exacerbated further as dense urban areas make sheltering people displaced by natural disasters particularly difficult due to the lack of open space, reducing the ability to establish temporary shelters (Edwards, 2019). In addition, only 50% of damaged affordable apartments were repaired 5 years after the earthquake, further reducing the ability to recover efficiently (Comerio, 1997).

In Los Angeles County and surrounding areas, the losses were concentrated in pockets of neighborhoods, with 38 census tracts containing 100 or more vacant units (Comerio, 1997). Many properties remained vacated and in disrepair for years after the earthquake. In contrast to the experience in the Bay Area five years earlier, high vacancies in the region's housing stock along with falling housing prices prior to the earthquake meant that there was limited cash flow and equity in the market (Comerio, 1997). Furthermore, federal government recovery measures focused primarily on single-family dwellings, and less than half of the qualifying multi-family units received support from federal loan programs (Comerio, 1997) (Winslow, 1998). This meant that owners of mult-family dwellings had to rely on their own personal finances to facilitate recovery, taking on additional debt for repairs (Comerio, 1997). 30% of apartment buildings

were repaired, while an additional 60% of apartment buildings were still at the planning stage for repairs one year after the earthquake (Comerio, 1997).

These vacated census tracts caused a ripple effect that led to the formation of 13 "ghost towns," each containing an area of several blocks where on average 40% of housing was vacated, with a high of 90% in some areas (Stallings, 1996)(Comerio, 1997). These ghost towns soon attracted antisocial behaviors as local gang members and squatters moved into the vacated buildings, bringing a rise in drug related crimes, prostitution, arson, and other forms of violence (Stallings, 1996). With the rise of these antisocial behaviors, residents living in nearby, functional buildings fled, as did local businesses, deepening the crisis and straining the city's recovery efforts until the city instituted measures to reverse the trend (Stallings, 1996).

Considering the experiences of the recoveries from Loma Prieta and Northridge, ensuring the resilience of soft-story structures through retrofitting ordinances can be seen as a form of social equity for lower income groups. A memorandum from the City of Oakland on the 25th anniversary of the 1989 Loma Prieta earthquake recognized this issue. The memorandum highlighted that the 22,000 soft-story rental units within the city were primarily occupied by historically lower-income groups, including elderly and minority residents, and represented a significant portion of the city's inventory of affordable housing (Gardener, 2014). The situation is similar across the Bay in San Francisco. In 2012, the San Francisco Bay Area Planning and Urban Research Association (SPUR) determined that if a 7.2 magnitude earthquake were to strike San Francisco, a significant portion of the multi-family wooden-frame soft-story residence inventory rendered unusable would be in the Mission, Richmond, Sunset, and Western Addition districts (Barkely, 2012). During that time the median family income of San Francisco as a whole was $103,000, while the median family income of the Mission district was 40% below

($62,000); the Richmond district 37% below median ($65,000); the Sunset district 36% below median ($66,000); and the Western Addition district 44% below median ($58,000) (Barkely, 2012)(USDHUD, 2019). Ensuring that soft-story residences are retrofitted to be earthquake resilient is crucial to protecting vulnerable populations, and thus, quickening recovery after an earthquake event.

Using the 2008 ShakeOut scenario, Hua Kang, Zhengxiang Yi, and Henry Burton constructed a post-earthquake recovery model to analyze the potential effectiveness of the City of Los Angeles' current mandatory retrofit ordinance. Using the current Los Angeles county building inventory, statistical, geological, and structural data, the study analyzes two scenarios: one against the current inventory, and one where all soft-story buildings have been retrofitted. The results provide a significant and positive insight into the benefits of earthquake resiliency measures. Retrofitting all soft-story structures reduced the fraction of all buildings considered to be "completely damaged" by 25%, or 70% if only considering soft-story structures (Kang, 2019). This is significant, as "completely damaged" state buildings would make up only 5.2% of the total inventory but would account for 13.5% of all occupants, as multi-family dwellings constitute the overwhelming majority of soft-story buildings (Kang, 2019). Thus, the retrofit ordinance with full compliance would reduce the total percentage of occupants in completely damaged state buildings by 30% (Kang, 2019). Furthermore, the study suggests that Los Angeles' soft-story ordinance with full compliance would reduce the time to reach 90% occupancy after an earthquake by 64%, and the time to reach 95% occupancy by 14% (Kang, 2019).

METHODOLOGY

The first goal of this research was to determine which local governments in the State of California currently have a mandatory or voluntary soft-story housing retrofitting program enacted within their jurisdictions. The secondary goal of this study was to compare the various jurisdictions' program elements in order to discover commonalities between programs leading to a larger discussion of trends and best practices. What this study did not attempt to do, however, was to make any assertions about the best practices and types of soft-story retrofits themselves from an engineering standpoint. The science of retrofitting buildings for earthquake resilience is a topic about which there exists an abundance of research and expertise. What this study does is present what programs and ordinances are currently in use by local governments across the State of California to employ those resilience methods.

In order to accomplish these objectives, this study has employed qualitative policy analysis methodologies (Bardach, 2015). The qualitative data required for this study has come from analyzing the ordinances and retrofitting programs of the cities selected to be in this study. In conducting this portion of the analysis this study has collected data regarding whether the ordinances in question contain any provisions relating to whether there are financing options available from the jurisdiction, whether there are any incentives or fee waivers for compliance, how the schedule for compliance is determined, whether there are any enforcement tools to ensure compliance, whether tenant cost sharing is allowed, and finally, whether the program itself is mandatory or voluntary. The ordinances and programs themselves have been accessed directly through the relevant local government's website, online archives, and internet databases in order to obtain this data.

Having been collected, this data has been divided and formatted into two tables representing the jurisdictions of Northern California (Table 1) and Southern California (Table 2). In dividing the survey between two geographic regions, this study has attempted to determine whether there any regional differences or trends between northern and southern California jurisdictions. The tables have been constructed in such a way that an "X" will indicate the explicit presence of the previously mentioned variables within the ordinance. If the ordinance does not explicitly mention the variable, the box has been left blank. If the variable exists outside of the ordinance, such as a policy or program that has been enacted after the ordinance has been enacted, the box has been checked with an "O."

Since this study has relied solely on publicly attainable information, and considering that there are no human subjects in the research design, this research has an Institutional Research Board (IRB) exclusion.

The cities that have been selected to be included in this study are as follows:

- Alameda
- Berkeley
- Beverly Hills
- Burbank
- Fremont
- Long Beach
- Los Angeles
- Oakland
- Pasadena
- San Francisco

- Santa Monica
- West Hollywood

The cities listed represent a significant portion of soft-story housing within the State of California that is at risk of earthquake-related damage, with all of them having a soft-story retrofit ordinance currently enacted.

FINDINGS

Northern California

Table 1: Northern California Ordinances and Provisions Therein.

Northern California						
Does the ordinance include provisions for...	Alameda (2009)	Berkeley (2014)	Fremont (2007)	Oakland (2007b)	Oakland (2019)	San Francisco (2013)
Mandatory Status	X	X	X		X	X
Financing from Jurisdiction	O	O				
Incentives	X	X		X, O	X	X
Fee Waivers	X		X			X
Compliance Schedule	X	X	X		X	X
Enforcement Tools	X	X	X		X	X
Tenant Cost Sharing					X	X

"X" indicates the inclusion in a jurisdiction's ordinance
"O" indicates existence outside the jurisdiction's ordinance

Source: (City of Alameda, 2009), (City of Berkeley, 2014), (City of Fremont, 2007), (City of Oakland, 2007b), (City of Oakland, 2019), (City of San Francisco, 2013).

Mandatory status

All ordinances that have been enacted and are still in effect in the San Francisco Bay Area are mandatory. The only exception to this has been the 2007 voluntary retrofit ordinance in Oakland.

Financing options from jurisdiction

No soft-story retrofit ordinance in the San Francisco Bay Area explicitly provides any provision for financial support from the jurisdiction to support property owners in retrofitting properties.

Incentives

Four jurisdictions have included an incentive provision within their ordinance to encourage property owners to retrofit their soft-story structures. Alameda, Berkeley, Oakland's 2019 mandatory ordinance, and San Francisco have all included a provision that provides a 15-year

exemption for properties that complete a retrofit from further seismic upgrades so long as the standard of the retrofit under the jurisdiction's ordinance is met and maintained. Oakland's 2007 voluntary ordinance provided an incentive that allowed property owners that had completed and certified a soft-story retrofit to apply to receive a portion of the transfer tax for a newly purchased residential building which could not exceed .5% of purchase price or $5,000, whichever was lesser.

Fee Waivers

Alameda's soft-story retrofit provided a waiver for engineering review report fees based on when the report was submitted. Property owners were eligible for a 100% fee waiver when the engineering review report was submitted within 3 months of notice that the property was included to the city's soft-story inventory, a 75% waiver if submitted within 6 months of notice, a 50% waiver if submitted within 9 months of notice, and a 25% waiver if submitted in 12 months of notice. Furthermore, Alameda waived all plan review and inspection fees so long as work was completed within 18 months of notice.

The City of Fremont also included language allowing certain fees to be waived, but the waivers are not applicable to condominiums, can only be used for work related to the retrofitting, and the work must be done according to the timetable deadlines as set by the city.

Oakland's 2007 voluntary ordinance allowed property owners upon certification of completed work within one year of permit submission to apply for a determinate permit fee incentive that lowered the building permit fee to $250.

The City of San Francisco waived fees for submittal or review of the initial screening form for their retrofit ordinance.

Compliance schedule

The City of Alameda has taken the most straightforward approach to their compliance timetable requiring that properties must be in compliance within 18 months of notice of inclusion to the soft-story inventory.

Berkeley mandates that a permit to retrofit had to be submitted by 12/31/2016, roughly 16 months from the date the ordinance was passed in July of 2014. Furthermore, Berkeley mandates that the retrofit work must be completed within two years of submitting the permit to retrofit.

The City of Fremont divided their soft-story inventory into two separate groups, each with their own deadlines for compliance. The first group includes properties with 10 or more units, or properties with more than two stories, and are required to submit plans and have permits issued within two years of notice and to have work completed within four years of notice. Fremont's group two properties are those that have less than 10 units and less than three stories and are required to have plans submitted and permits issued within three years of notice and work completed within five years of notice.

Oakland's 2019 mandatory ordinance divided properties into three tiers, each with its own deadlines for compliance. Tier 1 buildings include those with 20 or more units, buildings not eligible for Tier 2 or Tier 3 status, or buildings that did not complete a mandatory screening on or before July 28, 2011, regardless of number of units or eligibility for other tiers. Such buildings must complete an evaluation or affidavit of compliance within two years of notice, obtain a retrofit permit or evaluation report within three years of notice, and have completed work inspected, or file final affidavit of compliance within four years of notice. Tier 2 includes

buildings that are not eligible for Tier 3, have between five and 19 units, or have a legally permitted commercial occupancy within the wooden frame target story. Such buildings must complete an evaluation or affidavit of compliance within three years of notice, obtain a retrofit permit or evaluation report within four years of notice, and have completed work inspected, or file final affidavit of compliance with five years of notice. Oakland's Tier 3 buildings include those with a residential occupancy in the wooden frame target story and those otherwise assigned to this tier. Such buildings must complete an evaluation or affidavit of compliance within four years of notice, obtain a retrofit permit or evaluation report within five years of notice, and have completed work inspected, or file final affidavit of compliance within six years of notice.

The City of San Francisco has broken down their soft-story inventory into four separate tiers for deadline compliance. Regarding San Francisco's compliance timetable, years are measured as starting at 90 days from the operative date of the ordinance. Tier 1 includes buildings that have an occupancy classification A, E, R-2.1, R-3.1, or R-4 on any floor of the structure. Such buildings must submit a screening form within one year of notice, apply for a retrofit permit with retrofit plans within two years, and have retrofit work completed with issuance of CFC2 within four years. Tier 2 buildings include those with 15 or more units, not including buildings already assigned to Tier 1 or 4. Such buildings must submit a screening form within one year, apply for a retrofit permit with retrofit plans within three years, and have retrofit work completed with issuance of CFC2 within five years. Tier 3 buildings are those that do not fall into any other tier. Such buildings must submit a screening form within one year, apply for a retrofit permit with retrofit plans within four years, and have retrofit work completed with issuance of CFC2 within six years. Tier 4 buildings are those that contain an occupancy classification of B or M on the first floor, or in the basement/underfloor where any part extends

above grade or is in a mapped liquefaction zone, excluding buildings already assigned to Tier 1. Such buildings must submit a screening form within one year, apply for a retrofit permit with retrofit plans within three years, and have retrofit work completed with issuance of CFC2 within seven years. The City of San Francisco mandates that all work be completed by December 31, 2020.

Compliance enforcement

Every mandatory program surveyed in the Bay Area contains a provision for compliance enforcement; Oakland's 2007 ordinance and San Jose's retrofit program were entirely voluntary and therefore had no enforcement mechanisms.

The City of Alameda in their ordinance explicitly states that any person(s) found to be unlawfully using a property not in compliance would be subject to all remedies available to the city.

Berkeley states in their ordinance that any property found not in compliance with their retrofit ordinance may be declared a public nuisance and abated at the city's discretion.

Fremont's retrofit ordinance includes language stating that any person using a property not in compliance is guilty of a misdemeanor, excluding any possible tenants. Furthermore, the City of Fremont may demolish the structure at cost to the owner if doing so would be found to be adequately protecting public health.

Oakland's 2019 mandatory retrofit ordinance includes fines and penalties for failing to obtain a building permit, file an evaluation report, or complete permitted work on time. In addition, noncompliance actions may include forcing the property owner to notify tenants and all parties with financial interest of the potentially seismically hazardous designation of the property in writing, at the owner's expense and duty, and/or requiring notices be displayed designating the

building as potentially seismically hazardous. The City of Oakland may also file suit to compel compliance.

San Francisco in their mandatory retrofit ordinance states that any building found not in compliance with any action will post a notice designating the building to be in violation of the requirements of the San Francisco building code regarding earthquake safety until the building is made compliant.

Tenant cost sharing

Only two jurisdictions explicitly address the issue of tenant cost sharing in their mandatory retrofit ordinances: Oakland and San Francisco. Oakland's 2019 ordinance states that up to 70% up capital improvement costs may be passed on to the tenants through rent increases, and that such increases would be governed by the Residential Rent Adjustment Program Board. The City of San Francisco similarly allows 100% of retrofitting costs to be passed through to the tenants as governed by the San Francisco Rent Board, and allows tenants to apply for a hardship exemption if need be.

Southern California

Table 2: Southern California Ordinances and Provisions Therein.

Southern California							
Does the ordinance include provisions for...	Beverly Hills (2018)	Burbank (2019)	Long Beach (2016)	Los Angeles (2015)	Pasadena (2019)	Santa Monica (2017)	West Hollywood (2017)
Mandatory Status	X			X	X	X	X
Financing from Jurisdiction							
Incentives							
Fee Waivers							
Compliance Schedule	X			X	X	X	X
Enforcement Tools	X			X	X		X
Tenant Cost Sharing				O			O

"X" indicates the explicit inclusion in a jurisdiction's ordinance
"O" indicates existence outside the jurisdiction's ordinance

Source: (City of Beverly Hills, 2018), (City of Burbank, 2019), (City of Long Beach, 2016), (City of Los Angeles, 2015, 2016b), (City of Pasadena, 2019), (City of Santa Monica, 2017), (City of West Hollywood, 2017).

Mandatory status

Of all the soft-story retrofit ordinances in Southern California, only two are not mandatory: Burbank and Long Beach.

Financing options from jurisdiction

No jurisdiction within Southern California explicitly includes provisions for financial assistance for property owners to retrofit their soft-story buildings within their ordinance.

Incentives

No jurisdiction within Southern California explicitly includes incentive provisions to encourage property owners to retrofit their soft-story structures within their ordinance.

Fee waivers

No jurisdiction within Southern California explicitly includes fee waivers within their ordinance to encourage property owners to retrofit their soft-story structures.

Compliance schedule

Beverly Hills has developed three priority tiers for compliance affecting when property owners receive their notice. Priority 1 buildings are those that are three or more stories, Priority 2 are those that have two stories and six or more units, and lastly Priority 3 which includes all other buildings not in Priority 1 or 2. From notice, the deadline to submit a screening form is six months, a retrofit plan must be submitted one year from notice, a building permit must be obtained two years from notice, with construction beginning 2.5 years from notice and completed three years form notice.

The City of Los Angeles in their soft-story retrofit ordinance requires a structural analysis to be completed within two years of notice that the property has been identified as a soft-story structure, must obtain permits after three and half years from notice, and must complete construction within seven years from notice. In dividing up their inventory, the City of Los Angeles has prioritized buildings into three tiers with further categories for each tier. Priority 1 includes buildings with 16 or more units which is subdivided into buildings with three or more stories and two-story buildings. Priority 2 are buildings that have three or less stories and less than 16 units. Priority 3 includes those buildings not covered by Priority 1 or 2 and is further divided into four subcategories: buildings with a) 9-15 units, b) 7-8 units, c) 4-6 units, and finally d) condominiums and commercial properties.

For their compliance timetable, the City of Pasadena divided their inventory into three priority levels which affects when the building will receive their notice. Priority 1 buildings are those with three or more stories, or have 25 or more units, or is a historic building. Priority 2 buildings are those that have 10 to 24 units. Priority 3 buildings are non-historic, 2 stories, with 5-9 units in total. The time to receive notice is staggered between priorities, but all buildings must obtain retrofit plans and permits within three years of notice and complete construction within 7 years of notice.

Santa Monica in their retrofit ordinance requires that properties submit a structural evaluation report within two years of notice, submit retrofit plans and apply for a permit within three years of notice, and receive final approval of completed work within six years of notice. Furthermore, the City of Santa Monica prioritizes enforcement of soft-story retrofits in this order: buildings with three or more stories and less than 16 units, buildings with 16 or more units, buildings with seven to 15 units, and finally buildings with six or less units.

The City of West Hollywood divided their inventory into three priority levels, which affects when the building will receive their notice. Priority 1 buildings are those with 16 or more units, Priority 2 buildings are those that have three or more stories with less than 16 units, and Priority 3 buildings represent the remaining buildings in the West Hollywood inventory. The time to receive notice is staggered between priorities, but all buildings must submit a screening report within one year of notice, submit retrofit plans within two years of notice, obtain a retrofit permit and commence construction within four years of notice, and complete retrofit construction within five years from notice.

Compliance enforcement

The City of Beverly Hills' retrofit ordinance declares that is unlawful and considered a misdemeanor for any person(s), not including tenants, to use or occupy a structure not in full compliance of the provisions of the ordinance. The city reserves the right to subject violators to prosecution and or administrative enforcement.

In order to enforce compliance, the City of Los Angeles includes enforcement language in their retrofit ordinance stating that should a property be found not in compliance, it would be unlawful and considered to be a misdemeanor to use the property for any purpose by any persons, excluding tenants, and that all remedies for violators would be available.

The City of Pasadena's ordinance states that should a property be found not in compliance, it would be unlawful to use the building for any purpose by any persons, not including tenants, and that by doing so would be considered a misdemeanor. Each person or entity will be guilty of a separate offense each and every day or portion thereof where a violation is committed, punishable by a fine of up to $1000 and/or 6 months' imprisonment.

The City of West Hollywood's ordinance states that should a property be found not in compliance, it would be unlawful to use the building for any purpose by any persons, not including tenants, and that by doing so would be considered a misdemeanor. Each person or entity will be guilty of a separate offense each and every day or portion thereof where a violation is committed, punishable by a fine of up to $1000 and/or 6 months' imprisonment.

Tenant cost sharing

No jurisdiction within Southern California explicitly includes provisions regarding tenant cost sharing measures for the cost of retrofits within their ordinances.

ANALYSIS

The data demonstrates that there exist a variety of approaches to developing and implementing a soft-story retrofit ordinance. Some conclusions can be drawn from data pulled from surveying the various ordinances represented here: a) distinct regional approaches have formed between the two halves of California and b) within those regional generalities, jurisdictions have adapted with some differentiations to fit local priorities.

As illustrated by the previous tables, regional styles have emerged between jurisdictions in northern and southern California. This indicates that jurisdictions "piggyback," in a sense, building off each other's efforts and thus creating similarities between ordinances. This is evident in Northern California where Oakland in 2019 adopted San Francisco's compliance priority tiers almost in their entirety. For larger cities like San Francisco and Oakland, sorting the soft-story inventory by a set of priority tiers, a jurisdiction can reduce the strain on its administrative capacities by metering out the retrofits over a period of time instead of issuing orders city wide simultaneously. Further similarities in the Northern California region include the cases of Alameda, Berkeley, Oakland in 2019, and San Francisco which all adopted similar incentives, exempting properties that retrofit within compliance of their respective ordinances for 15 years from further seismic retrofitting requirements. Additionally, in Southern California, the cities of Beverly Hills, Pasadena, Santa Monica, and West Hollywood all implemented priority tiers in much the same way that Los Angeles did in 2015.

Through these regional behaviors, the emergence of a "follow the leader" approach where smaller jurisdictions respond to the motions of larger jurisdictions becomes apparent. Northern California bucks this trend slightly, as the city of Fremont was the first to enact a mandatory ordinance in 2007, with Oakland enacting their first ordinance in the same year and

Alameda two years later in 2009. After San Francisco enacted their ordinance in 2013 at the end of their CAPSS study, the city of Fremont adopted a mandatory ordinance in 2014 with Oakland revisiting their voluntary ordinance, developing it into a mandatory program in 2019. This "follow the leader" approach is best seen in Southern California where two years after San Francisco, a city with one of the largest concentrations of story-story buildings, Los Angeles, implemented their own mandatory retrofitting ordinance in 2015. Shortly after, other cities in the region enacted their own retrofitting ordinances starting with Long Beach in 2016, Santa Monica and West Hollywood in 2017, Beverly Hills in 2018, and Burbank and Pasadena in 2019. Larger, diverse, and prominent jurisdictions such as San Francisco and Los Angeles are in a prime position to serve as leaders in their region for earthquake resilience. This is made especially true as it is jurisdictions such as San Francisco and Los Angeles that have the means, technical expertise, and funding to pursue the research and development of seismic safety programs. By taking the initiative, smaller jurisdictions are more likely to follow suit as they share in the wealth of knowledge their regional partners can provide.

These trends point to something that comes as unsurprising: jurisdictions are talking to and cooperating with one another. When developing ordinances and programs to ensure earthquake resilience, cooperation and communication are the critical cornerstones of such endeavors, as a major earthquake will not be contained to manmade city limits, and will instead impact multiple jurisdictions simultaneously. This makes it essential that regions at risk of earthquakes develop earthquake resiliency measures concurrently in order to avoid discrepancies in affected populations and to allow for a more rapid recovery.

While it is important to note the trend of regional approaches and commonalities between the retrofit ordinances examined here, it is also important to note the differences and deviations

between jurisdictions. Oakland's 2019 mandatory ordinance and San Francisco 2013 ordinance help illustrate this point. When revisiting their soft-story retrofit ordinance, Oakland took cues from the work San Francisco did previously, notably in the way Oakland modeled their compliance priority tiers. However, while Oakland carried over the framework of San Francisco's tier system, they changed the definitions of the tiers to represent what they considered to be their own local priorities. There is no need to reinvent the wheel; jurisdictions can use what other cities have done not so much as a rule but as a guide that can be modeled to fit its environment.

Perhaps the largest contrast between ordinances is the difference between the three voluntary ordinances surveyed: Oakland in 2007, Burbank, and Long Beach. These three ordinances provide a sliding scale regarding the depth of their content. The City of Oakland's ordinance contains more passages regarding scope and engineering design guidelines than certain mandatory ordinances included in this study. Furthermore, Oakland's voluntary ordinance is the only ordinance, either voluntary or mandatory, that offers property owners a built-in financial incentive for retrofitting their buildings to compliance. The City of Long Beach has taken a simpler approach when compared to Oakland's voluntary ordinance and only provides a general scope, with a section for engineering guidelines and standards without the addition of incentives. Burbank's ordinance, only a paragraph in length, however, simply states that the city adopts Chapter A4 of the California Already Existing Building Code for the purpose of providing engineering guidelines and standards for voluntary soft-story retrofits. While on paper, Burbank's ordinance looks insufficient at a glance when compared to Oakland and Long Beach's ordinances, that is only a surface level examination, however. Burbank's ordinance is certainly lacking the incentives of Oakland's voluntary ordinance, but the basic engineering

requirements to ensure a structure's resiliency during an earthquake event are not fundamentally different from one ordinance to another.

In ensuring earthquake resilience some jurisdictions have created programs and policies after the enactment and in support of the ordinance. No jurisdiction explicitly included provisions for financing and facilitation options from the city within the ordinance, however, two jurisdictions provided direct support to property owners outside of the retrofit ordinance itself: Alameda and Berkeley. The City of Alameda set aside a pool of $100,000 in assistance for property owners who have 51% low to moderate income occupancy, as well as owners of historic structures, through the Soft Story Structural Assessment: Grant For Rental Units Program (Alameda Housing Authority, 2009). The City of Berkeley provided design grants of $5,000 at a cap of 75% of cost. Construction grants were also provided with properties of 5 or more units eligible to receive $20,000 in grants capped at 30% of cost, and properties with 1-4 units eligible to receive $15,000 capped at 40% of cost (City of Berkeley, n.d). Furthermore, after enacting their 2007 voluntary ordinance, the City of Oakland established the New Homeowner Voluntary Seismic Strengthening Reimbursement Incentive Program, which allowed new owners of older homes one year in which to retrofit their residences to the standards of the voluntary retrofit ordinance and, provided they completed the work according to plan, receive up to $5,000 reimbursement for their expenses (City of Oakland, 2007a). Oakland's program was in addition to the incentives built already into the ordinance. The City of Los Angeles implemented the Seismic Retrofit Work Cost Recovery Program which allows for a temporary rent surcharge to tenants through either a pass-through of up to 50% of total seismic retrofit costs divided equally among all rental units, if approved by the Housing and Community Investment Department of Los Angeles, or a maximum rent increase of $38 per month for 120

months with the option to extend until the full approved amount to be passed through has been collected (City of Los Angeles, 2016a).

In addition, other sources of support for retrofitting soft-story buildings exist both at the state and private level. The State of California operates the California Capital Access Program (CalCAP): Seismic Safety Financing Program which incentivizes lenders to finance seismic retrofits for both residential and commercial properties by providing loan loss coverage. Jurisdictions such as the City of San Francisco have partnered with private lenders to provide retrofit financing options through Property Assessed Clean Energy (PACE) loans (Counterpointe SRE, 2017). PACE programs allow a property owner to receive 100% financing by having a special non ad-valorem tax assessment placed on title of the property which can be paid off over a series of years. Financing alternatives such as CalCAP and PACE programs help to fill in the gaps that some jurisdictions have trouble filling when crafting a retrofit ordinance.

Jurisdictions may be reluctant to include financing options in their ordinances or provide their own local grant programs, as that would be a use of public, taxpayer dollars to subsidize the retrofitting of private properties. While the retrofitting can certainly be argued to be in the interest of the public good, some jurisdictions may be sensitive to that particular issue, as there is potential for backlash from community stakeholders who wish to see those funds spent on other competing priorities. Instead of trying to craft an all-encompassing retrofit ordinance that provides a solution to the questions of supporting property owners through finance options, incentives, or tenant cost sharing options, it may be more strategic to omit those in favor of a more streamlined, focused ordinance that deals solely with scope, compliance, schedule, and engineering standards. This way the goal of ensuring long-term earthquake resilience within the community can become actionable without being mired down in other political matters.

Despite the potential political conflict that might arise around developing and implementing a soft-story ordinance, the vast majority of ordinances surveyed were mandatory. The only exceptions were Oakland in 2007, Burbank, and Long Beach, and as the data indicates, Oakland reversed their decision, implementing a mandatory ordinance 12 years later. Burbank and Long Beach, then, are very much the exception to the trend, as every ordinance prior and since, both in northern and southern California, has been mandatory. This means that despite the possible peer-pressure of having their regional neighbor and partner jurisdictions adopt mandatory ordinances, local concerns took a higher priority.

While this study focused solely on ordinances, ordinances are not the only recourse for earthquake safety and resilience. The city of San Jose, for example, developed in partnership with San Jose State University the Seismic Retrofit Program. Uncertain over issues of liability, the public's reaction, and the possible pressure to offset any potential costs associated with retrofitting, the Seismic Retrofit Program was established in order to educate and encourage property owners to voluntarily retrofit (Winslow, 1998). To do this, an engineering firm was contracted to develop generalized blueprints and estimates for the most common retrofits, informational packets were assembled and distributed to interested parties, and workshops were held at San Jose State University to help inform property owners (Winslow, 1998). While the program showed some limited success in having property owners retrofit, with only three property owners having applied for permits it represents an alternative to retrofit ordinances that jurisdictions can implement to promote earthquake resilience within their communities (Winslow, 1998).

Conclusion

Unlike hurricanes or tornadoes, earthquakes strike without any build up, without any chance to prepare or find shelter. The likelihood of a Northridge size 6.7 earthquake hitting the state of California by 2043 is 72% (USGS, 2016). This means that local governments must dedicate resources to ensuring that one of the most vulnerable types of housing, multi-family soft-story apartment complexes, will be able to maintain their structural integrity during an earthquake, sooner rather than later. In doing so, local governments will protect a significant source of affordable housing stock that primarily serve lower-income groups. This will reduce the strain on emergency and community services during the recovery of an earthquake, as people can more quickly return to their homes and to a sense of normalcy, quickening the recovery.

This study has compiled and analyzed the current efforts of local governments in the State of California to bolster their earthquake resilience through soft-story retrofit ordinances. It has found that jurisdictions have taken a regional approach to crafting their ordinances by following the example of their larger, local partners, namely the City of San Francisco and the City of Los Angeles. While the data indicates that a regional trend has developed through communication among regional local governments, the data also indicates that jurisdictions use their neighbors as guides and are sensitive to the needs and concerns of their own communities and stakeholders.

As each ordinance is created to reflect the needs of its jurisdiction, there may be no "right" way to construct a soft-story ordinance. Trying to determine the "effectiveness" of a soft-story ordinance is difficult, as each jurisdiction has varying standards of what buildings are covered by the scope of the ordinance, varying time frames for compliance, and often drastically different soft-story housing inventory. With that being said, in the timeframe of soft-story retrofit

ordinances covered by this study, 83.3% of the retrofit ordinances still in effect today are mandatory. Strictly speaking, if a jurisdiction is considering the problem of soft-story integrity during an earthquake event and how to ensure their resiliency, mandatory ordinances are the most effective when compared to voluntary ordinances or other programs in getting buildings retrofitted. By 2018, Alameda had achieved 60% compliance among its 184 soft-story building inventory, Berkeley achieved 70% compliance with its 272 building inventory, and Fremont achieved 100% compliance among its known 27 soft story buildings (Lin II, 2018). Considering that many property owners are wary at the initial financial cost of retrofitting, it remains to be seen how effective the City of Long Beach and the City of Burbank's voluntary retrofitting ordinances will be in promoting earthquake resilience in soft-story structures.

Again, what type of program or ordinance a jurisdiction implements is dictated by an agreement with local official and community stakeholders. However, as the nation battles the current COVID-19 pandemic, let this be a reminder to public administrators everywhere, that the value of the programs, methods, and initiatives designed to ensure resilience within the infrastructure for the purpose of safeguarding the public welfare cannot be overstated.

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