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Earthquake Ordinances for the City of Los Angeles, California

A Brief Case Study

by

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"A General Evaluation Approach to Risk-Benefit for Large Technological Systems and its Application to Nuclear Power"

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PREFACE

This report represents one aspect of a National Science Foundation funded study at UCLA entitled, "A General Evaluation Approach to Risk-Benefit for Large Technological Systems, and Its Application to Nuclear Power," (NSF Grants GI-39416 and OEP75-20318). The objectives of this project can be defined to include the following:

1) To make significant strides in the provision of improved bases or criteria for decision making, involving risk to the public health and safety (where a risk involves a combination of a hazard and the probability of that hazard).

2) To make significant strides in the structuring and development of improved, and possibly alternative, general methodologies for assessing risk and risk-benefit for technological systems.

3) To develop improvements in the techniques for the quantitative assessment of risk and benefit.

4) To apply methods of risk and risk-benefit assessment to specific applications in nuclear power (and possibly other technological systems) in order to test methodologies, to uncover needed improvements and gaps in technique and to provide a partial selective, independent assessment of the levels of risk arising from nuclear power.

Reports prepared previously under this grant include the following:

1. Mathematical Methods of Probabilistic Safety Analysis, G. E. Apostolakis, UCLA-ENG-7464 (September 1974).
2. Biostatistical Aspects of Risk-Benefit: The Use of Competing Risk Analysis, H. N. Sather, UCLA-ENG-7477 (September 1974).
3. Applying Cost-Benefit Concepts to Projects which Alter Human Mortality, J. Hirshleifer, T. Bergstrom, E. Rappaport,

UCLA-ENG-7478 (November 1974).

4. Historical Perspectives on Risk for Large Scale Technological Systems, W. Baldewicz, G. Haddock, Y. Lee, Prajoto, R. Whitley, and V. Denny, UCLA-ENG-7485 (December 1974).

5. A Prediction of the Reliability of the Core Auxiliary Cooling System for a HTGR, K. A. Solomon, D. Okrent, and W. E. Kastenberg, UCLA-ENG-7495 (January 1975).

6. Pressure Vessel Integrity and Weld Inspection Procedure, K. A. Solomon, D. Okrent, and W. E. Kastenberg, UCLA-ENG-7496 (January 1975).

7. A Survey of Expert Opinion on Low Probability Earthquakes, D. Okrent, UCLA-ENG-7515 (February 1975).

8. On the Average Probability Distribution of Peak Ground Acceleration in the U. S. Continent Due to Strong Earthquakes, T. Hsieh, D. Okrent, and G. E. Apostolakis, UCLA-ENG-7516 (March 1975).

9. The Effect of a Certain Class of Potential Common Mode Failures on the Reliability of Redundant Systems, George E. Apostolakis, UCLA-ENG-7528 (November 1975).

10. Risk-Benefit Methodology and Application: Some Papers Presented at the Engineering Foundation Workshop, September 22-26, 1975, Asilomar, California, D. Okrent, Ed., UCLA-ENG-7598 (December 1975).

11. A Computer-Oriented Approach to Fault-Tree Construction, S. L. Salem, G. E. Apostolakis, and D. Okrent, UCLA-ENG-7635 (April 1976).

12. The Effect of Human Error on the Availability of Periodically Inspected Redundant Systems, G. E. Apostolakis and P. P. Bansal, UCLA-ENG-7650 (May 1976).

13. An Integrated Safe Shutdown Heat Removal System for Light Water Reactors, J. C. Ebersole and D. Okrent, UCLA-ENG-7651 (May 1976).

14. On the Failure Modes of Alternate Containment Designs Following Postulated Core Meltdown, C. K. Chan, UCLA-ENG-7661 (June 1976).

15. Probability Intervals for the Top Event Unavailability of Fault Trees, Y. T. Lee and G. E. Apostolakis, UCLA-ENG-7663 (June 1976).

16. Statistical Models for Competing Risks Analysis, H. Sather, UCLA-ENG-7676 (August 1976).

17. On Risk Assessment in the Absence of Complete Data, W. E. Kastenberg, T. E. McKone, and D. Okrent, UCLA-ENG-7677 (August 1976).

18. Cost-Benefit Analysis and the Art of Motorcycle Maintenance, B. Fischhoff, UCLA-ENG-7685 (August 1976).

19. On the Probability of Loss of DC Power Following AC Failure in a Nuclear Power Plant, J. Chun and G. E. Apostolakis, UCLA-ENG-76112 (December 1976).

20. Some Probabilistic Aspects of the Seismic Risk of Nuclear Reactors, T. Hsieh and D. Okrent, UCLA-ENG-76113 (December 1976).

21. Incremental Net Social Benefit Associated with Using Nuclear-Fueled Power Plants, Ilan Maoz, UCLA-ENG-76117 (December 1976).

22. On Risk from the Storage of Hazardous Chemicals, K. A. Solomon, M. Rubin, and D. Okrent, UCLA-ENG-76125 (December 1976).

23. Failed Tendon Inspection via Monte Carlo, J. A. Grzesik and D. Okrent, UCLA-ENG-7709 (January 1977).

24. Decision Table Development for Use with the CAT Code for the Automated Fault-Tree Construction, J. S. Wu, S. L. Salem and G. E. Apostolakis, UCLA-ENG-7711 (January 1977).

25. How Safe is Safe Enough? A Psychometric Study of Attitudes Towards Technological Risks and Benefits, B. Fischhoff, P. Slovic, S. Lichtenstein, S. Read and B. Combs, UCLA-ENG-7717 (January 1977).

26. Relative Hazard Potential — The Basis for Definition of Safety Criteria for Fast Reactors, L. Cave and D. Ilberg, UCLA-ENG-7692 (Revised Version February 1977).

27. A Parametric Utility Comparison of Coal and Nuclear Electricity Generation, K. M. Maurer, UCLA-ENG-7719 (February 1977).

28. A Look at Alternative Core Disruption Accidents in LMFBR's, C. K. Chan, T. K. Min and D. Okrent, UCLA-ENG-7720 (February 1977).

29. Liability and Safety in Nuclear Power Plants, J. M. Marshall and L. I. Lieb, UCLA-ENG-7724 (February 1977).

30. Catastrophic Events Leading to De Facto Limits on Liability, K. A. Solomon and D. Okrent, UCLA-ENG-7732 (May 1977).

31. An Approach to Societal Risk Acceptance Criteria and Risk Management, D. Okrent and C. Whipple, UCLA-ENG-7746 (June 1977).

32. Some Aspects of the Fire Hazard in Nuclear Power Plants, M. Kazarians and G. Apostolakis, UCLA-ENG-7748 (July 1977).

ABSTRACT

The City Council of Los Angeles is faced with a problem common to many government decision makers: it must develop and enact building code ordinances which are designed to protect the safety of thousands of people against earthquake risk. What is somewhat special is that the Los Angeles Building Department has identified 300 "high risk" buildings, and has said that there may be as many as an additional 14,000 within the city. These high-risk buildings are primarily structures constructed to pre-1933 earthquake code standards. Estimates have been made that a strong earthquake which could severely damage many of these buildings has a probability in the range of one in thirty to one in one hundred per year. Estimates of the possible fatalities resulting from building failure in such an earthquake range from a few thousand to twenty thousand.

The Los Angeles City Council has considered the problem several times during the past three years, but has not yet acted definitively on the need for seismic improvement of old buildings, if any, or on a specification of required improvements.

A summary of some of the more important issues and constraints facing the City Council is as follows.

Most members of the scientific community agree that sometime in the foreseeable future a large earthquake will occur along the San Andreas Fault, or along the Newport-Inglewood Fault. However, there is no definitive technical basis for predicting the time and the precise location of this event, or the magnitude of the earthquake; thus, the time and extent of a potential damage is uncertain.

Assuming that the scientific community could agree quantitatively on the earthquake risk to buildings, and furthermore could convince the general population and the decision maker of their findings, a definition of "acceptable level of risk" may still be needed prior to developing a new or changed ordinance, because there will not be absolute safety even for those buildings which are modified or built to meet more stringent seismic codes.

The most significant factor which influences the enactment of earthquake legislation is the actual occurrence of a large, damaging earthquake in the general area. This can be seen by those ordinances which were enacted following such memorable earthquakes as the 1906 San Francisco, the 1933 Long Beach, and the 1971 San Fernando earthquakes. Whether further empirical evidence will be the basis for changes in the Los Angeles codes remains to be seen.

It is difficult to equate the safety risk associated with failing to enact a revised earthquake safety ordinance to the economic cost of enacting such an ordinance. The costs of retrofitting current seismic requirements on pre-1933 buildings may be very large, and there may be potentially adverse impacts of condemning buildings which are seismically sub-standard.

Risks are being imposed on members of the public (employees, shoppers, theatergoers, apartment-dwellers, etc.) without informing them of the current status of knowledge of the risks, as they themselves are affected, or with the provision of only limited information. What is an appropriate moral, ethical, and legal basis on which to proceed in such a situation? What should be done with regard to evaluating the seismic risk for post-1933 buildings?

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CHAPTER 1

INTRODUCTION

Following the 1933 Long Beach, California earthquake, major building code revisions were made that required a certain level of earthquake resistance in all new buildings. Since then, the code has been revised many times, with the current code requiring substantially different design and construction standards than were used in pre-1933 structures. The philosophy behind the code changes appears to be that the public is entitled to a "reasonable degree of safety" from earthquake-induced injury, which apparently was not provided by the pre-1933 Los Angeles Building Code.

The objective of this paper is to illustrate some of the difficulties in dealing with decisions involving building codes designed to protect against earthquake hazards. By bringing some of these issues to light, it is hoped that we will be better equipped to resolve some of the inherent problems of the decision-making process.

In this paper, we briefly examine the history of earthquakes in the Los Angeles area, identify the more recent proposed earthquake ordinances, discuss public sentiment regarding earthquake ordinances (as depicted in newspaper editorials), and compare the earthquake risk for unimproved and improved pre-1933 structures. Appendix C of this paper contains a brief UCLA report on the situation, as perceived in April 1976, and a copy of a briefing given to Governor Brown by the U.S. Geological Survey in March 1976.

It is noted that several years ago the City of Long Beach, California went through an extensive public examination of the adequacy of the seismic design of its older buildings and arrived at a new set of requirements.* The City of Los Angeles has not yet faced the problem fully or arrived at a decision.

*See for example, Wiggins and Moran "Earthquake Safety in the City of Long Beach," J. H. Wiggins Co. 1970.

CHAPTER 2

MAJOR EARTHQUAKES IN THE SOUTHERN CALIFORNIA AREA AND PROJECTED FREQUENCY OF FUTURE EVENTS

There were approximately 40 earthquakes in Southern California during the past two centuries which resulted primarily from activities along either the San Andreas or the Newport-Inglewood Faults. Of these, at least five had intensities larger than VII on the Modified Mercalli Scale* in downtown Los Angeles. These earthquakes are identified in Table 1.

A very rough estimate of the probability of having an intensity MM VII or greater earthquake in downtown Los Angeles can be obtained from historical evidence. There have been 5 such earthquakes in the past 57 years, or about one every eleven years.

Estimating the probability of an intensity MM VIII, IX, and X earthquake in downtown Los Angeles is more difficult because there is very little historical information on such events occurring in that area. However, if we average all earthquakes in Southern California over the past 200 years, we get the following return periods for an average site.

*See Appendix A for a discussion of the Modified Mercalli Scale.

Appendix B shows the 50 most significant earthquakes in Southern California in the past 200 years. It is extracted from Reference [1].

TABLE 1: MOVEMENTS ALONG THE SAN ANDREAS AND THE NEWPORT-INGLEWOOD FAULTS RESULTING IN EARTHQUAKES WHICH HAD INTENSITIES VII OR GREATER IN DOWNTOWN LOS ANGELES.*

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location
1920	June 22	34	118.5	-	VIII	III-VIII	Inglewood
1930	Aug. 31	33.9	118.6	5.2	VII	VII	Santa Monica Bay
1933	Mar. 11	33.6	118.0	6.3	IX	VII	Long Beach
1952	July 21	35.0	119.0	7.7	XI	VII	Kern County
1971	Feb. 9	34.4	118.4	6.4	VIII-IX	VII	San Fernando

*Data from 1769 to 1972

**I_o = Maximum modified Mercalli intensity for the earthquake

I_{LA} = Modified Mercalli intensity in Downtown Los Angeles

Southern California Modified Mercalli Scale Earthquake	Return Period* (Years)
VIII	8
IX	13
X	21
XI	35

Comparing our crude estimate of 11 years for an intensity MM VII earthquake in downtown Los Angeles with the above table, we see that downtown Los Angeles may have somewhat less frequent earthquakes than an average location in Southern California. However, the difference does not appear to be significant for our purposes. If we assume that the relative frequency of intensity MM VIII through XI earthquakes (as depicted in the table above) is typical for Los Angeles as well, then we can estimate the following return periods for earthquake intensities in downtown Los Angeles.

*The return period was estimated by knowing the frequency of specific magnitude earthquakes which have occurred in Southern California. These frequencies were obtained from information contained in Table 1 "Earthquakes Affecting Los Angeles and Orange Counties: 1769-1972" of Reference [1]. Because the return periods are for an "average site" anywhere in Southern California, some specific sites may have higher or lower return periods.

Downtown Los Angeles Modified Mercalli Scale Earthquake	Return Period* (Years)
VII	11
VIII	18
IX	30
X	50
XI	90

The extrapolation out to MM X and MM XI introduces increasing uncertainty. Depending somewhat on the definition of how large an area is included in "downtown Los Angeles", the return period estimated for an MM X or MM XI intensity may be too small by, say, a factor of 10; however, even a return period of 1000 years gives a probability of occurrence which is significant (e.g., larger than the chance of each individual dying in an automobile accident). Return interval estimates for, say, an MM IX can be made, using knowledge of specific faults, and one gets similar numbers to those given herein.

*The return periods in this table were obtained as follows:

- The return period for MM VII earthquake is equal to 11 years based on the history of five MM VIII earthquakes in 57 years in Los Angeles.
- The return period for a MM VIII earthquake in downtown Los Angeles is assumed to be 60% (or about 18 years) less frequent than the return period for a MM VII earthquake in downtown Los Angeles. This assumption is based on the fact that MM VIII earthquakes were historically about 60% less frequent than MM VII earthquakes in Southern California. The frequency of MM IX and larger earthquakes in L.A. is assumed to fall off at the same rate for Los Angeles as was estimated for an "average site" in southern California.

Since the quantitative values are only intended to provide a rough estimate of a potential hazard, this very crude method was employed for estimating earthquake recurrence intervals in Los Angeles.

CHAPTER 3

EVENTS FOLLOWING THE FEBRUARY 9, 1971 SAN FERNANDO EARTHQUAKE

It is more than a coincidence that, following a large earthquake, there is a rush of public concern, as demonstrated by newspaper editorials and the drafting of earthquake-related legislation. This is illustrated in Table 2, wherein is listed many of the "public events" which transpired after the San Fernando earthquake of 1971.

Table 2 is conceptually displayed in Figure 1. The earthquake gains public attention, the public reacts by communicating their thoughts (in newspaper editorials, for example), the decision makers gain information from both the general public and the technical community, and the decision maker (or his staff) drafts legislation.

TABLE 2: SIGNIFICANT EVENTS AND ORDINANCES FOLLOWING THE FEB. 9, 1971 SAN FERNANDO EARTHQUAKE

DATE	EVENT OR ORDINANCE
2/9/71	San Fernando Earthquake with magnitude 6.4, or with maximum modified Mercalli Intensity VII to IX in the San Fernando Valley and MM VII in central Los Angeles. The earthquake severely damaged the Veterans Hospital and the Olive View Hospital in the north San Fernando Valley. There was moderate damage in downtown Los Angeles, especially to older buildings with brick and masonry facings.
12/12/71	Geology Professor James Slosson warns California builders against forgetting the lesson of the 2/9/71 earthquake. He cites Los Angeles Ordinance forbidding building within 50 feet of the San Andreas Fault as being arbitrary and based on old, unreliable data.
5/20/75	Los Angeles City Council adopts May 20, 1975 Earthquake Safety Plan. The plant identified City's intention to eliminate hazards associated with older construction standards, (but did not impose specific requirements).
9/20/75	Los Angeles City Council adopts September 10, 1975 Seismic Safety Plan. The objectives of the plan included: • Encourage public awareness of earthquake hazards • Assure minimum design standards against earthquakes for critical structures such as dams and hospitals • Ensure City's emergency communications network after a major seismic disaster • Reduce risk of life and property loss as a result of an earthquake • Evaluate levels of risk with respect to earthquake damage • Determine the relative seismic risk in various parts of the City as a guide to new development • Minimize nonstructural damage from ground shaking

TABLE 2 (CONTINUED)

DATE	EVENT OR ORDINANCE
	• Guide in the determination of future land uses within zones of potentially higher seismic risk. • Facilitate post disaster recovery • Assure the sound and rational reconstruction of Los Angeles following a major disaster. The Seismic Safety Plan did not, of itself, impose any changed requirements.
3/12/76	Seismic Safety Committee analyzes possibility that 4,500 square mile crustal blister along San Andreas Fault may be premonition of impending major earthquake.
3/17/76	Briefing given to Governor Brown by the U.S. Geological Survey regarding this blister.
4/8/76	Los Angeles Times Editorial reports seismologists ability to forecast earthquakes as imminent. Comments that land swelling along San Andreas Fault may be precursor of extensive trembler, and that local government should therefore require 14,000 unreinforced-masonry buildings to be either strengthened or demolished.
4/15/76	The Los Angeles City Council fails to approve ordinance by the Conservation Bureau of the Department of Building and Safety, which, if approved, would have required the owners of unreinforced masonry buildings of 100 or more occupants and built prior to October 6, 1933, to either repair their buildings in accordance with the seismic code or demolish them.
8/28/76	The Los Angeles City Council approved changes in building codes policy which would require 14,000 old buildings to post public notices warning of risk of occupying unreinforced masonry buildings during earthquake. Policy change was accepted rather than requiring old buildings to improve structural standards. However, this policy has not yet been adopted and according to a City Councilperson, it is not expected to be.
10/25/76	The Los Angeles City Cuuncil's Building and Safety Committee recommends an ordinance requiring strengthening of all unreinforced masonry buildings in Los Angeles within ten years. They said that the Federal Government should be called on to provide loan and grant aid to prevent some of the major consequences of severe earthquake.

TABLE 2 (CONTINUED)

DATE	EVENT OR ORDINANCE
11/27/76	The Los Angeles City Council failed to act on proposed new ordinance that would apply current seismic safety standards to 14,000 earthquake-endangered buildings constructed prior to 1933.
11/29/76	Los Angeles Times Editorial claims that 75,000 to 100,000 persons regularly use the 14,000 buildings in question.
1/25/77	The Los Angeles City Council approves program of rehabilitation, rather than demolition, of 14,000 buildings which are made of unreinforced masonry and which would suffer major damage during an earthquake. The program also included a proposal of a two-year study to assess environmental impact, to identify buildings at risk, and to recommend those needed improvements to ensure safety. The Council did not explicitly define "rehabilitation" nor did they indicate what would be an acceptable level of safety.
1/78	According to a Los Angeles City Council member interviewed by the author, the Council is expected to approve, within about a year, a building code amendment for earthquake safety for existing buildings. These amendments are expected (by the Council member) to be "moderate revisions" of those building code amendments defeated by the City Council on April 15, 1976. The nature of these "moderate revisions" was not explicitly defined; however, it was suggested that some City Council members are reluctant to require very stringent safety codes because the costs of implementing such codes may be unacceptable to the building's owner.

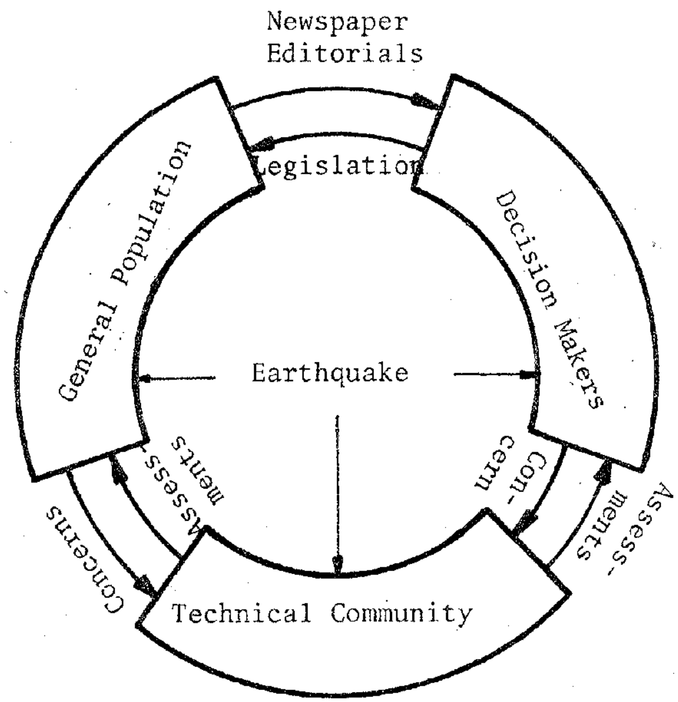

Figure 1

Earthquakes and Public Policy

CHAPTER 4

PROJECTED RISKS FROM EARTHQUAKES IN THE LOS ANGELES AREA FOR OLDER BUILDINGS

Various prior studies have estimated the seismic risk to pre-1933 buildings with and without structural improvements and to post-1933 buildings located in Southern California. One such study, by the National Oceanic and Atmospheric Administration (NOAA) [1], estimated the risks associated with two postulated earthquakes:

- An 8.3 Richter magnitude earthquake along the San Andreas Fault, and
- A 7.5 Richter magnitude earthquake along the Newport-Inglewood Fault.

Because of the larger distance between the San Andreas Fault and "downtown" Los Angeles compared to the distance between the Newport-Inglewood Fault and downtown Los Angeles, the effect of the earthquake on downtown Los Angeles buildings along the latter fault was estimated to be greater. Specifically, a 8.3 Richter magnitude along the San Andreas Fault (along a fault region nearest to Los Angeles) is expected to produce an intensity VIII quake in downtown Los Angeles, while a 7.5 Richter magnitude along the Newport-Inglewood Fault (in the Los Angeles area) is expected to produce an intensity IX quake (Figures 2 and 3, respectively).*

The probability of a pre-1933 structure with and without parapet corrections being destroyed is summarized in Table 3 [1]. According to this table, there is a 75% probability that an unimproved, pre-1933

*Figures 2 and 3 illustrate the estimated earthquake intensities in areas other than downtown Los Angeles. These figures are extracted form Reference [1].

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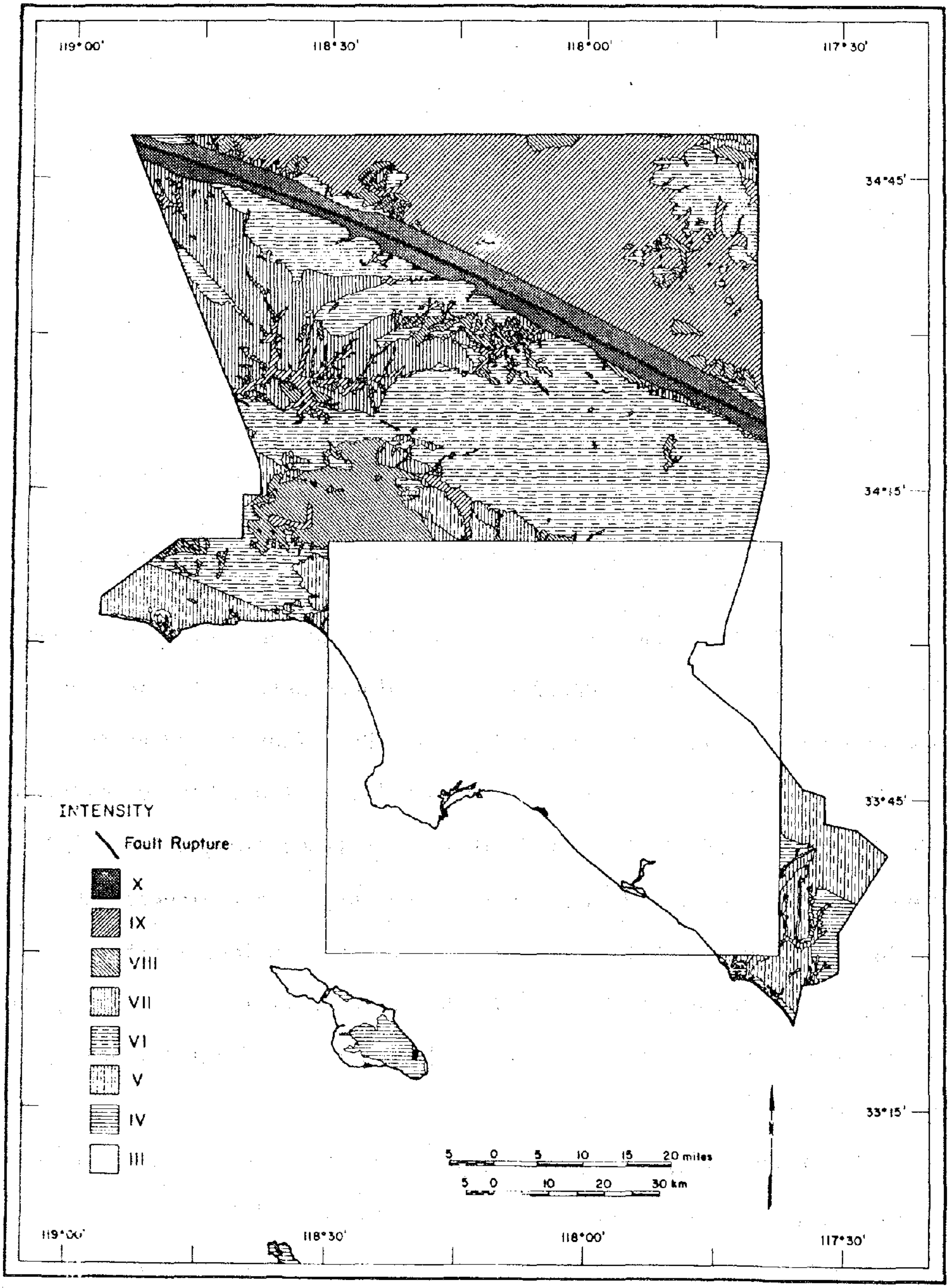

FIGURE 2. Estimated Modified Mercalli Intensity distribution in Los Angeles and Orange counties (exclusive of the Los Angeles Basin) for an earthquake of magnitude 8.3 on the San Andreas Fault. Surface fault rupture assumed.

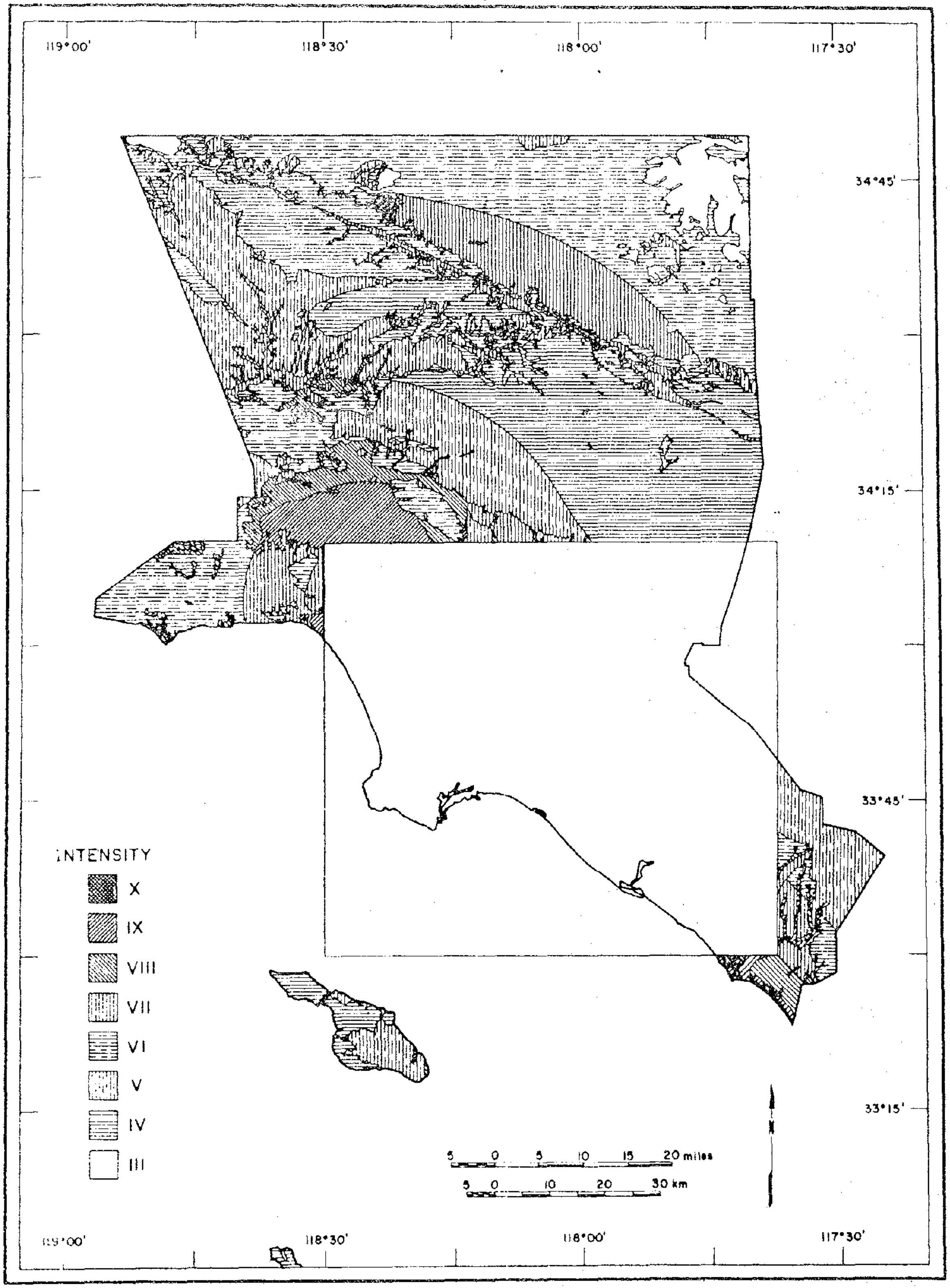

FIGURE 3 Estimated Modified Mercalli Intensity distribution in Los Angeles and Orange counties (exclusive of the Los Angeles Basin) for an earthquake of magnitude 7.5 on the Newport-Inglewood Fault.

TABLE 3. PROBABILITY THAT A PRE-1933 STRUCTURE WITH AND WITHOUT PARAPET WILL COLLAPSE [1].

EARTHQUAKE INTENSITY	PRE-1933 CONDITIONS		CORRECTED PARAPETS ON PRE-1933 STRUCTURE	
	PROBABILITY OF COLLAPSE*		PROBABILITY OF COLLAPSE*	
	WALLS	TOTAL BUILDING	WALLS	TOTAL BUILDING
VII	10%	5%	5%	0%
VIII	25%	15%	20%	10%
IX	50%	25%	40%	25%

*The probability of either wall or total building collapse is the sum of these two columns. For example, for a MM VII, the probability of either a wall collapse or building collapse in pre-1933 uncorrected buildings is 10% + 5% = 15%.

structure will suffer either total or only wall collapse if subjected to an Intensity IX shake, and a 65% probability for the same event assuming parapet corrections of the pre-1933 structure (a relatively small reduction).

Table 4 identifies the number of pre-1933 structures in downtown Los Angeles that would probably collapse (including major partial wall collapse) as a result of a magnitude 8.3 San Andreas Fault Earthquake and a magnitude 7.5 Newport-Inglewood Fault Earthquake at places on the faults near to Los Angeles [1].

If we assume that an average of 100 mortalities result from each building collapse, then an estimated 4,000 mortalities could result from the postulated San Andreas Earthquake and an estimated 13,000 mortalities could result from the postulated Newport-Inglewood Earthquake. (This ignores other possible sources of large numbers of fatalities, such as the gross failure of a large dam.)

In a briefing to Governor Brown by the U.S. Geological Survey, they stated that between 3,000 and 12,000 mortalities could result from a postulated event similar to our San Andreas postulated earthquake. (See Appendix C.)

TABLE 4. NON-EARTHQUAKE-RESISTANT BRICK MASONRY BUILDINGS SUBJECT TO COLLAPSE AS A RESULT OF POSTULATED EARTHQUAKES.*

POSTULATED EARTHQUAKE	NUMBER OF PRE-1933 UNIMPROVED STRUCTURE ESTIMATED TO COLLAPSE [1]
San Andreas Fault 8.3 Magnitude	381
Newport-Inglewood Fault 7.5 Magnitude	1311

*These are the number of pre-1933 unimproved structures located in downtown Los Angeles that will collapse as a result of either postulated earthquake (page 322 of Reference [1]).

CHAPTER 5

POLICY QUESTIONS

It has been estimated that perhaps as many as 10,000 or more mortalities could result from the collapse of the unimproved, pre-1933 structures located in downtown Los Angeles. This consequence might be expected as a result of a large postulated earthquake along either the San Andreas or the Newport-Inglewood Faults - an event that could occur with a rough probability of, say, one in twenty years to one in one hundred years.

Updating these pre-1933 structures in a limited way has been estimated to reduce the expected number of mortalities by perhaps only 10 or 20 percent.* Demolition of these structures and replacement by new structures is likely to have a much more significant impact on reducing these mortalities.

If one accepts the above information as being reasonably accurate, then several issues enter into a decision on the appropriate actions. Specifically:

- What is the cost of improving pre-1933 structures to current standards? (Estimates exist that this could cost up to 80% of the replacement cost) Can one relate this cost to the reduced risk?

- What would be the cost of replacing these unimproved 1933 structures with new ones? How can one relate this cost to the reduced risk and can one decide which is the better alternative — improving the pre-1933 structures or replacing them?

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*According to Table 3 [1], corrected parapets reduce the probability of collapse by about 10% and by our assumptions, a 10% reduction in collapse results in 10% less mortalities.

- What is an acceptable level of risk from earthquakes? Does this acceptable level differ from acceptable risks due to other natural events and from technologies?

- How much has society been willing to spend in the past to reduce risks by a specific amount? How do these amounts compare with proposed earthquake-resistant related costs?

- Since the risk of death from earthquake is not zero for buildings built since 1933, how do the post-1933 buildings fit into the overall picture? Must the seismic design of each be re-evaluated and against what standard? What risk is acceptable in a new building which meets the current code?

- To what extent, if any, are the city officials and/or the building owners (if privately owned) morally, ethically, or legally liable for permitting the continued use of buildings assessed to be high-risk buildings? What constitutes adequate information to those at risk? Should those at risk somehow be remunerated for this imposed risk? How long should such risks be permitted to continue?

- What should be the overall decision-making formula, and the basis thereof, for the City of Los Angeles?

APPENDIX A

MODIFIED MERCALLI SCALE OF INTENSITY

The modified Mercalli Scale of Intensity* categorizes the intensity of shaking due to an earthquake into twelve groups, given in Roman numerals (see Table A.1). These classifications are based on qualitative physical observations of motion rather than on mechanically recorded motion. This scale, unlike the Richter scale, is well suited for describing historic events.

*This scale, commonly used in the United States, was first published in the "Bulletin of the Seismological Society of America," Vol. 21, 1931 by H. O. Wood and Frank Neumann.

TABLE A.1

MODIFIED MERCALLI INTENSITY SCALE OF 1931

I. Not felt except by a very few under especially favorable circumstances.

II. Felt only be a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing.

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibration like passing of truck. Duration estimated.

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, doors disturbed; walls made creaking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop.

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of fallen plaster or damaged chimneys. Damage slight.

VII. Everybody runs outdoors. Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable in poorly built or badly designed structures; some chimneys broken. Noticed by persons driving motor cars.

VIII. Damage slight in specially designed structures; considerable in ordinary substantial buildings with partial collapse; great in poorly built structures. Panel walls thrown out of frame structures. Fall of chimney, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Disturbed persons driving motor cars.

IX. Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb; great in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken.

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks.

XI. Few, if any, (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipe lines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage total. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

See the "Bulletin of the Seismological Society of America," Vol. 21, pp. 277/83, (1931), for complete details of this Intensity Scale.

County area was the 1933 Long Beach event, which occurred on the Newport-Inglewood Fault. The most active fault in the Southern California area in the past 50 years has been the San Jacinto Fault, earthquakes occurred along this fault in 1899, 1918, and 1968.

Using the Modified Mercalli scale, we are able to utilize several hundred years of recorded history in order to gain some insight into the frequency of occurrence of damaging earthquakes.

However, because the Modified Mercalli scale is qualitative rather than quantitative and because of other deficiencies in the scale*, its application is limited to order of magnitude type calculations, at best.

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*For example, the scale is deficient to describe the damage caused by ground motion in the 1 to 3 second range.

TABLE B.1 EARTHQUAKES AFFECTING LOS ANGELES AND ORANGE COUNTIES: 1769-1972 [1]

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location and Damage
1769	July 28	34	118	-	X	-	Los Angeles Area. Four violent shocks. Many more during the following week. Alarmed the native Indians.
1812	Dec. 8	-	-	-	VIII-IX	-	San Juan Capistrano. Church at San Juan Capistrano destroyed killing 40 persons.
1812	Dec. 21	34	120	-	X	-	Santa Barbara Channel. Damaging in Santa Barbara, Ventura, and northern Los Angeles counties. Many mission buildings destroyed or damaged.
1827	Sept.23(?)	34	118	-	-	-	Los Angeles. People ran outdoors in panic.
1852	Nov. 27-30	34.5	119	-	VIII-IX	-	Lockwood Valley. Fissures 30 miles long in Lockwood Valley.
1855	July 11 or 12	34	118.5		VIII	-	Los Angeles County. Almost every building in Los Angeles damaged.
1857	Jan. 9	35	119	-	X-XI	-	Fort Tejon. Buildings and trees thrown down at the Fort. In Los Angeles, motion slow and caused hanging grapes to swing up to the rafters.
1872	March 26	36.5	118	-	X-XI	-	Owens Valley. At Lone Pine 27 were killed and most houses destroyed.
1889	Aug. 28	34	118	-	VI	VI	Near Pomona. At Los Angeles clocks stopped, ceilings cracked and people ran into the streets.

TABLE B.1 (CONTINUED)

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location and Damage
1890	Feb. 9	34	117.5	-	VI	-	Los Angeles area. At Los Angeles most people were awakened and windows rattled.
1892	Feb. 24	31.5	116.5	-	VIII-IX (in USA)	-	Baja, California. Intensity probably X near epicenter in Mexico. Felt at Los Angeles.
1893	April 4	34.5	118.5	-	VIII-IX	-	Newhall-Pico Canyon. Earth fissured and chimneys wrecked in Newhall and Pico Canyon, but strong at Los Angeles.
1894	July 30	35	118	7	VI	VI	Los Angeles area. Broke some panes of glass in Los Angeles.
1899	July 22	34.5	117.5	-	VIII	VI	Cajon Pass. Slides in mountains 20 miles from Pass.
1899	Dec. 25	33.5	116.4	-	IX	-	San Jacinto and Hemet. Nearly all brick buildings severely damaged at Hemet. Six killed near San Jacinto. People badly frightened in Los Angeles.
1902	July 28 & 31	34.5	120.5	-	VIII	-	Near Santa Barbara. Some buildings damaged, pipeline twisted and broken, two oil tanks destroyed, ground fissured.
1903	Dec. 25	34	118	-	VI	VI	Los Angeles area. In Los Angeles, some plaster and bricks thrown down.
1907	Sept. 20	34.2(?)	117.1	6	VII	-	Near San Bernardino. Damage to buildings in San Bernardino and San Jacinto. Large buildings swayed in Los Angeles.

TABLE B.1 (CONTINUED)

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location and Damage
1910	May 15	33.77	117.4	6.0	VII	-	Lake Elsinore District.
1916	Oct. 23	34.9	118.9	6	VII	III	Tejon Pass.
1918	April 21	33.8	117.0	6.8	IX	V	San Jacinto and Hemet. $200,000 property damage in two places.
1920	June 22	34	118.5	-	VIII	III-VIII	Inglewood. Wrecked some buildings. Upset cemetery monuments.
1920	July 16	34	118.5	-	VI	VI	Los Angeles. Seven shocks with origins just northwest of the Los Angeles business district. Broke street lamps; knocked bricks from cornices.
1922	March 10	34.8	120.3	6.5	IX	III	Cholame Valley. Felt feebly in Los Angeles.
1923	July 23	34.0	117.25	6.25	VII	-	San Bernardino Valley. Damage to masonry buildings and many chimneys in San Bernardino.
1925	June 29	34.3	119.8	6.3	VIII-IX	-	Santa Barbara. $8 million in Santa Barbara.
1927	Nov. 4	34.5	121.5	7.5	IX-X	I-III	West of Point Arguello. Chimneys wrecked at Lompoc.
1929	July 8	34	118	4.7	VII	-	Whittier. Felt in downtown Los Angeles but little damage; windows broken, pictures and other swinging objects swayed. Chimneys fell in Whittier.
1930	Aug. 31	33.9	118.6	5.2	VII	VII	Santa Monica Bay. At Los Angeles minor cracks in building, fallen plaster, broken dishes.

TABLE B1. (CONTINUED)

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location and Damage
1933	March 11	33.6	118.0	6.3	IX	VII	Long Beach. $41,000,000 damage. 120 killed. Buildings collapsed in Long Beach and Compton.
1933	Oct. 2	33.8	118.1	5.4	VI	VI	Signal Hill. Cracked plaster, some damaged street lamps and broken dishes and windows in Los Angeles.
1934	June 8	35.8	120.4	6.0	VIII	-	Parkfield.
1934	Dec. 30	32	114.8	7.1	X	IV	Lower California. Crevices opened. Telephone poles shaken down.
1937	March 27	33.5	116.5	6.0	VII	-	Terwilliger Valley.
1939	Dec. 27	33.8	118.1	4.5	VI	V	Long Beach. Considerable minor damage at Long Beach.
1940	Oct. 11	33.8	118.4	4.7	VI	V	Off Redondo Beach. Minor damage at a few places.
1941	July 1	34.3	119.6	5.9	VIII	V	Santa Barbara Channel. $100,000 total damage, 25% of it to drug and liquor stocks and 10% to plate glass.
1941	Oct. 22	33.8	118.2	4.9	VII	VI	Gardena. Damage estimated at $10,000 in Gardena.
1941	Nov. 14	33.8	118.2	5.4	VII-VIII	-	Torrance-Gardena. Damage approximately $1,000,000.

TABLE B.1 (CONTINUED)

Year	Date	Lat(^{o}N)	Long(^{o}W)	Mag	I_o*	I_{LA}**	Location and Damage
1944	June 19	33.9	118.2	4.5	VI	V	Near Dominguez Junction. Two shocks. Overturned objects, cracked plaster and broke windows at several localities.
1944	June 19	33.9	118.2	-	V	IV	Near Dominguez Junction. One report of slight plaster cracks in Gardena.
1946	March 15	35.7	118.1	6.25	VII	V	Walker Pass. Felt by many in Pasadena and Los Angeles. Near Walker Pass, damage to adobe structures, cracks in brick chimney, fall of plaster.
1951	Dec. 25	32.8	118.4	-	VI	V	San Clemente Island. Slight damage. Plaster cracks in Gardena.
1952	July 21	35.0	119.0	7.7	XI	VII	Kern County. Damage estimates upward of $50 million. Twelve persons killed, nine of them from the fall of a brick wall in Tehachapi.
1952	July 21	35.0	119	6.4	V	IV	Major aftershock of Kern County earthquake.
1952	July 23	35.4	118.6	6.1	VII	IV	Major aftershock of Kern County earthquake.
1952	July 29	35.4	118.9	6.1	VII	III	Major aftershock of Kern County earthquake.
1952	Aug. 22	35.3	118.9	5.8	VIII	IV	Heavy damage at Bakersfield. Aftershock of 7.7 mag. July 21 shock.
1952	Nov. 22	35.8	121.2	6.0	VII	IV	-

TABLE B.1 (CONTINUED)

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location and Damage
1961	April 4	-	-	-	IV	-	Terminal Island. On Terminal Island, subsurface damage to oil well pipes estimated at approximately $4.5 million.
1961	Oct. 20	33.6	118.0	4.3	VI	IV	Near Huntington Beach. Series of shocks. Slight damage mainly cracked plaster, broken windows, and loss of stock in a number of stores.
1964	Aug. 30	34.25	118.5	4.0	V	IV	Los Angeles County. Switchboard jammed with calls.
1965	April 15	34.1	117.5	4.5	VI	IV	San Bernardino Valley. Slight damage. Cracked plaster and broken windows.
1965	Nov. 12	34.0	118.2	3.0	VI	VI	Los Angeles County. Plaster cracked slightly.
1967	Jan. 8	33.6	118.4	3.8-4	V	-	Los Angeles County coastal area. First of series of 13 shocks.
1967	June 15	34.0	118.0	4.1	VI	V	Los Angeles and Orange counties. Underground telephone cables twisted. Hair line foundation cracks at San Gabriel.
1968	April 9	33.2	116.1	6.5	VII	VI	Borrego Mountain. In two downtown Los Angeles buildings, the only damage was reopened or slightly enlarged plaster cracks from the 1933 and 1952 shocks.

TABLE B.1 (CONTINUED)

Year	Date	Lat(°N)	Long(°W)	Mag	I_o*	I_{LA}**	Location and Damage
1969	Feb. 28	34.5	118.1	4.3	VI	IV	Palmdale. At Palmdale fluorescent lights fell and windows broke.
1969	April 28	33.35	118.35	5.9	VII	-	Borrego Springs. In Los Angeles, tall buildings swayed. Brick walls cracked at Borrego Springs.
1969	Oct. 24	33.3	119.2	5.1	V	V	Los Angeles, Orange, and Ventura counties. Very slight plaster cracking at Downey.
1970	Sept. 12	34.3	117.5	5.4	VII	V	Lytle Creek. At Lytle Creek, ground cracks, landslide, disturbed water. Chimneys, tombstones, elevated water tanks, etc., cracked, twisted and overturned.
1971	Feb. 9	34.4	118.4	6.4	VIII-IX	VII	San Fernando. Collapse and severe damage at Veterans Hospital and Olive View Hospital. In downtown Los Angeles, moderate damage, especially to older type buildings with brick and masonry facings; portions of old buildings collapsed, killing one person.
1971	March 31	34.3	118.5	4.6	VII	IV	West end of San Fernando Valley. Most damaging after-shock of San Fernando earthquake. Over 300 homes and business establishments damaged. Foundations cracked, walls shifted; many chimneys damaged and windows broken.

*Maximum Modified Mercalli Intensity for the earthquake.
**Modified Mercalli Intensity in central Los Angeles

APPENDIX C

EARTHQUAKE STANDARDS AND GOVERNOR'S BRIEFING

This appendix contains a letter to Mayor Bradley, requesting information on earthquake ordinances, and the response of his office to the letter. The letter of request has, as an attachment, "A Report on Earthquake Standards in Older Los Angeles Buildings" and " A Briefing to Governor Brown by the U.S. Geological Survey."

UNIVERSITY OF CALIFORNIA, LOS ANGELES

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ENERGY AND KINETICS DEPARTMENT
SCHOOL OF ENGINEERING AND APPLIED SCIENCE
LOS ANGELES, CALIFORNIA 90024

May 14, 1976

The Honorable Tom Bradley, Mayor
Los Angeles City Hall
200 N. Spring
Los Angeles, CA 90012

Dear Mayor Bradley:

As part of more general studies on risks in society, we have begun examining some of the risks arising from the effects of earthquakes on public or commercial buildings. In particular, we are interested in understanding the risks from older structures which may not meet current codes, and the steps which have been taken to evaluate the seismic risk from such structures. One of our students, Mr. Mark Rubin, has undertaken a brief survey of this question in the City of Los Angeles. A copy of a draft report which he completed in April is enclosed.

It is our impression from recent news broadcasts that, in fact, active consideration is currently being given by the City of Los Angeles to increasing the seismic resistance of 300 buildings in Los Angeles.

We would very much appreciate learning the details of this program, as well as obtaining comments by appropriate offices of the city government as to the correctness of Mr. Rubin's report.

Our general goal is to try to understand better how governmental representatives of society are actually making judgments concerning acceptable risk and the tradeoffs between cost and risk.

Thank you for your assistance.

I expect you have seen it before, but, on the small chance that you have not, I am enclosing a copy of a briefing given Governor Brown by the U.S. Geological Survey on March 17, 1976.

Sincerely,

David Okrent

David Okrent
Professor of Engineering
and Applied Science

DO:jd

CITY OF LOS ANGELES

CALIFORNIA

TOM BRADLEY
MAYOR

DEPARTMENT OF
BUILDING AND SAFETY
R. J. WILLIAMS
GENERAL MANAGER

CONSERVATION BUREAU
ROOM 425, CITY HALL
LOS ANGELES, CALIF. 90012
TELEPHONE 624-7221

July 22, 1976

Mr. David Okrent
Energy and Kinetics Department
School of Engineering and
Applied Science
Los Angeles, California 90024

PROPOSED EARTHQUAKE ORDINANCE FOR THE CITY OF LOS ANGELES

In your letter to Mayor Tom Bradley on May 14, 1976, you requested information regarding a proposed ordinance which will provide for the abatement of the hazardous unreinforced masonry buildings in the City of Los Angeles.

The Conservation Bureau of the Department of Building and Safety has prepared and submitted to the City Council an ordinance which, if approved, will require the owners of unreinforced masonry buildings that house Group A, B or S assembly occupancies of 100 or more occupants and were built prior to October 6, 1933, to either repair their buildings in accordance with the seismic requirements of the present code or demolish them.

The Department estimates that the proposed ordinance will affect approximately 300 buildings within the City of Los Angeles. However, due to limited staffing and budgets, we have not determined the identity of these buildings.

Enclosed is a copy of the proposed ordinance for your information. For further information please call Mr. Warren O'Brien or Mr. Earl Schwartz at 485-2238.

R. J. Williams

R. J. WILLIAMS
General Manager

ao

Enclosure

cc: Mayor Tom Bradley

Report on Earthquake Standards in Older Los Angeles Buildings

by

M. Rubin

April, 1976

Following the 1933 Long Beach earthquake, major building code revisions were made that required a certain level of earthquake resistance in all new buildings. Since then, the code has been revised many times, with the current code requiring substantially different design and construction standards than were used in pre-1933 structures. The philosophy behind the code changes appears to be that the public is entitled to a "reasonable degree of safety" from earthquake-induced injury, which apparently was not provided by the pre-1933 Los Angeles Building Code.

Because it is presently considered necessary to safeguard the public by requiring new structures to meet tight seismic standards, it is of interest to consider whether there are any old buildings in the city built before 1933 which do not meet current codes and therefore subject the public to higher levels of risk than are presently acceptable in newer structures.

For the purpose of this study, we were concerned with establishing the existence of large buildings not meeting current code, which have high non-occupational habitation densities. The type of structures looked at in the study were primarily theaters, hotels, and department stores. These types of structures have the potential for very large assemblies of people, at a much higher density than might be seen in a strictly occupational environment. Therefore, it was determined that structures of this sort, if they presented to their occupants a higher degree of risk than is found in new buildings, might have the greatest impact on the per person level of risk to Los Angeles residents from earthquake injury.

The structures listed below in Table C.1 fit the constraints of our study. They were all constructed before 1933, do not meet current code, and have large public access.

TABLE C.1

Building	Address	Date Built	Comments
Los Angeles Theatre	615 S. Broadway	before 1906	
Bullock's	7th and Hill	1917	
Biltmore Hotel	515 S. Olive	1922	910 rooms
Alexandria Hotel	501 S. Spring	before 1928	
Clark Hotel	426 S. Spring	before 1914	
Stilwell Hotel	838 S. Grand	1912	233 rooms
Bradbury Bldg.	304 S. Olive	before 1933	
City Hall	200 N. Spring	1926	
Ambassador Hotel	3400 Wilshire	1919	480 rooms
Orpheum Theatre	842 S. Broadway	before 1909	
Paramount Theatre	6838 Hollywood	1927	1500 seats
Egyptian Theatre	6712 Hollywood	1921	1341 seats
Million Dollar Theatre	307 S. Broadway	1917	2093 seats

The Los Angeles Building Code, as contained in the city's Municipal Code, requires that any structure must meet the building code in effect at the time of its construction. No building code changes act retroactively, and no retrofitting of old structures to bring them up to current code is required.

There is a provision in the building code that allows the city to require the repair or demolition of any "unsafe" structure. However, an official in the Building Department stated that it is very difficult for the city to carry out this process, due to the legal problems that develop. He stated that if the owner of the structure wished to fight the demolition order, there are "years and years" of legal procedures, during which the structure continues to function.

As to whether pre-1933 structures are *a priori* unsafe, there is some difference of opinion. The same Building Department official believed that there is definitely a greater element of risk to the occupants of a building not up to current seismic code, but he felt that many of the older buildings were not so unsafe as to require demolition. He stated that no quantitative studies had been done to determine exactly how much greater the risk of injury was in an old building. But he indicated that he felt most of the injuries observed in the older structures would come from falling debris rather than complete structural collapse.

An Assistant City Attorney replied, however, that his office does not believe that a building is unsafe simply because it was built before the current codes were developed. He did indicate, though, that the city has adopted provisions where non-earthquake-resistant theaters could not expand without adopting current standards.

The city of Long Beach has currently embarked on a program of requiring many older buildings to be brought up to current code. This action was based on a California State Supreme Court decision (Bakerfield v. Miller, LA 28224), which Long Beach felt made it liable if it allowed structurally unsafe buildings to stand. The Assistant City Attorney, on reviewing the case, felt that the decision gave Long Beach the right to force old buildings up to current code, but did not require the city to do so. Therefore, he did not feel that Los Angeles was legally obligated to force all structures to conform to the currently accepted building code. He felt that the cost to bring all old buildings up to code would be astronomical, and was not called for.

The Assistant City Attorney did state, however, that if the City Building Department did find a structure unsafe, his office would issue a demolition order. Looking into this statement does, however, expose a very probable weakness in the city's control of building safety. The Building Department ceased the inspection of commercial buildings over ten years ago, and there is currently no ongoing review of plans to determine which structures would offer the potential of substantial injury to its occupants in case of an earthquake.

There is a proposal being prepared by the Building Department that would insert into the Municipal Code a provision that would demand that places of public assembly (such as theaters and churches), which are constructed of unreinforced masonry, be modified to meet more rigorous seismic standards.* The Building Department favors

*This proposed ordinance is not expected to be introduced to the Los Angeles City Council prior to January 1, 1978.

this approach, because it would remove the ambiguity of the current "unsafe structure" term in the code, and replace it with a specific definition which would make support of court action easier.

This may be a positive step; however, many of the structures we looked at used internal steel structural members and would therefore be exempted from the proposed regulations.

At this time, it is not clear how the city is judging what constitutes acceptable risk, or if there is potential liability on the part of the city or the building owners, were occupants of such buildings killed during an earthquake.

UNITED STATES

DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

SUMMARY OF BRIEFING TO STAFF OF

EDMUND G. BROWN, JR., GOVERNOR OF CALIFORNIA

March 17, 1976

1. Over 4500 square miles of southern California rose 5 to 10 inches since 1961.

2. Destructive earthquakes at San Fernando, California, in 1971, and Niigata, Japan, in 1964, were preceded by land uplifts of less than 5 inches. Uplifts, however, have been observed without subsequent earthquakes.

3. The uplift occurs along the section of the San Andreas fault where a major earthquake ($M > 8$) occurred in 1857 and where another great earthquake is inevitable, possibly within the next decade.

   While some evidence can be interpreted as precursory to a major earthquake in this region, there is no basis now for predicting the time it will take place. The sum of the evidence, however, justifies a warning that a great earthquake will take place in this area and also justifies preparedness actions.

4. If an earthquake similar to that in 1857 occurred today in this region about 30 miles north of Los Angeles, the probable losses in Orange and Los Angeles Counties alone are estimated as follows:

   40,000 buildings would collapse or be seriously damaged,
   3,000 to 12,000 people killed,
   12,000 to 48,000 people hospitalized,
   $15 to 25 billion damage.

   Failure of one of the larger dams could leave 100,000 homeless and tens of thousands dead.

5. It is possible but less certain that one or more damaging earthquakes may take place within this region prior to a great earthquake.

Studies of the area are underway by the U.S.G.S., the California Division of Mines and Geology, and several universities. Some additional instruments have been installed and new funds of $2.1M are to be provided in the FY77 budget. Hopefully a predictive capability will be developed in advance of the earthquake, but emergency plans should be developed on the assumption that there will be no advance notice.

7. If data become available supporting a prediction in California, the evidence will be evaluated by the U.S.G.S. and transmitted to the Governor.

PROPOSED CODE AMENDMENTS
FOR
EARTHQUAKE SAFETY FOR
EXISTING ASSEMBLY OCCUPANCIES
AS REVISED AFTER A
PUBLIC HEARING HELD ON
APRIL 20, 1976 BY THE
BOARD OF BUILDING
AND
SAFETY COMMISSIONERS

ITEM NO. 1

Revise Division 5 by adding a new Section 91.0514 to read as follows:

SEC. 91.0514 - EARTHQUAKE SAFETY STANDARDS FOR EXISTING BUILDINGS HOUSING ASSEMBLY OCCUPANCIES.

(a) PURPOSE: The purpose of this section is to safeguard life, limb, health, property and public welfare in the more hazardous buildings where these buildings are subject to major damage from earthquakes. This is to be done by causing the abatement of the life and property hazards present in older buildings housing large assembly occupancies.

(b) SCOPE: The provisions of this Section shall apply to every building which meets all of the following criteria:

1. The building was constructed prior to October 6, 1933.

2. The building has, on the effective date of this ordinance, unreinforced masonry walls which provide the primary vertical support for a floor or roof. For the purpose of this subsection primary vertical support is defined as support for over 100 pounds per linear foot of super-imposed load.

3. The building houses a Group A, B or S Occupancy where the total occupant load capacity of all such occupancies, regardless of division walls, is 100 or more.

(c) CONSTRUCTION REQUIREMENTS: Buildings within the scope of this Section are deemed to be dangerous and hazardous. They shall be brought into conformance with the current horizontal force requirements of Division 23 of this code or shall be demolished.

EXCEPTION:

1. The requirements of this subsection are not intended to prevent the Superintendent of Building from allowing alternate materials, methods of construction or design interpretations as specified in Sections 91.2305 and 98.0501 of the Los Angeles Municipal Code.

2. The Superintendent of Building may consider alternate building standards of repair for qualified historic buildings as set forth in Chapter B2, Part 2 of Title 24 of the California Administrative Code.

ITEM NO. 2

Revise Division 6 by adding a new Section 91.0609 to read as follows:

SEC. 91.0609 - EXISTING GROUP A OCCUPANCIES

Existing Group A Occupancies which are within the scope of Section 91.0514 shall conform to the construction requirements of that Section.

ITEM NO. 3

Revise Division 7 by adding a new Section 91.0708 to read as follows:

SEC. 91.0708 - EXISTING GROUP B OCCUPANCIES

Existing Group B Occupancies which are within the scope of Section 91.0514 shall conform to the construction requirements of that Section.

ITEM NO. 4

Revise Subsection 91.0809 (h) by adding a new Subdivision to read as follows:

SEC. 91.0809 (h)

6. Existing Group S Occupancies which are within the scope of Section 91.0514 shall conform to the construction requirements of that Section.

ITEM NO. 5

Revise Division 1 by adding a new Section 91.0103 (r) to read as follows:

SEC. 91.0103 (r) - EARTHQUAKE SAFETY FOR EXISTING BUILDINGS

1. NOTIFICATION: Whenever the Department determines by inspection that an existing building is within the scope of Section 91.0514 of this Code it shall order that such building be made to conform to the requirements of that Section or be demolished.

The order shall be in writing and shall be served either personally or by certified or registered mail upon the owner as shown on the last equalized assessment roll and upon the person, if any, in real or apparent charge or control of the building.

The order shall specify the conditions which exist that cause the subject building to be classified as dangerous and hazardous and thus within the scope of Section 91.0514 the order shall also direct that necessary plans be submitted and permits be obtained not later than two years after the service of the order, and that the building be corrected to meet the minimum requirements of Section 91.0514 not later than four years after such service.

2. RECORDATION: At the time that the Department serves the aforementioned order, the Superintendent of Building shall file with the Office of the County Recorder a certificate stating that the subject building has been classified as dangerous and hazardous and thus within the scope of Section 91.0514 of the Los Angeles Municipal Code, and that the owner thereof has been so notified and has been ordered to repair the building so as to meet the minimum requirements of that Section or to demolish the building. The dates of required compliance shall be included in the certificate.

After all necessary corrective work has been performed, the Superintendent of Building shall file with the Office of the County Recorder a certificate terminating the status of the subject building as being classified as dangerous and hazardous within the scope of Section 91.0514 of the Los Angeles Municipal Code.

3. ENFORCEMENT: If the owner or other person in charge and control of the subject building fails to comply with the aforementioned order within the time periods as set forth in Subdivision 1 of this Subsection, the Superintendent of Building shall order the buildings to be vacated and remain vacated until all required corrective work has been completed.

REFERENCES

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5. Townley, Sidney D. and Maxwell W. Allen, "Descriptive Catalogue of Earthquakes of the Pacific Coast of the United States 1767 to 1928," Bull. of the Seismic Soc. of America, Vol. 29.

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7. Author(s)
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Part of Study, "A General Evaluation Approach to Risk-Benefit for Large Technological Systems and Its Application to Nuclear Power."

16. Abstract (Limit: 200 words)

The City Council of Los Angeles must develop and enact building ordinances which are designed to protect the safety of thousands of people against earthquake risk. The Los Angeles Building Department has identified 300 "high risk" buildings, and has said that there may be as many as an additional 14,000 within the city, all of which were constructed prior to the 1933 earthquake code standards. The objective of this paper is to illustrate some of the difficulties in dealing with decisions involving the building code revisions designed to protect against earthquake hazards. Discussed are: (1) the history of earthquakes in the Los Angeles area; (2) recent proposed earthquake ordinances; (3) public sentiment regarding earthquake ordinances (as depicted in newspaper editorials); and (4) comparisons of earthquake risk for unimproved and improved pre-1933 structures. An appendix contains a brief UCLA report on the situation, as perceived in April 1976, and a copy of a briefing given to Governor Brown by the U.S. Geological Survey in March 1976.

17. Document Analysis a. Descriptors

Earthquakes	Construction
Earthquake resistant structures	Risk
Building codes	Hazards
Safety	

b. Identifiers/Open-Ended Terms

Los Angeles, CA

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
NTIS.	20. Security Class (This Page)	22. Price
		62
		A04-A01

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) [illegible] Commerce