EARTHQUAKE INSURANCE AND MICROZONED GEOLOGIC HAZARDS: UNITED STATES PRACTICE

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SUMMARY

Engineering and scientific microzonation applications to earthquake insurance are cost limited by the size of insurance premiums. High value buildings with high premiums allow a detailed examination of site specific geotechnical information. Generalized microzonation maps have best utility for low valued buildings. Experience indicates that the most effective usage comes from maps relating soil characteristics to monetary loss patterns by class of construction materials. Applying microzonation maps of active faults to dwellings is difficult for economic reasons while landsliding has difficult technical-economic problems. There are clear needs to improve microzonation techniques to suit insurance and other financial requirements.

INTRODUCTION

Earthquake engineers and scientists feel, with some justification, that their findings when applied by financial institutions should lead to savings to the public and also result in safer construction. Within this view, differential earthquake insurance premiums should acknowledge the degree of earthquake damage control which is included in the design as well as site related earthquake geologic hazards. In this paper, insurance practice in California, USA, will be used as an example of current practice and thinking, admitting that significant variants exist around the world. Emphasis is placed on single family dwellings and microzonation.

Earthquake insurance rates (and thereby premiums) are related to a combination of site conditions and to the earthquake damage potential of the structure itself. This paper, however, will be limited to a discussion of the first of these (site conditions) for which land-use and microzonation procedures are appropriate.

Microzonation with respect to geologic hazards has different meanings among members of the engineering and research communities and those

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who apply the results of their research. In this paper, the definition of microzonation is restricted to mean local maps which delineate varying degrees of each of three earthquake geologic hazards with respect to construction: (1) active fault traces, (2) potential landslide areas, and (3) structurally poor ground areas such as marshes. Resulting damage patterns are normally determined by others, doing so on an individual building analysis basis or on a building materials class basis. Seismicity (frequency of occurrence) is considered on a different map or set of maps. The two kinds of maps (geologic hazards and seismicity) complement each other and must be used together.

ENGINEERING/SCIENCE COMPONENTS OF EARTHQUAKE INSURANCE

Two fundamental components determine the basic rate for an individual building (or "risk" in insurance terminology). First, the building's probable maximum monetary loss must be determined for a maximum probable earthquake using a given recurrence interval (often 300 years). Second, the seismicity of the area must be factored into the insurance rate. The resulting basic rate may be modified by many factors, including geologic hazards, hazardous roof appendages, exposure hazards from adjoining structures, unrepaired previous earthquake damage, and the like.

The first rating component (probable maximum damage) may be based on a building classification system determined by either (1) materials of construction or by (2) the extent and adequacy of its damage control features. More often than not, economics dictate that the first of these two methods be applied to older non-earthquake resistive buildings of any value as well as to modern low-value earthquake resistive buildings. Moderate and high-value earthquake resistive buildings may warrant significant engineering attention, consistent with the economic caveat that these engineering expenses must be reasonable with respect to the premiums or justified by rate reductions based on this engineering attention. Table 1 is a summary of one major building classification and rating system showing its application to coastal California.

STATUS OF MICROZONATION PRACTICES IN INSURANCE

Earthquake premiums from a high-valued building (such as a high-rise) normally warrant an engineering review of construction drawings and geotechnical reports which, for modern buildings, should consider the factors included on microzonation maps. On the other end of the building value scale, site specific geotechnical reports rarely exist on individual single family wood frame dwellings, although they do exist for many modern housing subdivisions in California. Thus, microzonation maps of cities and other jurisdictions are important for the evaluation of low-valued structures and emphasis will henceforth be given to these.

From an equity standpoint, it is imperative that insurance rating methods be fair and be uniformly applied. This means that criteria for the preparation of microzonation maps must be such that all independent investigators can develop essentially the same results from the same source data. This is not the usual case when examining many current microzonation maps. One should also bear in mind that the insurance user of these maps normally does not have a professional background.

TABLE 1

SIMPLIFIED EARTHQUAKE BUILDING CLASSIFICATIONS AND RATES SAN FRANCISCO AND LOS ANGELES

(After Insurance Services Office)

Building Class	Summary Description	Story Height Limit	Major Special Conditions	Building Rate Cents/$100	Deductible (in %)	Evaluation Required by Professional Engineer
11 (1)	Wood frame -- habitational	2	-	12.9	** 5	
11 (2)	Wood frame -- small	3	Non-dwellings up to 3,000 sq. ft.	21.4	** 5	
12	Wood frame -- other	-	-	21.4	** 5	
21	All-metal -- small	1	Up to 20,000 sq. ft. area	12.9	5	
22	All-metal -- large	-	-	21.4	5	
31	Steel frame -- superior	-	Superior earthquake resistive	21.4	5	Yes
32	Steel frame -- ordinary	-	Monolithic concrete floors	30.0	5	
33	Steel frame -- intermediate	-	Intermediate earthquake resistive	25.7	5	Yes
34	Steel frame -- other	-	Wood, metal, precast concrete floors	42.8	5	
41	Reinf. concrete -- superior	-	Superior earthquake resistive	25.7	5	Yes
42	Reinf. concrete -- ordinary	-	Monolithic concrete floors	42.8	5	
43	Reinf. concrete - intermediate	-	Intermediate earthquake resistive	34.2	5	Yes
44	Reinf. concrete -- precast	-	Structural precast concrete	42.8	10	
45	Reinf. concrete -- other	-	Wood, metal floors; mixed concrete & steel frame	42.8	10	
52	Mixed constr. -- superior	1	Superior earthquake resistive	34.2	5	Yes
53	Mixed constr.	1	Ordinary earthquake resistive	42.8	10	*Yes
54	Mixed constr. -- intermediate	-	Intermediate earthquake resistive	51.3	10	*Yes
54	Mixed constr.	-	***Ordinary non-earthquake resistive	90.0	10	
55	Mixed constr.	-	Hollow masonry, adobe	135.0	10	
61 thru 65	Special earthquake resistive	-	Special design for damage control	12.9 to 30.0	5	Yes

*Unless exempted (in certain specified jurisdiction).
**Masonry veneered structures may take variable penalty.
***Excluding hollow tile, hollow masonry, adobe, and cavity walls when used as part of a structural system.

Structurally Poor Ground

Usable insurance oriented microzonation maps of metropolitan areas in California and a few areas elsewhere exist where property values are high and substantial amounts of earthquake insurance are written. The further application of various kinds of insurance microzonation maps showing structurally poor ground awaits the development and general acceptance of consistent mapping criteria. Additionally, it may be some time before certain special microzonation problems have generally accepted solutions. Significant unresolved problem areas have been identified in Santa Rosa, California from damage patterns observed after the 1906 and 1969 earthquakes, in Caracas after the 1967 earthquake, and in San Fernando after the 1971 earthquake.

Geologically Active Faults

In California, microzonation maps show certain active faults within well-defined "special studies zones" as required by the Alquist-Priolo Act. However, the amount of potential destruction to dwellings from surface faulting is comparatively small as may be seen in Table 2 (Algermissen, 1972). This table shows that the probability of a dwelling being in the 50 meter fault zone is about 1:1000 along the Hayward fault and about 1:5000 along the San Andreas fault. However, based on experience from previous strike-slip fault movements, the damage probabilities would appear to be even more remote than the ratios suggest.

TABLE 2

DWELLINGS SUBJECTED TO VIBRATION AND TO FAULTING
METROPOLITAN SAN FRANCISCO BAY AREA

	*Dwellings at Risk	**Dwellings on or Near Fault Trace
San Andreas Fault:		
Recurrence of 1906 earthquake	1,203,121	237
Hayward Fault:		
Magnitude = 7.0	1,203,121	1,138

*Limited to a study area consisting of the 10 San Francisco Bay Area Counties.

**Dwellings within 50 meters of the fault. Hayward fault figure proportionally adjusted from 300 meter zone to 50 meter zone.

As a result, most insurance companies do not find it economically feasible to determine dwelling location with respect to active faults, and fault proximity is not a component of the rate making process. Therefore, the excellent Alquist-Priolo maps have negligible insurance impact on low-valued structures. The economic aspects will be discussed in more detail in a following paragraph.

Landsliding (Earthquake Induced)

Landslide microzonation maps have been difficult to interpret and apply on an equitable and consistent basis by non-professional personnel. Consider, for example, a map showing existing landslides in an area before development begins. Is one to assume that all new construction will include provisions which will correct existing landslide conditions according to best practice as required by law (building code)? If not, then how can an insurance rate be made without evaluating a soil report, and how can this be economically done? Does an old landslide now represent a stable condition, or is it a most likely candidate for further movement? Or will the next movement take place at a location between two recent landslides? What about hillside construction which is 10, 20, or 30 years old? It would seem that substantial amounts of study are needed, including clarification of criteria, before landslide hazard maps will have their rightful place in microzonation use by financial institutions.

EARTHQUAKE INSURANCE IN CALIFORNIA

Earthquake insurance has been marketed by American insurance companies since at least 1916. However, it has never been widely purchased, being an estimated 7% of dwellings carrying fire insurance in metropolitan San Francisco and Los Angeles. In spite of the availability of the coverage, aggregate premiums in California in 1978 were only $23,158,724 for all coverages identifiable as earthquake on all classifications of property including habitational. The 5 percent deductible is often held as a deterrent to the purchase of dwelling earthquake insurance. On the other hand, Kunreuther, et al (1978) concluded: "It seems likely that, unless the hazard appears probable, it will not be viewed as a problem and the individual will not consider protective measures such as insurance" (p. 243).

ECONOMIC CONSIDERATIONS

Homeowner Viewpoint

Apart from psychological reasons (Kunreuther, 1978), economic considerations should influence an individual's decision on purchasing earthquake insurance. A uniform 25% rate penalty for structurally poor ground is applied to all non-dwelling properties in mapped areas; let us examine its comparative economic impact if it is also applied to dwellings.

In Table 3, a 25% rate penalty for structurally poor ground has been separately listed and brings the total earthquake premium to $12.50 monthly. Fire insurance premiums and property taxes have not been included. While the mortgage in the example is $60,000, the sale price of the land and improvements would be $75,000 (with a 20% down payment). Experience has shown that a home buyer or developer is not greatly swayed by a $10 monthly increase in payments. (The change of 0.25% in the mortgage interest rate from 1976 to 1977 was of a greater dollar amount than the earthquake insurance premium. Housing sales were not significantly affected by this change in interest rates.) The 1979 data have not been included due to instability in mortgage interest rates and marketing conditions resulting from inflation and governmental efforts to combat inflation.

TABLE 3

MORTGAGE AND EARTHQUAKE INSURANCE PAYMENTS
METROPOLITAN SAN FRANCISCO BAY AREA

	Year		
	1976	1977	1978
Mortgage:			
30 year, $60,000 mortgage, 20% down payment*			
Mortgage interest rate	8 3/4%	9%	10%
Monthly payment (interest plus principal)	$472.03	$482.78	$526.55
Earthquake Insurance:			
Monthly "Homeowners Policy" earthquake premium**	$ 10.00	$ 10.00	$ 10.00
Increased monthly earthquake premium for structurally poor ground	$ 2.50	$ 2.50	$ 2.50

*Land at 30% of land plus improvement (Bay Area average in 1978)

**Based on amount of mortgage at its inception. 5% deductible applies. Rate is $2.00 per $1,000.

One recent private study conducted by the author on the geographic distribution of almost $1,000 million in earthquake dwelling insurance showed:

Area	Homeowner Earthquake Policies to Total Homeowner Policies
San Francisco Bay Area	7:100
Waterfront housing in San Mateo County	21 to 32:100

It appears that homeowners may be aware of their geologic hazards on the San Mateo waterfront and be willing to pay for added insurance in their highly publicized hazard area. But they are not discouraged from living there. Quadrupling this geologic hazard penalty to $10 per month probably would not discourage a sailing enthusiast from wanting to anchor his boat at his home.

One may conclude from the foregoing that economic incentives through present rate penalties are not an effective means to influence most homeowners or builders.

Insurance Company Viewpoint

An insurance company must pragmatically examine the cost of a microzonation program in the processing of dwelling policies which include earthquake coverage against the available additional premiums generated by the program. If a microzonation program were introduced into a company's procedure, it would be necessary to apply it nationwide to all dwelling property on which earthquake is written to avoid the charge of unfair discrimination.

Experience data do not exist on premium income vs. costs for microzonation, but a hypothetical case will give indicative answers. It is reasonable to estimate that perhaps 1 in 50 dwellings in California are in areas for which a 25% rate surcharge could be made for insurance microzoned structurally poor ground. Further, assume a statewide average value for insured dwellings at $60,000. The annual premium increase for the 25% rate penalty on a $2.00/$1,000.00 homeowners/dwelling policy would be $30.00. Since every policy would have to be reviewed to see if the rate penalty should be applied, then the $30.00 premium must be spread over 50 policies, or $0.60 for each policy.

In company operations, premiums for homeowner policies are allocated on percentages such as the following (after "Bests Aggregates and Averages, Property-Casualty, 1977," Stock Companies, p. 113):

Losses and adjustment expense	65.2%
Production and outside costs	18.5%
Internal expense and inspection costs	10.1%
Federal and state taxes	2.9%
Profit and contingency reserves	3.3%
	100.0%

On this basis, 10.1% of the surcharge premium of $30.00, or $3.03, would be available to pay the cost of the microzonation program for 50 policies, or 6 cents per policy. This 6 cents can be multiplied by the number of years that the policy may be renewed without re-examination -- possibly ten years. Business judgment has indicated that the final result is not economically feasible.

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