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Mitigation Policy Issues and Initiatives

OPTIMAL TIMING FOR MANDATORY RETROFIT ORDINANCES

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ABSTRACT

Designers of a mandatory seismic retrofit ordinance face a tradeoff in choosing the time interval between enactment of the ordinance and the deadline for compliance. If this "compliance interval" is too short, many owners experience financial hardship. If the interval is too long, a deadly earthquake may strike before the buildings are retrofitted. The City of Los Angeles has a mandatory seismic mitigation ordinance. Most owners had to pay out of pocket, and found three years insufficient to save up the amount needed for retrofit. Financial hardship can be quantified by the ratio of the annual sinking fund payment to the building's income. The distribution of these ratios gives policymakers insight into the impact of a contemplated compliance interval. For San Francisco, the optimal compliance interval is about seven years. For a city in Seismic Zone 2 with similar economic conditions, the optimal time is about nine years. However, 9 years may be an upper bound. The unreinforced masonry buildings in California are old, constructed before 1934. In St. Louis, construction of unreinforced masonry has been common until 1987. Thus, on average the buildings are newer and perhaps command more income.

INTRODUCTION

In designing a mandatory seismic retrofit ordinance, some key issues include: which buildings to target for retrofit; what standards for retrofit; what deadlines to impose for retrofit. This paper looks at one kind of building with a particular standard, and focuses instead on the issue of timing. (The buildings at issue are unreinforced masonry bearing wall buildings. The standard is the one recommended by the California Seismic Safety Commission, which eliminates about 90 percent of the life loss for about 20 percent of replacement cost.)

Designers of a mandatory seismic retrofit ordinance face a tradeoff in choosing the time interval between enactment of the ordinance and the deadline for compliance. If this "compliance interval" is too short, many owners experience financial hardship. Their political opposition can block the adoption of a mandatory ordinance in the first place. If the interval is too long, a deadly earthquake may strike before the buildings are retrofitted.

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The experience of the City of Los Angeles is enlightening. It has had a mandatory seismic mitigation ordinance for unreinforced masonry bearing wall buildings since 1981. More than 8000 such buildings remained since they were constructed, before 1934. For the category with the greatest number of buildings, owners had three years to comply from the time that they were served notice. Most owners had to pay out of pocket, and many owners found that three years are not enough time to save up the amount needed to pay for retrofit. As many as 30 percent of the owners missed the compliance deadline. Nearly all the residential buildings were served notice by September of 1986 [1]. More retrofits were completed in 1991 than in any other year [2]. So, in practice it took many owners five years to do the job.

A compliance interval of three years causes two problems. First, in a proposed ordinance, the threat of financial hardship arouses political opposition by owners. Second, in an existing ordinance, the short deadline puts many owners in a lose-lose situation: disrupt the income stream now by large payments into a sinking fund (to set aside for financing retrofit), or lose the building by selling it to someone with the resources to retrofit it. Obviously, the two problems are related. The political opposition is intended to prevent the financial hardship.

The Demolition Option

Some owners in Los Angeles decided to demolish their buildings rather than retrofit them. Apparently for them, the difference between the value of current use and the value of a vacant lot was less than the cost of retrofit. In particular, in transition neighborhoods, where redevelopment is taking place anyway, it makes sense to replace old buildings with modern facilities that command higher rent levels [3].

Most owners prefer to keep the buildings. About 20 percent of the bearing wall buildings in Los Angeles were demolished About 1300 demolitions took place before March 1991. In the following year, while the number of retrofits increased, the number of demolitions dropped to 100.

FINANCIAL HARDSHIP

Let financial hardship be quantified in two ways. The first is the "owner-burden ratio," the ratio of the annualized cost of retrofit (12 percent interest, 10 year amortization) to the annual net income assuming current uses and rent levels. The owner-burden ratio, ω, is given by

$$\omega = \frac{0.12 \times e^{-0.12 \times 10} / (1 - e^{-0.12 \times 10}) C}{I} = \frac{0.171 C}{I}, \tag{1}$$

where C is the cost of retrofit and I is the building's annual net income. This concept is of interest because tables of owner-burden ratios have been compiled for San Francisco unreinforced masonry buildings [4]. Figure 1 shows owner-burden ratios for selected San Francisco buildings. The cost of retrofit is based on a standard similar to that of the Uniform Code of Building Conservation, Appendix Chapter 1 [5].

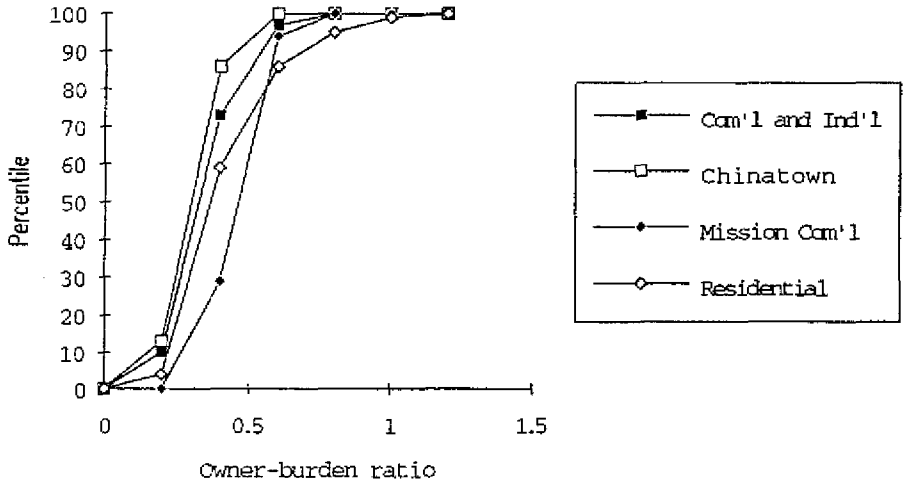

FIGURE 1. Owner-burden ratios for selected San Francisco buildings

However, for the owner that is unable to obtain a loan, the financial hardship comes from setting aside money into a sinking fund until the deadline for compliance. Let the "income disruption ratio" be ratio of the annual deposit to the sinking fund to the annual net income of the building. The income disruption ratio, D, is given by

$$D = \frac{C}{IT} e^{-rT}, \tag{2}$$

where r is the interest rate on savings and also the growth rate for net income, and T is the compliance time. The assumption is that each of the T installments has a present discounted value of $(C/T)e^{-rT}$, and that each installment is a constant fraction of a growing net income. The income disruption ratio is related to the owner-burden ratio by

$$D = \frac{\omega}{0.171T} e^{-rT}. \tag{3}$$

Clearly the income disruption ratio is a decreasing function of the compliance interval.

This simple model does not consider some other considerations regarding timing. For example, in any city the availability of contractors is limited. Not all owners can perform the retrofits simultaneously. The shorter the compliance interval, the more difficult to schedule all the work. Also, the shorter the compliance time, the higher the demand for retrofit in a given year, so the higher the price charged by overworked contractors. These costs are a decreasing function of the compliance interval. It is hard to generalize about the importance of these considerations, but for compliance intervals on the order of two years, they would be of great importance.

COMPLIANCE INTERVAL IN MODEL ORDINANCE

Table 1 shows the provisions of model ordinance recommended by the California Seismic Safety Commission for cities and counties in Seismic Zone 4. The periods for service of order begin when a local government passes a mandatory retrofit program. The orders are served after the period for service of order has expired. After an order has been served, the owner has three years to complete the structural alteration [6].

The ordinance has a provision by which the building official can send out an informative bulletin before the service of order. So owners of buildings with rating classification III or IV might have one to four years of forewarning before their three-year deadline takes effect.

Do these intervals make sense for Seismic Zone 4? What would be sensible for Seismic Zone 2 or 3?

TABLE 1. Provision of model ordinance

Rating Classification	Occupant load	Periods for service of order
I	N/A	N/A
II	100 or more	180 days
III-A	100 or more	1 year
III-B	51 to 99	2 years
III-C	20 to 50	3 years
IV	less than 20	4 years

ESTIMATES OF FINANCIAL HARDSHIP

Other cities are not identical with San Francisco. Subsets of the San Francisco data can be used to create a range of scenarios that captures much of the variability among cities. In particular, a "worst-case scenario" is derived, with the hope that most cities are better off than this scenario. Likewise, a "best-case scenario" is thought to bound the possibilities at the other end. Figures 2 and 3 (on next page) show the distributions of income disruption ratios as a function of compliance interval. The percentiles ("PCT") refer to the percentage of buildings for which the income disruption ratio is smaller than the number shown in the table.

All of the unreinforced masonry buildings in California were constructed before 1934. So the scenarios refer to old buildings. The scenarios might have limited relevance to cities outside California, where many unreinforced masonry buildings are newer. In St. Louis, for example, construction of unreinforced masonry has been common until 1987. Thus, on average the buildings are newer and perhaps command more income for the owners. So, the distribution of income disruption ratios might be even better than the best-case scenario discussed in this paper.

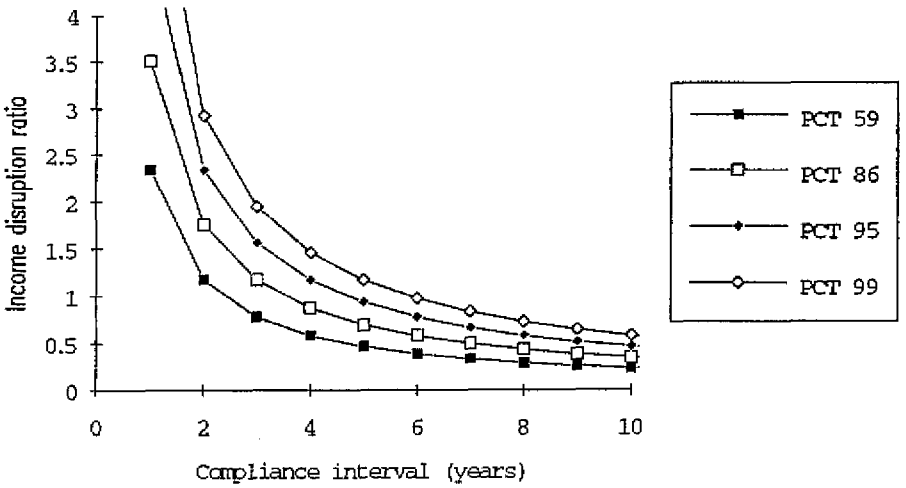

FIGURE 2. Income disruption ratios, worst-case scenario.

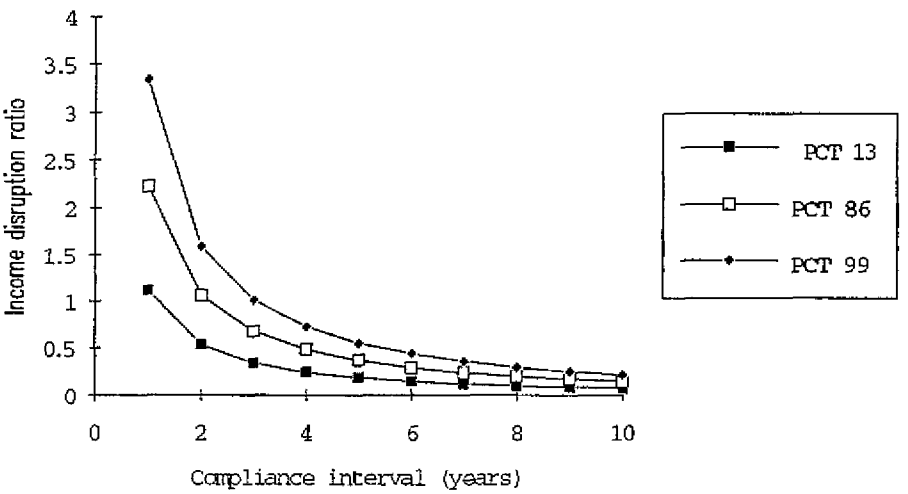

FIGURE 3. Income disruption ratios, best-case scenario.

Worst-case Scenario

The worst-case scenario occurs for a city with a distribution like that of San Francisco's residential buildings, with a stagnant economy ($r = 0$). Figure 2 shows the distribution of income disruption ratios as a function of compliance interval. For example, for a compliance interval of three years, 86 percent of the owners had income disruption ratios of 1.17 or less. The curves in Figure 2 can be considered upper bounds on the income disruption ratio.

Notice that for compliance time less than 7 years, the income disruption ratio exceeds 1 for some owners. That means that even if they devote all of the building's income to saving up for retrofit, it will not be enough when the deadline passes. Such owners will have strong motivation to oppose a proposed retrofit ordinance. For a compliance interval of three years, as suggested by the Model Ordinance, around 30 percent of owners would lose all their income for three years.

Best-case Scenario

The best-case scenario occurs for a city with a distribution like that of San Francisco's Chinatown buildings, with a fast-growing economy ($r = 0.05$). Figure 3 shows the distribution of income disruption ratios as a function of compliance interval. Note that the scale is the same as on Figure 2, but the income disruption ratios are much lower in the best-case scenario than they are in the worst-case scenario.

Notice that for compliance time of 3 years, the income disruption ratio exceeds 0.5 for many owners, even in the best-case scenario. Note that for a compliance time of 5 years, nearly everyone has an income disruption ratio below 1/2.

POLITICAL CONSIDERATIONS

As of mid-1991, nearly all of the local governments in California's Seismic Zone 4 had some sort of mitigation program for unreinforced masonry buildings. Some of these programs are effective in reducing hazards, others are not. Where there are fewer than 200 such buildings in the jurisdiction, half of the governments chose mandatory ordinances. In those cities and counties with more than 200 such buildings, only 38 percent had chosen mandatory ordinances. Ironically, where the hazards are the greatest, hazard reduction is not likely to be required. As of mid-1992, San Francisco (2,080 bearing wall unreinforced masonry buildings) and Oakland (1,666 unreinforced masonry buildings) still lack effective ordinances. Evidently, opposition by owners is indeed a potent political force, and where there are many owners, there is much opposition.

Extending the compliance interval reduces the financial hardship on owners. This in turn reduces their opposition to a mandatory ordinance. An extended compliance interval may delay hazard abatement by a few years relative to the three years recommended by the model ordinance. However, an extended compliance interval may be just the compromise needed to get an effective ordinance at all.

Seismic Zone 4

The intent of the model ordinance is for retrofit of buildings to occur three to seven years after a local government initiates its own mitigation program. That time is divided into a period for service of order (one to four years for classification III and IV) and a compliance interval of three years. If a local government had confidence in its administrative competence, it could write its ordinance to limit the periods of service to one year, and allow longer compliance intervals. This compromise would not unduly prolong the toleration of hazardous buildings.

Other Zones

Outside Seismic Zone 4, the case for mandatory retrofit is not so strong. So further concessions would be necessary to reduce the opposition by owners. Also, the probability of a fatal earthquake occurring during the compliance interval is smaller in Seismic Zone 2 or 3, relative to the probability in Seismic Zone 4.

CONCLUSIONS

A compliance interval of three years does not seem like a good idea. The experience of Los Angeles showed that it took five years for owners to comply with difficulty. According to Tables 2 and 3, average income disruption ratios range from 0.51 to 0.69. Large cities in Seismic Zone 4 lack effective mitigation programs because of owner opposition.

For Seismic Zone 4, the compliance interval should be at least 5 years, preferably longer. Perhaps 7 years is a good figure. The extra two years reduces every owner's income disruption ratio by 40 percent. The extra two years of compliance interval might not even put anybody at additional risk, if on average this concession results in speeding up the adoption of a mandatory ordinance by two years.

For Seismic Zones 2 and 3, the compliance interval should be longer than that of Seismic Zone 4. For a compliance interval of 9 years, the income disruption ratio ranges from 0.17 to 0.39 for 86 percent of the buildings. Even for the worst case, only about 5 percent of the buildings exceed 0.5. Cities outside California may not even resemble neighborhoods of San Francisco. The unreinforced masonry buildings in California are old, constructed before 1934. In St. Louis, for example, construction of unreinforced masonry has been common until 1987. Thus, on average the buildings are newer and perhaps command more income for the owners. So perhaps 9 years is too long if most buildings are relatively new.

Unfortunately, this paper does not derive a tidy formula by which one can objectively calculate the optimal compliance period. At best, policymakers can stare at Tables 2 and 3, which presumably bound the plausible range of possibilities, and try to guess how much pain that owners are willing to tolerate. Or better yet, policymakers should try to obtain corresponding data for their own city. Ultimately it comes down to a value judgment. If this paper illuminates and clarifies that value judgment, then it has been successful.

REFERENCES

1. M. Comerio. "Impacts of the Los Angeles Retrofit Ordinance on Residential Buildings." *Earthquake Spectra* 8 (1): 79-94 (February 1992).

2. K. Deppe, Chief, Earthquake Safety Division, Los Angeles Department of Building and Safety. Personal communication. April 1992.

3. M. Tyler and P. Gregory. *Strengthening Unreinforced Masonry Buildings in Los Angeles*. Portola Valley, California: William Spangle and Associates, 1990.

4. Recht Hausrath & Associates. *Seismic Retrofitting Alternatives for San Francisco's Unreinforced Buildings: Socioeconomic and Land Use Implications of Alternative Requirements*. Oakland, California: Recht Hausrath & Associates, 1990.

5. International Conference of Building Officials. *Uniform Code for Building Conservation, 1991 Edition.* Whittier, California: International Conference of Building Officials, 1991.

6. Seismic Safety Commission. *Recommended Model Ordinance for the Seismic Retrofit of Hazardous Unreinforced Masonry Bearing Wall Buildings, SSC 91-03*. Sacramento: California Seismic Safety Commission, 1991.