City of Palo Alto (ID # 8207)

City Council Staff Report

Report Type: Action Items **Meeting Date: 10/16/2017**

Summary Title: Vulnerable Buildings Seismic Risk Assessment Study

Title: Direct Staff to Return to Policy and Services Committee With Amendments to the Municipal Code for the Regulation of Seismic Vulnerable Buildings and Receive a Summary Presentation of the Vulnerable Buildings Seismic Risk Assessment Study Previously Transmitted to the City Council on April 17, 2017

From: City Manager

Lead Department: Development Services Department

Recommendations

1. Accept the result of the Seismic Risk Assessment Study prepared by Rutherford + Chekene as the basis for improvements to the City's seismic risk management program and ordinance.
2. Provide direction to staff regarding parameters for amendments to program, to be included in an ordinance for consideration at a future public hearing. At minimum, City Council direction is needed to address program options, building types, disclosures, and incentive options.
3. Direct staff to return to the Policy and Services Committee with:
    a. Strategy and costs to further define and verify the current inventory of vulnerable buildings.
    b. Strategy and costs to assess community, business and economic implications of implementing new program options.
    c. Community outreach plan and costs which seeks feedback from affected property owners about the program options, building types, timelines, incentive options, and to clarify wider impacts on housing availability, occupant turnover, business operations, including associated community costs and benefits to various constituencies from new risk reduction strategies.
    d. Suggested draft updates to local regulations, policies, and procedures including an analysis of any potential CEQA requirements and related costs based on City Council direction of program options, building types, disclosures and incentives.

Background

In 1986, the City Council adopted the Seismic Hazards and Identification Program, codified in

the Palo Alto Municipal Code, to establish a mandatory evaluation and reporting program including incentives for property owners to voluntarily upgrade their structurally deficient buildings. Three categories of buildings are addressed in the ordinance:

1. Category I Buildings: Buildings constructed of unreinforced masonry (URM), except for those smaller than 1,900 square feet with six or fewer occupants. These buildings are located in the Downtown Commercial area.
2. Category II Buildings: Buildings constructed prior to January 1, 1935, containing one hundred (100) or more occupants.
3. Category III Buildings: Buildings constructed prior to August 1, 1976, containing three hundred (300) or more occupants.

On September 15, 2014, several weeks after August 24, 2014 Napa Valley earthquake, the City Council received an update from the Office of Emergency Services regarding the Threats and Hazard Identification Risk Assessment report. During the study session, City Council suggested that the Policy and Services Committee:

1. Identify and prioritize buildings that pose potential risks in earthquakes, including soft story buildings and other types of construction.
2. Review and summarize best practices from other government agencies regarding prioritization of various seismically vulnerable buildings, including retrofit incentives and requirements.
3. Review current or pending State legislation related to soft-story buildings and other structurally deficient buildings.

On December 9, 2014 the Council's Policy and Services Committee recommended the City Council authorize a Request for Proposal to prepare an update to the City's Seismic Hazards Identification Program and update the inventory of structurally deficient buildings in the multi-family, commercial and industrial areas of the city, categorizing building typologies to include: 1. URM, 2. Soft-Story, 3. Tilt-Up Construction, 4. Non-ductile Concrete, and 5. Steel Moment Frame.

On August 17, 2015, City Council approved a contract with Rutherford + Chekene to complete a study and provide recommendations for improvement of City's Seismic Program. On April 17, 2017, staff advanced a comprehensive information report to City Council including the results of the Rutherford + Chekene report.

Discussion

The April 17, 2017 staff report (attached) is a thorough analysis including a 34 page staff summary of the Rutherford + Chekene's 110 page report. The Rutherford + Chekene report is also attached however any non-pertinent appendixes have been removed to save paper. All documents related to the study and previous staff reports are located on the City's website:

http://www.cityofpaloalto.org/gov/depts/ds/srmag.asp.

In addition to the support from consultant, staff convened a Seismic Risk Management Advisory Group (SRMAG). The group consisted of residents, experienced contractors, property owners and local advocates. Six meetings were held, led by the Rutherford + Chekene and included staff from Building, Planning, Fire, Office of Emergency Services, and Public Works. The intent of the SRMAG process was not to gain consensus or ratify any particularly policy proposal, but rather to gauge community interest, clarify alternative directions, and highlight key issues that need to be addressed moving forward.

The SRMAG expressed little to no support for leaving the status quo program unchanged. Strong support did exist for: 1. taking action to resolve buildings (through retrofit or demolition) already in the program, particularly URM buildings, 2. addressing more building types, particularly soft story wood-frame, and 3. utilizing a variety of disclosure measures and potentially some incentives. All presentations and minutes from the meetings are also available on the aforementioned website. Attachment A summarizes policy options that came out of the Seismic Risk Assessment, as presented to staff and discussed by the SRMAG.

Staff recommends that the Council and community read the April 17, 2017 staff report and Seismic Risk Assessment Study. Information provided in this staff report is summarized to provide City Council with specific focus areas related to the broad policy direction needed at this stage of analysis.

Policy Direction

At this step, being cognizant that staff will be returning to the Policy and Services Committee with further scoping, staff requests that City Council, at minimum, provide direction to address program options, building types, disclosure measures, and incentive options. As a starting point for discussion, staff recommendations for each topic are given below.

Program Options:

Staff recommends that City Council directed staff to pursue number 5 as listed below. The results of the SRMAG process resulted in this staff recommendation.

1. Status quo;
2. Increase number of building types regulated, but retrofit remains voluntary;
3. Increase number of building types regulated with additional disclosure measures incorporated;
4. Increase number of building types regulated, some building types have voluntary retrofit and a few building types have mandatory retrofit, with enforcement by a trigger threshold when the building is sold or undergoes substantial renovation;
5. Increase number of building types regulated, retrofits for some categories are voluntary and a few categories are mandatory, with enforcement by a fixed timeline;
6. Increase number of building types regulated, but more categories are required to have

mandatory retrofits.

Building Types:
Staff recommends adding four new building types as listed in numbers 4 -7 below. Attachment A is a summary table indicating the category, approximate number of buildings in each category, the building type, date of construction, occupant levels, threshold elements, deadlines and potential incentives.

1. Existing: Category I Buildings: Buildings constructed of unreinforced masonry (except for those smaller than 1,900 square feet with six (6) or fewer occupants). These buildings are located in the Downtown Commercial area.
2. Existing: Category II Buildings: Buildings constructed prior to January 1, 1935, containing one hundred (100) or more occupants.
3. Existing: Category III Buildings: Buildings constructed prior to August 1, 1976, containing three hundred (300) or more occupants.
4. Proposed: Category IV Buildings: Buildings constructed of soft-story wood frame, prior to 1977.
5. Proposed: Category V Buildings: Building constructed of tilt-up, prior to 1998.
6. Proposed: Category VI Buildings: Building constructed of soft-story concrete, prior to 1977.
7. Proposed: Category VII Buildings: Buildings constructed of steel moment frame, prior to 1998.

Types of Disclosure Measures
Staff recommends that City Council direct staff to pursue all options and return to Policy and Services with recommendation per building type. Attachment B is a table describing the disclosures listed below with their description, examples of use, advantages, and disadvantages. Given that staff has to further define and verify the current inventory of vulnerable buildings and assess community, business and economic implications, having all measures available will be helpful.

1. Mandatory disclosure at the time of sale
2. Recorded notice on deed
3. Public listing of affected properties
4. External signage
5. Tenant notification
6. Earthquake performance rating system

Types of Incentives
Staff recommends that City Council direct staff to pursue all options and return to Policy and Services with recommendation per building type. Attachment C is a table describing the incentives listed below with their description, examples of use, advantages, and disadvantages. Given that staff has to further define and verify the current inventory of vulnerable buildings and assess community, business and economic implications, having all available incentives may

decrease compliance timelines.

1. Expedited Planning Entitlement
2. Density or Intensity Bonuses, such as Floor-to-Area Ratio (FAR) bonues
3. Exemptions for Non-Conformities
4. Zoning Incentives
5. Condominium Conversion Assistance
6. Exemption from Future Retrofit Requirements
7. Transfer of Development Rights (TDR's)
8. Permission to add units (such as in soft-story wood frame apartment construction)
9. Expedited Building Permitting
10. Technical Assistance

Summary of Seismic Risk Assessment Study Key Findings

Due the volume and depth of information provided in the April 17, 2017 staff report as well as the Seismic Risk Assessment Study, staff and our consultant have prepared a high level key findings. Staff recommends the City Council and community read the April 17, 2017 staff report and the Seismic Risk Assessment Study.

1. Thirty years later, Palo Alto's existing mandatory evaluation, voluntary retrofit program has been largely successful at addressing buildings with URM load-bearing walls.
2. The modest scope of the existing program and lessons learned from seismic events since the program was adopted, means that we now believe there are vulnerable building types that have not been addressed. Five additional categories were identified from the Risk Assessment Study as meeting the criteria of being potentially hazardous and having a meaningful presence in Palo Alto. The decision whether to include some or all of these five categories in an expanded seismic retrofit program is an important policy decision. Based on an initial review, there are approximately 635 buildings located throughout the City, both residential and commercial uses, that may fall into these categories.
3. If no action is taken, losses in these buildings from a large nearby seismic event may be significant, on the order of $2 billion. That estimate does not include lives lost, economic disruption, loss of housing, emergency services costs, displacement or other effects.
4. Estimated losses could be reduced by up to one third to one half if all the identified vulnerable structures were retrofitted. For all five additional categories recommended for consideration, analysis of protype retrofitting strategies showed high likelihood of being cost-effective. In other words, losses avoided will exceed retrofit costs, in some categories by fourfold or more. This does not suggest that all of the retrofits would necessarily be financially feasible for current building owners, particularly in the absence of incentives and/or favorable financing terms.
5. Over the past ten years, an increasing number of California cities have expanded their seismic mitigation programs to address one or more of the five additional vulnerable building types identified in the Risk Assessment. In particular, five Bay Area cities (San Leandro, Fremont, Berkeley, Oakland and San Francisco) have well-established mandatory

retrofit programs for soft-story wood frame buildings, which are typically multi-family residential or mixed use. Cities with newer programs include Los Angeles and West Hollywood. Several cities have also implemented or are actively considering ordinances for tilt-up and older concrete structures.

6. Most programs package together a variety of policy features and timelines that differ by building type(s) and priority tiers. Education, notification and appeal, evaluation, permit application and retrofit deadlines are implemented in phases during an overall timeframe ranging from two to 25 years. A variety of incentives can also be offered for some or all affected owners, but in fact, very few cities offer any kind of significant financial assistance beyond fee waivers.

Resource Impact

Implementation of future City Council action and development of an expanded Seismic Hazards and Identification program and ordinance would result in additional costs to private property owners. Attachment D is a table of financing tools provide by Rutherford + Chekene. Staff is not seeking Council input at this stage. Upon returning to Policy and Services Committee, staff will provide recommendations for possible financing strategies.

Staff time from Development Services, Planning and Community Environment, Fire, Office of Emergency Services, and Public Works departments will continue to be needed. Additionally, consulting services to further define and verify the current inventory of vulnerable buildings; assess community, business and economic implications; and to determine scope of updates to local regulations, policies and procedures will be required. Staff will return to the Policy and Services Committee with funding recommendations.

Environmental Review

No environment review is necessary under California Environmental Quality Act (CEQA) at this time, as staff is continuing to collect information for City Council action. Staff will conduct the appropriate level of environmental assessment may be required prior to adoption of updates to the City's Seismic program.

Attachments:

- Attachment A - Program Options and Building Types
- Attachment B - Types of Disclosure Approaches
- Attachment C - Types of Policy Incentives
- Attachment D - Types of Financial Tools
- Attachment E - 4-17-17 Staff Report
- Attachment F - Seismic Risk Assessment Study by Rutherford + Chekene

Summary of Recommended Policy Directions from the Seismic Risk Management Program Advisory Group

Category	Approx. Number	Building Type	Date of Construction	Occupants	Evaluation Report	Voluntary, Triggered, or Mandatory Retrofit[1]	Deadlines for Evaluation Report and Retrofit Construction (years)[2]	Disclosure	Potential Incentives
Current Program (Potential Revision in *Italics*)									
I	10	Un-reinforced masonry	NA	Over 6 (and over 1,900 sf)	Required	*Mandatory*	Report: Expired Construction: *2-4*	*Website listing and tenant notification*	*Fee waiver, expedited permitting, FAR bonus/ transfer of development rights (TDR)*
II	4	Any	Before 1/1/35	Over 100	Required	Voluntary *or Triggered*	Report: Expired Construction • Voluntary: Not required • *Triggered: At sale or renovation*		
III	9	Any	Before 8/1/76	Over 300	Required	Voluntary *or Triggered*			
Expanded Program									
IV	294	Soft-story wood frame	Before 1977	Any	Required	Triggered or Mandatory	Report: 2-4 Construction • Triggered: At sale or renovation • Mandatory: 4-6	Same as above	Fee waiver, expedited permitting, TDR, parking exemptions, permission to add units
V	99	Tilt-up	Before 1998	Any	Required	Triggered or Mandatory	Report: 2-4 Construction • Triggered: At sale or renovation • Mandatory: 4-6	Same as above	Same as Categories I, II and III
VI	37	Soft-story concrete	Before 1977	Any	Required	Voluntary, Triggered or Mandatory	Report: 2-4 Construction • Voluntary: Not required • Triggered: At sale or renovation • Mandatory: 6-8	Same as above	Same as Categories I, II and III
VII	35	Steel moment frame	Before 1998	Any	Required	Voluntary, Triggered or Mandatory			
VIII	TBD	Other older nonductile concrete	Before 1977	Any	Not rec. at this time	Not recommended at this time	Report: NA Construction: NA	NA	NA

[1]Voluntary: Retrofit is voluntary.
Triggered: Retrofit is triggered when the building is sold or undergoes substantial renovation.
Mandatory: Retrofit is required per a fixed timeline.

[2]Deadlines provide a potential range. Timelines would vary depending on tiers or priority groupings of different subcategories.

Table 4: Description of disclosure approaches used in local earthquake risk reduction programs.

Name	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Mandatory Disclosure at Time of Sale	Sellers of property are required to disclose features that could relate to earthquake performance.	California Earthquake Fault Zone disclosure; Sellers of pre-1960 homes are required to fill out to the best of their knowledge and provide buyers with Residential Earthquake Hazards Report.	Empowers buyers to be aware of any known existing hazard issues.	Anecdotally, many buyers do not pay enough attention to these disclosures, which occur during emotional, busy decisionmaking periods. They may not seek expert information to interpret the reported information. It is also possible that sellers shirk on the disclosure requirements if buyers do not know that they are supposed to receive them. Difficult to enforce.
Recorded Notice on Deed	Jurisdictions can record on the property title or deed the fact that the building is subject to additional requirements related to its earthquake vulnerable status.	For soft-story wood frame: Oakland, Berkeley, and San Francisco.	Relatively low cost for jurisdictions to implement. Empowers buyers but also mortgage companies to be aware of any known existing hazard issues.	Anecdotally, it is not clear how many buyers or mortgage companies pay attention to these notices. Such notices are primarily effective only at time of sale or refinance.

Table 4 (continued)

Name	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Public Listing of Affected Properties	Jurisdictions that operate web sites to describe their programs can feature a full list of property addresses, potentially also including also the compliance status of the property. In general, owner names are not listed, though that information is available if a member of the public searched for it separately.	For soft-story wood frame: Oakland, Berkeley, and San Francisco.	Relatively low cost for jurisdictions to implement. Could be used by tenants and buyers when searching for properties, thus empowering well-informed market negotiations over pricing.	Website information needs to be updated on a regular basis in order to be perceived as fair and useful. Public lists work better if the property addresses are searchable, rather than static (e.g., on a pdf).
External Signage	Jurisdictions that operate web sites to describe their programs can feature a full list of property addresses, potentially also including the compliance status of the property. Some lists are searchable, while others are static.	California state requires a sign on all URM buildings. Similar signage has been required since 2007 on soft-story wood frame buildings in the City of Berkeley.	Advocates argue that signs are justified based on the public's right to know. The physical presence and repeated viewing of signage may make the issue more salient for visitors, employees, lease holders, and owners alike.	Owners may view the signs as stigmatizing or threatening to property value or business revenues, but anecdotally, it is not clear how much visitors, employees, residents, and other users of a building pay attention to signage when entering or leaving a property.

Table 4 (continued)

Name	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Tenant Notification	Owners are required to present straightforward, standardized information about the listed status of the property. Some jurisdictions require proof of notification (e.g., tenant signature) to be returned and kept on file with the city.	For soft-story wood frame: Oakland, Berkeley, and San Francisco.	Tenant notification may be more influential than signage because it is personalized and the information is delivered at a useful time in that person's decision process. Advocates claim that tenant notification is justified based on the public's right to know.	To be effective, tenant notification should be required to occur well before the potential tenant is ready to sign the lease.
Earthquake Performance Rating Systems	Owners can be either encouraged or required to have their building rated on a standardized scale that classifies expected building performance in an earthquake in an easier to understand format, for instance from one to five stars. Viable rating systems exist for many building types.	The City of Los Angeles in 2015 officially launched a voluntary effort to encourage owners to rate their properties using the US Resiliency Council system and pledged to rate its own public buildings as well.	Rating system use is common for institutions like universities and hospitals. Mechanisms for implementing performance ratings for commercial use have recently matured and are now viable. Ratings have the potential to inform owner, renter and buyer decisions, creating a market effect.	Obtaining a rating potentially adds cost to a design project. Ratings systems such as USRC's are relatively new and not yet widely implemented.

Attachment C

Policy Incentives Used in Local Earthquake Risk Reduction Programs.

Type of Incentive	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Density or Intensity Bonuses	Specific increases in the maximum allowable building density or intensity to help offset the added costs of seismic upgrades.	Palo Alto's Floor Area Ratio bonus program.	Owners that invest in a retrofit can expand their projects in order to increase future revenue.	Typically, feasible only in areas of high growth. Sometimes controversial because of potential community impacts such as increased traffic, parking needs, and rental rates.
Exemptions for Non-Conformities	Relief from timelines or waivers of required work such as fire resistance upgrades and sprinklers, Title 24 energy analysis and upgrades, parking, setback or other current code measures that would otherwise be triggered by the size of the project being undertaken for projects involving qualifying retrofit work.	None identified.	Offering relief from what may be expensive rehabilitation of nonconforming uses can make seismic retrofits easier to design and more affordable.	May be viewed as an excessive concession to owners among some members of the public.

Attachment C

Type of Incentive	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Zoning Incentives	Specific concessions regarding encroachment into setbacks, increased allowable floor/area ratios (FAR), height limits, or onsite parking requirements to help offset the added costs of seismic upgrades.	Since 1986, Palo Alto allowed owners of included buildings in the downtown area to expand the floor area if the owner performed seismic upgrades. Buildings were also exempted from onsite parking requirements and fees for offsite parking.	Useful when bond financing options are prohibitively costly or not much more attractive than private credit terms. Most likely to work when zoning plans in the community generally call for limited to no growth. Costs to the city are mainly in the form of technical and design cost review of proposed projects.	Similarly-situated properties must be treated alike so as to avoid claims of "spot zoning." Citizens may object to special treatment for work that could be seen as essential anyhow. Not likely to work in locations with little development pressure or where the community favors growth.
Condominium Conversion Assistance	Process expediting for condo conversion for properties that seismically retrofit.	None identified.	In jurisdictions where condo conversation rates are capped or allocated by lottery, offering priority to buildings that retrofit could be an effective tool to promote seismic upgrading of multifamily buildings.	May negatively impact other housing affordability goals. Only available to owners that can afford it, unless accompanied by other assistance programs.
Exemption from Future Retrofit Requirements	Relief from imposition of future retrofit requirements for a certain period following completion of qualifying seismic work.	The City of Berkeley offered a 15-year exemption from future retrofit requirements for soft-story wood frame properties that did a retrofit concurrent with its mandatory evaluation program.	This can motivate owners to complete retrofit work sooner rather than later in order to reduce uncertainty about future city policies, and allows owners to better anticipate business expenses over a longer term.	The jurisdiction could not easily impose new regulation on exempted properties, even if such policies became warranted by new technologies or knowledge.

Attachment C

Type of Incentive	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Transfer of Development Rights (TDR)	TDR allow owners to transfer unused development rights that are comparable to the value of the retrofit to another site.	Very commonly used for historic preservation, including in Palo Alto.	Useful when the use of the building in question is not likely to generate added value to justify the costs of the retrofit work. This is most useful when retrofit costs can be particularly high and there are natural or regulatory use restrictions.	Careful analysis of construction costs is necessary to avoid situations of under- or over-compensation.
Expedited Permits, Inspections, and Reviews	Prioritization, expediting, or bypassing of certain internal protocols for over the counter permits and inspection processes for projects involving seismic retrofit work.	Several Bay Area cities have anecdotally stated that this is their internal policy, but no official records of such were identified.	This can relieve the burden of time and hassle for owners in getting permits and inspections, which are a significant source of cost and uncertainty for owners during retrofit projects.	Requires flexibility on the part of city staff and plan check consultants.
Technical Assistance	Case-management style assistance for owners and/or engineers during the process of obtaining financing, complying, permitting, and carrying out retrofit projects. This is different than engineering advice about how to resolve specific technical issues of design.	Cities such as Berkeley have found it necessary to maintain additional staff to operate their mitigation programs. A significant portion of their staff time is devoted to owner and engineer consultation.	Knowledgeable staff can help owners navigate complex issues such as investigating and applying for incentives (if offered), following guidelines, or addressing the necessary standards.	Labor costs to the city for additional staff. Difficulty sustaining project funding and staff continuity over time.

Attachment D

Financial Tools Used in Local Earthquake Risk Reduction Programs.

Financial Tools	Description	Examples of Use	Advantages	Costs, Issues or Concerns
General Obligation or Special District Bonds	Direct provision of funds for qualifying retrofit work based on voter approval of issuance of new municipal or state debt to be repaid by taxation.	This mechanism is commonly used for seismic improvements to infrastructure, but also has been used in URM building programs and for retrofit of historic properties. One URM example is the city of Long Beach, which offered 11.3% interest financing to participating members of a Special District created for URM building owners.	Once passed, this type of funding can be distributed over time as provided for in the approved wording.	Must be approved by two thirds of voters, which sets a high bar even if there is significant public support. Jurisdictions must administer the allocation of funds and have at times not been able to use all of it. Owner education about the provisions of the program is critical. Owners of highly leveraged buildings and buildings in depressed areas may be unable to meet prerequisite loan-to-value ratio criteria. Retrofits are generally not revenue-generating improvements upon which financing can be leveraged.
Grants	Direct provision of funds for qualifying retrofit work.	CEA's Earthquake Brace & Bolt program for single family homes.	Some sources exist for city-scale projects or privately-owned buildings, such as FEMA Pre-Disaster Mitigation Grants.	Limited sources exist. Programs can be difficult to manage administratively. Fairness concerns exist over which owners can benefit.

Attachment D

Financial Tools	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Property-Assessed Financing Loans	Also known as a Property Assessed Clean Energy (PACE) program, this works as a loan to an individual property owner, transferrable to future owners, where the upfront costs of qualifying work are repaid over a period of approximately 20 years through the owner's property tax assessment.	San Francisco's PACE program.	Provides an upfront way for owners to access private capital to afford retrofit projects. The loan can be paid off over time through higher rents or at future sale, as well as being transferrable to future owners.	Administratively complex for both jurisdictions and owners. Challenges include setting up this complex financing instrument which has heavy involvement of third parties, barriers to owners that want to refinance, and barriers to the transfer of a PACE-financed properties to a new owner. Owners may not need it if affordable regular market capital is available. Lenders may resist allowing an additional lien.
Tax Credits	Waiver of a portion of a business, parcel, or income tax for a number of years to encourage owners to retrofit.	Although vetoed by the Governor, the legislature of California passed AB 428 in 2015, which would have offered up to 30% credit for qualifying retrofit costs.	The funding source can be outside the local jurisdiction, and depending on the clarity of program requirements, owners can count on the funds as part of planning their project.	Owners would need to be aware of the credit and verify qualifying work and complete all follow up documentation. Mostly benefits owners already intending to retrofit and those with more financial and business sophistication.

Financial Tools	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Real Estate Transfer Tax Rebates	Building owners can apply for a rebate of a fraction (usually 1/3, up to a cap) of the amount of the transfer tax owed to the city for a property at sale for any qualifying seismic improvement expenditures made within a certain period before or after transfer of title.	This policy has existed in Berkeley since 1991 for residential dwellings up to four units and in San Francisco since 2008 for properties worth $5 million or more.	In Berkeley, the program was immediately popular and eventually highly influential in increasing support for other earthquake policies because it touched so many community members and firmly established a tone that the city takes seismic risk seriously and will put its "money where its mouth is." About half the single-family homes and one third of the smaller rental buildings in Berkeley have claimed the credit, leading to widespread community awareness of seismic safety issues.	The jurisdiction forgoes tax revenue. Anecdotally in Berkeley, city officials had no easy way to assess the quality of work done. Some experts suspect that some of the funds went to incomplete or improperly done retrofits.
Waivers or Reductions of Building Department Fees	Full waivers, fixed, or percentage-based reductions of building permit fee reductions.	The Jurisdictions of San Francisco, Berkeley, and Alameda have offered flat or waived plan check fees as an incentive for owners to retrofit their buildings. Oakland currently offers a flat permit fee of $250 for owners of qualified single-family residences to perform seismic retrofits.	Modestly reduces the cost of a retrofit project. Easy for city to implement. Perceived by owners as a significant gesture of good will by owners, who may feel it is "the least the city could do."	This measure has direct loss of revenue implications for the jurisdiction.

Attachment D

Financial Tools	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Pass Through of Retrofit Costs to Tenants	For residential properties in jurisdictions with rent control laws in place, owners who seismically retrofit their buildings could be allowed to pass through all or a fraction the costs of these retrofits to renters in rent-controlled units, amortized over a particular time period such as 10 years.	Berkeley is 100% pass-through, San Francisco is 50%, and Oakland is %75.	Perceived as fair by owners because tenants that benefit most from the retrofit work pay a share of it. Owners can use this anticipated source of revenue as a basis for securing a loan.	Tenants with fixed or low incomes might suffer hardship with the added costs, although hardship provisions can lessen those effects.
Special District or Historic Designation Tax Reductions	Creation of Mello-Roos, Mills Act, historic or other special districts that are then eligible for special loans, grants, or tax credits.	For URM buildings, the jurisdictions of St. Helena and West Hollywood used Mello-Roos funding.	Provides a clear way for a local jurisdiction to provide direct funding or special financing rates for privately-owned vulnerable properties.	Can be difficult for jurisdictions to initiate and carry out. Owners must join the special district at the outset or will be left out of future funding availability.

City of Palo Alto (ID # 7095)

City Council Staff Report

Report Type: Informational Report **Meeting Date: 4/17/2017**

Summary Title: Palo Alto Seismic Risk Assessment Study Results

Title: Palo Alto Seismic Risk Assessment Study Results

From: City Manager

Lead Department: Development Services Department

RECOMMENDATION

This is an Informational Report, no City Council action is required at this time. Staff recommends that the City Council review the Seismic Risk Assessment Study prepared by Rutherford + Chekene, structural engineers. The study includes input from City of Palo Alto's Seismic Risk Management Advisory Group. Once Council is familiar with this study, staff will prepare to return for a study session and direction.

EXECUTIVE SUMMARY

This informational item is intended to give the City Council advance background for an upcoming study session related to a Seismic Risk Assessment Study of vulnerable building construction in Palo Alto. In 2014, following the 6.0 magnitude earthquake in August 2014 in the Napa Valley and the Office of Emergency Service's Threats and Hazard Identification and Risk Assessment Report, the Council directed staff to identify and prioritize buildings that pose a potential seismic hazard in Palo Alto; review 'best practices' used by other communities for addressing retrofit of seismically vulnerable buildings; and review current and pending State legislation addressing these building types.

Rutherford + Chekene was selected to perform a comprehensive assessment of the expected performance of the City's building stock in potential earthquakes, including a community engagement effort to help identify resiliency goals and associated mitigation policies and programs. Specific details about the report can be found in this staff report and attached consultant report. (Attachments B)

In this staff report, staff has summarized the outcome of the Seismic Risk Assessment and the Advisory Group's input on revisions to consider for the City's Building and Zoning Ordinances. Some of the study recommendations have significant policy and cost implications that will require further study and Council review. All of these recommendations are discussed in this staff report and in the detailed technical reports attached. (Attachments B and G)

Next steps following council study session on this matter may include public outreach to educate the community on vulnerable buildings. Staff, with the help of consultants, will review potential incentives for retrofits and policies to minimize displacement of existing uses and tenants. Staff would return to the Council with a recommendation to revise the current seismic mitigation ordinance based on findings and community feedback. To be effective, there will need to be a plan for staffing the program. Finally, during the study session staff will also discuss potential policy implications such as displacement of existing building uses and tenants, incentives for voluntary building retrofits, and the effects these benefits might have on construction.

BACKGROUND

On September 15, 2014, the City Council directed staff to work with the Policy and Services Committee to address the following:

A. Identification and prioritization of buildings that pose a potential hazard in an earthquake, including soft-story buildings and other types of construction
B. Review of "best practices" from other cities regarding prioritization of various seismically vulnerable buildings, including retrofit incentives and requirements
C. Review of current or pending State legislation related to soft-story buildings and other structurally deficient buildings

Two events precipitated the Council's direction: (1) the 6.0 magnitude earthquake on August 24, 2014, in Napa Valley and (2) the City Council's review of the Office of Emergency Service's Threats and Hazard Identification and Risk Assessment report on September 15, 2014, which identified over 130 seismically vulnerable buildings. (Attachment C)
<http://www.cityofpaloalto.org/civicax/filebank/documents/43866>

Current Code Provisions, Building Identification and Prioritization

In 1986, the City Council adopted the Seismic Hazards and Identification Program codified at PAMC Section 16.42. (Attachment A) This ordinance established a mandatory evaluation and reporting program and created incentives for property owners primarily in the Downtown area to voluntarily upgrade their structurally deficient buildings. Three categories of buildings were identified, including:

1. Category I Buildings: Buildings constructed of unreinforced masonry (except for those smaller than 1,900 square feet with six (6) or fewer occupants). These buildings are located in the Downtown Commercial area.
2. Category II Buildings: Buildings constructed prior to January 1, 1935, containing one hundred (100) or more occupants.
3. Category III Buildings: Buildings constructed prior to August 1, 1976, containing three hundred (300) or more occupants.

The categories used in 1986 were developed by a citizens' committee, reviewed by staff and the Policy and Services Committee, and adopted by the City Council. These categories were created to record known URM buildings and other potentially structurally deficient buildings with relatively high numbers of occupants.

This program identified 89 buildings and was successful in two significant ways. One hundred percent (100%) of the property owners complied with the ordinance and submitted engineering reports detailing structural deficiencies and recommendations to strengthen structures to alleviate the threat of collapse. Further, approximately seventy-four percent (74%), or sixty-six buildings, were strengthened, demolished, or proposed to be demolished. See (Attachment D) for current status of all inventoried properties.

Part of this success may be attributed to incentives that allowed upfront engineering report costs be applied toward permit fees and the ability for property owners in the Downtown Commercial (CD) district to add up to 2,500 square feet of new floor area, or twenty-five percent (25%) of the existing building area, whichever is greater, to the site without having to provide additional parking. This floor area bonus could be used onsite or transferred to another owner or property in the Downtown Commercial district. Approximately twenty-one (21) property owners took advantage of this incentive.

Despite its successes, twenty-three (23) buildings identified from that original inventory remain vulnerable. Further, there are other building types in the City that were not surveyed prior to adoption of the 1986 ordinance. For example, problems with soft story wood-frame construction were documented following the 1994 Northridge Earthquake, which resulted in changes to construction industry standards a few years later.

In 2003, the Collaborative for Disaster Mitigation at San Jose State University completed an "Inventory of Soft-First Story Multi-Family Dwellings in Santa Clara County." According to the report, the City of Palo Alto had 130 soft story multi-family buildings including 1,263 residential units housing 3,158 occupants.

Other construction types of concern that were not surveyed in 1986 include non-ductile concrete buildings, older steel moment frame buildings, and older concrete tilt-up buildings, in addition to soft story wood-frame construction.

The City's existing ordinance requires annual reporting to the City Council on the status of the program. This reporting appears to have ended in 2004 for unknown reasons. More recently, the City Council adopted an ordinance (Attachment E - update to ORD 5356) modifying the seismic incentive so that parking must now be provided if an owner seeks to add 2,500 square feet or 25% of the total building area in the CD District.

Policy and Services Recommendation and Council Authorization

On December 9, 2014, the Policy and Services Committee of the Palo Alto City Council

recommended the City Council authorize a Request for Proposal (RFP) to develop information for use in updating the City's Seismic Hazards Identification Program (Ordinance 3666). See Staff Report 5293 "Discussion of Updating the Seismic Safety Chapter of the Municipal Code for Hazardous Buildings" (Attachment D). The City Council approved the recommendation and an RFP was prepared. A consulting team led by Rutherford + Chekene was selected to:

A. Develop summarize relevant state and local seismic mitigation legislation
B. Obtain detailed information on Palo Alto's existing building stock
C. Develop conceptual retrofits for vulnerable building types
D. Make loss estimates of expected damage to current and retrofitted building
E. Work with a City advisory group to develop policy recommendations for consideration by the Council.

A stakeholder Advisory Group was convened and was an essential element in discussing earthquake risks in Palo Alto's existing building stock prepared by the consultant team and in reviewing policy alternatives. Members included people with a range of relevant expertise and interests, including interested citizens, earthquake risk and engineering experts, local developers and owners, and representatives of various community groups. City departments also participated in the Advisory Group, including Building, Planning, Fire, Office of Emergency Services, and Public Works. See Attachment F for a list of Advisory Group members.

City Policy Implications

Currently, the City is in the process of updating its Comprehensive Plan. In its Goal statements, this document expresses the community's vision for its future. Further, in its policies, the Plan defines the appropriate actions to implement the vision. The Seismic Risk Assessment Study's findings and its guiding conclusions informed by the Seismic Risk Management Advisory Group are integral to several key elements of the Comprehensive Plan: the Safety Element, the Housing Element, and the approach to, and needs for, coordinated Community Emergency Services. Policies being considered in the Comprehensive Plan Safety Element support regular review and update of the City's seismic retrofit regulations.

Although focused on multiple family and commercial structures, the seismic risk assessment identifies both the type of seismically vulnerable structures and the geographic areas in the community that will be most affected by a major earthquake. To gage the impact, the study looked at the cost of retrofitting each type of structure. It also evaluated the community impact of the aftermath of a major earthquake in terms of loss of property and effect on the City's economy.

Palo Alto is currently participating with the other cities in the County in updating the State and Federally mandated five-year update of the Santa Clara County Local Hazard Mitigation

Plan (Santa Clara LHMP) as required by the Federal Disaster Mitigation Act of 2000. This plan is required before Palo Alto can request FEMA assistance following a natural disaster. The Local Hazard Mitigation Plan focuses on community mitigations to fire, flood and earthquake events.

The data in the Seismic Risk Assessment Study will be useful as a tool to inform the Santa Clara LHMP about the City's needs in the event of a major earthquake. The Council's subsequent direction on revising of the City's seismic renovation requirements will be integrated into Palo Alto's mitigations outlined in the Santa Clara LHMP plan.

The Seismic Risk Assessment Study and its implementation have important implications for both City and emergency planning policy. First and foremost, the study provides valuable information for the development of the City's long range planning policy expressed in the Comprehensive Plan in areas of community safety, housing, and coordination of community services, which also includes community education and neighborhood volunteers. It also provides information that can be used to refine the community's vision regarding its residents' wellbeing and improve its preparedness for a major seismic event by addressing risk to loss of life and property associated with vulnerable building types. The information can also improve the community's ability to recover from a major seismic event including displacement of residents and businesses, loss of housing and commercial buildings and community wide economic impacts and recovery.

Other policy implications involve the potential for displacement of existing uses and tenants if building owners need to remove the uses/tenants to upgrade their buildings or if they increase rents to cover the cost of engineering studies and retrofit work, and the how this displacement can be minimized. Also, potential incentives for voluntary building retrofits may need to be considered along with changes to the existing zoning incentives (Transfer of Development Rights program) that grant bonus square footage to buildings that are retrofitted downtown, and the potential impacts/benefits that might result from new incentives or modifications.

SEISMIC RISK ASSESSMENT STUDY

The risk assessment carried out by R+C included a series of task reports. They have been combined into one composite report as Attachment B and include surveys of state and local seismic policies and practices, an inventory of buildings in Palo Alto, a summary of vulnerable building categories, conceptual seismic retrofitting of representative vulnerable buildings, loss estimates for the current condition of the building stock and if buildings are retrofit, a review of past seismic retrofits in Palo Alto from selected City records, and a discussion of additional recommended program features for an improved seismic risk mitigation program.

Table 1 summarizes the outcome of the seismic risk assessment and includes the Advisory Group discussions. The table is organized around eight vulnerable building categories or building types. Categories I, II and III encompass the identified vulnerable buildings for the

Attachment E

Table 1: Summary of Recommended Policy Directions from the Seismic Risk Management Program Advisory Group

Category	Approx. Number	Building Type	Date of Construction	Occupants	Evaluation Report	Voluntary, Triggered, or Mandatory Retrofit[1]	Deadlines for Evaluation Report and Retrofit Construction (years)[2]	Disclosure	Potential Incentives
Current Program (Potential Revision in *Italics*)									
I	10	Un-reinforced masonry	N/A	Over 6 (and over 1,900 sf)	Required	*Mandatory*	Report: Expired Construction: *2-4*	*Website listing and tenant notification*	*Fee waiver, expedited permitting, FAR bonus/ transfer of development rights (TDR)*
II	4	Any	Before 1/1/35	Over 100	Required	Voluntary *or Triggered*	Report: Expired Construction • Voluntary: Not required • *Triggered: At sale or renovation*		
III	9	Any	Before 8/1/76	Over 300	Required	Voluntary *or Triggered*			
Expanded Program									
IV	294	Soft-story wood frame	Before 1977	Any	Required	Triggered or Mandatory	Report: 2-4 Construction • Triggered: At sale or renovation • Mandatory: 4-6	Same as above	Fee waiver, expedited permitting, TDR, parking exemptions, permission to add units
V	99	Tilt-up	Before 1998	Any	Required	Triggered or Mandatory	Report: 2-4 Construction • Triggered: At sale or renovation • Mandatory: 4-6	Same as above	Same as Categories I, II and III
VI	37	Soft-story concrete	Before 1977	Any	Required	Voluntary, Triggered or Mandatory	Report: 2-4 Construction • Voluntary: Not required • Triggered: At sale or renovation • Mandatory: 6-8	Same as above	Same as Categories I, II and III
VII	35	Steel moment frame	Before 1998	Any	Required	Voluntary, Triggered or Mandatory			
VIII	TBD	Other older non-ductile concrete	Before 1977	Any	Not rec. at this time	Not recommended at this time	Report: N/A Construction: NA	N/A	N/A

[1]Voluntary: Retrofit is voluntary.
Triggered: Retrofit is triggered when the building is sold or undergoes substantial renovation.
Mandatory: Retrofit is required per a fixed timeline.

[2]Deadlines provide a potential range. Timelines would vary depending on tiers or priority groupings of different subcategories.



Figure 1: Category IV, Wood-frame Soft Story Building built before 1977 Earthquake Damage



Figure 2: Category I, Unreinforced Masonry Building Earthquake Damage



Figure 3: Category I, Unreinforced Masonry Building Earthquake Damage

Survey of State and Local Seismic Policies

The risk assessment study includes two reports that address (1) a detailed review of the seismic risk management policy context within the State of California including relevant State legislation, and (2) the status of local seismic safety and mitigation programs. Development of the reports included searches of legislative data bases, search and review of published and online reports and materials, phone interviews with community leaders as well as local and State government staff, and development of insights from the consulting team based on their experiences in this arena. The two reports were discussed at Advisory Group meetings and helped inform the development of potential seismic risk management policies relevant to Palo Alto.

State Level Policy Review

The report on State level risk mitigation policies provides review of relevant historic and pending State legislation related to seismic risk mitigation of vulnerable buildings. High level legislative findings from the report include the following:

A. Palo Alto is affected by numerous relevant California existing laws and regulations dating from the 1930s through the present. These laws regulate many aspects of Palo Alto's built environment, including certain classes of building uses such as hospitals, public schools, and essential facilities; setting code minimums for new construction; and mandating land use planning and real estate disclosure measures for natural hazards including earthquakes. Unreinforced masonry (URM) is at present the only structural system type for which the State requires local jurisdictions to have a program.
B. If it so chooses, Palo Alto has wide authority to expand or strengthen its approaches to seismic mitigation. The power to do more about earthquake vulnerabilities is primarily in the hands of the local jurisdictions that have significant discretion in the kinds of policies they can adopt.
C. Palo Alto has many additional actions it can take to make sure it is complying and taking greatest possible advantage of State level regulations and opportunities. In particular, opportunities exist now to align a new seismic program with two ongoing mandated planning efforts the City is already engaged in: Palo Alto's Comprehensive Plan update and the Santa Clara County Local Hazard Mitigation Plan update.

Based on what state laws allow and in some cases recommend policy directions Palo Alto could pursue going forward include the following:

A. Implement measures to increase the effectiveness of its current program, for instance by offering additional or larger incentives or devoting more resources to program visibility and implementation
B. Expand the City's current voluntary seismic mitigation programs to address additional building types, uses, or sizes

C. Add mandatory screening or evaluation measures for one or more vulnerable building types such as soft-story wood frame or concrete buildings
D. Upgrade the City's current voluntary URM program to make retrofitting mandatory
E. Create a program that mandates seismic retrofits for one or more additional (non-URM) vulnerable building types
F. Craft a program that combines any or all of the above measures. Local precedents for all of these types of approaches exist
G. Continue the status quo current program

Local Program Best Practice Assessment

The local program best practices assessment report reviews current practices among local jurisdictions and agencies that require seismic retrofitting. The report summarizes what has been done legislatively and programmatically to increase awareness, assess, and motivate mitigation of seismically vulnerable buildings.

Palo Alto is currently laying a solid foundation for future program development by investing in new inventory and risk information as well as community outreach and internal staff discussions. In doing so, it is joining a group of leading California coastal jurisdictions such as Berkeley, Oakland, San Francisco and Los Angeles that have recently stepped up their earthquake risk reduction efforts. San Leandro and Fremont have also had policies in place for over a decade. While there is much learning and information sharing going on, each jurisdiction has developed their own customized policy package. There is no single best model that Palo Alto can straightforwardly adopt. Existing local approaches differ widely in the following ways:

A. Policy mechanisms used to achieve progress
B. Scope of targeted building types or uses addressed
C. Prioritization for retrofit among vulnerable structures and compliance timeframes
D. Types of incentives offered to property owners
E. Disclosure measures used to increase public awareness

Policy Mechanisms

The policy mechanisms being used by other jurisdictions range from inventory only with no subsequent requirements to mandatory retrofit completion in under five years. In between are more gradual approaches such as voluntary retrofit advocacy, incentives, provisions that make building deficiencies more visible to the public (disclosure measures), and mandatory screening and evaluation requirements. An important policy decision is whether any mandated actions are implemented on a fixed timeline or triggered at sale or at some renovation cost threshold.

Scope of targeted building types and characteristics

The most commonly addressed building type is unreinforced masonry (URM) construction due to state law SB 547, passed in 1986. Over half of URM building programs in the state require mandatory retrofit, often but not always, with a time frame on the order of ten to twenty years. By 2006, seventy percent of all identified URM buildings statewide were either demolished or retrofitted. Retrofit rates on average were three times higher in jurisdictions with mandatory retrofit compared to voluntary programs. Jurisdictions used a wide variety of both financial and policy incentives to assist URM building owners. Some voluntary URM building programs coupled with incentives, including Palo Alto's, have achieved similar rates of success to mandatory programs.

More recent programs have focused on soft-story wood frame multi-family residential buildings, including ten Bay Area jurisdictions and, most recently, Los Angeles as of 2015. Soft-story wood frame building programs range in requirements from notification only to mandatory retrofit. Several jurisdictions have innovatively used intermediate mandatory screening and evaluation phases to further assess risk exposure and determine the final set of buildings that will be affected by retrofit requirements. Soft-story wood frame programs have largely been supported in the local community. Compliance timeframes in soft-story wood frame programs tend to be short, on the order of two to seven years.

A comparatively small number of Southern California jurisdictions have acted to address older concrete buildings, including Los Angeles, Burbank, Santa Monica, and Long Beach. Non-ductile concrete frame and tilt-up concrete structures, in particular, are known to pose serious risks. Programs aimed at older concrete buildings range from voluntary guidelines to mandatory evaluation and full retrofit requirements. Timeframes on mandatory retrofit of older concrete buildings vary greatly, from years to decades. Information about the implementation and outcomes of these few programs is very limited.

Incentives

To complement program compliance requirements, jurisdictions can offer either financial or policy oriented incentives. Financial incentives in increasing order of cost and implementation difficulty include: waivers or reductions of building department fees, pass through of retrofit costs to tenants (in jurisdictions with rent control), property-assessed financing loads, subsidized or special term loans, real estate transfer tax rebates, special district or historic designation tax reductions, tax credits, grants, and general obligation bonds. Program incentives in order of increasing difficulty include exemption from future retrofit requirements, expedited reviews, exemption or relief from standards or non-conforming conditions, condominium conversion assistance, technical assistance for retrofitting, zoning incentives, transfer of development rights, and density or intensity bonus such as a floor area or floor area ratio bonus. Jurisdictions vary widely in the extent and type of incentives offered, and many offer a number of different types of incentives.

Disclosure Measures

Public disclosure provides a powerful mechanism for influencing the opinions and actions of owners, renters, and buyers, particularly in programs without mandatory retrofitting requirements. Officially publicizing a city's concerns about deficiencies of a specific building type could, for instance, change public opinion about the resale or rental value of listed properties, an owner's eligibility for refinancing or future loan terms, or the cost of purchasing property and earthquake insurance.

Jurisdictions have used a variety of techniques to motivate attention to seismic risk concerns.

Disclosure measures include the following:

A. Mandatory disclosure at time of sale: Sellers of property are required to disclose features that could relate to earthquake performance.
B. Recorded notice on deed: Jurisdictions can record on the property title or deed, the fact that the building is subject to additional requirements related to its seismic vulnerability status.
C. Public listing of affected properties: Jurisdictions that operate web sites to describe their programs can feature a full list of property addresses and the compliance status of the property. Generally, owner names are not listed.
D. External signage: California law requires signage on all URM buildings. Similar signage has been required since 2007 on soft-story wood frame buildings in the City of Berkeley and non-complying soft-story wood frame buildings in San Francisco.
E. Tenant notification: Owners are required to present straightforward, standardized information about the listed status of the property.
F. Earthquake performance rating systems: Owners can be either encouraged or required to have their building rated on a standardized scale that classifies expected performance in an earthquake. In 2015, the City of Los Angeles launched a voluntary effort to encourage owners to rate the properties using the US Resiliency Council's rating system and pledged to rate its own public buildings. For more information about the US Resiliency Council, see their website at <http://www.usrc.org/>.

Palo Alto Options

Based on the review of state and other jurisdiction policies, alternative program options for Palo Alto were identified:

1. Status Quo: In this option, the existing ordinance with its mandatory evaluation, voluntary retrofit approach remains in place without changes. Floor area ratio bonuses are (were) available and could continue to be offered.
2. Increase Number of Building Types Regulated, but Retrofit Remains Voluntary: Additional categories of structures are added to the mandatory evaluation requirements beyond those of the current ordinance. These could include any or

all of the building types discussed above, potentially also using additional location, use, or occupancy criteria.

3. Increase Number of Building Types Regulated with Additional Disclosure Measures Incorporated: This option would be similar to Option 2, but with increased use of disclosure measures such as prominently posting the building list on the City website, notifying tenants, requiring signage, and/or recording notice on the property title.
4. Increase Number of Building Types Regulated, Some Building Types Have Voluntary Retrofit and a Few Building Types Have Mandatory Retrofit, with Enforcement by a *Trigger Threshold*: This option builds on Option 3, but retrofitting would be required for some building types at whenever future time a building is sold or undergoes substantial renovation above a set threshold.
5. Increase Number of Building Types Regulated, Retrofits for Some Categories are Voluntary and a Few Categories are Mandatory, with Enforcement by a *Fixed Timeline*: This option would be similar to Option 4, but retrofitting is required according to a fixed timeline. Timelines and enforcement emphasis could vary depending on tiers or priority groupings to motivate prompt action for the most vulnerable or socially important structures.
6. Increase Number of Building Types Regulated, but More Categories are Required to Have Mandatory Retrofits: This alternative is similar to Option 5, but retrofitting would be required for additional categories on a fixed timeline.

Other Program Features and Implementation Factors

By updating its current ordinance, Palo Alto has a variety of opportunities to expand and better link its earthquake mitigation program efforts to other City efforts in support of community resilience goals. For instance, Palo Alto could encourage a building occupancy and resumption program like San Francisco, encourage or fund installation of strong motion instruments, or pursue special programs or requirements for cell phone towers, facades, private schools, and/or post-earthquake shelter facilities. A detailed description of several leading local program models and planning resources for these types of efforts are included in Attachment B.

Building Inventory

Summary of Survey Methodology

One of the first steps in the Seismic Risk Assessment Study was to develop a digital inventory of buildings in Palo Alto that includes all the information necessary to build the exposure model for the loss estimate. Information sources used to develop the inventory included county tax assessor files, City GIS files, a survey done by the Palo Alto Fire Department and San Jose State University of soft-story wood frame buildings, field notes from the building department files of selected buildings when the 1986 ordinance was being developed, Google Earth and Street View visual reviews, and an extensive visual sidewalk survey.

After the sidewalk surveys and additional quality assurance refinements, the study identified a total of 2,632 buildings in the study group for Palo Alto. This included 66 buildings subject to Palo Alto's current seismic mitigation ordinance, because 23 of the original 89 buildings subject to the ordinance have been demolished.

Not all buildings were field surveyed and not all key attributes needed for loss estimation were available for all buildings. For buildings that were not surveyed and were missing information, the missing attributes were developed using statistical comparisons with buildings that were surveyed on a sector- by- sector basis. A multi-step procedure was developed to fill in other missing attributes based on the best available comparative information. As a result, while the information for buildings that were not surveyed may not be fully accurate at the individual building level, the overall data set is seen as sufficiently representative for the type of loss estimates used in the project and relative comparisons made between different building types that are discussed ahead.

Replacement Cost Values for Palo Alto

In addition to the information discussed above, a locally-customized replacement cost had to be established for each building. Standard 2014 *RS Means* Replacement Cost values included in the project loss estimation software (Hazus) used were reviewed as a starting point, but not considered representative for Palo Alto. R+C and Vanir Construction Management prepared adjustments to RS Means values to capture 2016 data and local factors unique to Palo Alto. These were reviewed by a task group of the City's project Advisory Group that included local design professionals and developers familiar with the local cost climate. The group recommended an increase of the values in general and identified target values for selected common occupancies. Based on these recommendations, R+C updated the values and Vanir reviewed them and revised the non-targeted occupancies for estimating consistency. The resulting replacement costs are shown in Table 2, and were used in the loss calculations. It is noted that resulting costs are 1.7-2.6 times the RS Means-based Hazus default values (2014 cost data), and that costs are intended to be representative of averages across the town.

Table 2: Average $/SF replacement building cost by Hazus occupancy class.

Occupancy Class	RS Means 2014 Average Palo Alto Cost[1] [$/SF]	Market Factor for Palo Alto	Escalation Factor from 2014 costs to 2016 costs	Demo & Minimal Sitework (5' around building) [$/SF]	Soft Cost Premium[2]	Average 2016 Palo Alto Cost w/ Soft Costs [$/SF]	Multiplier (Replaced with Soft Costs / RS Means)
Multi Family, duplex	$130.75	40%	10%	$17.50	20%	$263	2.01
Multi Family, triplex/quad	$114.94	40%	10%	$17.50	20%	$233	2.03
Multi Family, 5-9 units	$206.41	40%	10%	$17.50	20%	$402	1.95
Multi Family, 10-19 units	$194.12	40%	10%	$17.50	20%	$380	1.96
Multi Family, 20-49 units	$212.26	40%	10%	$17.50	20%	$413	1.95
Multi Family, 50+ units	$199.90	40%	10%	$17.50	20%	$390	1.95
Temporary Lodging	$217.83	40%	10%	$17.50	20%	$424	1.94
Institutional Dormitory	$234.44	50%	14%	$25.00	20%	$511	2.18
Nursing Homes	$238.07	50%	12%	$25.00	20%	$510	2.14
Retail Trade	$121.66	80%	10%	$17.50	20%	$310	2.55
Wholesale Trade	$118.13	60%	10%	$17.50	20%	$$270	2.29
Personal & Repair Services	$143.47	60%	10%	$17.50	20%	$324	2.26
Professional/Technical/ Business Services	$194.52	65%	12%	$17.50	20%	$452	2.33
Banks	$281.88	40%	12%	$25.00	20%	$560	1.99
Hospitals	$372.59	50%	14%	$35.00	20%	$807	2.16
Medical Office/Clinics	$267.85	20%	10%	$17.50	20%	$445	1.66
Entertainment/Recreation	$248.61	25%	12%	$25.00	20%	$448	1.80
Theaters	$186.45	35%	12%	$25.00	20%	$368	1.98
Parking	$84.59	20%	10%	$17.50	20%	$155	1.83
Heavy	$144.71	25%	10%	$17.50	20%	$260	1.80
Light	$118.13	25%	10%	$17.50	20%	$216	1.83
Food/Drugs/Chemicals	$229.48	30%	12%	$17.50	20%	$422	1.84
Metal/Minerals Processing	$229.48	30%	12%	$17.50	20%	$422	1.84
High Technology	$229.48	40%	14%	$17.50	20%	$461	2.01
Construction	$118.13	30%	10%	$17.50	20%	$224	1.89
Church	$118.13	50%	12%	$25.00	20%	$268	2.27
Agriculture	$199.08	10%	12%	$17.50	20%	$315	1.58
General Services	$152.63	40%	10%	$17.50	35%	$341	2.23
Emergency Response	$259.52	40%	14%	$25.00	35%	$593	2.28
Schools/Libraries	$193.00	40%	12%	$25.00	35%	$442	2.29
Colleges/Universities	$214.91	60%	12%	$25.00	35%	$554	2.58

Notes:

1. RS Means average cost includes RS Means default location factors to adjust national average to Palo Alto of 15% for residential and 11% for commercial.
2. Soft costs include architect and engineer design fees, testing and inspection, utility connection fee, permits, and an allowance for owner change order contingency.
3. Costs are intended to be representative of average in Palo Alto across the town, including downtown areas together with other areas in the city.
4. Costs were previously prepared following a 3/7/2016 discussion with the Palo Alto Seismic Risk Program Advisory Group Technical Advisory Committee. Table includes minor updates based on internal review between

Rutherford + Chekene and Vanir Construction Management to achieve improved relative ratios between different occupancy types.

Number and Distribution of Vulnerable Buildings by Aggregate Size and Value

Table 3 shows how the number and aggregate value of Palo Alto's buildings is distributed by type of structure, using the FEMA Model Building Type classification system for structural system. The table is sorted by aggregate building value. Wood frame buildings make up about 60% of the number of buildings and represent 35% of the total value. About 20% of the buildings are concrete, and they represent over 40% of the total value. Of the remaining 20%, about two-thirds are masonry buildings, and one-third steel. However, the steel buildings represent about twice the value of the masonry buildings.

Table 3: Distribution of number of buildings, building area, and building value by Model Building Type.

Model Building Type	Number of Buildings	Aggregate Square Feet (1,000)	Aggregate Building Value ($M)
Concrete shear wall (C2)	318	9,699	4,082
Concrete tilt-up (PC1)	242	8,054	3,368
Wood frame larger residential (W1A)	331	8,403	3,232
Wood frame commercial/industrial (W2)	307	6,209	2,369
Steel braced frame (S2)	50	3,116	1,391
Wood frame smaller residential (W1)	898	3,821	1,278
Steel moment frame (S1)	75	3,005	1,242
Reinforced masonry, wood floor (RM1)	285	2,806	1,209
Reinforced masonry, concrete floor (RM2)	30	574	211
Steel light metal frame (S3)	41	533	177
Precast concrete frame (PC2)	5	334	125
Concrete moment frame (C1)	18	325	117
Steel frame with concrete shear walls (S4)	13	162	72
Unreinforced masonry bearing wall (URM)	9	274	15
Concrete with masonry infill (C3)	8	26	8
Steel frame with masonry infill (S5)	2	6	3
Totals	**2,632**	**47,346**	**18,899**

The study group of buildings can be further divided into age groups separated by significant milestones in building code implementation. The following age groups were selected: pre-1927, 1927-1961, 1962-1976, 1977-1997, and 1998 to present. The milestones reflected include the first earthquake code in Palo Alto in 1926, adoption of the 1961 Uniform Building Code (UBC) and associated more stringent design requirements, code changes in the 1976 UBC following the 1971 San Fernando Earthquake, and code changes in the 1998 UBC following the 1994 Northridge Earthquake. Figure 1 shows a histogram of the year built of the buildings in the study group.

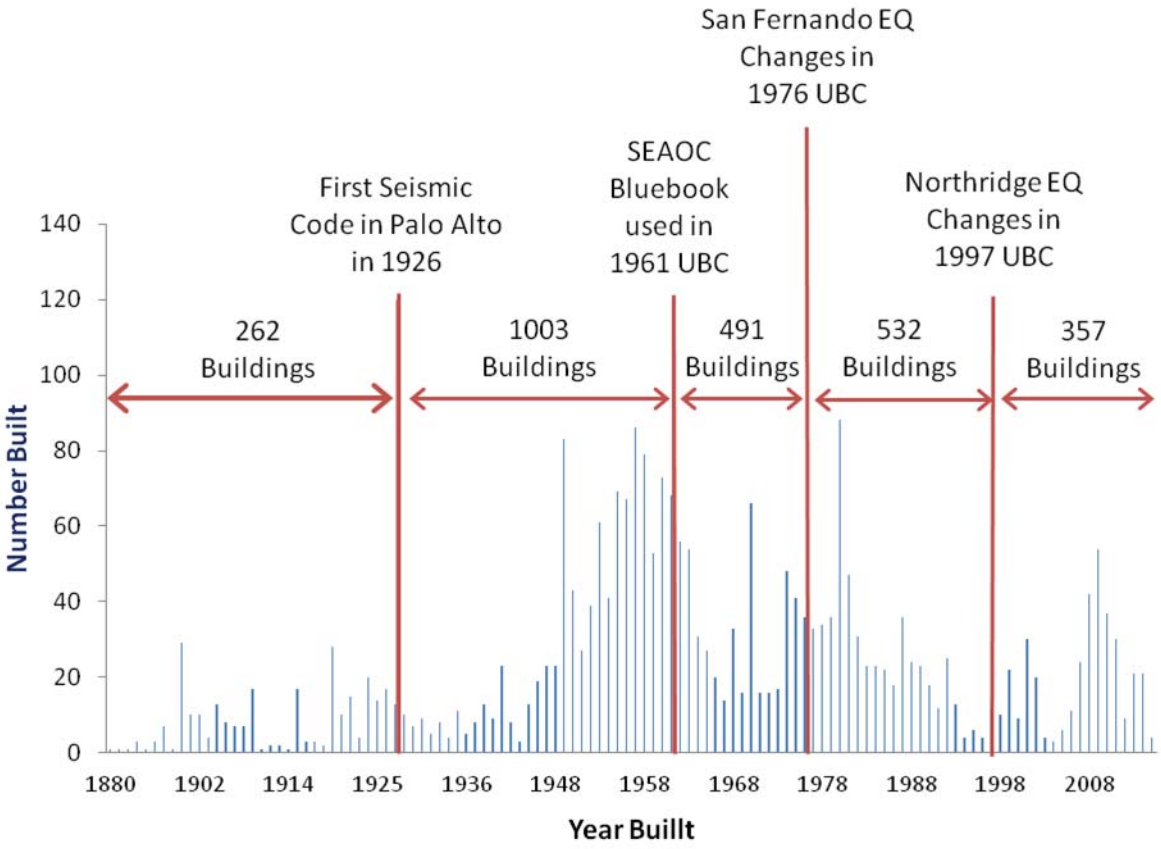


Figure 1: Distribution of year built of buildings in study group with significant changes in the building design practice.

Vulnerable Building Categories

One of the important tasks in the risk assessment study was to identify potentially vulnerable building categories specific to Palo Alto. Using the building inventory that was developed early in the project, R+C identified potentially vulnerable structural system types based on insights from past earthquake events, milestone improvements in seismic code requirements made in Palo Alto, rankings in prominent seismic risk assessment tools such as the 2015 edition of FEMA P-154 *Rapid Visual Screening of Buildings for Potential Seismic Hazards,* results from past seismic risk assessment studies in California communities, and engineering judgment. The building categories were then evaluated in analytical loss estimate studies, described ahead, which helped to narrow in on the most important categories for Palo Alto. Key building vulnerability metrics include the risk of deaths and injuries, the cost of damage, and the extent of downtime or loss of use. Buildings in the identified vulnerable building categories tend to perform poorly with respect to all three of these metrics though the relative degree of vulnerability to each factor varies.

Community Resilience

Community resilience is improved if residents have homes that remain usable after an earthquake and if businesses can still operate. From a program perspective, the consultant team and advisory group believe that the greatest reduction in losses and the largest benefit to community resilience will come from seismically retrofitting building types known to be both potentially hazardous and present in significant numbers in Palo Alto. .

In addition to the three categories already in Palo Alto's seismic hazard identification ordinance (Categories I, II, and III below), five additional categories of vulnerable building types were identified. All five categories meet the criteria of being potentially hazardous and having a significant presence in Palo Alto. The eight categories and the approximate number of buildings included in each category are as follows:

1. Category I: Constructed of unreinforced masonry, except for those small than 1,900 square feet with six or few occupants (10 remaining buildings in Palo Alto)
2. Category II: Constructed prior to January 1, 1935 containing 100 or more occupants (4 remaining buildings)
3. Category III: Constructed prior to August 1, 1976 containing 300 or more occupants (9 remaining buildings)
4. Category IV: Pre-1977 soft-story wood frame (294 buildings)
5. Category V: Pre-1998 tilt-up concrete (99 buildings)
6. Category VI: Pre-1977 concrete soft-story (37 buildings)
7. Category VII: Pre-1998 steel moment frame (35 buildings)
8. Category VIII: Other pre-1977 concrete construction (170 buildings)

The technical assessment confirms that the potential reduction in losses from retrofitting is significant for these categories.

Conceptual Seismic Retrofitting of Representative Vulnerable Buildings

Retrofit was considered for all buildings that have not already been retrofitted and were either constructed before 1961 or between 1962 and the "benchmark" year with a soft story. A "benchmark" year is when the code requirements for that building type became similar to those currently in place. Consistent with typical practice, the performance of the retrofitted buildings in an earthquake is assumed to be less than that of newly constructed buildings.

For estimating the cost of retrofit for the improved buildings, R+C developed conceptual designs for Model Building Types that represent a significant number and value of Palo Alto's building stock, as well as a significant loss and loss reduction after retrofit. This process identified wood frame (W1, W1A, W2), steel moment frame (S1), concrete shear wall (C2), concrete tilt-up (PC1), and reinforced masonry (RM1) and unreinforced masonry (URM) as appropriate candidates. For each Model Building Type, the age, square footage and number of stories were reviewed to identify a "prototype" building. In cases where the prototype building was not representative of more than two-thirds of the total number of buildings, multiple prototypes were considered.

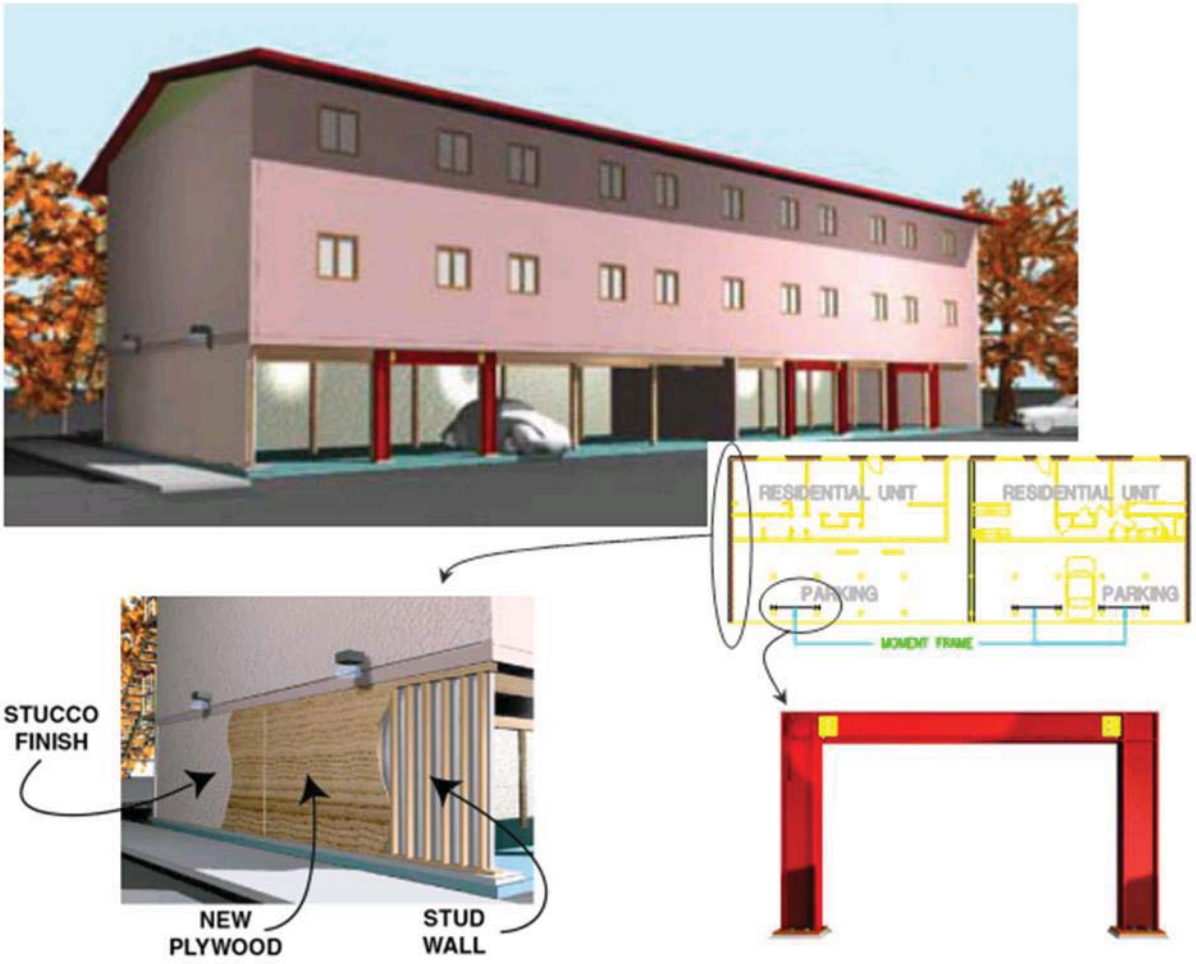


Figure 2: Retrofit scheme for Large Multi-family Soft-Story Wood Frame Building.

An example of a conceptual retrofit for the W1A prototype building is shown in Figure 2 from a 2000 brochure by R+C for the City of San Jose entitled "Practical Solutions for Improving the Seismic Performance of Buildings with Tuck-under Parking." The retrofit elements were keyed to representative details in 2006 FEMA 547 *Techniques for the Seismic*

Rehabilitation of Existing Buildings, and a written description of collateral impacts was developed as well to provide sufficient detail to allow a rough order of magnitude cost estimate to be prepared.

The cost estimators of Vanir Construction Management used the conceptual designs to estimate a range of probable cost to implement the retrofits. The retrofit costs for each prototype building are shown in Table 4. These costs include hard costs, which are the costs the owner pays the contractor, plus a design contingency since these are conceptual retrofits. The estimate further includes soft costs, representing architect and engineer design fees, testing and inspection costs, permit fees, and an owner change order contingency.

Considered costs do not include hazardous material abatement, costs associated with performing the work while occupants are using the building, triggered accessibility upgrades, cost premiums associated with retrofit of a historic building, tenant relocation or business interruption during construction, project management, renovation, financing, repair of existing conditions, and legal fees. These costs are more variable and project and site specific, and are typically not included in loss estimates for this type of study.

The retrofit costs were extrapolated to Model Building Types not represented by a prototype retrofit as shown in the fifth column of Table 4.

Additional information the conceptual retrofits and their estimate cost is contained in Attachment B.

Table 4: Conceptual retrofit cost.

Retrofit Prototype	Model Building Type	Stories	Square Feet	Used for Model Building Types	Used for Square Feet	Average Retrofit Cost ($/SF)
1	Wood frame smaller residential (W1)	2	5,320	W1	All	12
2	Wood frame larger residential (W1A)	2	9,500	W1A	< 15,000	11
3	Wood frame larger residential (W1A)	3	30,000	W1A	≥ 15,000	6
4	Wood frame commercial/industrial (W2)	2	10,000	W2	All	14
5	Steel moment frame (S1)	2	43,900	S1, S2, S3	All	10
6	Concrete shear wall (C2)	1	5,000	C1, C2, S4, PC2	< 10,000	50
7	Concrete shear wall (C2)	2	17,280	C1, C2, S4, PC2	≥ 10,000	40
8	Concrete tilt-up (PC1)	1	18,435	PC1	< 25,000	29
9	Concrete tilt-up (PC1)	2	38,400	PC1	≥ 25,000	21
10	Reinforced masonry, wood floor (RM1)	1	2,750	RM1, RM2	< 5,000	74
11	Reinforced masonry, wood floor (RM1)	2	8,150	RM1, RM2	≥ 5,000	46
12	Unreinforced masonry bearing wall (URM)	1	5,000	URM, S5, C3	All	110

Loss Estimate Findings for Current Condition

Hazus is a geographic information system (GIS) based, standardized, nationally applicable multi-hazard loss estimation methodology and software tool. It is used by local, state, and federal government officials for preparedness, emergency response, and mitigation planning. The Advanced Engineering Building Module from the latest Hazus version 3.1 was used to conduct the loss estimates in the study so that individual buildings could be analyzed using the specific inventory data collected for Palo Alto.

Analyses were conducted for two specific earthquake scenarios developed by the United States Geological Survey (USGS): a major M7.9 San Andreas Fault event, and a strong M6.7 San Andreas Fault event.

Contour plots for the short period spectral acceleration for the two M6.7 and M7.9 scenarios are shown in Figure 3. Spectral acceleration is a measure of the building response to shaking at the site.

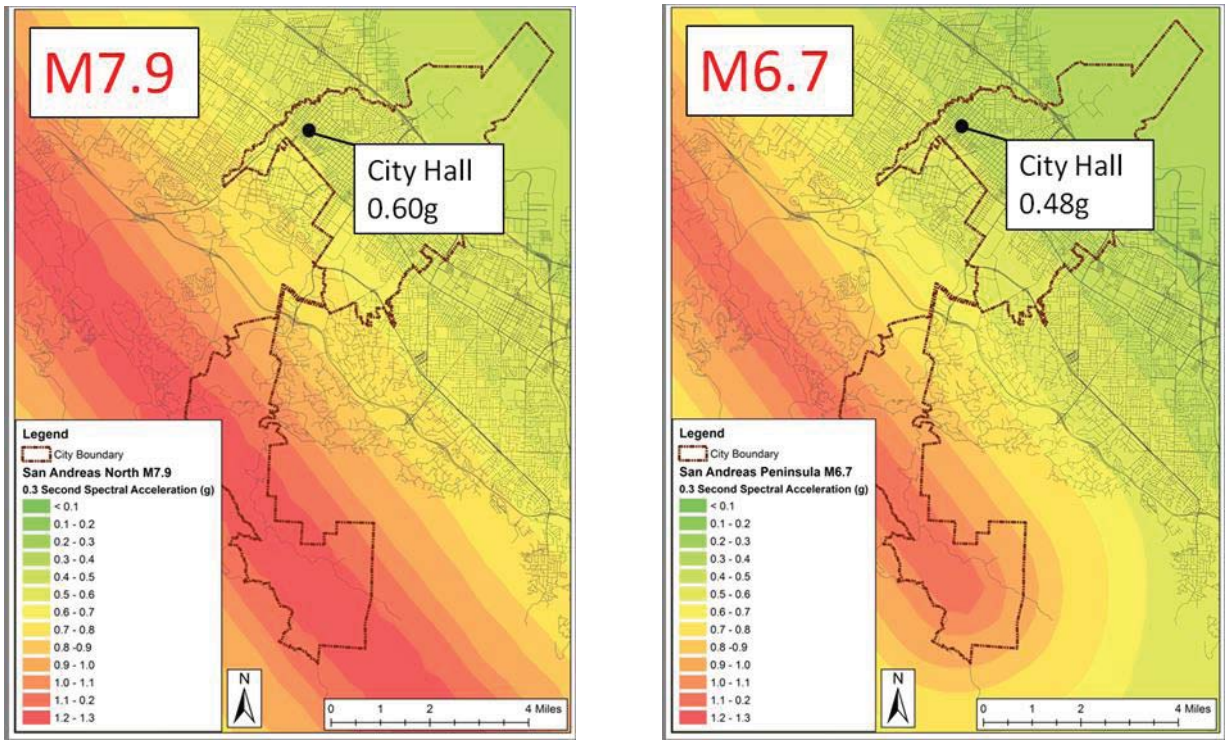


Figure 2: Predicted short period spectral acceleration in vicinity of Palo Alto (city boundary shown) for two selected San Andreas Fault scenarios.

Estimated Losses for Buildings in Their Current Condition

Table 5 summarizes the total loss calculated by Hazus for the as-is condition for the two earthquake scenarios. The results show that the estimated losses to Palo Alto buildings and contents in a M6.7 scenario will be significant, on the order of $1.2 billion. Though ground shaking in the M7.9 scenario is only about 25% larger than it is in the M6.7 scenario, overall building and content losses double to $2.4 billion. Average building damage and content damage also approximately double with a M7.9 event. The difference in the number of buildings that are heavily damaged with the larger earthquake is more pronounced with a 12-fold increase from the M6.7 to the M7.9 scenarios. This is shown in the fourth column of Table 5 as the number of buildings with a damage ratio exceeding 20%.

Table 5: Total losses for study group in as-is condition.

Earthquake Scenario	Building Value[1] ($B)	Content Value[2] ($B)	Number of Bldgs. with Damage Ratio ≥ 20%[3]	Estimated Building Damage[4] ($B)	Estimated Content Damage[4] ($B)	Total Building and Content Damage ($B)
M7.9	18.9	17.3	224	1.7	0.7	2.4
M6.7	18.9	17.3	19	0.8	0.4	1.2
Ratio of M7.9/M6.7				2	2	2

Notes:

1. Building value is the complete replacement cost for the building, and includes the structure, architectural, mechanical, electrical, and plumbing components (e.g., ceilings and lighting).
2. Content value includes the complete replacement cost of furniture and equipment that is not integral with the structure (e.g., computers and other supplies). They are estimated as a percent of structure replacement value, dependent on occupancy.
3. Damage ratio is defined as the cost of repairing damage divided by the replacement cost of the building.
4. Estimated building and content damage cost is the cost associated with repair and replacement of the building and its content.

To put the loss from building damage in context, the average annual valuation of Palo Alto construction permits was $400M between 2013 and 2016 (which represents a boom period). The total loss of $1.7B in a major M7.9 earthquake represents more than four years' worth of construction, and the total loss of $0.8B in a strong M6.7 earthquake represents more than two years' worth of construction.

It should be noted that these losses do not include the effects of lives lost and business disruption, or the ripple effects in the local economy or real estate market. Much of this loss will not be insured.

Estimated Losses by Building Type

It is important to look at multiple metrics when deciding which buildings are the most vulnerable and significant to the community as a whole. Table 6 breaks out the estimated loss and damage ratio for various model building types, and it can be seen that it depends on the metric used which building type is considered the poorest performer. Looking at the total loss alone, concrete bearing wall buildings and commercial wood frame buildings are responsible for the highest total loss. This tracks well with the earlier finding that these structural systems are the most prevalent ones. If we look at the highest average building damage ratio instead, buildings with unreinforced masonry bearing walls and unreinforced masonry infills are the most prone to damage. However, not very many of them exist in Palo Alto, and as a result they do not represent much of the aggregate loss.

Additional information on the loss estimate for the existing building stock is contained in Attachment B.

Table 6: Top three vulnerable building types ranked by total loss, average damage ratio, and number of severely damaged buildings.

Building Type	Number of Buildings	Building Value ($M)	M7.9 EQ Total Building + Content Losses ($M)	M7.9 EQ Average Building Damage Ratio	M7.9 EQ Number of Bldgs. with Damage Ratio ≥ 20%
Concrete shear wall (C2)	318	4,082	**477**	14%	75
Concrete tilt-up (PC1)	242	3,368	**365**	12%	32
Wood frame commercial/industrial (W2)	307	2,369	**216**	9%	9
Steel frame with masonry infill (S5)	2	3	1	**38%**	1
Unreinforced masonry bearing wall (URM)	9	15	4	**29%**	9
Concrete frame with masonry infill (C3)	8	8	2	**29%**	6
Concrete shear wall (C2)	318	4,082	477	14%	**75**
Concrete tilt-up (PC1)	242	3,368	365	12%	**32**
Steel moment frame (S1)	75	1,242	130	18%	**27**

Loss Estimate Findings with Buildings Retrofitted

A second Hazus AEBM run was done assuming a retrofitted building stock. For this model run, it was assumed that a building would be retrofitted if it has not already been retrofitted and was either constructed before 1961 or between 1962 and the benchmark year with a soft story. The Hazus model was rerun with the updated properties simulating retrofit.

Table 7 shows the resulting total losses and damage ratios after buildings have been retrofitted. Though total losses are still significant, comparing the results of Table 7 with Table 5 shows a reduction in total loss of 45% for the M7.9 scenario, and 33% for the M6.7 scenario. In other words, aggregate loss to the community if all considered properties were retrofit could be reduced by one third in a very plausible event and almost halved in a much larger event.

Another important improvement is the reduction of the number of buildings with more than 20% damage. The M7.9 scenario shows a reduction from 224 buildings to 6 buildings. This means that the probability of building collapse and resulting injuries and fatalities has become very low.

Finally, the damage and loss of the M7.9 scenario remain approximately two times the amount of loss sustained in the M6.7 scenario. This suggests that the retrofit has a similar impact for both levels of ground shaking.

Table 7: Total losses after retrofitting.

Earthquake Scenario	Building Value ($B)	Content Value ($B)	Estimated Building Damage ($B)	Number of Bldgs. with Damage Ratio ≥ 20%	Estimated Content Damage ($B)	Total Building & Content Damage ($B)
M7.9	18.9	17.3	0.9	6	0.5	1.3
M6.7	18.9	17.3	0.5	0	0.3	0.8
Ratio of M7.9/M6.7			2	-	2	2

Table 8 breaks out the reduction in total loss by model building type for the M7.9 scenario, and shows the associated retrofit cost. The average reduction in loss varies by building type. URM buildings showed the highest reduction in loss after retrofit as a percentage of the loss itself. Steel braced framed buildings showed the lowest reduction in losses as a percentage of the loss itself. Wood frame and concrete buildings are responsible for the largest reduction in total loss, with wood frame construction representing over 20% of the loss reduction, and concrete buildings over 50%.

It should be noted that the data in Table 8 also includes buildings that were not retrofitted. As a result, further parsing of the data is needed to better understand which buildings are responsible for the most loss, and those that can be improved more cost-effectively.

Table 8: Comparison of retrofit benefits and costs by Model Building Type.

Model Building Type	M7.9 EQ	M7.9 EQ	Average	Retrofit

	Average Damage ($/SF)	Total Damage Reduction ($1,000)	Damage Reduction ($/SF)	Cost ($/SF)
Wood frame smaller residential (W1)	16	13,775	4	12
Wood frame larger residential (W1A)	25	61,317	7	6-11
Wood frame commercial/industrial (W2)	50	160,155	26	14
Steel moment frame (S1)	62	76,150	25	10
Steel braced frame (S2)	44	24,222	8	10
Steel light metal frame (S3)	108	38,163	72	10
Steel frame with concrete shear walls (S4)	101	11,118	69	40-50
Steel frame with masonry infill (S5)	247	695	121	110
Concrete moment frame (C1)	55	8,045	25	40-50
Concrete shear wall (C2)	70	336,574	35	40-50
Concrete frame with masonry infill (C3)	120	865	34	110
Concrete tilt-up (PC1)	68	218,491	27	21-29
Precast concrete frame (PC2)	21	0	0	21-29
Reinforced masonry, wood floor (RM1)	59	87,697	31	46-74
Reinforced masonry, concrete floor (RM2)	35	3,727	6	46-74
Unreinforced Masonry Bearing Wall (URM)	23	5,216	19	110
Totals	**51**	**1,046,210**	**22**	

Table 9 shows those types of buildings that may be considered good candidates for a retrofit program. Although representing only about 15% of the total inventory, these buildings are responsible for over 30% of the total loss. This is reflected in the considerably higher than average loss (fourth column of Table 9). The benefit of retrofit is also considerable for this group of buildings, since they are responsible for over 50% of the reduction in loss. Additionally, the cost to retrofit them is only a fraction of the losses avoided in a major event, ranging from a third for the concrete buildings to a tenth for the steel frames. Note that these values are based on conceptual retrofits. Actual retrofit costs for individual buildings would vary substantially. The steel moment frame benefit-to-cost ratio is higher than expected by engineering judgment, caused in part by a comparatively low retrofit cost for this Model Building Type.

Additional information on the loss estimate for the retrofitted building stock is contained in Attachment B.

Table 9: Comparison of benefits and costs by selected Model Building Type, date and characteristics.

Model Building Type	Number of Buildings	Total SF (1,000)	M7.9 EQ Average Loss by	M7.9 EQ Average Loss	Average Cost to Retrofit	(Average Loss Avoided)

			Building ($/SF)	Avoided by Retrofit ($/SF)	($/SF)	/ (Average Retrofit Cost)
Pre-1977 wood frame soft-story (W1, W1A, W2)	294	3,690	66	46	12	4
Pre-1998 tilt-up (PC1)	99	3,078	106	71	23	3
Pre-1977 concrete soft-story (C1, C2, C3)	37	842	149	108	42	3
Pre-1998 steel moment frame (S1)	35	690	152	110	10	11

Review of Past Seismic Retrofits

To gain a better understanding of the quality of the retrofits and identify relevant issues to updating Palo Alto's seismic risk mitigation program, a sample of the submitted engineering studies and building retrofits drawings for existing buildings was reviewed.

The review identified the following relevant needs for future seismic risk mitigation programs:

A. Clear identification of retrofit design intent, scope, and limitations, also for voluntary retrofits
B. Identification of existing structural systems
C. Decision on requirements for buildings that have had partial seismic retrofits completed; and may have remaining seismic deficiencies

Additional Recommended Program Features

In addition to expansion of the building categories included within the City's seismic risk mitigation program and refinement of disclosure measures and incentive options, a number of other program features are recommended. They are described in Attachment B, and include the following:

A. *Use the current inventory, taking note of its limitations* - The inventory developed for the effort to date involved use of digital information and field surveys. A complete field survey of all buildings in Palo Alto was outside the scope of the project. However, the inventory that has been developed is an excellent resource. The first step in any future ordinance will involve notification of building owners that they may be subject to the requirements of the ordinance. Those buildings that were field surveyed and fall within the scope of the ordinance can be notified using the existing inventory. For the remaining buildings, additional field survey is recommended. This would be a rapid visual assessment and could be conducted by City staff or outside consultants.

B. *Use an initial screening form phase* - Typically, as part of the notification process, a screening form of about one page in length is sent, and the owner is required to have a design professional, such as a structural engineer or architect, complete the form. This cost for to confirm whether or not the building actually is subject to the City's ordinance should be relatively nominal.

C. *Clearly specify seismic evaluation and retrofit scope* - For all buildings subject to regulation, the seismic evaluation (and retrofit) methodology for each building category will need to be defined. Industry consensus standards exist and cover the vulnerable building categories identified for Palo Alto. These include the 2015 *International Existing Building Code (IEBC)* and 2014 ASCE 41-13 *Seismic Evaluation and Retrofit of Existing Buildings*. Both are currently being updated by groups of engineers and building officials. For soft-story wood frame buildings, there is also the 2012 FEMA P-807 *Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings with Weak First Stories.* For steel moment frame buildings, there is also the 2000 FEMA 351 *Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Moment Resisting Steel Structures*. The following table provides recommended evaluation and retrofit standards.

D. *Provide detailed evaluation report submittal requirements* - Minimum submittal requirements for evaluation reports will need to be defined. The above evaluation and retrofit standards provide some guidance but a short clear set of requirements will be beneficial.

E. *Specify how past partial retrofits will be handled: In the past, some buildings have had partial seismic retrofits where only selected portions of the seismic force-resisting system have been upgraded; Some seismic deficiencies may still exist in these structures. If mandatory retrofit requirements are implemented that provide for comprehensive retrofitting of the full seismic load path, there may be buildings with previous partial retrofits that do not fully comply and need remaining deficiencies to*

be addressed. The seismic evaluation reports will help identify these cases.

F. *Update both new and existing building permit submittal requirements: Review of City records found that basic information such as the building structural system, date of construction, and retrofit standard used (where applicable) are not readily available. It is recommended that submittals for permit for both new buildings and existing building renovations require this information. This will allow the city to have a much better understanding of its total building stock and its expected performance in an earthquake.*

G. *Write a new ordinance or set of ordinances to update the program: After the Council has provided direction and the above issues have been addressed, an updated ordinance will need to be written.*

H. *Carefully address program management and interdepartmental coordination needs: To successfully manage Palo Alto's updated Seismic Risk Mitigation Program, an effective management plan is needed so that progress is monitored by the City and community intent is achieved.*

I. *Delineate department and key staff responsibilities: For Palo Alto's updated Seismic Risk Mitigation Program, City staff will be responsible for several categories of activities. These will include the basic activities such as managing the notification and inventory process, reviewing evaluation reports and plan checking retrofit construction documents, and field inspections of retrofit work. Less obvious activities will include evaluating requested exceptions to the program or alternative means of compliance; managing feedback from design professionals, owners, and the public; tying pre-earthquake retrofitting to post-earthquake safety evaluations records; and managing post-earthquake safety evaluation, repair, and recovery plans. Depending on the scale of the updated program, it is possible that additional staff members, consultants, and/or an appropriately experienced structural engineer may be needed to provide advice on technical and program management issues, particularly as the program moves to final definition and to initial implementation. Later, as is done in some communities, it may be desirable to create volunteer review boards of local structural engineers who review questions on the evaluation and retrofit criteria and provide the City with technical opinions that staff can use.*

Table 10: Recommended Evaluation and Retrofit Standards.

Category	Description	Evaluation and Retrofit Standards
I	Unreinforced masonry	IEBC Appendix Chapter A1
II	Built before 1/1/35 with 100 or more occupants	ASCE 41
III	Built before 8/1/76 with 300 or more occupants	ASCE 41
IV	Pre-1977 soft-story wood frame	IEBC Appendix Chapter A4, ASCE 41, or FEMA P-807
V	Pre-1998 tilt-up	IEBC Appendix Chapter A2 and ASCE 41
VI	Pre-1977 soft-story concrete	ASCE 41
VII	Pre-1998 steel moment frame	ASCE 41, or FEMA 351
VIII	Other pre-1977 concrete	ASCE 41

ADVISORY GROUP INPUT

Summary Report of the Advisory Group

The purpose of convening an Advisory Group composed of members with local expertise and construction experience was not to create a consensus document or ratify particular recommendations by majority vote. Instead, the goal was to educate, solicit, and explore the range of issues and opinions among interested parties who participated. A summary report, reviewed by all the members of the Group, was prepared to document their input in to the study (Attachment G). The Advisory Group was a first step in community engagement regarding seismic hazard reduction in Palo Alto. It was intended that the information in the Advisory Group's summary memo would be provided to the City Council as they consider potential revisions to the City of Palo Alto's seismic risk management program and seismic hazard identification ordinance.

Preferred Policy Directions

In summary, discussions with the Advisory Group revealed little to no support for maintaining the status quo. Strong support did exist for retrofitting buildings already in the program, particularly URM buildings, and for addressing more building types, particularly soft-story wood frame buildings and older concrete tilt-ups.

For buildings addressed in the current ordinance, the group generally thought a mandatory retrofit requirement would be feasible and fair. Three decades later, market forces alone have clearly not been enough to motivate upgrade of these remaining structures. Because the barriers to retrofit work for these properties are not known, case-by-case management by City staff may be necessary. There was hesitance, however, about extending or increasing incentives for owners that had not voluntarily taken advantage of the FAR bonus available in the past.

More detailed conversations took place about other building category priorities and

policy features focused on extending the vulnerable building types they addressed and the requirements for retrofit compliance. These program alternatives are incorporated into Options 3, 4, and 5 (see the "Survey of State and Local Seismic Policies" section). The Advisory Group was briefed on structural types generally known to be vulnerable that are common or significant to Palo Alto and estimated to have reasonable loss reduction to retrofit cost ratios. The Group's goal was to focus on a subset of categories that seemed to have high potential to benefit the owner, occupants, and the broader community. Some participants showed greater concern about residential properties, and debated whether commercial and residential properties should be treated the same or differently.

The Advisory Group showed high interest in addressing multi-family residential earthquake risks, in particular by starting a soft-story wood frame program as many other California cities have done. One soft-story wood frame program approach discussed was to have two phases: 1) owners following notification would be given several years to do a voluntary retrofit, along with more generous incentives; and 2) later a mandatory timeline would kick in and incentives would be phased out. The group noted that exemptions such as parking requirements, permission to add other unit(s), or the ability to transfer development rights for additional square footage would likely be attractive and useful incentives for the multi-family soft story building type.

Other vulnerable building categories of concern were also reviewed, including pre-1977 tilt-up concrete structures. There are a modest number of these buildings in Palo Alto, but Advisory Group members noted that their uses are changing. Many buildings previously used as warehouses are now being repurposed for office space. The higher occupancies increase the public safety stakes of any seismic deficiencies. Currently, there is no mandate in the regulations to address earthquake vulnerabilities while other upgrades and build out are being done to these structures. A substantial renovation trigger mandate might make sense, but the percent of the value of the structure used as a trigger might need to be lowered in order to get compliance. Such properties with more than one story should perhaps receive higher priority for retrofit.

Potential Issues for Future Study and Consideration

For some issues, based in part on Advisory Group discussions, additional information may be beneficial to help develop a strategy and to better understand potential impacts on key stakeholders and community concerns. Some of these issues are primarily economic and were outside the scope of the current study. The City Council may wish to direct staff and/or outside consultants to investigate some of these items in more detail as the seismic risk management program effort proceeds. These issues include the following:

A. *Occupants and tenants*
    a. How much would a typical retrofit add to the monthly rent of a multifamily

soft-story wood frame apartment tenant?

b. Would some tenants be unable to afford a rent increase and seek housing elsewhere in Palo Alto or move outside the city (and if so, how many might be displaced)?
c. If soft-story wood frame apartments in Palo Alto are retrofitted in time before the next major earthquake, how much less displacement of residents would occur as a result of the earthquake?
d. What categories of buildings are most important to address in order to help maintain the commercial viability and vitality of the City's core business districts and tax base?

B. *Property owners, developers, and business owners*
   a. What are the characteristics of property owners that would be affected?
   b. How might small businesses be affected compared to larger ones?
   c. How many property owners are in need of lower cost capital or other substantial financial assistance to fund retrofitting?

C. *Impacts of Seismic Restoration on Retention of Historic Structures in the City*
   a. How can we ensure that the review of initial seismic evaluations identify those structures that are listed in the City's Historic Inventory or potentially significant and flag them for attention during subsequent review?
   b. How can we develop a clear process for reviewing proposed seismic retrofits to historic structures that is coordinated among responsible city departments and is consistent with current regulations and Community policies?
   c. How can we ensure that property owners take advantage of Seek out retrofit alternatives that are consistent with the Historic Building Code, historic characteristics of the structure, and provide the required most risk reduction?

D. *City departmental resources and budgets*
   a. What would be the loss in revenue to the Building Department if fee waivers were offered?
   b. What would be the staffing and budgetary needs over time to administer an expanded program that addresses additional building types?
   c. What kinds of interdepartmental cooperation and staff resources in other departments are necessary to ensure effective implementation and coordination with other city planning and public safety efforts?
   d. What would be the costs to provide and administer any incentives offered to property owners?

E. *Overall community economic health*
   a. What kind of benefits could accrue to Palo Alto in terms of maintaining community function and ability to recover if various building categories are retrofitted in time before the next major earthquake?

F. *Other related issues*

a. It was brought up in the Advisory Group that the Building Department needs flexibility and authority to take steps to get tough seismic mitigation projects done. One idea was to grant the Building Official the ability to classify certain projects (with well-specified criteria) as warranting a kind of "seismic safety" or "earthquake resilience" fast tracking, with city departments agreeing to coordinate on a specified accelerated project review timeframe.
b. Although outside the formal scope of this planning effort, several Advisory Group members commented that it would be desirable for the City to do some kind of assessment of any earthquake mitigation needs in public buildings and facilities serving the City.
c. Advisory group members recommended the community be informed of Palo Alto's overall potential seismic risk by providing a summary of potential impacts on the City's website, including the expected performance of vulnerable buildings.
d. The group also had a high degree of support for recommending that the City initiate and nest future earthquake mitigation programs within a broader disaster or community resilience initiative, as cities such as Los Angeles, Berkeley, and San Francisco have done. This could be incorporated into the update of the City's Comprehensive Plan Safety Element. There was insufficient time in the project's six advisory group meetings to consider potential initiatives to assess risks for cell phone towers, water supply, facades, private schools, post-earthquake shelter facilities, and/or other assets important to community recovery.

TIMELINE

The timeline for updating the current seismic mitigation regulation is dependent on Council's review of the Seismic Risk Assessment Study and directions to staff.

RESOURCE IMPACT

Implementation of the report recommendations would result in additional costs to private property owners and prior to any decision to proceed, staff is proposing additional public outreach at a cost of about $50,000. Technical requirements and design guidelines to support a new ordinance would require additional consultant services at an estimated cost of $50,000. If desired, an analysis of the fiscal impact on residents and business could be prepared for an additional $50,000. Any incentives offered to building owners could also have a cost to the City, which would not be known until those incentives are further defined.

ENVIRONMENTAL REVIEW

The preparation of the Seismic Risk Assessment Study is exempt from environmental review under the California Environmental Quality Act (CEQA) Guidelines Section 15306 (Information collection leading to an action which a public agency has not yet approved, adopted, or funded).

TABLE OF CONTENTS FOR ATTACHMENTS

A. Palo Alto Municipal Code, Chapter 16.42: Seismic Hazards Identification Program
B. Seismic Risk Assessment Study. The study includes the following items.
    a. Legislative Review Report
    b. Local Program Best Practices Assessment
    c. Building Inventory for Loss Estimate
    d. Conceptual Seismic Retrofits and Cost Estimate
    e. Loss Estimate of Existing Building Stock
    f. Loss Estimate of Retrofitted Building Stock
    g. Review of Past Retrofits
    h. Additional Recommended Program Features
C. Threat and Hazard Identification and Risk Assessment (August 2014)
D. Policy and Services Committee Staff Report 5293, Discussion of Updating the Seismic Safety Chapter of the Municipal Code for Hazardous Buildings (December 9, 2014)
E. Palo Alto Municipal Code, Chapter 18.18: Downtown Commercial (CD) District
F. Seismic Risk Management Program Advisory Group Members
G. Seismic Risk Management Program Advisory Group Summary Report on Process, Discussions, and Outcomes (November 21, 2016)
H. Advisory Group Meeting Minutes, Presentations and Handouts (contained at the Seismic Risk Management Advisory Group website at <http://www.cityofpaloalto.org/gov/depts/ds/srmag.asp>

Attachments:

- Attachments
- Attachment_A_-_PAMC_16.42_Seismic_Hazards_ID_Prgm[1]
- Attachment_B_-_Palo_Alto_Seismic_Risk_Assessment_Study_-_Final_Report_-_2016_12_21[1]
- Attachment_C_-_Palo_Alto_Threats_Hazards_Risk_Assessment_(August_2014.1)[1]
- Attachment_D_-_Policy_and_Services_Staff_Report_5293[1]
- Attachment_E_-_PAMC_18.18_CD_District[1]
- Attachment_F_-_Seismic_Risk_Management_Program_Advisory_Committee_Members_01.15.16[1]
- Attachment_G_-_Palo_Alto_Seismic_Risk_Mgt_Prog_AG_Summary_Rev_2016_11_21[1]
- Attachment_H_-_SRMP_Advisory_Group_Agenda-Minutes-Presentations-Handouts[1]

Attachment F

Final Report

Seismic Risk Assessment Study

Palo Alto, California



21 December 2016
#2015-087S

Rutherford + Chekene
375 Beale Street, Suite 310
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Attachment F

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CHAPTER I.

INTRODUCTION

In 1986, the City of Palo Alto was one of the first cities in California to establish a comprehensive seismic mitigation program. It covers unreinforced masonry buildings, buildings built before 1935 with over 100 occupants, and buildings built before August 1, 1976 with over 300 occupants. After 30 years, 75% of the 89 buildings included in the program have been demolished or retrofitted. The 2014 South Napa Earthquake spurred the City to reevaluate its program. They engaged a team led by Rutherford + Chekene (R+C) to perform a comprehensive assessment of the expected performance of the City's building stock in potential earthquakes, and started a community engagement effort to help identify resiliency goals and associated mitigation policies and programs. The R+C project team includes Sharyl Rabinovici, a public policy and community engagement specialist; Hope Seligson (initially with MMI Engineering and now Seligson Consulting) for loss estimating; and Vanir Construction Management for cost estimation of building replacement cost and retrofitting.

The technical assessment covered over 2,500 buildings (single family and two-family residences were excluded) with a wide array of potentially vulnerable structural systems. The findings show that the estimated losses to Palo Alto buildings and contents in a M7.9 scenario event will be significant, on the order of $2.4 billion. Furthermore, this figure does not include business disruption, or ripple effects in the local economy or real estate market, nor does it include the economic value of loss of life. Among the categories of highest concern are pre-1977 "soft-story" wood frame, pre-1978 tilt-up concrete, pre-1977 cast-in-place concrete construction, and pre-1998 steel moment frames. The technical assessment revealed that the potential reduction in losses from retrofitting these buildings is over $1 billion in a M7.9 scenario event.

R+C's scope included a series of tasks and associated task reports and presentations. These included the following:

- A survey of state and local seismic policies and best practices;
- Development of a building inventory for Palo Alto using digital information and field surveys;
- Assignment of costs to buildings and contents in the inventory;

- Description of vulnerable building categories, including five additional categories not covered under the current ordinance;
- Conceptual seismic retrofitting of representative vulnerable buildings;
- Loss estimate findings in a major seismic event for the current condition and after retrofitting;
- Review of past seismic retrofits; and
- Discussion of additional recommended program features.

These task reports and presentation information have been compiled to form this Seismic Risk Assessment Study. Each chapter in the study addresses one or more of the project task efforts. Appendices provide additional details for selected tasks.

A Seismic Risk Management Advisory Group made up of community and industry stakeholders and City staff was appointed and was also an essential component of the overall project. The Advisory Group insured that local building experience and community priorities were considered as the study moved forward. The group met six times with City staff and the R+C team over a period of nine months. The Advisory Group was introduced to the findings regarding the community's earthquake vulnerability, impacts on vulnerable building types, as well as the 'best practices' used by other communities to promote community wide welfare and to encourage seismic retrofit of various vulnerable buildings types. The Advisory Group then discussed the assessment findings and formulated potential directions for City of Palo Alto leaders to consider going forward in updating the City's seismic mitigation programs. At the end of the Advisory Group process, a summary memo, reviewed by all members of the Group, was prepared to document their input to the study. The November 21, 2016 memo is entitled "Seismic Risk Management Program Advisory Group Summary Report on Process, Discussions, and Outcomes."

The following table summarizes the outcome of the seismic risk assessment and includes the Advisory Group discussions. The table is organized around eight vulnerable building categories or building types. Categories I, II and III encompass the identified vulnerable buildings for the 1986 ordinance and are primarily located in the downtown commercial district. Categories IV through VIII include additional buildings at risk, as identified in the Seismic Risk Assessment Study. These buildings are located throughout the city.

There was little to no support for maintaining the status quo within the Advisory Group. As shown in the following table, the Advisory Group favored requiring property-owner prepared seismic evaluation reports for all categories, except for Category VIII (other older nonductile concrete buildings). They also favored mandatory retrofit for the remaining Category I unreinforced masonry buildings identified

in the 1986 ordinance that have not been seismically retrofitted or demolished. For the Category II and III buildings in the current ordinance, retrofit should be required when a certain event or "trigger" occurs such as when a substantial renovation occurs or the property is put up for sale. Among the new vulnerable building types, the greatest concern was expressed for soft-story wood frame buildings and older concrete tilt-up buildings. The Advisory Group thought that retrofit of these structures should be either mandatory or triggered by substantial renovation or sale. The Advisory Group was concerned about delay in the retrofit of these structures given the number of the vulnerable buildings, the number of people who could be affected should the buildings be significantly damaged, and the considerable cost to the community if the structures in these categories were lost because of an earthquake. The Advisory Group considered a timeline of 2-4 years for the mandatory evaluation report and 4-8 years to complete mandatory retrofit construction. The Advisory Group supported increasing disclosure measures on building status through website listing and tenant notification. They also suggested that the most beneficial financial and policy incentives to encourage compliance with the new requirements would be fee waivers, expedited permitting, and property-assessed financing tools.

Following the preparation of the Advisory Group summary, R+C assisted City staff in preparing a staff memo for an upcoming City Council meeting. It includes more detailed recommendations to the Council on proposed revisions to the City's seismic hazard mitigation ordinance and recommends that the Council provide direction to City staff on revising and expanding the City's building code and related ordinances.

Summary of Recommended Policy Directions from the Seismic Risk Management Program Advisory Group

Category	Approx. Number	Building Type	Date of Construction	Occupants	Evaluation Report	Voluntary, Triggered, or Mandatory Retrofit[1]	Deadlines for Evaluation Report and Retrofit Construction (years)[2]	Disclosure	Potential Incentives
Current Program (Potential Revision in *Italics*)									
I	10	Un-reinforced masonry	NA	Over 6 (and over 1,900 sf)	Required	*Mandatory*	Report: Expired Construction: *2-4*	*Website listing and tenant notification*	*Fee waiver, expedited permitting, FAR bonus/ transfer of development rights (TDR)*
II	4	Any	Before 1/1/35	Over 100	Required	Voluntary *or Triggered*	Report: Expired Construction • Voluntary: Not required • *Triggered: At sale or renovation*		
III	9	Any	Before 8/1/76	Over 300	Required	Voluntary *or Triggered*			
Expanded Program									
IV	294	Soft-story wood frame	Before 1977	Any	Required	Triggered or Mandatory	Report: 2-4 Construction • Triggered: At sale or renovation • Mandatory: 4-6	Same as above	Fee waiver, expedited permitting, TDR, parking exemptions, permission to add units
V	99	Tilt-up	Before 1998	Any	Required	Triggered or Mandatory	Report: 2-4 Construction • Triggered: At sale or renovation • Mandatory: 4-6	Same as above	Same as Categories I, II and III
VI	37	Soft-story concrete	Before 1977	Any	Required	Voluntary, Triggered or Mandatory	Report: 2-4 Construction • Voluntary: Not required • Triggered: At sale or renovation • Mandatory: 6-8	Same as above	Same as Categories I, II and III
VII	35	Steel moment frame	Before 1998	Any	Required	Voluntary, Triggered or Mandatory			
VIII	TBD	Other older nonductile concrete	Before 1977	Any	Not rec. at this time	Not recommended at this time	Report: NA Construction: NA	NA	NA

[1]Voluntary: Retrofit is voluntary.
Triggered: Retrofit is triggered when the building is sold or undergoes substantial renovation.
Mandatory: Retrofit is required per a fixed timeline.

[2]Deadlines provide a potential range. Timelines would vary depending on tiers or priority groupings of different subcategories.

CHAPTER II.

LEGISLATIVE REVIEW REPORT

Executive Summary

This chapter summarizes the seismic risk management policy context within the state of California to support Palo Alto's current effort to update its program. The report was prepared per Task 2 of the Consulting Agreement between Rutherford + Chekene and the City of Palo Alto, dated August 17, 2015. The scope of Task 2 is to:

- Review existing and pending State legislation related to soft-story buildings and other seismically vulnerable buildings and provide a brief summary.
- Provide a concise review of relevant and pending state legislation, with a summary that can be presented at community and staff meetings or in reports to Council.

The process of creating this legislative review included searches of legislative data bases, search and review of published and online reports and materials, several phone interviews with leaders in the engineering profession as well as local and state government staff, and development of insights from the consulting team based on their experiences in this arena.

High level findings include the following:

- **Palo Alto is affected by numerous relevant California existing laws and regulations dating from the 1930s through the present.** These laws regulate many aspects of Palo Alto's built environment, including certain classes of building uses such as hospitals, public schools, and essential facilities; setting code minimums for new construction; and mandating land use planning and real estate disclosure measures for natural hazards including earthquakes. Unreinforced masonry (URM) is at present the only *structural system type* for which the state requires local jurisdictions to have a program.
- **If it so chooses, Palo Alto has wide authority to expand or strengthen its approaches to seismic mitigation.** The power to do more about earthquake vulnerabilities is primarily in the hands of the local jurisdictions that have significant discretion in the kinds of policies they can adopt.

- **Palo Alto has many additional actions it can take to make sure it is complying and taking greatest possible advantage of state level regulations and opportunities.** In particular, opportunities exist now to align a new seismic program with two ongoing mandated planning efforts the City is already engaged in: Palo Alto's General Plan and its Local Hazard Mitigation Plan.

Based on what state laws allow and in some cases recommend, many broad policy directions exist for Palo Alto going forward in terms of updating its seismic mitigation program. For example, Palo Alto could choose to:

(1) implement measures to increase the effectiveness of its current program, for instance by offering additional or larger incentives or devoting more resources to program visibility and implementation;

(2) expand the City's current voluntary seismic mitigation programs to address additional building types or uses;

(3) add mandatory screening or evaluation measures for one or more vulnerable building types such as soft-story buildings or older concrete structures;

(4) upgrade the City's current voluntary URM program to make retrofitting mandatory;

(5) create a program that mandates seismic retrofits for one or more additional (non-URM) vulnerable building types;

(6) craft a program that combines any or all of the above measures. Local precedents for all these types of approaches exist and are described and discussed in a separate Task 3 report; or,

(7) continue the status quo current program.

Although formally outside the scope of the current effort, Palo Alto also has additional opportunities for strengthening and expanding its earthquake-related efforts in terms of land use planning, public education and awareness, and small residential structures, such as:

(8) develop partnerships with the private and non-profit sectors to promote insurance take up and business continuity planning; and,

(9) devote more resources to increasing awareness among its citizens about low cost or free ways to become more aware and prepared for disasters more broadly.

Ultimately, the recommended policy directions and action steps for Palo Alto will be informed by related efforts in this project to analyze the most current vulnerability information available, and later determined through an inclusive decisionmaking process going forward.

1. INTRODUCTION

This report surveys the public policy landscape in the state of California related to earthquake mitigation and describes each policy or program's relevance for Palo Alto and similar jurisdictions. The scope is intentionally broad so that it can serve as a primer or look-up resource for persons with varied levels of background knowledge about the topic. Section 2 organizes information about the reviewed policies, programs, and institutions based on the type of policy or program. These range from building codes and mitigation mandates to educational efforts and tax-based loan financing strategies.

Section 3 briefly provides information about current State level policy leadership and the small amount of earthquake-related recent and proposed legislation. Section 4 presents options for Palo Alto through a summary of the review's findings. Appendices A and B to this report provide detailed tables of current and pending or recent legislative proposals, respectively.

The process of creating this Legislative Review included searches of the California's *LegInfo* database,[1] search and review of published and online reports and materials, several phone interviews with state and engineering profession leaders, and development of insights from the consulting team based on their experiences in this arena. This review covered over 50 related individual existing laws or passed referenda, in addition to the state's Existing and Historic Building Code provisions.

2. CURRENT CALIFORNIA SEISMIC-RELATED BUILDING CODES, LEGISLATION, AND KEY INSTITUTIONS

This section presents legislation and programs in narrative format to address interrelationships among these laws and to present broader implications for Palo Alto. Relevant laws and programs related to Palo Alto's obligations and opportunities regarding earthquake mitigation are categorized by type and how each works. Specific laws referenced are shown in bold. The accompanying table in Appendix A lists the identified relevant current state legislation organized by year established.

State laws related to seismic safety can be categorized as relating to building codes, targeting of existing building types or uses, land use planning, real estate practice requirements, and financial policies such as the tax code, insurance, and incentives.

[1] http://www.leginfo.ca.gov (Accessed January 13, 2016).

Building Codes

New construction in Palo Alto is governed by the **California Building Code (CBC)** that is updated every three years. Updates are adopted by the City Council. The International Building Code (IBC) is the underlying model code on which the provisions of the CBC are based. Legally, every local jurisdiction in California is required to adopt the state building code and to enforce that code. Above and beyond the minimums of the CBC, each jurisdiction has flexibility if justified by local climatic, geological (including seismic), and topographical conditions. Several jurisdictions have done that as part of their seismic mitigation programs, as detailed later and in Chapter III.

Standards for rehabilitation, renovation, repairs, retrofits, or additions to existing structures exist in Chapter 34 of the CBC. The International Existing Building Code (IEBC) provides additional specific methodologies that jurisdictions may decide to adopt in whole or in reference to particular sections.

The City of Palo Alto has its own Historic Building Inventory of hundreds of buildings as well as several Historic Districts and both state and federally designated historic properties. Therefore, the **State Historical Building Code**[2] is also relevant, as administered by the Division of the State Architect (DSA) under the Department of General Services. Officially designated historic structures are subject to different rules for rehabilitation which are generally more flexible and permissive than those in Chapter 34 of the CBC. Local jurisdictions can specify enhancements for seismic reasons as long as the justifications and nature of such changes are fully public and documented on record with the State Historical Building Safety Board.[3] A detailed list of key provisions is given on the DSA website[4].

Targeted Building Types

Unreinforced Masonry (URM)

Inventories of specific building types have formed the backbone of California seismic policy towards existing buildings since at least the 1930s, but it was the **1986 Unreinforced Masonry (URM) Law** that firmly established the precedent of using inventories to promote retrofits of existing seismically vulnerable buildings. Through this policy, in Section 8875 of the California Government Code, the State Legislature required all 366 local governments in Seismic Zone 4 (the highest hazard level) to inventory their URM buildings, establish some kind of loss-

[2] Health and Safety Code, Division 13, Part 2.7, §18950-18961.

[3] "Each local agency may make changes or modifications in the requirements contained in the California Historical Building Code, as described in Section 18944.7, as it determines are reasonably necessary because of local climatic, geological, seismic, and topographical conditions. The local agency shall make an express finding that the modifications or changes are needed, and the finding shall be available as a public record. A copy of the finding and change or modification shall be filed with the State Historical Building Safety Board. No modification or change shall become effective or operative for any purpose until the finding and modification or change has been filed with the board." [Health and Safety Code §18959.f.]

[4] http://www.dgs.ca.gov/dsa/AboutUs/shbsb/shbsb_health_safety.aspx (Accessed January 23, 2016).

reduction or remediation program within four years, and report progress to the California Seismic Safety Commission (CSSC).

Each county or municipality was allowed to design its own program. In general, three main types of local programs were utilized: 1) mandatory retrofit, 2) voluntary retrofit, and 3) notice to owners that the structure is a URM building. When retrofits were encouraged or required, the local government set the standards to be met. Palo Alto already had an inventory and program in place for URMs at the time the law was passed, and thus it was mainly subject to the reporting requirements.

Mandatory signage was later required and is another controversial aspect of the State's approach to URM buildings. Section 8875.8 of the Government Code increased enforcement efforts on the requirement for warning placards to be posted at the entrances to un-retrofitted URM buildings. In 2006, URM building owners had posted 758 signs (see Figure 1 for required text); almost all jurisdictions report the signage had no noticeable effects (CSSC, Status of the Unreinforced Masonry Building Law, 2006).

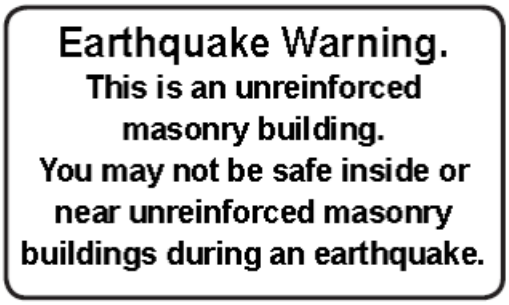


Figure 1: URM sign example text.

Reviews of the URM Law by the CSSC have shown it to be a success over the long term. In 2006 (the last comprehensive state survey available), compliance with the policy was 93%, and over 70% of identified URM buildings have been either retrofitted or demolished (CSSC, Status of the Unreinforced Masonry Building Law, 2006). More than half (52%) of affected jurisdictions adopted a mandatory program, which has proven by far to be the most effective type. Eighty-seven percent of identified properties have been retrofitted or demolished in jurisdictions with mandatory programs, compared to thirteen to 25 percent in jurisdictions with other program types.

Some of the URM law's influences are subtler. The state URM law is credited with creating greater awareness among community leaders and increasing practical experience and capacity to address seismic policy implementation in local jurisdictions. It set the precedent of preserving "local choice" in how to address the problems of seismically-vulnerable existing buildings. This law also brought some public attention to the issue, through exposure to warning signs at building entrances. In jurisdictions with highly effective programs, the URM law likely set the stage for greater willingness to adopt stronger, more proactive approaches for other building types.

Targeted Building Uses

Hospitals

Palo Alto is host to at least two major hospitals, the Palo Alto Veteran's Administration Hospital and the Lucile Packard Children's Hospital, as well as a number of urgent care clinics and other health care facilities, for instance related to Stanford Hospital. State-mandated seismic minimums and upgrade requirements for hospitals were put in place in 1973 through **SB 1953** and periodically amended since. The Office of Statewide Health Planning & Development (OSHPD) develops guidelines, administers the program, and oversees compliance.

Extraordinary resources have been spent to upgrade and develop new hospitals in response to SB1953, resulting in major improvements to both seismic safety and in patient care (OSHPD, 2005). However, progress has been slower than hoped, in part because of the costs of achieving the high levels of performance that the law demands but also because of program complexity and organizational difficulties in managing upgrade programs. A comprehensive study of SB 1953 implementation showed that even organizational leaders highly motivated to reduce risk in the context of strict mandates were not always able to achieve timely progress (Alesch, 2012).

Public Schools

Following the 1933 Long Beach quake that rendered over 230 Southern California schools unsafe, the Field Act was passed to require higher seismic design minimums in new public school construction. The **1939 Garrison Act** required school districts to retrofit or replace pre-Field Act schools. However, many schools did not comply until the mid-1970s.The Division of the State Architect (DSA) oversees this program, and since 2002 has done tracking via the "AB

300 List." [5] Further detail about Field Act implementation statewide can be found in formal state reports (See, e.g., CSSC, 2009).

The status of approximately six Palo Alto area schools that have buildings on the "AB 300 List," could be relevant to future policy development efforts depending on the extent to which the city relies on schools in its emergency response plans. Functioning schools are also known to play a large role in resumption of local business activity as part of recovery.

Essential Services Buildings

State law recognizes that buildings that house mission-critical jurisdictional services and administrative functions should be safe and functional after a major local event. Palo Alto is required by the **California Essential Services Building Seismic Safety Act of 1986** to follow enhanced regulations during the design, rehabilitation, and construction of essential service facilities, defined as fire stations, police, California Highway Patrol, or sheriff offices, or any buildings used in part or whole to conduct emergency communications and operations. As with hospitals, the DSA develops and maintains the design and construction requirements and tracks compliance for this law.

Land Use, Zoning, and Real Estate Disclosure Requirements

General Plan Requirements

According to the **State Planning and Zoning Law**, Palo Alto and other California jurisdictions have been required since 1971 to address earthquake vulnerabilities in their General Plans, currently in the Safety Element.[6] The Governor's Office of Planning and Research (OPR) provides General Plan Guidelines for what jurisdictions must do in creating and implementing their plans, mostly recently in 2011.[7] Typical earthquake-related provisions focus on avoiding development in hazardous areas (for instance near known faults) and adoption of zoning and use requirements that can reduce hazards (such as creation of retention and recharge basins to lessen the impacts of storms).

Palo Alto's last General Plan was adopted over ten years ago. Since 2008, staff have been reviewing and updating different elements in turn. An analysis should be undertaken of any relevant earthquake hazard-related aspects in it, and care should be taken to align and integrate future mitigation program efforts with the City's updated General Plan, which is

[5] http://www.documents.dgs.ca.gov/dsa/ab300/AB_300_List.pdf (Accessed January 23, 2016). List described as up to date as of Thursday, September 10, 2015.

[6] Government Code §65300-65303.4.

[7] https://www.opr.ca.gov/docs/complete_pzd_2011.pdf (Accessed, March 6, 2016).

currently in development. As of 2016, Palo Alto is working on a comprehensive update to be in effect through 2020 to 2030. More detail is available on a city website designed specifically as part of a highly engaged community involvement process.[8]

Zoning

Palo Alto is on the list of California cities that contain some areas designated by the state as an "Earthquake Fault Zone" (Hart, 2010). The California Geological Survey (CGS) under the California Department of Conservation (DOC) oversees implementation of the **Alquist-Priolo Earthquake Fault Zoning Act of 1972**, a particularly important legacy policy in understanding California earthquake risk management policy. The CGS regularly conducts and updates studies that identify active faults. Buildings within an "Earthquake Fault Zone" face additional planning, use, and disclosure obligations. Additionally, the **1990 Hazards Mapping Act** gave DOC responsibility for mapping areas prone to liquefaction, earthquake-induced landslides, and amplified ground shaking. Within these mapped Zones of Required Investigation, geotechnical investigations to identify hazards and formulate mitigation measures are required before permitting most development.

Small Residential Real Estate Mandates and Disclosures

All sellers of real property in Palo Alto are required to disclose certain facts about the building location and its condition related to earthquake hazards. These requirements began with the **Natural Hazards Disclosure Act of 1990**, which has detailed provisions for what sellers of real property are obligated to do and what kinds of information they must provide prior to point of sale. Requirements are more extensive when the property being sold lies within one or more of the state-mapped hazard areas, including landslides, liquefaction, and Earthquake Fault Zones."[9]

Since 1993, all sellers of residential properties of four units or less must under Government Code Section 8897.1-8897.5:

- Inform the buyer about known home weaknesses related to earthquake risk;
- Properly strap the water heater;
- If the home was built before 1960, deliver a copy to the buyer of the *Homeowner's Guide to Earthquake Safety*[10] brochure produced by the CSSC *(The real estate agent is holds responsibility for this requirement being met)*;

[8] http://www.paloaltocompplan.org/ (Accessed January 23, 2016).
[9] http://www.conservation.ca.gov/cgs/rghm/ap/Pages/disclose.aspx (Accessed January 20, 2016).
[10] Available at: http://www.seismic.ca.gov/pub/CSSC_2005_HOGreduced.pdf (Accessed February 1, 2016).

- Deliver to buyers a Natural Hazards Disclosure Form telling buyers whether the home is in an Earthquake Fault Zone or in a Seismic Hazard Zone; and,
- Complete and deliver to buyers a *Residential Earthquake Hazards Report*.

A similar document called the *Commercial Property Owners Guide to Earthquake Safety*[11] makes recommendations for commercial property buyers and sellers at the time of sale. The only requirement is that sellers must deliver a copy of the booklet to a buyer, "as soon as practicable before the transfer," (Government Code, Section 8893.2) if the property was built before 1975 and has precast (tilt-up) concrete or reinforced masonry walls and wood-frame floors or roofs.

Palo Alto currently features links to both the aforementioned guides on its Building Department website.

Legal Obligations to Tenants

California case law in *Green v. Superior Court* (1974, 10 Cal.3d 616) established that a rental unit must be "fit to live in," or "habitable." In legal terms, "habitable" means that the rental unit is appropriate for occupation by human beings and that it substantially complies with state and local building and health codes that materially affect tenants' health and safety (CA Civil Code §1941, 1941.1).

At time of writing, no common law precedents could be identified regarding thresholds related to seismic risk that would be actionable for tenants to reasonably claim breach of a landlord's implied warranty of habitability. California law is broad by stating that "other conditions may make a rented property not habitable" (CA Civil Code §1941, 1941.1). For example, a rented property may not be habitable if it does not substantially comply with building and housing code standards that materially affect tenants' health and safety (CDCA, 2012). This could be a lead or mold hazard, sanitation issues, or an endangering nuisance, but also potentially if the building is *substandard* because of a structural hazard.

In seeking to develop any new programs, Palo Alto should consider conducting a legal analysis of this important but untested aspect of seismic mitigation policy. Some housing and tenant rights groups have asserted that soft-story and other generally accepted seismic vulnerabilities may constitute a deficiency that a landlord has an obligation to repair, regardless of whether the local jurisdiction has required such work. Citizen complaints of this nature surfaced in Berkeley for instance in 2008 to 2010 (personal communication, 2010 with Jay Kelekian, City of Berkeley Rent Stabilization Board President).

[11] Available at: http://www.seismic.ca.gov/pub/CSSC_2006-02_COG.pdf (Accessed February 1, 2016).

Special Earthquake-Related State-Level Entities and Programs

Following are a few more important state-level entities and resources of which Palo Alto can take advantage.

California Seismic Safety Commission (CSSC)

The California Seismic Safety Commission (CSSC), established in 1975, advises the Governor, Legislature, and state and local governments on aspects of earthquake vulnerability and policy. Its staff offer technical assistance to cities in developing and carrying out seismic related programs. The CSSC is responsible for maintaining a five-year California Earthquake Loss Reduction Plan to establish strategy and coordination for state and local government actions to mitigate earthquake hazards. The most recent statewide Loss Reduction Plan was published in 2013 (CSSC, 2013). It contains detailed lists of policy issues and recommendations that, while comprehensive, prioritized, and sensible, have had limited traction owing to lack of elected official leadership and budget. Other duties include tracking progress on the state URM law and deriving policy lessons from earthquake events. Several CSSC publications are among the best resources for evaluating local mitigation programs.

California Earthquake Authority (CEA)

The California Earthquake Authority (CEA) is a privately-funded, publically managed non-profit entity that provides private insurance policies to homeowners and renters. Eligibility includes homes of four units or less through participating insurers. The earthquake insurance take-up rate statewide is around ten percent. As of January 2016, CEA-affiliated underwriters can now offer a premium discount up to 20% for mitigation investments made. The number of small residential buildings in Palo Alto whose owners carry earthquake insurance is not known, but those that do or that purchase it from hereon could be eligible for this discount. Palo Alto could potentially work to make sure this benefit is better advertised and utilized by building owners.

Additionally, a substantial portion of CEA's annual premium intake is legislatively required to be spent on efforts to achieve mitigation in one-to-four unit homes throughout the state. These funds have been invested in research as well as an important new mitigation grant program for small residential houses called Earthquake Brace and Bolt, which is further described in the Financial Incentives section on the California Residential Mitigation Program. Currently, enrollment for cities is closed but expansion is planned in the future.

Governor's Office of Emergency Services

Formerly known as the California Emergency Management Agency, the Governor's Office of Emergency Services (Cal-OES) coordinates statewide emergency preparedness and response activities. Palo Alto might have untapped opportunities to train City employees at CAL-OES's

Specialized Training Institute.[12] For instance, they have an "Essential Emergency Services Concepts – Earthquakes."

Financial Provisions, Tax Code, and Other Incentive Policies

The potential difficulty of affording retrofit work is universally recognized as a barrier for public and private owners alike. A variety of reports have attempted to catalog incentive, financing and in-kind assistance options that are relevant to city earthquake and resilience programs (See e.g., ABAG, 1992; ATC, 2010; ABAG, 2014; MMC, 2015).

This section highlights a few key pieces of enabling state legislation and federal tax programs that jurisdictions such as Palo Alto could utilize. Specific examples of how different jurisdictions have used specific financing and incentive programs are analyzed in the Task 3 Report.

General Obligation, Special District, and Mello-Roos District Bonds

Palo Alto is allowed to take on general obligation bond debt to help pay for retrofit or construction of new public buildings and to generate funds for providing loans to private owners for seismic work if doing so constitutes a compelling public purpose (Government Code §43600-43638; Government Code §29900-29930).

Advocates have also speculated that communities might be able to use the **Mello-Roos Community Facilities Act of 1982** (Government Code §53311-53317.5). This act allows localities in California to create special Capital Facilities Districts that can sell bonds to generate funds for infrastructure and community facilities and then levy additional property taxes on the real property owners in that district. Such taxes are not subject to Proposition 13 restrictions on property tax increases. Covered services may include streets, water, sewage and drainage, electricity, infrastructure, schools, parks and police protection in old or newly developing areas. The tax paid is used to make the payments of principal and interest on the bonds.

Historic Property Tax Reductions

Palo Alto has many historic structures and may be able to take advantage of the **Mills Act of 1972,**[13] which gives local governments the authority to enter into contracts with owners who restore and maintain historic properties. In exchange, the property owners could get significant property tax savings. Although cumbersome, St. Helena, California is one example of a city that used this tool to help owners of unreinforced masonry buildings to seismically retrofit (ABAG, unpublished soft-story report, 2015).

[12] See: http://www.caloes.ca.gov/cal-oes-divisions/california-specialized-training-institute (Accessed February 1, 2016).

[13] California Government Code, Article 12, §50280-50290, California Revenue and Taxation Code, article 1.9, §439-439.4. Further information available at: http://www.ohp.parks.ca.gov/?page_id=21412 (Accessed February 1, 2016).

Limits on Increases on Property Tax for Seismic Retrofit Costs

Existing state tax law (**California Revenue and Taxation Code** §74.5) provides that the cost of an earthquake retrofit should not increase the property assessment used to determine the amount of property taxes. The extent to which building owners take advantage of this benefit is unknown and might be low because of requirements to submit specific information to their County Assessor's Office *prior* to conducting retrofit work. Many Assessors' Offices do not have forms for this purpose and their staff is not trained to process this benefit. At this time, it is not known how Santa Clara County manages this issue. Palo Alto could potentially work to make sure this benefit is better advertised and truly available to building owners.

Property Assessed Clean Energy (PACE) Financing

New financing programs are starting to exist that could help owners in Palo Alto who might have difficulty securing financing on their own for a seismic retrofit. Based on the Property Assessed Clean Energy (PACE) model first pioneered for solar improvements, owners can apply for 100 percent financing for seismic retrofit work at competitive fixed rates over the useful life of the improvements, to be repaid over up to 20 years with an assessment added to the property's tax bill. The levy stays with the building upon sale and costs can be shared with tenants. Both Berkeley and San Francisco are participating in the open access AllianceNRG Program[14] that offer residential property owners this financing solution primarily for sustainability upgrades and seismic strengthening projects for soft-story construction are also eligible. The AllianceNRG program is offered through California's Statewide Community Development Authority (CSCDA) and partnerships with additional communities are now being offered state-wide since 2015.

After the concept was launched in Berkeley in 2008, PACE programs stalled in 2010 the country's two biggest home lenders, Fannie Mae and Freddie Mac, decided not to underwrite mortgages for PACE customers because it added too much risk in the event of a default because the PACE loan took precedence over the mortgage. Anecdotally, jurisdictions have had some difficulties implementing this type of program for energy improvements.[15] Challenges include setting up this complex financing instrument which has heavy involvement of third parties, barriers to owners that want to refinance, and barriers to the transfer of a PACE-financed properties to a new owner.

[14] https://www.alliancenrg.com/retail/ (Accessed January 20, 2016).

[15] See e.g., http://www.voiceofsandiego.org/topics/science-environment/some-homeowners-looking-to-move-must-deal-with-a-change-of-pace/ (Accessed February 2, 2016.

California Residential Mitigation Program (CRMP)

Palo Alto and other cities can benefit if the citizens can stay in their homes and "shelter in place" following a major local quake. One new important effort on this front is the California Residential Mitigation Program (CRMP). It was formed in August 2011 to carry out mitigation programs to assist California homeowners who wish to seismically retrofit their houses. CRMP's goal is to provide grants and other types of assistance and incentives for these mitigation efforts. The California Residential Mitigation Program is a joint-exercise-of-powers entity (JPA) formed by two core members: the California Earthquake Authority (a public instrumentality of the State of California known as CEA) and the Governor's Office of Emergency Services (Cal-OES). CRMP is a legally separate entity from its members.

The first of these programs, **Earthquake Brace + Bolt**: Funds to Strengthen Your Foundation (EBB)[16] was launched as a pilot project in September 2013 in selected zip codes only. EBB offers a cash grant up of to $3,000 for qualifying bolts or sill anchoring installment. Homeowners must register and be accepted into the program, with a cap on the number of participants. The current registration window was open from January 20 to February 20, 2016. Participation is determined by lottery if more applications are received than funds are available. At present, no Palo Alto zip codes are in the program. The selection of the specific neighborhoods and zip codes was based upon analysis of U.S. Census data identifying areas of high seismicity and having a concentration of owner-occupied homes built in 1979 or earlier. According to personal communications with CEA mitigation program representatives, Palo Alto zip codes are not likely to be prioritized highly owing to the modest number of very old single family homes.

Federally Mandated Municipal Obligations and Opportunities

Even though the focus of this review is California, two particularly relevant federal programs for Palo Alto are described below. As with the state, no centralized governmental authority exists at the federal level to regulate issues of seismic safety. Instead, authorities and strategies are widely distributed among agencies at the local, state, and federal levels. For instance, the Department of Housing and Urban Development operates several initiatives related to safer homes and resilient communities,[17] and the General Services Administration must confront seismic risk concerns as it manages most federal facilities. The federal role is concentrated in FEMA and principally focused on emergency response and recovery, although mitigation is also addressed.

[16] https://www.earthquakebracebolt.com/ (Accessed January 23, 2016)

[17] See, e.g., the Smart Growth America Resilience States program, http://www.smartgrowthamerica.org/resilience/ (Accessed February 1, 2016).

Local Hazard Mitigation Planning Under the Disaster Management Act

The federal **Disaster Management Act of 2000** (DMA) and subsequent amendments specify that local jurisdictions and states must have approved Hazard Mitigation Plans in place in order to be eligible for aid following Stafford Act Disaster declarations and a variety of other benefits. The State of California Multi-Hazard Mitigation Plan of 2013[18] is a comprehensive source of information about state level requirements, mitigation strategies, as well as local and state progress and opportunities for coordination (CSSC, 2013b).

Palo Alto current complies with the DMA through its participation in the 2011 Santa Clara County's Office of Emergency Services Annex to a 2010 region-wide "umbrella" Local Hazard Mitigation Plan (LHMP) created by the Association of Bay Area Governments (ABAG). To create the plan, representatives from County departments, private sector businesses, stakeholders, and thirteen of the fifteen incorporated cities in Santa Clara County collaborated in identifying and prioritizing potential and existing hazards. Mitigation objectives were identified and prioritized and specific action steps are listed, many of which have been taken. Palo Alto is currently preparing its contributions for updates to the Santa Clara County LHMP which must be completed, submitted to the state, and approved by June 2017. The LHMP process creates an opportunity to build synergies between an updated seismic program and other mitigation efforts city and county-wide.

Federal Emergency Management Agency (FEMA) Pre-Disaster Mitigation Grants

Cities such as Palo Alto are eligible to apply to the **Pre-Disaster Mitigation (PDM) Grant Program**[19], created by Section 203 of the federal Robert T. Stafford Disaster Relief and Emergency Assistance Act, funded annually by Congressional appropriation. The program aims to assist States, territories, Federally-recognized tribes, and local communities in implementing a sustained pre-disaster natural hazard mitigation program. Cities must submit a detailed application during an open window to an annual competition. This program awards planning and project grants as well as providing assistance in raising public awareness about reducing future losses before disaster strikes. The program works on a 75%/25% cost share between FEMA and the local jurisdiction, respectively, with a maximum grant of $3 million. Cities can submit applications for multiple projects. Palo Alto could apply for support for future projects ranging from updating city owned structures, direct financing or grants to a private class of buildings or specific important structure.

[18] Available at: http://hazardmitigation.calema.ca.gov/docs/SHMP_Final_2013.pdf (Accessed February 1, 2016).

[19] http://www.fema.gov/hazard-mitigation-grant-program (Accessed January 15, 2016).

The disaster occurrence that opens a funding availability window does not necessarily have to affect Palo Alto directly. For instance, *any* California jurisdiction with an active LHMP was permitted to propose projects based on the Presidential Disaster Declaration for the 2015 Valley and Butte fires.

Finally, if City of Palo Alto employees have not already taken advantage of it, training opportunities are available at the FEMA Emergency Management Institute in Maryland.[20]

3. Legislative Leadership and Recent Developments

Palo Alto citizens are represented in the state Senate by Jerry Hill (D) and in the Assembly by Rich Gordon (D), 24th District, both with terms ending in 2016. High earthquake exposure throughout coastal California has led legislators from a variety of districts to author legislative proposals. Most recently, leadership has come from elected officials Nazarian, Chiu, and Monning.

Several different committees in the California Assembly and Senate have jurisdiction over issues related to seismic safety and mitigation, building codes, and earthquake-related programs. In the Assembly, the Committee on Housing and Community Development has jurisdiction over building standards, common interest developments, eminent domain, farm worker housing, homeless programs, housing discrimination, housing finance (including redevelopment), housing, natural disaster assistance and preparedness, land use planning, mobile homes/manufactured housing, and rent control. The Assembly Committee on Local Government has authority over a range of General Plan, city finance, and housing policies. The most relevant Senate committee is Transportation and Housing, which governs issues such as transfer of ownership, financing districts, manufactured housing, building codes and standards, and common interest developments.

Through these committees, legislators have considered several pieces of legislation related to earthquake mitigation in recent years. This review identified around ten such pieces of legislation debated in the 2013 to 2015 California legislative sessions, including passed, pending, vetoed or never fully heard bills (see Appendix B). Three key legislative proposals of interest to Palo Alto are briefly described here.

Vetoed: Seismic Mitigation Tax Credits

In the most recent session, Assembly Member Adrin Nazarian (District 46 in the San Fernando Valley) has sponsored legislation to create a state-wide seismic mitigation tax credit. The 2015 version **AB 428** passed the legislature but was vetoed by the Governor based on funding availability, lack of technical and administrative capacity in the Franchise Tax Board, and the

[20] https://training.fema.gov/emi.aspx (Accessed February 1, 2016).

program's potential complexity. The law would create a first-come first serve state tax credit equal to 30 percent of a "qualified taxpayer's" "qualified costs" incurred for "seismic retrofit construction."

Pending: Permissions to Expand CEA Insurance Mitigation Discounts

CEA was active in promoting legislation last year to empower the CRMP to offer grants for small residential retrofit work. Currently pending are **AB 1429** (Chiu) and **AB 1440** (Nazarian) that will provide $3 million dollars to the CRMP for expanding its current EBB program.

Dead: Soft-Story and Older Concrete Mitigation Program Authorization

AB 2181 (Bloom)[21] would authorize each city, city and county, or county to require that owners assess the earthquake hazard of soft story residential buildings and older concrete residential buildings. It includes older concrete residential buildings constructed prior to the adoption of building codes that ensure ductility, and to initiates programs to inform owners, residents and the public about such dangers. There is no state law that forbids such programs, but this law if passed would remove any ambiguity that such programs are permitted and further justify local actions to that effect.

4. CONCLUSIONS

Palo Alto is affected by numerous California laws and regulations related to seismically vulnerable structures, dating from the 1930s to the present day. The requirements relate to many aspect of the city's built environment, including:

- Code minimums for new construction;
- Standards for seismic rehabilitation, including special provisions for historic properties;
- Special programs and expectations for certain classes of use such as hospitals and public schools, and essential facilities;
- Mandatory and voluntary unreinforced masonry programs;
- Mandated zoning and land use planning requirements that restrict use and add requirements;
- Grant and insurance programs available to one to four unit dwellings;
- Financing authorities such as issuance of general obligation bonds and provisions for handling of property taxes for the costs of needed seismic retrofit; and

[21] http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB2181 (Accessed February 1, 2016.

- Real estate disclosure requirements.

Beyond some recent and pending efforts related to funding small residential mitigation grant programs and Earthquake Early Warning, there is no apparent momentum at this time for new statewide initiatives. That being said, Palo Alto can take any of several actions listed below to make sure it is complying with and taking the greatest possible advantage of existing state laws and programs. For example:

- **Palo Alto could confirm that all its URM buildings maintain the required signage.**
- **Palo Alto could investigate the status of the approximately six Palo Alto area schools that have buildings on the State's "AB 300 List" related to the Garrison Act.**
- **Palo Alto could identify and review the status of public facilities covered under the Essential Services Building Seismic Safety Act and review its policies for guiding future planning for or rehabilitation of such structures.**
- **Palo Alto could take advantage of the current update process for its Local Hazard Mitigation Plan to develop a strong, coherent, shared vision for how the city is going to address earthquake risk, and encourage jurisdictions and special districts nearby to do the same.** Resources from FEMA Hazard Mitigation Grants and knowledgeable partners such as the Association of Bay Area Governments may be available to assist in this effort.
- **Palo Alto could work carefully to incorporate the most up-to-date assessment of local earthquake vulnerabilities as it revises the Safety Element of its General Plan.**
- **Palo Alto could make sure its employees have taken advantage of the best available state and federal emergency management training programs that are relevant to earthquake disasters and recovery.**
- **Palo Alto could develop partnerships and devote resources to more fully realizing the benefits of statewide offerings of tax relief and requirements regarding real estate disclosure in private sales.** These policies aim to empower buyers and sellers to be better informed and able to make better mitigation decisions for themselves but may be carried out incorrectly and are under-enforced. Palo Alto could, for instance, work to make sure building owners apply for relief from any property assessment increases that would otherwise result from investing in an earthquake retrofit.
- **Palo Alto could seek closer ties to the California Earthquake Authority to help in promoting mitigation and insurance coverage for one to four unit homes.** CEA has recently been one of

the lead entities in offering policy ideas and grant funding for earthquake mitigation of small residential structures.

- **Palo Alto could evaluate whether it contains any vulnerable historic properties that might be eligible for tax credits under the Mills Act.** This Act provides the most significant direct source of financial support from the state for local seismic retrofitting.
- **Palo Alto could investigate the issue of seismic habilitability minimums for suspected earthquake vulnerable buildings.** Legal uncertainty exists about whether tenants are already entitled under current state law to request that their landlord upgrade a structure for being "substandard."
- **Palo Alto could join with fellow jurisdictions in advocating for changes in state law to promote seismic mitigation.**
- **Palo Alto could develop partnerships and devote resources to bringing more awareness among its citizens about low cost or free ways to become more aware and prepared for disasters more broadly.** Cal-OES and many other state and non-profit institutions offer free online tools such as http://myhazards.caloes.ca.gov/ to help citizens understand their risks and take private action.

The power to address unmet seismic safety and recovery concerns clearly rests in the hands of cities, counties, and special districts. If it so chooses, Palo Alto has legal authority to widen and/or strengthen its structural mitigation program. Based on what state laws allow and in some cases recommends, this review revealed the following non-exhaustive list of policy directions Palo Alto could pursue going forward:

1. **Palo Alto could implement measures to energize and raise the effectiveness of its current program (outlined in City of Palo Alto Municipal Code 16.40), for instance by offering additional or larger incentives or devoting more resources to program visibility and implementation.** Making the current program more effective would likely require additional funding sources. Other jurisdictions are experimenting with some success in using tools such as the new state-wide PACE financing program. Palo Alto could investigate opportunities to establish special Mello-Roos or Mills Act districts to help finance local seismic mitigation.
2. **Palo Alto could expand its voluntary seismic mitigation program to address one or more combinations of additional building types, occupancy levels, or uses.** The State Legislature has

formally passed advisory legislation that encourages jurisdictions to adopt policies for building types like soft-story and older concrete.[22]

3. **Palo Alto could create mandatory screening or evaluation measures for one or more vulnerable building types such as soft-story buildings or older concrete structures.** Local precedents for these approaches exist and are described and discussed in a separate Task 3 report.

4. **Palo Alto could make its current voluntary URM program mandatory.** Mandatory URM programs in the State have been on average three times more effective than voluntary ones.

5. **Palo Alto could create a program that mandates seismic retrofits for one or more additional (non-URM) vulnerable building types.** The State Legislature has formally passed legislation that authorizes cities to adopt rehabilitation requirements for such programs This is important because cities must reference acceptable standards that state clearly how owners can comply with the requirement to retrofit.

6. **Palo Alto could craft a program that combines any or all of the above measures.** The Task 3 report shows that most leading local earthquake programs involve a customized mixture of goals, requirements, and features.

7. **Palo Alto could continue the status quo current program.** Nothing under current state law requires Palo Alto to change its current approach.

The City of Palo Alto is currently gathering up to date earthquake risk information about its building stock and engaging its citizens and local experts in order to develop and evaluate specific policy alternatives. The ultimate goal is to recommend to city leaders the best possible policy directions for Palo Alto moving forward.

[22] Health and Safety Code §19160-19168 http://www.leginfo.ca.gov/cgi-bin/displaycode?section=hsc&group=19001-20000&file=19160-19168

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CHAPTER III

LOCAL PROGRAM BEST PRACTICES ASSESSMENT

Executive Summary

This chapter summarizes the status of local seismic safety and mitigation programs in California with the purpose of informing Palo Alto's effort to update its own approach. It has been prepared per Task 3 of the Consulting Agreement between Rutherford + Chekene and the City of Palo Alto. The content builds on the state-level policy review presented in Chapter II. The scope of Task 3 is to:

- Review present best practices among jurisdictions and agencies in this area that require seismic retrofitting and provide incentives, and deliver a brief summary.
- Provide a concise and practical written summary of what other jurisdictions and counties have done legislatively and programmatically to increase awareness about, assess, and motivate mitigation of seismically vulnerable buildings, both listing and helpfully classifying various approaches that have been used.

The process of creating this review included search and review of published and online reports and materials, several phone interviews with community leaders as well as local and state government staff, and development of insights from the consulting team based on their experiences in this arena.

Palo Alto is currently laying a solid foundation for future program development by investing in new inventory and risk information as well as community outreach and internal staff discussions. In doing so, it is joining a group of leading coastal California coastal jurisdictions such as Berkeley, Oakland, San Francisco, and Los Angeles that have recently stepped up their earthquake risk reduction efforts. While there is much learning and information sharing going on, each jurisdiction has developed their own customized policy package, and there is no single best model that Palo Alto can straightforwardly adopt. Existing local approaches differ widely in the following ways:

- Policy mechanisms used to achieve progress;

- Scope of targeted building types or uses addressed;
- Prioritization and compliance timeframes; and
- Types of incentives offered.

Policy mechanisms in use range all the way from inventory only to mandatory retrofit with timeframes under five years. In between are more gradual approaches such as voluntary retrofit advocacy, incentives, provisions that make building deficiencies more visible to the public (disclosure measures), and mandatory screening and evaluation requirements. An important policy decision is whether any mandated actions are implemented on a fixed timeline or triggered at sale or at some renovation cost threshold.

Targeted building types and characteristics also vary. The most commonly addressed building type is ***unreinforced masonry (URM)*** construction due to state law SB 547, as discussed in the Task 2 report. Over half of URM programs in the state require mandatory retrofit, often but not always with a time frame on the order of ten to twenty years. By 2006, seventy percent of all identified URMs were either demolished or retrofit. Retrofit rates are on average three times higher in jurisdictions with mandatory retrofit compared to voluntary programs. Jurisdictions used a wide variety of both financial and policy incentives to assist URM owners. Some voluntary URM programs, including Palo Alto's, coupled with incentives, have achieved similar rates of success to mandatory programs.

Newer programs have focused on ***soft-story wood frame buildings***, including ten Bay Area jurisdictions and most recently Los Angeles as of 2015. Soft-story wood frame building programs also range in requirements from notification only to mandatory retrofit, but several jurisdictions have innovatively used intermediate mandatory screening and evaluation phases to further assess risk exposure and determine the final set of buildings that will be affected by retrofit requirements. Soft-story wood frame programs have largely been supported in the local community. Even voluntary soft-story wood frame programs can be effective at motivating retrofit action; one fourth of the soft-story wood frame buildings in the City of Berkeley were voluntarily retrofit within a few years after a mandatory evaluation ordinance was implemented. Compliance timeframes in soft-story wood frame programs tend to be short, on the order of two to seven years.

A comparatively small number of southern California jurisdictions have acted to address ***older concrete buildings***, including Los Angeles, Burbank, Santa Monica, and Long Beach. Nonductile concrete frame and tilt-up concrete structures in particular are known to pose serious risks. Programs aimed at older concrete range from voluntary guidelines to mandatory evaluation

and full retrofit requirements. Timeframes here vary greatly, from years to decades. Information about the implementation and outcomes of these few programs is very limited.

Coming out of this local program review, alternative policy approaches for Palo Alto's consideration include:

Option 1: Status Quo. In this option, the existing ordinance with its mandatory evaluation, voluntary retrofit approach remains in place without changes. Floor area ratio bonuses are (were) available and could continue to be offered.

Option 2: Increase Scope, but Retrofit Remains Voluntary. Additional categories of structures are added to the mandatory evaluation requirements. These could include any or all of the building types discussed above, potentially also using additional location, use, or occupancy criteria.

Option 3: Similar to Option 2, but Additional Disclosure Measures are Incorporated. This option would be similar to Option 2, but with increased use of disclosure measures such as prominently posting the building list on the City website, notifying tenants, requiring signage, and/or recording notice on the property title.

Option 4: Increase Scope, Some Categories are Voluntary and a Few Categories are Mandatory, with Enforcement by Trigger Threshold

This option builds on Option 3, but retrofitting would be required for some building types *at whenever future time a building is sold or undergoes substantial renovation* above a set threshold.

Option 5: Increase Scope, Some Categories are Voluntary and a Few Categories are Mandatory, with Enforcement by a Fixed Timeline

This option would be similar to Option 4, but retrofitting is required *according to a fixed timeline*. Timelines and enforcement emphasis could vary depending on tiers or priority groupings to motivate prompt action for the most vulnerable or socially important structures.

Option 6: Increase Scope, but More Categories are Mandatory

This alternative is similar to Option 5, but retrofitting would be required for additional categories on a fixed timeline. Palo Alto can also make its programs more stringent over time. Explicit phasing has been successful in jurisdictions like Berkeley and San Francisco for generating political consensus and enhancing administrative feasibility.

Other program features and implementation factors should be considered in designing a future program. Palo Alto will need to decide whether location, occupancy type, and/or number of occupants should be included in the scope or just the timeline categories. Whether and which incentives to offer is an important issue from a political and economic feasibility perspective, one that affected community members will want to see inclusively addressed. The community should also be involved in discussing which if any disclosure measures are considered necessary and appropriate, such as signage.

Additionally, based on the work of cities such as Berkeley, San Francisco, and Los Angeles, Palo Alto has a variety of opportunities to expand and better connect its earthquake mitigation program efforts to other city efforts in support of community resilience goals more broadly. For instance, Palo Alto could encourage building occupancy and resumption program like San Francisco, encourage or fund installation of strong motion instruments, or pursue special programs or requirements for cell phone towers, facades, private schools, and/or post-earthquake shelter facilities. Several leading local program models and planning resources for these types of efforts are introduced in Appendix D.

1. INTRODUCTION

This document is meant to be a resource and guide for the Palo Alto community and city leadership as they weigh program needs and options for seismic mitigation policymaking going forward. It offers comprehensive information on many topics so readers with different backgrounds can advance their understanding, along with summary tables and conclusions specific to Palo Alto's present effort.

The approach taken was to document and assess existing and proposed programs that a selected set of other jurisdictions are using to address earthquake vulnerabilities in local buildings. This was done using analysis of city websites and documents, search and review of published and online reports, several phone interviews with local officials and engineering profession leaders, and development of insights from the consulting team based on their experiences in this area.

Focusing on a selected set of jurisdictions was appropriate for several reasons. First, relatively few jurisdictions are developing leading earthquake mitigation programs, and those are the most informative models to draw upon. Second, data about jurisdictional programs is very limited. Much of the information that does exist is anecdotal, and it was not within the scope of this review to collect comprehensive new data or to cover a large number of jurisdiction programs statewide or in other countries. Finally, this review emphasizes classification of

similarities and distinctions among a range of leading jurisdiction earthquake structural mitigation efforts. Policies related to wider earthquake hazard science and awareness, emergency management, and longer term recovery programs that have local relevance are briefly mentioned, but are also beyond the scope of this report.

Following this introduction, Section 2 describes and compares a range of existing local policies and programs. The information is organized by key features (for instance, the types of buildings regulated, the kinds of requirements imposed on them, and the types of incentives offered).

Section 3 presents summary conclusions for Palo Alto. Figures throughout and two appendices provide further detail on a range of program elements. Formal recommendations for Palo Alto will evolve after completion of other project tasks, and through the process of Advisory Group and City staff discussions.

2. Analysis of Policy Features and Outcomes of Local Seismic Risk Mitigation Programs

This section analyzes the state of local earthquake policymaking in California by presenting major types, similarities, and differences in program features. The word "features" indicates here a wide array of program nuances, including but going well beyond the characteristics of the buildings being targeted and the basic policy mechanism used, namely voluntary or mandatory retrofit requirements. Woven throughout are examples of jurisdictional programs that exemplify certain of these features and distinctions, along with discussion of program outcomes and effectiveness. Analyzing programs this way highlights options and key factors that Palo Alto should consider and tradeoffs it may need to confront in developing its own seismic mitigation strategy going forward.

Much innovation in local earthquake risk reduction policy is happening in California from which Palo Alto can learn. This is particularly true in the case of soft-story wood frame residential buildings,[23] for which mandatory retrofit ordinances are now in place in Fremont, San Francisco, Berkeley, and Los Angeles. However, what makes one program different from or more successful than others cannot be understood simply by identifying the types of structures addressed. Also important are the specific set of requirements that owners must comply with, the timeframes in which requirements must be carried out, and the types and sizes of the incentives offered.

Comprehensive, summary information to inform this review are rare. In-depth California Seismic Safety Commission URM reports cover every city and county for URM law compliance up to 2006. But beyond URM programs, data to support this assessment was limited and largely anecdotal because comprehensive research on seismic mitigation programs is rare. An

[23] "Soft-story" refers to a condition where one of the stories in a multi-story building, usually a parking level that doesn't require partitions for functionality, is weaker and/or too flexible compared to the story above it. Another acronym sometimes used is "Soft-, Weak-, or Open-Front" buildings, or SWOFs. During strong ground shaking, concentration of damage in the soft or weak story can significantly increase the chance of collapse or damage sufficient to render the building unusable after the event. Many communities are concerned with soft-story wood frame buildings. Most of this type of construction can be found in apartment buildings built in the 1960s and 1970s with first floor garage openings and some mixed-use properties with ground floor commercial space. In that era, the safety risks of soft-stories were not yet fully understood. Vast numbers of these buildings exist in California communities that grew substantially prior to the 1980s and 90s when building code changes were introduced. Findings related to evaluating and improving soft-story wood frame performance can be found in FEMA P-807, available at: https://www.fema.gov/media-library/assets/documents/32681 (Accessed February 3, 2016).

Association of Bay Area Governments (ABAG) survey that collected program information from one third of California jurisdictions in the 1990s documented a wide variety of program implementation, effectiveness, and incentive approaches; however, its information is now significantly out of date. Policies of certain leading jurisdictions have been studied in depth at various windows in time, such as Palo Alto) (Herman et al, 1990), Berkeley (Rabinovici, 2012; Chakos, 2002), Oakland (Olson, 1999), and Los Angeles (Comerio, 1992). These studies reveal how unique and complicated local earthquake mitigation programs can be, not just in format but also implementation. Outcomes cannot be understood without considering the local building stock and economic context, concurrent policy developments, political support, local government resources and administrative capacity, how policy features are combined, community engagement strategies used, and emphasis put on enforcement.

At the outset, Palo Alto's unique current program and historic role in the evolution of earthquake mitigation program design should be recognized. Its 1986 law was among the first to require owners of suspected hazardous properties to have a qualified engineer *evaluate* their buildings. In addition, Palo Alto's Seismic Hazards Identification Program (Chapter 16.42) addressed three categories of buildings: URM buildings (Category 1), structures built before 1935 with over 100 occupants (Category 2); and structures built before August 1976 with over 300 occupants (Category 3). This demonstrates how ***occupancy level*** and ***year built*** can also be used in combination with other factors as the basis for inclusion in a program. The mandatory evaluation reports for these structures were due in 1990. The September 2014 status of affected properties is shown in Table 1.

Table 1: Status as of September 2014 of properties included under Palo Alto's current earthquake risk reduction ordinance.

	Category I – URM over 1900 sq.ft. and over six occupants	Category II – Built before 1935 and over 100 occupants	Category III – Built before 8/1/76 and over 300 occupants	All Categories
Retrofit	22	13	5	40
Demolished	14	2	5	21
Demolition Proposed	0	0	4	4
Exempt	1	0	0	1
No Change	10	4	9	23
Totals	**47**	**19**	**23**	**89**

Source: 12/9/14 City of Palo Alto Policy and Services Committee staff report.

Palo Alto's decision to focus on these three categories grew out of a broader earthquake risk assessment effort going on at that time. City leaders initiated a comprehensive search of paper records and a street walk-style inventory of a wide variety of seismically-vulnerable building types in 1984. They then engaged the community in a deliberative process to assess risk and determine priorities among building types and policy approaches (Herman, Russell, et al. 1990; CSSC 2006).

The following section describes alternative ways different jurisdictions have chosen which buildings to target.

Scope: Targeted Structural Systems, Year Built, and Other Characteristics

The primary feature that varies among jurisdictional programs is the types and characteristics of the structures that are addressed. As discussed in the Task 2 report, California's earthquake policy history started in the 1930s with laws that increased design requirements for buildings related to one particular *use*—public schools, and banned ***new construction*** of one particular ***structural system or type***—buildings with unreinforced masonry (URM) load bearing walls. Much later in the 1970s and 80s, both state and local new laws were passed targeting URMs built before 1933, certain ***locations*** (e.g., hazard zoning with prohibitions or heightened evaluation and design scrutiny for new construction or rehabilitation in those zones), a wider

set of ***uses*** (e.g., hospitals and essential services buildings) and additional structural types (e.g., older concrete buildings and manufactured homes).

The choices jurisdictions make about which buildings to target are closely tied to the legal basis underlying earthquake mitigation policymaking. Laws that impose added burdens or responsibilities on certain properties or people must clearly specify which buildings are applicable and justify why for those particular buildings have been selected. A compelling, documentable, and actionable public purpose must exist to invoke a jurisdiction's police powers and responsibility for public wellbeing.

The central rationale for regulating seismically vulnerable structures is safety; a strong case for government intervention exists where there is an unacceptably high likelihood of collapse or damage that could lead to human entrapment, injury, or death. Technical research, evidence, and evolving standards of practice in structural engineering must exist for this to be considered reasonable. Once a new practice becomes embedded in a model building code, construction to former code standards is no longer allowed. Jurisdictions review permits and inspect construction work in progress, but lax compliance cannot entirely be ruled out.

For any particular structural system, year built (or age) is the most commonly used risk indicator because it reflects the building code version that was in effect when a structure was first constructed. What was once considered an acceptable construction practice may become obsolete or even be considered negligent years later. Code updates are usually made on a three-year cycle to keep up with changes in construction practices, technologic advancements, and improved understanding how buildings perform under loads, but adoption by jurisdictions can be uneven and lag behind many years.

Jurisdictions must also address which code year built they will use as inclusion criteria for their earthquake mitigation programs. Benchmarking to newer standards may be justified if it reaches more buildings that could experience significant damage in an earthquake, but a larger percent of building owners and tenants will be affected. Code changes are also proposed based on lessons learned from practical experience over time, in this case from earthquake performance outcomes in jurisdictions all around the world.

Unreinforced Masonry Buildings

URM buildings have been a concern for collapse and falling debris hazard ever since the 1933 Long Beach earthquake, after which new construction of URM structures in California was outlawed. The most significant contemporary law addressing a specific

building type is the 1986 state legislation (Senate Bill 547). This state mandate, also summarized in the Task 2 report, required jurisdictions to identify and adopt programs for addressing existing URM buildings. Several jurisdictions (most prominently Long Beach, Los Angeles, Santa Cruz, Palo Alto, and San Francisco) had existing URM building ordinances and programs in place prior to the state mandate. Counties and municipalities were allowed to craft their own approach, resulting in a wide range of strategies.

In general, three main types of local programs were utilized: 1) mandatory retrofit, 2) voluntary retrofit, and 3) notice to owners that the structure is a URM building. When retrofits were encouraged or required, the local government set the standards to be met. More than half (52%) of affected jurisdictions adopted a mandatory program, which has proven by far to be the most effective type. Eighty-seven percent of identified properties have been retrofitted or demolished in jurisdictions with mandatory programs, compared to thirteen to 25 percent in jurisdictions with other program types.

Reviews of the URM Law by the CSSC have shown it to be a success over the long term. In 2006 (the last comprehensive state survey available), Compliance with the policy is nearly universal at 93%, and over 70% of identified URM buildings have been either retrofitted or demolished (CSSC, 2006). A comprehensive review of URM program formats throughout the Western United States is available from FEMA and the California Seismic Safety Commission (FEMA, 2009; CSSC, 2006).

Older Concrete Buildings

Older concrete structures (built pre-1970s and in some cases pre-1990s) exemplify the importance and difficulties of using code year as an indicator of seismic risk. Public awareness of older concrete risks may be lower than for soft-story wood frame buildings, but they are common in large numbers in the Western US and throughout California. The Concrete Coalition,[24] a network of engineers, research organizations, and policymakers, estimates that there are as many as 17,000 non-ductile concrete buildings in California (Concrete Coalition, 2011). The societal importance of older concrete structures can be significant, as they often have higher occupancies and are widely used for residential tall buildings, commercial, or even critical service facilities.

[24] Information about the Coalition can be found at the organization's website: http://www.concretecoalition.org/, Accessed March 18, 2016.

Poorly performing concrete structures can have devastating effects for occupants, owners, and communities, as numerous major quakes in California and abroad have demonstrated. The 1971 Sylmar earthquake brought down several concrete structures, killing 52, and the 1994 Northridge earthquake wrecked even more, including a Bullock's department store and Kaiser medical office. In the 2011 quake in Christchurch, New Zealand, two concrete office towers collapsed killing 133 people. Many of the 6,000 people killed in the 1995 earthquake in Kobe, Japan, were in concrete buildings.

A scenario report for the San Francisco Bay Area estimates that older concrete buildings in a repeat 1906-level event would contribute a large portion of the predicted deaths and injuries (ABAG, 1999). Also at risk are investors, the survival of occupying businesses, and livelihoods. Neighborhoods can be at risk too if a district has a high concentration of older concrete buildings, as they may be blighted or loose functionality or economic viability after an event.

Older concrete buildings of concern have a variety of features and are not always easy to characterize. One issue is nonductile (essentially too brittle, insufficiently reinforced) concrete, prior to enforcement of ductile concrete codes in the 1970s. Another is tilt-up structures, where a concrete is poured on the ground, cured, and then lifted (or "tilted") up and connected to roof and floor framing where the ties between the roof and wall and floors and walls are often inadequate.

Vulnerable concrete structures can be difficult to spot and often complex to retrofit (ATC, 2012). These are factors in why only a small number of California jurisdictions have adopted policies for older concrete (Table 2). The City of Los Angeles (Building Code Divisions 91 and 96) recently required evaluation and upgrade if needed for nonductile concrete structures and since Northridge has required triggered upgrading on pre-1976 tilt-ups. City of Santa Monica (Municipal Code 8.80) requires evaluation and upgrade if needed for nonductile concrete structures, along with other structural types. In 2014 Santa Monica hired the engineering firm Degenkolb to inventory buildings that might be subject to its requirements—a first step in reviving efforts that had been stalled for more than 20 years.[25] Two jurisdictions, Long Beach (Chapter 18.71) and Burbank, have taken the approach of providing voluntary guidance. Burbank's program addresses older reinforced concrete and concrete frame buildings with masonry infill.

[25] http://www.latimes.com/local/lanow/la-me-ln-santa-monica-will-hire-quake-engineers-to-id-all-vulnerable-buildings-20140527-story.html (Accessed March 20, 2016).

Table 2: Summary table of local programs for addressing older concrete building vulnerabilities.

Jurisdiction	Number of Older Concrete Buildings	Program Type	Targeted Building Characteristics	Deadline for Screening	Deadline for Evaluation	Deadline for Completion
Los Angeles	Unknown (Concrete Coalition inventory* = 1500)	Mandatory evaluation leading to mandatory retrofit	Pre-1976 tilt-ups and nonductile concrete	3 years	10 years	25 years
Santa Monica	Unknown (Concrete Coalition estimate* = 173)	Mandatory evaluation leading to mandatory retrofit	Pre-1978 nonductile concrete.	n/a	275 days	Deadlines vary from 1 to 4 years after evaluation report submission, depending on priority tiers. **
Long Beach	Unknown (Concrete Coalition estimate* = 396)	Voluntary guidance	Nonductile concrete	n/a		
Burbank	Unknown (Concrete Coalition estimate* = 132)	Voluntary guidance	Commercial pre-1977 reinforced concrete and concrete frame buildings with masonry infill	n/a		

* Source: (Concrete Coalition, 2011).

** Santa Monica's Building Type definitions are: Type I: building that are vital in the event of an emergency; Type II: >100 occupants; Type Ill: 20 - 100 occupants; Type IV: < 20 occupants.

Soft-Story Wood Frame Buildings

Wood frame soft-story buildings are a good example of a vulnerable building type that gained widespread attention after performing poorly in specific earthquake events. In October 1989, the hazard and widespread presence of this building type were made

evident by the dramatic and costly collapses and fires in the San Francisco Marina District in the Loma Prieta earthquake. Then again, in the Northridge event in 1994, widespread damage and several high profile collapses occurred. The Northridge-Meadows apartment complex collapse that led to sixteen deaths in particular captured media, public, and expert attention.

Following these events, soft-story residential buildings started to be viewed as not just a threat to the owner's pocketbook but to the surrounding community; tenant safety and local recovery could also be at stake. Given their prevalence, losing hundreds of soft-story apartment buildings could have large impacts on community. For example, soft-story buildings constituted about half (7,700) of the 16,000 housing units rendered uninhabitable in the Bay Area by the 1989 Loma Prieta Earthquake and over 34,000 of the housing units rendered uninhabitable by the Northridge Earthquake in 1994 (ABAG, 2003). Table 3 describes a wide range of local efforts to address soft-story wood frame buildings, highlighting key program features and distinctions (many of which are discussed in later sections regarding prioritization, timing, and policy mechanisms).

Table 3: Summary of local soft-story wood frame policy efforts showing key distinguishing program features.

(Sources: Rabinovici, 2012; ABAG, 2016).

Jurisdiction	Year	Number of Soft-story Buildings	Program Type	Targeted Building Characteristics	Priorities or Tiers	Deadline for Evaluation	Deadline for Permit	Deadline for Completion
Los Angeles	2015	unknown	Mandatory Evaluation leading to Mandatory Retrofit	Pre-1978 wood-frame structures with soft, weak or open front first floor conditions with two or more stories and five or more units. Only *enforcement* is prioritized by tiers.	**Priority I -** Buildings containing 16 or more dwelling units. **Priority II** - Buildings with three stories or more, containing fewer than 16 dwelling units. **Priority III** - Buildings not falling within the definition of Priority I or II.	1 year	2 years	7 years
Oakland	2015	1,380	Mandatory Screening (passed 2009) leading to Mandatory Retrofit	Pre-1985 multi-family wood frame structures with five or more units	n/a			

Table 3 (continued).

Jurisdiction	Year	Number of Soft-story Buildings	Program Type	Targeted Building Characteristics	Priorities or Tiers	Deadline for Evaluation	Deadline for Permit	Deadline for Completion
Berkeley	2014	310 (at time of 2005 ordinance)	Mandatory evaluation law (2005) leading to mandatory retrofit (2014)	Multi-family wood frame structures with five or more units	n/a	2 years (under previous soft-story evaluation ordinance)	2 years	4 years
San Francisco	2013	2,800	Mandatory evaluation leading to mandatory retrofit	Wood frame construction with five or more residential units and two or more stories with permit for construction submitted prior to January 1, 1978 and five or more units	**Tier I** - Any building containing educational, assembly, or residential care facility uses (Building Code Occupancy E, A, R2.1, R3.1, or R4)	1.5 years	2.5 years	4.5 years
					Tier II - Any building containing 15 or more dwelling units	2.5 years	3.5 years	5.5 years
					Tier III - Any building not falling within another tier	3.5 years	4.5 years	6.5 years
					Tier IV - Any building containing ground floor commercial uses (Building Code Occupancy B or M), or any building in a mapped liquefaction zone	4.5 years	5.5 years	7.5 years

Table 3 (continued).

Jurisdiction	Year	Number of Soft-story Buildings	Program Type	Targeted Building Characteristics	Priorities or Tiers	Deadline for Evaluation	Deadline for Permit	Deadline for Completion
Alameda	2011	70	Mandatory evaluation	Five or more units	n/a	2 years		
Fremont	2005	22	Mandatory retrofit	Apartment house with more than ten units or more than two stories	**Group 1** - Apartment house with more than ten units or more than two stories	n/a	2 years	4 years
					Group II - Apartment house with ten or less units and fewer than three stories high	n/a	2.5 years	5 years

Public Purpose, Occupancy, Location, and Other Considerations

Another stated goal of seismic mitigation laws is to promote continuity of vital services related to the community's social and economic viability. In addition to direct safety concerns, this further justifies targeting special uses and ***buildings that affect larger numbers of people*** such as schools, critical public buildings, and hospitals. Beyond critical community functions, however, it is less obvious where to draw the line between public and private risks and benefits. How many people need to live or work in a building before a suspected earthquake vulnerability becomes something an owner or tenant should not be allowed to make decisions about on their own?

The answer involves some sense of proportionality. In other words, local governments tend to seek a reasonable balance between the number of building owners that will need to comply and the burden of compliance, with the public benefits that will be achieved (which we can assume to be protection of health and preservation of community functionality). That is a key reason why buildings with higher ***occupancy*** or higher ***residential unit total*** are sometimes targeted. Such buildings not only have more human beings that work or live in them, but the fate of the buildings also has a larger impact on local housing availability, parking, and other community impacts. For instance, most existing soft-story wood frame programs are targeted at multifamily buildings with five or more residential units (see Table 3). Larger structures are also presumably worth more, so the owner is more likely to have sufficient equity in the property or cash flow to make capital upgrades.

A structure's ***number of stories*** may also relate to the degree of risk or perceptions of public importance. Problematically, more stories may not always translate into higher risk; for example, two-story soft-story buildings may not necessarily be less dangerous compared to three story ones, depending on the materials used and the positioning of occupied units (Bonowitz and Rabinovici, 2012).

A good example of a program that uses ***location*** or ***zoning*** as part of its targeting is Palo Alto's Municipal Code Chapter 18.18.070 Floor Area Bonuses incentive. The incentive is only available for buildings in Commercial Downtown (CD) District, which has sub-zones based on CD-C Commercial, CD-S Service, and CD-N Neighborhood designations. Zoning benefits are different for each of these designations, the square footage, and also if the building in question is ***historic property***.

Ownership structure is another potential scoping issue, for instance, whether condominiums should be included.[26] The City of Berkeley did not include condominiums in its soft-story wood frame building ordinance, but the jurisdictions of San Francisco and Fremont did. Condominiums often face additional barriers in both voluntary and mandatory retrofit policy settings, because homeowner association policies and practices can make it difficult to agree on what should be done and to obtain financing. Anecdotally, in Palo Alto and elsewhere, properties where a majority of owners want to retrofit have not been able to accomplish that work because of hold-out members that do not want to proceed or pay an additional assessment in order for the association to be able to afford it. The overall influence on retrofit behavior of either including or excluding condominiums is not known.

A final point that should be noted about program scope is that some properties that would otherwise be subject to a law can be classified as exempt for certain reasons. For instance, most jurisdictional ordinances offer exemptions for buildings that have had significant recent renovations or retrofit upgrades that addressed the hazardous condition. Some jurisdictions explicitly include protocols for hardship provisions such as extended timelines that might be made available for individual or institutional owners that can demonstrate an unusual degree of difficulty raising sufficient funds to comply.

Timelines, Pacing, and Prioritization

For several reasons, jurisdictions find it useful to both prioritize and pace their earthquake program efforts. Time is a powerful ally and policy variable. Once a jurisdiction commits to the idea of a new program, timeframes can be used to make implementation manageable and soften the economic impacts of the program on city staff and budgets, on owners, and on the local economy. Retrofitting is also a process that cannot be sped up beyond a certain point. Design, arrangement of financing, and completion of retrofit work can be an arduous process, naturally taking from months to years. Lengthier time windows allow owners to plan for how to comply in the way that works best for them. Longer time frames can also work to the advantage of jurisdictions, which rarely have sufficient administrative capacity, political will, and community tolerance to take on multiple seismic risk issues simultaneously over a short

[26] Keep in mind that condominium status can change. The City of Berkeley decided not to include condominium properties on its Suspected High Hazard Building list. However, owners in some apartment buildings in the process of being converted to condominium status when needing complying with the law experienced difficulty getting loans (Rabinovici, 2012).

period of time. Following are several examples of how different jurisdictions have used timing as part of their program structure.

Trigger-Enforced Timing

Some jurisdictions have opted to require earthquake retrofit to be done only when the property is sold and/or an owner submits plans for renovation, additions, or rehabilitation that meets certain criteria, for instance 50% of the assessed value. This is similar to triggers for energy upgrading, sewer lateral replacement for single family homes, modifications for Americans with Disabilities Act compliance, or sprinkler and other fire code changes.

A jurisdiction taking this approach does not need to inventory vulnerable structures in advance and may be able to do project reviews at current staffing levels. However, there are several downsides. Owners may resent encountering these potentially substantial "surprise" costs when initiating a project, and might strategically manipulate project valuation to avoid needing to comply, resulting in lower fees for the city. For those owners that are aware of the provisions, potentially important non-seismic renovation work that would have been done otherwise might be postponed as a result of increased project cost and complexity. Most importantly, critical safety and resilience retrofit work might go decades without being done.

Proactively-Enforced Timing with Phasing and/or Prioritization

Proactive enforcement means that a jurisdiction identifies, notifies, and actively seeks to help owners participate or comply in a program. It is common when these programs include mandates to use a ***variety of time frames for buildings with different characteristics***. For instance, Los Angeles's 2015 ordinance requires compliance for soft-stories within seven years and older concrete within 25 years. Another common strategy is to classify buildings of a *single* targeted structural type into ***tiers or priority levels among a particular type of building,*** for instance based on age, number of stories, unit totals, or occupancy. Compliance can then be mandated sooner in order from most to least serious in terms of estimated risk and social importance. Time frames for soft-story programs, for instance, commonly relax deadlines by about one year per tier (See Deadlines by programs in Table 3). Both of these phasing approaches allows jurisdictions to set a feasible administrative pace and put an early focus on buildings with vulnerabilities and characteristics that most affect the public.

An overall pacing strategy can also be used to ***phase implementation of a larger set of resilience policies and programs*** that go beyond different building types to address other aspects of community earthquake vulnerability. For instance, San Francisco mandated soft-story wood frame building retrofitting, then mandated its 120 private schools to do seismic evaluations of their buildings regardless of structure type,[27] and then embarked on efforts to assess and create programs for poorly anchored façades and unreinforced masonry chimneys.

All three approaches – 1) phasing and compliance time frames that differ for structures, 2) in different priority tiers, 3) within a multifaceted comprehensive plan – were used in recommendations from San Francisco's decade-long Community Action Plan for Seismic Safety (CAPSS) project (ATC, 2010). Figure 2 shows an earlier version of how San Francisco thought about address different building types and uses more or less quickly and with gradually increasing requirements.

Later, these concepts were embedded into the jurisdiction's policies as part of San Francisco's 30-year Earthquake Safety Implementation Plan (SF ESIP, 2011). That plan represents a commitment by the city to phase in additional efforts over this extended period, and deliberately addressed a wide range of vulnerable structure types, uses, or occupancy combinations considered important to community resilience (e.g., private schools, façades). Additional advantages of long time frames are to allow more time for detailed studies or research if needed, for political or community consensus to develop, and give owners ample notice of bigger changes to come.

[27] Ordinance text available at: http://sfgov.org/esip/sites/default/files/FileCenter/Documents/12716-Ordinance%20No%20202-14%20Private%20Schools%20EQ%20Evaluation.pdf (Accessed February 3, 2016).

Figure 2: Excerpt of Table 5 from the summary San Francisco CAPSS Project report (ATC, 2010) showing recommended timelines for prioritizing and phasing different kinds of efforts to address a variety of building types and uses.

Table 5 Recommended Timeframe* for Applying the Three-Step Strategy to Key Categories of Buildings

Building Categories	2010-2015	2015-2020	2020-2025	2025-2030	2030-2035	2035-2040
Wood-frame residential buildings with three or more stories and five or more units**						
Concrete tilt-up buildings						
Residential buildings with three and four units						
Private K-12 schools and private universities						
Assisted living facilities						
Concrete residential buildings built before 1980						
Other types of residential buildings with more than five units						
Hotels and motels serving tourists						
Critical retail stores and suppliers						
Single family homes and two unit residences						
Concrete non-residential buildings built before 1980						
Houses of worship						
Preschools and daycare centers						
Buildings used by large audiences						
Historic buildings						
Large buildings with welded steel moment frames built before 1994						
Early retrofitted buildings						
All other building types						

*The mandatory evaluation or retrofit program would begin at the start of the period and be completed by the end of the period.

**See Table 3 for the detailed schedule proposed in the draft ordinance developed by the Mayoral Task Force.

Color key***:

Step 1: Facilitate a market in which earthquake performance is valued	
Step 2a: Nudge market by requiring evaluation upon sale	
Step 2b: Nudge market by requiring evaluation by a deadline	
Step 3: Implementation period to require retrofit by a deadline	

*** Note: all previous steps remain in effect after advancing to a higher step.

Note: Categories represented in rows are not mutually exclusive. For instance, some private school facilities may be located in a house of worship or historic structures.

Policy Mechanisms and Requirements

In addition to creating a set of targeting and eligibility criteria, jurisdictions can use a variety of methods to motivate appropriate seismic upgrades to be done. Requiring owners to do retrofit work is only one approach. Other tools range from simple notification, disclosure measures,[28] offering incentives, voluntary retrofit initiatives, and mandated screenings or evaluations, each of which is described below in more detail. Another major distinction is whether a jurisdiction implements requirements only when triggered during rehabilitation projects that meet certain criteria, or proactively, such as doing an inventory to identify affected properties and imposed deadlines.

Figure 3 provides definitions of a spectrum of policy mechanisms that have been used. This view corrects the false impression that jurisdictional programs have to be either "voluntary" or "mandatory." In reality, most jurisdictions create a *policy package* that combines several approaches. Furthermore, that package can evolve over time as more and more buildings are upgraded, new information or technical recommendations become available, or with changes in the political or economic climate.

Inventory

Identifying the number and locations of buildings of concern is an essential first step to finding out which buildings are the most vulnerable and how significant those issues may be for the community. Many jurisdictions launch their earthquake program development process with a special-purpose, one-time discovery effort meant to compile data about potentially seismic at-risk properties and to gauge the scope of the issues faced by the community. This can be difficult and time consuming, and jurisdictions often rely on outside consultants or professional organizations and academic volunteers for assistance. Existing property databases generally contain less than complete information to be able to draw conclusions, and some relevant information may only exist in paper form. Street-walks, side walk surveys, or visits to a selected sample of properties are common.

It is important to distinguish early investigation and risk analysis efforts that might involve only a subset of properties from the development of an exhaustive list of properties meeting certain criteria that could be officially noticed or subjected to a

[28] Disclosure policies are designed to increase the transparency and openness surrounding an issue of social importance. Examples include mandatory disclosure to tenants, freedom of information requirements, public signage, searchable online listing, or official notice placed on a title or deed. These are described in Table .

particular ordinance. The City of Berkeley is one jurisdiction that used a list created by staff and consultants as the basis for determining which properties should be included on that city's suspected hazardous properties list. Other cities have instead chosen to put buildings on an initial suspected hazard list based on zoning, number of units, or other generally available criteria.

Palo Alto's current investigation into updating its seismic risk management program involves review of digital records, paper records, and side walk surveys. The side walk survey portion includes approximately half of the buildings of interest. A similar detailed field effort would be needed on the remaining portion of buildings to develop a comprehensive inventory list.

No inventory list will be perfect, so no matter which approach is used, some kind of appeal, confirmation, or screening processes are needed before granting any exemptions or enforcing requirements. Depending on the building type, issues of improper inclusion or exclusion from a list may be more or less likely. For example, rapid visual determination is easier for wood frame soft-story conditions, but it would be hard for even an experienced engineer to identify a steel moment frame, braced frame building, or a concrete frame building when the structural elements are hidden from view by architectural finishes.

Figure 3: Diagram showing a spectrum of mitigation policy approaches ranging from least to most stringent.



Inventory Only	*Notify Only*	*Voluntary Retrofit*	*Disclosure Approaches*	*Mandatory Screening*	*Mandatory Evaluation*	*Mandatory Retrofit*
Staff, consultants, and/or a volunteer organization has created an inventory of one or more suspected hazard building types, but the list is not officially released to the public or acted upon.	An inventory exists and a policy has been established to notify owners if their property is on a suspected hazard building list.	Owners of properties on a publically available list are formally encouraged to retrofit, possibly by offering of technical assistance, financial help, or policy incentives.	Properties on a publically available list are subject to one or more methods of forced information sharing, such as tenant notification, public signage, or recorded notice on the property title.	Owners of properties on a publically available list are required to submit a form within a fixed time window that is filled out by a licensed building professional. Typically, the goal is to determine whether the property has certain characteristics that *might* associate with risk.*	Owners of properties on a publically available list are required submit within a fixed time window a formal evaluation completed by a licensed engineer. Typically, a determination is then made about whether the property has certain risk features.*	Owners of properties on a publically available list are required to complete a retrofit by a certain date. This step may be implemented following a screening or evaluation phase.*

* Note: Implementation and enforcement might be either: 1) triggered by sale or a significant work threshold or 2) via a proactive compliance timeline.

Notification

Once an inventory is created, a jurisdiction either by default or deliberately chooses whether or not to make that list public or take further actions. Some jurisdictions have created a list then not acted on it for a decade or more. For example, in the case of soft-story wood frame buildings, Santa Clara County's list has remained dormant since 2003, and nine years passed between the creation of a list and when the City of Berkeley passed its soft-story ordinance.

The most basic step is to notify owners that their property is on some kind of suspected earthquake hazard list. This is currently the URM policy of a small number of California jurisdictions, and the soft-story wood frame policy in the jurisdictions of San Leandro, Sebastapol, and Richmond. Available data about notification only programs shows them to have little impact; for instance, seven percent of URM properties in jurisdictions with this type of program are retrofit as of 2006 (CSSC, Status of the Unreinforced Masonry Building Law, 2006).

Little evidence exists about potential liability and market value impacts from becoming a "listed" earthquake vulnerable building. However, concern exists that mere creation of a list could have negative impacts if it becomes public (see more about Disclosure Approaches below). A Freedom of Information Act (FOIA) filing (for instance, by a journalist or citizen) could be used to compel a jurisdiction to reveal a list that has remained dormant. This happened in the case of Los Angeles with the Concrete Coalition's inventory of suspected concrete structures.[29] Experts in the earthquake field believe that media coverage of the list contributed to eventual passage of that city's mandatory evaluation ordinance in 2015, which included concrete structures. In sum, notification programs may have several downsides for owners while offering little in terms of on the ground risk reduction for the community.

Voluntary Retrofit

Following an inventory and notification process, or even after a mandatory screening or evaluation phase (see below), jurisdictions can choose to let owners decide whether or not to retrofit their building. Simply urging building owners that own a potentially earthquake vulnerable building may be enough to lead some to voluntarily retrofit.

[29] Key Los Angeles Times articles can be found at: http://graphics.latimes.com/me-earthquake-concrete/ and http://www.latimes.com/local/lanow/la-me-ln-concrete-buildings-list-20140125-story.html (Accessed April 11, 2016).

Retrofit rates for jurisdictions with voluntary URM retrofit programs averaged 16% in 2006 (CSSC, Status of the Unreinforced Masonry Building Law, 2006), and likely much lower than that for soft-stories (though no systematic data currently exist).

Jurisdictions that take a voluntary route often do so because they have a small number (presumably less socially-significant set) of vulnerable buildings. Another factor can be a sense that public support is lacking among decision makers, residents, or other stakeholders for mandatory requirements, perhaps because of local economic conditions that would make it difficult for owners to afford or get financing. The anticipated cost of the retrofit work can also come into play, as it can be more palatable to require owners to make investments that are a smaller share of the building's overall value.

Despite perceptions of politically feasibility and some measurable voluntary retrofit response, programs without mandates are almost always much less effective at actually reducing earthquake risk in the community in a significant way. Several factors appear to contribute to the handful of voluntary programs that have worked well. First and foremost, voluntary programs vary in the level of resources devoted, sustained effort, and set of complementary measures taken by the jurisdiction. The more dedicated a jurisdiction is to having a successful voluntary program, the more likely it is to have one. One tactic is to provide case by case assistance to owners in taking steps over time, a tactic sometimes used by jurisdictions with a small number of affected buildings. Another is to offer significant financial or policy incentives (examples of which are discussed below). On the public awareness front, providing educational materials that explain the risks to an owner and to the broader community and the benefits of protecting their financial investment may help.

Another thing that can make voluntary programs more successful is to threaten to institute a mandatory program in the future. Historically, many jurisdictions did adopt a voluntary URM program first, and then shifted to mandates later on. In the past five years, this has also happened with soft-story wood frame policies in the case of Oakland, San Francisco, and Berkeley. An explicit multi-phased approach was particularly effective in Berkeley, where one fourth of building owners affected by a mandatory evaluation requirement invested in a voluntary retrofit within the first two years. Owner interviews showed this was partly because they wanted to get a head start on later mandates that appeared inevitable (Rabinovici, 2012).

Disclosure Approaches

Notification and many voluntary programs are based on the idea that information and communication by themselves can influence the opinions and actions of owners, renters, and buyers. Officially publicizing a city's concerns about deficiencies of a specific building type could, for instance, change public opinion about the resale or rental value of listed properties, an owner's eligibility for refinancing or future loan terms, or the cost of purchasing earthquake insurance.

Jurisdictions have used a variety of techniques to motivate attention to seismic risk concerns. As discussed in the Task 2 report, **mandatory disclosure at time of sale** is a key part of state laws for pre-1960 homes in earthquake fault zones (CSSC, 2005). The most prominent policy is the state requirement for **signage** on all URM buildings. Similar signage has been required since 2007 on soft-story wood frame buildings in the City of Berkeley (Figure 4), and non-complying soft-story wood frame buildings in San Francisco Figure 5.

In Oakland, Berkeley, and San Francisco **tenants must be notified in writing,** and **official notices are recorded on the deed** for all listed soft-story wood frame buildings.



Figure 4: Photo of the warning sign mandated to be posted on buildings on the City of Berkeley's Suspected Earthquake Hazard Building List (*Photo: S. Rabinovici, 2011*).



Figure 5: Required placard for soft-story wood frame buildings that failed to comply on time with the mandatory screening phase of San Francisco's mandatory retrofit program.

In the case of soft-story wood frame buildings, leading jurisdictions have also put a public, sometimes searchable ***list of affected properties on a jurisdiction's website***, based on the idea that renters should be entitled to easily accessible information before they sign a lease. Such lists include the street address and potentially also the compliance status of the property. Owner names or contact information are not given, although anyone could search for that information through public permit and property records. Table 4 describes each of these tools in more detail and gives examples of use as well as advantages and disadvantages.

What all these measures have in common is that they make seismic risk issues more transparent and visible to affected members of the public. Disclosure is different than and goes beyond general public awareness. These measures are also meant to inform people about *specific* seismically vulnerable buildings, with the idea that it might change offering prices, mortgage availability and terms, rental or purchase decisions, or even whether someone wants to enter or stay very long in a building. In theory, as owners, tenants, bankers, and potential buyers become more informed, they can better incorporate seismic risk in their mitigation decisionmaking and assessment of property values.

Evidence suggests that notification, notices, and public lists can and do influence beliefs and behavior. For example, some soft-story wood frame condominium owners in Berkeley reported difficulty refinancing (Rabinovici, 2012). Even *perception* of market awareness can change opinions, even if there is little to no documented impact. In Berkeley, some owners said the worried at first about reduced demand or market price for units in their buildings and this motivated them to retrofit; however, these same owners years later did not report experiencing any problems with tenant recruitment or lost rental income (Rabinovici, 2012).

Earthquake warning signage was a prominent part of the state's URM program requirements; however, there is little evidence to show that such warnings are effective. A study of California Proposition 61 carcinogen and reproductive health warnings suggests that signs are not very powerful and become less influential on behavior over time as people become used to them. Some building users may even be personally annoyed by warning signs, because it reminds them of a risk that they can personally do little about. Some owners of soft-story wood frame buildings in Berkeley

reported having *tenants* that actively complained about or repeatedly ripped the required warning signs off the walls (Rabinovici, 2012).

Table 4: Description of disclosure approaches used in local earthquake risk reduction programs.

Name	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Mandatory Disclosure at Time of Sale	Sellers of property are required to disclose features that could relate to earthquake performance.	California Earthquake Fault Zone disclosure; Sellers of pre-1960 homes are required to fill out to the best of their knowledge and provide buyers with Residential Earthquake Hazards Report.	Empowers buyers to be aware of any known existing hazard issues.	Anecdotally, many buyers do not pay enough attention to these disclosures, which occur during emotional, busy decisionmaking periods. They may not seek expert information to interpret the reported information. It is also possible that sellers shirk on the disclosure requirements if buyers do not know that they are supposed to receive them. Difficult to enforce.
Recorded Notice on Deed	Jurisdictions can record on the property title or deed the fact that the building is subject to additional requirements related to its earthquake vulnerable status.	For soft-story wood frame: Oakland, Berkeley, and San Francisco.	Relatively low cost for jurisdictions to implement. Empowers buyers but also mortgage companies to be aware of any known existing hazard issues.	Anecdotally, it is not clear how many buyers or mortgage companies pay attention to these notices. Such notices are primarily effective only at time of sale or refinance.

Table 4 (continued)

Name	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Public Listing of Affected Properties	Jurisdictions that operate web sites to describe their programs can feature a full list of property addresses, potentially also including also the compliance status of the property. In general, owner names are not listed, though that information is available if a member of the public searched for it separately.	For soft-story wood frame: Oakland, Berkeley, and San Francisco.	Relatively low cost for jurisdictions to implement. Could be used by tenants and buyers when searching for properties, thus empowering well-informed market negotiations over pricing.	Website information needs to be updated on a regular basis in order to be perceived as fair and useful. Public lists work better if the property addresses are searchable, rather than static (e.g., on a pdf).
External Signage	Jurisdictions that operate web sites to describe their programs can feature a full list of property addresses, potentially also including the compliance status of the property. Some lists are searchable, while others are static.	California state requires a sign on all URM buildings. Similar signage has been required since 2007 on soft-story wood frame buildings in the City of Berkeley.	Advocates argue that signs are justified based on the public's right to know. The physical presence and repeated viewing of signage may make the issue more salient for visitors, employees, lease holders, and owners alike.	Owners may view the signs as stigmatizing or threatening to property value or business revenues, but anecdotally, it is not clear how much visitors, employees, residents, and other users of a building pay attention to signage when entering or leaving a property.

Table 4 (continued)

Name	Description	Examples of Use	Advantages	Costs, Issues or Concerns
Tenant Notification	Owners are required to present straightforward, standardized information about the listed status of the property. Some jurisdictions require proof of notification (e.g., tenant signature) to be returned and kept on file with the city.	For soft-story wood frame: Oakland, Berkeley, and San Francisco.	Tenant notification may be more influential than signage because it is personalized and the information is delivered at a useful time in that person's decision process. Advocates claim that tenant notification is justified based on the public's right to know.	To be effective, tenant notification should be required to occur well before the potential tenant is ready to sign the lease.
Earthquake Performance Rating Systems	Owners can be either encouraged or required to have their building rated on a standardized scale that classifies expected building performance in an earthquake in an easier to understand format, for instance from one to five stars. Viable rating systems exist for many building types.	The City of Los Angeles in 2015 officially launched a voluntary effort to encourage owners to rate their properties using the US Resiliency Council system and pledged to rate its own public buildings as well.	Rating system use is common for institutions like universities and hospitals. Mechanisms for implementing performance ratings for commercial use have recently matured and are now viable. Ratings have the potential to inform owner, renter and buyer decisions, creating a market effect.	Obtaining a rating potentially adds cost to a design project. Ratings systems such as USRC's are relatively new and not yet widely implemented.

An advantage of disclosure measures is they tend to be relatively inexpensive for jurisdictions to administer. Up to date website posting of the list of affected properties and their compliance status encourages people to visit the site as needed over time, people see signs every time they enter or exit, and properties may exchange hands many times. Eventually, a tipping point in community awareness and opinion about a class of properties can occur, as it did in the case of Berkeley for soft-story wood frame buildings.

The use of *positive* disclosure remains an untapped potential influence on market value of retrofitted properties as well as owners' retrofit decisions. This review did not identify any city programs that have taken the positive approach of recognizing or rewarding owners or announcing buildings that have been retrofit. One recent development is the existence of viable ***earthquake rating systems***. In November 2015, the non-profit US Resiliency Council[30] launched a non-profit credentialing and verification service through which owners can obtain externally checked, state-of-the-art assessment of the expected safety levels, repair costs, and time to regain function for their property. USRC ratings have the potential to play the same kind of role that the US Green Building Council did in promoting sustainable design, both for new construction and for retrofits.

USRC's system has already been adopted one California jurisdiction's policy. Los Angeles Mayor Eric Garcetti cited USRC ratings in that city's Resilience by Design report (City of Los Angeles, 2015), asking building owners to voluntarily use it, pledging to educate the public about seismic performance rating systems and how the information can be used, and announcing the intention to use it or some similar system to rate all city-owned buildings.

Mandatory Screening

Screening programs help jurisdictions collect more information about targeted potentially vulnerable buildings in a community, usually as a first step to later more stringent requirements for the subset that are found to have features indicating significant deficiencies. With relatively low cost and difficulty for owners, the jurisdiction can both make the issue visible and filter out properties that do not meet the eligibility or targeting criteria, thereby reducing the burdensome handling of errors and omission at a later stage. They also help jurisdictions determine the overall scope of the problem—how many buildings exist that have certain risk characteristics and how significant of a threat they pose in aggregate. This can help build the case for further legislation.

[30] The organization's website is: www.usrc.org (Accessed April 13, 2016).

For soft-story wood frame buildings, Oakland was a pioneer of the mandatory screening approach. An inventory of multifamily apartment buildings was created in 2008 with the help of volunteers and non-engineers under a contract with ABAG. This survey identified 24,273 residential units in 1,479 buildings with five or more units, between two and seven stories, built prior to 1991, that had wide open spaces for parking or commercial uses on the ground floor (ABAG, 2014). Spot testing suggested the list might have error rates that could potentially undermine future program effectiveness, and might be politically unacceptable (personal communication, Jeannie Perkins, 2008). Therefore, in 2009 the City passed ordinance Number 12966 which declared these buildings "potential soft-story buildings" and mandated submittal of a *Level 1 Screening–Non-Engineered Analysis*. The screening had to be performed by a registered design professional, licensed contractor or certified inspector, to provide some assurance of accuracy regarding features that might related to risk. Anecdotally, the cost to owners for this was generally around $200 to $500. This can be summarized as a *rule-in* screening approach.

Persons involved with analyzing Oakland's program (personal communication, Danielle Hutchings-Mieler, 2011) concluded that many owners were confused, compliance was lower than hoped, and exemptions may have been given without adequate quality control of the reported data. This later contributed to the decision to incorporate mandatory evaluation phase when the city of Oakland was ready to move towards a mandatory retrofit program. In other words, a less than satisfactory implementation of a screening phase can slow down progress towards and increase the effort required in future retrofit programming.

In its approach to soft-story wood frame buildings, San Francisco opted for a screening phase to weed out obviously non-affected properties, for instance those misidentified as having the correct number of units, stories, or first floor uses (primarily focusing on *ruling out* inappropriately included properties). Similar to Oakland, the screening had to be performed by a registered design professional, such as a licensed contractor, engineer, or architect. Compliance in filing screening forms by the initial deadline was 98%, a success which was helped by a suite of outreach activities including four waves of post card reminders, a retrofit fair, a weekly updated website, an advisory group process, and multiple public meetings. The compliance postcards used took advantage of real-time information sharing to "nudge" owners to respond, such as mentioning how many other owners had already taken action by that point (see Figure 6).

NOTICE

YOU ARE REQUIRED BY LAW
TO COMPLETE A SOFT STORY SCREENING FORM BY SEPTEMBER 15, 2014

Nearly 3000 buildings like yours have already returned their screening forms. Many owners have begun their required upgrades, while many are not required to retrofit at all. Act now to avoid penalties!

Dear Property Owner,

A building you own was noticed on September 15, 2013 as part of the **Mandatory Soft Story Retrofit Program**. All property owners noticed under this program are required to have a licensed design professional complete a screening form, though not all owners will be required to retrofit. This completed form must be submitted to the Department of Building Inspection by September 15, 2014. If this form is not returned the property will be in violation, resulting in fines, a hearing, and the posting of a placard notifying building occupants. Visit the DBI website to see the status of properties. Act today!

For another copy of this form or if you have any questions, please call 415-558-6699, email *softstory@sfgov.org*, or please visit *www.sfdbi.org/softstory*.

Figure 6: Front and back of a compliance reminder postcard sent to affected owners in the City of San Francisco's soft-story wood frame program.

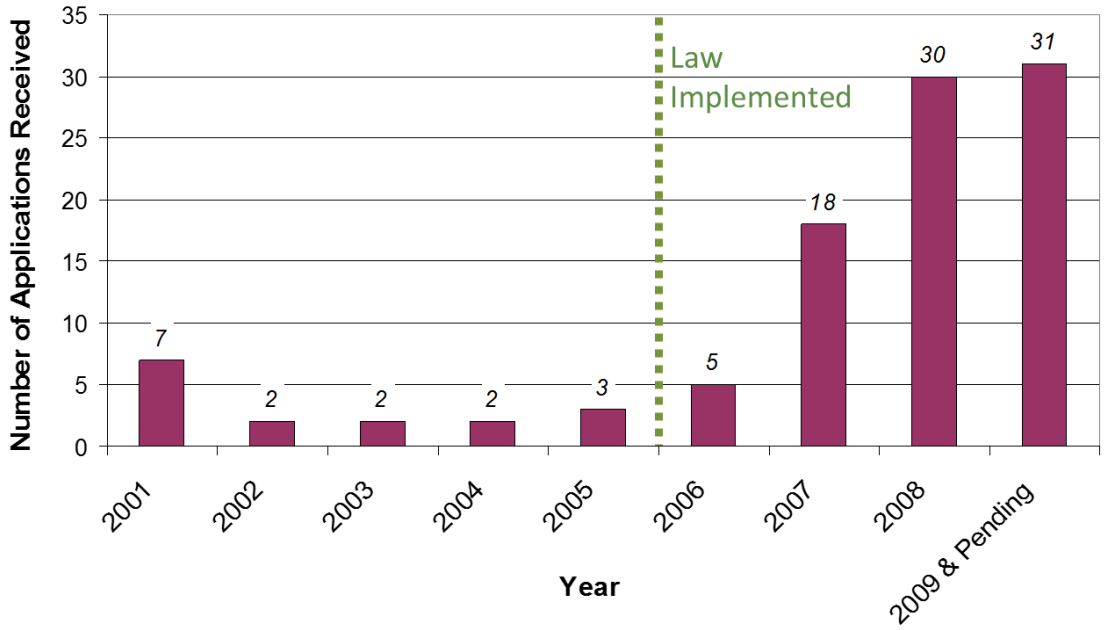
Mandatory Evaluation

In the 1980s, Palo Alto was an early innovator with the technique of requiring owners of certain buildings in a community to file a formal engineering evaluation (Herman et. al., 1990). Because a licensed engineer (or structural engineer) must perform this work, such evaluations are approximately an order of magnitude more expensive than screenings. Evaluation costs for soft-story wood frame buildings in Berkeley, for example, were approximately $2,000 to $5,000 (Rabinovici, 2012). However, evaluation costs may vary substantially for other building types that are more difficult to assess, in other jurisdictions, and/or where evaluation requirements are more extensive or complex.

Evaluation programs are costlier for jurisdictions to administrate than screening programs for a variety of reasons, but provide several advantages. Jurisdictions typically give owners more time to comply longer, owners need more guidance on how to comply, and there is increased need for processing time and more qualified reviewer labor. In Berkeley, report review was contracted out to plan checkers for a flat fee of $583 per evaluation report, and this did not cover jurisdiction staff time.

On the benefits side, evaluations offer greater hope of achieving tangible risk reduction. As noted, a remarkable one in four soft-story wood frame building owners voluntarily retrofit in the wake of mandatory evaluation policy implementation in Berkeley, which meant over 2,000 of its residents now live in buildings that likely would not have been retrofitted otherwise. Interviews with soft-story wood frame owners in Berkeley also showed that many considered mandatory evaluation more fair than a voluntary retrofit program because it "leveled the playing field" (Rabinovici, 2012). Rather than having retrofit practices in their community determined *ad hoc*, all owners of similar properties were now being treated alike.

However, the benefits of mandatory evaluation are undeniably uncertain and dependent on whether community circumstances are conducive to create a significant voluntary retrofit effect (Figure 7).



Note: Data collected April 2010, Source: D. Lambert, personal communication.

Figure 7: Graph showing a seven-fold increase in permit applications in the four years immediately following passage of Berkeley's 2005 mandatory evaluation law for soft-story wood frame buildings.

Mandatory Retrofit

Through California's URM law, hospital, and school programs as well as soft-story wood frame buildings at the local scale, there is clear precedent for imposing earthquake retrofit work to be done for certain buildings. This is the most effective type of program for ensuring that on the ground risk reduction will be done. As discussed in the Task 2 report, on average over four times as many URM building cases have been retrofit in California in mandatory programs (70%) compared to voluntary ones (16%). However, because mandatory programs require all buildings to be addressed, owners with the most marginal properties cannot avoid taking action, in some cases leading to higher demolition rates (Comerio, 1992). In the case of URM buildings, mandatory retrofit programs did have higher demolition rates than voluntary programs, 17% compared to 8% respectively (CSSC, Status of the Unreinforced Masonry Building Law, 2006).

Depending on the program timeline, it may take years to decades for tangible risk reduction to be realized. Retrofit projects naturally occur in steps, and can only be carried out as quickly as

financing, contracting, any tenant relocation, or construction logistics allow. Thus, compliance periods for mandatory retrofit programs need to be longer than for mandatory screening or evaluation programs. For URM buildings, many jurisdictions tended to set deadlines of ten years or more, followed by generous extensions. For soft-story wood frame programs, jurisdictions have given owners one to three years for first steps such as appeals, hiring an engineer, complete an acceptable engineering report, or submit a permit application and retrofit plan. Following that, owners are typically given another one to three years to complete construction (see Table 3), in part to secure financing, time to work around planned vacancies, and for adequate design. Longer timelines or exemptions can be offered for complex buildings that may require costlier or innovative engineering solutions (for instance, historic properties). Again, this is where phasing or tiers can be helpful.

Another difficult aspect of retrofit programs (even voluntary ones) is that jurisdictions need to set specific expectations for what constitutes an acceptable retrofit. Jurisdictions have handled this in a variety of ways. Retrofit ordinances typically directly reference one or more particular standards (or equivalent criteria). The table of soft-story wood frame programs (Table 3) shows that five or more standards have been referenced recently and several jurisdictions reference more than one, which can increase compliance ambiguity and the level of reviewer skill required but also an engineer's discretion to use the one most appropriate for their client's situation.

Also at issue is how much and how far a building's vulnerabilities should be retrofit. For instance, in the case of soft-story wood frame buildings, a retrofit can be designed to address only the first story weaknesses, rather than all seismic vulnerabilities that are identified. Jurisdictions such as San Francisco and Berkeley have chosen this route, in part because it lessened political resistance to creating a mandate and addressed the most severe deficiencies. Other deficiencies above the first story may remain and may lead to damage in an earthquake.

In the case of mandatory evaluation or retrofit programs, owners and their engineers will also need guidance about how to prepare an acceptable evaluation, and how to submit a concurrent retrofit permit application. Owners in Berkeley realized a major financial advantage to paying their engineer to do both an evaluation for the jurisdiction and a full set of retrofit plans at the same time (Rabinovici, 2012), so having clear retrofit standards in place already was a major boon to those owners.

The potentially negative effects on public safety and on owners of choosing a longer compliance timeline should be noted. Earthquakes can occur at any time, so a program that offers longer compliance windows in effect allows people in the community to spend more time using and owning buildings that the jurisdiction has deemed unacceptable in the long run. Also, real liability consequences may exist for owners that delay in doing mandated retrofit work, even before an accepted compliance window has elapsed. A California Appellate court awarded $2 million to family members of two women who died in a URM collapse in the 2003 San Simeon earthquake.[31] In doing so, the court rejected the defendant's claim that they had no duty to retrofit the building until 2018, the deadline established by the San Louis Obispo mandatory retrofit ordinance.

Incentives

To complement any of the above program formats, jurisdictions can offer either financing- or policy-oriented incentives. Many ways exist to encourage and ease the path for owners to complete either voluntary or required retrofit work, or even to help them submit timely screening forms or engineering reports. Financial incentives and tools provide monetary assistance, either directly to an owner or via the jurisdiction. ***Financial incentives*** include measures such as tax credits, tax rebates, grants, or fee waivers that make a retrofit less expensive to complete. ***Financial tools*** (e.g., special low-interest financing programs) provide a mechanism for an owner to obtain the necessary funding, potentially at lower cost or paid back in ways other than for a traditional loan. ***Policy incentives*** are meant to encourage private funding of mitigation, and include for example expedited review, exemptions, development bonuses, or technical assistance. These measures offer owners indirect but potentially valuable benefits as they take each mitigation steps.

Figure 8 provides a summary list of potential incentive types, while Appendix C gives details about example uses, advantages, and disadvantages of each.

A group of agencies completed an inventory of jurisdiction incentive strategies using a survey of California local governments in the mid-90s (ABAG, Seismic Retrofit Incentive Programs: A Handbook for Local Governments, 1996). Though outdated and only 35% of contacted jurisdictions participated, the report summarizes the types of URM and other earthquake programs that different jurisdictions adopted and the kinds of assistance that owners could receive. The researchers also did interviews to collect detailed information about fifteen illustrative cases at the time, including Palo Alto.

[31] See press coverage: http://calcoastnews.com/2010/06/court-finds-paso-robles-business-owners-liable-for-earthquake-deaths/ Accessed April 13, 2016.

	FINANCIAL TOOLS AND INCENTIVES (mechanisms that make financing more accessible or directly reduce project costs)	POLICY INCENTIVES (mechanisms that deliver indirect benefits to owners)
COST AND IMPLEMENTATION DIFFICULTY — Lower	Waivers or Reductions of Building Department Fees	Exemption from Future Retrofit Requirements
	Pass Through of Retrofit Costs to Tenants (for jurisdictions with rent control)	Expedited Permits, Inspections, and Reviews
	Property-Assessed Financing Loans (PACE)	Exemptions or Relief from Standards or Non-Conforming Conditions
	Subsidized or Special Term Loans	Condominium Conversion Assistance
	Real Estate Transfer Tax Rebates	Technical Assistance for Retrofit Projects
	Special District or Historic Designation Tax Reductions	Zoning Incentives (e.g., relief from use restrictions)
	Tax Credits	Transfer of Development Rights (TDR)
	Grants	Density or Intensity Bonuses (e.g., Floor Area Bonus)
Higher	General Obligation or Special Purpose Bonds	

Figure 8: Types of financial incentives and tools as well as policy incentives that have been used in local earthquake risk reduction programs in California, in approximate order top to bottom from lowest to highest cost and difficulty of implementation.

Several points stand out in the ABAG report regarding incentive use and effectiveness. First, most jurisdictions offer a number of different incentives, rather than just one approach. This makes sense

because building and owner circumstances vary widely; what may help one owner might be irrelevant or inappropriate for another and *vice versa*. Second, jurisdictions have taken widely different approaches with incentives, from offering almost nothing to offering substantial loans and grants. Jurisdictions tend to come up with incentive offerings closely tailored to their own goals and circumstances, based on economic conditions, building stock vulnerabilities, political will, and other factors. As a result, there is no single best incentive package to offer.

Another key point is that creation and operation of incentive programs is intense and must be locally customized. Extensive community education and involvement are required to assess needs, design and advertise the incentive offerings, and to help owners take advantage of them. Guiding community members through the mitigation process is time consuming and difficult, usually requiring at least one full time staff member who also has to coordinate with staff across several departments. That means the personalities, technical skills, and political savvy of the internal team will be critical, and likely variable over time, due to natural staff and political turnover issues.

The effectiveness of different incentive approaches, individually or in packages, has not been systematically studied. Both ABAG and the San Francisco CAPSS project have produced high level lists of potential incentive tools (ABAG, 2014; Samant & Tobin, 2008) but do not specify which tools are being used where and to what effect. Many listed approaches are rarely or no longer being used. All the variety makes it difficult to draw overall conclusions as to which incentives have worked "best" where and why.

3. Implications and Potential Policy Directions for Palo Alto

Palo Alto is a medium sized, compact city with a diverse population and vibrant local economy. Nested in the heart of Silicon Valley, the cost of living and development pressures are high, and space for growth is limited. A high degree of interconnectedness with surrounding communities and a dynamic natural environment is also evident.

As a community, Palo Alto cannot ignore its proximity to several major faults and the fact that it has many different vulnerable building types. The estimated losses in a major event are significant. Fortunately, Palo Alto has a legacy of proactive policy leadership in addressing earthquake risks, and a relatively high degree of citizen and local government capacity. The potential benefits from retrofitting are large. City leaders, by investing this year in risk assessment and a policy development dialog, have demonstrated their capability and will to act.

This review found no simple best local earthquake mitigation policy model for Palo Alto to follow. Each of the jurisdictions mentioned in this report has crafted, often over a decade or more, a unique package of measures suited to their own local economic, social, political, and risk realities. Palo Alto must do the same.

In developing its own strategy, Palo Alto can learn from this variety among local mitigation programs. It can build on the successful framework of its own existing program while also combining and tailoring new elements that are working for other jurisdictions.

Choosing Goals and Desired Outcomes

One way to measure success is in relation to program goals and resource realities. From that standpoint, each of the programs mentioned in this report is successful to some degree.

Some jurisdictions set out to do what they could with limited resources, progressing only the first steps of developing an earthquake mitigation program. The City of Richmond, for example, developed an inventory, hosted a community meeting, and notified owners as part of creating a very low cost voluntary approach to soft-story wood frame buildings. The good news is that by doing so, it achieved meaningful progress relative to jurisdictions that have done nothing. Public leaders and the broader community are more aware, city reputation and visibility have been enhanced, and city staff are now better connected to a network of local earthquake professionals that can help facilitate future action if and when that becomes possible. The bad news is that Richmond has been stymied so far by the departure of key staff, limited jurisdictional resources, and the limited resources of its soft-story wood frame building owners and tenants; a more aggressive retrofit program is not realistic until an outside source of funding is found.

At the other extreme, a few leading jurisdictions set out to comprehensively assess earthquake vulnerabilities and risk reduction opportunities community-wide through a lengthy, relatively expensive, and collaboratively-informed processes. San Francisco and more recently Los Angeles are the most prominent users of this approach, producing in-depth reports and resilience plans intended to guide city efforts for decades. Importantly, these plans encompass many city activities and roles, types of buildings and building uses, different phases of the disaster cycle, and explicitly seek to connect earthquake mitigation efforts to a host of other community resilience concerns, from sea level rise to water supply reliability to telecommunications operations (Several leading local program models and planning resources for these types of efforts are introduced in Appendix D).

In between are jurisdictions where program goals are *either* narrower in scope with more vigorous requirements (such as the City of Fremont's mandatory retrofit program for soft-stories) or wider

scope with less vigorous requirements (such as the City of Santa Monica, which mandates retrofits for soft-story wood frame buildings and nonductile older concrete structures but only when triggered by a substantial renovation).

The City of Berkeley took a phased, relatively aggressive approach to soft-stories, but has yet to put in place a program to address the 50 or so tilt-up concrete structures it has identified. Oakland is also somewhat unique in being a larger city that has mandated soft-story retrofits without initially taking a comprehensive approach. However, both Berkeley and Oakland benefited first from substantial volunteer professional involvement and later from sizeable, multi-year Rockefeller Foundation 100 Resilient Cities grants. Through the early help of both volunteers and consultants, Berkeley and Oakland laid the groundwork for mandatory programs that likely helped to attract the additional philanthropic attention and assistance. Berkeley has now produced, and Oakland is on its way to producing, a comprehensive resilience assessment and plan similar to what was done by San Francisco and Los Angeles.

In this light, Palo Alto is currently in the "middle" group in terms of its scope and requirements for seismic safety compared to other leading jurisdictions. Palo Alto set new policy precedents in the 1980s with its community engagement, mandatory evaluation, and voluntary retrofit programs for three different categories of structures. However, this only addressed a small subset of its overall vulnerable building stock. By investing in data collection and community discussions this year, Palo Alto is now poised to move forward into a new position of seismic policy leadership.

It is critical to first clarify community values and goals before designing a program to try to achieve them. All stakeholders should be invited to participate in discussions of what matters most to the City and the people who live, work, and invest in it. Common broad goals include increased public safety, reduced private property damage, and reduced downtime and displacement of businesses, consumers, and residents. However, addressing of different building types may advance these goals to different degrees and with different levels of certainty and speed. For instance, addressing soft-story wood frame housing may have little direct benefit for local businesses but would reduce renter displacement. Retrofit of older concrete structures might address concerns about provision of basic services after an event, but would have little or no benefit for housing.

If the goal is to achieve the greatest reduction in losses, Palo Alto should address building types known to be potentially hazardous *that occur in large numbers*. Once community discussions lead to a sense of priorities and preferences, trade-offs and alternatives for pursuing each goal can be understood and considered.

Wherever Palo Alto chooses to focus, it should strategically combine policy features to promote risk reduction. As this report revealed, regardless of scope, the most effective programs use a package of measures to tip the balance away from the status quo by publicizing and increasing the consequences of not retrofitting while also publicizing, easing the costs, and increasing the benefits of retrofitting.

Potential Policy Directions

Coming out of this local program review is a list of alternative approaches for Palo Alto to consider:

Option 1: Status Quo

In this option, the existing ordinance with its mandatory evaluation, voluntary retrofit approach remains in place without changes. This covers 89 buildings and has three categories: Category I—unreinforced masonry (except for under 1,900 sf with 6 residents), Category II—built before 1/1/1935 with 100 or more occupants, and Category III—built before 8/1/1976 with 300 or more occupants. As of 12/9/14, City records indicated that sixty-six of the buildings had been either retrofit, demolished, planned to be demolished, or found exempt, while 23 remained unaddressed. Evaluation was mandatory, and owner funded but retrofit is voluntary. The list is publically available by request, but not advertised. Floor area ratio bonuses are (were) available.

Option 2: Increase Scope, but Retrofit Remains Voluntary

Additional categories of structures would be added to the mandatory evaluation requirements. Palo Alto can consider programs for soft-story wood frame buildings, older concrete buildings, older tilt-up buildings, and older steel moment frame buildings. Precedents exist for programs addressing each of these structural types that pose well-identified, publicly important risks. Completion of an evaluation report could be separated into different timelines, for instance three to ten years, depending on degree of hazard. Palo Alto could also use location, occupancy type, and/or number of occupants as criteria in defining the scope or compliance timelines.

Option 3: Similar to Option 2, but Additional Disclosure Measures are Incorporated

This option would be similar to Option 2, but the list of buildings and status could be prominently posted on City website, tenants could be notified, signage could be required, and/or a recorded notice could be added to the property title. These options enhance transparency with the public and reward owners that retrofit by increasing the perceived benefits of retrofitting among potential tenants and buyers. Relatively inexpensive measures like these have been shown to be effective in increasing public awareness and motivating greater consideration of earthquake risk in private decisionmaking, including voluntary retrofits.

Option 4: Increase Scope, Some Categories are Voluntary and a Few Categories are Mandatory, with Enforcement by Trigger Threshold

This option builds on Option 3, but retrofitting would be required for some building types *at whenever future time a building is sold or undergoes substantial renovation* above a set threshold.

Option 5: Increase Scope, Some Categories are Voluntary and a Few Categories are Mandatory, with Enforcement by a Fixed Timeline

This option would be similar to Option 4, but retrofitting is required *according to a fixed timeline*. Timelines and enforcement emphasis could vary depending on tiers or priority groupings to motivate prompt action for the most vulnerable or socially important structures. In some cases, longer time frames are adopted for some building types such as older concrete, to ease the burden on owners and allow for technical advancement in retrofit techniques.

Option 6: Similar to Option 5, but More Categories are Mandatory

This alternative is similar to Option 5, but retrofitting would be required for additional categories. Palo Alto can also make its programs more stringent over time. Explicit phasing has been successful in jurisdictions like Berkeley and San Francisco for generating political consensus and enhancing administrative feasibility.

This array of options can be also be shown in diagram format (Figure 9), which shows how a number of jurisdictions in this report have positioned themselves in terms of the relative strength of their requirements and the number and scope of the building types addressed.

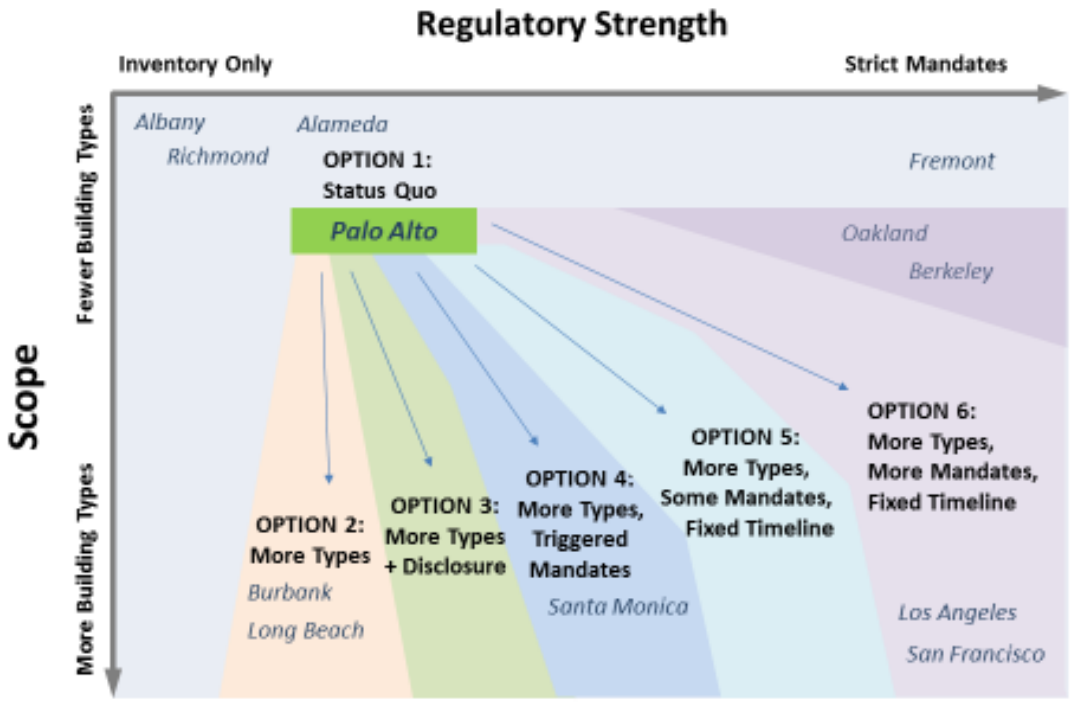


Figure 9: Diagram showing alternative policy directions for Palo Alto in the context of other jurisdictional earthquake mitigation programs.

When considering options, Palo Also leaders and community members should keep in mind the following additional findings from this review:

- Mandating retrofit is the surest way to achieve risk reduction.
- Jurisdictions are increasingly using disclosure measures to motivate retrofits in both voluntary and mandatory programs, and such approaches have been shown to be powerful and relatively low cost to implement.
- Many mandatory programs use intermediate mandatory screening and/or evaluation phases to better gauge the risk and filter out properties that need not comply before implementing retrofit requirements.
- Fixed timelines allow a jurisdiction to prioritize and control the pace of risk reduction, provide a predictable planning horizon for owners.

Incentive Options and Considerations

By offering a strategic set of incentives and devoting a steady, adequate program budget, Palo Alto can create a program that eases the financial and logistical burdens on owners and provides adequate technical assistance to support retrofit project completion. Small incentives are meaningful and helpful to owners, while larger incentives may be critical for a subset of owners that face particularly complex or costly projects.

Palo Alto has several traits that could make policy incentives (non-monetary assistance) particularly effective. One is a relatively manageable number of affected buildings for some building types. This means city staff might be able to provide high quality assistance to owners in complying and taking advantage of any special programs. Palo Alto is a highly desirable locale with a highly educated, real estate savvy population, and robust real estate market. Palo Alto has experience using policy incentives in the past, so staff and many owners are familiar with them.

Despite limited data on their use or effectiveness, incentives can be politically important and provide a variety of benefits. Below are some specific ways incentives could play a role in Palo Alto's future program and some steps that Palo Alto can take to create a package of incentives effectively tailored to its own goals and circumstances.

- **It is good to offer small incentives to all owners because it fosters positive interest in the program and builds community good will.** Modest incentives, on the order of a few hundred dollars, help acknowledge the public value that is being created by the efforts undertaken by owners. For example, offering fee waivers is a gesture that owners will appreciate, if not expect. Expedited permitting is likely to be viewed similarly, because time equates with money. Policy incentives tend to be in the direct control of the City to implement, and are often cost-effective and very helpful for owners in smoothing the path and easing the hassle of doing retrofit work.
- **Incentives are especially important to the outcomes of voluntary programs. Incentives play slightly different roles in mandatory compared to voluntary programs.** In the case of mandated upgrades, incentives essentially ease the burden of doing what has to be done or to make it happen more quickly. In the case of, voluntary programs, the goal of incentives is to motivate retrofit work to occur that might not have otherwise. In this way, incentive offerings are more critical to the *degree of risk reduction achieved* in the case of voluntary programs, and to *political viability, perceptions of program fairness, and speed* of risk reduction achieved in the case of mandatory programs. Bottom line, in the case of URMs, a small number of voluntary programs with substantial incentives have achieved similar

success compared to mandatory programs. With soft-story wood frame buildings, voluntary programs in the absence of incentives alone have not been enough to motivate retrofit work to be done. An exception is for owners in financial hardship, where incentives are most meaningful in mandatory programs.

- **Design the incentive strategy to match the circumstances of the locally targeted building stock.** FAR bonuses are likely irrelevant for soft-story wood frame buildings which are seldom renovated to include more units or changes of use, but relaxing of parking requirements or special provisions for condominiums may help. Mixed-used and historic buildings may require deeper financial assistance when they face high costs associated with retrofitting due to complex design issues, ADA compliance, and imposed restrictions on changes in use.

- **Take time to assess actual need for incentives and the types that will make the most difference to affected Palo Alto owners.** Larger *policy* incentives like FAR bonuses can be very effective, especially in higher income, higher growth communities like Palo Alto. In contrast, larger *financial* incentives can be difficult to orchestrate and have not always been as necessary or useful as hoped. Surprisingly, jurisdictions have sometimes found they have to "sell" incentives programs to owners. Certain strategies tend to be very challenging and costly to get the incentive to work compared to the amount of good they seem to do. Such may be the case with PACE financing,[32] as seen through the experiences of San Francisco and Berkeley for soft-story wood frame buildings. When private market capital is affordable, loan programs may not be needed or utilized. Use of larger, more complex incentive instruments in general increases the amount of hand holding that is needed and the amount of time until retrofits are completed.

- **Consider offering larger incentives to only those owners or properties that qualify or meet certain social importance or hardship criteria.** Interviews in Berkeley (Rabinovici 2012) showed that soft-story wood frame building owners were open to the possibility of need-based financial help. They did not want financing programs to reward ignorance or risky business practices, but as long as the criteria are clear and the process is fair and transparent, many expressed support for programs that would help fellow owners that are truly burdened or in need. There was also support for using social or resilience importance as part of the criteria for special financing eligibility.

[32] Information about San Francisco's PACE program can be found at: http://www.sfgov.org/esip/seismic-retrofit-financing Accessed April 11, 2016. Information about Berkeley's PACE programs can be found at: http://www.ci.berkeley.ca.us/PACE/ (Accessed May 2, 2016.)

- **Integrate incentives as seamlessly as possible into the overall compliance process.** Incentives work best when they are delivered in a timely way, right when people are already making important property or financial decisions. One notable example is the City of Berkeley's transfer tax rebate for single family home seismic improvements, which is available retroactively two years before through two years after time of sale. Another is Palo Alto's floor area ratio (FAR) bonus for retrofit of designated vulnerable structures, which allowed owners the chance to plan in additional space at the same time a retrofit is being designed.

- **Beyond money, it will be important to offer technical assistance, and this can be very helpful and even critical for some owners and engineers.** Retrofitting is not a simple process, and ironically it can become even harder for an owner if it happens as part of a jurisdictional program that requires or is intended to encourage it. Obtaining financing, especially through special programs, may also require intense staff effort.

- **Beware of the timing and costs of seeking public support for new bond financing.** In Berkeley, attempts were made to make a pool of funds available to owners through a transfer tax increase measure on the November 2002 ballot, but it failed to get the required two thirds vote. Participants in retrospect considered the campaign poorly run, but the state of the local economy probably played more of a role than any decrease in support for mandatory retrofit in concept.

- **Consider creation of formal cost-sharing arrangements between tenants and owners.** Part of the financial equation surrounding any upgrade work is the owner's ability to capitalize on the value added to the structure. In the case of rent control, the rate for pass through of capital improvements is a matter of law. Jurisdictions like Oakland, Berkeley, and San Francisco have negotiated cost-sharing arrangements ranging from 50 to 100% that allow owners to increase rents up to a certain percent of the retrofit cost, over a specified time period (usually 10 years). Even though Palo Alto does not have a rent control ordinance, it could establish a permitted amortization schedule into any new retrofit law, which could lessen the impact for tenants of any resulting rent increases.

Disclosure Measure Options

With relatively modest expense for a jurisdiction, disclosure measures can inform the populace and leverage social and market awareness to amplify program effectiveness. In effect, signage, tenant notification, internet lists, and other disclosure tactics make more transparent both useful risk information and the policies a city is using to address risk.

Public perception of disclosure policies has been on balance positive but not without critique. On the one hand, revealing property addresses that are subject to an ordinance can be thought of as making more accessible information that is already public. It spares all parties of going through the time and hassle of formal information requests. It is also consistent with a philosophy of the public's right to know, and may be legally protective for both owners and jurisdictions against accusations that important risk information is being held back. On the other hand, the media has at times portrayed signage as a shaming device, though this may depend on a sign or placard's particular graphic design and wording. Soft-story wood frame owners in Berkeley described the overall suite of disclosure measures imposed there as a "scarlet letter."

San Francisco included disclosure practices as part of its first "nudging" phase in their program plan. In essence, before and in complement to implementing mandates, San Francisco's plan called for trying to increase understanding in the real estate market empower tenants, buyers, and even owners (who could now more credibly and prominently claim credit for early compliance, retrofitting ahead of schedule, or voluntarily taking extra steps).

Evidence about the effectiveness of disclosure, either together with other policy requirements or separately, is quite limited. In at least one case, voluntary retrofit programs combined with disclosure measures have achieved significant risk reduction. Berkeley's mandatory soft-story evaluation program had several prominent disclosure features and resulted in a 25% voluntary retrofit rate in the first four years (Rabinovici, 2012).

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CHAPTER IV.

BUILDING INVENTORY FOR LOSS ESTIMATE

One of the first steps in the study was to develop a digital inventory of buildings in Palo Alto that includes all the information necessary to build the exposure model for the loss estimate. Information sources used to develop the inventory included county tax assessor files, City GIS files, a survey done by the Palo Alto Fire Department and San Jose State University of soft-story wood frame buildings, field notes from the building department files of selected buildings when the 1986 ordinance was being developed, Google Earth and Street View visual reviews, and an extensive sidewalk survey.

The Santa Clara County tax assessor's files, which included 21,187 parcels of real estate in the City of Palo Alto, were used as a starting point to develop the building inventory. The 15,198 parcels designated as single family or two-family residences were first removed, as these were excluded from the study, leaving 5,989 parcels of interest. A parcel is not always equivalent to a building. On one hand, there are some sites where there is one owner and one tax parcel, but there are multiple buildings. Sometimes, it is easy to distinguish the separate buildings from an application like Google Earth or Street View as there is sufficient separation between the structures; in other cases, a field survey is needed when the seismic separation is small (or not present). On the other hand, condominiums can be a single structure, but have multiple owners and thus multiple separate taxpayers and parcel numbers. For the 3,630 residential parcels with three or more units, we found 1,324 distinct buildings. Of the remaining 5,989 – 3,630 = 2,359 tax parcels, we found that 961 tax parcels were identified as "possessory interest." They are used at the city-owned Palo Alto airport for administration of property taxes for concessionaires and for other purposes at other locations in the city, and they do not represent buildings. When they were removed, there were 1,398 non-residential buildings. They were combined with the 1,324 residential buildings for a total of 2,722 buildings.

The assessor's data typically included parcel number (APN), year built, occupancy type, square footage, and number of stories. These data were supplemented with ArcGIS shape files of building and parcel outline from City GIS files, providing the geospatial location of each parcel (by latitude/longitude).

In addition to this information, the exposure model requires basic data on structural system needed to classify each building into a Hazus Model Building Type. For some buildings, this information was

available from earlier inventory efforts, including a select set of inventory forms used in developing the current seismic mitigation program, and a survey by SJSU and the City's Fire Department of soft-story wood frame buildings. However, for many buildings no structural system could be assigned based on available records.

The field survey was used to assign the seismic force-resisting system (using the basic FEMA Model Building Type classification system), and to confirm and supplement information acquired from the digital files for number of stories, occupancy (using the Hazus occupancy categories), building area, and year built. In addition, buildings were surveyed for vertical and plan irregularities.

After the sidewalk surveys and additional quality assurance refinements, we identified a total of 2,632 buildings in the study group for Palo Alto. This included 66 buildings subject to Palo Alto's current seismic mitigation ordinance, because 23 of the original 89 buildings subject to the ordinance have been demolished.

Not all buildings were field surveyed and not all key attributes needed for loss estimation were available for all buildings. For buildings that were not surveyed and were missing information, the missing attributes were developed using statistical comparisons with buildings that were surveyed on a sector by sector basis. A multi-step procedure was developed to fill in other missing attributes based on the best available comparative information. For example, buildings with missing occupancy and number of stories were assigned occupancies and number of stories with the same distribution of occupancies for surveyed buildings in that sector. For buildings with missing square footage data, the median values in the sector for residential and non-residential buildings were used. In assigning missing seismic force-resisting system information and year built, some rules were applied based on typical building practices. As a result, while the information for buildings that were not surveyed may not be fully accurate at the individual building level, the overall data set is seen as sufficiently representative for the type of loss estimates used in the project and relative comparisons made between different building types that are discussed ahead.

In addition to the information discussed above, a replacement cost had to be established for each building. Standard 2014 RS Means Replacement Cost values included in the loss estimation software (Hazus) used were reviewed as a starting point, but not considered representative for Palo Alto. R+C and Vanir Construction Management prepared adjustments to RS Means values to capture 2016 data and local factors. These were reviewed by a task group of the City's project Advisory Group that included local design professionals and developers familiar with the local cost climate. The group recommended an increase of the values in general, and identified target values for selected common occupancies. Based on these recommendations, R+C updated the values and Vanir reviewed them and revised the non-targeted occupancies for estimating consistency. The resulting replacement costs are shown in Table 5, and were used in the loss calculations. It is noted that resulting costs are 1.7-2.6

times the RS Means-based Hazus default values (2014 cost data), and that costs are intended to be representative of averages across the town.

Table 5: Average $/SF replacement building cost by Hazus occupancy class.

Occupancy Class	RS Means 2014 Average Palo Alto Cost[1] [$/SF]	Market Factor for Palo Alto	Escalation Factor from 2014 costs to 2016 costs	Demo & Minimal Sitework (5' around building) [$/SF]	Soft Cost Premium[2]	Average 2016 Palo Alto Cost w/ Soft Costs [$/SF]	Multiplier (Replaced with Soft Costs / RS Means)
Multi Family, duplex	$130.75	40%	10%	$17.50	20%	$263	2.01
Multi Family, triplex/quad	$114.94	40%	10%	$17.50	20%	$233	2.03
Multi Family, 5-9 units	$206.41	40%	10%	$17.50	20%	$402	1.95
Multi Family, 10-19 units	$194.12	40%	10%	$17.50	20%	$380	1.96
Multi Family, 20-49 units	$212.26	40%	10%	$17.50	20%	$413	1.95
Multi Family, 50+ units	$199.90	40%	10%	$17.50	20%	$390	1.95
Temporary Lodging	$217.83	40%	10%	$17.50	20%	$424	1.94
Institutional Dormitory	$234.44	50%	14%	$25.00	20%	$511	2.18
Nursing Homes	$238.07	50%	12%	$25.00	20%	$510	2.14
Retail Trade	$121.66	80%	10%	$17.50	20%	$310	2.55
Wholesale Trade	$118.13	60%	10%	$17.50	20%	$$270	2.29
Personal & Repair Services	$143.47	60%	10%	$17.50	20%	$324	2.26
Professional/Technical/ Business Services	$194.52	65%	12%	$17.50	20%	$452	2.33
Banks	$281.88	40%	12%	$25.00	20%	$560	1.99
Hospitals	$372.59	50%	14%	$35.00	20%	$807	2.16
Medical Office/Clinics	$267.85	20%	10%	$17.50	20%	$445	1.66
Entertainment/Recreation	$248.61	25%	12%	$25.00	20%	$448	1.80
Theaters	$186.45	35%	12%	$25.00	20%	$368	1.98
Parking	$84.59	20%	10%	$17.50	20%	$155	1.83
Heavy	$144.71	25%	10%	$17.50	20%	$260	1.80
Light	$118.13	25%	10%	$17.50	20%	$216	1.83
Food/Drugs/Chemicals	$229.48	30%	12%	$17.50	20%	$422	1.84
Metal/Minerals Processing	$229.48	30%	12%	$17.50	20%	$422	1.84
High Technology	$229.48	40%	14%	$17.50	20%	$461	2.01

Table 5: Average $/SF replacement building cost by Hazus occupancy class.

Occupancy Class	RS Means 2014 Average Palo Alto Cost[1] [$/SF]	Market Factor for Palo Alto	Escalation Factor from 2014 costs to 2016 costs	Demo & Minimal Sitework (5' around building) [$/SF]	Soft Cost Premium[2]	Average 2016 Palo Alto Cost w/ Soft Costs [$/SF]	Multiplier (Replaced with Soft Costs / RS Means)
Construction	$118.13	30%	10%	$17.50	20%	$224	1.89
Church	$118.13	50%	12%	$25.00	20%	$268	2.27
Agriculture	$199.08	10%	12%	$17.50	20%	$315	1.58
General Services	$152.63	40%	10%	$17.50	35%	$341	2.23
Emergency Response	$259.52	40%	14%	$25.00	35%	$593	2.28
Schools/Libraries	$193.00	40%	12%	$25.00	35%	$442	2.29
Colleges/Universities	$214.91	60%	12%	$25.00	35%	$554	2.58

Notes:

1. RS Means average cost includes RS Means default location factors to adjust national average to Palo Alto of 15% for residential and 11% for commercial.
2. Soft costs include architect and engineer design fees, testing and inspection, utility connection fee, permits, and an allowance for owner change order contingency.
3. Costs are intended to be representative of average in Palo Alto across the town, including downtown areas together with other areas in the city.
4. Costs were previously prepared following a 3/7/2016 discussion with the Palo Alto Seismic Risk Program Advisory Group Technical Advisory Committee. Table includes minor updates based on internal review between Rutherford + Chekene and Vanir Construction Management to achieve improved relative ratios between different occupancy types.

Table 6 shows how the number and aggregate value of Palo Alto's buildings is distributed by structural system, using the FEMA Model Building Type classification system for structural system. The table is sorted by aggregate building value. Wood frame buildings make up about 60% of the number of buildings, and represent 35% of the total value. About 20% of the buildings are concrete, and they represent over 40% of the total value. Of the remaining 20%, about two-thirds are masonry buildings, and one-third steel. However, the steel buildings represent about twice the value of the masonry buildings.

Table 6: Distribution of number of buildings, building area, and building value by Model Building Type.

Model Building Type	Number of Buildings	Aggregate Square Feet (1,000)	Aggregate Building Value ($M)
Concrete shear wall (C2)	318	9,699	4,082
Concrete tilt-up (PC1)	242	8,054	3,368
Wood frame larger residential (W1A)	331	8,403	3,232
Wood frame commercial/industrial (W2)	307	6,209	2,369
Steel braced frame (S2)	50	3,116	1,391
Wood frame smaller residential (W1)	898	3,821	1,278
Steel moment frame (S1)	75	3,005	1,242
Reinforced masonry, wood floor (RM1)	285	2,806	1,209
Reinforced masonry, concrete floor (RM2)	30	574	211
Steel light metal frame (S3)	41	533	177
Precast concrete frame (PC2)	5	334	125
Concrete moment frame (C1)	18	325	117
Steel frame with concrete shear walls (S4)	13	162	72
Unreinforced masonry bearing wall (URM)	9	274	15
Concrete with masonry infill (C3)	8	26	8
Steel frame with masonry infill (S5)	2	6	3
Totals	**2,632**	**47,346**	**18,899**

The study group can be further divided into age groups separated by significant milestones in building code implementation. The following age groups were selected: pre-1927, 1927-1961, 1962-1976, 1977-1997, and 1998 until now. The milestones reflected include the first earthquake code in Palo Alto in 1926, adoption of the 1961 Uniform Building Code (UBC) and associated higher forces, code changes in the 1976 UBC following the 1971 San Fernando Earthquake, and code changes in the 1998 UBC following the 1994 Northridge Earthquake. Figure 10 shows a histogram of the year built of the buildings in the study group.

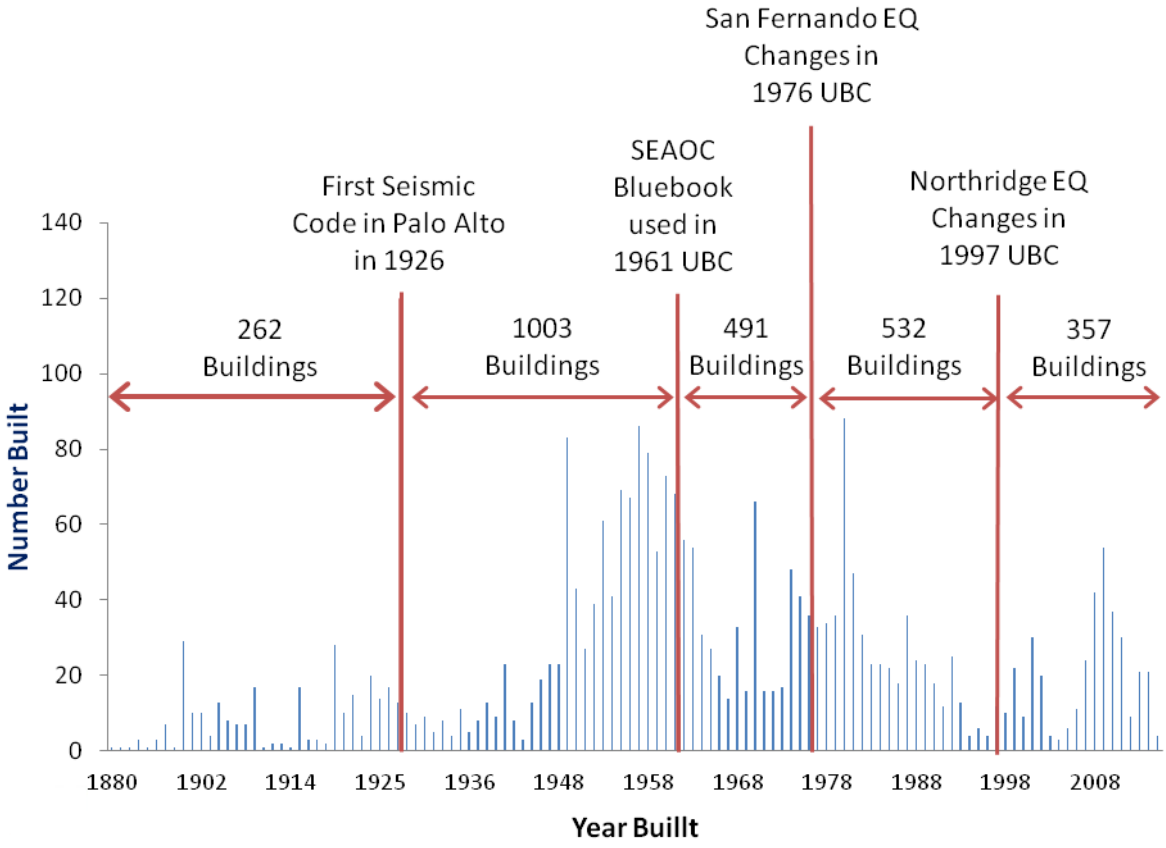


Figure 10: Distribution of year built of buildings in study group with significant changes in the building design practice.

CHAPTER V.

VULNERABLE BUILDING CATEGORIES

One of the important tasks in the risk assessment study was to identify potentially vulnerable building categories specific to Palo Alto using the building inventory that was developed early in the risk assessment study. Potentially vulnerable structural system types were identified based on experience in past earthquake events, knowledge of milestones when improvements in seismic code requirements were made in Palo Alto, rankings in prominent seismic risk assessment tools such as the 2015 edition of FEMA P-154 *Rapid Visual Screening of Buildings for Potential Seismic Hazards,* results from past seismic risk assessment studies in California communities, and engineering judgment. The building categories were then evaluated in analytical loss estimate studies described ahead which helped to confirm the selected categories as appropriate for Palo Alto. Key building vulnerability metrics include the risk of deaths and injuries, the cost of damage, and the extent of downtime or loss of use. Buildings in the identified vulnerable building categories tend to perform poorly with respect to all three of these metrics though the relative degree of vulnerability to each factor varies.

Community resilience is improved if residents have homes that remain usable after an earthquake event, and if businesses can still operate. From a program perspective, the consultant team and Advisory Group believe the greatest reduction in losses and the largest benefit to community resilience will come from seismically retrofitting building types know to be both potentially hazardous and present in significant numbers in Palo Alto.

In addition to the three categories already in Palo Alto's seismic hazard identification ordinance (Categories I, II, and III below), five additional categories of vulnerable building types were identified. All five categories meet the criteria of being potentially hazardous and having a significant presence in Palo Alto. The eight categories and the approximate number of buildings included in each category are as follows:

- Category I: Constructed of unreinforced masonry, except for those small than 1,900 square feet with six or few occupants (10 remaining buildings in Palo Alto);
- Category II: Constructed prior to January 1, 1935 containing 100 or more occupants (4 remaining buildings);

- Category III: Constructed prior to August 1, 1976 containing 300 or more occupants (9 remaining buildings);
- Category IV: Pre-1977 soft-story wood frame (294 buildings);
- Category V: Pre-1998 tilt-up concrete (99 buildings);
- Category VI: Pre-1977 concrete soft-story (37 buildings);
- Category VII: Pre-1998 steel moment frame (35 buildings);
- Category VIII: Other pre-1977 concrete construction (170 buildings).

The loss estimate discussed ahead in Chapter VIII confirmed that the potential reduction in losses from retrofitting is significant for these categories.

CHAPTER VI.

CONCEPTUAL SEISMIC RETROFITTING OF REPRESENTATIVE VULNERABLE BUILDINGS

Retrofit was considered for all buildings that have not already been retrofitted and were either constructed before 1961 or between 1962 and the "benchmark" year with a soft story. A "benchmark" year is when the code requirements for that building type became similar to those currently in place. Buildings built after a benchmark year are assumed not to have significant seismic deficiencies and are typically not seismically retrofitted. Consistent with typical practice, the performance of the retrofitted buildings in an earthquake is assumed to be less than that of newly constructed buildings.

For estimating the cost of retrofit for the improved buildings, Rutherford + Chekene developed conceptual designs for Model Building Types that represent a significant number and value of Palo Alto's building stock, as well as a significant loss and loss reduction after retrofit. This process identified wood frame (W1, W1A, W2), steel moment frame (S1), concrete shear wall (C2), concrete tilt-up (PC1), and reinforced masonry (RM1) and unreinforced masonry (URM) as appropriate candidates. For each Model Building Type, the age, square footage and number of stories were reviewed to identify a "prototype" building. In cases where the prototype building was not representative of more than two-thirds of the total number of buildings, it was judged that multiple prototypes should be considered.

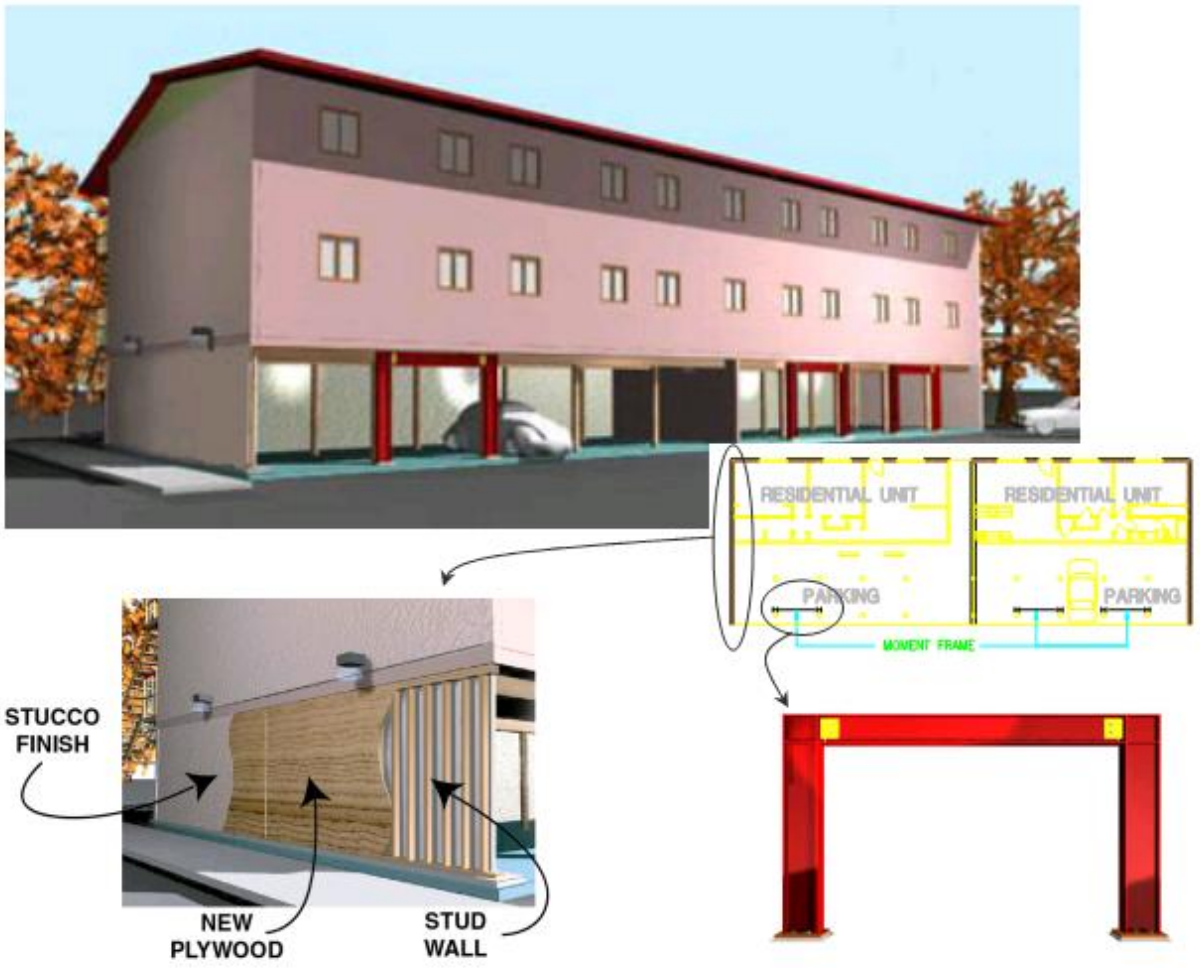


Figure 11: Retrofit scheme for Large Multi-family Soft-Story Wood Frame Building.

For example, for the W1A Model Building Type there were a significant number of two-story and three-story buildings with a significant difference in average square footage. Therefore, a two-story and a three-story prototype building were developed to represent this Model Building Type. Eventually this led to the 12 prototype buildings shown in Table 7.

Based on a review of buildings of size similar to the prototypes, representative floor plans were developed. A conceptual retrofit was then shown on the floor plans. An example of a conceptual retrofit for the W1A prototype building is shown in Figure 11 from a 2000 brochure by Rutherford + Chekene for the City of San Jose entitled “Practical Solutions for Improving the Seismic Performance of Buildings with Tuckunder Parking.” The retrofit elements were keyed to representative details in 2006 FEMA 547 *Techniques for the Seismic Rehabilitation of Existing Buildings*, and a written description of

collateral impacts was developed as well to provide sufficient detail to allow a rough order of magnitude cost estimate to be prepared. The conceptual retrofit designs, description of collateral impacts, and referenced details are included in Appendix E.

The cost estimators of Vanir Construction Management used the conceptual designs to estimate a range of probable cost to implement the retrofits. The retrofit costs for each prototype building are shown in Table 7. These costs include hard costs, which are the costs the owner pays the contractor, plus a design contingency as these are conceptual retrofits. The estimate further includes soft costs, representing architect and engineer design fees, testing and inspection costs, permit fees, and an owner change order contingency.

Considered costs do not include hazardous material abatement, costs associated with performing the work while occupants are using the building, triggered accessibility upgrades, cost premiums associated with retrofit of a historic building, tenant relocation or business interruption during construction, project management, renovation, financing, repair of existing conditions, and legal fees. These costs are more variable and project and site specific, and are typically not included in loss estimates for this type of study. A detailed breakdown of estimated cost is included in Appendix F

The retrofit costs were extrapolated to Model Building Types not represented by a prototype retrofit as shown in the fifth column of Table 7.

Table 7: Conceptual retrofit cost.

Retrofit Prototype	Model Building Type	Stories	Square Feet	Used for Model Building Types	Used for Square Feet	Average Retrofit Cost ($/SF)
1	Wood frame smaller residential (W1)	2	5,320	W1	All	12
2	Wood frame larger residential (W1A)	2	9,500	W1A	< 15,000	11
3	Wood frame larger residential (W1A)	3	30,000	W1A	≥ 15,000	6
4	Wood frame commercial/industrial (W2)	2	10,000	W2	All	14
5	Steel moment frame (S1)	2	43,900	S1, S2, S3	All	10
6	Concrete shear wall (C2)	1	5,000	C1, C2, S4, PC2	< 10,000	50
7	Concrete shear wall (C2)	2	17,280	C1, C2, S4, PC2	≥ 10,000	40
8	Concrete tilt-up (PC1)	1	18,435	PC1	< 25,000	29
9	Concrete tilt-up (PC1)	2	38,400	PC1	≥ 25,000	21
10	Reinforced masonry, wood floor (RM1)	1	2,750	RM1, RM2	< 5,000	74
11	Reinforced masonry, wood floor (RM1)	2	8,150	RM1, RM2	≥ 5,000	46
12	Unreinforced masonry bearing wall (URM)	1	5,000	URM, S5, C3	All	110

CHAPTER VII.

LOSS ESTIMATING FINDINGS FOR EXISTING BUILDING STOCK

Hazus is a geographic information system (GIS) based, standardized, nationally applicable multi-hazard loss estimation methodology and software tool. It is used by local, state, and federal government officials for preparedness, emergency response, and mitigation planning. FEMA has recently released the latest version of Hazus (Hazus 3.1) which includes building inventory data reflecting 2010 census data for residential structures and costs to 2014. Rather than using the embedded inventory data for Palo Alto, which are estimated from census data, a detailed earthquake risk assessment of the individual buildings in the study group was conducted using the Hazus Advanced Engineering Building Module (AEBM).

Direct loss is calculated through a complex process in Hazus. In essence, the engine consists of a large database of "fragility functions". These fragility functions describe the probability of exceeding threshold damage levels as a function of a seismic demand parameter. For example, spectral displacement is linked to slight, moderate, extensive and complete damage states to describe the performance of a structural system. The estimated level of damage for the level of ground shaking under consideration is then used to assign the costs to repair or replace the damage to the building's structural and nonstructural systems and contents (the loss). Each Hazus fragility function represents a combination of Model Building Type, number of stories, and seismic design level.

Analyses were conducted for two specific earthquake scenarios developed by the United States Geological Survey (USGS), a major M7.9 San Andreas Fault event, and a strong M6.7 San Andreas Fault event.

The USGS has developed a suite of ShakeMap earthquake scenarios for different faults around California. In the San Francisco Bay Area, they include events of different magnitude on a number of faults, such as various segments of the San Andreas Fault and the Hayward Fault. The largest scenario is a M7.9 event on the San Andreas Fault which represents a repeat of the 1906 earthquake. In this scenario, all four segments (Santa Cruz Mountains, Peninsula, North Coast, and Offshore) of the San Andreas Fault are assumed to rupture. There is a M7.2 event on the Peninsula segment with an

epicenter somewhat south of Palo Alto. In addition to the scenarios, a ShakeMap of the 1989 Loma Prieta earthquake which had an epicenter southwest of Palo Alto is also available.

In reviewing the available scenarios, the repeat of the 1906 earthquake provided a desirable, easy to communicate upper bound scenario. Since the 1989 Loma Prieta event did relatively little damage to buildings in Palo Alto (though there was substantial damage to some of the older buildings at nearby Stanford University), it was judged to be too small to provide meaningful information for policy choices in Palo Alto. Most of the Hayward Fault scenarios also produce small to moderate shaking in Palo Alto. Review of the M7.2 San Andreas scenario found that it produced relatively similar peak ground acceleration and short period spectral accelerations to those of the M7.9 scenario. Tom Holzer, an engineering geologist with the USGS, is a member of the project Advisory Group. With his help and the ShakeMap team at USGS, two other scenarios were developed between the M7.2 scenario and the Loma Prieta earthquake. These are a M6.9 scenario and a M6.7 scenario on the Peninsula segment of the San Andreas with an epicenter directly adjacent to downtown Palo Alto.

In the end, the M6.7 scenario was selected in addition to the M7.9 scenario. The M6.7 scenario provided values somewhat smaller than the M7.9 scenario event, values large enough to be meaningful, and is a magnitude size commonly used in USGS communications. It also has a substantially lower equivalent return period from the M7.9 scenario.

Contour plots for the short period spectral acceleration for the two M6.7 and M7.9 scenarios are shown in Figure 12.

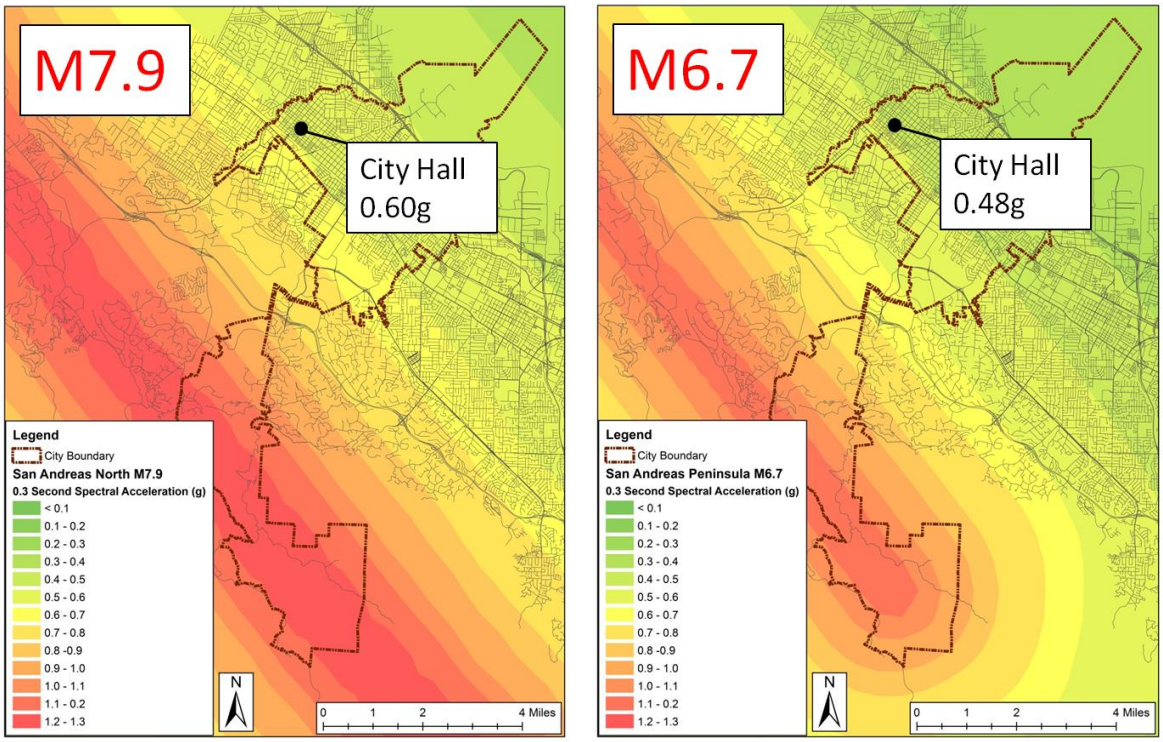


Figure 12: Predicted short period spectral acceleration in vicinity of Palo Alto (city boundary shown) for two selected San Andreas Fault scenarios.

Table 8 summarizes the total loss calculated by Hazus for the as-is condition for the two earthquake scenarios. The results show that the estimated losses to Palo Alto buildings and contents in a M6.7 scenario will be significant, on the order of $1.2 billion. Though ground shaking in the M7.9 scenario is only about 25% larger than it is in the M6.7 scenario, overall building and content losses double to $2.4 billion. Average building damage and content damage also approximately double with a M7.9 event. The difference in the number of buildings that are heavily damaged with the larger earthquake is more pronounced with a 12-fold increase from the M6.7 to the M7.9 scenarios. This is shown in the fourth column of Table 8 as the number of buildings with a damage ratio exceeding 20%.

Table 8: Total losses for study group in as-is condition.

Earthquake Scenario	Building Value[1] ($B)	Content Value[2] ($B)	Number of Bldgs with Damage Ratio ≥ 20%[3]	Estimated Building Damage[4] ($B)	Estimated Content Damage[4] ($B)	Total Building and Content Damage ($B)
M7.9	18.9	17.3	224	1.7	0.7	2.4
M6.7	18.9	17.3	19	0.8	0.4	1.2
Ratio of M7.9/M6.7				2	2	2

Notes:

1. Building value is the complete replacement cost for the building, and includes the structure, architectural, mechanical, electrical, and plumbing components (e.g., ceilings and lighting).
2. Content value includes the complete replacement cost of furniture and equipment that is not integral with the structure (e.g., computers and other supplies). They are estimated as a percent of structure replacement value, dependent on occupancy.
3. Damage ratio is defined as the cost of repairing damage divided by the replacement cost of the building.
4. Estimated building and content damage cost is the cost associated with repair and replacement of the building and its content.

To put the loss from building damage in context, the average annual valuation of Palo Alto construction permits was $400M between 2013 and 2016 (which represents a boom period). The total loss in a major M7.9 earthquake represents more than four years' worth of construction, and the total loss in a strong M6.7 earthquake represents more than two years worth of construction.

It should be noted that these losses do not include the effects of lives lost and business disruption, or the ripple effects in the local economy or real estate market, and that much of this loss will not be insured.

Table 9 breaks out the estimated loss and damage ratio for various model building types, and it can be seen that it depends on the metric used which building type is considered the poorest performer. Looking at the total loss alone, concrete bearing wall buildings and commercial wood frame buildings are responsible for the highest total loss. This tracks well with the earlier finding that these structural systems are the most prevalent ones. If we look at the highest average building damage ratio instead, buildings with unreinforced masonry bearing walls and unreinforced masonry infills are the most prone to damage. However, not very many of them exist in Palo Alto, and as a result they do not represent much of the aggregate loss. It is therefore important to look at multiple metrics when deciding which buildings are the most vulnerable and significant to the community as a whole.

Table 9: Top three vulnerable building types ranked by total loss, average damage ratio, and number of severely damaged buildings.

Building Type	Number of Buildings	Building Value ($M)	M7.9 EQ Total Building + Content Losses ($M)	M7.9 EQ Average Building Damage Ratio	M7.9 EQ Number of Bldgs with Damage Ratio ≥ 20%
Concrete shear wall (C2)	318	4,082	**477**	14%	75
Concrete tilt-up (PC1)	242	3,368	**365**	12%	32
Wood frame commercial/industrial (W2)	307	2,369	**216**	9%	9
Steel frame with masonry infill (S5)	2	3	1	**38%**	1
Unreinforced masonry bearing wall (URM)	9	15	4	**29%**	9
Concrete frame with masonry infill (C3)	8	8	2	**29%**	6
Concrete shear wall (C2)	318	4,082	477	14%	**75**
Concrete tilt-up (PC1)	242	3,368	365	12%	**32**
Steel moment frame (S1)	75	1,242	130	18%	**27**

CHAPTER VIII.

LOSS ESTIMATING FINDINGS WITH BUILDINGS RETROFITTED

A second Hazus AEBM run was done assuming a retrofitted building stock. For this run, it was assumed that a building would be retrofitted if it has not already been retrofitted and is either constructed before 1961 or between 1962 and the benchmark year with a soft story. The Hazus model was rerun with the updated fragilities simulating retrofit.

Table 10 shows the resulting total losses and damage ratios. Though total losses are still significant, comparing the results of Table 10 with Table 8 shows a reduction in total loss of 45% for the M7.9 scenario, and 33% for the M6.7 scenario. In other words, aggregate loss to the community if all considered properties were retrofit could be reduced by one third in a very plausible event and almost halved in a much larger event.

Another important improvement is the reduction of the number of buildings with more than 20% damage. The M7.9 scenario shows a reduction from 224 buildings to 6 buildings, meaning that the probability of building collapse and resulting injuries and fatalities has become very low.

Finally, the damage and loss of the M7.9 scenario remain approximately two times the amount sustained in the M6.7 scenario. This suggests that the retrofit has a similar impact for both levels of ground shaking.

Table 10: Total losses after retrofitting.

Earthquake Scenario	Building Value ($B)	Content Value ($B)	Estimated Building Damage ($B)	Number of Bldgs with Damage Ratio ≥ 20%	Estimated Content Damage ($B)	Total Building & Content Damage ($B)
M7.9	18.9	17.3	0.9	6	0.5	1.3
M6.7	18.9	17.3	0.5	0	0.3	0.8
Ratio of M7.9/M6.7			2	-	2	2

Table 11 breaks out the reduction in total loss by model building type for the M7.9 scenario, and shows the associated retrofit cost. The average reduction in loss varies by building type, with URM buildings showing the highest reduction in loss after retrofit of 80%, and steel braced frames showing an 18%

reduction at the low end. On average, the retrofit costs are on the order of the damage reduction for this scenario, though by building type the average damage reduction (loss avoided) divided by retrofit cost ranges from 0.14 for steel light frame buildings to almost eight for reinforced masonry buildings. Wood frame and concrete buildings are responsible for the largest reduction in total loss, with wood frame construction representing over 20% of the loss reduction, and concrete buildings over 50%.

It should be noted that the data in Table 11 also includes buildings that were not retrofitted. As a result, further parsing of the data is needed to better understand which buildings are responsible for the most loss, and those that can be improved more cost-effectively.

Table 11: Comparison of retrofit benefits and costs by Model Building Type.

Model Building Type	M7.9 EQ Average Damage ($/SF)	M7.9 EQ Total Damage Reduction ($1,000)	Average Damage Reduction ($/SF)	Retrofit Cost ($/SF)
Wood frame smaller residential (W1)	16	13,775	4	12
Wood frame larger residential (W1A)	25	61,317	7	6-11
Wood frame commercial/industrial (W2)	50	160,155	26	14
Steel moment frame (S1)	62	76,150	25	10
Steel braced frame (S2)	44	24,222	8	10
Steel light metal frame (S3)	108	38,163	72	10
Steel frame with concrete shear walls (S4)	101	11,118	69	40-50
Steel frame with masonry infill (S5)	247	695	121	110
Concrete moment frame (C1)	55	8,045	25	40-50
Concrete shear wall (C2)	70	336,574	35	40-50
Concrete frame with masonry infill (C3)	120	865	34	110
Concrete tilt-up (PC1)	68	218,491	27	21-29
Precast concrete frame (PC2)	21	0	0	21-29
Reinforced masonry, wood floor (RM1)	59	87,697	31	46-74
Reinforced masonry, concrete floor (RM2)	35	3,727	6	46-74
Unreinforced Masonry Bearing Wall (URM)	23	5,216	19	110
Totals	**51**	**1,046,210**	**22**	

Table 12 shows those buildings types that may be considered good candidates for a retrofit program. Although representing only about 15% of the total inventory, these buildings are responsible for over 30% of the total loss. This is reflected in the considerably higher than average loss (fourth column of Table 12). The benefit of retrofit is also considerable for this group of buildings, as they are responsible for over 50% of the reduction in loss. Additionally, the cost to retrofit them is only a fraction of the losses avoided in a major event, ranging from a third for the concrete buildings to a tenth for the steel frames. Note that these values are based on conceptual retrofits. Actual retrofit costs for individual buildings would vary substantially, and the steel moment frame benefit-to-cost ratio is higher than expected by engineering judgment. This is caused in part by a comparatively low retrofit cost for this Model Building Type.

Table 12: Comparison of benefits and costs by selected Model Building Type, date and characteristics.

Model Building Type	Number of Buildings	Total SF (1,000)	M7.9 EQ Average Loss by Building ($/SF)	M7.9 EQ Average Loss Avoided by Retrofit ($/SF)	Average Cost to Retrofit ($/SF)	(Average Loss Avoided) / (Average Retrofit Cost)
Pre-1977 wood frame soft-story (W1, W1A, W2)	294	3,690	66	46	12	4
Pre-1998 tilt-up (PC1)	99	3,078	106	71	23	3
Pre-1977 concrete soft-story (C1, C2, C3)	37	842	149	108	42	3
Pre-1998 steel moment frame (S1)	35	690	152	110	10	11

CHAPTER IX.

REVIEW OF PAST SEISMIC RETROFITS

To gain a better understanding of the quality of the retrofits and identify relevant issues to updating Palo Alto's seismic risk mitigation program, a sample of the submitted engineering studies and building retrofit drawings was reviewed.

Ten buildings were selected, so that their permit history could be reviewed and documents could be retrieved from the archives of the Building Department. They were distributed over the three existing hazardous buildings categories, and also included soft-story wood frame buildings. Records were retrieved for four Category I buildings (to reflect the higher number of these), two Category II buildings, two Category III buildings, and two soft-story wood frame buildings.

The City tracked permit numbers for the retrofit projects in their "hazardous buildings" database. Even so, it proved difficult to retrieve associated documents. After careful review of the City's records, some archived documents showing structural modifications were retrieved. The type of documents available varied from building to building. In about half of the cases, plans were available, and in the other half, the documents consisted of calculations with sketches.

For one of the Category I buildings, plans showing a comprehensive retrofit were available. The 2001 California Building Code was referenced for seismic design. In a second case, the retrieved plans show retrofit of a section of the building that appears to be intended to improve the original retrofit. It was unclear if other sections of the building were improved in a similar fashion. In the third case, structural calculations were provided. It is unclear what criteria were used, as the 1991 UCBC is used for certain elements and the regular UBC seismic load calculations for global loading. The set of plans retrieved for the last building is for a tenant improvement that appears to have been constructed a few years after the original seismic retrofit. Interestingly, the structural engineer referenced the 1977 UBC as the seismic design criteria. The building is identified on the plans as a concrete building, rather than a URM building.

For the Category II buildings, in one case only the permit application worksheet was available; in the other case there were detailed calculations and sketches (no construction documents). The permit

application for the first building indicates that shear walls were added as part of a voluntary seismic upgrade. The sketches for the second building indicated that the retrofit was designed to mitigate the deficiencies identified in the evaluation report. It references both elements and loads from the earlier study.

For the Category III buildings, it appears that in both cases the projects were driven by modifications or additions to the existing building. Since no plans were archived, and the calculations could not be easily followed, it was not clear if the existing building was fully evaluated and if all deficiencies found in the original evaluation report were addressed.

In 2003, the Collaborative for Disaster Mitigation at San Jose State University completed an "Inventory of Soft-First Story Multi-Family Dwellings in Santa Clara County". According to the report the City of Palo Alto had 130 soft-first story multi-family buildings including 1,263 residential units housing 3,158. The list of addresses from the San Jose State University report was updated with information from the City of Palo Alto Fire Department, and resulted in a reduced list of 108 addresses. According to this list, which was included in a recent Staff Report to Palo Alto's Policy and Services Committee[33], six buildings were improved voluntarily. Two sets of plans were retrieved and reviewed; in one case the plans improved two buildings with the same plan as a mirror image. One of the permits was issued in 2006 and one in 2009. It appears that in both cases the buildings were of a more recent vintage, as plans show that existing plywood shear walls are present. On both sets of plans design criteria were referenced, with one building referring to the 2001 California Building Code, and one Appendix Chapter A4 of the 2006 International Existing Building Code.

Review of the submitted engineering studies and building retrofit drawings identified the following relevant needs for future seismic risk mitigation programs:

- Clear identification of retrofit design intent, scope, and limitations, also for voluntary retrofits;
- Identification of existing structural systems;
- Decision on requirements for buildings that have had partial seismic retrofits completed, and may have remaining seismic deficiencies.

[33] Policy and Services Committee Staff Report 5293, Discussion of Updating the Seismic Safety Chapter of the Municipal Code for Hazardous Buildings, December 9, 2014, available online at https://www.cityofpaloalto.org/civicax/filebank/documents/44945 (accessed 12/21/2016)

CHAPTER X.

ADDITIONAL RECOMMENDED PROGRAM FEATURES

In addition to expansion of the building categories included within the City's seismic risk mitigation program and refinement of disclosure measures and incentive options, a number of other program features are recommended. They are described in the following:

- *Use the current inventory, taking note of its limitations:* The inventory developed for the effort to date involved use of digital information and field surveys. A complete field survey of all buildings in Palo Alto was outside the scope of the project. However, the inventory that has been developed is an excellent resource. The first step in any future ordinance will involve notification of building owners that they may be subject to the requirements of the ordinance. Those buildings that were field surveyed and fall within the scope of the ordinance can be notified using the existing inventory. For the remaining buildings, additional field survey is recommended. This would be a rapid visual assessment and could be conducted by City staff or outside consultants.

- *Use an initial screening form phase:* Typically, as part of the notification process, a screening form of about one-page in length is sent, and the owner is required to have a design professional, such as a structural engineer or architect, complete the form for a relatively nominal cost to confirm whether or not the building actually is subject to the City's ordinance. Some buildings may appear from a rapid visual assessment to be one of the building categories covered, but upon closer review they are exempt. This approach has been taken in many communities in the past, and thus sample forms are available that can be easily tailored for Palo Alto.

- *Clearly specify seismic evaluation and retrofit scope:* The seismic evaluation (and retrofit) methodology for each building category will need to be defined after the building categories included in the updated ordinance are determined. Industry consensus standards exist and cover the vulnerable building categories identified for Palo Alto. These include the 2015 *International Existing Building Code (IEBC)* and 2014 ASCE 41-13 *Seismic Evaluation and Retrofit of Existing Buildings*. Both are currently being updated by groups of engineers and building

officials. For soft-story wood frame buildings, there is also the 2012 FEMA P-807 *Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings with Weak First Stories.* For steel moment frame buildings, there is also the 2000 FEMA 351 *Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Moment Resisting Steel Structures*. ASCE 41 has three tiers of evaluation: Tier 1, Tier 2, and Tier 3. Tier 1 is primarily a screening tool. As a minimum standard, Tier 2 is recommended. Table 13 provides recommended evaluation and retrofit standards.

Table 13: Recommended Evaluation and Retrofit Standards

Category	Description	Evaluation and Retrofit Standards
I	Unreinforced masonry	IEBC Appendix Chapter A1
II	Built before 1/1/35 with 100 or more occupants	ASCE 41
III	Built before 8/1/76 with 300 or more occupants	ASCE 41
IV	Pre-1977 soft-story wood frame	IEBC Appendix Chapter A4, ASCE 41, or FEMA P-807
V	Pre-1998 tilt-up	IEBC Appendix Chapter A2 and ASCE 41
VI	Pre-1977 soft-story concrete	ASCE 41
VII	Pre-1998 steel moment frame	ASCE 41, or FEMA 351
VIII	Other pre-1977 concrete	ASCE 41

- *Provide detailed evaluation report submittal requirements:* Minimum submittal requirements for evaluation reports will need to be defined. The above evaluation and retrofit standards provide some guidance but a short clear set of requirements will be beneficial. This will include such items as address, construction date, size, number of stories above and below grade, owner, occupancy type, structural system type, the location and features of the primary structural system, the extent of field review, material properties, the evaluation criteria and methodology used, whether the structure meets the evaluation criteria, identified seismic

deficiencies if it does not. The current ordinance requires identification of retrofit measures to address seismic deficiencies. Even in a voluntary program, it is recommended that this be continued to help owners, tenants, and the City better understand what is necessary to mitigate the issues that exist.

- *Specify how past partial retrofits will be handled:* In the past, some buildings have had partial seismic retrofits where only selected portions of the seismic force-resisting system have been upgraded, and some seismic deficiencies may still exist in these structures. If mandatory retrofit requirements are implemented that provide for comprehensive retrofitting of the full seismic load path, there may be buildings with previous partial retrofits that do not fully comply and need remaining deficiencies to be addressed. This will be identified in the seismic evaluation report.

- *Update both new and existing building permit submittal requirements:* Review of City records found that basic information such as the building structural system, date of construction, and retrofit standard used (where applicable) are not readily available. It is recommended that submittals for permit for both new buildings and existing building renovations require this information. For structural systems, both the categorization found in ASCE 41 and the ASCE 7 Table 12.2-1 is recommended. This will allow the city to have a much better understanding of its building stock and its expected performance in an earthquake.

- *Write a new ordinance or set of ordinances to update the program:* After the Council has provided direction and the above issues have been addressed, an updated ordinance will need to formally be written. This can be done by City staff, but will likely benefit from the involvement of an appropriately experienced structural engineering consultant.

- *Carefully address program management and interdepartmental coordination needs:* To successfully manage Palo Alto's updated Seismic Risk Mitigation Program, an effective management plan is needed so that progress is monitored by the City and community intent is achieved. It will include a realistic list of information that can be easily input, summarized, and tracked in digital records such as the submittal requirements recommended above and that can be used to link the seismic risk program data to other digital records such as assessor files or GIS systems; quality assurance procedures for checking information; clearly defined roles and responsibilities; timelines and requirements for reporting of information internally and externally; procedures for gathering, assessing and implementing community feedback and suggestions; and links between the seismic risk mitigation program and activities that will occur following an earthquake, such as postearthquake safety evaluation.

- *Delineate department and key staff responsibilities:* For Palo Alto's updated Seismic Risk Mitigation Program, City staff will be responsible for several categories of activities.. These will include the basic activities such as managing the notification and inventory process, reviewing evaluation reports and plan checking retrofit construction documents, and field inspections of retrofit work. Less obvious activities will include evaluating requested exceptions to the program or alternative means of compliance; managing feedback from design professionals, owners, and the public; tying pre-earthquake retrofitting to post-earthquake safety evaluations records; and managing post-earthquake safety evaluation, repair, and recovery plans. Depending on the scale of the updated program, it is possible that addition staff members or consultants will be needed to handle the work flow. The City may also benefit from an appropriately experienced structural engineer to provide advice on technical and program management issues, particularly as the program moves to final definition and then to initial implementation. Later, as is done in some communities, it may be desirable to create volunteer review boards of local structural engineers who review questions on the evaluation and retrofit criteria and provide the city with technical opinions that staff can use.

CHAPTER XI.

QUESTIONS TO GUIDE COUNCIL DELIBERATIONS AND POTENTIAL ISSUES FOR FUTURE STUDY

1. QUESTIONS TO HELP GUIDE COUNCIL DELIBERATIONS

Preferred policy directions were developed with the Advisory Group and staff as discussed in Chapter I and include expansion of the building categories currently covered by the City's ordinance, movement toward mandatory requirements for some categories, additional disclosure measures and use of incentives to increase the effectiveness and likelihood of compliance and of success. To help the Council in its deliberations, a series of questions are given here. They are similar to questions and issues discussed by the Advisory Group.

1. Does the Council wish to expand the current seismic hazard program to cover more vulnerable building categories?
2. If so, which of the building categories in Table 1 should be included? The Advisory Group proposed that the existing Categories I-III, plus the Categories IV-VII, be included as follows. The categories are:
   a. Category I: Constructed of unreinforced masonry, except for those smaller than 1,900 square feet with six or fewer occupants (in the current ordinance)
   b. Category II: Constructed prior to January 1, 1935 containing 100 or more occupants (in the current ordinance)
   c. Category III: Constructed prior to August 1, 1976 containing 300 or more occupants (in the current ordinance)
   d. Category IV: Pre-1977 soft-story wood frame
   e. Category V: Pre-1998 tilt-up concrete
   f. Category VI: Pre-1977 concrete soft-story
   g. Category VII: Pre-1998 steel moment frame

   An eighth category (Category VIII other older nonductile concrete buildings) was discussed, but because of the lack of inexpensive analytical methods for reliably identifying the worst of these buildings, inclusion of this building category in an updated ordinance is not recommended at this

time. Such buildings could be included in the future when the engineering community has developed appropriate analytical methods.

3. In addition to mandatory initial evaluation requirements, should one or more of the categories of buildings be subject to mandatory retrofit requirements? The Advisory Group had a consensus on mandatory requirements for renovation for unreinforced masonry buildings and there was strong support among many members for other categories such as soft-story wood frame buildings and tilt-up buildings, particularly those with high occupancies.

4. Should the City develop a trigger mechanism based on sale or substantial renovation where seismic retrofit is required? If so, which building categories should be subject to a trigger mechanism? There was support among some Advisory Group members for a trigger mechanism for some building categories, such as tilt-up industrial buildings, particularly those that are being converted to office buildings and increasing the occupant load and thus exposure to seismic risk.

5. What public disclosure or notice measures of the need for retrofitting a building should be pursued? The Advisory Group supported website listing and tenant notification, but there was low support for placing notices on property titles or for signage or placing placards on the outside of buildings. Other possibilities include encouraging earthquake performance rating systems and disclosing them to the public or developing such a rating system for city-owned buildings.

6. What incentive measures to encourage property owners undertake a structural retrofit should be pursued?

   The Advisory Group supported incentives for fee waivers, expedited permitting, and property-assessed financing tools. There was minimal interest in deep financial assistance such as establishing a special district or passing of bond measure to assist property owners financially. . Opinions were split on the use of transfer of development rights, floor area ratio bonuses, and parking exemptions.

8. How much time do you feel is reasonable for property owners of at risk buildings in the community to: a) prepare the initial structural evaluation reports for regulated buildings; and b), to complete mandatory structural retrofits to their buildings?

2. POTENTIAL ISSUES FOR FUTURE STUDY AND CONSIDERATION

For some issues, based in part on Advisory Group discussions, additional information may be beneficial to help develop a strategy and to better understand potential impacts on key stakeholders and community concerns. Some of these issues are primarily economic and were outside the scope of the current study. The City Council may wish to direct staff and/or outside consultants to investigate some of these items in more detail as the seismic risk management program effort proceeds. These issues include the following:

- *Occupants and tenants*
  - How much would a typical retrofit add to the monthly rent of a multifamily soft-story wood frame apartment tenant?
  - Would some tenants be unable to afford a rent increase and seek housing elsewhere in Palo Alto or move outside the city (and if so, how many might be displaced)?
  - If soft-story wood frame apartments in Palo Alto are retrofitted in time before the next major earthquake, how much less displacement of residents would occur as a result of the earthquake?
  - What categories of buildings are most important to address in order to help maintain the commercial viability and vitality of the City's core business districts and tax base?
- *Property owners, developers, and business owners*
  - What are the characteristics of property owners that would be affected?
  - How might small businesses be affected compared to larger ones?
  - How many property owners are in need of lower cost capital or other substantial financial assistance to fund retrofitting?
- *Impacts of Seismic Restoration on Retention of Historic Structures in the City*
  - Insure that the review of initial seismic evaluations identify those structures that are listed in the City's Historic Inventory and flag them for attention during subsequent review.
  - Develop a clear process for reviewing proposed seismic retrofits to historic structures that is coordinated among responsible city departments and is consistent with current regulations and Community policies.
  - Seek out retrofit alternatives that are consistent with the Historic Building Code, historic characteristics of the structure, and provide the most risk reduction.
- *City departmental resources and budgets*
  - What would be the loss in revenue to the Building Department if fee waivers were offered?
  - What would be the staffing and budgetary needs over time to administer an expanded program that addresses additional building types?
  - What kinds of interdepartmental cooperation and staff resources in other departments are necessary to ensure effective implementation and coordination with other city planning and public safety efforts?

- *Overall community economic health*
  - What kind of benefits could accrue to Palo Alto in terms of maintaining community function and ability to recover if various building categories are retrofitted in time before the next major earthquake?
- *Other related issues*
  - It was brought up in the Advisory Group that the Building Department needs flexibility and authority to take steps to get tough seismic mitigation projects done. One idea was to grant the Building Official the ability to classify certain projects (with well-specified criteria) as warranting a kind of "seismic safety" or "earthquake resilience" fast tracking, with city departments agreeing to coordinate on a specified accelerated project review timeframe.
  - Although outside the formal scope of this planning effort, several Advisory Group members commented that it would be desirable for the City to do some kind of assessment of any earthquake mitigation needs in public buildings and facilities serving the City.
  - Advisory group members recommended the community be informed of Palo Alto's overall potential seismic risk by providing a summary of potential impacts on the City's website, including the expected performance of vulnerable buildings.
  - The group also had a high degree of support for recommending that the City initiate and nest future earthquake mitigation programs within a broader disaster or community resilience initiative, as cities such as Los Angeles, Berkeley, and San Francisco have done. This could be incorporated into the update of the City's Comprehensive Plan Safety Element. There was insufficient time in the project's six advisory group meetings to consider potential initiatives to assess risks for cell phone towers, water supply, facades, private schools, post-earthquake shelter facilities, and/or other assets important to community recovery.