Soft-Story Residential Buildings in Earthquakes – Risk and Public Policy Opportunities for Oakland

What happens to housing in earthquakes?

In a major (magnitude 7 or so) earthquake on the Hayward fault, ABAG estimates that **26,000** of the 163,000 housing units in Oakland will become uninhabitable. Most **(14,700)** of the uninhabitable units will be in "soft story" apartment and condominium buildings that contain 3 or more units. Some people likely will be killed and many more injured due to this damage. Some gas lines will rupture and start fires that can spread to neighboring buildings. This extensive damage also will lengthen the City's post-disaster recovery, permanently change the architectural character of neighborhoods, and reduce the amount of affordable housing. Apartments and condos most likely to be damaged house those with the fewest resources after earthquakes and thus **most likely to need shelter** for the longest periods of time. ABAG estimates a demand for **21,500 shelter beds** in Oakland, far more than the estimated Oakland capacity for fewer than 5,000 beds in ADA-accessible facilities.

Soft-story apartments and condominiums were responsible for about **two-thirds** of the 46,000 uninhabitable housing units in the Northridge earthquake and a high percentage of the fatalities.

Soft-story apartment collapse in Northridge earthquake

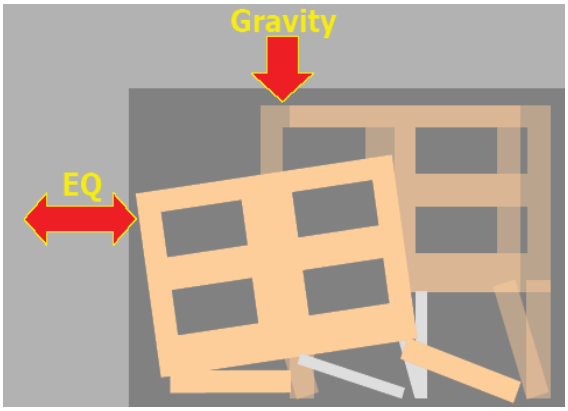

Diagram of collapsed building

What are soft-story buildings?

Many apartments and condos can collapse in earthquakes because they have parking on all or part of the first floor, or open commercial space on that first floor. These buildings typically have outside walls with large openings due to garage doors and display windows, as well as few internal walls, making this story "weak" or "soft" and likely to lean or fall over in earthquakes.

Because of improvements in recent building codes for new construction, these soft-story buildings were likely built prior to 1990 and the most problematic buildings were built prior to 1980. They also are more likely to be a problem if they have wood-framing in the walls of the first floor (whether or not it is covered by stucco).

This document reviews the extent of the soft-story problem in Oakland and describes some ideas for action that could be taken by the city in conjunction with – or separate from – a mandatory requirement for retrofit.

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How many potential soft-story buildings are in Oakland?

In Oakland, ABAG, assisted by volunteer earthquake professionals*, determined that **1,479 buildings containing 24,273 have 5 or more units, parking or commercial on at least part of the first floor, AND 2 or more stories**. These buildings are those most likely to have a soft-story. Of these, **942 buildings containing 12, 991 units** have EITHER at least one wall that is 80% or more "open" on the first floor OR have at least two walls that are 50% or more "open" on the first floor. These buildings are even more likely to be soft-story buildings.

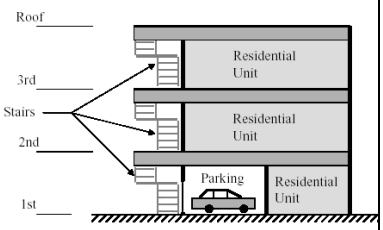
Volunteer earthquake professionals assisted ABAG in collecting data on multifamily residential buildings in Oakland. The scope of the effort involved looking at parcels identified by the Alameda County Assessor's Office as having buildings on them (1) with 5 or more units, (2) between 2 and 7 stories in height, and (3) built prior to 1990. In the process of visiting these parcels, we found 53 additional buildings that fit these criteria that were not listed as buildings to visit, largely because they were listed as having "zero" stories. Thus, a total of 3,959 total parcels were visited and data were collected on 2,908 buildings to develop this list of final list of 1,479 potential soft-story buildings.

The volunteers collected information on (1) use of the first floor, (2) whether or not the building was on a significant** slope, and (3) "openness" of the first floor. "Openness" was defined using the same criteria as a similar San Francisco inventory project using similar volunteer earthquake professionals. Unlike San Francisco, this number includes 2-story buildings, not just buildings with 3 or more stories, because Oakland's buildings will be exposed to higher levels of shaking since they are closer to the Hayward fault.

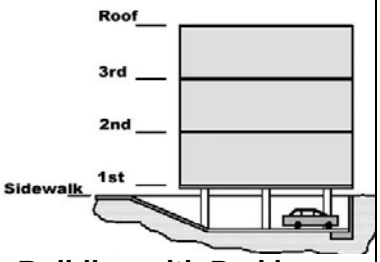
If only those buildings with **3 or more stories** are counted, while maintaining the criteria of either commercial or parking on the first floor, and the concept of openness, (as was done by San Francisco) the result is **538 buildings containing 8,957 units** out of the 1,479 potential soft-story buildings.

* The volunteers were people interested in earthquakes and public safety – mostly building design professionals, earthquake scientists, home inspectors, or university students – who are members of the Structural Engineers Association of Northern California (SEAONC), the Earthquake Engineering Research Institute Northern California Chapter (EERI-NC), the American Institute of Architects (AIA), the American Society of Home Inspectors (ASHI), or other related professional organization.
** See page 4 for more information on the issue of significant slope.

These inventories include buildings with "tuck under" parking so there are housing units on the first floor, as well as buildings with only parking on the first floor.



Tuck-Under Parking



Building with Parking on Entire First Floor

… and in other communities?

Other Bay Area cities have inventoried multifamily residential buildings to estimate the number of potential soft-story buildings in their cities.

- The Emergency Preparedness Council of ***Santa Clara County*** and its cities hired the Collaborative for Disaster Mitigation at San Jose State University to count and map soft-story buildings. Their inventory defines a multifamily building as one containing 4 or more units. They identified 2,630 buildings containing 33,119 units.
- The ***Cities of Alameda and San Leandro*** are creating inventories.
- The ***City of Berkeley*** inventoried multifamily buildings containing 5 or more units, with 2 or more stories, and built prior to 1995. The City identified approximately 400 buildings containing about 5,000 units.
- ***San Francisco*** inventoried multifamily buildings containing 5 or more units, with 3 or more stories, and built prior to 1973. The Department of Building Inspection, with the help of volunteers, identified 4,400 buildings with parking or commercial on the first floor, of which about 2,800 buildings containing 29,000 housing units had openings spanning 80% of one side or 50% or more of two or more sides.

What actions may be appropriate IMMEDIATELY?

- The City Fire Department should consider the map and database of these potentially soft-story buildings as it makes plans to prioritize **search and rescue operations** after earthquakes. In addition, ABAG should identify a clear mechanism to provide all inventory data to the City with the understanding that the list of buildings is not a list of soft-story buildings, but buildings likely at risk. **Volunteers did not enter these buildings or perform engineering evaluations.**
- The City, working with the American Red Cross and others, has identified places to shelter less than 5,000 people in ADA-accessible facilities. The City needs to continue working to identify shelters given the estimated need to shelter **21,500 people** in the City after a large Hayward quake, about half from damaged soft-story apartments and condos. Retrofitting soft-story buildings would significantly decrease shelter needs.
- The City of Oakland and Pacific Gas and Electric Company (PG&E) need to develop a program to place **automatic shut-off values** that detect excess flow (due to major leaks or breaks) on gas lines prior to entering, or being attached to, these buildings. Placing valves on the "upstream" (PG&E) side of these meters creates the safest and most cost-effective solution. Typically, a single gas line comes up to the building and then the line splits to service (for example) 14 gas meters in a 14-unit building. If the owner has to install a shut-off device, they end up with 14 devices, whereas PG&E only needs to install one. In addition, since the principal mode of failure for these buildings is collapse of the ground floor (exactly where these gas meters are located), it makes no sense to put the shut-off device on the wall that is going to collapse, meaning that a break on the "up stream" side of the device could not be detected and thus the gas would not be shut-off.

What type of MANDATORY program might be appropriate?

Few voluntary programs result in extensive retrofitting. In the case of unreinforced masonry buildings, cities with voluntary programs noted that 24% of buildings were retrofitted after decades, while 87% of buildings in cities with mandatory programs were retrofitted (California State Seismic Safety Commission, 2006).

The **first step** in an effective retrofit program might be to require owners to submit a "**screening**" of all **1,479 buildings** with parking and/or commercial on the first floor. This evaluation should be conducted by a licensed engineer, architect, home inspector, or contractor with experience in wood-frame construction. More information on the screening is contained on the following page. (A screening should cost an owner about $500, versus a full engineering evaluation required by Berkeley that costs $5,000 - $10,000.)

The due date of the 1,479 screening can be staggered using various criteria, including neighborhood, number of stories, or number of housing units. Later, evaluations could be required of 3- and 4-unit buildings. **Based on a statistical sample, about 1,060 4-unit buildings and 370 3-unit buildings in Oakland have parking or commercial on the first floor. Almost all (97%) have significant openings. However, the vast majority of units are in the buildings with 5 or more units (24,273 of about 30,600 units).**

The City should ensure that owners have a simple way to show that their property does **not** meet the program criteria if it complies with the 1988 Uniform Building Code or later – or due to the lack of commercial or parking areas on the first floor – or due to building(s) containing 4 or fewer units each.

In one timeline, for those buildings that show a potential problem based on the screenings, the City could require full retrofit designs be submitted 12 months after the due date for the screening, with permits pulled 6 months later, and construction completed 18 months later. In this example, all buildings would be retrofitted in 5 years following the initiation of the program.

Based on the experience of cities mandating unreinforced masonry retrofits, the City needs to provide the building department with mechanisms for program enforcement, including collection of increasingly higher fines and receivership authority under existing law to complete the necessary work.

As this program is implemented, the Building Department should be encouraged to note ways to streamline the process, bringing recommendations for change back to the City Council for amending applicable ordinances and standards.

Oakland would not be the first city to mandate retrofits for soft-story buildings. Fremont has such a requirement for apartments (not condos).

MORE INFO - Description of a soft-story screening

The Concern - Oakland's list of potential soft-story buildings is not a list of hazardous buildings. Rather, it is a list of those buildings volunteers identified as having parking or commercial space on the first floor, as viewed from "public" areas (sometimes confined to the sidewalk). While the list, as discussed, also has information the volunteers collected on the "openness" of the outside walls of the first floor of the building, the volunteers did not enter these buildings or make any structural engineering judgments.

Several communities have similar lists, including Santa Clara County, San Jose, and the other cities in Santa Clara County, as well as San Francisco. Other communities are developing similar lists. The concern about "releasing" the specific buildings on these lists is similar to that for "releasing" the data for Oakland - that errors are inevitable.

Thus, there needs to be an effective way for the City – and building owners – to determine if these building are structurally "suspicious" enough to warrant structural evaluations and designs of potential retrofits. It is inappropriate for owners to be required to pay $10,000 each for structural evaluations based on the judgment of volunteers (in the case of San Francisco and Oakland) or of engineering graduate students (in the case of Santa Clara County and its cities). Thus, we are encouraging a Phase 1 screening that could include the following steps:

STEP 1: Screen for Significant Slope – Oakland has hills and soft-story buildings on hills are more vulnerable to damage and need to be evaluated by a design professional. Thus, the first step in the screening should be to evaluate if the building is on a significant slope. Based on building code criteria, this is defined as a slope greater than 10:1 on any outside wall line or a "stepped" foundation. If the slope is significant, the building will be placed on a list of potential soft-story buildings and will not be required to have an Area Demand Ratio calculated in Step 2.

As a way to estimate how many buildings will be on the building list due to slope issues, one can use the data on significant slope from the ABAG-led inventory. In this inventory, slope was defined as a "drop" of at least six feet in at least one of the two directions of the building. Using this simple rule, 21% (618 of 2,908) of the buildings reviewed are on a significant slope. A higher percent (29% or 435 of 1,479) of the buildings with parking and/or commercial on at least a portion of the first floor are on a significant slope.

STEP 2: Calculate the Area Demand Ratio – Area Demand Ratio (ADR) is an effective screening. ADR is "calculated by summing the square footage of all floor and roof areas above the story under consideration and dividing it by the total linear footage of all walls in the story and load direction under consideration. Wall length counted includes all full-height wall segments including both shear walls and partition walls that extend to the gypsum board ceiling. Walls that are known to have exposed studs on one face (such as the small house cripple walls) have their length divided by two." *

ADR is best explained using an example.
Top number in ratio - In the case of a typical 2-story apartment building where the first floor contains some parking, the total square footage would be the square footage of the "footprint" of the building, say 10,000 square feet times 2 (10,000 for the ceiling of the first floor, and a second 10,000 for the roof) = 20,000. If the same building were 3-stories, the total square footage would be 30,000.
Bottom number in ratio - The linear wall length on the first floor in one direction might be 400 feet, and in the second direction might be 600 feet
ADR calculation – In this example, the ADRs for the 3-story building are 75 in one direction and 50 in the other direction. The ADRs for the 2-story building with the same 10,000 square foot footprint and the same wall lengths on the first floor are 50 in one direction and 33 in the other direction. The researchers proposing the use of ADRs show that ADRs of greater than 50 are an issue, and of less than 25 are not, typically, of concern. **The difficulty comes with those in the range of 25 to 50, where a policy decision on program scope is needed.** One possibility is to require that these buildings be evaluated, but give owners additional time to comply.

STEP 3: Screen for Configuration – Many of these buildings are not rectangular. They are shaped, in footprint, like an "L" or "U" or "T." These odd configurations can be particularly problematic if the open walls are concentrated in one part of these buildings. Thus, if one "wing" of this configuration is 25% or more (or some other percentage chosen showing "significance") of another "wing," the ADR calculations should be performed separately.

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* Cobeen, K., Russell, J.E., and Dolan, J.D., 2004, *Recommendations for Earthquake Resistance in the Design and Construction of Woodframe Buildings*, CUREE document W-30b. San Francisco is evaluating use of this technique, as well.

Voluntary and mandatory retrofit incentives

Different incentives may be appropriate for residential buildings of 5 or more units since these may be defined as commercial, whereas 3- or 4-unit apartments may be defined as residential.

Sometimes cities view building departments as logical leads for **all** activities associated with earthquake retrofits. However, incentive programs work best if a variety of departments are involved. Planning and community development can also encourage retrofits through the imaginative use of ***financial, procedural, and land use incentives***.

- **Parking, zoning, and density trade-offs –** Oakland might allow owners to have fewer parking spaces per unit in exchange for retrofit work in parking areas. An owner might be allowed to add an additional ground-floor unit to a building to partially offset the cost of a retrofit, even if addition of such a unit might result in densities that exceed those of existing zoning.
- **Redevelopment and CDBG funds** – Oakland Community Development Block Grant (CDBG) funds or Oakland Redevelopment funds could be used as an incentive for retrofit of housing in identified neighborhoods. CDBG funds are given to cities by the U.S. Department of Housing and Urban Development. California law requires that a portion of Redevelopment funds help ensure decent affordable low- and moderate-income housing.
- **Tax credits** – Oakland might waive a portion of a business tax for a number of years to encourage owners to retrofit. Or a portion of the property transfer tax might be rebated to subsidize this work.
- **Transfer of development rights** – Oakland might allow rights to additional units in an area be sold or transferred to parcels with soft-story buildings as another way to allow construction of additional units that could help recoup the cost of retrofitting.

- **Reducing setbacks** – Setbacks to the street or to adjacent properties might be reduced to create an opportunity for construction of an additional unit, the rents from which might be used to partially offset the costs of retrofitting. For example, a new two-story unit might be constructed with windows facing the street for added security.
- **Coordination with rent control boards** – Coordination with rent control boards may result in at least part of the costs of retrofit work being passed on to tenants through increased rents.
- **Waiving or reduction of building permit fees** – Building permit fee reductions, while a loss of revenue to the City, signifies a major gesture of "good will" to the owners of these buildings.

Retrofit standards and code enforcement

If an owner voluntarily decides to upgrade the earthquake resistance of a soft-story building, it is extremely important that the work be carefully designed to meet the expectations of the community. Current model retrofit codes focus on merely allowing occupants to safely evacuate the building, NOT to continue to live in these buildings after a major quake.

Oakland should ensure that the retrofit standard that it chooses specifically addresses the performance of these building retrofits. The desire is that most residents can remain in their homes after large earthquakes, even with some damage and with utilities that might not function. This is a higher performance objective than one that allows occupants to safely evacuate, with the expectation that the building might need to be demolished (the objective of most unreinforced masonry mandatory retrofit programs and model retrofit codes).

Thus, Oakland needs to ensure that it has an ordinance adopting the appropriate code for the performance it expects from these retrofits. It should also require that any retrofits, whether voluntary or mandatory, comply with this standard as a minimum. The 2009 IEBC Chapter A4 standard, allowing for some modifications provided by the SEAOC Existing Buildings Committee to meet the City's performance objective, is recommended.

The retrofits should be ***designed by an engineer who has applicable experience.***

Finally, as with retrofit for a related program on cripple wall retrofits, assigning specific building inspectors as liaisons in the building departments to provide ***technical assistance*** to owners in how to manage retrofits in a cost-effective manner is extremely effective in increasing the quality and speed of retrofits.

A role for disclosure programs

The best building codes in the world do nothing for buildings built before that code was enacted. Fixing problems in older buildings – retrofitting – is typically the responsibility of the building owner. Thus, local governments can promote retrofitting through targeted education of building owners. However, owners are reluctant to admit the potential problems of these buildings to tenants. **Thus, voluntary education and disclosure programs are of limited use.**

ABAG held a policy forum to brainstorm ideas on how to increase the pace of soft-story retrofitting. The consensus was that ***mandatory disclosure*** of the risk to current and prospective tenants, together with non-technical explanations (expressed as ***warnings***) of the risk, could be helpful. Mandatory disclosure to tenants should occur for existing tenants, before a new tenant signs a lease, and annually thereafter.

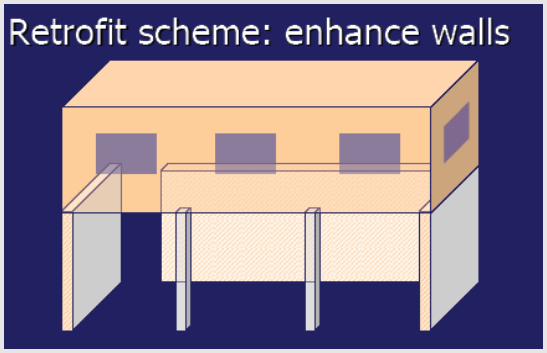
Does retrofitting make cent$?

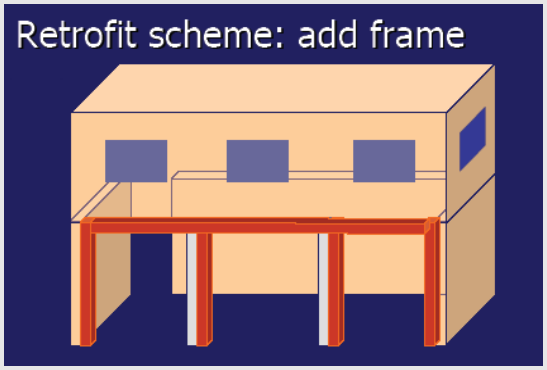
YES! Not only does earthquake retrofitting of buildings save lives, but it can also reduce post-earthquake losses to building owners, including: (1) loss of income from leases or rents while a damaged building is uninhabitable or under repair, (2) costs of repairs or demolition (likely to increase following a disaster as resources become scarce), (3) loss of appliances and fixtures, and (4) costs associated with potential lawsuits.

Retrofit can be relatively simple and cost effective. Researchers at Caltech examined two common retrofit schemes - adding or strengthening a wall down the length of the building, and adding a steel frame to the front of the parking area. The addition of the shear wall had a benefit-cost ratio in high seismic areas of up to 7:1, and the steel frame retrofit had a benefit-cost ratio of up to 4:1. The Caltech researchers were quite conservative in their loss estimates; they only looked at structural damage to the building itself.

Retrofitting benefits more than just the owner. Other common losses avoided benefit the **occupants** rather than the building owner, including loss of contents, alternate living expenses, and deaths and injuries, all of which significantly increase the benefit-cost ratios. Other benefits accrue to the **community**, including the "green" benefits of not having to demolish and rebuild, but rather make relatively minor repairs, as well as the reduction of fire risk, a secondary disaster that can cause significant damage to the surrounding areas.

The San Francisco Community Action Plan for Seismic Safety (CAPSS) 2009 report on soft-story buildings estimates that the typical costs of retrofitting will range from $58,000 to $114,000 per building, or $13,000 to $19,000 per unit, in San Francisco.





The depth and size of the new foundation for the frame can make a large difference in damage.

NOTE – Both estimated retrofit costs and repair costs in the Caltech report are lower than estimated Bay Area costs. Benefit-cost ratios vary depending on location and current building values. January 2009 data on home and condo sales for Oakland notes a drop of approximately 50% in home values since spring 2005. However, it is unlikely that the costs of retrofitting – and of post-quake repairs – have dropped. For comparison, typical 2005 value of these units in Oakland (for the structure only, not contents or land) is $84,000.

CREDITS – Pamphlet prepared by J. Perkins, ABAG Earthquake and Hazards Program Consultant, using funding, in part, from FEMA, through CalEMA, to develop a pilot soft-story program. It has been reviewed by the ABAG Earthquake and Hazards Outreach Review Committee. Volunteers were recruited and provided with maps by ABAG Research Interns Erika Amir and Kate Magary. Color diagrams courtesy of D. Bonowitz; Black & white diagrams courtesy of City of San Jose/CDM. Cost-benefit analysis from "Cost Effectiveness of Seismically Better Woodframe Housing," by K. Porter, C. Scawthorn, and J. Beck, *2005 Annual Hazards Research and Applications Workshop*, *July 10-13, 2005,* Natural Hazards Research & Applications Information Center, Univ. of Colorado at Boulder. The 2009 CAPSS report on soft-story buildings is available at http://www.sfcapss.org/PDFs/HereTodayHereTomorrow.pdf.