CITY OF ALBANY
PLANNING AND ZONING AGENDA
STAFF REPORT

Agenda date: July 27, 2010
Prepared by: LJ
Reviewed by: JB

ITEM/ **7a**

SUBJECT: **Discussion of Soft-Story Residential Building Policies.** Discussion of issues concerning soft-story residential buildings in the Albany, and possible programs to mitigate potential problems in the case of an earthquake.

STAFF RECOMMENDATION

No action is taken at this time. For discussion only.

BACKGROUND

Seismic safety is a significant concern to the City. There is more than a 60% chance of a major damaging earthquake striking the Bay Area in the next 30 years, and it is important to mitigate the potential disastrous effects of such an event.

In 1990, the State of California adopted Senate Bill 547. This bill required all cities and counties to identify Unreinforced Masonry (URM) buildings, propose how to seismically mitigate the buildings, and report findings to the State Seismic Safety Commission. In December 2004, the City Council adopted a mandatory URM ordinance. Under the ordinance, property owners of suspected URM buildings were given one year in which to submit evidence that their building is or is not a URM building. If the property is a URM building, a plan for retrofitting the property must be submitting within another year, and construction must be completed the following year.

Unfortunately, the unreinforced masonry ordinance addresses only one area of risk associated with earthquakes. There are still many residential apartment buildings that were constructed in the 1950's and 1960's, prior to building code updates for seismic safety. Although not constructed of unreinforced masonry, many of these buildings have soft stories on the first floor, usually due to ground floor parking levels, and are particularly hazardous during earthquakes. Staff would like to discuss the options for programs or ordinances that would help mitigate the hazards of soft-story buildings in Albany.

DISCUSSION

Many cities in the Bay Area have passed soft-story building ordinances or initiated programs that encourage buildings owners to retrofit their buildings. Most programs do not require retrofits of soft-story buildings, but do require building owners to notify tenants and post warning signs around their buildings. The predominant portion of programs also only apply to buildings that are 5 or more units, which may not necessarily be applicable for the scale of buildings in Albany.

Berkeley has the most extensive seismic program, with a soft-story building ordinance that was passed in 2005. Berkeley's program includes a full inventory of the City's soft-story buildings, which is available for public viewing. The ordinance requires owners of multi-unit soft-story buildings to submit an engineering report evaluating the seismic performance of their building. Buildings with seismic weaknesses are required to post this information at entrances and to notify tenants. In order for a building to be removed from the list, the owner must retrofit the building according to City standards. Another aspect of Berkeley's program is a transfer tax that is charged when residential properties are sold: the new owner can choose to use a portion of those funds for seismic upgrades on the property, in lieu of paying the tax. Though building owners are not mandated to retrofit their buildings, since the ordinance was passed, approximately 10% of buildings on the inventory have elected to voluntarily retrofit their buildings. The City of Berkeley is considering making retrofits mandatory in the near future.

In 2007, the City of Fremont passed an ordinance similar to the City of Berkeley for voluntary retrofits of multi-unit soft-story residential buildings. In 2009, Oakland also passed a similar ordinance, which requires owners of buildings built prior to 1991 with 5 or more units, and parking or commercial space on the ground floor, to hire a civil or structural engineer to do an inspection of the building. If the screening confirms that the building has a soft-story, and engineering evaluation report must be submitted to the City, and notice must given to the tenants and future occupants of the buildings.

Other cities, such as San Jose and San Francisco have completed preliminary inventories of the soft-story buildings in their jurisdiction, and are also working on programs to deal with the problem. San Francisco is discussing the idea of mandating retrofits of seismically unsafe buildings.

Next Steps

Staff has conducted a preliminary inventory of potential soft-story buildings along Adams Street in Albany. In this area alone, approximately 20 potential soft-story buildings were counted, housing approximately 140 units. Many of the buildings were more than 5 units, some were less. If Adams Street is an representative sample of multi-family housing in the City as a whole, the potential hazard caused soft-story buildings throughout the City is a significant concern.

Options for soft-story building programs could include ones similar to Berkeley and Oakland, but it may be beneficial to take smaller steps before beginning such a project. Completing a full inventory of the City's soft-story buildings would be an important first step, and may require the assistance of a structural engineer. In addition, day-to-day implementation of new policies may be beyond the technical training and time available with existing staff. Thus, staff recommends that the Commission discuss ideas for programs encouraging voluntary retrofits of existing soft-story buildings.

REDUCING OUR RISK BY THE 100TH ANNIVERSARY OF THE 1906 EARTHQUAKE
QUAKE '06

NORTHERN CALIFORNIA CHAPTER

Residential Buildings Committee

Soft Story Fact Sheet

1. How many Bay Area residents live in multi-family buildings?
Over 7 million people live in the 10 Bay Area counties. Over 25% of them, about 1.9 million people, live in multi-family buildings. In San Francisco, about 40%, or 300,000 people, live in multi-family buildings.

There are about 90,000 multi-family buildings in the Bay Area, with about 800,000 units. Excluding small 3- and 4-unit buildings, there are about 40,000 buildings, with 600,000 units.

2. How many of those are "soft story" buildings, and how many people live in them?
Overall, about 1 in 6, or 15,000, are soft story buildings. Over half a million Bay Area residents live in soft story buildings.

In San Francisco, about 180,000 people live in about 5700 soft story buildings. A Department of Building Inspection study projects that soft story buildings will account for about half of San Francisco's total economic loss in a magnitude 7.2 San Andreas earthquake.

Santa Clara County has 2630 soft story buildings, about 36% of all multi-family buildings. These soft story buildings have over 33,000 units and house about 90,000 people.

3. How many Bay Area jurisdictions have surveyed their soft story buildings?
Only 1 county (of 10), and only 3 individual cities (of over 100).

Santa Clara County has counted its soft story buildings and housing units and produced approximate maps for each of its 17 cities. Berkeley has identified about 400 soft story buildings with about 5000 units. Fremont has identified 28 soft story buildings with a total of about 1000 units. San Leandro has identified about 350 soft story buildings from a preliminary survey.

4. How many jurisdictions have mandated a soft story retrofit or mitigation program?
None. Berkeley proposed an increase in its property transfer tax in part to retrofit soft-story housing, but the proposal was not approved by the required 2/3 majority in the November 2002 election. San Leandro and Fremont have adopted engineering standards for voluntary retrofits. San Jose has prepared documents to help owners assess their vulnerability.

5. How much does it cost to strengthen a typical soft story apartment building?
To prevent collapse, between $3000 and $9000 per unit, or $4 to $10 per square foot, depending on several variables. To limit loss of housing/rental income, $14,000 to $20,000 per unit. A Berkeley study estimated that only 2% of buildings would lose parking spaces if retrofitted.

Repair costs after the 1994 Northridge earthquake—for those buildings that did not collapse—averaged about $20 per square foot. One 200-unit complex heavily damaged in the 1971 San Fernando earthquake was repaired and strengthened for $17,500 per unit; in 1994, the same buildings were "green-tagged," and cosmetic repairs cost only $500 per unit.

6. How many Bay Area owners have voluntarily retrofitted their soft story buildings?
Unknown, but certainly fewer than in greater Los Angeles. After the 1994 Northridge earthquake, Los Angeles adopted engineering standards for voluntary retrofit of soft story buildings. As of July 2002, only about 20 permits had been issued for this type of work.

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Notes and Sources

1. From 2000 Census, about 7,039,000 people live in these 10 counties (about 80% of them in the first five): Santa Clara, Alameda, Contra Costa, San Francisco, San Mateo, Sonoma, Solano, Santa Cruz, Marin, Napa. Note: ABAG stats do not include Santa Cruz County.

The population in multi-family housing is estimated from the number of housing units in buildings with 3 or more units and from the average household size in renter-occupied units (2000 Census). The estimate probably includes some condominium owners. San Francisco is different from other Bay Area counties: 65% of S.F. housing units are rentals. In the other 9 Bay Area counties, 39% of units are rentals.

The number of multi-family buildings is estimated from the number of housing units in buildings of different sizes (2000 Census). Buildings with more than 20 units are assumed to average 50 units per building. Selvaduray et al. report 310,000 units in 7400 multi-family buildings in Santa Clara County; 310,000 is significantly higher than the number given by the 2000 Census data.

2. Bay Area data: Estimated by extrapolating the 36% figure from Santa Clara County to the estimated number of multi-family buildings with 5 or more units in all counties but San Francisco, plus 5000 from San Francisco. The soft story population is then estimated with average values of 15 units per building and households of 2.5 people. See the notes following re Santa Clara and San Francisco.

San Francisco: Loss estimate from SF DBI. A soft-story building must be at least two stories tall. The 2000 Census data do not track building size, so the numbers are estimated as follows. San Francisco has about 146,000 occupied units in buildings with more than 5 units; these are likely to be multi-story. From the Census breakdown of units per building, we estimate about 10,000 buildings with more than 5 units. Subtract about 750 multi-story unreinforced masonry residential buildings (Recht Hausrath) to estimate about 9200 wood buildings. Of those, 62% are estimated to be soft story buildings (SF DBI), giving 5700. From 5700, estimate 15 units per building with 2.1 people per unit (per the Census data), for 180,000.

Santa Clara data from Selvaduray et al. Population estimated using average renter-occupied household size (2.8) in Santa Clara County from 2000 Census.

3. Sources: For Santa Clara, Selvaduray et al. For Berkeley, Barrett. For Fremont, Abolhoda. For San Leandro, Schock. See also the EERI-NC Best Practice at http://quake06.org/quake06/best_practices/IMSSB.html.

4. Sources: Fremont ordinance 2363. At its September 2002 City Council meeting, San Leandro adopted Chapter 4 of the *Guidelines for Seismic Retrofit of Existing Buildings*; see Schock. For San Jose, Vukazich and Rutherford and Chekene. Note: Most cities list earthquake risk reduction as a priority in their General Plans. Many (Hayward and Alameda, for example) specifically cite the threat posed by soft story buildings but have no specific programs to address that threat.

5. $3000/unit: Vukazich. Other retrofit costs: Rutherford and Chekene. The retrofit costs listed are hard construction costs only; they do not include other upgrades, lost rent, financing, tenant relocation costs, etc. Berkeley study: Barrett. Repair costs in 1971 (1995 dollars): Mendes. Repair costs for 42 buildings in epicentral area in 1994: Schierle. 200-unit complex: Mendes.

6. Source: Schnitger.

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

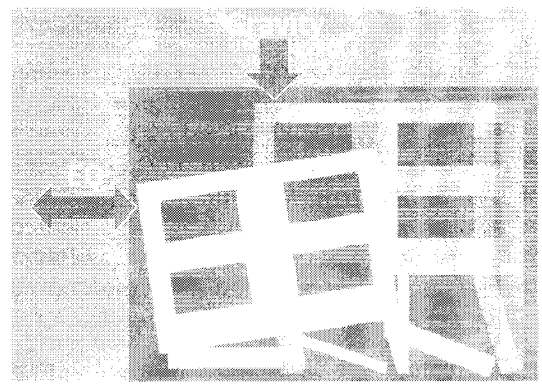


Diagram of collapsed building

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.

Table of Contents:

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.

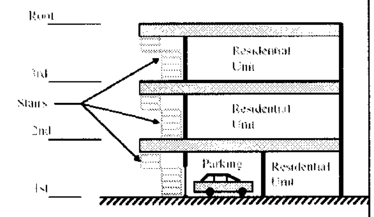
The volunteers collected information on (1) use of the first floor, (2) whether or not the building was on a significant** slope, and (3) "openness" of the first floor. "Openness" was defined using the same criteria as a similar San Francisco inventory project using similar volunteer earthquake professionals. 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.

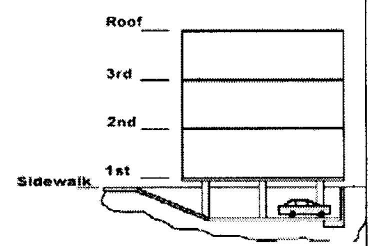
* The volunteers were people interested in earthquakes and public safety – mostly building design professionals, earthquake scientists, home inspectors, or university students – who are members of the Structural Engineers Association of Northern California (SEAONC), the Earthquake Engineering Research 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.

* 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.

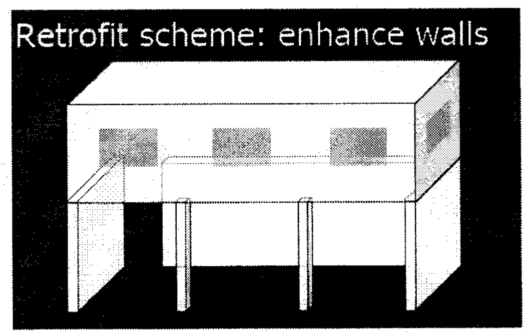
Does retrofitting make cent$?

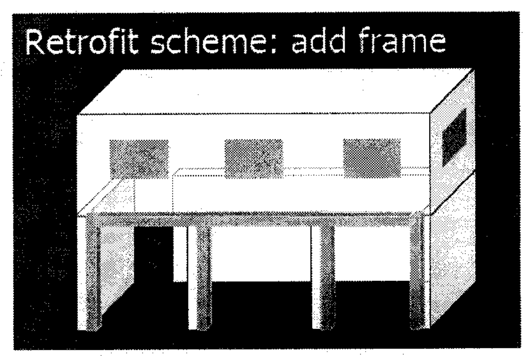
YES! Not only does earthquake retrofitting of buildings save lives, but it can also reduce post-earthquake losses to building owners, including: (1) loss of income from leases or rents while a damaged building is uninhabitable or under repair, (2) costs of repairs or demolition (likely to increase following 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,J uly 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.

City of San Jose

Residential Seismic Safety Program

August 1998

The Apartment Owner's Guide to Earthquake Safety

A Handbook for Owners to Identify
Seismic Hazards in Low Rise Apartment Buildings

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San Jose State University

Table of Contents

Purpose of this Handbook

When building owners think about the seismic safety of their buildings, several questions come to mind:

- How does a building resist earthquake forces?
- How safe is my building?
- If my building has seismic weaknesses, how can I fix them?
- How much will it cost?

This handbook is intended to be used by building owners to attempt to answer these difficult questions as accurately as possible by identifying structural weaknesses and understanding how to mitigate these weaknesses.

It should be obvious that the rapid visual screening procedures outlined in this handbook cannot provide highly reliable estimates of seismic performance and are intended only to identify those buildings where reasonable doubts exist. **If any questions exist in applying these techniques, you should err on the side of requiring the building to be investigated in further detail by a design professional. A design professional is a licensed Architect, Civil Engineer, or Structural Engineer with wood frame retrofit experience.**

If you identify a seismic weakness after using this handbook and would like to pursue retrofitting your building, you should first contact a design professional to perform a detailed analysis and, if necessary, create a design for your specific building. Guidelines for hiring design professionals can be found in the *Commercial Property Owner's Guide to Earthquake Safety* published by the California Seismic Safety Commission.

***The Apartment Owner's Guide to Earthquake Safety* is intended to provide information to building owners and is not a design guide for engineers or contractors. A permit is required for all seismic retrofit work, including all work described in this guide.**

I. Introduction

Recent seismic events such as the Loma Prieta, Northridge, and Kobe earthquakes have shown that in addition to loss of human life and property damage, these events can have far reaching political and economic effects on their respective communities. Identifying and reinforcing buildings that lack adequate seismic resistance can reduce this risk to the community. Wood framed apartment buildings, particularly those with first story tuck-under parking, have proven to be vulnerable to earthquake damage. Owners of low-rise apartment buildings in San Jose should be concerned for the following reasons:

A major earthquake is likely to occur in San Jose. San Jose is located in an active seismic region, and is vulnerable to severe ruptures on both the Southern Hayward Fault and the Peninsula Segment of the San Andreas Fault. The United States Geological Survey (USGS) estimates that the combined chance of a major earthquake from either fault is 46% in the next 30 years.

Apartment buildings constructed similarly to those that collapsed in recent earthquakes can be found in San Jose. The Northridge earthquake was the first major disaster where extensive residential damage data was systematically collected, and the results are sobering. Due to the Northridge earthquake there were 2700 multi-family dwellings (30,000 living units) that were vacated or had significant structural damage. Due to the similarities of the housing stock, it is reasonable to expect similar damage in San Jose. In fact, recent studies performed by the Association of Bay Area Governments (ABAG) and EQE International estimate that a major earthquake on the Hayward Fault will result in major structural damage to San Jose's residential housing. The Northridge earthquake has finally dispelled the myth that wood construction is largely immune to earthquake shaking. Although the 1971 San Fernando and 1989 Loma Prieta earthquakes provided evidence of the weakness of some wood buildings, the $10 billion of damage to wood buildings and loss of life in a moderate earthquake like Northridge is final proof.

Apartment owners may be held liable for the safety of residents. California Law makes the owner responsible for building safety even if the owner is unaware of structural deficiencies. One prominent example is the lawsuit against the owner of the Northridge Meadows Apartments whose collapse resulted in the death of sixteen people. Many apartment owners in Los Angeles are currently looking toward strengthening their buildings to both improve resident safety and prevent economic loss.

In the opinion of most structural engineers, a significant amount of the damage to multi-unit structures observed in the Northridge earthquake could have been prevented. In order to reduce the risk to human life and property, the City of San Jose Office of Emergency Services (OES) has implemented a Residential Seismic Safety Program (RSSP) funded by the Community Development Block Grant program. The goal of this program is to provide greater seismic resistance for the existing housing stock, an activity that is of special importance in the current San Jose housing market. One of the objectives of the RSSP is to provide an educational program to encourage multi-unit residential building owners to evaluate the seismic safety of their buildings.

II. Understanding Earthquake Behavior of Residential Buildings

Most of the multi-unit residential buildings in San Jose are predominantly wood frame construction, ranging in height from one to three stories. This section provides a simple overview of how these buildings are designed to resist earthquake forces.

In order to design simple structures like low rise residential buildings, engineers idealize earthquake ground accelerations as horizontal forces applied at the elevated floor and roof levels. These horizontal forces are carried to the foundation by specially designed walls called shearwalls. Figure 1 illustrates this lateral force idealization for a two-story structure. Note that only the walls parallel to the seismic load act as shearwalls and so walls perpendicular to the load are not shown in the figure. Figure 2 shows the forces on the individual elements of the building in order to illustrate how horizontal seismic loads are transmitted through the building down to the foundation. The seismic forces are carried by the floors and roof to the shearwalls. The floor and roof framing specially designed to carry seismic loads to the walls is termed a diaphragm by structural engineers. The diaphragms and shearwalls act together to carry seismic load to the foundation. Since this particular type of system looks like a box, the system is often called a box system. This box system is the most common lateral force resisting system for low rise multi-unit residential construction.

For the building to effectively carry the seismic loads, both the diaphragms and the shearwalls must be strong enough and stiff enough to resist excessive deformation. From examining the behavior of structures in recent earthquakes, by far the most effective method for providing strength and stiffness to diaphragms and shearwalls is to sheath them with structural grade plywood securely nailed to the wood framing. One of the primary reasons that older multi-unit buildings have performed poorly in past earthquakes is due to shearwalls being sheathed with inadequate materials such as gypsum wallboard or stucco instead of plywood.

Another concept that is important in understanding the behavior of buildings in earthquakes is the idea of a "soft" story. It is advantageous in multi-unit construction to provide parking for the residents on the first floor of the building. Unfortunately, this practice often creates what is termed a soft story by structural engineers. A soft story building is one in which one level (usually the first story) is significantly less rigid than any of the other levels above. Since residential units contain many walls to separate rooms and individual units, the upper levels of multi-unit construction tend to be very rigid. A first floor parking area, commonly called tuck-under parking, creates a first floor which is almost entirely free of walls, and thus is much softer (less rigid) than the residential units above.

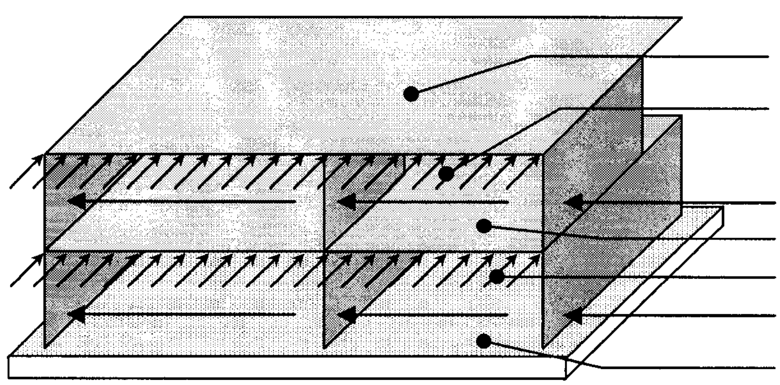


Figure 1. Seismic force resisting system for a box structure.

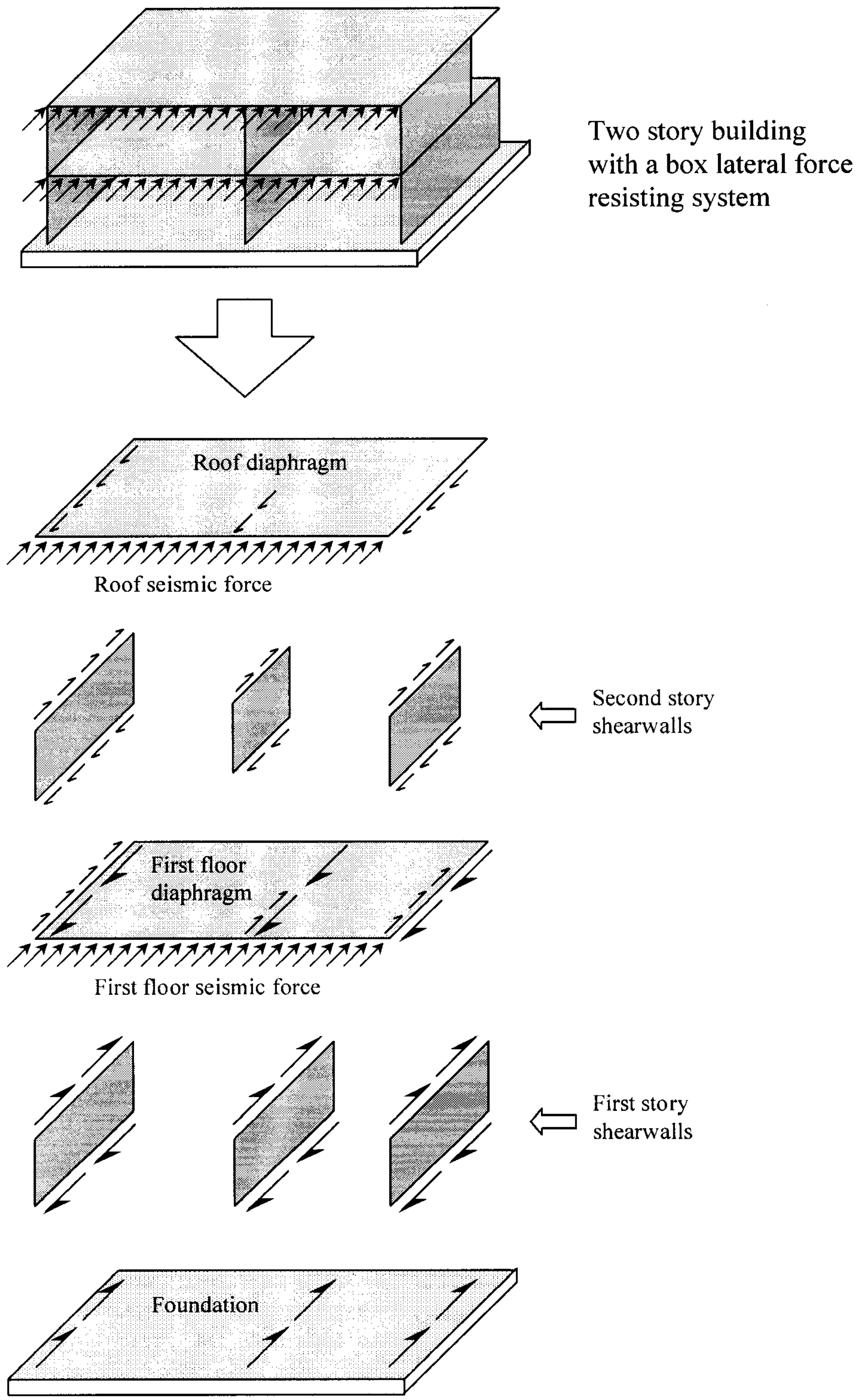


Figure 2. Seismic forces on the elements of a box structure

Expected Seismic Performance of Residential Buildings

Predicting the performance of buildings subjected to earthquakes is difficult, if not impossible, due to uncertainties in the earthquake motion, soil conditions, workmanship, and many other factors. Performance of similar structures in past earthquakes is the best indication of future performance. Nearly all of the residential buildings in California are designed according to guidelines set forth by the Uniform Building Code (UBC) which is revised every three years. A building designed according to code provisions should be able to:

- Resist minor level earthquake without damage;
- Resist a moderate level earthquake without structural damage, but possibly experience some nonstructural damage;
- Resist a major earthquake without collapse, but possibly with some structural and nonstructural damage.

Due to the evolution of building codes, there will always exist older structures that will not be able to achieve expected seismic performance. Wood buildings with tuck-under parking and buildings with unbraced cripple walls have now been identified as performing worse than expected. Seismic retrofit is the term given to procedures that strengthen these structures to improve seismic performance.

Performance History of Multiunit Residential Construction

Wood is the most popular construction material in California and accounts for the majority of residential buildings as well as many commercial buildings. In the past, earthquake damage to wood construction has been much less than that of unreinforced masonry and nonductile concrete buildings. In recent years, three types of wood building construction have proven to be vulnerable to earthquakes:

- Buildings with unbraced cripple walls;
- Buildings with soft first stories due to tuck-under parking areas;
- Hillside homes inadequately supported on steep foundations.

Because of their predominance in San Jose, this handbook addresses seismic weaknesses for the first two types of buildings, with particular emphasis on tuck-under parking buildings. The poor performance of these structures can be attributed primarily to the following:

- The presence of a very flexible first level due to tuck-under parking or unbraced cripple walls;
- The failure of shearwalls constructed from timber studs sheathed with stucco or gypsum board.

Stucco and gupsum board shearwalls coupled with tuck-under parking are present in many wood framed apartment buildings built prior to 1976. The primary reason for this is that the 1976 edition of the UBC contained revisions due to observed performance of buildings in the 1971 San Fernando earthquake. The most significant of these revisions was to decrease the allowable strength of both stucco and gypsum board shearwalls and to increase the seismic load by forty percent. The direct result was the increased use of plywood shearwalls in wood construction and while tuck-under parking was not eliminated it was discouraged. Figure 3 shows damage to stucco shearwalls in a tuck-under parking building following the San Fernando Earthquake. All of the damaged multi-unit buildings inspected after the Northridge earthquake had failed stucco or gypsum board shearwalls. The performance of these weak shearwalls was often made worse by sloppy construction and poor quality control.

Unbraced Cripple Walls

Most buildings that have a crawl space beneath the first floor level are supported by "cripple" walls. Figure 4 shows the view from the interior of the crawl space of an unbraced cripple wall building. The short (1-5 foot tall) walls between the exterior foundation and the first floor level are called cripple walls because they are shorter than full height walls. These cripple walls usually carry a significant portion of the weight of the building. The seismic vulnerability of buildings with cripple walls is that if these walls are not braced adequately to act as shearwalls, the upper portion of the building can fall off of its foundation due to the lateral shifting of the cripple walls. Figure 5 is a good illustration of an unbraced cripple wall failure in the Northridge earthquake. Many buildings with unbraced cripple walls were damaged in both the 1971 San Fernando earthquake and the 1994 Northridge earthquake. It should be noted that cripple wall construction is more common for single family residential construction than for multi-unit residential construction, but in San Jose there are many subdivided buildings with unbraced cripple walls. In particular, Victorian style buildings often have this type of foundation.

Tuck-Under Parking

As previously mentioned, multistory wood apartment or condominium buildings with open first-story parking and many upper-story walls are classic soft story structures. It is estimated that 200 of these buildings either collapsed or came close to collapsing in the Northridge earthquake. The mode of collapse generally followed the pattern of the first story parking level collapsing with the upper stories riding down remaining almost completely intact. The soft first story is often comprised of exterior shearwalls on three sides with very flimsy steel or timber posts on the fourth side. These posts are inadequate to resist the seismic forces and subsequent large deformation that they are subjected to in a major earthquake. Figure 6 shows a tuck-under parking building that collapsed during the Northridge earthquake. Note the collapsed steel posts indicated by the white arrows and the upper stories remaining almost completely intact. This figure illustrates the inherent weakness of the tuck-under parking configuration and the dangers to human life and property (16 people died in this particular building).

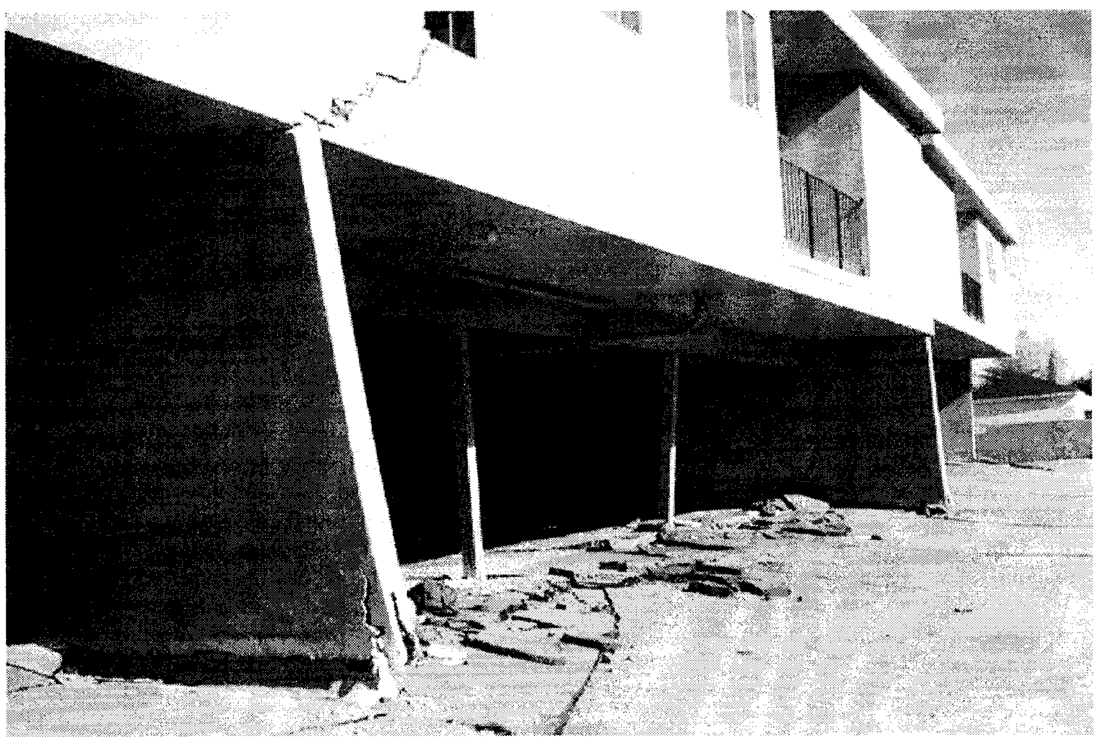


Figure 3. Damage to a tuck-under parking building with stucco shearwalls

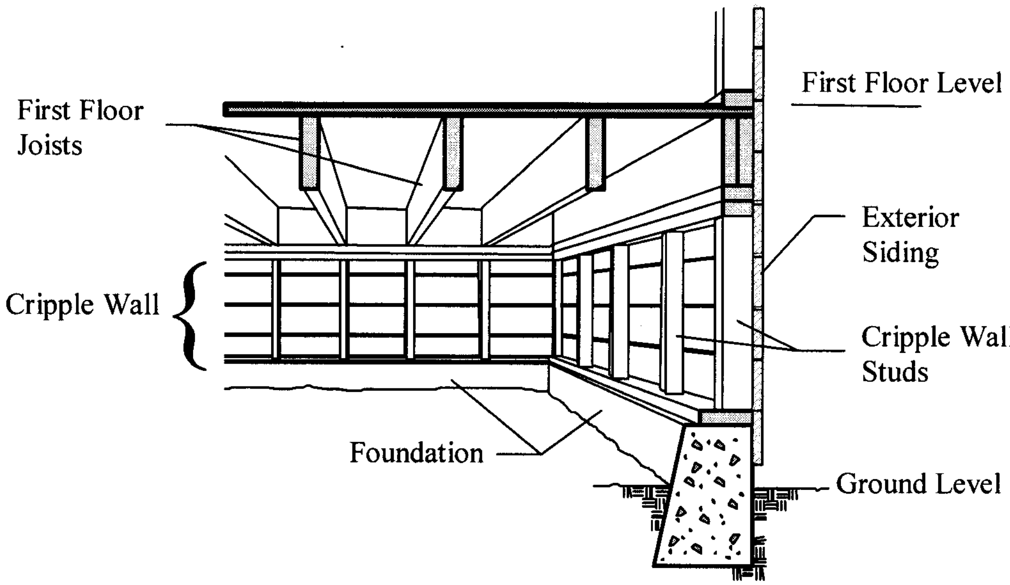


Figure 4. Unbraced cripple wall.

Figure 5. Cripple wall damage in the Northridge earthquake

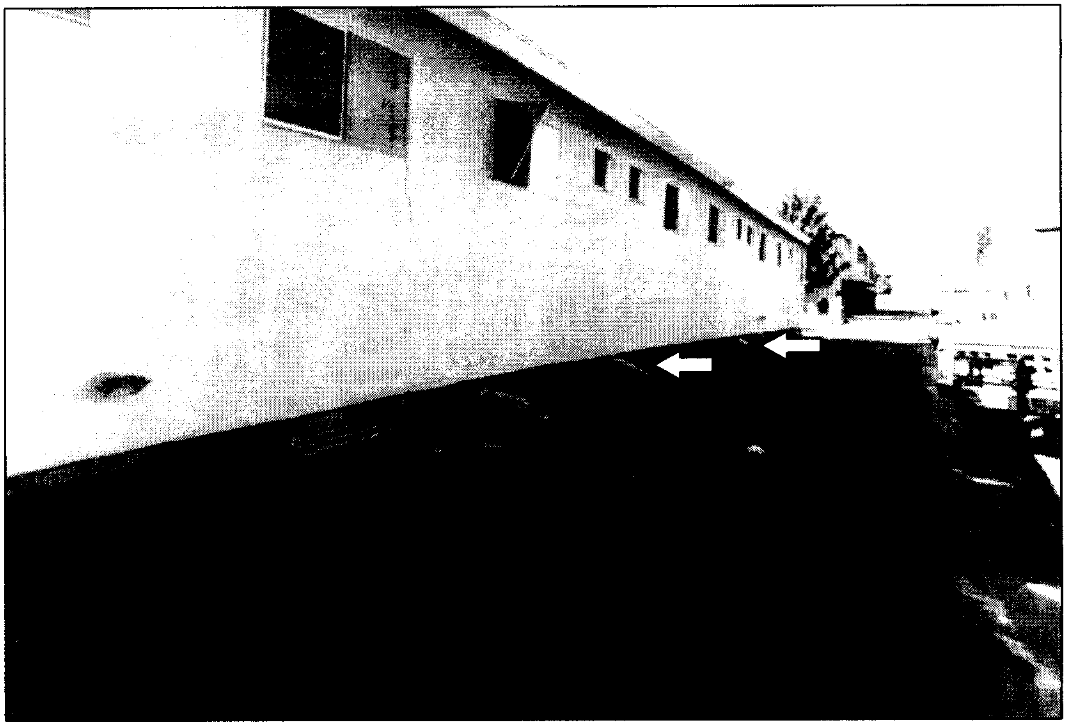


Figure 6. Damage to a tuck-under parking building in the Northridge earthquake.

III. Rapid Screening Procedure to Evaluate Seismic Performance

The Rapid Screening Procedure (RSP) is intended to be an instrument for non-engineers to approximately evaluate the seismic performance of a building based on visual examination. This visual screening process is based on Applied Technology Council (ATC) guidelines. The final result of the RSP is to generate a Structural Score S which is related to the probability of the building sustaining life-threatening damage in the event of a severe earthquake. A low Structural Score indicates that the building requires additional study by a licensed design professional. A high Structural Score indicates that the building is probably adequate. Since this handbook is based on ATC guidelines set forth in the ATC-21 document, key terms such as Structural Score and Rapid Screening Procedure used in the original document are also used in this handbook.

This method is meant to give a fast and inexpensive measure of the seismic risk of a building and cannot replace a detailed analysis by a design professional based on review of structural drawings, examination of the building structure, and engineering calculations. If a detailed review is indeed performed by a design professional, the Data Collection Form provided in this handbook is designed to provide useful preliminary information.

Rapid Screening Procedure and the Data Collection Form

This section presents an overview of the RSP and contains detailed information on how to fill out the Data Collection Form shown in Figure 7. The result of this survey is a finding as to whether the building in question should or should not be subjected to a more detailed investigation as to its seismic adequacy. This survey is intended to be consistent with ATC guidelines and the following statement from the original document applies:

It should be obvious that no rapid visual examination can provide highly reliable estimates of seismic performance, and the RSP method is simply intended to identify those buildings where reasonable doubts exist. It should be recognized that the RSP is a simple screening procedure and as such is limited. In some cases the RSP may miss buildings that in reality are seismically weak, so that if questions exist in the surveyor's mind regarding a particular building, the surveyor should err on the side of requiring the building to be investigated in further detail.

The ATC-21 document categorizes 12 types of buildings and rates the relative seismic performance of each building type based on past performance. The relative seismic risk is summarized by a Basic Structural Hazard score that reflects the estimated likelihood of a typical building of that category sustaining major damage in the event of a strong earthquake. Major damage is defined by repairs that would cost 60 percent of the building's value. This value of 60 percent was selected because this much damage often results in the building being deemed a total economic loss, and also this is the approximate threshold where life safety (building collapse) begins to become a serious hazard. The Basic Structural Hazard scores for the 12 building types range from 1 to 8.5, where higher values indicate better seismic performance. Because this handbook is concerned with multi-unit residential structures, which are primarily wood framed in San Jose, the Basic Structural Hazard score prescribed by ATC-21 for wood buildings of 6.5 is used. **Note that if the building in question is not predominately wood construction, this handbook does not apply and ATC-21 should be used if the building is to be evaluated.**

In addition to the Basic Structural Hazard score there are significant factors, such as irregularities in the structural system, deterioration of the structural materials (e.g. dryrot in wood framing), and adverse soil conditions that can negatively affect a building's seismic performance. In order to account for these factors a series of Performance Modification Factors (PMFs) have been determined, which when subtracted from the Basic Structural Hazard score, result in the final Structural Score S for the building being surveyed. These PMFs are described in detail later in this section.

As mentioned previously, the Structural Score is an approximate measure of the adequacy of the building. A high Structural Score is good, and a low score indicates the possibility of poor seismic performance, and that the building should be

Address ______________________________

______________________ Zip Code __________

Number of Stories ______________ Year Built __________

Inspector ______________________ Date __________

Total Floor Area (square feet) __________

Photo

Structural Score and Modifiers

Basic Score	**6.5**
Pre 1990	-2.0
Tuck Under Parking (choose one)	
Wood Parking Level	-2.5
Concrete or Block Masonry Parking Level	-1.5
Unbraced Cripple Wall	-2.5
Plan Irregularity	-1.0
Poor Condition	-0.5
Soil Condition (from ABAG maps)	
MMI VIII	-0.3
MMI IX	-0.6
MMI X	-0.9

Final Structural Score:

NOTE: Detailed evaluation recommended for Final Scores of 2 or less

Sketch

Comments

Figure 7. Data Collection Form.

reviewed in detail by a licensed design professional. By the ATC-21 guidelines, a Structural Score of 2 or less indicates that the building may not meet modern seismic criteria and the building should be investigated further.

The remainder of this chapter is devoted to explaining each element of the data collection form. Detailed information is provided for each PMF and general instructions for filling out the form are given.

Survey Tools

The survey is designed to be simple with few tools needed to conduct the survey. The following is a list of items that may be needed in performing the survey as described in this handbook.

- Pen or pencil
- Clipboard for holding the survey form
- Camera, preferably instant (e.g., Polaroid)
- Tape to affix photo
- Straight edge to aid in sketching
- Copy of handbook

Building Age and Structural Information

Before performing the survey, as much information about the building should be gathered as possible. A very important piece of information is the age of the building. Obviously, the more information that can be gathered regarding the building, the more confidence the person conducting the survey has in the Structural Score. In addition, if the building is deemed to require further review by a design professional, any drawings or design information will aid in this review. The building owner's own files containing drawings and specifications are the most useful source of information. If the owner's files are incomplete, the following resources may provide information:

Assessor's files: Assessor's files usually contain information about ownership, the assessed value of the land, and improvements made. Useful information such as the age of the building, the square footage, and the number of stories can sometimes be found from assessor's files.

Building Department files: Building department files can vary greatly and can, in some cases, provide a great deal of information. In general, files (or microfilm) may contain permits, plans, and structural calculations required by the city for a building permit. It should be noted that building department files may have gaps or are discarded periodically and thus information for older buildings may be difficult to find.

Previous Studies: In some cases, buildings may have been a part of a previous building inventory or similar study. In these cases, useful building information may be contained in the study.

Information on Soil Condition

Because soil conditions can greatly affect the seismic performance of a building and due to the fact that soil information cannot be determined visually, collecting soil information should be one of the tasks performed prior to conducting the survey of the building. Fortunately, shaking intensity maps are available for the San Jose area neighborhoods from the Association of Bay Area Governments (ABAG). Figure 8 is an example of a shaking intensity map for Northeast San Jose due to a 7.0 Richter magnitude earthquake on the Southern Hayward Fault. Shaking intensity is measured by the Modified Mercalli Index (MMI) which measures damage intensity. The shaking intensity in the neighborhood that the building lies in can be found from these ABAG maps and the appropriate PMF can be found from the table below:

Shaking Intensity	PMF
MMI VII or below	0.0
MMI VIII	-0.3
MMI IX	-0.6
MMI X	-0.9

Shaking intensity maps for several faults are available, but the faults that are most critical for San Jose are the Southern Hayward, Hayward, Northern Calaveras, and San Andreas Faults. The shaking intensity maps can be purchased from ABAG at the following address:

Association of Bay Area Governments (ABAG)
P.O. Box 2050
Oakland, CA 94604
Tel: (510) 464-7900

Or can be downloaded free from the ABAG website at:

http://www.abag.ca.gov.

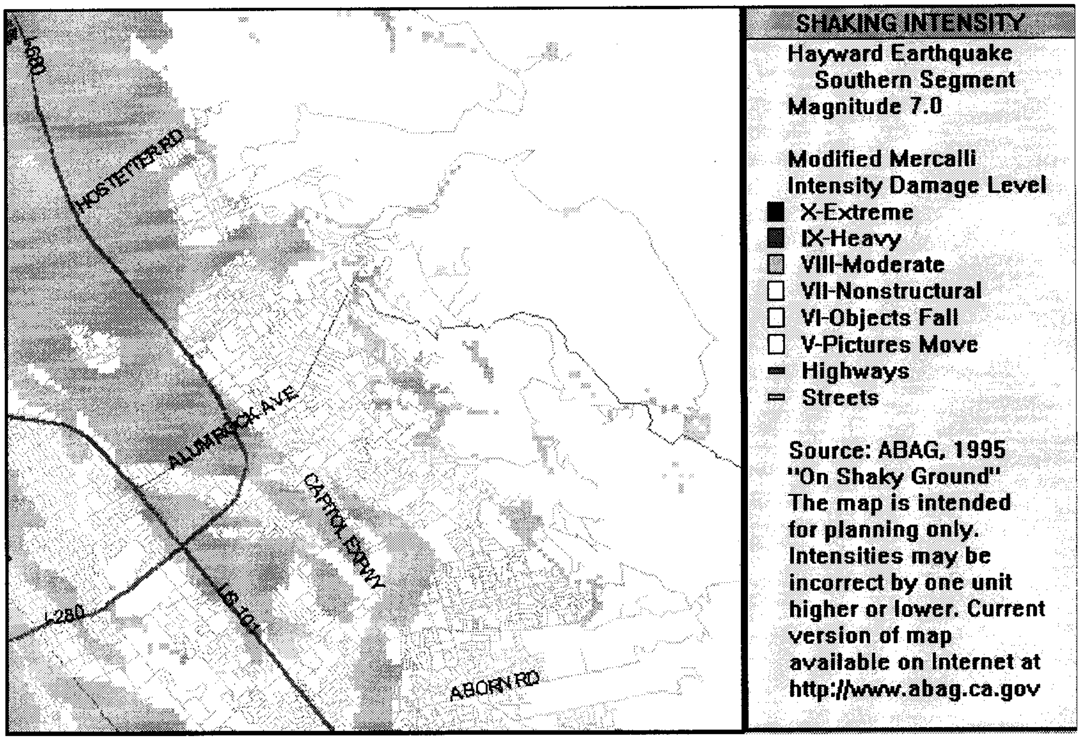


Figure 8. Shaking intensity map for Northeast San Jose from ABAG.

Filling Out the Data Collection Form

The following sections outline how to fill out the Data Collection Form section-by-section.

Basic Building Information

The person conducting the survey should include all of the information in this section (located in the upper left-hand corner of the Data Collection Form) which includes the address, number of stories, year built, approximate total floor area (in square feet), date of the survey, and the name of the inspector.

Photo

In order to provide a visual reference to the building and its surroundings, space is provided to affix a photo of the building on the Data Collection Form.

Sketch

Space is provided on the form for a sketch of the building which should include some approximate dimensions for the building.

Basic Structural Hazard Score

As mentioned in the preceding section, the basic structural score for a multi-unit wood frame buildings is 6.5. This value is based on guidelines set forth by the ATC-21. This basic score can be modified depending on factors such as year of construction, soil conditions, building configurations that have been known to affect the seismic performance of buildings. The following sections describe the factors that modify the Basic Structural Hazard Score.

Performance Modification Factors (PMFs) to the Basic Structural Hazard Score

All of the possible PMFs are listed on the Data Collection Form. Once the appropriate PMFs for the building are found they should be circled by the inspector on the Data Collection Form.

Building Constructed Prior to 1990 (PMF: –2.0)

The benchmark year for multi-unit timber construction in San Jose is 1990. Buildings built prior to this date may have seismic resisting elements that have proven to be inadequate in recent earthquakes. The justification for 1990 as the benchmark year lies in the fact that as a result of post-earthquake evaluation of structures and research, earthquake design loads have increased and allowable capacities for poorly performing materials, like stucco and gypsum wallboard, have been reduced. Significant changes in the 1976 and 1988 editions of the Uniform Building

Code (UBC) have had the effect of increasing the use of plywood shear walls in timber construction. The 1988 UBC was not fully adopted in San Jose until 1990, and so prior to 1990 the use of timber walls sheathed with gypsum wallboard, gypsum lath and plaster, and stucco for shear walls was common. Walls sheathed with these materials have performed poorly in earthquakes compared to walls sheathed with structural grade plywood.

Tuck-Under Parking

Tuck-under parking is a common term given to multi-story structures whose first level consists of parking spaces located directly below the upper level residential units. An approximate guideline is a building whose first story consists of greater than 40% open parking area, can be characterized as a tuck-under parking building.

Wood Parking Level (PMF: -2.5)

Figure 9 represents a generic tuck-under parking building typical of those that can be found in San Jose. The construction is primarily of wood with steel beams or posts sometimes visible at the ground floor parking level. Note that the upper floors are entirely comprised of residential units while the parking level is comprised of 40% to 60% open parking area. Note that Figure 9 is meant as an illustrative guideline, and that many other possible configurations are possible.

Concrete or Block Masonry Parking Level (PMF: -1.5)

Figure 10 shows another tuck-under parking configuration that may be found in San Jose where the parking level is built from concrete or concrete block masonry. As shown in the figure, the parking level is usually below the street level with two or three levels of wood constructed residential units above. This configuration usually performs better than the previously mentioned all timber construction, but is still vulnerable to damage, particularly if the concrete is in poor condition.

Unbraced Cripple Wall (PMF: -2.5)

In order to identify if cripple walls are adequately braced, the inspector needs to go into the crawlspace of the building and look for plywood panels sheathing the interior of the cripple walls. If no plywood sheathing is present (see Figure 3) the cripple walls are not adequately braced.

Plan Irregularity (PMF: -1.0)

Seismic weaknesses can be exacerbated by building configurations that are irregular in that they contain significant projections from the main building. Buildings that are "L", "T", "U", or "E" shaped in their plan shape can incur additional damage at the sharp re-entrant corners. If the length of any projection is greater than 15 percent of the plan dimension in the given direction, the structure can be considered to have a plan irregularity. Figure 11 illustrates this criterion for plan irregularity and the location of vulnerable areas for several irregular configurations. For example, for the "L" shaped building in Figure 11: if L = 150 ft then the projection would classify as a plan irregularity if it were longer than 0.15*(150 ft) = 22.5 ft.

Poor Condition (PMF: -0.5)

The effect of poor condition or maintenance on seismic behavior is difficult to quantify. Poor condition affects the seismic behavior when it results in building materials that are weaker than those originally called for in the structural design. Examples of poor condition include the following:

- Excessive or uneven ground settlement, usually detected by cracking on the exterior of the building;
- Main member rotting due to water damage (dryrot), pest damage (e.g. termite), or rusting of metal connectors (bolts, nails).
- Concrete surfaces that exhibit rust stains and/or exposed steel reinforcement.

Soil Condition (PMF: 0.0 to –0.9)

Soil conditions can greatly affect earthquake ground motion intensity. For this reason the RSP includes a PMF for soil type based on Modified Mercalli Index shaking intensity. The shaking intensity in the neighborhood that the building lies in can be found from the ABAG maps mentioned previously, and the appropriate PMF can be found.

Structural Score

The final Structural Score is obtained by subtracting all of the PMFs that apply to the building from the Basic Structural Hazard score. The Structural Score should be recorded it in the space provided on the Data Collection Form. Note that final scores of 2 or less indicate that further detailed evaluation of the building is recommended.

Comments

Space is provided for the inspector to write any additional information that may be valuable in assessing the seismic performance of the building. If the inspector is uncertain of any PMFs used or in data collection (such as the age of the building) an explanation of the uncertainty may be noted here.

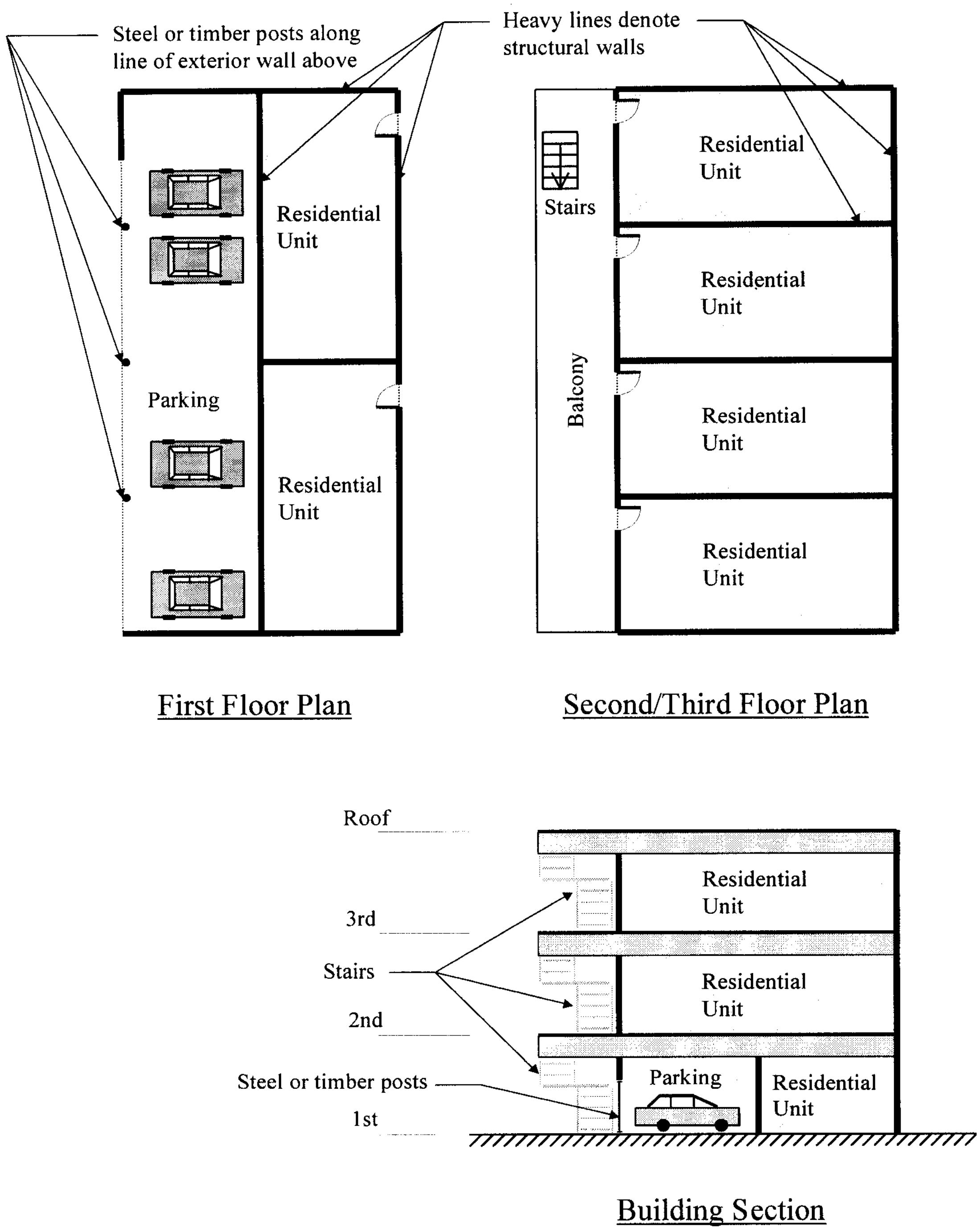


Figure 9. Generic tuck-under parking building.

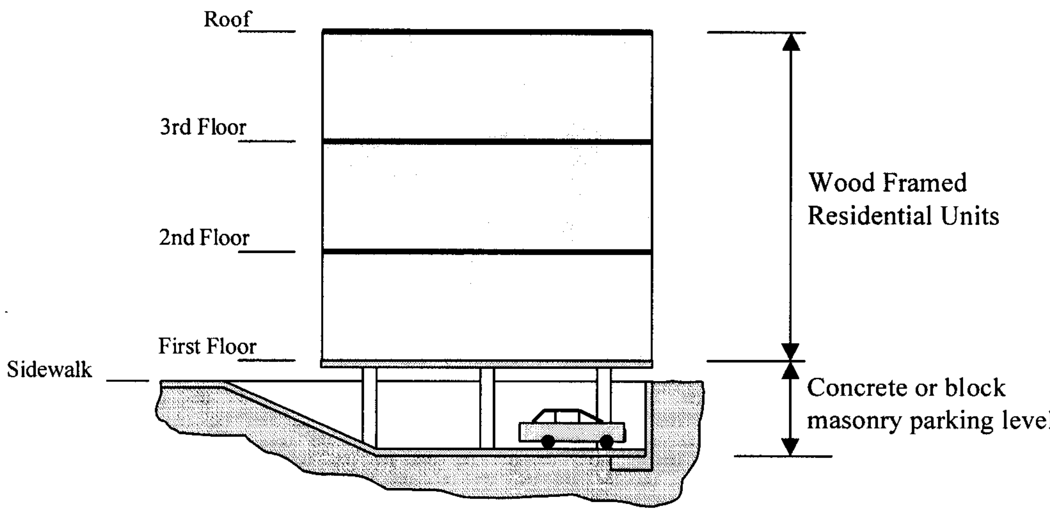


Figure 10. Tuck-under parking building with concrete parking level.

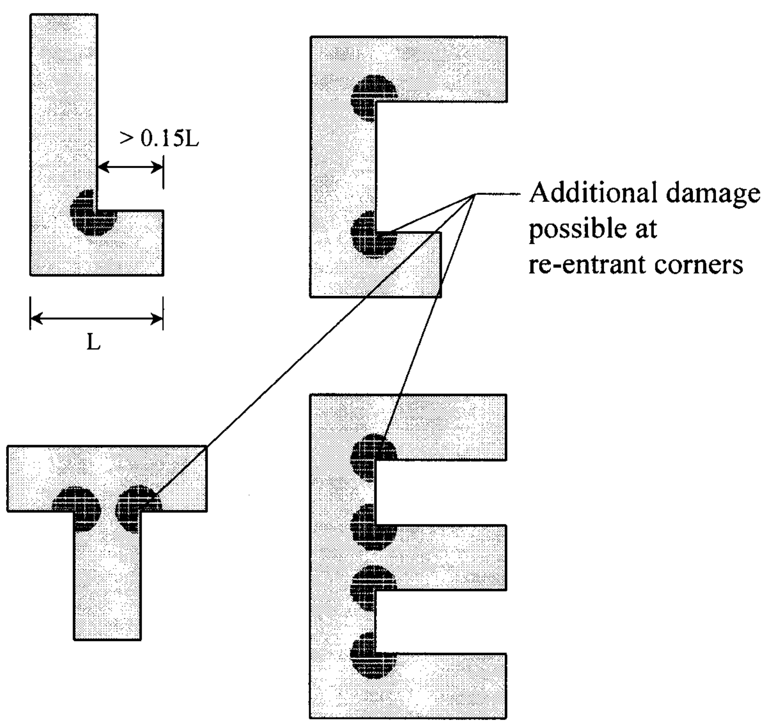


Figure 11. Examples of buildings with plan irregularities.

Interpretation of Structural Scores

Once the survey has been performed, the natural question that arises is what does this score mean. As previously mentioned, the structural score is linked to the likelihood of the building sustaining major life-threatening damage given the occurrence of an earthquake that is reasonable to expect in that community.

The question of what constitutes an acceptable seismic score still remains. In many ways it is up to the community to weigh the cost of safety versus the benefits. The City of San Jose has taken the approach that the identification of potentially hazardous buildings and the mitigation of their hazards will not only save lives and prevent injuries to the residents of the community, but will minimize economic losses and disruption to the daily lives of the people in the community. The "cut-off" value of 2 used by the City of San Jose in this handbook is based on the value recommended by ATC-21.

IV. Example RSP Evaluation of a Building

In order to illustrate the RSP and how to fill out the Data Collection Form, the following example is presented. A photo of the example building is shown in Figure 12 and the completed Data Collection Form for this building is shown in Figure 13.

Pre Field Data Collection

The age of the building is a very important factor that determines the standard as to which the building is designed. From review of the owners records, it is determined that this building was constructed in 1968. Also, from the ABAG maps, the building lies in a neighborhood that has a maximum shaking intensity of VIII on the Modified Mercalli Index.

Rapid Screening Procedure (RSP)

From a visual inspection, the owner determines that:

- This building is predominantly wood framed;
- The first floor is over 40% open parking area;
- The building is regular in its plan dimension (rectangular);
- There are no signs of dryrot or faulty construction.

In addition, the owner has sketched the plan and elevation view of the building including approximate dimensions.

From the visual survey and data collection, the PMFs that apply to this building are circled on the Data Collection Form. The circled PMFs as indicated on Figure 13 are:

- Building Constructed prior to 1990 (PMF: –2.0);
- Tuck-Under Parking, wood framed parking level (PMF: –2.5);
- Shaking Intensity of MMI VIII (PMF: –0.3).

Thus, the Final Structural Score is calculated by subtracting the PMFs from the Basic Hazard Score:

6.5 –2.0 –2.5 –0.3 = **1.7**

The Final Structural Score of 1.7 is less than 2.0 and it is noted in the comment section that for this building a detailed evaluation by a design professional is recommended.

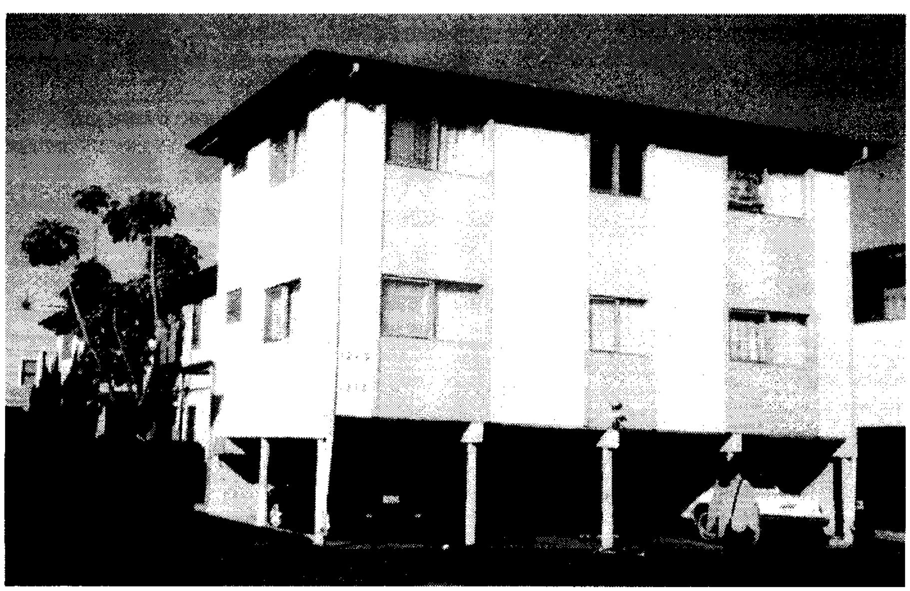


Figure 12. Photo of building for RSP example.

City of San Jose Multiunit Residential Building
Seismic Hazard Checklist

Address 525 MEADOW AVE.
OURTOWN Zip Code 98888
Number of Stories 3 Year Built 1968
Inspector S. VUKAZICH Date 11/11/97
Total Floor Area (square feet) 1920

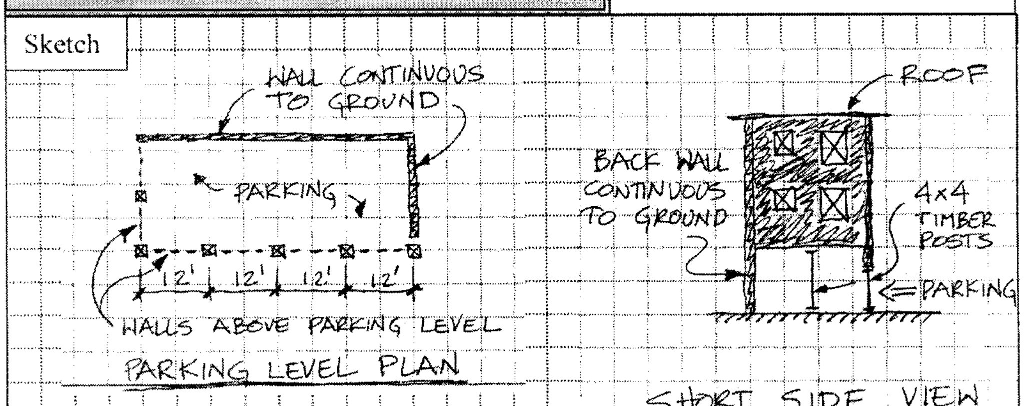
Structural Score and Modifiers

Basic Score	6.5
Pre 1990	(-2.0)
Tuck Under Parking (choose one)	
Wood Parking Level	(-2.5)
Concrete or Block Masonry Parking Level	-1.5
Unbraced Cripple Wall	-2.5
Plan Irregularity	-1.0
Poor Condition	-0.5
Soil Condition (from ABAG maps)	
MMI VIII	(-0.3)
MMI IX	-0.6
MMI X	-0.9

Final Structural Score: 1.7

NOTE: Detailed evaluation recommended for Final Scores of 2 or less

Sketch



Comments

FINAL SCORE => 1.7 < 2
DETAILED EVALUATION
IS RECOMMENDED

Figure 13. Example of completed Data Collection Form.

V. Retrofit Strategies and Costs

This section outlines retrofit strategies for buildings that have seismic weaknesses that can be identified by the RSP. It should be noted that it is usually not economically possible to bring existing structures to a performance level equal to that of new construction. However it is almost always possible to greatly improve the seismic performance of older buildings by means of seismic retrofit. The following case study is a good example of the economic effectiveness of retrofitting a tuck-under parking building.

Case Study: Friday Apartments in Sylmar California

One case study that can be used to base retrofit strategies on is the Friday Apartments, a 200-unit apartment complex located in Sylmar California. The complex consists of several buildings with two stories of wood residential units above first floor tuck-under parking. The complex was built in 1964 and was damaged in the 1971 San Fernando earthquake. The damage was mostly confined to the tuck-under parking units which deformed excessively with some of the units permanently shifted more than three inches out of plumb. The reason for the damage can be attributed to the use of stucco and gypsum board shearwalls in the first story parking level. The damage resulted in the entire complex being shut down for one year for necessary repairs and retrofitting. In 1971, the following repairs were made:

- The permanently deformed buildings were jacked up and moved back over their original foundations;
- Plywood was added to all first story walls;
- New 5/8-inch diameter anchor bolts were added to anchor the new first floor plywood shearwalls.

The cost of the aforementioned repairs and retrofitting was $3,500,000 in 1995 dollars. The retrofitted complex was subjected to almost identical ground motions in the 1994 Northridge earthquake and was "green-tagged" and fully functional after the earthquake. The cost of all needed repairs after the Northridge earthquake and complete painting of the exterior of the building was performed at a cost of $100,000. Thus, seismic retrofitting of multi-unit tuck-under parking buildings can be effective from both a life safety and financial perspective.

Retrofit Strategy for Tuck-Under Parking Buildings

In order to retrofit a tuck-under parking building to performance levels near that of modern construction, significant work must be performed throughout the building. This "full" seismic retrofit would probably result in significant portions of the building being shut down, tenants being temporarily displaced, and loss of some of the first floor parking spaces. Because this full seismic retrofit is not economically practical, the City of San Jose is proposing a "life-safety" retrofit designed to concentrate on retrofitting the obviously vulnerable first story parking level first, and then to develop a long-range program to determine if strengthening in the upper stories is needed. The reason for this strategy is twofold; first the parking level has shown to be the most vulnerable, and secondly the first level can be retrofitted with minimal disruption and displacement of the tenants.

The performance objective for the life safety retrofit is to prevent a catastrophic collapse that can endanger the lives of the tenants. This retrofit probably cannot control excessive deflection at the parking level and thus significant structural damage may still occur in the case of a moderate earthquake, but building performance will be improved.

The life safety retrofit procedure for a typical tuck-under parking building is illustrated in Figure 14. The recommended steps are as follows:

- Remove all existing first story wall coverings and sheath the walls with structural plywood and add special shearwall hardware;
- Add a rigid steel frame to control deflection at the entrance to the parking area;
- Replace any framing members that are damaged or deteriorated;
- Check existing foundations.

It should be noted that every building will have a different set of circumstances and requirements. Thus, it is very difficult to determine exactly what measures will be needed for an individual building. Figure 14 is meant as a guide to give building owners an idea of what type of strengthening is typically required.

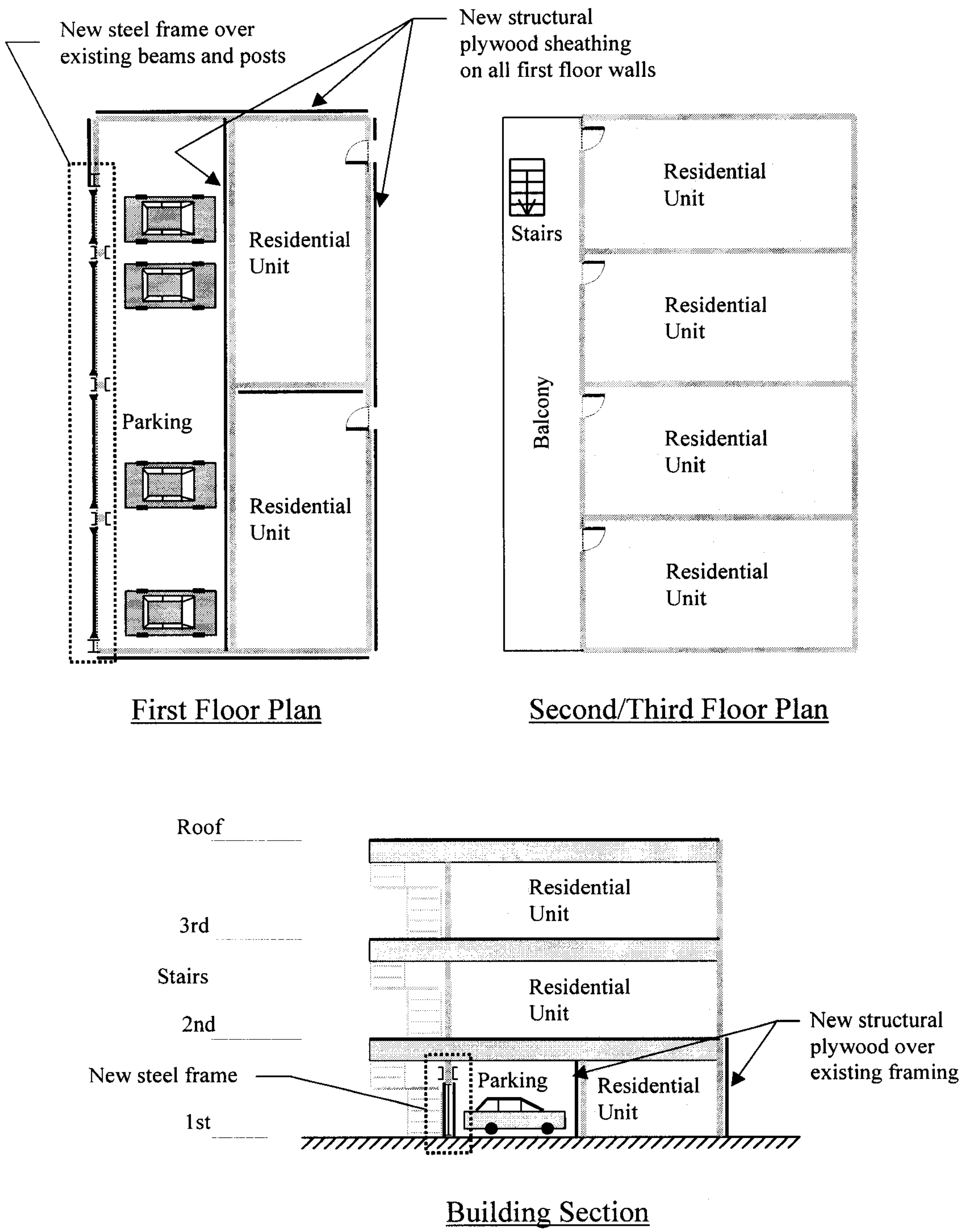


Figure 14. Life Safety retrofit strategy for a tuck-under parking building.

Approximate Cost of Retrofitting a Tuck-Under Parking Building

Table 1 represents approximate costs of retrofitting a generic tuck-under parking building to a life safety performance level and can be used as an approximate guideline. Note that actual costs can only be determined after a detailed analysis by a design professional and contractor. Also, circumstances like foundation replacement, ease of access, and replacement of damaged or deteriorated framing can add significant cost. The following cost analysis is based on a 25-unit complex with two stories above a first floor tuck under parking level. The total area of the living units is 17,360 square feet.

Table 1. Cost analysis for life safety retrofit of a 25-unit tuck-under parking building

Demolition	$5,746.00
Steel Frame	$26,500.00
Carpentry	$10,608.00
Finishes	$14,495.00
Subtotal	**$57,349.00**
General Conditions (12%)	$6,881.88
Overhead and Fee (15%)	$9,634.63
Contingency (5%)	$3,693.28
Total Cost	**$77,558.79**
Cost per square foot	**$4.47**
Cost per apartment unit	**$3,100.00**

The costs are based on 1995 dollars, and represent costs for one particular configuration. Note that this cost analysis does not include system improvements (mechanical, electrical, plumbing, fire), disabled access improvements, hazardous material removal, or architectural improvements.

The preceding cost analysis presented can be used as a guideline but the reality is that it is difficult to predict costs for multi-unit retrofits because there are very few examples to draw from. A realistic range for unit costs for tuck-under parking life safety retrofitting is $4 to $10 per square foot. Full seismic retrofitting is considerably more expensive, with unit costs in the range of $10 to $18 per square foot, not including possible additional costs due to loss of rent and tenant relocation.

Retrofit Strategy for Buildings with Unbraced Cripple Walls

Unbraced cripple walls are primarily a problem in single family homes, but there exist some multi-unit buildings in San Jose that have unbraced cripple walls. Buildings with unbraced cripple walls have a history of poor performance in many earthquakes with the building literally falling off of its foundation. Cripple walls are weak due to the inadequacy of exterior sheathing and stucco as bracing materials. Retrofit of unbraced cripple walls is a relatively simple procedure that involves installing structural grade

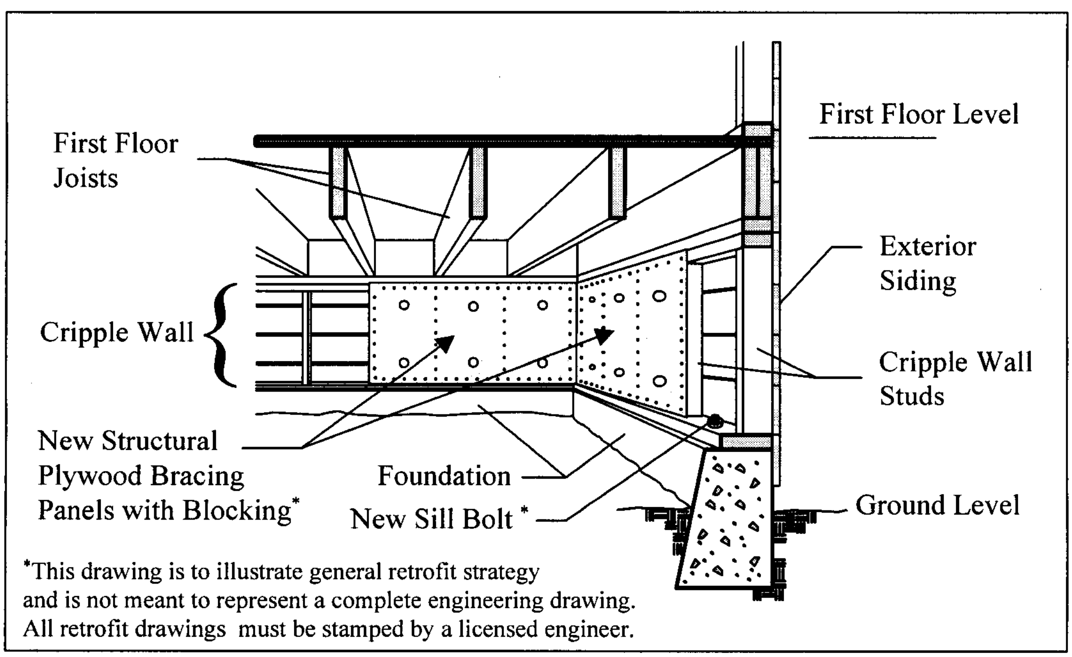


Figure 15. Retrofit strategy for an unbraced cripple wall building.

plywood bracing panels and connection hardware to the existing cripple wall studs. Figure 15 is a view from the crawlspace of a building with retrofitted cripple walls.

Because unbraced cripple wall retrofitting has been a recommended and relatively inexpensive procedure to perform, many buildings have been retrofitted in the Los Angeles area prior to the Northridge earthquake. There are well documented cases of retrofitted buildings performing very well in the Northridge earthquake in areas where unretrofitted buildings with similar construction sustained significant damage.

The recommended retrofit procedure for an unbraced cripple wall building is as follows:

- Check adequacy of existing foundation;
- Replace all damaged or deteriorated wood framing;
- Adequately bolt sill plate to the foundation;
- Provide structural grade plywood bracing panels on existing interior cripple wall studs;
- Install hardware to ensure positive attachment of the panels to the first floor level.

Note that the specific design for your building must be created by a design professional. Work must be completed by a licensed contractor under a City of San Jose building permit.

Approximate Cost of Retrofitting an Unbraced Cripple Wall Building

As previously mentioned, many retrofits of unbraced cripple wall buildings have been performed and the costs are well documented. One of the most important factors in the cost of retrofitting is the access and clearance available in the crawlspace work area. Crawl spaces of 10–18 inches in height can be considered difficult, 19-36 inches may be considered reasonable access, while crawlspaces with more than 36 inches of clearance can be considered excellent. In addition, if the work area is cluttered with plumbing, wiring, and ductwork will create extra work to relocate and/or work around them.

An unbraced cripple wall retrofit with a sound concrete foundation will have a unit cost in the range of $1.00 to $1.50 per square foot (based on total square footage of the building). A retrofit with a brick or unsound foundation that needs to be replaced with a new concrete foundation will have a unit cost in the range of $3.50 to $5.00 per square foot. Note that if the work area is cluttered or if less than reasonable access to the crawlspace is available, the aforementioned costs will increase between 20-50 percent.

VI. Should You Retrofit Your Building?

Obviously, the City of San Jose would like you to answer "yes" to this question if retrofit is recommended by a qualified design professional. Every building owner will have a different perspective as to whether the potential loss of income and perhaps human life in a future earthquake will justify the cost of seismic retrofit. Retrofitting programs for residential buildings are voluntary in nature and rely on building owners making educated choices as to what is best for them, their tenants, and the community. Currently, the City of San Jose is investigating the possibility of incentives that will help building owners offset the cost of retrofitting. Resources, such as tax credits and low interest loans, may already be available for some owners.

The damage and death that occurred in Northridge and other earthquakes has been well documented in the media and renters are choosing to avoid living in buildings that they perceive as unsafe. If you are reading this handbook, it means that you are concerned with the seismic safety of your building and the well being of your tenants. Hopefully, this handbook has provided information that will aid you in evaluating the seismic performance of your building.

One final thought: earthquakes in California are inevitable, earthquake damage and loss of life is not.

VII. Resources

Sources of Additional Information

Association of Bay Area Governments (ABAG)
P.O. Box 2050
Oakland, CA 94604
(510) 464-7900
http://www.abag.ca.gov

Board of Registration, Professional Engineers and Land Surveyors
2535 Capitol Oaks Drive Suite 300
Sacramento, CA 95833
(916) 263-2222

Structural Engineers Association of Northern California (SEAONC)
74 New Montgomery St., Suite 230
San Francisco, CA 94105-2411
(415) 974-5147
seaonc@ix.netcom.com

Contractors' State License Board
P.O. Box 26000
Sacramento, CA 95826
(916) 255-3900

Permit Information

For information about obtaining seismic retrofit construction permits in the City of San Jose, contact Ben Yousefi at (408) 277-5651.

Ordering Information

Copies of this handbook are available from the City of San Jose Office of Emergency Services. To order, call (408) 277-4595.

References

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Photo Credits

Figure 3 and Cover: Karl Steinbrugge. 1971.

Figures 5 and 6: City of Los Angeles Department of Building and Safety. 1994.

Figure 12: James Russell. 1994.