Earthquake Losses to Single-Family Dwellings: California Experience

U.S. GEOLOGICAL SURVEY BULLETIN 1939–A

Prepared in cooperation with the
State of California Department of Insurance

Cover: Damage caused by the 1933 Long Beach, California, earthquake. Photograph by Harold Engle, 1933.

Chapter A

Earthquake Losses to Single-Family Dwellings: California Experience

By KARL V. STEINBRUGGE and S.T. ALGERMISSEN

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ESTIMATION OF EARTHQUAKE LOSSES TO HOUSING IN CALIFORNIA

DEPARTMENT OF THE INTERIOR
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Earthquake Losses to Single-Family Dwellings: California Experience

By Karl V. Steinbrugge[1] and S.T. Algermissen

ABSTRACT

Most of the present methods for quantifying earthquake monetary losses to California wood-frame dwellings are based on summarized information on the 1933 Long Beach earthquake and on the partially analyzed 1971 San Fernando earthquake. Loss over deductible, for example, was not studied in the published reports that followed the 1971 San Fernando earthquake.

We reexamined the extant data from these two earthquakes, plus those from the 1983 Coalinga and 1987 Whittier Narrows earthquakes, and other, less well documented events in the contexts of dwelling market value and insured value. Differences between market value and insured value are significant for older houses.

Transfer of data from specific earthquakes to generalized loss-estimation methods requires commonality of data. Unusual construction characteristics and unusual geologic effects were eliminated from the data to achieve commonality. For example, information from the 1983 Coalinga earthquake shows that many dwellings were unanchored, which was contrary to the then generally accepted California practice; this circumstance was the result of houses moved to the city and placed on new foundations without anchors. In 1971 San Fernando earthquake, surface faulting and related ground movements at dwelling sites intensified damage. After standardizing the data, we developed a transfer function for earthquakes of other magnitudes.

A vital part of any loss-estimation method is the expected dwelling damage in the near vicinity of a fault rupture during a great earthquake. We examine two key factors, probable maximum loss and loss over deductible, from the standpoints of market value and insured value.

Our analysis included one-story, one-and-two-story, split-level, and two-story structures. There are four age groups: pre-1940, 1940–49, post-1949, and all ages. Further subdivision is by type of first floor: supported wood floor and concrete slab on grade. Although measurable differences in expected monetary losses exist among most of these dwelling characteristics, the most important from a practical standpoint are two age groups: pre-1940 construction and post-1939 construction. Available data allow the inclusion of any of the other dwelling characteristics that may be of user interest. The definition of the probable maximum loss, if applied to dwellings, has practical difficulties due to uncertainties in the evaluation of the loss-distribution curves. We propose an alternative method based on loss-over-deductible experience, in the forms of a graph and equations.

INTRODUCTION

This study examines two key factors in earthquake monetary loss estimation applied to California dwelling earthquake insurance: (1) probable maximum loss (PML), and (2) loss over deductible. The term PML, as used in California insurance practice, is defined in detail in the appendix. Loss over deductible is the entire loss minus a percentage of the dwelling value (either market or insured value). For an insured dwelling, loss over deductible is the insured loss, in other words, the loss that will be reimbursed by the insurer. Dollar deductible may be used instead of percent deductible in some cases.

Dwelling-loss data was acquired from field inspections and also, for three earthquakes, from insurance companies' paid-claims information. Presentation of the analyses of these two kinds of data sources is carried on in parallel from the standpoints of PML and loss over deductible. We analyzed the weaknesses and

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strengths of each approach to loss estimation. All data sources for each earthquake are independent of each other.

The private sector obviously has an interest in earthquake insurance. Dwelling-loss estimation is important to private commercial entities, such as savings and loan associations, banks, and mortgage holders. In the public sector, state insurance regulators have an interest in post-earthquake solvency of insurance companies. The California Department of Insurance issues an annual report on this subject (California Department of Insurance, 1981, and annually thereafter).

Loss information from non-insurance sources must be examined considering the basis on which the data were gathered. In a general sense, consider the "personal" versus "impersonal" viewpoints on loss and how each affects published loss statistics. For example, a wood-frame dwelling suffers minor interior and exterior plaster cracking but no structural damage. This could become a $100 "personal" loss if the homeowner pays for the paint and plaster patch and makes his own repairs for $100 out-of-pocket costs (with no outside labor). If, however, the loss is covered by other sources such as insurance, then the loss becomes "impersonal" from the homeowner's standpoint because someone else pays; the cost of the repairs if done by commercial painters might reasonably be $1,000, or 10 times the "personal" cost.

Similar loss interpretations are applicable to non-dwellings. For example, in the 1964 Alaskan earthquake, a major private school had substantial non-structural damage, mostly in the form of cracked plaster and tile damage in the lavatories. The cost of commercial repair of damage to this just-completed structure was beyond the school's resources. After considerable deliberation, the maintenance staff pointed out that they could make the repairs for only the cost of materials during school vacation periods. The cost of repairs became manageable because no new labor costs were included. The reported cost of repairs then became a "personal" basis rather than the much higher "impersonal" basis.

Readers with insurance backgrounds may have seen references to various magnitude scales in articles on earthquakes. The more common of these scales are: (a) local magnitude, M_L, or Richter magnitude; (b) body-wave magnitude, m_b; (c) surface-wave magnitude, M_s; (d) moment magnitude, M_w (Stover, 1988, p. 5). We use local magnitudes. Differences among these magnitude scales are not important for this study.

Acknowledgments

Confidence in loss-estimation methods is a direct function of comparisons with reality. Reality is the actual amount of money that changes hands and, for this study, is on an impersonal-loss basis. We are grateful for the detailed proprietary loss data made available by the State Farm Insurance Company and the Hartford Fire Insurance Company on the 1983 Coalinga earthquake. The State Farm Insurance Company and the California Department of Veterans Affairs supplied similar data on the 1987 Whittier Narrows earthquake.

The experience and insights of Frank E. McClure on loss-estimation methods significantly contributed to this study, and we thank him for his incisive comments.

Partial financial support for this study was provided by the State of California Department of Insurance through Richard J. Roth, Jr., Assistant Insurance Commissioner, and by the U.S. Geological Survey.

DATA SOURCES AND LOSS-OVER-DEDUCTIBLE COMPILATION

Principal sources of dwelling-loss data are the 1971 San Fernando, 1983 Coalinga, and 1987 Whittier Narrows earthquakes. Some useful, but limited, data are also available from the 1933 Long Beach shock. Numerical information also exists from the 1906 San Francisco earthquake, but changes in construction practices limit its relevance.

Variations in dwelling construction have been limited to those that lay persons can identify without technical assistance or much knowledge of construction practices. This criterion allows the development of low-cost dwelling inventories where large numbers of structures are involved. The usual dwelling variants are: (1) age; (2) construction of the first floor; and, to a lesser extent, (3) number of stories. Regional differences in construction practices throughout California are also factors. For example, the wood-frame dwellings in San Francisco's Sunset District are not typical of usual California dwelling construction from an earthquake-bracing standpoint. The reason for this is that these dwellings are on narrow sites with automobile parking and utility rooms on the ground floor. As a result, the inherent earthquake bracing found in conventional housing is commonly reduced due to fewer crosswalls.

PML's, deductibles, and losses over deductible are normally given as percentages, unless context indicates otherwise. The methods used here apply equally to dollar deductibles; one needs only to divide the dollar deductible by value to obtain the percent deductible.

The term "value" can have various meanings, two of which are of principal interest. "Insured value" is obtained from data from insurance sources and is used with insurance paid claims. The equivalence of insured value to replacement value in this study is discussed in a following section. "Market value" is obtained from non-insurance data, with the exception of some of the information on the 1933 Long Beach earthquake, which is of assessor origin. Numerical relationships among these meanings are discussed in following sections.

1971 San Fernando Earthquake

Data Sources

Data sources are of two types: field inspections, which were not related to insurance claims, and insurance claim records.

Three published reports are of interest: Steinbrugge and others (1971), Steinbrugge and Schader (1973), and McClure (1973). McClure (1973) provided a useful perspective with respect to the other data because the McClure study represents a thoroughly examined sample of damage to 169 dwellings. Data for Steinbrugge and others (1971) and Steinbrugge and Schader (1973) were developed from a field inspection of more than 12,000 single-family wood-frame dwellings by Pacific Fire Rating Bureau personnel. First, a pilot survey was necessary to determine the most heavily damaged areas. These areas were then located on a map and divided into convenient subareas. The inspection form identified each dwelling by address and block, age group, stories, first-floor construction, and degree of damage to the principal construction components. (Construction components are exterior wall types, brick chimneys if they exist, foundation type, and so forth.) Specifics of the inspection form are summarized in table 1.

The completed data forms for the 1971 report were reexamined after original publication. After instances of erroneously entered data were corrected, a total of 12,075 correct inspection reports existed. The original forms no longer exist, but much of their data had been computerized for non-insurance studies. The street addresses of dwellings surveyed are no longer available; present information only locates each dwelling by a tract number, which is a grouping of city blocks. See figure 14 for the size and location of each of these tracts along with the average percent loss to each tract.

The word description of the degree of damage to each construction component of each dwelling (table 1) was converted to a percent loss of dwelling value. Dwelling value was pre-earthquake market value, less land value, and was established by local realtors who were paid as consultants to the authors of the 1971 report (Steinbrugge and others, 1971). Percent loss of dwelling value for each component was summed to obtain the percent loss for the entire dwelling. Percent losses for

Table 1. Types of data acquired from dwelling inspections after the 1971 San Fernando earthquake

[For all one- to four-family dwellings of all types of construction. The guidelines below were used by the field inspectors to identify word descriptions of degrees of damage for San Fernando. The guidelines used for Coalinga may be found in the appendix to Steinbrugge and others (1990). Descriptions used for Coalinga were very similar to those for San Fernando, except for changes due to local construction variants]

```
Location

Age group:
     Pre-1940, 1940-1949, Post-1949

Number of stories:
     1, 2, 1&2, split level (there were no basements)

First floor type:
     Supported wood or concrete slab on grade

Foundation damage:
     None, slight, moderate, severe

Structural damage above foundation:
     None, slight, moderate, severe

Interior damage -- for plaster, gypsumboard, wood panel, or other:
     None, slight, moderate, severe

Exterior damage -- for stucco, wood, or other:
     None, slight, moderate, severe

Brick veneer -- by percent of wall(s) veneered, and
             -- by damage: None, slight, moderate, severe

Brick chimney -- by number of chimneys:  none, 1, or 2, and
              -- by damage: None, slight, moderate, severe, total

Brick chimney:  When found damaged, was it reinforced?

Geologic effects in terms of observed ground movements

Swimming pool damage:
     None, slight, moderate, severe
```

each component were developed by a construction specialist who had access to or was able to obtain repair-cost figures from contractors who made repairs in the area. Percent losses were to the nearest 1 percent. Repair-cost figures were broken down by construction component, building value (less than $20,000, low value; $20,000-$30,000, medium value; and more than $30,000, high value), and period of construction (pre-1940, 1940–49, and post-1949). Repair costs were not distorted by the increased work volume because there was a sufficiently large skilled-labor pool available and demands on construction materials were not large enough to distort local markets.

Single-Family Wood-Frame Dwellings, No Exclusions

Table 2, which applies to all inspected single-family wood-frame dwellings, shows losses over deductible for the range of 0–20 percent deductible. This kind of information had not been previously published. Dwelling inventory includes one-story, one-and-two-story, split-level, and two-story categories. The few brick-veneered dwellings are also included. Below-ground basements do not exist in this region.

Loss-over-deductible tables, such as table 2, may be readily computed if a number of individual dwellings have known values and losses. Assume a $100,000 dwelling with a $15,000 loss. For this structure, a 1 percent loss over deductible would be:

$$\text{Loss over deductible} = \$15{,}000 - (\$100{,}000 \times 1 \text{ percent}) = \$14{,}000, \text{ but never less than zero.}$$

This is repeated and summed for the entire inventory of dwellings, each with a specific value and loss. Dollar deductibles may be used as well as percentages.

Ages were visually determined. Pre-1940 architectural styles are identifiable from post-1949 styles. Older wood-frame structures have not performed as well in earthquakes as newer structures for a variety of reasons. Rot, termite infestation, and other deterioration between a wooden first floor and the ground surface have weakened many structures. Older houses commonly are not well anchored to their foundations, in some cases, not at all. Concrete foundations in older structures may not be reinforced, may not be continuous, and may have cracked due to settlements. A few older foundations may be brick or stone that lack earthquake resistance.

Wood floors are above the ground surface and normally have crawl spaces beneath them. These floors are supported by wood posts and commonly by wood "cripple" studs, which extend from the concrete foundation up to the wood floor. These studs may overturn during an earthquake if wood siding nailed to them has deteriorated, resulting in heavy damage to the dwelling. If the dwelling has a concrete floor slab on grade, and the structure is not anchored to the slab, dwelling failure is limited to the structure sliding off its foundation. Loss-over-deductible data that pertains to different floor construction types and age groups are included in table 2.

Table 3 is the loss distribution, by number of dwellings, using the same data as for table 2. The column headings on table 3 and similar tables are explained in detail in the "Loss distribution and probable maximum loss" section later in this report. Table 4 is similar to table 3, except that it shows the loss distribution, by percent of dwellings. Table 5 shows loss over deductible, in 1985 dollars, for the range of 0–10 percent deductible. Loss-over-deductible tables, such as table 2, are readily developed from field surveys of observed damage as well as from insurance claims. Loss and value are determined from each field survey, the deductible is applied to value less land value, and the final results are summed. Loss-distribution tables, such as table 3, are similarly developed.

Table 2, and other similar tabulations such as table 17, may also be useful for rate-deductible relationships. For example, using table 2, the loss over deductible at 5 percent deductible for post-1949 dwellings with wood or concrete floors is 4.82 percent, whereas at 12 percent deductible for pre-1940 dwellings it is 4.90 percent. All other things being equal, except the deductible, rates should be the same for both age groups because they have approximately the same expected loss.

All Wood-Frame Dwellings, Excluding Sites With Geologic Effects

The inspection forms allowed the inspector to note if ground disturbance was observed at or adjacent to the site. This disturbance could be in various forms, such as faulting, displaced sidewalks, liquefaction, and ground movements from unidentified sources (see plates in Steinbrugge and others, 1971; also plates in Oakeshott, 1975). Because inspection emphasis was on dwelling damage, it is quite likely that a number of dwellings were incorrectly coded as having no observable ground disturbance.

Table 6 shows loss over deductible for the range of 0–20 percent deductible, excluding dwellings on sites with geologic effects or soil amplification. Counterparts to tables 3–5 are not included in this report.

Intensified damage, which is attributed to amplification of ground motions, was observed where the San Fernando Valley alluvial deposits meet the San Gabriel Mountains on the north side of the valley. The Olive View Hospital, the Veterans Hospital, and wood-frame dwellings between and near these facilities are located in this area. All dwellings in this area were excluded even if no disturbed soil was observed.

Table 2. Dwelling loss experience for the 1971 San Fernando earthquake: Loss over deductible. All one-story, one-and-two-story, split-level, and two-story dwellings, including sites with geologic effects

	No. of Dwell.	Percent Loss Over Deductible: 0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	509	12.87	12.07	11.27	10.49	9.72	8.95	8.19	7.61	7.04	6.49	6.15
1940-49	2,714	9.48	8.62	7.76	6.91	6.07	5.23	4.39	3.61	2.84	2.07	1.87
Post-49	1,396	10.72	9.83	8.94	8.06	7.19	6.31	5.44	4.61	3.78	2.95	2.67
**All ages	4,709	10.22	9.35	8.50	7.65	6.81	5.96	5.12	4.36	3.59	2.83	2.59
2. Concrete floors:												
Age Group: Pre-1940	108	6.17	5.56	4.94	4.34	3.74	3.14	2.56	2.17	1.77	1.38	1.17
1940-49	1,769	7.99	7.26	6.54	5.83	5.12	4.42	3.73	3.16	2.59	2.05	1.82
Post-49	5,153	8.37	7.56	6.76	5.96	5.17	4.38	3.60	2.87	2.15	1.43	1.19
**All ages	7,106	8.24	7.46	6.68	5.90	5.14	4.37	3.62	2.94	2.26	1.59	1.36
*3. Wood or concrete floors:												
Age Group: Pre-1940	634	11.84	11.07	10.31	9.56	8.83	8.09	7.36	6.82	6.28	5.76	5.44
1940-49	4,541	8.93	8.12	7.32	6.52	5.73	4.94	4.16	3.47	2.77	2.09	1.88
Post-49	6,652	8.91	8.08	7.26	6.44	5.63	4.82	4.03	3.28	2.53	1.79	1.54
**All ages	12,075	9.03	8.22	7.41	6.61	5.82	5.03	4.24	3.53	2.82	2.12	1.88

	No. of Dwell.	Percent Loss Over Deductible: 10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	509	6.15	5.82	5.57	5.34	5.13	4.94	4.76	4.59	4.42	4.26	4.10
1940-49	2,714	1.87	1.69	1.58	1.50	1.42	1.35	1.28	1.21	1.15	1.09	1.03
Post-49	1,396	2.67	2.41	2.26	2.12	2.00	1.89	1.80	1.70	1.62	1.54	1.46
**All ages	4,709	2.59	2.36	2.23	2.11	2.00	1.91	1.82	1.74	1.66	1.58	1.50
2. Concrete floors:												
Age Group: Pre-1940	108	1.17	0.96	0.82	0.69	0.55	0.47	0.42	0.36	0.32	0.29	0.25
1940-49	1,769	1.82	1.59	1.45	1.31	1.17	1.08	1.00	0.91	0.84	0.76	0.70
Post-49	5,153	1.19	1.00	0.86	0.77	0.68	0.63	0.57	0.52	0.48	0.43	0.39
**All ages	7,106	1.36	1.15	1.01	0.91	0.81	0.74	0.68	0.62	0.57	0.51	0.47
*3. Wood or concrete floors:												
Age Group: Pre-1940	634	5.44	5.13	4.90	4.69	4.49	4.32	4.16	4.01	3.86	3.72	3.58
1940-49	4,541	1.88	1.68	1.55	1.44	1.34	1.26	1.18	1.11	1.04	0.97	0.91
Post-49	6,652	1.54	1.33	1.18	1.08	0.98	0.91	0.85	0.79	0.73	0.68	0.63
**All ages	12,075	1.88	1.67	1.52	1.41	1.31	1.23	1.16	1.08	1.02	0.96	0.90

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

Table 3. Dwelling loss experience for the 1971 San Fernando earthquake: Loss distribution by number of dwellings. All one-story, one-and-two-story, split-level, and two-story dwellings, including sites with geologic effects

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
0	101	19.8	375	13.8	155	11.1	652	13.8	42	38.9	490	27.7	1000	19.4	1551	21.8	149	23.5	875	19.3	1170	17.6	2295	19.0
1	2	20.2	11	14.2	5	11.5	19	14.2	0	38.9	6	28.0	14	19.7	20	22.1	2	23.8	17	19.6	19	17.9	40	19.3
2	6	21.4	27	15.2	2	11.6	35	15.0	1	39.8	9	28.5	14	19.9	25	22.5	7	24.9	36	20.4	17	18.1	61	19.8
3	9	23.2	14	15.7	14	12.6	39	15.8	0	39.8	14	29.3	41	20.7	56	23.2	10	26.5	28	21.1	56	19.0	97	20.6
4	0	23.2	0	15.7	3	12.8	3	15.9	0	39.8	1	29.4	14	21.0	16	23.5	0	26.5	1	21.1	20	19.3	22	20.8
5	2	23.6	1	15.8	3	13.0	6	16.0	3	42.6	29	31.0	68	22.3	103	24.9	5	27.3	32	21.8	71	20.3	112	21.8
6	96	42.4	187	22.7	48	16.5	334	23.1	19	60.2	215	43.2	252	27.2	491	31.8	117	45.7	404	30.7	307	25.0	836	28.7
7	3	43.0	5	22.8	3	16.7	11	23.3	0	60.2	1	43.2	17	27.6	19	32.1	3	46.2	7	30.8	20	25.3	31	28.9
8	11	45.2	12	23.3	7	17.2	30	24.0	1	61.1	42	45.6	45	28.4	91	33.4	12	48.1	55	32.0	53	26.1	124	30.0
9	104	65.6	1526	79.5	766	72.1	2436	75.7	19	78.7	559	77.2	2459	76.1	3055	76.4	125	67.8	2103	78.4	3253	75.0	5547	75.9
10	5	66.6	61	81.8	31	74.3	98	77.8	1	79.6	3	77.4	234	80.7	238	79.7	6	68.8	64	79.8	269	79.0	341	78.7
11	46	75.6	210	89.5	144	84.6	408	86.5	7	86.1	145	85.6	270	85.9	427	85.7	53	77.1	362	87.7	421	85.3	852	85.8
12	7	77.0	58	91.6	27	86.5	95	88.5	0	86.1	8	86.0	253	90.8	265	89.5	9	78.5	66	89.2	287	89.6	370	88.8
13	7	78.4	7	91.9	13	87.5	27	89.0	0	86.1	6	86.4	39	91.6	47	90.1	8	79.8	14	89.5	54	90.5	78	89.5
14	17	81.7	32	93.1	31	89.7	84	90.8	7	92.6	85	91.2	128	94.1	225	93.3	24	83.6	121	92.2	167	93.0	323	92.2
15	1	81.9	6	93.3	8	90.3	15	91.1	2	94.4	2	91.3	31	94.7	36	93.8	3	84.1	8	92.3	41	93.6	53	92.6
16	2	82.3	3	93.4	7	90.8	12	91.4	0	94.4	4	91.5	18	95.0	23	94.1	2	84.4	7	92.5	26	94.0	36	92.9
17	6	83.5	9	93.7	14	91.8	29	92.0	2	96.3	17	92.5	23	95.5	42	94.7	8	85.6	27	93.1	39	94.6	74	93.5
18	0	83.5	1	93.8	2	91.9	3	92.1	0	96.3	0	92.5	2	95.5	2	94.7	0	85.6	1	93.1	5	94.6	6	93.6
19	3	84.1	6	94.0	2	92.0	11	92.3	0	96.3	24	93.8	15	95.8	39	95.3	3	86.1	31	93.8	18	94.9	52	94.0
20	0	84.1	3	94.1	5	92.4	8	92.5	0	96.3	14	94.6	14	96.1	28	95.7	0	86.1	18	94.2	20	95.2	38	94.3
21	1	84.3	0	94.1	2	92.6	3	92.5	0	96.3	0	94.6	7	96.2	7	95.8	1	86.3	0	94.2	9	95.3	10	94.4
22	6	85.5	14	94.6	11	93.3	32	93.2	1	97.2	15	95.5	36	96.9	55	96.6	7	87.4	31	94.9	48	96.1	90	95.1
23	1	85.7	1	94.7	2	93.5	4	93.3	0	97.2	1	95.5	10	97.1	11	96.7	1	87.5	2	94.9	12	96.2	15	95.3
24	1	85.9	11	95.1	9	94.1	21	93.8	0	97.2	7	95.9	13	97.4	20	97.0	1	87.7	18	95.3	24	96.6	43	95.6
25	4	86.6	3	95.2	4	94.4	11	94.0	2	99.1	8	96.4	16	97.7	26	97.4	6	88.6	12	95.6	22	96.9	40	96.0
26	3	87.2	6	95.4	1	94.5	11	94.2	0	99.1	1	96.4	8	97.8	9	97.5	3	89.1	7	95.7	9	97.1	20	96.1
27	4	88.0	16	96.0	2	94.6	22	94.7	0	99.1	2	96.6	18	98.2	21	97.8	4	89.7	18	96.1	21	97.4	44	96.5
28	1	88.2	5	96.2	3	94.8	10	94.9	0	99.1	3	96.7	15	98.5	18	98.0	1	89.9	8	96.3	18	97.7	28	96.7
29	1	88.4	4	96.3	2	95.0	7	95.1	0	99.1	5	97.0	11	98.7	16	98.3	1	90.1	9	96.5	13	97.9	23	96.9
30	9	90.2	26	97.3	8	95.6	43	96.0	0	99.1	2	97.1	9	98.9	12	98.4	9	91.5	30	97.2	17	98.1	58	97.4
31	0	90.2	3	97.4	4	95.8	7	96.1	0	99.1	0	97.1	7	99.0	7	98.5	0	91.5	3	97.2	11	98.3	14	97.5
32	0	90.2	3	97.5	2	96.0	5	96.2	0	99.1	2	97.2	2	99.0	4	98.6	0	91.5	5	97.3	5	98.3	10	97.6
33	7	91.6	15	98.0	4	96.3	26	96.8	0	99.1	1	97.3	6	99.1	7	98.7	7	92.6	17	97.7	11	98.5	37	97.9
34	0	91.6	6	98.3	3	96.5	9	97.0	0	99.1	3	97.5	1	99.2	4	98.7	0	92.6	9	97.9	4	98.6	13	98.0
35	3	92.1	2	98.3	1	96.6	6	97.1	1	100.0	17	98.4	12	99.4	31	99.2	4	93.2	20	98.3	13	98.8	38	98.3
36	1	92.3	2	98.4	2	96.7	6	97.2	0	100.0	1	98.5	0	99.4	1	99.2	1	93.4	3	98.4	3	98.8	8	98.4
37	1	92.5	1	98.5	1	96.8	3	97.3	0	100.0	0	98.5	1	99.4	1	99.2	1	93.5	1	98.4	2	98.8	4	98.4
38	1	92.7	0	98.5	0	96.8	1	97.3	0	100.0	7	98.9	4	99.5	11	99.4	1	93.7	8	98.6	4	98.9	13	98.5
39	0	92.7	0	98.5	3	97.0	3	97.4	0	100.0	0	98.9	0	99.5	0	99.4	0	93.7	0	98.6	3	98.9	3	98.5
40	3	93.3	1	98.5	0	97.0	4	97.5	0	100.0	1	98.9	0	99.5	1	99.4	3	94.2	2	98.7	0	98.9	5	98.6
41	5	94.3	3	98.6	2	97.1	10	97.7	0	100.0	3	99.1	3	99.6	6	99.5	5	95.0	7	98.8	5	99.0	17	98.7
42	2	94.7	1	98.6	2	97.3	5	97.8	0	100.0	1	99.2	3	99.6	4	99.5	2	95.3	2	98.9	5	99.1	9	98.8
43	1	94.9	2	98.7	0	97.3	3	97.8	0	100.0	0	99.2	0	99.6	0	99.5	1	95.4	2	98.9	0	99.1	3	98.8
44	1	95.1	0	98.7	3	97.5	4	97.9	0	100.0	0	99.2	2	99.7	2	99.5	1	95.6	0	98.9	5	99.2	6	98.9
45	1	95.3	1	98.7	0	97.5	2	98.0	0	100.0	0	99.2	5	99.7	5	99.6	1	95.7	1	98.9	5	99.2	7	98.9

Table 3. Dwelling loss experience for the 1971 San Fernando earthquake: Loss distribution by number of dwellings. All one-story, one-and-two-story, split-level, and two-story dwellings, including sites with geologic effects—Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
46	0	95.3	0	98.7	0	97.5	0	98.0	0	100.0	0	99.2	1	99.8	1	99.6	0	95.7	0	98.9	1	99.3	1	98.9
47	0	95.3	0	98.7	0	97.5	0	98.0	0	100.0	1	99.2	0	99.8	1	99.6	0	95.7	1	98.9	0	99.3	1	98.9
48	1	95.5	2	98.8	3	97.7	6	98.1	0	100.0	7	99.6	1	99.8	8	99.7	1	95.9	9	99.1	4	99.3	14	99.1
49	2	95.9	2	98.9	2	97.9	6	98.2	0	100.0	2	99.7	1	99.8	3	99.8	2	96.2	4	99.2	3	99.4	9	99.1
50	0	95.9	2	99.0	2	98.0	4	98.3	0	100.0	1	99.8	0	99.8	1	99.8	0	96.2	3	99.3	2	99.4	5	99.2
51	1	96.1	2	99.0	5	98.4	8	98.5	0	100.0	1	99.8	0	99.8	1	99.8	1	96.4	3	99.4	5	99.5	9	99.3
52	0	96.1	0	99.0	4	98.6	4	98.6	0	100.0	0	99.8	2	99.8	2	99.8	0	96.4	0	99.4	6	99.6	6	99.3
53	0	96.1	2	99.1	3	98.9	6	98.7	0	100.0	1	99.9	3	99.9	4	99.9	0	96.4	3	99.4	7	99.7	11	99.4
54	0	96.1	0	99.1	1	98.9	1	98.7	0	100.0	0	99.9	0	99.9	0	99.9	0	96.4	0	99.4	1	99.7	1	99.4
55	1	96.3	0	99.1	0	98.9	1	98.7	0	100.0	1	99.9	0	99.9	1	99.9	1	96.5	1	99.4	0	99.7	2	99.4
56	2	96.7	0	99.1	2	99.1	4	98.8	0	100.0	0	99.9	0	99.9	0	99.9	2	96.8	0	99.4	2	99.7	4	99.5
57	0	96.7	1	99.2	0	99.1	1	98.8	0	100.0	0	99.9	1	99.9	1	99.9	0	96.8	1	99.5	1	99.7	2	99.5
58	2	97.1	0	99.2	1	99.1	3	98.9	0	100.0	1	100.0	1	99.9	2	100.0	3	97.3	1	99.5	2	99.8	6	99.5
59	0	97.1	0	99.2	2	99.3	3	99.0	0	100.0	0	100.0	0	99.9	0	100.0	0	97.3	0	99.5	2	99.8	3	99.5
60	1	97.2	1	99.2	4	99.6	6	99.1	0	100.0	0	100.0	0	99.9	0	100.0	2	97.6	1	99.5	4	99.8	7	99.6
61	0	97.2	5	99.4	1	99.6	6	99.2	0	100.0	0	100.0	0	99.9	0	100.0	0	97.6	5	99.6	2	99.9	7	99.7
62	0	97.2	1	99.4	0	99.6	1	99.2	0	100.0	0	100.0	1	100.0	1	100.0	0	97.6	1	99.6	1	99.9	2	99.7
63	0	97.2	2	99.5	0	99.6	2	99.3	0	100.0	0	100.0	0	100.0	0	100.0	0	97.6	2	99.7	0	99.9	2	99.7
64	1	97.4	6	99.7	1	99.7	9	99.5	0	100.0	0	100.0	0	100.0	0	100.0	1	97.8	6	99.8	1	99.9	9	99.8
65	0	97.4	0	99.7	0	99.7	0	99.5	0	100.0	0	100.0	0	100.0	0	100.0	0	97.8	0	99.8	0	99.9	0	99.8
>65	13	100.0	8	100.0	4	100.0	25	100.0	0	100.0	0	100.0	2	100.0	2	100.0	14	100.0	8	100.0	6	100.0	28	100.0

Table 4. Dwelling loss experience for the 1971 San Fernando earthquake: Loss distribution by percent of dwellings. All one-story, one-and-two-story, split-level, and two-story dwellings, including sites with geologic effects

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT
0	20	19.8	13.8	13.8	11.1	11.1	13.8	13.8	38.9	38.9	27.7	27.7	19.4	19.4	21.8	21.8	23.5	23.5	19.3	19.3	17.6	17.6	19.0	19.0
1	0	20.2	0.4	14.2	0.4	11.5	0.4	14.2	0.0	38.9	0.3	28.0	0.3	19.7	0.3	22.1	0.3	23.8	0.4	19.6	0.3	17.9	0.3	19.3
2	1	21.4	1.0	15.2	0.1	11.6	0.7	15.0	0.9	39.8	0.5	28.5	0.3	19.9	0.4	22.5	1.1	24.9	0.8	20.4	0.3	18.1	0.5	19.8
3	2	23.2	0.5	15.7	1.0	12.6	0.8	15.8	0.0	39.8	0.8	29.3	0.8	20.7	0.8	23.2	1.6	26.5	0.6	21.1	0.8	19.0	0.8	20.6
4	0	23.2	0.0	15.7	0.2	12.8	0.1	15.9	0.0	39.8	0.1	29.4	0.3	21.0	0.2	23.5	0.0	26.5	0.0	21.1	0.3	19.3	0.2	20.8
5	0	23.6	0.0	15.8	0.2	13.0	0.1	16.0	2.8	42.6	1.6	31.0	1.3	22.3	1.4	24.9	0.8	27.3	0.7	21.8	1.1	20.3	0.9	21.8
6	19	42.4	6.9	22.7	3.4	16.5	7.1	23.1	17.6	60.2	12.2	43.2	4.9	27.2	6.9	31.8	18.5	45.7	8.9	30.7	4.6	25.0	6.9	28.7
7	1	43.0	0.2	22.8	0.2	16.7	0.2	23.3	0.0	60.2	0.1	43.2	0.3	27.6	0.3	32.1	0.5	46.2	0.2	30.8	0.3	25.3	0.3	28.9
8	2	45.2	0.4	23.3	0.5	17.2	0.6	24.0	0.9	61.1	2.4	45.6	0.9	28.4	1.3	33.4	1.9	48.1	1.2	32.0	0.8	26.1	1.0	30.0
9	20	65.6	56.2	79.5	54.9	72.1	51.7	75.7	17.6	78.7	31.6	77.2	47.7	76.1	43.0	76.4	19.7	67.8	46.3	78.4	48.9	75.0	45.9	75.9
10	1	66.6	2.2	81.8	2.2	74.3	2.1	77.8	0.9	79.6	0.2	77.4	4.5	80.7	3.3	79.7	0.9	68.8	1.4	79.8	4.0	79.0	2.8	78.7
11	9	75.6	7.7	89.5	10.3	84.6	8.7	86.5	6.5	86.1	8.2	85.6	5.2	85.9	6.0	85.7	8.4	77.1	8.0	87.7	6.3	85.3	7.1	85.8
12	1	77.0	2.1	91.6	1.9	86.5	2.0	88.5	0.0	86.1	0.5	86.0	4.9	90.8	3.7	89.5	1.4	78.5	1.5	89.2	4.3	89.6	3.1	88.8
13	1	78.4	0.3	91.9	0.9	87.5	0.6	89.0	0.0	86.1	0.3	86.4	0.8	91.6	0.7	90.1	1.3	79.8	0.3	89.5	0.8	90.5	0.6	89.5
14	3	81.7	1.2	93.1	2.2	89.7	1.8	90.8	6.5	92.6	4.8	91.2	2.5	94.1	3.2	93.3	3.8	83.6	2.7	92.2	2.5	93.0	2.7	92.2
15	0	81.9	0.2	93.3	0.6	90.3	0.3	91.1	1.9	94.4	0.1	91.3	0.6	94.7	0.5	93.8	0.5	84.1	0.2	92.3	0.6	93.6	0.4	92.6
16	0	82.3	0.1	93.4	0.5	90.8	0.3	91.4	0.0	94.4	0.2	91.5	0.3	95.0	0.3	94.1	0.3	84.4	0.2	92.5	0.4	94.0	0.3	92.9
17	1	83.5	0.3	93.7	1.0	91.8	0.6	92.0	1.9	96.3	1.0	92.5	0.4	95.5	0.6	94.7	1.3	85.6	0.6	93.1	0.6	94.6	0.6	93.5
18	0	83.5	0.0	93.8	0.1	91.9	0.1	92.1	0.0	96.3	0.0	92.5	0.0	95.5	0.0	94.7	0.0	85.6	0.0	93.1	0.1	94.6	0.0	93.6
19	1	84.1	0.2	94.0	0.1	92.0	0.2	92.3	0.0	96.3	1.4	93.8	0.3	95.8	0.5	95.3	0.5	86.1	0.7	93.8	0.3	94.9	0.4	94.0
20	0	84.1	0.1	94.1	0.4	92.4	0.2	92.5	0.0	96.3	0.8	94.6	0.3	96.1	0.4	95.7	0.0	86.1	0.4	94.2	0.3	95.2	0.3	94.3
21	0	84.3	0.0	94.1	0.1	92.6	0.1	92.5	0.0	96.3	0.0	94.6	0.1	96.2	0.1	95.8	0.2	86.3	0.0	94.2	0.1	95.3	0.1	94.4
22	1	85.5	0.5	94.6	0.8	93.3	0.7	93.2	0.9	97.2	0.8	95.5	0.7	96.9	0.8	96.6	1.1	87.4	0.7	94.9	0.7	96.1	0.7	95.1
23	0	85.7	0.0	94.7	0.1	93.5	0.1	93.3	0.0	97.2	0.1	95.5	0.2	97.1	0.2	96.7	0.2	87.5	0.0	94.9	0.2	96.2	0.1	95.3
24	0	85.9	0.4	95.1	0.6	94.1	0.4	93.8	0.0	97.2	0.4	95.9	0.3	97.4	0.3	97.0	0.2	87.7	0.4	95.3	0.4	96.6	0.4	95.6
25	1	86.6	0.1	95.2	0.3	94.4	0.2	94.0	1.9	99.1	0.5	96.4	0.3	97.7	0.4	97.4	0.9	88.6	0.3	95.6	0.3	96.9	0.3	96.0
26	1	87.2	0.2	95.4	0.1	94.5	0.2	94.2	0.0	99.1	0.1	96.4	0.2	97.8	0.1	97.5	0.5	89.1	0.2	95.7	0.1	97.1	0.2	96.1
27	1	88.0	0.6	96.0	0.1	94.6	0.5	94.7	0.0	99.1	0.1	96.6	0.3	98.2	0.3	97.8	0.6	89.7	0.4	96.1	0.3	97.4	0.4	96.5
28	0	88.2	0.2	96.2	0.2	94.8	0.2	94.9	0.0	99.1	0.2	96.7	0.3	98.5	0.3	98.0	0.2	89.9	0.2	96.3	0.3	97.7	0.2	96.7
29	0	88.4	0.1	96.3	0.1	95.0	0.1	95.1	0.0	99.1	0.3	97.0	0.2	98.7	0.2	98.3	0.2	90.1	0.2	96.5	0.2	97.9	0.2	96.9
30	2	90.2	1.0	97.3	0.6	95.6	0.9	96.0	0.0	99.1	0.1	97.1	0.2	98.9	0.2	98.4	1.4	91.5	0.7	97.2	0.3	98.1	0.5	97.4
31	0	90.2	0.1	97.4	0.3	95.8	0.1	96.1	0.0	99.1	0.0	97.1	0.1	99.0	0.1	98.5	0.0	91.5	0.1	97.2	0.2	98.3	0.1	97.5
32	0	90.2	0.1	97.5	0.1	96.0	0.1	96.2	0.0	99.1	0.1	97.2	0.0	99.0	0.1	98.6	0.0	91.5	0.1	97.3	0.1	98.3	0.1	97.6
33	1	91.6	0.6	98.0	0.3	96.3	0.6	96.8	0.0	99.1	0.1	97.3	0.1	99.1	0.1	98.7	1.1	92.6	0.4	97.7	0.2	98.5	0.3	97.9
34	0	91.6	0.2	98.3	0.2	96.5	0.2	97.0	0.0	99.1	0.2	97.5	0.0	99.2	0.1	98.7	0.0	92.6	0.2	97.9	0.1	98.6	0.1	98.0
35	1	92.1	0.1	98.3	0.1	96.6	0.1	97.1	0.9	100.0	1.0	98.4	0.2	99.4	0.4	99.2	0.6	93.2	0.4	98.3	0.2	98.8	0.3	98.3
36	0	92.3	0.1	98.4	0.1	96.7	0.1	97.2	0.0	100.0	0.1	98.5	0.0	99.4	0.0	99.2	0.2	93.4	0.1	98.4	0.0	98.8	0.1	98.4
37	0	92.5	0.0	98.5	0.1	96.8	0.1	97.3	0.0	100.0	0.0	98.5	0.0	99.4	0.0	99.2	0.2	93.5	0.0	98.4	0.0	98.8	0.0	98.4
38	0	92.7	0.0	98.5	0.0	96.8	0.0	97.3	0.0	100.0	0.4	98.9	0.1	99.5	0.2	99.4	0.2	93.7	0.2	98.6	0.1	98.9	0.1	98.5
39	0	92.7	0.0	98.5	0.2	97.0	0.1	97.4	0.0	100.0	0.0	98.9	0.0	99.5	0.0	99.4	0.0	93.7	0.0	98.6	0.0	98.9	0.0	98.5
40	1	93.3	0.0	98.5	0.0	97.0	0.1	97.5	0.0	100.0	0.1	98.9	0.0	99.5	0.0	99.4	0.5	94.2	0.0	98.7	0.0	98.9	0.0	98.6
41	1	94.3	0.1	98.6	0.1	97.1	0.2	97.7	0.0	100.0	0.2	99.1	0.1	99.6	0.1	99.5	0.8	95.0	0.2	98.8	0.1	99.0	0.1	98.7
42	0	94.7	0.0	98.6	0.1	97.3	0.1	97.8	0.0	100.0	0.1	99.2	0.1	99.6	0.1	99.5	0.3	95.3	0.0	98.9	0.1	99.1	0.1	98.8
43	0	94.9	0.1	98.7	0.0	97.3	0.1	97.8	0.0	100.0	0.0	99.2	0.0	99.6	0.0	99.5	0.2	95.4	0.0	98.9	0.0	99.1	0.0	98.8
44	0	95.1	0.0	98.7	0.2	97.5	0.1	97.9	0.0	100.0	0.0	99.2	0.0	99.7	0.0	99.5	0.2	95.6	0.0	98.9	0.1	99.2	0.0	98.9
45	0	95.3	0.0	98.7	0.0	97.5	0.0	98.0	0.0	100.0	0.0	99.2	0.1	99.7	0.1	99.6	0.2	95.7	0.0	98.9	0.1	99.2	0.1	98.9

Table 4. Dwelling loss experience for the 1971 San Fernando earthquake: Loss distribution by percent of dwellings. All one-story, one-and-two-story, split-level, and two-story dwellings, including sites with geologic effects—Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT
46	0	95.3	0.0	98.7	0.0	97.5	0.0	98.0	0.0	100.0	0.0	99.2	0.0	99.8	0.0	99.6	0.0	95.7	0.0	98.9	0.0	99.3	0.0	98.9
47	0	95.3	0.0	98.7	0.0	97.5	0.0	98.0	0.0	100.0	0.1	99.2	0.0	99.8	0.0	99.6	0.0	95.7	0.0	98.9	0.0	99.3	0.0	98.9
48	0	95.5	0.1	98.8	0.2	97.7	0.1	98.1	0.0	100.0	0.4	99.6	0.0	99.8	0.1	99.7	0.2	95.9	0.2	99.1	0.1	99.3	0.1	99.1
49	0	95.9	0.1	98.9	0.1	97.9	0.1	98.2	0.0	100.0	0.1	99.7	0.0	99.8	0.0	99.8	0.3	96.2	0.1	99.2	0.0	99.4	0.1	99.1
50	0	95.9	0.1	99.0	0.1	98.0	0.1	98.3	0.0	100.0	0.1	99.8	0.0	99.8	0.0	99.8	0.0	96.2	0.1	99.3	0.0	99.4	0.0	99.2
51	0	96.1	0.1	99.0	0.4	98.4	0.2	98.5	0.0	100.0	0.1	99.8	0.0	99.8	0.0	99.8	0.2	96.4	0.1	99.4	0.1	99.5	0.1	99.3
52	0	96.1	0.0	99.0	0.3	98.6	0.1	98.6	0.0	100.0	0.0	99.8	0.0	99.8	0.0	99.8	0.0	96.4	0.0	99.4	0.1	99.6	0.0	99.3
53	0	96.1	0.1	99.1	0.2	98.9	0.1	98.7	0.0	100.0	0.1	99.9	0.1	99.9	0.1	99.9	0.0	96.4	0.1	99.4	0.1	99.7	0.1	99.4
54	0	96.1	0.0	99.1	0.1	98.9	0.0	98.7	0.0	100.0	0.0	99.9	0.0	99.9	0.0	99.9	0.0	96.4	0.0	99.4	0.0	99.7	0.0	99.4
55	0	96.3	0.0	99.1	0.0	98.9	0.0	98.7	0.0	100.0	0.1	99.9	0.0	99.9	0.0	99.9	0.2	96.5	0.0	99.4	0.0	99.7	0.0	99.4
56	0	96.7	0.0	99.1	0.1	99.1	0.1	98.8	0.0	100.0	0.0	99.9	0.0	99.9	0.0	99.9	0.3	96.8	0.0	99.4	0.0	99.7	0.0	99.5
57	0	96.7	0.0	99.2	0.0	99.1	0.0	98.8	0.0	100.0	0.0	99.9	0.0	99.9	0.0	99.9	0.0	96.8	0.0	99.5	0.0	99.7	0.0	99.5
58	0	97.1	0.0	99.2	0.1	99.1	0.1	98,9	0.0	100.0	0.1	100.0	0.0	99.9	0.0	100.0	0.5	97.3	0.0	99.5	0.0	99.8	0.0	99.5
59	0	97.1	0.0	99.2	0.1	99.3	0.1	99.0	0.0	100.0	0.0	100.0	0.0	99.9	0.0	100.0	0.0	97.3	0.0	99.5	0.0	99.8	0.0	99.5
60	0	97.2	0.0	99.2	0.3	99.6	0.1	99.1	0.0	100.0	0.0	100.0	0.0	99.9	0.0	100.0	0.3	97.6	0.0	99.5	0.1	99.8	0.1	99.6
61	0	97.2	0.2	99.4	0.1	99.6	0.1	99.2	0.0	100.0	0.0	100.0	0.0	99.9	0.0	100.0	0.0	97.6	0.1	99.6	0.0	99.9	0.1	99.7
62	0	97.2	0.0	99.4	0.0	99.6	0.0	99.2	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	97.6	0.0	99.6	0.0	99.9	0.0	99.7
63	0	97.2	0.1	99.5	0.0	99.6	0.0	99.3	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	97.6	0.0	99.7	0.0	99.9	0.0	99.7
64	0	97.4	0.2	99.7	0.1	99.7	0.2	99.5	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.2	97.8	0.1	99.8	0.0	99.9	0.1	99.8
65	0	97.4	0.0	99.7	0.0	99.7	0.0	99.5	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	97.8	0.0	99.8	0.0	99.9	0.0	99.8
>65	3	100.0	0.3	100.0	0.3	100.0	0.5	100.0	0.0	100.0	0.0	100.0	0.0	100.0	0.0	100.0	2.2	100.0	0.2	100.0	0.1	100.0	0.2	100.0

Table 5. Dwelling loss experience for the 1971 San Fernando earthquake: Loss over deductible, in millions of 1985 dollars. All one-story, one-and-two-story, split-level, and two-story dwellings, including sites with geologic effects

		Dollar Loss Over Deductible, in millions (1985 dollars)										
	No. of Dwell.	0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	509	5.43	5.09	4.75	4.42	4.09	3.76	3.43	3.19	2.95	2.72	2.57
1940-49	2,714	21.79	19.80	17.82	15.87	13.93	11.98	10.04	8.26	6.48	4.71	4.24
Post-49	1,396	13.46	12.37	11.28	10.19	9.12	8.05	6.98	5.96	4.94	3.92	3.57
**All ages	4,709	41.45	37.97	34.50	31.07	27.67	24.27	20.88	17.78	14.68	11.61	10.62
2. Concrete floors:												
Age Group: Pre-1940	108	0.60	0.54	0.48	0.42	0.36	0.30	0.25	0.21	0.17	0.14	0.11
1940-49	1,769	12.63	11.50	10.38	9.26	8.16	7.06	5.98	5.09	4.21	3.36	2.99
Post-49	5,153	42.54	38.43	34.34	30.26	26.24	22.23	18.31	14.66	11.04	7.46	6.24
**All ages	7,106	56.44	51.08	45.74	40.43	35.19	29.96	24.86	20.24	15.64	11.13	9.49
*3. Wood or concrete floors:												
Age Group: Pre-1940	634	6.27	5.86	5.45	5.05	4.66	4.26	3.87	3.58	3.30	3.02	2.85
1940-49	4,541	35.02	31.86	28.72	25.61	22.52	19.43	16.37	13.66	10.97	8.31	7.45
Post-49	6,652	57.17	51.89	46.62	41.37	36.19	31.03	25.96	21.21	16.48	11.81	10.19
**All ages	12,075	100.15	91.15	82.19	73.29	64.48	55.71	47.07	39.20	31.37	23.66	20.95

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

Table 6. Dwelling loss experience for the 1971 San Fernando earthquake: Loss over deductible, excluding sites with geologic effects

	No. of Dwell.	Percent Loss Over Deductible: 0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	468	11.40	10.61	9.82	9.05	8.30	7.55	6.80	6.26	5.72	5.20	4.89
1940-49	2,391	8.29	7.45	6.61	5.78	4.95	4.13	3.31	2.56	1.81	1.07	0.92
Post-49	1,184	9.13	8.25	7.37	6.50	5.64	4.78	3.92	3.10	2.28	1.46	1.24
**All ages	4,123	8.87	8.02	7.18	6.34	5.52	4.69	3.87	3.13	2.39	1.65	1.46
2. Concrete floors:												
Age Group: Pre-1940	106	6.40	5.78	5.17	4.56	3.94	3.33	2.75	2.33	1.92	1.50	1.26
1940-49	1,675	7.49	6.78	6.07	5.37	4.68	3.98	3.30	2.75	2.21	1.68	1.48
Post-49	4,343	7.69	6.91	6.14	5.36	4.60	3.84	3.09	2.38	1.68	0.98	0.78
**All ages	6,185	7.61	6.85	6.10	5.35	4.61	3.87	3.15	2.49	1.83	1.19	0.99
*3. Wood or concrete floors:												
Age Group: Pre-1940	589	10.43	9.67	8.93	8.19	7.47	6.74	6.03	5.51	5.00	4.50	4.21
1940-49	4,117	8.00	7.21	6.42	5.65	4.88	4.11	3.34	2.68	2.01	1.36	1.18
Post-49	5,596	8.02	7.22	6.43	5.63	4.85	4.06	3.29	2.56	1.83	1.11	0.90
**All ages	10,515	8.10	7.31	6.53	5.75	4.98	4.21	3.45	2.76	2.07	1.39	1.19

	No. of Dwell.	Percent Loss Over Deductible: 10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	468	4.89	4.60	4.39	4.20	4.03	3.88	3.74	3.60	3.48	3.35	3.22
1940-49	2,391	0.92	0.78	0.72	0.68	0.64	0.60	0.57	0.54	0.51	0.48	0.45
Post-49	1,184	1.24	1.03	0.92	0.83	0.75	0.69	0.64	0.59	0.55	0.51	0.47
**All ages	4,123	1.46	1.28	1.19	1.12	1.05	0.99	0.94	0.90	0.85	0.81	0.77
2. Concrete floors:												
Age Group: Pre-1940	106	1.26	1.04	0.88	0.72	0.56	0.48	0.42	0.37	0.33	0.29	0.25
1940-49	1,675	1.48	1.27	1.15	1.03	0.92	0.84	0.77	0.70	0.64	0.57	0.53
Post-49	4,343	0.78	0.62	0.51	0.45	0.40	0.36	0.33	0.30	0.27	0.24	0.21
**All ages	6,185	0.99	0.81	0.70	0.62	0.55	0.50	0.45	0.41	0.37	0.34	0.30
*3. Wood or concrete floors:												
Age Group: Pre-1940	589	4.21	3.93	3.73	3.55	3.38	3.25	3.13	3.00	2.89	2.78	2.68
1940-49	4,117	1.18	1.01	0.93	0.85	0.77	0.72	0.67	0.62	0.58	0.53	0.50
Post-49	5,596	0.90	0.73	0.62	0.55	0.48	0.44	0.40	0.37	0.34	0.30	0.27
**All ages	10,515	1.19	1.02	0.91	0.83	0.76	0.71	0.66	0.61	0.57	0.53	0.49

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

Exclusion of sites with special geologic effects is to provide a common geologic basis for transferring information to other areas that do not have special geologic conditions. In this manner, each site, area, or region elsewhere will require a geologic or soil factor in the loss-estimation algorithm. This important factor can not be overlooked in any adequate loss-estimation method.

One-Story Wood-Frame Dwellings, Excluding Sites With Geologic Effects

Another analysis further restricted the data to one-story dwellings, thereby eliminating one-and-two-story, split-level, and two-story structures.

Table 7 shows loss over deductible for the range of 0–20 percent deductible. Table 8 is the loss distribution, by number of dwellings; a detailed discussion of this table may be found in "Loss distribution and Probable Maximum Loss." Counterparts to tables 4 and 5 are not included in this report.

1983 Coalinga Earthquake

Data Sources

Data sources are of two types. The first type that is discussed is the information gained from field inspections that were not related to insurance claims. This is followed by a discussion of information from insurance claim records.

The 1983 Coalinga earthquake was examined for dwelling losses of many kinds, including loss over deductible (Steinbrugge and others, 1990). Examination of losses over deductible and PML's have been expanded here.

All one-to-four-family dwellings in Coalinga (population 6,769 as of 1983) were examined after the 1983 Coalinga earthquake to determine location by street address, city block, age group, stories, floor construction, and degree of damage to construction components. The inspection form was similar to that used for the 1971 San Fernando earthquake (table 1), but modified for local conditions.

At least three sides of each house were inspected, and the interiors of almost 60 percent of the houses were also examined. A total of 1,982 of the 2,041 inspected dwellings provided useful data.

Percent losses to each construction component were based on 1971 San Fernando experience, modified by experience from Coalinga contractors.

Dwelling values were pre-earthquake market values, less land values, as established by local realtors who were paid as consultants to the authors.

One-to-Four-Family Wood-Frame Dwellings

The 1983 Coalinga inspections included all one-to-four-family dwellings, whereas the 1971 San Fernando inspections were limited to single-family dwellings. This difference is not considered to be significant due to the few non-one-family dwellings in Coalinga and San Fernando.

There were no below-ground basements in either Coalinga or San Fernando.

All masonry-veneered dwellings were excluded in Coalinga but not in San Fernando. Few houses in San Fernando and Coalinga were veneered. If veneered, the amount was usually small, such as 1–10 percent of the total wall area. In Coalinga, 75.1 percent of those with small amounts of veneer had slight or no damage. The difference in treatment of brick veneer in the data bases of San Fernando and Coalinga does not have a significant impact on the results of this study.

Table 9 shows the loss over deductible for the range of 0–20 percent deductible. Tables 10 and 11 are the loss distributions, by number of dwellings and by percent of dwellings, respectively. A counterpart to table 5 is not included in this report.

One-to-Four-Family Wood-Frame Dwellings, Excluding Special Cases

The San Fernando commentary on age of dwelling and type of first-floor construction also applies to Coalinga.

By "special cases" is meant those dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Most of these, by far, had shifted on or fallen off their foundations.

An unusual construction characteristic was found in the dwellings that had been moved into the city of Coalinga from the nearby oil fields. These houses were not moved into any one particular area and were set on any available vacant lot. Perhaps 200 such dwellings were moved to Coalinga between about 1930 and the late 1950's. It is estimated that 90 percent of the dwellings imported prior to 1940 or 1945 were placed on wooden sills (directly on the earth). Dwellings moved to Coalinga after 1945, particularly after 1950, probably were placed on concrete foundations but apparently were not bolted thereto. In these latter instances, where failure was observed, the wooden foundation sills had been placed directly on the smooth (troweled in many cases) top surface of the concrete foundations. This construction peculiarity has not been found in other cities. The results of excluding these "special cases" are shown in table 12,

Table 7. Dwelling loss experience for the 1971 San Fernando earthquake: Loss over deductible, excluding sites with geologic effects and one-and-two-story and split-level dwellings

	No. of Dwell.	Percent Loss Over Deductible: 0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	465	11.41	10.63	9.84	9.07	8.32	7.57	6.83	6.28	5.75	5.23	4.92
1940-49	2,379	8.26	7.42	6.58	5.75	4.93	4.10	3.28	2.53	1.79	1.05	0.89
Post-49	1,148	8.72	7.85	6.97	6.10	5.24	4.39	3.53	2.71	1.90	1.08	0.87
**All ages	4,072	8.73	7.89	7.05	6.22	5.39	4.57	3.75	3.01	2.27	1.53	1.34
2. Concrete floors:												
Age Group: Pre-1940	106	6.40	5.78	5.17	4.56	3.94	3.33	2.75	2.33	1.92	1.50	1.26
1940-49	1,668	7.50	6.79	6.09	5.38	4.69	3.99	3.32	2.77	2.22	1.69	1.48
Post-49	4,142	7.56	6.78	6.01	5.24	4.48	3.72	2.97	2.26	1.56	0.85	0.67
**All ages	5,965	7.52	6.77	6.02	5.27	4.53	3.79	3.07	2.41	1.76	1.11	0.92
*3. Wood or concrete floors:												
Age Group: Pre-1940	586	10.44	9.68	8.94	8.20	7.48	6.76	6.05	5.53	5.02	4.52	4.23
1940-49	4,097	7.99	7.20	6.41	5.63	4.86	4.09	3.33	2.66	2.00	1.35	1.17
Post-49	5,353	7.83	7.03	6.24	5.44	4.66	3.88	3.11	2.38	1.65	0.92	0.73
**All ages	10,237	7.99	7.21	6.43	5.65	4.88	4.11	3.35	2.66	1.98	1.30	1.11

	No. of Dwell.	Percent Loss Over Deductible: 10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	465	4.92	4.63	4.42	4.23	4.05	3.91	3.77	3.63	3.50	3.37	3.25
1940-49	2,379	0.89	0.76	0.70	0.66	0.62	0.58	0.55	0.52	0.49	0.47	0.44
Post-49	1,148	0.87	0.68	0.59	0.51	0.45	0.40	0.36	0.32	0.29	0.26	0.24
**All ages	4,072	1.34	1.18	1.09	1.02	0.95	0.90	0.86	0.81	0.77	0.73	0.70
2. Concrete floors:												
Age Group: Pre-1940	106	1.26	1.04	0.88	0.72	0.56	0.48	0.42	0.37	0.33	0.29	0.25
1940-49	1,668	1.48	1.28	1.16	1.04	0.92	0.85	0.77	0.70	0.64	0.58	0.53
Post-49	4,142	0.67	0.51	0.41	0.36	0.30	0.27	0.25	0.22	0.20	0.17	0.15
**All ages	5,965	0.92	0.75	0.64	0.56	0.49	0.44	0.40	0.36	0.33	0.29	0.26
*3. Wood or concrete floors:												
Age Group: Pre-1940	586	4.23	3.95	3.75	3.57	3.40	3.27	3.14	3.02	2.91	2.80	2.69
1940-49	4,097	1.17	1.00	0.92	0.84	0.76	0.71	0.66	0.61	0.57	0.53	0.49
Post-49	5,353	0.73	0.57	0.46	0.40	0.34	0.31	0.28	0.25	0.22	0.20	0.18
**All ages	10,237	1.11	0.94	0.83	0.76	0.69	0.64	0.60	0.55	0.52	0.48	0.45

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

Table 8. Dwelling loss experience for the 1971 San Fernando earthquake: Loss distribution by number of dwellings, excluding sites with geologic effects and one-and-two-story and split-level dwellings

% LOSS	WOOD-PRE40 NO. DWELL.	WOOD-PRE40 SUM PCT	WOOD-4049 NO. DWELL.	WOOD-4049 SUM PCT	WOOD-POST49 NO. DWELL.	WOOD-POST49 SUM PCT	WOOD-ALL NO. DWELL.	WOOD-ALL SUM PCT	CONC-PRE40 NO. DWELL.	CONC-PRE40 SUM PCT	CONC-4049 NO. DWELL.	CONC-4049 SUM PCT	CONC-POST49 NO. DWELL.	CONC-POST49 SUM PCT	CONC-ALL NO. DWELL.	CONC-ALL SUM PCT	BOTH-PRE40 NO. DWELL.	BOTH-PRE40 SUM PCT	BOTH-4049 NO. DWELL.	BOTH-4049 SUM PCT	BOTH-POST49 NO. DWELL.	BOTH-POST49 SUM PCT	BOTH-ALL NO. DWELL.	BOTH-ALL SUM PCT
0	99	21.3	371	15.6	142	12.4	632	15.5	41	38.7	481	28.8	931	22.5	1469	24.6	146	24.9	862	21.0	1087	20.3	2187	21.4
1	2	21.7	11	16.1	3	12.6	17	15.9	0	38.7	6	29.2	12	22.8	18	24.9	2	25.3	17	21.5	15	20.6	36	21.7
2	6	23.0	26	17.2	2	12.8	34	16.8	0	38.7	9	29.7	11	23.0	21	25.3	6	26.3	35	22.3	13	20.8	55	22.3
3	9	24.9	13	17.7	15	14.1	39	17.7	0	38.7	14	30.6	34	23.9	49	26.1	10	28.0	27	23.0	50	21.8	90	23.1
4	0	24.9	0	17.7	3	14.4	3	17.8	0	38.7	1	30.6	3	23.9	4	26.2	0	28.0	1	23.0	7	21.9	8	23.2
5	2	25.4	1	17.7	2	14.5	5	17.9	3	41.5	28	32.3	45	25.0	78	27.5	5	28.8	31	23.7	47	22.8	87	24.1
6	95	45.8	179	25.3	41	18.1	319	25.8	18	58.5	210	44.9	181	29.4	411	34.4	115	48.5	391	33.3	224	27.0	736	31.2
7	2	46.2	4	25.4	3	18.4	9	26.0	0	58.5	1	45.0	5	29.5	6	34.5	2	48.8	6	33.4	8	27.1	16	31.4
8	8	48.0	12	25.9	3	18.6	23	26.5	0	58.5	41	47.4	9	29.7	52	35.3	8	50.2	54	34.8	13	27.3	78	32.2
9	100	69.5	1398	84.7	692	78.9	2226	81.2	19	76.4	533	79.4	2142	81.4	2708	80.7	121	70.8	1946	82.3	2853	80.6	4977	80.8
10	5	70.5	46	86.6	24	81.0	76	83.1	1	77.4	3	79.6	140	84.8	144	83.2	6	71.8	49	83.5	167	83.8	224	83.0
11	42	79.6	174	93.9	108	90.4	331	91.2	7	84.0	135	87.6	204	89.7	348	89.0	49	80.2	315	91.1	315	89.7	690	89.7
12	6	80.9	41	95.7	24	92.5	74	93.0	0	84.0	5	87.9	193	94.4	199	92.3	8	81.6	46	92.3	223	93.8	281	92.5
13	7	82.4	6	95.9	10	93.4	23	93.6	0	84.0	6	88.3	15	94.8	21	92.7	8	82.9	12	92.6	25	94.3	45	92.9
14	15	85.6	20	96.8	23	95.4	62	95.1	9	92.5	72	92.6	89	96.9	173	95.6	24	87.0	96	94.9	117	96.5	246	95.3
15	1	85.8	4	96.9	6	95.9	11	95.4	2	94.3	2	92.7	14	97.2	18	95.9	3	87.5	6	95.0	21	96.9	30	95.6
16	1	86.0	0	96.9	4	96.3	5	95.5	0	94.3	4	93.0	6	97.4	11	96.1	1	87.7	4	95.1	10	97.0	16	95.8
17	5	87.1	5	97.1	10	97.1	20	96.0	2	96.2	12	93.7	15	97.8	29	96.5	7	88.9	18	95.6	25	97.5	50	96.2
18	0	87.1	0	97.1	0	97.1	0	96.0	0	96.2	0	93.7	2	97.8	2	96.6	0	88.9	0	95.6	2	97.6	2	96.3
19	2	87.5	2	97.2	2	97.3	6	96.1	0	96.2	23	95.1	5	97.9	28	97.0	2	89.2	26	96.2	8	97.7	36	96.6
20	0	87.5	0	97.2	3	97.6	3	96.2	0	96.2	9	95.6	9	98.1	18	97.4	0	89.2	9	96.4	13	97.9	22	96.8
21	1	87.7	0	97.2	2	97.7	3	96.3	0	96.2	0	95.6	2	98.2	2	97.4	1	89.4	0	96.4	4	98.0	5	96.9
22	4	88.6	9	97.6	4	98.1	18	96.7	1	97.2	14	96.5	16	98.6	32	97.9	5	90.3	25	97.0	21	98.4	53	97.4
23	1	88.8	1	97.6	2	98.3	4	96.8	0	97.2	1	96.5	5	98.7	6	98.0	1	90.4	2	97.1	7	98.5	10	97.5
24	0	88.8	7	97.9	7	98.9	14	97.2	0	97.2	5	96.8	8	98.9	13	98.2	0	90.4	12	97.4	15	98.8	27	97.8
25	4	89.7	2	98.0	2	99.0	8	97.4	2	99.1	4	97.1	6	99.0	12	98.4	6	91.5	6	97.5	10	99.0	22	98.0
26	2	90.1	3	98.2	1	99.1	6	97.5	0	99.1	3	97.2	5	99.2	8	98.6	2	91.8	6	97.7	6	99.1	14	98.1
27	3	90.8	5	98.4	0	99.1	8	97.7	0	99.1	2	97.4	11	99.4	14	98.8	3	92.3	7	97.9	12	99.3	23	98.3
28	1	91.0	4	98.5	1	99.2	7	97.9	0	99.1	2	97.5	5	99.5	7	98.9	1	92.5	6	98.0	6	99.5	14	98.5
29	1	91.2	1	98.6	1	99.3	3	98.0	0	99.1	5	97.8	4	99.6	9	99.1	1	92.7	6	98.1	5	99.6	12	98.6
30	7	92.7	6	98.8	2	99.5	15	98.3	0	99.1	2	97.9	1	99.7	4	99.1	7	93.9	10	98.4	3	99.6	21	98.8
31	0	92.7	2	98.9	0	99.5	2	98.4	0.	99.1	1	98.0	2	99.7	3	99.2	0	93.9	3	98.5	2	99.6	5	98.8
32	0	92.7	2	99.0	1	99.6	3	98.5	0	99.1	1	98.0	1	99.7	2	99.2	0	93.9	3	98.5	2	99.7	5	98.9
33	6	94.0	3	99.1	1	99.7	10	98.7	0	99.1	0	98.0	3	99.8	3	99.3	6	94.9	3	98.6	4	99.8	13	99.0
34	0	94.0	2	99.2	0	99.7	2	98.7	0	99.1	8	98.5	0	99.8	8	99.4	0	94.9	10	98.9	0	99.8	10	99.1
35	2	94.4	0	99.2	0	99.7	2	98.8	1	100.0	11	99.2	0	99.8	13	99.6	3	95.4	12	99.1	0	99.8	16	99.3
36	1	94.6	0	99.2	1	99.7	2	98.8	0	100.0	0	99.2	0	99.8	0	99.6	1	95.6	0	99.1	2	99.8	3	99.3
37	1	94.8	1	99.2	1	99.8	3	98.9	0	100.0	0	99.2	0	99.8	0	99.6	1	95.7	1	99.2	1	99.8	3	99.3
38	0	94.8	0	99.2	0	99.8	0	98.9	0	100.0	4	99.4	1	99.8	5	99.7	0	95.7	5	99.3	1	99.8	6	99.4
39	0	94.8	0	99.2	0	99.8	0	98.9	0	100.0	0	99.4	0	99.8	0	99.7	0	95.7	0	99.3	0	99.8	0	99.4
40	3	95.5	0	99.2	0	99.8	3	99.0	0	100.0	1	99.5	0	99.8	1	99.7	3	96.2	1	99.3	0	99.8	4	99.4
41	1	95.7	1	99.3	0	99.8	2	99.0	0	100.0	0	99.5	1	99.9	1	99.7	1	96.4	2	99.4	1	99.9	4	99.5
42	1	95.9	0	99.3	0	99.8	1	99.1	0	100.0	0	99.5	0	99.9	0	99.7	1	96.6	0	99.4	0	99.9	1	99.5
43	1	96.1	1	99.3	0	99.8	2	99.1	0	100.0	0	99.5	0	99.9	0	99.7	1	96.8	1	99.4	0	99.9	2	99.5
44	0	96.1	0	99.3	0	99.8	0	99.1	0	100.0	0	99.5	0	99.9	0	99.7	0	96.8	0	99.4	0	99.9	0	99.5
45	0	96.1	0	99.3	0	99.8	0	99.1	0	100.0	0	99.5	2	99.9	2	99.8	0	96.8	0	99.4	2	99.9	2	99.5

Table 8. Dwelling loss experience for the 1971 San Fernando earthquake: Loss distribution by number of dwellings, excluding sites with geologic effects and one-and-two-story and split-level dwellings—Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
46	0	96.1	0	99.3	0	99.8	0	99.1	0	100.0	0	99.5	1	99.9	1	99.8	0	96.8	0	99.4	1	99.9	1	99.5
47	0	96.1	0	99.3	0	99.8	0	99.1	0	100.0	1	99.5	0	99.9	1	99.8	0	96.8	1	99.4	0	99.9	1	99.5
48	0	96.1	1	99.4	0	99.8	1	99.1	0	100.0	1	99.6	0	99.9	1	99.8	0	96.8	2	99.5	0	99.9	2	99.6
49	2	96.6	1	99.4	0	99.8	3	99.2	0	100.0	0	99.6	0	99.9	0	99.8	2	97.1	1	99.5	0	99.9	3	99.6
50	0	96.6	1	99.5	0	99.8	1	99.2	0	100.0	1	99.6	0	99.9	1	99.8	0	97.1	2	99.5	0	99.9	2	99.6
51	0	96.6	2	99.5	0	99.8	2	99.3	0	100.0	0	99.6	0	99.9	0	99.8	0	97.1	2	99.6	0	99.9	2	99.6
52	0	96.6	0	99.5	0	99.8	0	99.3	0	100.0	0	99.6	0	99.9	0	99.8	0	97.1	0	99.6	0	99.9	0	99.6
53	0	96.6	0	99.5	0	99.8	0	99.3	0	100.0	0	99.6	2	100.0	2	99.9	0	97.1	0	99.6	2	99.9	2	99.6
54	0	96.6	0	99.5	0	99.8	0	99.3	0	100.0	0	99.6	0	100.0	0	99.9	0	97.1	0	99.6	0	99.9	0	99.6
55	0	96.6	0	99.5	0	99.8	0	99.3	0	100.0	3	99.8	0	100.0	3	99.9	0	97.1	3	99.7	0	99.9	3	99.7
56	2	97.0	0	99.5	1	99.9	3	99.4	0	100.0	0	99.8	0	100.0	0	99.9	2	97.4	0	99.7	1	100.0	3	99.7
57	0	97.0	0	99.5	0	99.9	0	99.4	0	100.0	0	99.8	0	100.0	0	99.9	0	97.4	0	99.7	0	100.0	0	99.7
58	2	97.4	0	99.5	0	99.9	2	99.4	0	100.0	3	100.0	0	100.0	3	100.0	2	97.8	3	99.7	0	100.0	5	99.7
59	0	97.4	0	99.5	0	99.9	0	99.4	0	100.0	0	100.0	0	100.0	0	100.0	0	97.8	0	99.7	0	100.0	0	99.7
60	1	97.6	0	99.5	0	99.9	1	99.4	0	100.0	0	100.0	0	100.0	0	100.0	2	98.1	0	99.7	0	100.0	2	99.8
61	0	97.6	4	99.7	0	99.9	4	99.5	0	100.0	0	100.0	0	100.0	0	100.0	0	98.1	4	99.8	0	100.0	4	99.8
62	0	97.6	1	99.7	0	99.9	1	99.6	0	100.0	0	100.0	0	100.0	0	100.0	0	98.1	1	99.9	0	100.0	1	99.8
63	0	97.6	1	99.8	0	99.9	1	99.6	0	100.0	0	100.0	0	100.0	0	100.0	0	98.1	1	99.9	0	100.0	1	99.8
64	1	97.8	4	100.0	0	99.9	5	99.7	0	100.0	0	100.0	0	100.0	0	100.0	1	98.3	4	100.0	0	100.0	5	99.9
65	0	97.8	0	100.0	0	99.9	0	99.7	0	100.0	0	100.0	0	100.0	0	100.0	0	98.3	0	100.0	0	100.0	0	99.9
>65	10	100.0	1	100.0	1	100.0	12	100.0	0	100.0	0	100.0	1	100.0	1	100.0	10	100.0	1	100.0	2	100.0	13	100.0

Table 9. Dwelling loss experience for the 1983 Coalinga earthquake: Loss over deductible. All inspected wood-frame dwellings

	No. of Dwell.	Percent Loss Over Deductible 0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	802	28.20	27.25	26.31	25.36	24.47	23.58	22.69	21.86	21.02	20.21	19.47
1940-49	289	14.79	13.89	12.99	12.10	11.28	10.46	9.64	8.89	8.16	7.46	6.92
Post-49	360	14.88	13.91	12.95	12.00	11.09	10.20	9.31	8.47	7.63	6.81	6.11
**All ages	1,477	22.30	21.35	20.42	19.48	18.60	17.72	16.84	16.02	15.21	14.42	13.73
2. Concrete floors:												
Age Group: Pre-1940	19	17.05	16.16	15.26	14.37	13.47	12.63	11.79	11.05	10.32	9.58	9.11
1940-49	35	11.37	10.43	9.49	8.57	7.71	6.89	6.11	5.37	4.71	4.09	3.60
Post-49	396	9.23	8.33	7.45	6.60	5.83	5.08	4.35	3.67	3.01	2.39	2.00
**All ages	455	9.74	8.84	7.95	7.09	6.31	5.55	4.81	4.13	3.46	2.84	2.44
*3. Wood or concrete floors:												
Age Group: Pre-1940	845	28.19	27.24	26.30	25.35	24.46	23.57	22.68	21.85	21.02	20.20	19.47
1940-49	329	15.18	14.27	13.37	12.48	11.65	10.83	10.02	9.27	8.54	7.85	7.32
Post-49	763	11.90	10.97	10.05	9.16	8.32	7.51	6.71	5.95	5.21	4.49	3.95
**All ages	1,982	20.16	19.22	18.29	17.38	16.52	15.66	14.82	14.03	13.25	12.49	11.86

	No. of Dwell.	Percent Loss Over Deductible 10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	802	19.47	18.74	18.02	17.39	16.76	16.17	15.60	15.04	14.55	14.07	13.60
1940-49	289	6.92	6.39	5.89	5.45	5.02	4.67	4.33	4.01	3.76	3.53	3.31
Post-49	360	6.11	5.45	4.89	4.43	4.01	3.66	3.35	3.08	2.86	2.65	2.46
**All ages	1,477	13.73	13.05	12.42	11.86	11.32	10.83	10.38	9.94	9.56	9.19	8.84
2. Concrete floors:												
Age Group: Pre-1940	19	9.11	8.63	8.16	7.74	7.32	7.00	6.68	6.37	6.11	5.84	5.58
1940-49	35	3.60	3.17	2.77	2.54	2.31	2.14	2.00	1.89	1.80	1.71	1.63
Post-49	396	2.00	1.64	1.35	1.15	0.96	0.83	0.72	0.62	0.56	0.50	0.45
**All ages	455	2.44	2.06	1.76	1.54	1.34	1.19	1.07	0.96	0.89	0.82	0.75
*3. Wood or concrete floors:												
Age Group: Pre-1940	845	19.47	18.73	18.02	17.38	16.75	16.16	15.59	15.02	14.53	14.04	13.57
1940-49	329	7.32	6.79	6.30	5.87	5.46	5.12	4.80	4.49	4.25	4.03	3.81
Post-49	763	3.95	3.45	3.03	2.70	2.41	2.17	1.96	1.79	1.64	1.51	1.40
**All ages	1,982	11.86	11.25	10.69	10.20	9.74	9.32	8.93	8.56	8.24	7.93	7.63

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

Table 10. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by number of dwellings

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
0	44	5.5	27	9.3	9	2.5	81	5.5	2	10.5	2	5.7	40	10.1	44	9.7	46	5.4	30	9.1	50	6.6	127	6.4
1	1	5.6	3	10.4	6	4.2	10	6.2	0	10.5	0	5.7	8	12.1	8	11.4	1	5.6	3	10.0	14	8.4	18	7.3
2	0	5.6	2	11.1	4	5.3	6	6.6	0	10.5	1	8.6	10	14.6	11	13.8	0	5.6	3	10.9	14	10.2	17	8.2
3	40	10.6	19	17.6	14	9.2	74	11.6	0	10.5	2	14.3	34	23.2	37	22.0	42	10.5	21	17.3	50	16.8	115	14.0
4	2	10.8	1	18.0	4	10.3	7	12.1	1	15.8	1	17.1	8	25.3	10	24.2	3	10.9	2	17.9	12	18.3	17	14.8
5	2	11.1	1	18.3	5	11.7	8	12.6	0	15.8	2	22.9	6	26.8	8	25.9	2	11.1	3	18.8	11	19.8	16	15.6
6	46	16.8	20	25.3	14	15.6	81	18.1	2	26.3	1	25.7	21	32.1	25	31.4	48	16.8	21	25.2	35	24.4	106	21.0
7	0	16.8	3	26.3	3	16.4	7	18.6	0	26.3	3	34.3	7	33.8	10	33.6	0	16.8	6	27.1	10	25.7	17	21.8
8	12	18.3	13	30.8	5	17.8	30	20.6	0	26.3	1	37.1	17	38.1	18	37.6	13	18.3	14	31.3	22	28.6	49	24.3
9	65	26.4	44	46.0	42	29.4	154	31.0	5	52.6	5	51.4	91	61.1	101	59.8	70	26.6	49	46.2	133	46.0	256	37.2
10	2	26.7	2	46.7	17	34.2	22	32.5	0	52.6	2	57.1	12	64.1	14	62.9	2	26.9	4	47.4	29	49.8	36	39.1
11	12	28.2	10	50.2	38	44.7	60	36.6	0	52.6	1	60.0	27	71.0	29	69.2	12	28.3	11	50.8	65	58.3	89	43.5
12	66	36.4	16	55.7	32	53.6	115	44.3	1	57.9	6	77.1	34	79.5	41	78.2	67	36.2	22	57.4	67	67.1	157	51.5
13	6	37.2	3	56.7	16	58.1	26	46.1	0	57.9	0	77.1	9	81.8	9	80.2	6	36.9	3	58.4	25	70.4	35	53.2
14	30	40.9	24	65.1	24	64.7	78	51.4	2	68.4	2	82.9	18	86.4	22	85.1	32	40.7	26	66.3	43	76.0	101	58.3
15	20	43.4	4	66.4	16	69.2	41	54.2	0	68.4	1	85.7	10	88.9	11	87.5	20	43.1	5	67.8	26	79.4	52	60.9
16	7	44.3	4	67.8	15	73.3	27	56.0	0	68.4	1	88.6	7	90.7	9	89.5	7	43.9	5	69.3	22	82.3	36	62.8
17	54	51.0	22	75.4	14	77.2	90	62.1	1	73.7	1	91.4	12	93.7	14	92.5	57	50.7	23	76.3	26	85.7	106	68.1
18	3	51.4	4	76.8	8	79.4	17	63.2	0	73.7	0	91.4	2	94.2	2	93.0	3	51.0	4	77.5	10	87.0	19	69.1
19	14	53.1	4	78.2	7	81.4	25	64.9	0	73.7	0	91.4	4	95.2	4	93.8	14	52.7	4	78.7	12	88.6	30	70.6
20	21	55.7	6	80.3	3	82.2	30	67.0	0	73.7	0	91.4	4	96.2	5	94.9	24	55.5	7	80.9	8	89.6	40	72.6
21	2	56.0	0	80.3	6	83.9	8	67.5	0	73.7	0	91.4	1	96.5	1	95.2	2	55.7	0	80.9	7	90.6	9	73.1
22	20	58.5	9	83.4	10	86.7	40	70.2	1	78.9	0	91.4	3	97.2	4	96.0	22	58.3	9	83.6	13	92.3	45	75.3
23	1	58.6	1	83.7	4	87.8	7	70.7	1	84.2	0	91.4	1	97.5	2	96.5	2	58.6	1	83.9	5	92.9	9	75.8
24	13	60.2	1	84.1	4	88.9	19	72.0	1	89.5	0	91.4	1	97.7	2	96.9	14	60.2	1	84.2	5	93.6	21	76.8
25	28	63.7	12	88.2	6	90.6	46	75.1	0	89.5	0	91.4	1	98.0	1	97.1	30	63.8	12	87.8	7	94.5	49	79.3
26	3	64.1	0	88.2	3	91.4	6	75.5	0	89.5	0	91.4	0	98.0	0	97.1	3	64.1	0	87.8	3	94.9	6	79.6
27	28	67.6	4	89.6	4	92.5	37	78.0	0	89.5	1	94.3	1	98.2	2	97.6	30	67.7	5	89.4	5	95.5	41	81.7
28	7	68.5	4	91.0	2	93.1	14	78.9	0	89.5	0	94.3	3	99.0	3	98.2	7	68.5	4	90.6	5	96.2	17	82.5
29	1	68.6	0	91.0	0	93.1	1	79.0	0	89.5	0	94.3	1	99.2	1	98.5	1	68.6	0	90.6	1	96.3	2	82.6
30	13	70.2	4	92.4	2	93.6	20	80.4	0	89.5	1	97.1	0	99.2	1	98.7	13	70.2	5	92.1	2	96.6	21	83.7
31	1	70.3	0	92.4	2	94.2	3	80.6	0	89.5	0	97.1	0	99.2	0	98.7	1	70.3	0	92.1	2	96.9	3	83.9
32	8	71.3	1	92.7	1	94.4	10	81.2	0	89.5	0	97.1	0	99.2	0	98.7	9	71.4	1	92.4	1	97.0	11	84.4
33	16	73.3	2	93.4	2	95.0	20	82.6	0	89.5	0	97.1	1	99.5	1	98.9	16	73.3	2	93.0	3	97.4	21	85.5
34	0	73.3	1	93.8	2	95.6	3	82.8	0	89.5	0	97.1	0	99.5	0	98.9	0	73.3	1	93.3	2	97.6	3	85.6
35	16	75.3	2	94.5	3	96.4	21	84.2	0	89.5	0	97.1	0	99.5	0	98.9	17	75.3	2	93.9	3	98.0	22	86.7
36	1	75.4	0	94.5	2	96.9	3	84.4	0	89.5	0	97.1	0	99.5	0	98.9	1	75.4	0	93.9	2	98.3	3	86.9
37	4	75.9	2	95.2	0	96.9	6	84.8	1	94.7	0	97.1	0	99.5	1	99.1	5	76.0	2	94.5	0	98.3	7	87.2
38	1	76.1	1	95.5	1	97.2	3	85.0	0	94.7	0	97.1	0	99.5	0	99.1	1	76.1	1	94.8	1	98.4	3	87.4
39	0	76.1	1	95.8	0	97.2	1	85.1	0	94.7	0	97.1	0	99.5	0	99.1	0	76.1	1	95.1	0	98.4	1	87.4
40	23	78.9	0	95.8	1	97.5	26	86.9	0	94.7	0	97.1	0	99.5	0	99.1	24	78.9	1	95.1	1	98.6	27	88.8
41	6	79.7	0	95.8	0	97.5	6	87.3	0	94.7	0	97.1	0	99.5	0	99.1	6	79.6	0	95.1	0	98.6	6	89.1
42	0	79.7	0	95.8	1	97.8	1	87.3	0	94.7	0	97.1	0	99.5	0	99.1	0	79.6	0	95.1	1	98.7	1	89.2
43	3	80.0	1	96.2	0	97.8	4	87.6	0	94.7	0	97.1	0	99.5	0	99.1	4	80.1	1	95.4	0	98.7	5	89.4
44	0	80.0	0	96.2	0	97.8	0	87.6	0	94.7	0	97.1	0	99.5	0	99.1	0	80.1	0	95.4	0	98.7	0	89.4
45	0	80.0	0	96.2	0	97.8	0	87.6	0	94.7	0	97.1	0	99.5	0	99.1	0	80.1	0	95.4	0	98.7	0	89.4

Table 10. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by number of dwellings—Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
46	1	80.2	0	96.2	0	97.8	1	87.7	0	94.7	0	97.1	0	99.5	0	99.1	1	80.2	0	95.4	0	98.7	1	89.5
47	0	80.2	0	96.2	0	97.8	0	87.7	0	94.7	0	97.1	0	99.5	0	99.1	0	80.2	0	95.4	0	98.7	0	89.5
48	16	82.2	2	96.9	0	97.8	18	88.9	0	94.7	0	97.1	1	99.7	1	99.3	17	82.2	2	96.0	1	98.8	20	90.5
49	0	82.2	0	96.9	2	98.3	2	89.0	0	94.7	0	97.1	0	99.7	0	99.3	0	82.2	0	96.0	2	99.1	2	90.6
50	48	88.2	1	97.2	0	98.3	50	92.4	0	94.7	0	97.1	0	99.7	0	99.3	51	88.3	1	96.4	0	99.1	53	93.2
51	0	88.2	0	97.2	0	98.3	0	92.4	0	94.7	0	97.1	0	99.7	0	99.3	0	88.3	0	96.4	0	99.1	0	93.2
52	2	88.4	0	97.2	0	98.3	2	92.6	0	94.7	0	97.1	0	99.7	0	99.3	2	88.5	0	96.4	0	99.1	2	93.3
53	3	88.8	1	97.6	0	98.3	4	92.8	0	94.7	0	97.1	0	99.7	0	99.3	3	88.9	1	96.7	0	99.1	4	93.5
54	0	88.8	0	97.6	0	98.3	0	92.8	0	94.7	0	97.1	0	99.7	0	99.3	0	88.9	0	96.7	0	99.1	0	93.5
55	0	88.8	0	97.6	0	98.3	0	92.8	0	94.7	0	97.1	0	99.7	0	99.3	0	88.9	0	96.7	0	99.1	0	93.5
56	3	89.2	0	97.6	0	98.3	3	93.0	0	94.7	0	97.1	0	99.7	0	99.3	3	89.2	0	96.7	0	99.1	3	93.7
57	0	89.2	1	97.9	0	98.3	1	93.1	0	94.7	0	97.1	0	99.7	0	99.3	0	89.2	1	97.0	0	99.1	1	93.7
58	1	89.3	0	97.9	1	98.6	2	93.2	0	94.7	0	97.1	0	99.7	0	99.3	1	89.3	0	97.0	1	99.2	2	93.8
59	0	89.3	0	97.9	0	98.6	0	93.2	0	94.7	0	97.1	0	99.7	0	99.3	0	89.3	0	97.0	0	99.2	0	93.8
60	2	89.5	0	97.9	0	98.6	2	93.4	0	94.7	1	100.0	0	99.7	1	99.6	2	89.6	1	97.3	0	99.2	3	94.0
61	1	89.7	1	98.3	0	98.6	3	93.6	0	94.7	0	100.0	0	99.7	0	99.6	1	89.7	1	97.6	0	99.2	3	94.1
62	0	89.7	0	98.3	0	98.6	0	93.6	0	94.7	0	100.0	0	99.7	0	99.6	0	89.7	0	97.6	0	99.2	0	94.1
63	1	89.8	0	98.3	0	98.6	1	93.6	0	94.7	0	100.0	0	99.7	0	99.6	1	89.8	0	97.6	0	99.2	1	94.2
64	0	89.8	0	98.3	0	98.6	0	93.6	0	94.7	0	100.0	0	99.7	0	99.6	0	89.8	0	97.6	0	99.2	0	94.2
65	0	89.8	0	98.3	0	98.6	0	93.6	0	94.7	0	100.0	0	99.7	0	99.6	0	89.8	0	97.6	0	99.2	0	94.2
>65	82	100.0	5	100.0	5	100.0	94	100.0	1	100.0	0	100.0	1	100.0	2	100.0	86	100.0	8	100.0	6	100.0	115	100.0

Table 11. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by percent of dwellings

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT
0	5	5.5	9.3	9.3	2.5	2.5	5.5	5.5	10.5	10.5	5.7	5.7	10.1	10.1	9.7	9.7	5.4	5.4	9.1	9.1	6.6	6.6	6.4	6.4
1	0	5.6	1.0	10.4	1.7	4.2	0.7	6.2	0.0	10.5	0.0	5.7	2.0	12.1	1.8	11.4	0.1	5.6	0.9	10.0	1.8	8.4	0.9	7.3
2	0	5.6	0.7	11.1	1.1	5.3	0.4	6.6	0.0	10.5	2.9	8.6	2.5	14.6	2.4	13.8	0.0	5.6	0.9	10.9	1.8	10.2	0.9	8.2
3	5	10.6	6.6	17.6	3.9	9.2	5.0	11.6	0.0	10.5	5.7	14.3	8.6	23.2	8.1	22.0	5.0	10.5	6.4	17.3	6.6	16.8	5.8	14.0
4	0	10.8	0.3	18.0	1.1	10.3	0.5	12.1	5.3	15.8	2.9	17.1	2.0	25.3	2.2	24.2	0.4	10.9	0.6	17.9	1.6	18.3	0.9	14.8
5	0	11.1	0.3	18.3	1.4	11.7	0.5	12.6	0.0	15.8	5.7	22.9	1.5	26.8	1.8	25.9	0.2	11.1	0.9	18.8	1.4	19.8	0.8	15.6
6	6	16.8	6.9	25.3	3.9	15.6	5.5	18.1	10.5	26.3	2.9	25.7	5.3	32.1	5.5	31.4	5.7	16.8	6.4	25.2	4.6	24.4	5.3	21.0
7	0	16.8	1.0	26.3	0.8	16.4	0.5	18.6	0.0	26.3	8.6	34.3	1.8	33.8	2.2	33.6	0.0	16.8	1.8	27.1	1.3	25.7	0.9	21.8
8	1	18.3	4.5	30.8	1.4	17.8	2.0	20.6	0.0	26.3	2.9	37.1	4.3	38.1	4.0	37.6	1.5	18.3	4.3	31.3	2.9	28.6	2.5	24.3
9	8	26.4	15.2	46.0	11.7	29.4	10.4	31.0	26.3	52.6	14.3	51.4	23.0	61.1	22.2	59.8	8.3	26.6	14.9	46.2	17.4	46.0	12.9	37.2
10	0	26.7	0.7	46.7	4.7	34.2	1.5	32.5	0.0	52.6	5.7	57.1	3.0	64.1	3.1	62.9	0.2	26.9	1.2	47.4	3.8	49.8	1.8	39.1
11	1	28.2	3.5	50.2	10.6	44.7	4.1	36.6	0.0	52.6	2.9	60.0	6.8	71.0	6.4	69.2	1.4	28.3	3.3	50.8	8.5	58.3	4.5	43.5
12	8	36.4	5.5	55.7	8.9	53.6	7.8	44.3	5.3	57.9	17.1	77.1	8.6	79.5	9.0	78.2	7.9	36.2	6.7	57.4	8.8	67.1	7.9	51.5
13	1	37.2	1.0	56.7	4.4	58.1	1.8	46.1	0.0	57.9	0.0	77.1	2.3	81.8	2.0	80.2	0.7	36.9	0.9	58.4	3.3	70.4	1.8	53.2
14	4	40.9	8.3	65.1	6.7	64.7	5.3	51.4	10.5	68.4	5.7	82.9	4.5	86.4	4.8	85.1	3.8	40.7	7.9	66.3	5.6	76.0	5.1	58.3
15	2	43.4	1.4	66.4	4.4	69.2	2.8	54.2	0.0	68.4	2.9	85.7	2.5	88.9	2.4	87.5	2.4	43.1	1.5	67.8	3.4	79.4	2.6	60.9
16	1	44.3	1.4	67.8	4.2	73.3	1.8	56.0	0.0	68.4	2.9	88.6	1.8	90.7	2.0	89.5	0.8	43.9	1.5	69.3	2.9	82.3	1.8	62.8
17	7	51.0	7.6	75.4	3.9	77.2	6.1	62.1	5.3	73.7	2.9	91.4	3.0	93.7	3.1	92.5	6.7	50.7	7.0	76.3	3.4	85.7	5.3	68.1
18	0	51.4	1.4	76.8	2.2	79.4	1.2	63.2	0.0	73.7	0.0	91.4	0.5	94.2	0.4	93.0	0.4	51.0	1.2	77.5	1.3	87.0	1.0	69.1
19	2	53.1	1.4	78.2	1.9	81.4	1.7	64.9	0.0	73.7	0.0	91.4	1.0	95.2	0.9	93.8	1.7	52.7	1.2	78.7	1.6	88.6	1.5	70.6
20	3	55.7	2.1	80.3	0.8	82.2	2.0	67.0	0.0	73.7	0.0	91.4	1.0	96.2	1.1	94.9	2.8	55.5	2.1	80.9	1.0	89.6	2.0	72.6
21	0	56.0	0.0	80.3	1.7	83.9	0.5	67.5	0.0	73.7	0.0	91.4	0.3	96.5	0.2	95.2	0.2	55.7	0.0	80.9	0.9	90.6	0.5	73.1
22	2	58.5	3.1	83.4	2.8	86.7	2.7	70.2	5.3	78.9	0.0	91.4	0.8	97.2	0.9	96.0	2.6	58.3	2.7	83.6	1.7	92.3	2.3	75.3
23	0	58.6	0.3	83.7	1.1	87.8	0.5	70.7	5.3	84.2	0.0	91.4	0.3	97.5	0.4	96.5	0.2	58.6	0.3	83.9	0.7	92.9	0.5	75.8
24	2	60.2	0.3	84.1	1.1	88.9	1.3	72.0	5.3	89.5	0.0	91.4	0.3	97.7	0.4	96.9	1.7	60.2	0.3	84.2	0.7	93.6	1.1	76.8
25	3	63.7	4.2	88.2	1.7	90.6	3.1	75.1	0.0	89.5	0.0	91.4	0.3	98.0	0.2	97.1	3.6	63.8	3.6	87.8	0.9	94.5	2.5	79.3
26	0	64.1	0.0	88.2	0.8	91.4	0.4	75.5	0.0	89.5	0.0	91.4	0.0	98.0	0.0	97.1	0.4	64.1	0.0	87.8	0.4	94.9	0.3	79.6
27	3	67.6	1.4	89.6	1.1	92.5	2.5	78.0	0.0	89.5	2.9	94.3	0.3	98.2	0.4	97.6	3.6	67.7	1.5	89.4	0.7	95.5	2.1	81.7
28	1	68.5	1.4	91.0	0.6	93.1	0.9	78.9	0.0	89.5	0.0	94.3	0.8	99.0	0.7	98.2	0.8	68.5	1.2	90.6	0.7	96.2	0.9	82.5
29	0	68.6	0.0	91.0	0.0	93.1	0.1	79.0	0.0	89.5	0.0	94.3	0.3	99.2	0.2	98.5	0.1	68.6	0.0	90.6	0.1	96.3	0.1	82.6
30	2	70.2	1.4	92.4	0.6	93.6	1.4	80.4	0.0	89.5	2.9	97.1	0.0	99.2	0.2	98.7	1.5	70.2	1.5	92.1	0.3	96.6	1.1	83.7
31	0	70.3	0.0	92.4	0.6	94.2	0.2	80.6	0.0	89.5	0.0	97.1	0.0	99.2	0.0	98.7	0.1	70.3	0.0	92.1	0.3	96.9	0.2	83.9
32	1	71.3	0.3	92.7	0.3	94.4	0.7	81.2	0.0	89.5	0.0	97.1	0.0	99.2	0.0	98.7	1.1	71.4	0.3	92.4	0.1	97.0	0.6	84.4
33	2	73.3	0.7	93.4	0.6	95.0	1.4	82.6	0.0	89.5	0.0	97.1	0.3	99.5	0.2	98.9	1.9	73.3	0.6	93.0	0.4	97.4	1.1	85.5
34	0	73.3	0.3	93.8	0.6	95.6	0.2	82.8	0.0	89.5	0.0	97.1	0.0	99.5	0.0	98.9	0.0	73.3	0.3	93.3	0.3	97.6	0.2	85.6
35	2	75.3	0.7	94.5	0.8	96.4	1.4	84.2	0.0	89.5	0.0	97.1	0.0	99.5	0.0	98.9	2.0	75.3	0.6	93.9	0.4	98.0	1.1	86.7
36	0	75.4	0.0	94.5	0.6	96.9	0.2	84.4	0.0	89.5	0.0	97.1	0.0	99.5	0.0	98.9	0.1	75.4	0.0	93.9	0.3	98.3	0.2	86.9
37	0	75.9	0.7	95.2	0.0	96.9	0.4	84.8	5.3	94.7	0.0	97.1	0.0	99.5	0.2	99.1	0.6	76.0	0.6	94.5	0.0	98.3	0.4	87.2
38	0	76.1	0.3	95.5	0.3	97.2	0.2	85.0	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.1	76.1	0.3	94.8	0.1	98.4	0.2	87.4
39	0	76.1	0.3	95.8	0.0	97.2	0.1	85.1	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.0	76.1	0.3	95.1	0.0	98.4	0.1	87.4
40	3	78.9	0.0	95.8	0.3	97.5	1.8	86.9	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	2.8	78.9	0.0	95.1	0.1	98.6	1.4	88.8
41	1	79.7	0.0	95.8	0.0	97.5	0.4	87.3	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.7	79.6	0.0	95.1	0.0	98.6	0.3	89.1
42	0	79.7	0.0	95.8	0.3	97.8	0.1	87.3	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.0	79.6	0.0	95.1	0.1	98.7	0.1	89.2
43	0	80.0	0.3	96.2	0.0	97.8	0.3	87.6	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.5	80.1	0.3	95.4	0.0	98.7	0.3	89.4
44	0	80.0	0.0	96.2	0.0	97.8	0.0	87.6	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.0	80.1	0.0	95.4	0.0	98.7	0.0	89.4
45	0	80.0	0.0	96.2	0.0	97.8	0.0	87.6	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.0	80.1	0.0	95.4	0.0	98.7	0.0	89.4

Table 11. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by percent of dwellings—Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT	% DWELL.	SUM PCT
46	0	80.2	0.0	96.2	0.0	97.8	0.1	87.7	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.1	80.2	0.0	95.4	0.0	98.7	0.1	89.5
47	0	80.2	0.0	96.2	0.0	97.8	0.0	87.7	0.0	94.7	0.0	97.1	0.0	99.5	0.0	99.1	0.0	80.2	0.0	95.4	0.0	98.7	0.0	89.5
48	2	82.2	0.7	96.9	0.0	97.8	1.2	88.9	0.0	94.7	0.0	97.1	0.3	99.7	0.2	99.3	2.0	82.2	0.6	96.0	0.1	98.8	1.0	90.5
49	0	82.2	0.0	96.9	0.6	98.3	0.1	89.0	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.0	82.2	0.0	96.0	0.3	99.1	0.1	90.6
50	6	88.2	0.3	97.2	0.0	98.3	3.4	92.4	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	6.0	88.3	0.3	96.4	0.0	99.1	2.7	93.2
51	0	88.2	0.0	97.2	0.0	98.3	0.0	92.4	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.0	88.3	0.0	96.4	0.0	99.1	0.0	93.2
52	0	88.4	0.0	97.2	0.0	98.3	0.1	92.6	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.2	88.5	0.0	96.4	0.0	99.1	0.1	93.3
53	0	88.8	0.3	97.6	0.0	98.3	0.3	92.8	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.4	88.9	0.3	96.7	0.0	99.1	0.2	93.5
54	0	88.8	0.0	97.6	0.0	98.3	0.0	92.8	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.0	88.9	0.0	96.7	0.0	99.1	0.0	93.5
55	0	88.8	0.0	97.6	0.0	98.3	0.0	92.8	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.0	88.9	0.0	96.7	0.0	99.1	0.0	93.5
56	0	89.2	0.0	97.6	0.0	98.3	0.2	93.0	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.4	89.2	0.0	96.7	0.0	99.1	0.2	93.7
57	0	89.2	0.3	97.9	0.0	98.3	0.1	93.1	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.0	89.2	0.3	97.0	0.0	99.1	0.1	93.7
58	0	89.3	0.0	97.9	0.3	98.6	0.1	93.2	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.1	89.3	0.0	97.0	0.1	99.2	0.1	93.8
59	0	89.3	0.0	97.9	0.0	98.6	0.0	93.2	0.0	94.7	0.0	97.1	0.0	99.7	0.0	99.3	0.0	89.3	0.0	97.0	0.0	99.2	0.0	93.8
60	0	89.5	0.0	97.9	0.0	98.6	0.1	93.4	0.0	94.7	2.9	100.0	0.0	99.7	0.2	99.6	0.2	89.6	0.3	97.3	0.0	99.2	0.2	94.0
61	0	89.7	0.3	98.3	0.0	98.6	0.2	93.6	0.0	94.7	0.0	100.0	0.0	99.7	0.0	99.6	0.1	89.7	0.3	97.6	0.0	99.2	0.2	94.1
62	0	89.7	0.0	98.3	0.0	98.6	0.0	93.6	0.0	94.7	0.0	100.0	0.0	99.7	0.0	99.6	0.0	89.7	0.0	97.6	0.0	99.2	0.0	94.1
63	0	89.8	0.0	98.3	0.0	98.6	0.1	93.6	0.0	94.7	0.0	100.0	0.0	99.7	0.0	99.6	0.1	89.8	0.0	97.6	0.0	99.2	0.1	94.2
64	0	89.8	0.0	98.3	0.0	98.6	0.0	93.6	0.0	94.7	0.0	100.0	0.0	99.7	0.0	99.6	0.0	89.8	0.0	97.6	0.0	99.2	0.0	94.2
65	0	89.8	0.0	98.3	0.0	98.6	0.0	93.6	0.0	94.7	0.0	100.0	0.0	99.7	0.0	99.6	0.0	89.8	0.0	97.6	0.0	99.2	0.0	94.2
>65	10	100.0	1.7	100.0	1.4	100.0	6.4	100.0	5.3	100.0	0.0	100.0	0.3	100.0	0.4	100.0	10.2	100.0	2.4	100.0	0.8	100.0	5.8	100.0

which shows loss over deductible for the range of 0–10 percent deductible. Table 13 is the loss distribution, by number of dwellings. Counterparts to tables 4 and 5 are not included in this report.

One-to-Four-Family Wood-Frame Dwellings—Insurance Company Experience

Due to unusual legal problems, claims were paid by many companies under non-earthquake insurance policies even though the damage was due to earthquake. As a result, additional loss information became available from claims paid under the 10 percent earthquake deductible.

Insurance-loss experience was obtained from two insurance companies. Table 14 shows the loss over deductible (for the range of 0–20 percent deductible) experience for one company with information on 367 dwellings, which represents almost 20 percent of our 1,982 inspected dwellings. The second company provided similar loss information on 29 additional dwellings.

1933 Long Beach Earthquake

The loss data for the 1933 Long Beach earthquake lack detail and are not as extensive as data for the 1971 San Fernando and 1983 Coalinga earthquakes. However, the 1933 losses have major historic importance because they were the basis for many of today's loss-over-deductible practices, including those used by the California Department of Insurance.

Published wood-frame-dwelling data on the 1933 Long Beach earthquake are in a supplement to a study by Martel (1936). Martel (1936, p. 161) stated,

> The principal source of data, the building department of the county assessor's office, yielded assessed values and reductions in assessed value due to earthquake damage, when granted, for all the buildings. This information was supplemented and checked by use of Compton city building permits and by field surveys.
>
> The results of considering the damage percentage for wood frame residences *** as to location indicated that a central area, several blocks wide and extending north and south to the city limits, received slightly higher damage than either the east or west sides of Compton. However, since many old buildings of low value were in this area, the small increase in percentage damage of this area over the rest of the town does not definitely indicate much difference in intensity.
>
> The extent of damage for wood frame residences *** is very low; in fact in 95 percent of these buildings the damage was less than 5 percent ***.

A second source of information is a file of 590 one-page insurance summary reports in the "Adjuster's Special Report, Southern California Earthquake" (K.V. Steinbrugge, unpub. data). These reports on each property include location, construction (brick, frame, or "fireproof"), occupancy, property covered (type of coverage), value, insured value, loss, and other data. Only 32 wood-frame dwellings in Long Beach and Compton were included in these reports.

The following tabulates the Martel and insurance (adjuster) information:

	Martel (1936)		Insurance (adjuster)	
Damage in percent	[1]Number of dwellings	Percent of dwellings	[2]Number of dwellings	Percent of dwellings
0–4	4,334	94.7	8	15
5–24	131	2.9	18	56
25–49	63	1.4	6	19
50 and greater	36	0.8	None	None
Demolished	11	0.2	None	None

[1]Compton, Calif.
[2]Compton and Long Beach, Calif.

Because the insurance adjustment reports indicate that 5 or 10 percent deductibles were typical of these policies, persons with losses under the deductible most likely never filed claims and thereby data on such losses are probably not included in the range of 0–4 percent deductible.

Although the Martel (1936) data are the better of the two, they are of limited utility. Relationships among assessed values, market values, insured values, and replacement values are not clear. Dwelling construction has changed since 1933. In the interim, deterioration has occurred to many of the remaining dwellings. Performance of pre-1933 dwellings in future earthquakes is expected to be poorer than in the 1933 Long Beach earthquake.

Prior to the 1971 San Fernando earthquake, and also thereafter, it was common California insurance practice to use a 7 percent PML, which was judgmentally determined from Martel's (1936) statement "*** in 95 percent of these buildings the damage was less than 5 percent ***." The California Department of Insurance continued this practice.

RELATIONSHIPS AMONG CONSTRUCTION, GEOLOGIC EFFECTS, AND LOSS OVER DEDUCTIBLE

1971 San Fernando Earthquake

Recent and present dwelling construction falls into the "wood or concrete floors, post-1949" category in

Table 12. Dwelling loss experience for the 1983 Coalinga earthquake: Loss over deductible, excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection

	No. of Dwell.	Percent Loss Over Deductible										
		0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	167	8.35	7.61	6.88	6.15	5.45	4.75	4.07	3.56	3.06	2.57	2.28
1940-49	130	8.46	7.67	6.90	6.15	5.43	4.72	4.01	3.41	2.82	2.30	2.02
Post-49	226	10.51	9.55	8.62	7.70	6.84	5.99	5.14	4.34	3.55	2.78	2.17
**All ages	532	9.28	8.43	7.60	6.78	6.01	5.24	4.48	3.82	3.18	2.56	2.14
2. Concrete floors:												
Age Group: Pre-1940	9	5.78	5.00	4.22	3.44	2.67	2.00	1.33	0.89	0.44	0.00	0.00
1940-49	23	8.57	7.65	6.74	5.87	5.04	4.22	3.39	2.61	1.96	1.35	0.96
Post-49	300	7.52	6.65	5.81	5.00	4.29	3.59	2.91	2.26	1.64	1.06	0.77
**All ages	335	7.53	6.67	5.82	5.01	4.28	3.58	2.89	2.24	1.62	1.04	0.76
*3. Wood or concrete floors:												
Age Group: Pre-1940	177	8.21	7.47	6.74	6.01	5.30	4.60	3.92	3.41	2.91	2.42	2.15
1940-49	154	8.42	7.62	6.83	6.06	5.34	4.61	3.89	3.27	2.68	2.14	1.84
Post-49	530	8.78	7.87	6.99	6.14	5.36	4.60	3.85	3.15	2.45	1.79	1.37
**All ages	873	8.58	7.72	6.89	6.07	5.32	4.58	3.85	3.20	2.57	1.97	1.60

	No. of Dwell.	Percent Loss Over Deductible										
		10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	167	2.28	2.00	1.75	1.53	1.32	1.16	0.99	0.86	0.74	0.62	0.52
1940-49	130	2.02	1.75	1.52	1.30	1.09	0.94	0.78	0.65	0.56	0.48	0.40
Post-49	226	2.17	1.63	1.25	0.98	0.77	0.62	0.50	0.39	0.30	0.22	0.16
**All ages	532	2.14	1.75	1.45	1.21	1.01	0.86	0.71	0.59	0.49	0.40	0.33
2. Concrete floors:												
Age Group: Pre-1940	9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940-49	23	0.96	0.65	0.39	0.30	0.22	0.13	0.04	0.00	0.00	0.00	0.00
Post-49	300	0.77	0.52	0.36	0.28	0.21	0.16	0.12	0.09	0.06	0.05	0.04
**All ages	335	0.76	0.51	0.35	0.27	0.20	0.15	0.11	0.08	0.06	0.04	0.03
*3. Wood or concrete floors:												
Age Group: Pre-1940	177	2.15	1.89	1.65	1.45	1.24	1.09	0.94	0.81	0.69	0.58	0.49
1940-49	154	1.84	1.57	1.34	1.14	0.95	0.81	0.67	0.55	0.47	0.40	0.34
Post-49	530	1.37	1.00	0.74	0.58	0.44	0.35	0.28	0.22	0.16	0.12	0.09
**All ages	873	1.60	1.27	1.02	0.84	0.69	0.58	0.48	0.39	0.32	0.26	0.21

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

tables 2, 6, and 7. The reader should compare losses over deductible for this category in tables 2 and 6 at 10 percent deductible. (The 10 percent deductible was chosen because it is presently a common insurance deductible.) Inclusion of geologic factors increases the loss over deductible from 0.90 percent (table 6) to 1.54 percent (table 2), or a 71 percent increase. Any use of this 1971 San Fernando information for loss estimates in other regions should not ignore the distortions in loss data from geologic effects.

Table 7 shows losses over deductible for only one-story dwellings, thereby excluding one-and-two-story, split-level, and two-story dwellings. Compare tables 6 and 7 for wood or concrete floors in the post-1949 age group at 10 percent deductible. Including split-level, one-and-two-story, and two-story dwellings, the loss over deductible increases from 0.73 percent (table 7) to 0.90 percent (table 6), or a 23 percent increase. This 23 percent increase is the result of only a 243-dwelling increase in the number of one-and-two-story, split-level, and two-story dwellings (from 5,353 to 5,596). Certainly the modern one-story dwelling in San Fernando performed well compared to those of other heights.

Modern post-1949 houses of all heights performed significantly better than did pre-1940 dwellings; this has also been observed in studies of all other recent California earthquakes. Newer dwellings are far more likely to be bolted to their foundations than are older ones. Also, deterioration has not yet taken its toll on the newer dwellings.

Dwellings with concrete first floors on grade performed better than did those with supported wooden first floors, noticeably so with increasing age.

Figure 1 is a graphic representation of much of the information in tables 2 and 6. The curves can be reasonably approximated by straight lines from 0 to 10 percent deductible, but not from 0 to 20 percent deductible. This family of curves has similar characteristics.

Table 15 is an overview comparison among losses over deductible without regard to the type of first-floor construction. This table uses the same data as figure 1. The 5 and 10 percent deductibles are or have been commonly used, and some interest has been shown in a 15 percent deductible.

1983 Coalinga Earthquake

Non-Insurance Data

Losses over deductible for wood-frame dwellings, without exclusions for the 1983 Coalinga earthquake, are shown in table 9. Comparing table 9 with table 2 shows Coalinga losses over deductible to be much larger than those for San Fernando. San Fernando information in table 2 includes losses from faulting, liquefaction, and other geologic effects not found in Coalinga. The Coalinga magnitude was 6.7, slightly higher than 6.4 for San Fernando; these magnitudes are reasonably equal for the purpose of damage comparisons. Coalinga was close to the epicenter and energy release, whereas San Fernando was astride the faulting; both fall within the PML zone as defined for insurance purposes.

One strong reason for the discrepancies between Coalinga and San Fernando losses over deductible lies with the approximately 200 dwellings moved to Coalinga and not anchored to their foundations. It is possible to place upper and lower bounds on these special cases of unanchored houses. Values in table 9 are the upper bounds because they include all losses over deductible for all reasons, except ensuing fire. Values in table 12 are the lower bounds because they include all losses over deductible for one-to-four-family wood-frame dwellings, excluding possible aberrations such as dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before the time of inspection. Dwellings that had been moved to Coalinga were not new dwellings and belonged in the pre-1940 or 1940–49 age group. However, fallen older dwellings on cripple studs were not necessarily structures that had been moved to Coalinga.

A second reason appears to be the amplification of ground motions, which resulted in increased damage. There are certain areas that, during earthquakes, are shaken more severely than are other, nearby areas and yet do not have "poor ground" as commonly understood for the purpose of earthquake insurance. Figure 2 is an isoseismal map of the 1906 San Francisco earthquake. Coalinga is about 80 miles from the southern end of the 1906 San Francisco earthquake's rupture on the San Andreas fault. It will be noted that higher seismic intensities were observed in Coalinga, Los Banos, and elsewhere on the western side of San Joaquin Valley than at many locations that were actually closer to the 1906 faulting. Figure 2 indicates that Coalinga may have experienced intensities equal to those experienced in parts of San Francisco.

Damage at Coalinga from the 1906 event was summarized by Lawson (1908, v. 1, pt. 2, p. 318) as follows:

> The tops of a few of the walls of brick buildings were slightly damaged as shown by the accompanying photograph [note: parapet fell from a two-story structure]. A few dishes and bottles were thrown from the shelves, and water was slopped out of the tanks, but not capsized. At the oil wells no damage was done either to wells or pipe lines. At a pumping station, the brick lining of the furnace was slightly cracked. Considerable oil was thrown from the tanks. In a large

Table 13. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by number of dwellings, excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
0	44	26.3	27	20.8	9	4.0	81	15.2	2	22.2	2	8.7	40	13.3	44	13.1	46	26.0	30	19.5	50	9.4	127	14.5
1	1	26.9	3	23.1	6	6.6	10	17.1	0	22.2	0	8.7	8	16.0	8	15.5	1	26.6	3	21.4	14	12.1	18	16.6
2	0	26.9	2	24.6	4	8.4	6	18.2	0	22.2	1	13.0	10	19.3	11	18.8	0	26.6	3	23.4	14	14.7	17	18.6
3	5	29.9	5	28.5	12	13.7	23	22.6	0	22.2	1	17.4	27	28.3	29	27.5	5	29.4	6	27.3	41	22.5	54	24.7
4	1	30.5	0	28.5	2	14.6	3	23.1	1	33.3	0	17.4	7	30.7	8	29.9	2	30.5	0	27.3	9	24.2	11	26.0
5	1	31.1	1	29.2	2	15.5	4	23.9	0	33.3	0	17.4	2	31.3	2	30.4	1	31.1	1	27.9	4	24.9	6	26.7
6	31	49.7	14	40.0	10	19.9	56	34.4	2	55.6	1	21.7	13	35.7	17	35.5	33	49.7	15	37.7	23	29.2	73	35.1
7	0	49.7	2	41.5	2	20.8	5	35.3	0	55.6	3	34.8	6	37.7	9	38.2	0	49.7	5	40.9	8	30.8	14	36.7
8	2	50.9	8	47.7	5	23.0	15	38.2	0	55.6	1	39.1	12	41.7	13	42.1	3	51.4	9	46.8	17	34.0	29	40.0
9	34	71.3	31	71.5	36	38.9	104	57.7	4	100.0	5	60.9	89	71.3	98	71.3	38	72.9	36	70.1	125	57.5	202	63.1
10	1	71.9	2	73.1	17	46.5	21	61.7	0	100.0	2	69.6	12	75.3	14	75.5	1	73.4	4	72.7	29	63.0	35	67.1
11	5	74.9	5	76.9	35	61.9	45	70.1	0	100.0	1	73.9	26	84.0	28	83.9	5	76.3	6	76.6	61	74.5	73	75.5
12	6	78.4	2	78.5	24	72.6	32	76.1	0	100.0	4	91.3	22	91.3	26	91.6	6	79.7	6	80.5	46	83.2	58	82.1
13	0	78.4	1	79.2	14	78.8	16	79.1	0	100.0	0	91.3	5	93.0	5	93.1	0	79.7	1	81.2	19	86.8	21	84.5
14	9	83.8	7	84.6	15	85.4	31	85.0	0	100.0	0	91.3	6	95.0	6	94.9	9	84.7	7	85.7	22	90.9	38	88.9
15	0	83.8	0	84.6	5	87.6	5	85.9	0	100.0	0	91.3	4	96.3	4	96.1	0	84.7	0	85.7	9	92.6	9	89.9
16	4	86.2	3	86.9	4	89.4	11	88.0	0	100.0	1	95.7	1	96.7	2	96.7	4	87.0	4	88.3	5	93.6	13	91.4
17	3	88.0	5	90.8	3	90.7	11	90.0	0	100.0	1	100.0	3	97.7	4	97.9	3	88.7	6	92.2	6	94.7	15	93.1
18	0	88.0	1	91.5	4	92.5	5	91.0	0	100.0	0	100.0	2	98.3	2	98.5	0	88.7	1	92.9	6	95.8	7	93.9
19	4	90.4	1	92.3	4	94.2	9	92.7	0	100.0	0	100.0	2	99.0	2	99.1	4	91.0	1	93.5	6	97.0	11	95.2
20	2	91.6	0	92.3	2	95.1	4	93.4	0	100.0	0	100.0	0	99.0	0	99.1	2	92.1	0	93.5	2	97.4	4	95.6
21	0	91.6	0	92.3	0	95.1	0	93.4	0	100.0	0	100.0	0	99.0	0	99.1	0	92.1	0	93.5	0	97.4	0	95.6
22	5	94.6	3	94.6	4	96.9	12	95.7	0	100.0	0	100.0	2	99.7	2	99.7	5	94.9	3	95.5	6	98.5	14	97.3
23	1	95.2	0	94.6	4	98.7	5	96.6	0	100.0	0	100.0	0	99.7	0	99.7	1	95.5	0	95.5	4	99.2	5	97.8
24	3	97.0	1	95.4	0	98.7	4	97.4	0	100.0	0	100.0	0	99.7	0	99.7	3	97.2	1	96.1	0	99.2	4	98.3
25	1	97.6	4	98.5	1	99.1	6	98.5	0	100.0	0	100.0	0	99.7	0	99.7	1	97.7	4	98.7	1	99.4	6	99.0
26	0	97.6	0	98.5	2	100.0	2	98.9	0	100.0	0	100.0	0	99.7	0	99.7	0	97.7	0	98.7	2	99.8	2	99.2
27	0	97.6	0	98.5	0	100.0	0	98.9	0	100.0	0	100.0	1	100.0	1	100.0	0	97.7	0	98.7	1	100.0	1	99.3
28	0	97.6	1	99.2	0	100.0	1	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	97.7	1	99.4	0	100.0	1	99.4
29	1	98.2	0	99.2	0	100.0	1	99.2	0	100.0	0	100.0	0	100.0	0	100.0	1	98.3	0	99.4	0	100.0	1	99.5
30	1	98.8	0	99.2	0	100.0	1	99.4	0	100.0	0	100.0	0	100.0	0	100.0	1	98.9	0	99.4	0	100.0	1	99.7
31	0	98.8	0	99.2	0	100.0	0	99.4	0	100.0	0	100.0	0	100.0	0	100.0	0	98.9	0	99.4	0	100.0	0	99.7
32	0	98.8	0	99.2	0	100.0	0	99.4	0	100.0	0	100.0	0	100.0	0	100.0	0	98.9	0	99.4	0	100.0	0	99.7
33	0	98.8	0	99.2	0	100.0	0	99.4	0	100.0	0	100.0	0	100.0	0	100.0	0	98.9	0	99.4	0	100.0	0	99.7
34	0	98.8	1	100.0	0	100.0	1	99.6	0	100.0	0	100.0	0	100.0	0	100.0	0	98.9	1	100.0	0	100.0	1	99.8
35	1	99.4	0	100.0	0	100.0	1	99.8	0	100.0	0	100.0	0	100.0	0	100.0	1	99.4	0	100.0	0	100.0	1	99.9
36	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
37	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
38	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
39	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
40	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
41	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
42	0	99.4	0	100.0	0	100.0	0	99.8	0	100.0	0	100.0	0	100.0	0	100.0	0	99.4	0	100.0	0	100.0	0	99.9
43	1	100.0	0	100.0	0	100.0	1	100.0	0	100.0	0	100.0	0	100.0	0	100.0	1	100.0	0	100.0	0	100.0	1	100.0
44	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
45	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0

Table 13. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by number of dwellings, excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection—Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
46	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
47	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
48	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
49	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
50	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
51	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
52	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
53	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
54	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
55	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
56	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
57	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
58	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
59	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
60	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
61	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
62	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
63	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
64	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
65	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0
>65	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0	0	100.0

Table 14. Dwelling loss experience for the 1983 Coalinga earthquake: Loss over deductible, based on Insurance Source A data

	No. of Dwell.	Percent Loss Over Deductible 0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	138	26.40	25.50	24.70	23.96	23.27	22.59	21.94	21.32	20.75	20.25	19.75
1940-49	72	8.24	7.50	6.96	6.43	5.90	5.42	5.00	4.61	4.25	3.96	3.75
Post-49	63	5.25	4.35	3.48	2.73	2.10	1.63	1.30	1.03	0.83	0.71	0.62
**All ages	279	16.49	15.65	14.91	14.23	13.60	13.03	12.52	12.04	11.61	11.25	10.93
2. Concrete floors:												
Age Group: Pre-1940	3	5.33	4.33	3.67	3.00	2.33	1.67	1.00	0.33	0.00	0.00	0.00
1940-49	14	16.86	15.93	15.14	14.36	13.79	13.29	12.86	12.50	12.14	11.86	11.57
Post-49	84	5.04	4.26	3.62	3.00	2.52	2.10	1.76	1.51	1.33	1.24	1.15
**All ages	103	7.33	6.52	5.85	5.21	4.72	4.27	3.91	3.63	3.42	3.29	3.17
*3. Wood or concrete floors:												
Age Group: Pre-1940	144	26.10	25.21	24.42	23.69	23.01	22.33	21.69	21.08	20.52	20.03	19.55
1940-49	87	10.69	9.92	9.33	8.76	8.22	7.72	7.30	6.91	6.54	6.24	6.01
Post-49	148	5.15	4.32	3.57	2.90	2.35	1.91	1.57	1.30	1.11	1.01	0.92
**All ages	394	15.70	14.86	14.14	13.46	12.86	12.31	11.84	11.40	11.02	10.71	10.42

	No. of Dwell.	Percent Loss Over Deductible 10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	138	19.75	19.29	18.86	18.42	17.99	17.57	17.16	16.75	16.36	15.98	15.59
1940-49	72	3.75	3.58	3.44	3.32	3.21	3.11	3.03	2.94	2.86	2.81	2.75
Post-49	63	0.62	0.54	0.46	0.40	0.35	0.30	0.25	0.22	0.21	0.19	0.17
**All ages	279	10.93	10.63	10.36	10.10	9.84	9.59	9.35	9.12	8.90	8.69	8.48
2. Concrete floors:												
Age Group: Pre-1940	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940-49	14	11.57	11.29	11.00	10.71	10.43	10.14	9.86	9.57	9.29	9.00	8.71
Post-49	84	1.15	1.07	1.00	0.93	0.86	0.81	0.77	0.74	0.70	0.68	0.65
**All ages	103	3.17	3.06	2.95	2.84	2.74	2.65	2.57	2.50	2.42	2.35	2.28
*3. Wood or concrete floors:												
Age Group: Pre-1940	144	19.55	19.10	18.67	18.25	17.83	17.42	17.02	16.63	16.24	15.87	15.49
1940-49	87	6.01	5.82	5.64	5.48	5.33	5.20	5.07	4.94	4.82	4.71	4.61
Post-49	148	0.92	0.84	0.76	0.70	0.64	0.59	0.55	0.51	0.49	0.47	0.45
**All ages	394	10.42	10.16	9.92	9.68	9.45	9.23	9.01	8.80	8.60	8.41	8.22

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

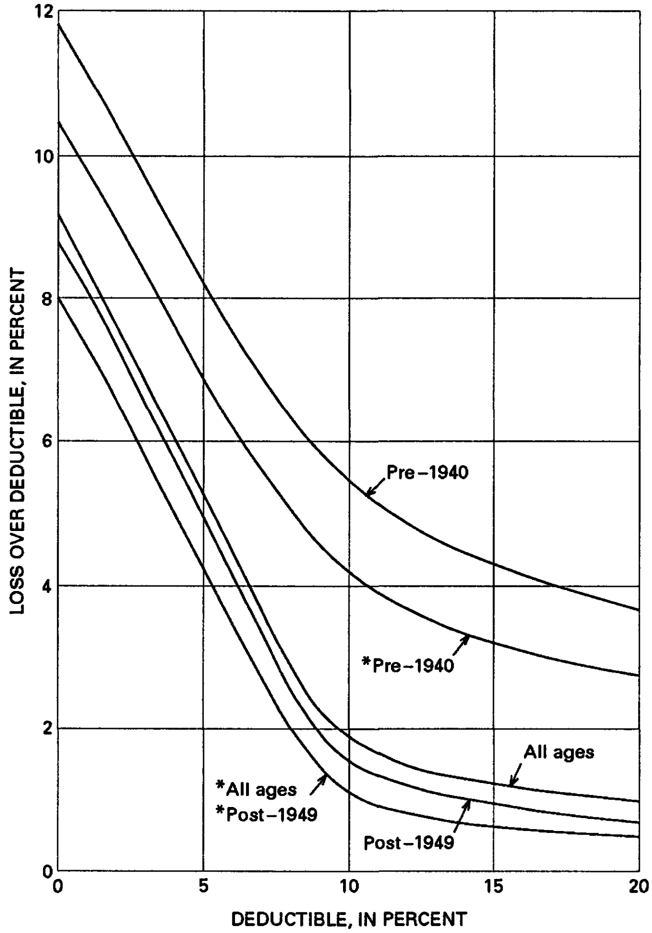

Figure 1. Graph showing loss over deductible versus deductible for 1971 San Fernando earthquake. Computations are based on 1971 market values, less land values. Asterisk (*) indicates that dwellings at sites with faulting, liquefaction, and other geologic effects are excluded.

reservoir containing No. 10 oil (very heavy), the oil was thrown up 10 inches on the northeast and southwest sides. In a pump having No. 16 grade, the oil was splashed 3 feet up the sides.

Although some people may question the accuracy of the reported 1906 intensity at Coalinga, it can not be doubted that the intensities along the western edge of the San Joaquin Valley were unexpectedly high. It is reasonable to believe that 1906 ground motions at Coalinga were amplified due to local geology and that the 1983 ground motions at Coalinga were also amplified, for the same reason.

Figure 3 is a graphic representation of most of the information in tables 9 and 12. The curves can be reasonably approximated by straight lines from 0 to 10 percent deductible, but not from 0 to 20 percent deductible. This family of curves is similar in form to that shown in figure 1 because the computational methodologies are similar.

Table 15. Overview of dwelling loss experience for the 1971 San Fernando earthquake: Loss over deductible

[One-story wood-frame dwellings. Values are market values, less land values. PRE40 (pre-1940), 4049 (1940–1949), POST49 (post-1949), excluding dwellings where the field inspector noted ground disturbance, such as faulting or ground movement (for example, sidewalk movement with respect to adjoining soil), and also excluding dwellings with apparent soil-amplification damage where San Fernando Valley alluvial deposits meet the San Gabriel Mountains to the north of the valley. Also excluding one-and-two-story, split-level, and two-story dwellings]

	% Loss Over Deductible					
				Excluding Special Cases*		
% Deduct.	All ages	Post-49	Pre-40	All ages	Post-49	Pre-40
0	9.0	8.9	11.8	8.0	7.8	10.4
5	5.0	4.8	8.1	4.1	3.9	6.8
10	1.9	1.5	5.4	1.1	0.7	4.3
15	1.2	0.9	4.3	0.6	0.3	3.3
Number of dwell.-->	12,075	6,652	634	10,237	5,353	586
Table--->	2	2	2	7	7	7

Table 16 is an overview comparison among losses over deductible without regard to the type of first-floor construction. This table uses the same data as figure 3.

Insurance Claim Data

Data (from Insurance Source A) in table 14 have no exclusions, whereas data in table 17 exclude dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before the time of inspection, or had more than one story. Tables 17 and 18 contain this insurance company loss experience on two different value bases: insured value and market value from 0 to 20 percent deductible.

Curves 3 and 4 in figure 4 are the Insurance Source A losses over deductible for dwellings of all ages, with exclusions as noted on the figure. Curves 1 and 2 are from our data, also with exclusions as noted on the figure. The two insurance curves (#3, #4) have similar shapes as do our two curves (#1, #2). There is a noticeable difference between the shapes of the insurance curves (#3, #4) and our curves (#1, #2). Improvements in our loss-estimation methodology should reduce the differences in the shapes of the curves. These four curves are based on tables 6, 12, 17, and 18.

Figure 5, similar to figure 4, is additionally limited to post-1949 construction. Previous comment pertaining to figure 4 also applies to figure 5. Figures 4 and 5 are representative of dwelling losses near the earthquake's energy release for magnitudes around 6.5.

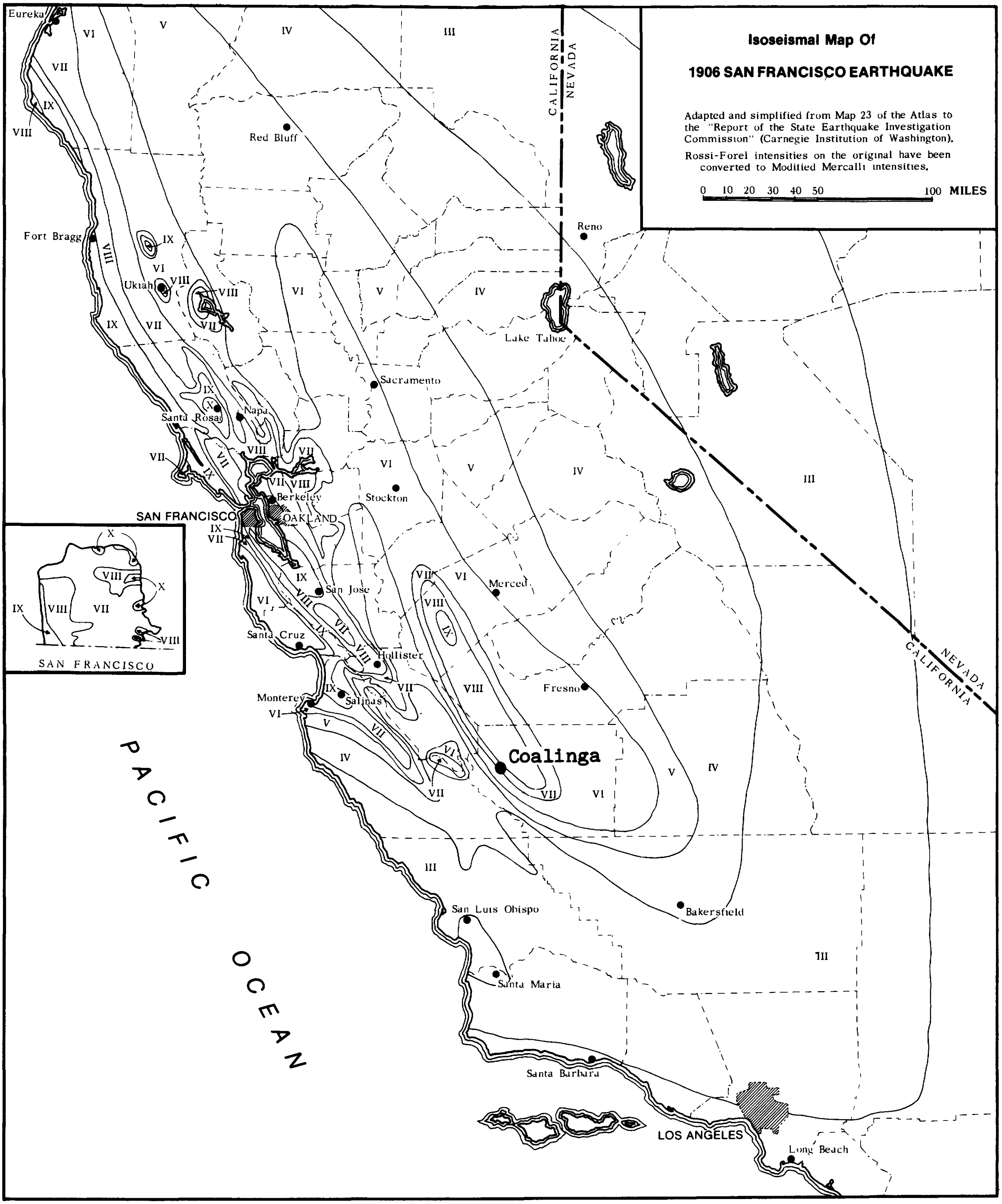

Figure 2. Isoseismal map of the 1906 San Francisco earthquake showing the location of Coalinga.

Table 16. Overview of dwelling loss experience for the 1971 San Fernando earthquake: Loss over deductible

[One-story wood-frame dwellings. Values are market values, less land values. PRE40 (pre-1940), 4049 (1940–1949), POST49 (post-1949), excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection]

	% Loss Over Deductible					
				Excluding Special Cases*		
% Deduct.	All ages	Post-49	Pre-40	All ages	Post-49	Pre-40
0	20.2	11.9	28.2	8.6	8.8	8.2
5	15.7	7.5	23.6	4.6	4.6	4.6
10	11.9	4.0	19.5	1.6	1.4	2.2
15	9.3	2.2	16.2	0.6	0.4	1.1
Number dwellings	1,982	763	845	873	530	177

Table 19 is of special interest. Our data for the 1971 San Fernando and 1983 Coalinga earthquakes are usually similar. Coalinga insured losses using insured values are low if compared to our market values for both Coalinga and San Fernando; a partial exception is the pre-1940-dwelling category. These differences can be examined two ways.

The first approach compares the aggregate losses from all paid claims with the aggregate losses for the same dwellings computed by our independent methods. A total of 331 dwellings were matched in the two dwelling inventories. Our methods produced an estimated $2,559,000 aggregate loss, whereas the aggregate paid claims was $2,375,000 (both in 1983 dollars) (Steinbrugge and others, 1990, table 20.15). This similarity indicates that our loss-estimation methods are adequate if dwelling values (market versus insured) are not involved.

The second approach involves an examination of the impacts of insured values versus market values on loss over deductible. Insured value is the face value of the policy. Except for new dwellings, market values are commonly less than replacement values. Visual observations confirmed this for older dwellings in Coalinga. An insured partial dwelling loss is paid in full until the stated value in the policy is reached. For example, a damaged older Coalinga dwelling would receive new or equivalent repair up to the face value of the policy. One exception is a new type of policy that replaces total losses regardless of policy amount. Even if not insured to full replacement value and for losses less than the policy face value, losses would be paid in full without respect to depreciation of finishes and other items, such as paint and plaster. As expected, losses over deductible for insured values in table 19 are less than those for market values.

Market values are constantly varying by location and over time. Dwelling market values, including land and without regard to age, averaged $192,600 in southern

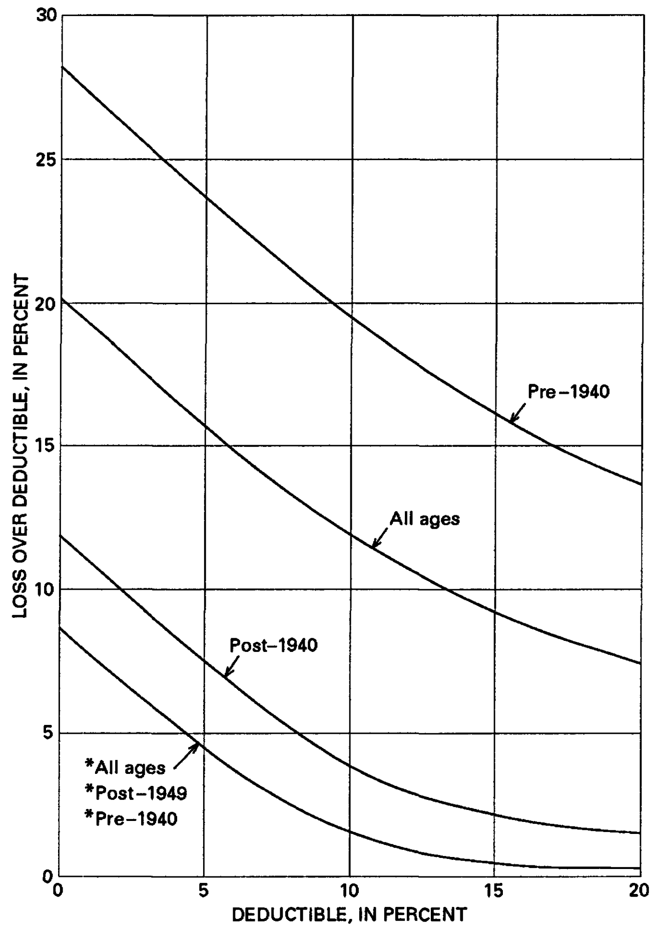

Figure 3. Graph showing loss over deductible versus deductible for 1983 Coalinga earthquake. Computations are based on 1983 market values, less land values. Asterisk (*) indicates that dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection are excluded.

California as of April, 1988 (Real Estate Research Council of Southern California, 1988). From the same source, in April of 1981 it was far less at $129,900. The average market value, including land, for the San Francisco Bay Area was $213,800 as of April, 1988 (Real Estate Research Council of Northern California, 1988), and is also changing rapidly. Insured values may lag in relationships to market value.

As a numerical example of the impacts of different kinds of values, consider an older house that has a replacement value of $200,000, a market value (less land value) of $150,000, a cost to repair earthquake damage of $25,000, and a 10 percent deductible of "value." Losses over deductible would be:

Market value basis ($25,000-$15,000)/$150,000, or 6.7 percent.

Insured value basis ($25,000-$20,000)/$200,000, or 2.5 percent.

Table 17. Dwelling loss experience for the 1983 Coalinga earthquake: Loss over deductible, Insurance Source A, insured values and paid claims; excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection or were higher than one story

	No. of Dwell.	Percent Loss Over Deductible										
		0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	31	9.35	8.58	7.97	7.42	6.87	6.39	5.97	5.61	5.29	5.06	4.87
1940-49	33	5.27	4.45	3.88	3.33	2.79	2.27	1.88	1.52	1.15	0.91	0.73
Post-49	42	5.31	4.38	3.50	2.76	2.17	1.76	1.48	1.21	1.02	0.90	0.79
**All ages	109	6.30	5.48	4.79	4.18	3.63	3.18	2.83	2.52	2.25	2.06	1.91
2. Concrete floors:												
Age Group: Pre-1940	1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940-49	8	5.88	5.00	4.25	3.50	3.00	2.50	2.13	1.88	1.63	1.50	1.38
Post-49	60	3.58	2.83	2.23	1.65	1.22	0.85	0.60	0.42	0.28	0.23	0.20
**All ages	69	3.81	3.04	2.43	1.84	1.41	1.03	0.77	0.58	0.43	0.38	0.33
*3. Wood or concrete floors:												
Age Group: Pre-1940	32	9.09	8.31	7.72	7.19	6.66	6.19	5.78	5.44	5.13	4.91	4.72
1940-49	41	5.39	4.56	3.95	3.37	2.83	2.32	1.93	1.59	1.24	1.02	0.85
Post-49	102	4.29	3.47	2.75	2.11	1.61	1.23	0.96	0.75	0.59	0.51	0.44
**All ages	178	5.34	4.53	3.88	3.28	2.77	2.35	2.03	1.77	1.54	1.41	1.30

	No. of Dwell.	Percent Loss Over Deductible										
		10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	31	4.87	4.68	4.48	4.29	4.10	3.90	3.71	3.52	3.32	3.16	3.00
1940-49	33	0.73	0.61	0.52	0.42	0.36	0.30	0.24	0.18	0.12	0.09	0.06
Post-49	42	0.79	0.69	0.60	0.52	0.48	0.43	0.38	0.33	0.31	0.29	0.26
**All ages	109	1.91	1.78	1.66	1.55	1.46	1.37	1.28	1.18	1.10	1.04	0.97
2. Concrete floors:												
Age Group: Pre-1940	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940-49	8	1.38	1.25	1.13	1.00	0.88	0.75	0.63	0.50	0.38	0.25	0.13
Post-49	60	0.20	0.17	0.13	0.10	0.07	0.05	0.03	0.02	0.00	0.00	0.00
**All ages	69	0.33	0.29	0.25	0.20	0.16	0.13	0.10	0.07	0.04	0.03	0.01
*3. Wood or concrete floors:												
Age Group: Pre-1940	32	4.72	4.53	4.34	4.16	3.97	3.78	3.59	3.41	3.22	3.06	2.91
1940-49	41	0.85	0.73	0.63	0.54	0.46	0.39	0.32	0.24	0.17	0.12	0.07
Post-49	102	0.44	0.38	0.32	0.27	0.24	0.21	0.18	0.15	0.13	0.12	0.11
**All ages	178	1.30	1.20	1.11	1.03	0.96	0.89	0.82	0.75	0.69	0.65	0.60

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

Table 18. Dwelling loss experience for the 1983 Coalinga earthquake: Loss over deductible, Insurance Source A, realtor market values, less land values; excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection or were higher than one story

		Percent Loss Over Deductible										
	No. of Dwell.	0% ded.	1% ded.	2% ded.	3% ded.	4% ded.	5% ded.	6% ded.	7% ded.	8% ded.	9% ded.	10% ded.
1. Wood floors:												
Age Group: Pre-1940	31	15.42	14.68	14.06	13.45	12.84	12.23	11.65	11.23	10.87	10.52	10.19
1940-49	33	8.55	7.70	6.97	6.33	5.76	5.18	4.61	4.09	3.58	3.06	2.58
Post-49	42	8.00	7.05	6.14	5.29	4.48	3.81	3.21	2.79	2.40	2.07	1.76
**All ages	109	10.06	9.22	8.48	7.78	7.12	6.51	5.94	5.50	5.10	4.72	4.36
2. Concrete floors:												
Age Group: Pre-1940	1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940-49	8	8.13	7.13	6.25	5.63	5.00	4.38	3.88	3.38	2.88	2.50	2.25
Post-49	60	5.62	4.85	4.17	3.55	2.95	2.45	2.02	1.65	1.43	1.23	1.07
**All ages	69	5.84	5.04	4.35	3.74	3.14	2.64	2.20	1.83	1.58	1.36	1.19
*3. Wood or concrete floors:												
Age Group: Pre-1940	32	14.97	14.22	13.63	13.03	12.44	11.84	11.28	10.88	10.53	10.19	9.88
1940-49	41	8.46	7.59	6.83	6.20	5.61	5.02	4.46	3.95	3.44	2.95	2.51
Post-49	102	6.60	5.75	4.98	4.26	3.58	3.01	2.51	2.12	1.83	1.58	1.35
**All ages	178	8.43	7.60	6.88	6.21	5.58	5.01	4.49	4.08	3.74	3.42	3.13

		Percent Loss Over Deductible										
	No. of Dwell.	10% ded.	11% ded.	12% ded.	13% ded.	14% ded.	15% ded.	16% ded.	17% ded.	18% ded.	19% ded.	20% ded.
1. Wood floors:												
Age Group: Pre-1940	31	10.19	9.87	9.58	9.35	9.16	8.97	8.77	8.58	8.39	8.19	8.00
1940-49	33	2.58	2.18	1.82	1.52	1.24	1.03	0.85	0.70	0.55	0.42	0.33
Post-49	42	1.76	1.52	1.36	1.21	1.10	1.00	0.93	0.86	0.79	0.74	0.69
**All ages	109	4.36	4.06	3.80	3.59	3.40	3.25	3.11	2.98	2.85	2.74	2.64
2. Concrete floors:												
Age Group: Pre-1940	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1940-49	8	2.25	2.13	2.00	1.88	1.75	1.63	1.50	1.38	1.25	1.13	1.00
Post-49	60	1.07	0.93	0.83	0.75	0.68	0.62	0.57	0.52	0.47	0.42	0.38
**All ages	69	1.19	1.06	0.96	0.87	0.80	0.72	0.67	0.61	0.55	0.49	0.45
*3. Wood or concrete floors:												
Age Group: Pre-1940	32	9.88	9.56	9.28	9.06	8.88	8.69	8.50	8.31	8.13	7.94	7.75
1940-49	41	2.51	2.17	1.85	1.59	1.34	1.15	0.98	0.83	0.68	0.56	0.46
Post-49	102	1.35	1.18	1.05	0.94	0.85	0.77	0.72	0.66	0.60	0.55	0.51
**All ages	178	3.13	2.89	2.70	2.53	2.39	2.27	2.16	2.06	1.96	1.87	1.79

*Includes unknown floor types not included above.
**Includes unknown dwelling ages not included above.

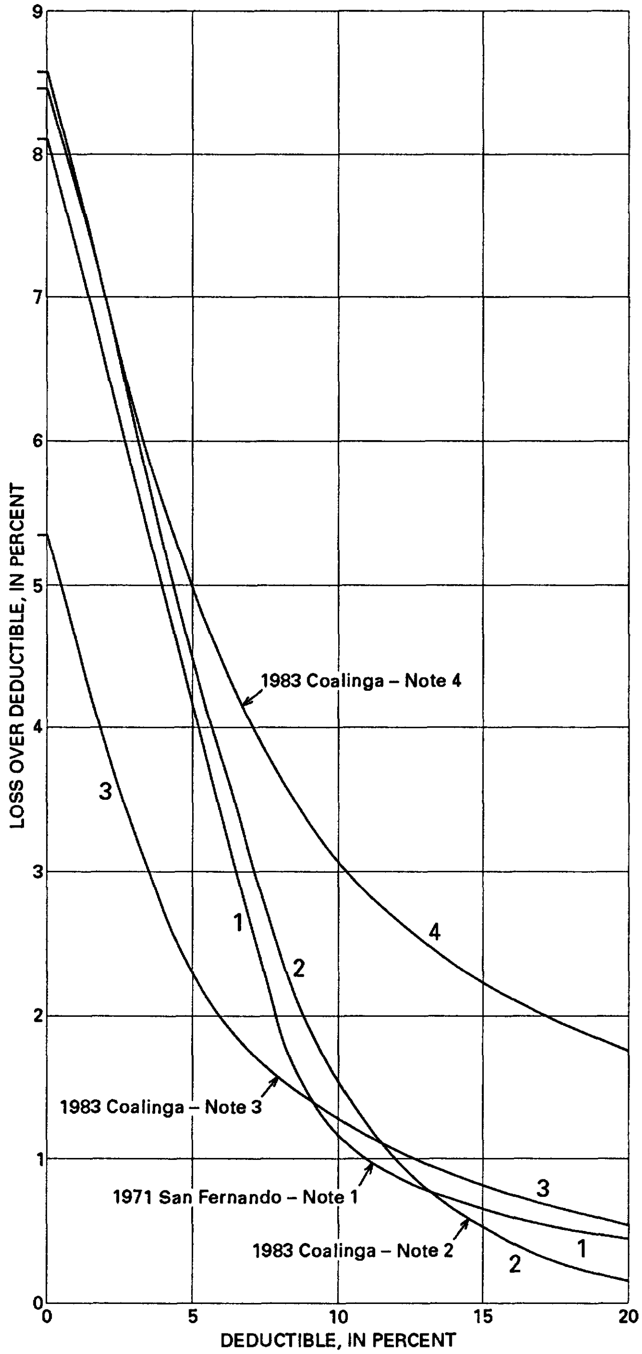

Figure 4. Graph showing loss over deductible versus deductible for 1971 San Fernando and 1983 Coalinga earthquakes and comparing our data and Insurance Source A data (applicable to dwellings of all ages).

Note 1: Our data, excluding dwellings at sites with faulting, liquefaction, and other geologic effects. Data from table 6.

Note 2: Our data, excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Data from table 12.

Note 3: Insurance Source A data, using insured values and paid claims and excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Data from table 17.

Note 4: Insurance Source A data, using realtor pre-earthquake market values, less land values, and excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Data from table 18.

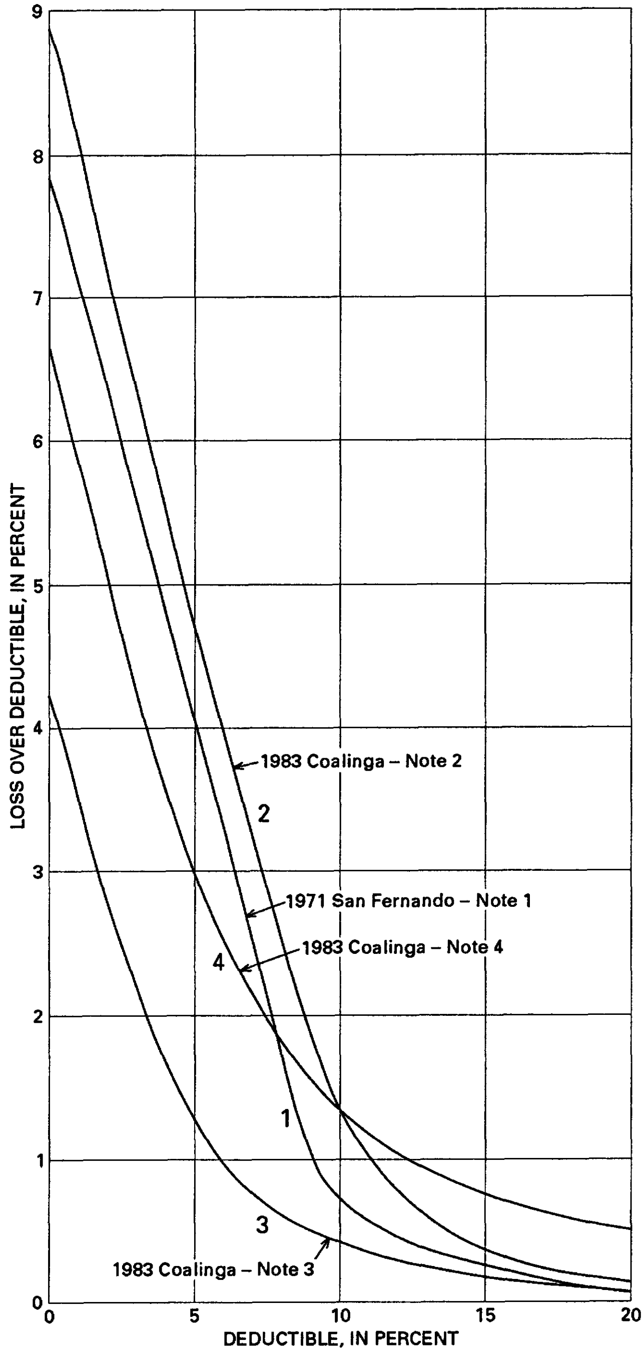

Figure 5. Graph showing loss over deductible versus deductible for 1971 San Fernando and 1983 Coalinga earthquakes and comparing our data and Insurance Source A data (applicable to post-1949 dwellings).

Note 1: Our data, excluding dwellings at sites with faulting, liquefaction, and other geologic effects. Also excluding one-and-two-story and two-story dwellings. Data from table 7.

Note 2: Our data, excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Data from table 12.

Note 3: Insurance Source A data, using insured values and paid claims and excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Data from table 17.

Note 4: Insurance Source A data, using realtor pre-earthquake market values, less land values, and excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection. Data from table 18.

Table 19. Comparison of loss over deductible between our data and Insurance Source A data for the 1971 San Fernando and 1983 Coalinga earthquakes

[1971 San Fernando data: excluding dwellings at or adjacent to sites with observed ground disturbance or other geologic effects and excluding one-and-two-story, split-level, and two-story dwellings. 1983 Coalinga data: excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection]

[Insurance Source A data: insured values are from their records, losses are from their paid claims. Market values are pre-earthquake values, less land values, from realtors]

	No Age Restrictions				Post-1949 Dwellings				1940-49 Dwellings				Pre-1940 Dwellings			
	Authors' Data		Insurance Co. A		Authors' Data		Insurance Co. A		Authors' Data		Insurance Co. A		Authors' Data		Insurance Co. A	
	1971 San Fernando	1983 Coalinga	1983 Coalinga		1971 San Fernando	1983 Coalinga	1983 Coalinga		1971 San Fernando	1983 Coalinga	1983 Coalinga		1971 San Fernando	1983 Coalinga	1983 Coalinga	
% Ded.	Market Value	Market Value	Insured Value	Market Value	Market Value	Market Value	Insured Value	Market Value	Market Value	Market Value	Insured Value	Market Value	Market Value	Market Value	Insured Value	Market Value
0	8.0	8.6	5.3	8.4	7.8	8.8	4.3	6.6	8.0	8.4	5.4	8.5	10.4	8.2	9.1	15.0
1	7.2	7.7	4.5	7.6	7.0	7.9	3.5	5.8	7.2	7.6	4.6	7.6	9.7	7.5	8.3	14.2
2	6.4	6.9	3.9	6.9	6.2	7.0	2.8	5.0	6.4	6.8	4.0	6.8	8.9	6.7	7.7	13.6
3	5.7	6.1	3.3	6.2	5.4	6.1	2.1	4.3	5.6	6.1	3.4	6.2	8.2	6.0	7.2	13.0
4	4.9	5.3	2.8	5.6	4.7	5.4	1.6	3.6	4.9	5.3	2.8	5.6	7.5	5.3	6.7	12.4
5	4.1	4.6	2.4	5.0	3.9	4.6	1.2	3.0	4.1	4.6	2.3	5.0	6.8	4.6	6.2	11.8
6	3.4	3.9	2.0	4.5	3.1	3.9	1.0	2.5	3.3	3.9	1.9	4.5	6.1	3.9	5.8	11.3
7	2.7	3.2	1.8	4.1	2.4	3.2	0.8	2.1	2.7	3.3	1.6	4.0	5.5	3.4	5.4	10.9
8	2.0	2.6	1.5	3.7	1.7	2.5	0.6	1.8	2.0	2.7	1.2	3.4	5.0	2.9	5.1	10.5
9	1.3	2.0	1.4	3.4	0.9	1.8	0.5	1.6	1.4	2.1	1.0	3.0	4.5	2.4	4.9	10.2
10	1.1	1.6	1.3	3.1	0.7	1.4	0.4	1.4	1.2	1.8	0.9	2.5	4.2	2.2	4.7	9.9
Number of dwellings:	10,237	873	178	178	5,353	530	102	102	4,097	154	41	41	586	177	32	32
Reference tables:	7	12	17	18	7	12	17	18	7	12	17	18	7	12	17	18

Quite evidently, computation on an insured-value basis will generally produce losses over deductible that are less than those produced by computation on a market-value basis.

Turning next to San Fernando, 94 percent of the data in table 19 were for the post-1949 and 1940–49 age groups. From our experience in 1971, market values and insured values were close to being the same because, in part, most of the 1940–49 houses appeared to be of late 1940's construction.

The amount of insurance to replacement value was known for each Insurance Source A dwelling, and replacement values were used in the calculations. Some dwellings had no damage, and consequently the owners did not submit claims. These structures were included in the dwelling inventory along with those having claims.

It must be remembered from the "Data sources and loss-over-deductible compilation" section that the insurance company losses discussed here were at essentially zero earthquake deductible for legal reasons. Their losses-over-deductible percentages were based upon the application of the deductible percentage against the amount of insurance that was determined to be replacement cost. Losses over deductible for insured value can vary depending upon whether the amount of dwelling insurance equals replacement cost, actual cash value, or some other value, and to what value the percent deductible applies.

In summary, data in the columns of table 19 that are headed "market value" are consistent for each age group, except for "pre-1940 dwellings," which show slightly less consistency. The values in the "insured value" column are less than those in the "market value" column for all categories, except for our "market value" column under "pre-1940 dwellings."

Lastly, insurance company data are considered to be more reliable than our data in the range of 0–20 percent deductible. However, our methods are satisfactory for approximate aggregate loss estimation immediately after the earthquake and in regions where no earthquake-loss experience exists.

LOSS DISTRIBUTION AND PROBABLE MAXIMUM LOSS (PML)

Our data and the insurance companies' data were examined for loss distribution and PML's. A discussion of the full definition of PML and its origins is included in the appendix.

Table 8 shows our loss distribution of the 1971 San Fernando earthquake for the same data as in table 7. Table 13 is our loss distribution of the 1983 Coalinga earthquake for the same data as in table 12. Table 20 shows Insurance Source A loss distributions for the 1983 Coalinga earthquake. The number of dwellings for each "percent loss" is shown to indicate data quality.

Headings on tables 3, 4, 8, 10, 11, 13, and 20 have these meanings:

WOOD–PRE40 refers to dwellings having a wood first story floor and constructed prior to 1940. WOOD–4049 also is for wood floors, but for construction between 1940 and 1949. WOOD–POST49 is for subsequent construction. WOOD–ALL groups together all wood floors, regardless of date of construction.

CONC refers to concrete first floor laid directly on soil. (By and large there are no basements in California.) The CONC variants are the same as those for wood.

BOTH includes both wood and concrete floors. The variants are the same as those for wood. For one instance, BOTH–ALL refers to both wood and concrete floors regardless of age group.

% LOSS is the percent total loss per dwelling. For our data, it was determined on a market value basis using the information from the forms submitted by the field inspectors. For insurance source data, it was determined on a replacement cost basis using paid claim information.

NO. DWELL. is the number of dwellings having the indicated % LOSS. For our data, dwellings having 2/3 or greater loss were considered to be constructive total losses, and therefore the tabulations lump together all losses over 65 percent.

% DWELL. has the same meaning as NO. DWELL., except that the number of dwellings is expressed in percentage of the total number of dwellings.

SUM PCT is the equivalent of the area under a distribution curve from 0 percent to the % LOSS. For example, in table 3 under BOTH–ALL (last column) at 12 % LOSS is found 88.8 percent. This means that 88.8 percent of all wood-frame dwellings had 12 percent loss or less.

Applying the PML definition of "9 out of 10" (see appendix) to tables 8 and 13 develops the PML values for the 1971 San Fernando and 1983 Coalinga earthquakes in table 21. For example, using BOTH–ALL from the last column of table 8, the PML is 11 percent at 90 percent cumulative loss (SUM PCT). It is to be recalled that this information is on a market-value basis.

Tables 8 and 13, and all similar tables, are based on a 0 percent deductible. See the appendix under "Sensitivity: Loss over deductible versus dwelling PML changes" for changes in PML that result from non-zero deductibles.

Distribution Curve

Consider a distribution curve drawn from table 8 or from any of the other tables using our data. The curve would be skewed toward the low end of the percent loss, with the peak at about 9 percent loss. The curve rapidly flattens to the right of this peak. There is another peak at losses equal to or exceeding 65 percent because general practice often finds a structure to be a constructive total loss at or exceeding two-thirds of its value. Changes in damage patterns to a few houses can result in significant changes to some PML's. For one such example in table 8 applied to WOOD-PRE40, the PML is 26 percent at 90 percent cumulative loss; slight changes in damage estimates to a very few houses can radically change the PML's. Most other dwelling categories in table 8 are less sensitive.

The loss distribution data in tables 8 and 13 do not provide for a smooth curve. There are a number of peaks and valleys, with a particularly large peak at 9 percent loss. This unevenness is inherent in the loss-estimation model. The field inspector was required to make a choice among degrees of damage to an interior finish: none, slight, moderate, or severe. There were similar choices for other construction components. Loss to each construction component was determined from the contractor repair data to the nearest percent of the dwelling's pre-earthquake market value, less land value. For example, damage to interior gypsumboard finishes, cabinets, plumbing, and other interior components, was determined on the average to be as follows:

Degree of damage	Percent loss
None	0
Slight	6
Moderate	14
Severe	26

Degrees of damage and percentages often exist in the context of other damage. Severe interior finish damage normally did not occur unless the dwelling also fell from its cripple studs or slid off its foundation. Severe damage to the interior finish might be accompanied by more damage if the exterior finish was plaster rather than wood siding. However, the partial failure of an exterior, unreinforced brick chimney might not be accompanied by other damage if it fell away from the dwelling. Jumps in percent loss to interior finish from 0 percent (none) to 6 percent (slight) to 14 percent (moderate) to 26 percent (severe), as well as other increments for other construction components, lead to the peaks and valleys in the loss distribution.

Uncertainties Concerning Degrees of Damage

Certain degrees of damage are dominant in the computational process. Possibly the most important is the distribution of the degrees of damage to gypsumboard interior finishes:

Degree of Damage	Percent loss	
	San Fernando[1]	Coalinga[2]
None	4.2	19.8
Slight	78.4	69.3
Moderate	11.1	9.7
Severe	6.3	1.2
	100.0	100.0

[1]Steinbrugge and others (1971), table 8.
[2]Steinbrugge and others (1990), tables 20.6, 20.7, and 20.8.

In this table "Slight" is predominant and, from the previous table, represents 6 percent of the total loss to the dwelling. It is not unreasonable that this might become an 8 percent loss using different contractors, different loss-estimation criteria, or different acceptable repair practices. Our calculations using other than 6 percent total loss for "slight" show that the 9 percent peak changes about 1 percent for each 1 percent change in the percent loss assigned to "slight."

Changing the percent loss from 6 to 8 percent for "slight" also impacts on the loss over deductible. For wood or concrete floors of all ages, the losses over deductible are:

Interior finish damage	Deductible, in percent							
	0	2	4	5	6	8	10	Source
"Slight" at 6 percent	20.2	18.3	16.5	15.7	14.8	13.3	11.9	Table 9.
"Slight" at 8 percent	21.2	19.4	17.6	16.7	15.9	14.2	12.7	Unpublished table.

At a 10 percent deductible, the 2 percent difference between 6 and 8 percent for "slight" amounts to a 7 percent increase in the loss over deductible. Reasonable combinations of other damage gradings can show larger increases or decreases.

Other Uncertainties

Field data were acquired under strong time constraints, and recording errors no doubt occurred. Repairs in progress during the inspections made damage observations suspect in some cases.

Field inspectors undoubtedly were not always accurate in their estimates of dwelling age. Age determined from insurance files did not agree with the inspector's determination in some cases.

It is likely that the field inspectors did not find all the San Fernando sites with or adjacent to observable ground disturbances.

Contractor records on repair costs and adjustor claim information were not distorted by labor and material scarcities which would probably develop after a great earthquake.

Despite these uncertainties, the fact that aggregate losses computed from insurance claims reasonably agreed with those computed by our methods provides a certain amount of confidence.

Insurance Company Data on Probable Maximum Loss (PML) and Loss Distribution

Applying the PML definition of "9 out of 10" to table 20 does not result in meaningful answers in most cases, and the remaining answers are not of the desired quality. Table 21 under the subheading Insurance Company A lists the PML percentages from table 20 for categories that contain 50 or more dwellings. Note that WOOD-ALL has a range of 13–16 percent in tables 20 and 21.

Figure 6 shows the loss distribution from 0 percent loss to 15 percent loss, at 0 percent deductible, as a function of the percent of dwellings. The reasons for the 9 percent peak in our data have been discussed in the "Distribution curve" section. The Insurance Source A data in figure 6 is more orderly than our data and shows no large peak at 9 percent.

Figure 7 is another viewpoint on the data shown in figure 6. As in figure 6, there are fewer irregularities in the Insurance Source A data than in our data. The Insurance Source A data are the more realistic of the two data bases.

JUDGMENTAL CONSIDERATIONS

Probable Maximum Loss (PML) For Magnitude 6.5 Earthquakes

A percent PML that is applicable to all California dwellings requires judgmental decisions founded on all the foregoing diverse data. "Judgment PML" in column 5 of table 21 is based on the following considerations.

Construction anomalies are excluded in order to have better commonality of data. San Fernando geologic anomalies are also excluded. Increased damage in Coalinga due to apparent soil amplification, however, is considered in the "Judgment PML." All these factors are consistent with the definition of the PML.

Many San Fernando dwellings in the post-1949 age group were newly built at the time of the 1971 San Fernando earthquake and should have had better than average building code supervision; the reverse was partially true for Coalinga dwellings at the time of the 1983 Coalinga earthquake. Therefore, for average post-1949 housing, PML's are probably slightly understated for San Fernando and probably overstated for Coalinga. Judgment PML is 12 percent for the post-1949 age group for floors of all types.

Dwellings in the 1940–49 age group were somewhat difficult to date in the field, and consequently the quality of the data probably suffered. This time period includes the World War II years with the restrictions on construction and the transitions in architectural styles. An increase in the PML for the 1940–49 group is more likely than a decrease when compared with the post-1949 group; therefore, the PML for San Fernando wood-floor 1940–49 age group appears to be anomalously low. Judgment PML is 14 percent for the 1940–49 age group for all types of floors.

San Fernando PML values for the pre-1940 age group are substantially higher than those for other San Fernando age groups. PML's are also markedly different between San Fernando and Coalinga for wood floors within this age group. The PML for the pre-1940 Coalinga dwellings is substantially too low due to the number of excluded houses being off on their foundations. If these had not been excluded, then the PML's would have exceeded 65 percent (table 10, BOTH–PRE40), which would have been excessive. A wide divergence between San Fernando and Coalinga PML's can be partially attributed to difficulties in consistently dating construction to a single decade. Judgment PML's for the pre-1940 age group differed by floor type and are of poorer quality than those for other age groups.

As the inventory of older dwellings decreases due to demolition and as the post-1949 inventory increases due to new construction, the post-1949 and "all ages" groups are becoming increasingly important. We may use changes in California census population (data from California Department of Finance) as an index to changes in the dwelling inventory:

1940 population	6,907.387
1940–1950 population growth	3,678,836
1950–1988 population growth	18,075,777
January 1, 1989 population	28,662,000

Assuming a direct relationship between the number of dwellings and population, more than two-thirds of the present dwellings probably are post-1949, whereas less than probably one-fifth of the present dwellings are pre-1940. The PML for the "all ages"

ages" group must be slightly higher than that for the post-1949 group because the "all ages" group includes older, deficient structures; therefore the judgment PML for the "all ages" group is 13 percent.

In regard to the 1933 Long Beach earthquake, Martel (1936, p. 161) stated, "The extent of damage for wood frame residences *** is very low; in fact in 95 percent of these buildings the damage was less than 5 percent ***." The Long Beach analysis relied heavily on information from the assessor's office and on information for values and losses from the building department. Assessors' valuations in California have not always represented market values, but have been closer to market than insured values. In consideration of this uncertainty, we have given preference to the San Fernando and Coalinga PML's for calculation of the Judgment PML's in table 21. The validity of commingling insured values with market values in table 21 to obtain Judgment PML values is somewhat questionable.

Judgment PML values in table 21 indicate that no distinctions should be made between floor types for practical applications and that age groups should be limited to pre-1940 and post-1939.

Loss Over Deductible For Magnitude 6.5 Earthquakes

The Coalinga and San Fernando loss-over-deductible experiences differ from each other. There is a judgmental basis for using these for general California application. We assume that the curves in figures 1, 3, 4, and 5 can be shifted up or down as a direct function of a "state factor" from table 21:

State factor = (Judgment PML)/(1971 San Fernando PML)

Multiplication of loss-over-deductible values from tables such as table 2 by the state factor from table 21 results in approximate generalized loss-over-deductible values for all California wood-frame dwellings near the fault in a magnitude 6.5 earthquake if no geologic anomalies are present.

TRANSFERABILITY TO OTHER EARTHQUAKES

Different earthquakes at different locations will show different damage patterns as a result of variations in:

(1) Wood-frame dwelling construction,
(2) Geologic environment (faulting, landslide, "poor ground"),
(3) Distances to faulting (energy release), and
(4) Earthquake magnitude.

Transferability of the results of this analysis to other earthquakes requires commonality of data for each category of construction characteristics, geologic conditions, and earthquake magnitude. With commonality, a transfer function can be used to apply these parameters to other conditions and locations. Variants in wood-frame dwelling construction have been identified and quantified so that reasonable commonality exists.

Dwellings with damage caused by unusual geologic conditions have been identified and removed from the data bases. Unusual geologic conditions must be reentered in the loss algorithm on a site- or area-specific basis.

In our model, the area within 10 kilometers (6 miles) on either side of the faulting is presumed to be within a zone of equal shaking damage for dwellings on consolidated alluvium; this area is defined as the PML zone. This generalization does not include site displacement due to faulting. As an example of displacement, strike-slip faulting moves structures horizontally near the faulting by about half of the amount of the fault offset. The 10-kilometer (6 mile) distance approximates the usual focal depth of many California earthquakes. This PML zone criterion is met by the 1933 Long Beach, 1971 San Fernando, 1983 Coalinga, and most likely the 1906 San Francisco earthquakes. The 1987 Whittier Narrows earthquake was deeper than normal [focal depth of 14 kilometers (9 miles)], and no surface faulting is known. The 1989 Loma Prieta earthquake also was abnormally deep [focal depth of 18 kilometers (11 miles)], and no surface faulting is known. Damage attenuation for distances greater than 10 kilometers (6 miles) from the fault rupture is not part of this study.

Earthquakes of Magnitudes Other Than 6.5

The magnitude of the 1971 San Fernando earthquake was 6.4, that of the 1983 Coalinga earthquake was 6.7, and that of the 1933 Long Beach earthquake was 6.3. These magnitudes are sufficiently similar to be considered the same for loss-over-deductible purposes. A 6.5 magnitude has been considered representative for all three events. The magnitude of the 1987 Whitter Narrows earthquake was 5.9, which is less than that of the other three events.

Only the 1906 San Francisco earthquake has useable loss experience for wood-frame dwellings on firm soil in the near vicinity of a great earthquake. More than 1,000 dwellings were examined immediately after that

Table 20. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by number of dwellings, Insurance Source A; excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection or were higher than one story

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
0	7	22.6	6	18.2	3	7.1	19	17.4	0	0.0	1	12.5	15	25.0	16	23.2	7	21.9	7	17.1	18	17.6	35	19.7
1	5	38.7	8	42.4	2	11.9	15	31.2	1	100.0	1	25.0	9	40.0	11	39.1	6	40.6	9	39.0	11	28.4	26	34.3
2	2	45.2	1	45.5	6	26.2	9	39.4	0	100.0	0	25.0	1	41.7	1	40.6	2	46.9	1	41.5	7	35.3	10	39.9
3	0	45.2	0	45.5	6	40.5	6	45.0	0	100.0	2	50.0	9	56.7	11	56.5	0	46.9	2	46.3	15	50.0	17	49.4
4	2	51.6	1	48.5	8	59.5	11	55.0	0	100.0	0	50.0	4	63.3	4	62.3	2	53.1	1	48.8	12	61.8	15	57.9
5	2	58.1	4	60.6	5	71.4	11	65.1	0	100.0	1	62.5	7	75.0	8	73.9	2	59.4	5	61.0	12	73.5	19	68.5
6	2	64.5	1	63.6	1	73.8	4	68.8	0	100.0	1	75.0	4	81.7	5	81.2	2	65.6	2	65.9	5	78.4	9	73.6
7	1	67.7	0	63.6	3	81.0	4	72.5	0	100.0	0	75.0	3	86.7	3	85.5	1	68.8	0	65.9	6	84.3	7	77.5
8	3	77.4	4	75.8	3	88.1	10	81.7	0	100.0	1	87.5	5	95.0	6	94.2	3	78.1	5	78.0	8	92.2	16	86.5
9	1	80.6	2	81.8	0	88.1	3	84.4	0	100.0	0	87.5	1	96.7	1	95.7	1	81.3	2	82.9	1	93.1	4	88.8
10	0	80.6	2	87.9	1	90.5	3	87.2	0	100.0	0	87.5	0	96.7	0	95.7	0	81.3	2	87.8	1	94.1	3	90.4
11	0	80.6	1	90.9	0	90.5	1	88.1	0	100.0	0	87.5	0	96.7	0	95.7	0	81.3	1	90.2	0	94.1	1	91.0
12	0	80.6	0	90.9	1	92.9	1	89.0	0	100.0	0	87.5	0	96.7	0	95.7	0	81.3	0	90.2	1	95.1	1	91.6
13	0	80.6	1	93.9	1	95.2	2	90.8	0	100.0	0	87.5	0	96.7	0	95.7	0	81.3	1	92.7	1	96.1	2	92.7
14	0	80.6	0	93.9	0	95.2	0	90.8	0	100.0	0	87.5	1	98.3	1	97.1	0	81.3	0	92.7	1	97.1	1	93.3
15	0	80.6	0	93.9	0	95.2	0	90.8	0	100.0	0	87.5	0	98.3	0	97.1	0	81.3	0	92.7	0	97.1	0	93.3
16	0	80.6	0	93.9	0	95.2	0	90.8	0	100.0	0	87.5	0	98.3	0	97.1	0	81.3	0	92.7	0	97.1	0	93.3
17	0	80.6	0	93.9	1	97.6	1	91.7	0	100.0	0	87.5	0	98.3	0	97.1	0	81.3	0	92.7	1	98.0	1	93.8
18	1	83.9	1	97.0	0	97.6	2	93.6	0	100.0	0	87.5	1	100.0	1	98.6	1	84.4	1	95.1	1	99.0	3	95.5
19	0	83.9	0	97.0	0	97.6	0	93.6	0	100.0	0	87.5	0	100.0	0	98.6	0	84.4	0	95.1	0	99.0	0	95.5
20	0	83.9	0	97.0	0	97.6	0	93.6	0	100.0	0	87.5	0	100.0	0	98.6	0	84.4	0	95.1	0	99.0	0	95.5
21	1	87.1	0	97.0	0	97.6	1	94.5	0	100.0	1	100.0	0	100.0	1	100.0	1	87.5	1	97.6	0	99.0	2	96.6
22	0	87.1	1	100.0	0	97.6	1	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	1	100.0	0	99.0	1	97.2
23	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
24	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
25	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
26	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
27	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
28	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
29	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
30	0	87.1	0	100.0	0	97.6	0	95.4	0	100.0	0	100.0	0	100.0	0	100.0	0	87.5	0	100.0	0	99.0	0	97.2
31	1	90.3	0	100.0	1	100.0	2	97.2	0	100.0	0	100.0	0	100.0	0	100.0	1	90.6	0	100.0	1	100.0	2	98.3
32	0	90.3	0	100.0	0	100.0	0	97.2	0	100.0	0	100.0	0	100.0	0	100.0	0	90.6	0	100.0	0	100.0	0	98.3
33	0	90.3	0	100.0	0	100.0	0	97.2	0	100.0	0	100.0	0	100.0	0	100.0	0	90.6	0	100.0	0	100.0	0	98.3
34	0	90.3	0	100.0	0	100.0	0	97.2	0	100.0	0	100.0	0	100.0	0	100.0	0	90.6	0	100.0	0	100.0	0	98.3
35	1	93.5	0	100.0	0	100.0	1	98.2	0	100.0	0	100.0	0	100.0	0	100.0	1	93.8	0	100.0	0	100.0	1	98.9
36	0	93.5	0	100.0	0	100.0	0	98.2	0	100.0	0	100.0	0	100.0	0	100.0	0	93.8	0	100.0	0	100.0	0	98.9
37	0	93.5	0	100.0	0	100.0	0	98.2	0	100.0	0	100.0	0	100.0	0	100.0	0	93.8	0	100.0	0	100.0	0	98.9
38	0	93.5	0	100.0	0	100.0	0	98.2	0	100.0	0	100.0	0	100.0	0	100.0	0	93.8	0	100.0	0	100.0	0	98.9
39	1	96.8	0	100.0	0	100.0	1	99.1	0	100.0	0	100.0	0	100.0	0	100.0	1	96.9	0	100.0	0	100.0	1	99.4
40	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
41	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
42	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
43	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
44	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
45	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4

Table 20. Dwelling loss experience for the 1983 Coalinga earthquake: Loss distribution by number of dwellings, Insurance Source A; excluding dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection or were higher than one story —Continued

	WOOD-PRE40		WOOD-4049		WOOD-POST49		WOOD-ALL		CONC-PRE40		CONC-4049		CONC-POST49		CONC-ALL		BOTH-PRE40		BOTH-4049		BOTH-POST49		BOTH-ALL	
% LOSS	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT	NO. DWELL.	SUM PCT
46	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
47	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
48	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
49	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
50	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
51	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
52	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
53	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
54	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
55	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
56	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
57	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
58	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
59	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
60	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
61	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
62	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
63	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
64	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
65	0	96.8	0	100.0	0	100.0	0	99.1	0	100.0	0	100.0	0	100.0	0	100.0	0	96.9	0	100.0	0	100.0	0	99.4
>65	1	100.0	0	100.0	0	100.0	1	100.0	0	100.0	0	100.0	0	100.0	0	100.0	1	100.0	0	100.0	0	100.0	1	100.0

Table 21. Probable Maximum Loss of wood-frame dwellings in magnitude 6.5 earthquakes

[Excluding geologic effects and construction anomalies]

	Probable Maximum Loss (PML) At Zero Deductible				
	Authors' Data		Ins. Co. A		
	1971 San Fernando ***Value (Table 8)	1983 Coalinga Market Val. (Table 13)	1983 Coalinga Insured Val. (Table 20)	Judgment PML	State Factor****
Wood floors:					
Age Group:					
Pre-1940	26%	19%	**	28%	1.08
1940-49	10%	17%	**	14%	1.40
Post-49	11%	16%	**	12%	1.09
All ages	11%	17%	13% to 16%	13%	1.18
Concrete floors:					
Age Group:					
Pre-1940	14%	*	**	18%	1.29
1940-49	13%	*	**	14%	1.08
Post-49	11%	*	7%	12%	1.09
All ages	11%	12%	8%	13%	1.18
Wood or concrete floors:					
Age Group:					
Pre-1940	22%	19%	**	22%	1.00
1940-49	11%	16%	**	14%	1.27
Post-49	11%	14%	8%	12%	1.09
All ages	11%	15%	10%	13%	1.18

*Not meaningful.
**Less than 50 dwellings.
***Authors' data are market values, but are same as insured values for new construction.
****(State Factor) = (Judgment PML)/(1971 San Fernando)

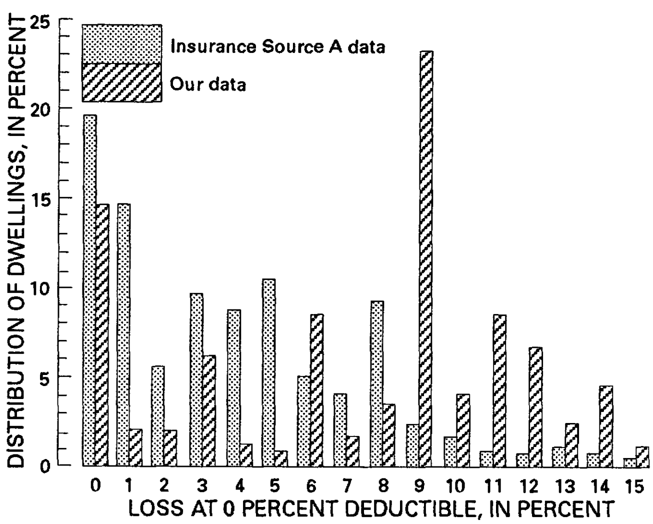

Figure 6. Graph showing distribution of dwellings versus loss at 0 percent deductible for the 1983 Coalinga earthquake and comparing our data and Insurance Source A data. Dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection or were higher than one story are excluded.

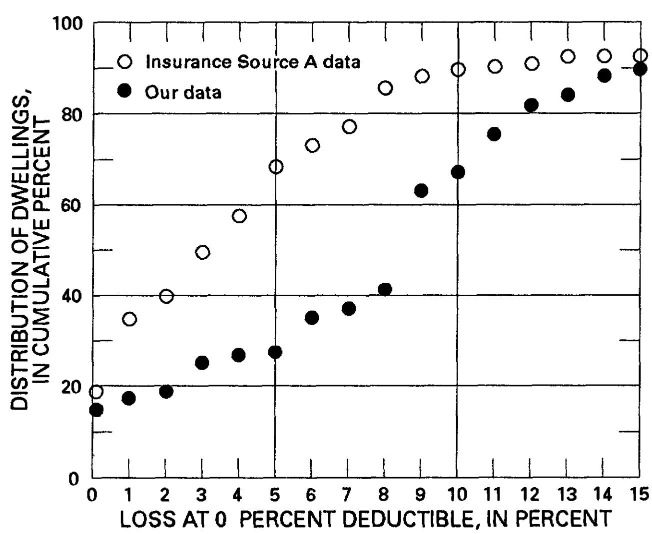

Figure 7. Graph showing distribution of dwellings versus loss at 0 percent deductible for the 1983 Coalinga earthquake and comparing our data and Insurance Source A data. This figure is similar to figure 6, except that the distribution of dwellings is in cumulative percent. Dwellings that had shifted on their foundations or were posted as hazardous or had been demolished before time of inspection or were higher than one story are excluded.

Table 22. Loss over deductible for conventional wood-frame dwellings

[First-story floor of any material. Uncertainty factor = 1.50]

	Percent Loss Over Deductible for Deductibles of:																				
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%	14%	15%	16%	17%	18%	19%	20%
All ages:																					
Mag. = 5.0	6.2	5.6	5.1	4.5	4.1	3.7	3.3	3.0	2.7	2.4	2.2	2.0	1.8	1.6	1.4	1.3	1.2	1.0	0.9	0.8	0.8
Mag. = 5.5	6.7	6.0	5.4	4.9	4.4	3.9	3.5	3.2	2.9	2.6	2.3	2.1	1.9	1.7	1.5	1.4	1.2	1.1	1.0	0.9	0.8
Mag. = 6.0	7.1	6.4	5.7	5.2	4.7	4.2	3.8	3.4	3.1	2.8	2.5	2.2	2.0	1.8	1.6	1.5	1.3	1.2	1.1	1.0	0.9
Mag. = 6.5	7.5	6.8	6.1	5.5	4.9	4.4	4.0	3.6	3.2	2.9	2.6	2.4	2.1	1.9	1.7	1.6	1.4	1.3	1.1	1.0	0.9
Mag. = 7.0	8.0	7.2	6.4	5.8	5.2	4.7	4.2	3.8	3.4	3.1	2.8	2.5	2.2	2.0	1.8	1.6	1.5	1.3	1.2	1.1	1.0
Mag. = 7.5	8.4	7.5	6.8	6.1	5.5	5.0	4.5	4.0	3.6	3.2	2.9	2.6	2.4	2.1	1.9	1.7	1.6	1.4	1.3	1.1	1.0
Mag. = 8.0	8.8	7.9	7.1	6.4	5.8	5.2	4.7	4.2	3.8	3.4	3.1	2.8	2.5	2.2	2.0	1.8	1.6	1.5	1.3	1.2	1.1
Mag. = 8.25	9.0	8.1	7.3	6.6	5.9	5.3	4.8	4.3	3.9	3.5	3.1	2.8	2.6	2.3	2.1	1.9	1.7	1.5	1.4	1.2	1.1
Post-1939:																					
Mag. = 5.0	4.5	3.7	3.1	2.6	2.1	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1
Mag. = 5.5	4.8	4.0	3.3	2.8	2.3	1.9	1.6	1.3	1.1	0.9	0.8	0.6	0.5	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Mag. = 6.0	5.1	4.2	3.5	2.9	2.4	2.0	1.7	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1
Mag. = 6.5	5.4	4.5	3.7	3.1	2.6	2.2	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1
Mag. = 7.0	5.7	4.8	4.0	3.3	2.7	2.3	1.9	1.6	1.3	1.1	0.9	0.8	0.6	0.5	0.4	0.4	0.3	0.2	0.2	0.2	0.1
Mag. = 7.5	6.0	5.0	4.2	3.5	2.9	2.4	2.0	1.7	1.4	1.1	1.0	0.8	0.7	0.5	0.5	0.4	0.3	0.3	0.2	0.2	0.2
Mag. = 8.0	6.3	5.3	4.4	3.6	3.0	2.5	2.1	1.7	1.4	1.2	1.0	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2
Mag. = 8.25	6.5	5.4	4.5	3.7	3.1	2.6	2.1	1.8	1.5	1.2	1.0	0.9	0.7	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.2
Pre-1940:																					
Mag. = 5.0	10.4	9.8	9.3	8.8	8.4	7.9	7.5	7.1	6.8	6.4	6.1	5.7	5.4	5.2	4.9	4.6	4.4	4.2	3.9	3.7	3.5
Mag. = 5.5	11.1	10.5	10.0	9.4	8.9	8.5	8.0	7.6	7.2	6.8	6.5	6.1	5.8	5.5	5.2	4.9	4.7	4.4	4.2	4.0	3.8
Mag. = 6.0	11.8	11.2	10.6	10.1	9.5	9.0	8.6	8.1	7.7	7.3	6.9	6.5	6.2	5.9	5.6	5.3	5.0	4.7	4.5	4.2	4.0
Mag. = 6.5	12.5	11.9	11.3	10.7	10.1	9.6	9.1	8.6	8.1	7.7	7.3	6.9	6.6	6.2	5.9	5.6	5.3	5.0	4.8	4.5	4.3
Mag. = 7.0	13.2	12.6	11.9	11.3	10.7	10.1	9.6	9.1	8.6	8.2	7.7	7.3	6.9	6.6	6.2	5.9	5.6	5.3	5.0	4.8	4.5
Mag. = 7.5	14.0	13.2	12.5	11.9	11.3	10.7	10.1	9.6	9.1	8.6	8.1	7.7	7.3	6.9	6.6	6.2	5.9	5.6	5.3	5.0	4.8
Mag. = 8.0	14.7	13.9	13.2	12.5	11.8	11.2	10.6	10.1	9.5	9.0	8.6	8.1	7.7	7.3	6.9	6.5	6.2	5.9	5.6	5.3	5.0
Mag. = 8.25	15.0	14.2	13.5	12.8	12.1	11.5	10.9	10.3	9.8	9.3	8.8	8.3	7.9	7.5	7.1	6.7	6.3	6.0	5.7	5.4	5.1

earthquake in the cities from Belmont to Redwood City. All dwellings were within 1–4 miles of the San Andreas fault. Damage information is from Lawson (1908), beginning on page 354 of volume I, part 2.

Some comparisons between San Francisco in 1906 and Coalinga in 1983 are of interest. In San Francisco in 1906, the dwelling foundations were unreinforced brick, unreinforced concrete, or wood. Foundation anchorage generally did not exist by today's standards. Of 842 dwellings, 190 (23 percent) shifted on their foundations. In Coalinga in 1983, 11 percent of all dwellings shifted a measurable amount; 24 percent of pre-1940 dwellings shifted a measurable amount (Steinbrugge and others, 1990). Interestingly, the percentage of older Coalinga dwellings that shifted was about the same (24 versus 23 percent) as that of the dwellings that shifted in San Francisco. Admittedly, wood-frame dwelling constructions, including foundations, were different in the two cities.

Brick chimneys were not reinforced in 1906. Of 1,097 brick chimneys from Belmont to Redwood City that were examined, 88 percent had fallen. In Coalinga, 130 of 158 (82 percent) pre-1949 chimneys had at least moderate damage. Again, the comparison is of interest because damage percentages are similar.

It is estimated that 20 percent represents the increased dwelling damage from magnitude 6.5 to 8.25, with all other conditions being equal. From this, a linear expression between magnitude and increase in loss (magnitude factor) is:

$$\text{Magnitude factor} = (0.114 \times \text{Magnitude}) + 0.259$$

This is based on a magnitude of 6.5. The three significant figures exceed the data quality.

Probable Maximum Loss (PML)

The Judgment PML at magnitude 6.5 from table 21 is modified by a magnitude factor to obtain PML's for other magnitudes. There is no need to include an uncertainty factor to compensate for the already discussed limitations because the uncertainty is covered by the "9 out of 10" definition for PML. The resultant PML's at 0 percent deductible for floors of all kinds after applying the magnitude factor for selected magnitudes are:

	Magnitude				
Age group	6.5	7.0	7.5	8.0	8.25
Pre-1940, in percent	22.0	23.3	24.5	25.7	26.4
1940–49, in percent	14.0	14.8	15.6	16.4	16.8
Post-1949, in percent	12.0	12.7	13.4	14.1	14.4
All ages, in percent	13.0	13.7	14.5	15.2	15.6

It is practical to combine the 1940–49 age group with the post-1949 age group. Dwelling-population relationships examined under "Probable maximum loss (PML) for magnitude 6.5 earthquakes" showed that post-1949 dwellings outnumber 1940–49 dwellings by five-fold. For practical purposes, the post-1949 PML's can be used for both age groups, as follows:

	Magnitude				
Age group	6.5	7.0	7.5	8.0	8.25
Pre-1940, in percent	22.0	23.3	24.5	25.7	26.4
post-1939, in percent	12.0	12.7	13.4	14.1	14.4
All ages, in percent	13.0	13.7	14.5	15.2	15.6

The above PML compilations are to three significant figures for display purposes. The PML's in table 21 are to two significant figures, and the above tabulation is reasonable only to two significant figures, at most.

Loss over Deductible

Curve 3 in figure 4 is considered to be the most useful for loss-over-deductible applications. The explanations that accompany figures 6 and 7 provide supportive reasoning for curve 3 in the range of 0–9 percent deductible. Beyond 9 percent deductible, insurance data showed a seemingly large number of total losses that were not borne out by our inspections—the insurance total losses may possibly have been influenced by the then-current legal considerations. However, losses over deductible are low beyond the 10 percent deductible for curves 1, 2, and 3, and supporting data for these curves are sparse. Curve 3 is the most conservative of these three curves and is accordingly considered to be the best fit. Calculation methods for loss-over-deductible curves and tables were such that constructive total losses were included; thus the peak for losses that exceed 65 percent was included.

Unlike the PML definition, the loss-over-deductible tables, such as table 2, do not include an uncertainty factor. However, it is appropriate to include such a factor. We judge that a 50 percent uncertainty factor is reasonable compensation for the many identified limitations involved with loss-over-deductible data. This uncertainty factor also allows the inclusion of one-and-two-story, split-level, and two-story dwellings. The term "conventional dwellings" will include these height variants in the subsequent discussions. Conventional dwellings do not include houses on steeply sloping sites where the downside is supported by tall columns or walls. Also not included are houses with basements and those with minimal first-story crosswalls found in the western sections of San Francisco. Geologic effects are not included, but must be included in the loss-estimation algorithm on a site- or area-specific basis.

Regression equations were developed for curve 3 data. These equations were then multiplied by:

(1) State factor from table 21 (for general application in California),
(2) Uncertainty factor which increases values by 50 percent (or user-modified), and
(3) Magnitude factor (transfer function for different magnitudes).

Mathematical equations are presented in the "Overview, findings, and recommendations" section at the end of this report, as are tabular (table 22) and graphical alternatives (fig. 15).

1987 WHITTIER NARROWS EARTHQUAKE

Reconnaissance surveys of dwellings immediately after the 1987 Whittier Narrows earthquake found few damaged structures and few fallen masonry chimneys in the epicentral area and elsewhere, except 6 or more miles away in sections of the city of Whittier. This is in some contrast to the experience from the previously discussed earthquakes.

Dwelling deductibles for earthquake insurance in California were commonly 5 percent of insured values until a few years before the 1987 Whittier Narrows earthquake. The 1983 Coalinga earthquake was an anomaly in the history of the deductible due to previously mentioned legal reasons, and essentially 0 percent deductibles were commonly applied to Coalinga losses. Deductibles generally had risen to 10 percent by the time of the 1987 Whittier Narrows earthquake. However, there were a few important exceptions in the amount of earthquake insurance written in the context of the amount of the accompanying homeowner policy.

Two data sources were investigated. Insurance Source C used a variable deductible, and almost all the policies had deductibles within a range of 3–9 percent. Insurance Source D had a minimal deductible of $250. Both types of deductible provided opportunities for examination of a greater number of losses than would be possible with a 10 percent deductible.

The context of this discussion of the Whittier Narrows earthquake indicates whether "dwelling" refers to the structure and (or) its contents. However, to minimize possible misunderstandings, "building" refers to the structure, whereas "dwelling" refers to the structure plus its contents.

ZIP distance is the distance in miles between a population-weighted ZIP-centroid and the nearest point on the computed below-surface fault rupture plane (source of energy release). One model estimates the below-surface rupture length to be 5 mi for this magnitude 5.9 earthquake on a thrust fault at a depth of 10 mi. These were used in the distance-to-ZIP- centroid calculations (Steinbrugge and others, 1984).

Insurance Source C

Insurance Source C provided information on homeowner dwellings for 63 ZIP's that had earthquake claims on record. Of these claims, 398 were paid earthquake claims, out of 19,870 policies with earthquake, as well as homeowner, coverage. Forty of the 63 ZIP's had two or fewer paid claims out of usually many hundreds of earthquake policies in each ZIP. ZIP's with a minimal number of paid claims were in some cases located 10 or more miles from the earthquake's energy release; one ZIP was 37 miles away.

Insurance Source C is a very large writer of dwelling insurance, possibly the largest in the earthquake-affected area. Their underwriting and marketing practices tended to give uniform market penetration throughout the area. There was no marketing selectivity by dwelling age, soil condition, or hillside location. As a result, their loss data do not include these kinds of biases and the findings are considered to be representative of the affected area.

Available data for each policy included location, year built, building value, contents value, loss to building, loss to contents, loss due to additional living expense, amount of homeowner building insurance, amount of homeowner contents insurance, amount of insurance to replacement value, amount of earthquake coverage, and amount of a variable earthquake-insurance deductible. There was no information on masonry veneer, if any, nor on the number of stories. Normally the dwellings were one story. All buildings were wood frame.

Geographic Distribution of Losses

Region With Paid Earthquake Claims

The open triangles in figure 8 show the locations of each population-weighted ZIP centroid. Distance to the earthquake epicenter may be scaled. The figures next to each ZIP centroid are, for one example: 90601 which is the ZIP number (in Whittier in this instance); 280/79/28.21 mean, respectively, the number of earthquake policies in the ZIP, the number of paid claims, and the paid claims as a percentage of the number of policies.

A total of 95 percent of the paid claims were located in the ZIP's shown in figure 8; the remainder were scattered beyond the map's boundaries. Although the exact location of each earthquake policy was

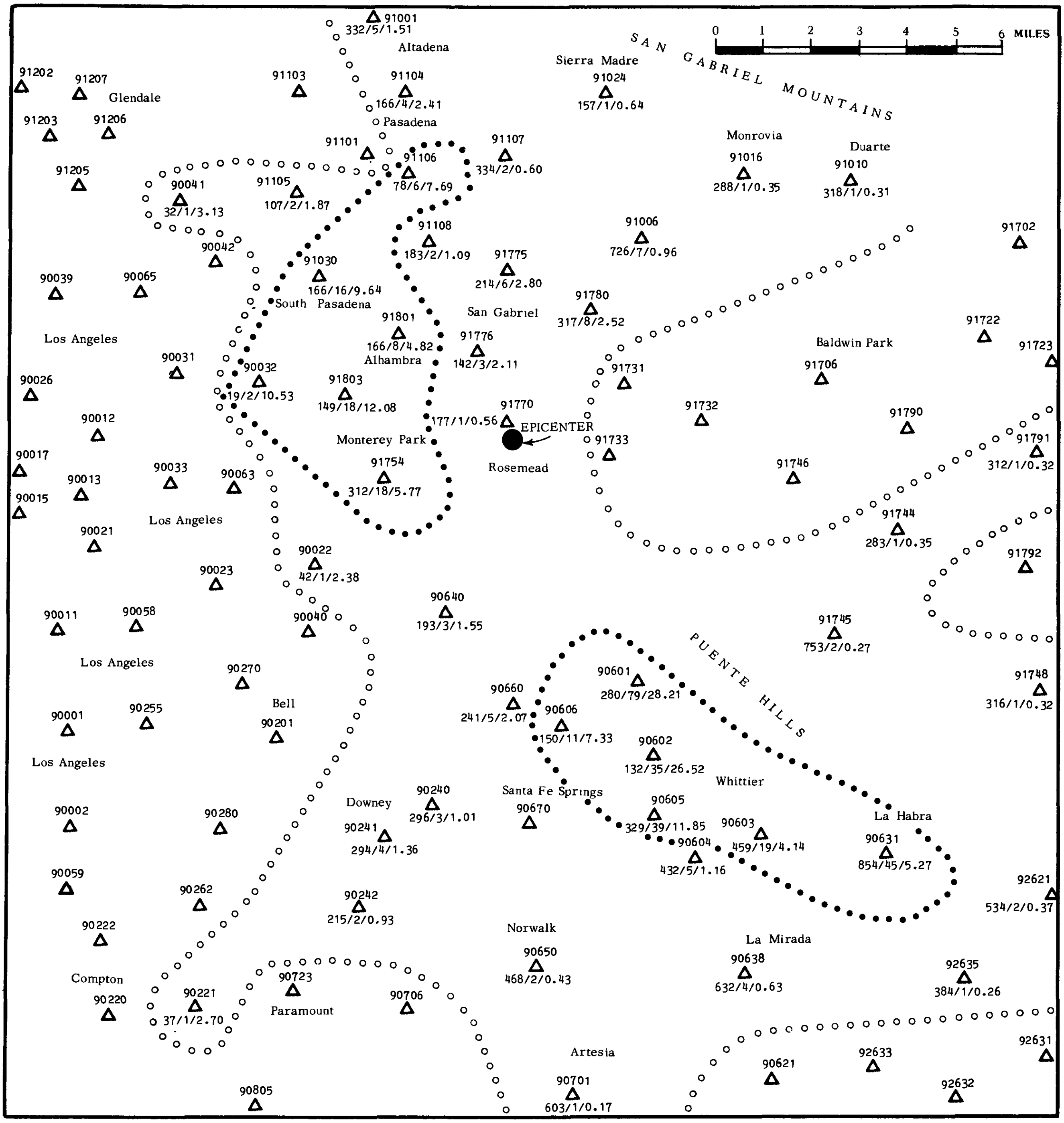

Figure 8. Map showing the epicenter of the 1987 Whittier Narrows earthquake and the location of the population-weighted ZIP centroids (open triangles). The ZIP number is shown above each triangle. Other numbers, such as 280/79/28.21, refer to loss data for Insurance Source C; see text for explanation. Lines of open circles separate the ZIP's with no paid claims from those with paid claims. Lines of solid circles enclose areas of higher than usual losses.

available, data were grouped by ZIP's rather than by smaller areas due to the small number of paid claims in most ZIP's.

The percentage of paid claims to number of earthquake policies in each ZIP was used as an index to the comparative losses among ZIP's. Other indexes that use the variable deductible and other parameters created difficulties and were discarded.

The lines formed by the open circles in figure 8 separate the ZIP's with no paid claims from those with paid claims. The shape of the enclosed area is irregular; the widest parts of the enclosed area are to the north and the southeast of the epicenter. Losses over deductible drop off rapidly to the west of the epicenter. There also are a larger number of losses to the north and to the southeast of the epicenter than elsewhere. The boundary line to the east is unusual in that it approaches the epicenter. Indeed, if ZIP 91770 adjacent to the epicenter had one fewer paid claim, then the epicenter would have been in an area with no paid claims!

The locations of the lines formed by the open circles are of poor quality; they are predominately determined by ZIP's that have only one paid claim rather than by those that have none. In its favor, this method provided a contiguous paid-claim pattern except for ZIP 90670 at Santa Fe Springs. However, it must be remembered the deductible was a variable, and therefore percentage-compared paid claims are not necessarily on the same basis—particularly so if single paid claims are the determinant for locations of the dividing lines. The number of earthquake policies in those ZIP's that have a single paid claim was also a variable and ranged from a few tens to more commonly a few hundreds. Local surficial geology and dwelling construction characteristics undoubtedly were variability factors.

Areas With Highest Number of Paid Claims

The loss index (percentage of paid claims to earthquake policies) identified two zones of higher than usual losses (delineated by lines of solid circles). One zone extends northward from Monterey Park to Pasadena; its highest index number is 12 percent.

The more important zone is that containing the cities of Whittier and La Habra where the index rose to 28 for one ZIP and over 26 for a second ZIP. La Habra is contiguous to the southeast of Whittier and also has a high index. It should be noted that all these ZIPs are at or near the southern base of the Puente Hills and near the Whittier fault (the earthquake did not occur on this fault). Field observations indicated that the highest concentrations of damage were often found along the base of these hills. It is possible that mapping for geologic microzonation studies can be identified with locations of insured dwellings, but this is beyond the scope of this examination.

Although sections of the boundaries are imprecise and could be in error by miles, the general delineation of the geographic distribution of losses shown in figure 8 is reasonable.

The concentration of damage in Whittier has been examined from a seismological standpoint by Kawase and Aki (1990). They stated in the abstract to their paper:

> The results show that the amplification due to the hill relative to the flat surface is more than 1.5 for all the source models. Since this amplification is nearly independent of the source type and spectrum, we conclude that the combined effect of the topographic irregularity and critically incident SV waves might be responsible for the concentration of damage observed during the Whittier Narrows earthquake.

Deductibles and Losses Over Deductible

The deductible was unusual in that it was a variable. The amount of earthquake coverage was selectable by the assured but could not be less than $100,000 and could differ from the amount of the homeowner policy. The homeowner policy was close to or at the replacement value, but the earthquake policy was tied to neither the homeowner policy nor the replacement value. The deductible was 10 percent of the amount of the earthquake policy and was applicable to the sum of the building, contents, and additional living expense.

Dollar deductibles were converted into percent deductibles using building replacement values plus contents values. The distribution of dwellings as a function of the deductible for 19,862 dwellings (out of 19,870) is shown in figure 9. This distribution included all earthquake-insured dwellings, whether there were paid claims or not. Distributions for paid claims in (1) the Whittier–La Habra zone, (2) the Pasadena–Monterey Park zone, and (3) all ZIP's that had paid claims, were very similar to that shown in figure 9. All distributions tended to be similarly skewed. A distribution peak at 5–6 percent was found in all cases. The average deductible applied to 19,857 earthquake-insured dwellings was 5.8 percent. This deductible was about the same for the Whittier–La Habra zone, the Pasadena–Monterey Park zone, and elsewhere.

The losses over deductible were generally less than 10 percent and rarely greater than 20 percent. Less than 2 percent of the dwellings in the severely shaken cities of Whittier and La Habra had losses over deductible greater than 60 percent. About 1 percent had losses over deductible greater than 60 percent for all ZIP's that had paid claims. These low percentages should be used with caution because the number of dwellings were quite small compared to the entire inventory of dwellings with paid claims.

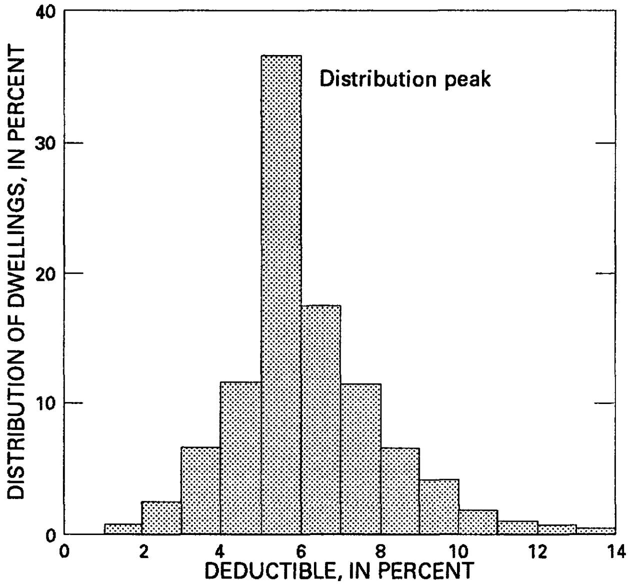

Figure 9. Graph showing distribution of dwellings versus deductible, based on replacement cost of all earthquake-insured dwellings.

An examination of the distribution of losses over deductible as a function of deductible shows wide variations and very few dwellings in each category (see table 23 for one such example). More than 7,200 dwellings in the total dwelling inventory of more than 19,000 dwellings had deductibles that ranged from 5 to 6 percent, but only 24 dwellings had losses over deductible of 0–1 percent.

The average deductible of 5.8 percent provided more loss data than could have come from a more conventional 10 percent deductible. It was hoped that the variable deductible would produce a range of deductibles that had useful losses over deductible. Table 24 summarizes the most important loss-over-deductible data. The listings are limited to the zones and regions that had 100 or more paid claims. The third through seventh columns are the losses over deductible for deductible ranges 2–3 percent through 6–7 percent. Other deductible ranges fell on the lower portions of the distribution, and each contained less than 5 percent of the total number of paid claims. There is an evident trend in the third through seventh columns in table 24 toward lower losses over deductible as the deductible increases, but the data scatter is significant. Slopes of straight lines through these data using linear-regression methods were (in descending order of zones/regions): –0.188, –0.216, –0.392, and –0.014. The choice of a straight-line slope is based on figures 4 and 5 where small sections of the curves can be approximated by straight lines. These straight-line slopes may be compared with that obtained from equation 6 (discussed in the "Loss over deductible approach" section later in this report), which is the generic loss-over-deductible equation for the "all ages" group. Differentiating this equation and substituting 5 for X obtains a slope of –0.591, which is at some variance with the other slopes.

An alternate and approximate approach seems warranted. The last column in table 24 is the average of all losses over deductible for deductible of 0–100 percent. The values in this column closely approximate the weighted averages of the percentages for deductible of 2–3 percent through 6–7 percent in this table. Another view of these data is the average loss over deductible for deductibles in the range of 0–100 percent (see, for example, the value of 1.01 at the bottom of the next to last column in table 23). These two views are compared in table 25. The first view is biased toward the distribution peak, whereas the second view is biased toward the average of the skewed distribution. The average of these two views is shown in the second column of table 26 and will be used in the following discussions.

Adjustment For Magnitude 8.25 Earthquake and Uncertainty Factor of 1.5

Loss-over-deductible relationships for the previously discussed 1933 Long Beach, 1971 San Fernando, and 1983 Coalinga earthquakes were based on magnitudes about 6.5. A 20 percent increase in the loss over deductible for these events was considered appropriate for a magnitude 8.25 event (see magnitude factor in the "Earthquakes of magnitudes other than 6.5" section). Assuming a linear relationship, then the magnitude factor that is necessary to obtain a loss over deductible for a magnitude 8.25 rather than a magnitude 5.9 earthquake is a 30 percent rather than a 20 percent increase.

Table 26 shows the results of applying these factors. The second column of table 26, which is a compromise between two different views of the data, is the average of the second and third columns of table 25. The third column of table 26 includes the user-selectable uncertainty factor of 1.50. The fourth column includes both the magnitude and uncertainty factors. "Adjusted loss" in the column headings refers to the inclusion of these factors. The 5 percent deductible was judgmentally selected as being between the average deductible (5.8 percent) and the peak of the loss-over-deductible distribution.

Commentary on Loss-Over-Deductible Results

The last two columns of table 26 show expected values based on the previously discussed three earthquakes. These expected values, which are from table 22, are applicable only to those zones/regions where there are no increases in losses due to geologic effects or unknown reasons.

Table 23. Number of dwellings with losses over deductible in Whittier and La Habra, on the basis of percent deductible

[Percent losses are based on replacement cost]

PERCENT DEDUCTIBLE	PERCENT LOSS OVER DEDUCTIBLE: ZERO	> 0 TO 1	> 1 TO 2	> 2 TO 3	> 3 TO 4	> 4 TO 5	> 5 TO 6	> 6 TO 7	> 7 TO 8	> 8 TO 9	> 9 TO 10	> 10 TO 11	> 11 TO 12	> 12 TO 13	> 13 TO 14	> 14	COUNT OF: ALL DWEL.	COUNT OF: PAID CLAIM DWEL.	AVERAGE % LOSS OVER % DEDUCT.: ALL DWEL.	AVERAGE % LOSS OVER % DEDUCT.: PAID CLAIM DWEL.*
ZERO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
> 0 - 1	7	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	11	4	2.77	7.61
> 1 - 2	42	0	0	2	1	0	0	0	0	0	0	0	1	0	0	2	48	6	1.73	13.83
> 2 - 3	103	1	2	1	0	1	2	1	1	0	1	0	0	0	0	4	117	14	1.26	10.56
> 3 - 4	211	9	3	6	2	4	2	3	1	2	1	1	2	0	1	4	252	41	1.09	6.70
> 4 - 5	763	14	9	6	3	6	4	5	5	1	1	1	2	5	1	25	851	88	1.24	12.03
> 5 - 6	494	1	0	5	4	3	3	0	1	1	0	0	3	0	0	12	527	33	0.83	13.26
> 6 - 7	366	1	3	2	4	6	0	0	0	1	0	0	1	1	0	4	389	23	0.45	7.66
> 7 - 8	197	1	1	0	1	0	1	1	2	1	0	0	0	0	0	4	209	12	1.33	23.24
> 8 - 9	130	1	0	1	1	1	1	0	0	0	1	0	0	0	0	1	137	7	0.34	6.66
> 9 - 10	48	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	51	3	2.10	35.64
> 10 - 11	24	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	26	2	0.54	6.97
> 11 - 12	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0.00	0.00
> 12 - 13	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0.00	0.00
> 13 - 14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
> 14 - 15	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0.00	0.00
> 15 - 16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
> 16 - 17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
> 17 - 18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
> 18 - 19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
> 19 - 20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	0.00
																	2,630	233	1.01	11.39

*Excludes dwellings with no paid claims.

Table 24. Comparison of loss over deductible and percent deductible, Insurance Source C

[Percent deductibles less than 2–3 percent and greater than 6–7 percent contain fewer than 5 percent of the paid claims in each category]

Zone/Region*	No. of Paid Claims	Average % Loss Over Deductible For % Deductible of: 2%-3%	3%-4%	4%-5%	5%-6%	6%-7%	% Loss/ Deduct. For Deduct. >0%-100%
Whittier - La Habra:							
All ages	233	1.26%	1.09%	1.24%	0.83%	0.45%	1.24%
Post-1939 constr.	200	1.13%	1.07%	1.06%	0.43%	0.37%	1.06%
ZIPs 90601/90602	114	3.93%	2.83%	4.20%	3.63%	1.57%	4.20%
All ZIPs with paid claims	398	0.22%	0.15%	0.19%	0.19%	0.13%	0.19%

*Limited to zones/regions having 100 or more paid claims.

Table 25. Summary of losses over deductible, Insurance Source C

[All values in percent]

Zone/Region	Average % Loss Over % Deductible At 4%-5% Deductible	**Average % Loss Over % Deductible For Entire Range Of % Deductibles
Whittier - La Habra:		
All ages	1.24%	1.01%
Post-1939 constr.	1.06%	0.76%
*Pre-1940 constr.	9.50%	10.23%
ZIPs 90601/90602	4.20%	3.77%
*Pasadena to Monterey Park	0.27%	0.47%
All ZIPs with paid claims	0.19%	0.19%
*All ZIPs with paid claims, other than Whittier - La Habra and Pasadena to Monterey Park	0.04%	0.04%

*Fewer than 100 paid claims.
**Entire range is 0% deductible through 100% deductible.

Except for the Whittier–La Habra zone, the losses over deductible for the 1987 Whittier Narrows earthquake are remarkably low compared with those for 1933 Long Beach, 1971 San Fernando, and 1983 Coalinga earthquakes. One may validly question whether loss information for a magnitude 5.9 earthquake can be extrapolated to magnitude 8.25 earthquakes—despite this, the data are valid for the Whittier Narrows and similar earthquakes. One may also challenge the transfer of these data to other California magnitude 5.9 earthquakes because the focal depth of the Whittier Narrows earthquake was 14 kilometers (9 miles), whereas those for Coalinga and San Fernando were 8 kilometers (5 miles). Lastly, there is no proof that the mechanism of energy release and energy spatial distributions are the same for all events.

The loss relationship between post-1939 and pre-1940 construction in the Whittier–La Habra zone is about ten-fold greater for the older construction, which is much higher than expected. It may be that the actual geographic distribution of dwellings by age and by area resulted in some bias. However, reconnaissance surveys shortly after the event clearly showed that older dwellings were much more vulnerable than were newer ones.

The great sensitivity to loss is also surprising for what appears to have been geophysically related conditions in the Whittier ZIP's 90601 and 90602. This area had not previously been mapped as vulnerable.

Insurance Source D

Insurance Source D is the State of California's Department of Veterans Affairs. Their enabling legislation (Article 3.8, Disaster Indemnity, Section 989.4, of State Benefits for Veterans, Division 4) states:

> The department shall maintain an Indemnity Fund, which is hereby created in the State Treasury, for the purpose of indemnifying eligible

Table 26. Adjusted percent loss over 5 percent deductible for magnitude 5.9 and 8.25 earthquakes, Insurance Source C

[All values in percent]

Zone/Region	Whittier Narrows EQ			**Other 3 EQ	
	Average of Cols. 2 & 3 Of Table 25	Adjusted Loss Over 5% Deductible		Adjusted Loss Over 5% Deductible	
		Mag=5.9	Mag=8.25	Mag=5.9	Mag=8.25
*Whittier - La Habra:					
All ages	1.13%	1.70%	2.20%		
Post-1939 constr.	0.91%	1.37%	1.77%		
*Pre-1940 constr.	9.87%	14.81%	19.25%		
ZIPs 90601/90602	3.99%	5.99%	7.78%		
*Pasadena to Monterey Park	0.37%	0.56%	0.72%		
All ZIPs with paid claims	0.19%	0.29%	0.37%		
*All ZIPs with paid claims, other than Whittier - La Habra and Pasadena to Monterey Park	0.04%	0.06%	0.08%	4.2%	5.3%

*Fewer than 100 paid claims.
**1933 Long Beach, 1971 San Fernando, and 1983 Coalinga earthquakes.

purchasers, for the cost of repairing damage in excess of two hundred fifty dollars ($250) caused by flood, earthquake or other perils not otherwise covered by insurance required of purchasers pursuant to Section 987.2. Money accruing to the Indemnity Fund is hereby appropriated for carrying out the purposes of this article.

The foregoing applies to all loans made by the Department of Veterans Affairs for the purchase of dwellings by qualified veterans.

Insurance Source D provided data on 480 paid claims located in 146 ZIP's. These ZIP's contained 9,230 earthquake policies in force as of June 21, 1988. The earthquake occurred on October 1, 1987, almost 9 months prior. It is quite probable that the foregoing count of earthquake policies reasonably reflected conditions at the time of the earthquake because this coverage was mandated and thereby would not have been influenced by pre- and post-earthquake owner views on the need for such coverage. One hundred out of the 146 ZIP's had two or fewer paid claims, which reduced the number of ZIP's that had good loss data on a ZIP basis. Only 12 ZIP's had 10 or more paid claims.

The low deductible is advantageous because it provides an opportunity to examine a range of losses over deductible beginning at essentially 0 percent deductible. Paid-claim information on each dwelling consisted of ZIP Code, street name but no address (only an identifying block number), city, year built, number of stories, whether first floor was concrete slab on grade or supported wood floor, insured amount, and amount of paid claim. Other information on ZIP's that had paid claims was on an aggregate basis for each ZIP and not on an individual dwelling basis; it consisted of the number of policies in force and their aggregate insured value as of June 21, 1988. These insurance policies did not cover dwelling contents, medical expenses, or additional living expense, as did the more conventional policies.

Distribution of Losses

By Type of First Floor

Loss distribution by type of first floor with the $250 deductible was:

Floor type	Number of dwellings with paid claims	Percent loss
Supported wood	238	6.6
Concrete slab on grade	85	4.7
Unknown	157	4.4

Dwellings with supported wood floors did not perform as well as did those with concrete slabs laid directly on the ground. The difference is significant because the increase in loss amounted to about 40 percent. This may be approximately compared with 1971 San Fernando experience where, in table 6, is shown in the "all ages" group at 0 percent deductible:

Floor type	Percent loss
Supported wood (wood floors, in table 6)	8.87
Concrete slab on grade (concrete floors, in table 6).	7.61

The increase in loss amounted to 17 percent. The Whittier Narrows loss experience is considered to be more representative of California because, in the San Fernando event, the supported-wood-floor dwellings were mostly very new and rot, as well as, other deterioration, had not yet occurred. This view is supported by a comparison of the "pre-1940" age groups in table 6. Other kinds of comparisons can be made using table 15.

By Number of Stories

Loss distribution by number of stories with the $250 deductible was:

Number of stories	Number of dwellings with paid claims	Percent loss
One	418	5.8
One and two	15	2.4
Two or more	40	5.1
Unknown	7	3.7

The data on the one-and-two-story dwellings are too few in number to be more than somewhat suggestive. Comparisons with the 1971 San Fernando earthquake are not very useful because, in the 1971 event, only 3 percent of the dwellings were in this height category (Steinbrugge and others, 1971, table 7). These comments are also true to a lesser extent for the two-story dwellings.

By Age Group

Loss distribution by age group with the $250 deductible was:

Age group	Number of dwellings with paid claims	Percent loss
Pre-1940	81	10.1
Post-1939	392	4.7
Unknown	7	3.7

As for all previous earthquakes, older dwellings suffered more extensively than did more recent ones. The reasons for this have been previously discussed.

Comparisons may also be made with 1971 San Fernando experience using information from table 6. Comparisons should not be taken too literally because the post-1949 dwellings in table 6 would, at this writing (1990), be almost 20 years older and some deterioration would increase the 1971 losses should the identical earthquake reoccur today.

By Geographic Distribution

Table 27 is a listing of the loss information for each ZIP in ascending order of distance from the fault-rupture model that was discussed previously. "NA" means that the information was not available. The fifth column is the percentage of paid claims, based on information from the third and fourth columns; the eighth column is the percent loss based on information from the sixth and seventh columns. The percent loss (eighth column) uses the aggregate of dwelling insurance of all policies, whether claims were paid or not. This, of course, is the preferred percentage because percent losses must be on the basis of all dwelling values at risk in a ZIP and not just those that have losses.

A total of 359 paid claims out of 480 policies (75 percent) are summarized by ZIP in figure 10. The remainder of the paid claims are scattered among 84 ZIP's that are located outside the map area; one ZIP has five paid claims, one has four paid claims, and the other 81 ZIP's have three or fewer paid claims. Figure 10 contains most of the meaningful data; the rest of the data are scattered over a wide area—three paid claims were located more than 100 miles from the epicenter.

The numbers adjacent to the population-weighted ZIP centroids, which are marked by the open triangles, have a different meaning from those on figure 8, due principally to the differences in deductibles; Insurance Source C had a variable deductible, whereas Insurance Source D had a fixed $250 deductible. The average percent loss at 0 percent deductible for Insurance Source D can be closely approximated by adding the deductible to the paid claim shown in the eighth column of table 27. Losses less than $250 obviously would not have been included with the paid-claim information. The figures next to each ZIP centroid are, for one example: 90601 which is the ZIP number (Whittier in this case); the 79/26/5.62 mean, respectively, the number of policies in force, the number of paid claims, and the average percent loss at the approximate zero deductible for all insured dwellings. The latter information was limited to ZIP's with paid claims.

One may locate the high-loss areas in a manner somewhat similar to that used for figure 8. ZIP's that had fewer than 20 policies were excluded, thereby eliminating 9 out of 62 ZIP's. Not to have done so would have included ZIP 90002 with two policies and one loss and ZIP 90015 with one policy and one loss. With this data restriction and also the limitation of losses to those greater than 0.50 percent, areas of higher than average losses are bounded by the lines formed by open circles. As in the case for Insurance Source C, the highest percent losses were in Whittier ZIP's 90601 (5.62 percent) and 90602 (6.14 percent). These high-loss areas are similar to those shown in figure 8. The reader can replot the loss contours to suit alternate viewpoints with the information shown in figure 10. Alternate valid limiting criteria will give somewhat different results, but the general locations of areas of highest losses will be the same. The extended north-south distribution of losses compared with its east-west distribution is not as evident in figure 10 as it is in figure 8. ZIP 91770, near the

Table 27. Dwelling loss experience for the 1987 Whittier Narrows earthquake: Insurance Source D

[Sorted in order of distance from the modeled energy release]

ZIP	ZIP TO FAULT RUPTURE DIST. mi.	NUMBER OF DWELLINGS WITH: EQ INS.	PAID CLAIM	PCT. PAID CLAIMS	*AGGREGATE DWELLING INSURANCE (dollars)	AGGREGATE PAID CLAIMS (dollars)	**PCT. LOSS	AGGREGATE INS. AMT. HAVING PAID CLAIMS (DOLLARS)
91733	0.6	34	2	5.88	2,187,000	1,660	0.10	100,000
91754	0.7	91	16	17.58	6,788,000	115,610	1.76	1,498,000
91770	0.7	85	2	2.35	6,174,000	7,830	0.13	116,000
91771	0.7	NA	1	NA	NA	9,650	NA	48,000
91732	0.9	53	1	1.89	3,232,000	500	0.02	75,000
91803	0.9	32	8	25.00	2,351,000	56,877	2.50	723,000
91731	1.4	28	1	3.57	1,878,000	8,041	0.44	104,000
91776	2.1	28	2	7.14	2,083,000	10,996	0.55	126,000
91801	2.1	37	10	27.03	2,892,000	49,819	1.81	973,000
90640	2.8	81	6	7.41	7,333,000	12,460	0.19	559,000
91780	2.8	99	11	11.11	7,897,000	60,973	0.81	890,000
91746	2.9	38	3	7.89	2,397,000	2,464	0.13	265,000
90022	3.2	22	2	9.09	1,708,000	6,961	0.44	133,000
90032	3.2	45	9	20.00	3,256,000	39,590	1.29	721,000
91030	3.6	18	3	16.67	2,106,000	30,109	1.47	289,000
90063	3.7	9	4	44.44	648,000	27,050	4.33	337,000
90601	4.1	79	26	32.91	6,241,000	344,121	5.62	2,094,000
91775	4.1	54	3	5.56	4,500,000	7,971	0.19	232,000
90660	4.8	177	22	12.43	12,308,000	92,889	0.80	1,859,000
91006	4.8	103	7	6.80	10,119,000	24,449	0.26	821,000
91790	5.2	152	3	1.97	11,800,000	13,933	0.12	209,000
90042	5.4	41	5	12.20	3,195,000	69,005	2.20	446,000
91745	5.4	145	5	3.45	13,277,000	23,853	0.19	449,000
90606	5.5	115	26	22.61	8,039,000	130,171	1.70	1,940,000
91106	5.5	7	2	28.57	672,000	2,787	0.49	247,000
91744	5.5	102	1	0.98	6,872,000	50	0.00	39,000
91016	5.8	78	2	2.56	5,484,000	18,120	0.34	151,000
90602	6.2	36	12	33.33	2,851,000	172,071	6.14	1,052,000
91107	6.2	40	3	7.50	3,275,000	10,495	0.34	313,000
91010	6.5	53	1	1.89	3,540,000	1,150	0.04	126,000
90041	6.6	27	4	14.81	2,730,000	23,198	0.89	502,000
90065	6.7	38	1	2.63	3,601,000	849	0.03	88,000
90240	6.9	56	3	5.36	5,397,000	5,758	0.12	341,000
90609	6.9	NA	2	NA	NA	5,545	NA	178,000
91791	7.4	68	3	4.41	6,179,000	11,880	0.20	305,000
90255	7.5	19	1	5.26	1,277,000	9,414	0.76	72,000
90026	7.6	5	3	60.00	623,000	17,855	2.99	321,000
90670	7.6	45	6	13.33	2,961,000	16,904	0.62	520,000
91024	7.6	19	1	5.26	1,738,000	4,180	0.25	155,000
91104	7.6	34	4	11.76	2,494,000	54,757	2.24	411,000
91792	7.9	30	2	6.67	1,899,000	2,035	0.13	217,000
90015	8.1	1	1	100.00	76,000	2,222	3.25	75,000
90039	8.2	16	3	18.75	2,041,000	6,502	0.36	392,000
90241	8.3	68	5	7.35	6,162,000	13,640	0.24	468,000
90605	8.3	127	30	23.62	10,796,000	123,558	1.21	2,837,000
90280	8.6	89	1	1.12	6,077,000	850	0.02	56,000
90603	8.6	103	17	16.50	8,944,000	68,573	0.81	1,714,000
91723	8.8	65	1	1.54	5,327,000	12,432	0.24	87,000
91206	8.9	16	1	6.25	1,792,000	600	0.05	147,000
90604	9.0	160	15	9.38	13,968,000	50,711	0.39	1,360,000
91001	9.0	43	2	4.65	4,462,000	5,460	0.13	333,000
91748	9.3	93	6	6.45	7,850,000	27,269	0.37	485,000
90027	9.6	4	1	25.00	319,000	1,950	0.69	75,000
90242	9.7	69	2	2.90	5,619,000	2,378	0.05	202,000
91724	9.9	65	1	1.54	5,561,000	3,730	0.07	85,000
90037	10.0	4	1	25.00	340,000	2,720	0.87	82,000
90631	10.1	137	10	7.30	13,008,000	20,445	0.18	1,281,000
90002	10.2	2	1	50.00	149,000	3,550	2.55	89,000
90650	10.3	201	6	2.99	13,092,000	14,295	0.12	463,000
90262	10.4	33	2	6.06	2,267,000	2,600	0.14	167,000

Table 27. Dwelling loss experience for the 1987 Whittier Narrows earthquake: Insurance Source D—Continued

[Sorted in order of distance from the modeled energy release]

ZIP	ZIP TO FAULT RUPTURE DIST. mi.	NUMBER OF DWELLINGS WITH: EQ INS.	PAID CLAIM	PCT. PAID CLAIMS	*AGGREGATE DWELLING INSURANCE (dollars)	AGGREGATE PAID CLAIMS (dollars)	**PCT. LOSS	AGGREGATE INS. AMT. HAVING PAID CLAIMS (DOLLARS)
90638	10.4	187	13	6.95	15,530,000	76,284	0.51	1,255,000
90003	10.6	4	1	25.00	244,000	10,450	4.39	70,000
90062	11.1	3	2	66.67	256,000	4,275	1.87	168,000
90221	11.7	20	1	5.00	1,507,000	3,170	0.23	89,000
90706	11.7	125	6	4.80	9,871,000	27,721	0.30	546,000
90044	11.9	11	1	9.09	871,000	4,218	0.51	66,000
90068	12.2	11	2	18.18	1,494,000	5,628	0.41	346,000
90043	12.4	18	3	16.67	1,817,000	23,612	1.34	269,000
90047	12.4	15	1	6.67	1,127,000	7,350	0.67	79,000
90008	12.5	9	1	11.11	803,000	3,550	0.47	73,000
90036	12.6	4	1	25.00	681,000	1,050	0.19	180,000
91765	12.7	68	1	1.47	5,394,000	2,825	0.06	94,000
90016	12.8	17	1	5.88	1,189,000	7,550	0.66	106,000
91773	12.9	97	2	2.06	8,864,000	3,007	0.04	169,000
92635	13.0	24	2	8.33	1,950,000	4,778	0.27	260,000
90220	13.3	13	3	23.08	847,000	12,536	1.57	243,000
90621	13.3	12	1	8.33	594,000	9,592	1.66	50,000
90305	13.4	5	1	20.00	370,000	5,800	1.64	93,000
91214	13.6	95	1	1.05	8,666,000	615	0.01	108,000
90805	14.1	102	4	3.92	6,435,000	30,526	0.49	255,000
91505	14.2	55	1	1.82	4,391,000	26,650	0.61	125,000
90712	14.5	117	2	1.71	9,007,000	10,844	0.13	183,000
90713	14.5	124	5	4.03	10,133,000	5,254	0.06	518,000
90301	14.9	15	1	6.67	971,000	570	0.08	112,000
91602	15.1	7	1	14.29	773,000	275	0.07	121,000
90620	15.2	105	1	0.95	8,451,000	4,035	0.05	77,000
90715	15.2	36	1	2.78	2,846,000	236	0.02	65,000
90249	15.5	33	1	3.03	2,287,000	2,660	0.13	50,000
90034	15.6	10	2	20.00	806,000	6,860	0.91	136,000
90230	16.0	27	3	11.11	2,264,000	4,241	0.22	269,000
90807	16.1	52	4	7.69	4,156,000	9,610	0.26	341,000
91766	16.1	80	1	1.25	5,703,000	534	0.01	89,000
90251	16.3	2	1	50.00	129,000	9,150	7.29	53,000
90630	16.5	94	1	1.06	8,081,000	1,281	0.02	62,000
90808	16.5	150	3	2.00	13,462,000	15,525	0.12	285,000
91042	16.5	55	1	1.82	4,316,000	1,020	0.03	48,000
91767	16.7	105	3	2.86	7,584,000	5,019	0.08	219,000
90260	17.2	18	1	5.56	1,112,000	4,450	0.42	62,000
92686	17.2	49	1	2.04	5,631,000	5,309	0.10	105,000
90504	17.4	46	4	8.70	4,319,000	25,382	0.61	423,000
92806	17.4	26	1	3.85	2,618,000	1,225	0.06	116,000
90066	17.7	36	1	2.78	3,973,000	3,950	0.11	222,000
90806	18.2	40	2	5.00	2,662,000	12,869	0.50	128,000
90720	18.6	56	2	3.57	6,059,000	2,780	0.05	232,000
90815	18.6	131	2	1.53	12,132,000	3,732	0.03	301,000
91763	18.9	71	1	1.41	5,119,000	514	0.01	125,000
92640	19.5	47	1	2.13	3,618,000	1,531	0.05	85,000
90405	19.8	7	1	14.29	585,000	3,125	0.58	58,000
90503	20.1	30	1	3.33	3,042,000	582	0.03	86,000
91451	20.6	NA	1	NA	NA	22,398	NA	182,000
91762	20.6	91	1	1.10	6,755,000	2,325	0.04	74,000
90803	20.7	24	2	8.33	1,486,000	5,925	0.43	224,000
90277	21.4	7	1	14.29	652,000	6,700	1.07	149,000
91786	21.5	177	3	1.69	15,405,000	10,498	0.07	225,000
92683	21.5	103	1	0.97	8,120,000	500	0.01	69,000
91406	22.8	46	1	2.17	3,667,000	1,125	0.04	128,000
91761	23.0	116	1	0.86	8,662,000	1,106	0.02	54,000
92647	23.5	97	1	1.03	9,621,000	2,000	0.02	116,000
91342	23.8	126	2	1.59	9,969,000	6,700	0.07	208,000
90732	24.3	32	1	3.13	2,338,000	725	0.04	101,000

Table 27. Dwelling loss experience for the 1987 Whittier Narrows earthquake: Insurance Source D—Continued

ZIP	ZIP TO FAULT RUPTURE DIST. mi.	NUMBER OF DWELLINGS WITH: EQ INS.	PAID CLAIM	PCT. PAID CLAIMS	*AGGREGATE DWELLING INSURANCE (dollars)	AGGREGATE PAID CLAIMS (dollars)	**PCT. LOSS	AGGREGATE INS. AMT. HAVING PAID CLAIMS (DOLLARS)
92705	24.5	25	2	8.00	2,786,000	4,956	0.20	276,000
91701	25.1	166	2	1.20	15,525,000	2,465	0.02	232,000
92680	25.1	35	1	2.86	2,555,000	1,562	0.07	81,000
91335	25.4	62	1	1.61	4,562,000	15,775	0.35	91,000
91344	26.0	114	3	2.63	12,749,000	15,403	0.13	427,000
92626	27.1	22	2	9.09	2,132,000	2,049	0.12	257,000
91306	27.8	57	1	1.75	5,105,000	1,223	0.03	94,000
91307	30.8	16	1	6.25	1,509,000	4,700	0.33	92,000
91321	31.4	63	2	3.17	5,206,000	27,741	0.54	293,000
91351	31.4	100	1	1.00	8,510,000	1,135	0.02	47,000
93550	35.2	469	1	0.21	35,215,000	618	0.00	77,000
93065	38.9	138	1	0.72	12,008,000	2,750	0.02	102,000
92371	39.2	27	1	3.70	1,735,000	500	0.04	54,000
93536	42.4	100	1	1.00	8,772,000	915	0.01	86,000
92629	44.2	15	1	6.67	1,745,000	3,650	0.22	80,000
92404	44.5	252	1	0.40	18,821,000	250	0.00	75,000
92346	47.2	190	1	0.53	16,031,000	1,657	0.01	133,000
92308	55.7	87	1	1.15	7,279,000	250	0.01	100,000
93004	61.5	56	1	1.79	4,502,000	366	0.01	100,000
92390	65.2	35	1	2.86	2,802,000	6,564	0.24	72,000
92008	74.0	89	1	1.12	7,026,000	880	0.02	103,000
92025	85.4	139	1	0.72	12,100,000	165	0.00	75,000
92261	98.2	2	1	50.00	113,000	465	0.63	113,000
92115	105.4	112	1	0.89	7,924,000	5,442	0.07	125,000
92042	105.8	44	1	2.27	3,174,000	2,318	0.08	60,000
92036	107.9	13	1	7.69	972,000	21,335	2.22	116,000
		9,230	480		754,125,000	2,466,399		44,549,000

NOTES: 1. Totals do not include NA entries. NA means not available.
2. Total of 146 ZIPs.
3. Number of pre-1940 dwellings with paid claims: 81
4. Number of post-1939 dwellings with paid claims: 392
5. Number of unknown age dwellings with paid claims: 7

*All earthquake policies, with or without paid claims.
**Aggregate paid claims plus $250 deductible per claim divided by aggregate dwelling insurance.

epicenter, has 0.13 percent losses for 85 policies, whereas adjacent ZIP's to the west have losses that exceed 1 percent. It should be noted that the low losses in the vicinity of the epicenter are common for both Insurance Sources C and D. Insurance Source D provides, as did Insurance Source C, some data for future microzonation studies.

Loss Over Deductible

Percent-loss-over-deductible versus percent-deductible relationships are not presented for Insurance Source D data due to the small amount of information in the PML zone. See similar discussion on Insurance Source C for additional limitations.

Loss Attenuation With Distance From Seismic Energy Release

Although an analysis of loss attenuation with distance from the source of seismic energy is not a goal of this study, this earthquake provided an opportunity to examine some of the problems associated with this subject. This opportunity was especially true for Insurance Source D because its low deductible resulted in more widespread losses than did the higher deductible that was commonly used by other companies.

A graph of percent loss as a function of distance from the fault rupture zone is shown in figure 11. Excluded were ZIP's that contained fewer than 20 earthquake policies. If these ZIP's had not been

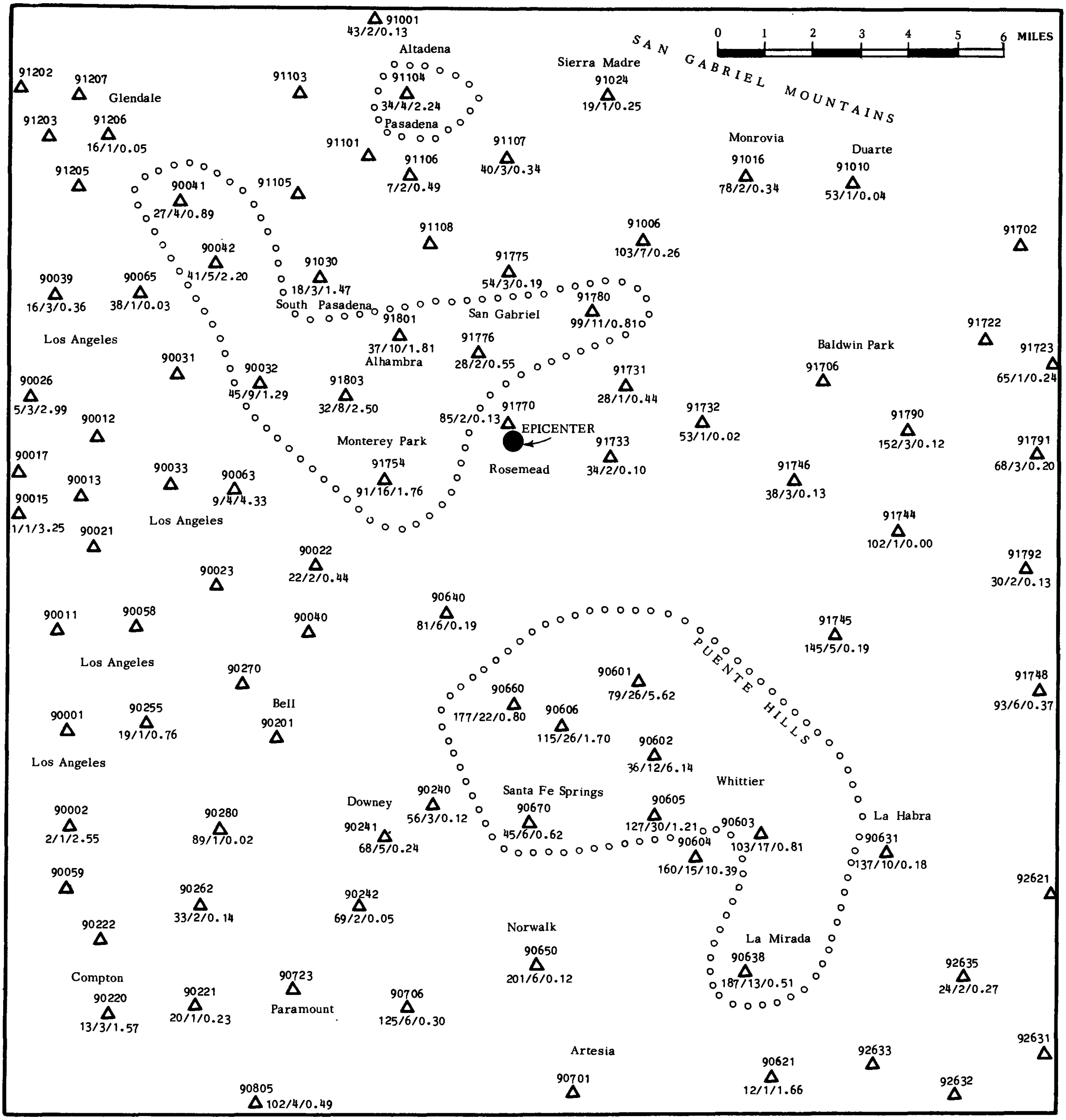

Figure 10. Map showing the epicenter of the 1987 Whittier Narrows earthquake and the location of the population-weighted ZIP centroids (open triangles). The ZIP number is shown above each triangle. Other numbers, such a 79/26/5.62, refer to loss data from Insurance Source D; see text for explanation. Lines of open circles enclose areas of higher than usual losses.

excluded, then even a moderate change in a single loss could have significantly affected the loss percentage. Also excluded were ZIP's with no paid claims. A straight-line equation determined by regression methods, which excluded losses greater than 1 percent and ZIP's with fewer than 20 earthquake policies, was essentially a level line. The implication is that damage did not noticeably attenuate with distance as far as 15 miles. Losses greater than 1 percent are in higher than average loss zones, possibly due to geophysical causes. This viewpoint has

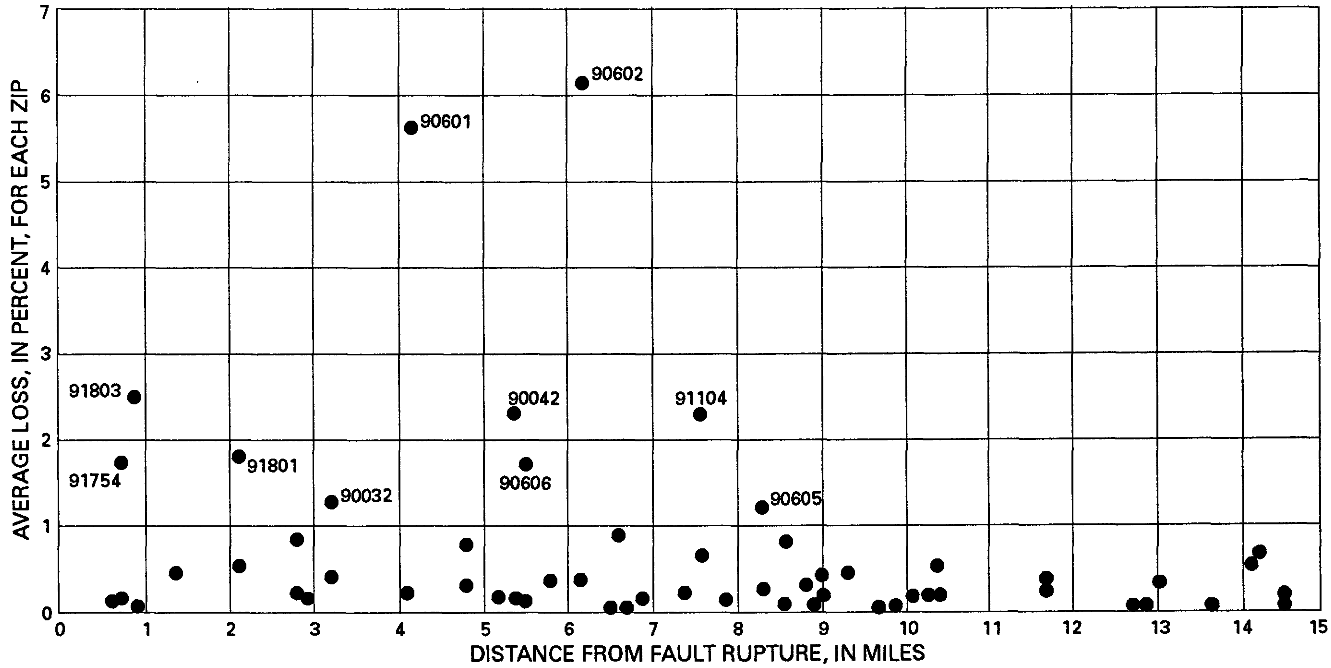

Figure 11. Graph showing average loss for each ZIP (dot) versus distance from fault rupture for the 1987 Whittier Narrows earthquake. ZIP's with no paid claims (that is, losses, if any, less than $250) are not shown. ZIP's with losses greater than 1 percent deducible are identified by ZIP.

serious limitations in the light of the east-west geographic distribution of damage (figure 10), but there is no evidence of a significant reduction in loss with distance in the north-south direction.

Figure 12 is another examination of the same data except that it is bracketed by ZIP into greater than 1-mile distances from the source of seismic energy release. The values greater than 1 percent show the effects of the two zones of high damage in figure 10. The graph suggests that attenuation begins at 8 miles.

Neither figure 11 nor figure 12 is definitive but is only suggestive at best. It should be recalled that all data for the 1987 Whittier Narrows earthquake include the effects of a deeper than usual focal depth and a smaller

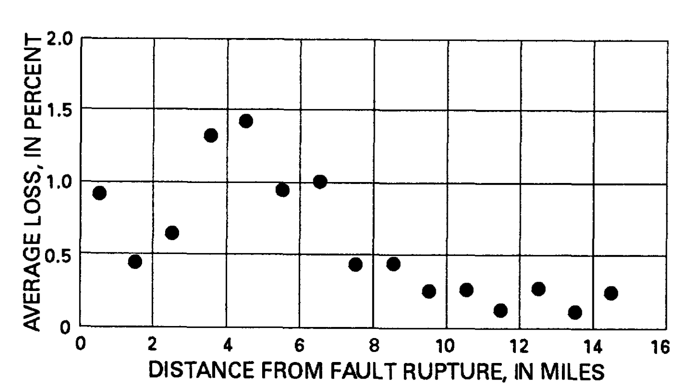

Figure 12. Graph showing average loss for 1-mile interval (dot) versus distance from fault rupture for the 1987 Whittier Narrows earthquake.

energy release than for the other earthquakes in this study. However, the observations are not in significant conflict with the assumptions for the PML zone discussed in the appendix.

OVERVIEW, FINDINGS, AND RECOMMENDATIONS

Overview

The private and public sectors need to know the amounts of the losses that will have to be supported by each sector, both on an aggregate basis and on an individual-dwelling basis. Apportionment of loss among the involved parties may be in the the form of (1) an insurance deductible, (2) a forgiveness feature in a government loan, or (3) other practices that divide the loss between involved parties. We explored our available data both with and without a deductible. It was evident that the amount and consistency of data were not fully satisfactory.

Insurance loss experience has been favored over that with governmental involvement because insurance loss does not include grants, biases to those claiming losses for tax-related purposes, incomplete or avoided repairs to save money, or improvements beyond repair to the original state (Steinbrugge and Schader, 1973).

Intensity Observations as an Alternative Data Source

Intensity observations have been used as the bases for loss estimation. In the United States, the Modified Mercalli Intensity (MMI) scale of 1931 (Wood and Neumann, 1931) is the scale most commonly in use. The MMI scale is a descriptive scale of earthquake effects with 12 degrees or grades which range from I (not felt) to XII (damage nearly total). The grades of intensity of most interest in describing damage are VI (minor nonstructural damage) through X (most masonry and frame structures destroyed). Intensity maps have been prepared for many earthquakes and published in the technical literature. Two Federal agencies, the U.S. Coast and Geodetic Survey (1928–1973) and the U.S. Geological Survey (1974 to the present), have undertaken routinely to produce both listings of intensities and maps for all significantly felt earthquakes in the United States. These studies represent by far the largest available data base of descriptions of earthquake damage. As has been frequently noted (for examples, Steinbrugge and others, 1984; Steinbrugge, 1986), there are a number of problems in the use of MMI data in loss estimation. For examples:

(1) The descriptions of damage to structures are too general.

(2) The descriptions of damage refer to a building stock that is not representative of the contemporary building stock; that is to say, the characteristics of the contemporary building stock have changed significantly since the publication of the MMI scale in 1931.

(3) Intensity data are generally presented as contour maps (isoseismals), and the actual observations of intensity may or may not be plotted on the map. Because contouring is a smoothing process, the actual distribution of intensities may be generalized in an undesirable way for loss estimation.

(4) The practice in the United States has been, at least in the routine intensity investigations of the two Federal agencies mentioned above, to assign the highest observed intensity to any given area, even though this intensity (or degree of damage) may not have been widely observed. Thus, it is difficult to determine what percentage of dwellings in an area assigned a particular intensity have actually experienced that level of intensity.

The use of intensity data, therefore, poses a dilemma. The large data base of intensity observations provides only a general guide to the distribution and percent damage by class of construction that is required for loss assessment. Detailed damage studies as presented in this paper are preferable but are usually not available. Numerous attempts have been made to describe damage by class of construction in terms of intensity (Algermissen and Steinbrugge, 1978; Applied Technology Council, 1985); success has been limited.

Intensity data may possibly be integrated into loss studies in another way. Figure 13 shows the distribution of intensity with distance (X) from the fault rupture for earthquakes in northern California. I is the intensity at any distance, and I_0' is the mean maximum intensity. Note that intensities vary around the regression curve by several degrees of intensity. Although some of the variations in intensity probably reflect errors in assignment of intensity, much of the deviation from a smooth attenuation curve is related to site response. Site response is taken here to mean the modification of ground shaking (and hence damage) related to the geotechnical properties of the materials beneath the site to depths of about 1 kilometer (0.6 mile) or less.

The analysis of these site effects in terms of the detailed loss studies in this paper would be a worthwhile endeavor as it would provide additional information for the estimation of future losses.

Table 28 lists five well-studied earthquakes for which intensities shown on the customary isoseismal maps can be compared with actual losses. The isoseismal map of the 1969 Santa Rosa earthquake (Steinbrugge and others, 1970, p. 95) provided the basis for reproduction in publications such as "United States Earthquakes, 1969" (von Hake and Cloud, 1971). The most severely damaged dwelling areas were examined to develop a dollar-loss map (Steinbrugge and others, 1970, fig. 18). Rinehart and others (1976) then estimated the Modified Mercalli Intensities to be V for Zone A, VI for Zone B, VII for Zone C, and VIII for Zone D, and obtained dwelling values. We computed approximate average percent losses for each zone, except Zone D where no useable upper bound existed; these percentages are listed in table 28.

For the 1971 San Fernando earthquake, Rinehart and others (1976, p. 36) refined the Scott (1945) isoseismal map to show zones of MMI VII, VIII, and IX. We computed the 13.2 percent loss using the previously described individual damage inspections of about 7,890 houses in the Rinehart and others (1976) MMI IX region. Adequate field-inspection data do not exist for other intensities.

Table 29 is another viewpoint of the intensity-loss correlations of the 1971 San Fernando earthquake. Field inspectors were trained for their roles in intensity evaluation. A special DAJ intensity scale (Johnsen and Duke, 1973) was developed to suit local conditions. In general, the DAJ scale was "designed to correspond roughly with the Modified Mercalli Scale of 1931" (Johnsen and Duke, 1973). The vast majority of the observed structures were single-family wood-frame

Table 28. Modified Mercalli Intensities and dwelling percent losses: Five California earthquakes

Earthquake	Modified Mercalli Intensity	Percent Loss (and Reference)
1933 Long Beach	VII-IX (1)	Less than 5% (see text under "1933 Long Beach Earthquake")
1969 Santa Rosa	VII-VIII (2)	Undetermined
	V	0.2% (see text)
	VI	1.6% (see text)
	VII	6.8% (see text)
1971 San Fernando	X (3)	9.03% (Table 2)
	IX	13.2% (see text)
1983 Coalinga	VIII (4)	20.16% (Table 9); 15.70% (Table 14)
1987 Whittier Narrows	VIII (5)	5.62% (Table 27, ZIP 90601)

Intensities from customary isoseismal maps found in:
(1) Neumann (1935). See Fig. 2 (MMI = VIII) and page 11 (MMI = VII-IX).
(2) Scott (1970) in Steinbrugge and others (1970). See page 95.
(3) Scott (1973). See Fig 2.
(4) Stover (1987). See Fig. 13.
(5) Kawase and Aki (1990). See Figs. 1 and 2.

dwellings; other kinds of construction materials and occupancies were commingled. The correlations between percent loss and intensity are better than those found in table 28 but still not as satisfactory as one might desire for loss estimation. MMI X in table 28 probably represents maximum rather than average conditions, whereas intensities in table 29 probably represent average conditions.

Historically, percent loss has been derived from intensity. One may view this relationship in the reverse order by defining intensity in terms of percent loss as shown in figure 7 of Rinehart and others (1976). Our reexamination of the source data determined that the original percent losses were incorrect due to subsequent improvements in dwelling component damage ratios and also probably due to programming errors in the no-longer-extant original program. Figure 14 shows the corrected percent-loss values for all dwellings in each tract, regardless of age. Setting these problems aside, the general outlines of the intensity areas as a function of

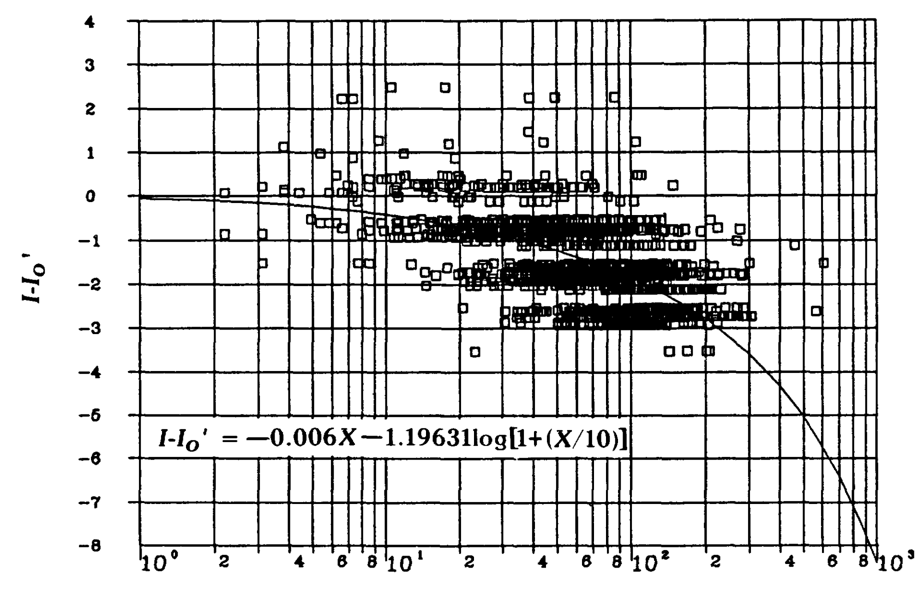

Figure 13. Graph showing intensity versus distance from fault rupture for earthquakes in northern California. I is the intensity at distance X from the fault rupture, and I_0' is the mean maximum intensity.

Table 29. Modified Mercalli Intensities and dwelling percent losses: 1971 San Fernando earthquake

Intensity Location	Percent Loss	Estimated DAJ Intensity
T:4	19.3%	8.5
T:13	14.4%	8
T:14	11.9%	8.5
T:6	11.7%	7.5
T:1	11.6%	8
T:5	11.6%	8+
T:2	10.7%	8-
T:3	9.9%	7.5
T:11	9.5%	6+ or 7
T:16	9.1%	8-
T:10	6.9%	7
T:17	5.6%	6+ or 7
T:22	4.7%	7
T:12	3.7%	7

Intensity location and percent loss are from unpublished data in the files of K.V. Steinbrugge and S.T. Algermissen.

Intensities from Johnsen and Duke (1973, fig. 1).

percent losses remain similar. The stippling of the tracts in figure 14 distinguishes tracts that have losses greater than 9 percent from those that have losses less than 9 percent. One prominent zone of losses greater than 9 percent is along the base of the San Gabriel Mountains; another zone is in an area of ground disturbance on the valley floor. These ground disturbances were related to surface faulting (plates in Steinbrugge and others, 1971; Oakeshott, 1975). A few areas of high percent losses extend southwesterly from this zone, which suggests a continuation of the ground disturbances. Another small zone contains tracts 19 and 31 and may be related to the nearby liquified soil area. Had the intensity criteria been applied only to new houses, then tracts 16 and 19 would have had losses just less than 9 percent, which would not have resulted in significant changes to the MMI IX zones.

Despite this criticism, isoseismal maps can be excellent in a qualitative sense. Consider the 1987 Whittier Narrows earthquake. Figures 8 and 10 compare reasonably well with figures 1 and 2 of Kawase and Aki (1990).

In summary, isoseismal maps can be used for loss-estimation purposes if better data are not available. Table 28 exemplifies the problems. Continued development of the thinking behind figure 13 is expected to produce better results in loss-estimation methods, which, in many regions, must rely solely on isoseismal maps.

Findings

Insurance-company data are considered to be more reliable than our data in the 0–20 percent range where such insurance-loss experience exists. Our methods are satisfactory for approximate loss estimations at 0 percent deductible immediately after the earthquake and also for regions where no insurance-loss experience exists.

With the presently common 10 percent deductible on dwellings in California, it is likely that future insurance-loss experience under a 10 percent deductible will be limited because most losses are less than 10 percent. Thus, there is increasing interest and need to develop alternate methodologies for estimates of losses that might not be covered by insurance.

Somewhat parallel lines of inquiry have been followed during the examination of PML and loss over deductible, as discussed below.

Probable-Maximum-Loss (PML) Approach

The PML approach is in conventional insurance use for all classes of structures. As discussed in the appendix, PML has its origin in the commercial and industrial insurance markets for which loss estimates are commonly made on an individual risk basis. Loss estimates for wood-frame dwellings are not commonly made on an individual risk basis.

Loss-distribution curves for building classes other than wood frame and all metal are approximately

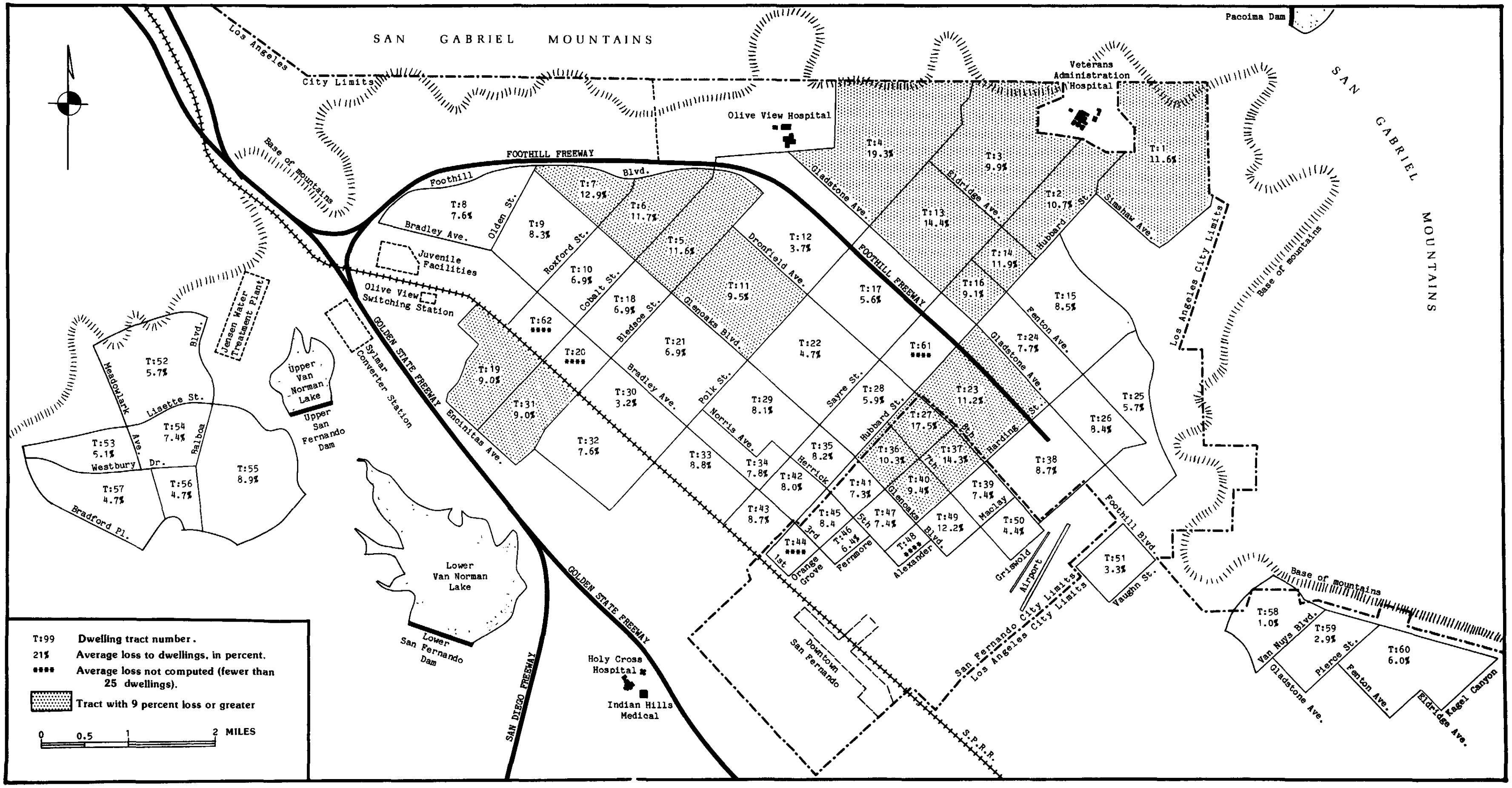

Figure 14. Map showing the city of San Fernando and the Sylmar and Pacoima districts of Los Angeles, which were part of the 1971 San Fernando earthquake region. Percentages indicate the average losses to dwellings of all ages in the numbered tracts (for example, 14.4 percent in tract 13).

symmetrical or skewed to the right. As an example of skewing to the right, unreinforced-brick masonry structures have conventional PML's of 70 percent at 0 percent deductible. The peak of PML for unreinforced-brick masonry structures may be about 70 percent, whereas the PML for wood-frame dwellings is highest from 1 percent to about 9 percent.

The effect of deductibles on aggregate losses for high-PML building classes, such as unreinforced-brick structures, is much less than that for low-PML dwellings. For example, using a 10 percent deductible, a 70 percent PML unreinforced-brick structure will have a loss over deductible of 60 percent on a simplistic, but realistic, analysis basis. Wood-frame dwellings with their low PML's must be considered on a more sophisticated basis; see appendix under "Sensitivity: Loss over deductible versus dwelling PML changes." If the PML and the deductible are close, the relationships between them must become more complex to preserve accuracy.

The softness in the dwelling PML values is evident in all distribution curves. The weaknesses in the PML approach when applied to dwellings warrants an examination of an alternative approach, such as one based on loss-over-deductible experience.

Loss-Over-Deductible Approach

Loss-over-deductible curves and data from various sources and earthquakes were adjusted for commonalities in construction and geologic conditions and also modified for a variable magnitude.

Equations for loss over deductible are given below and are applicable for the range of 0–20 percent deductble. These equations apply to one-story, one-and-two-story, split-level, and two-story wood-frame dwellings that have floors of any kind with exclusions as previously mentioned. The regression equations used data from table 17. Arrangement of the terms in the equations is:

(Loss over deductible) = (State factor from table 21) × (magnitude factor) × (regression equation with uncertainty factor F)

Equation 1, pre-1940:
$$Y = (1.00) \times (0.114 M + 0.259) \times (8.354 F e^{-0.05389 X})$$

Equation 2, post-1939:
$$Y = (1.09) \times (0.114 M + 0.259) \times (3.308 F e^{-0.1843 X})$$

Equation 3, all ages:
$$Y = (1.18) \times (0.114 M + 0.259) \times (4.251 F e^{-0.1053 X})$$

where Y = loss over deductible, in percent,
X = deductible, in percent
M = earthquake magnitude, and
F = uncertainty factor (1.50, but user-changeable).

Simplifying for general use, with M = 8.25 as the maximum credible magnitude:

Equation 4, pre–1940: $Y = 15.031 e^{-0.05389 X}$
Equation 5, post–1939: $Y = 6.488 e^{-0.1843 X}$
Equation 6, all ages: $Y = 9.025 e^{-0.1053 X}$

Table 22 is derived from equations 4–6. Values in this table include an uncertainty factor of 1.50, and the values may be changed to any other factor by direct proportion. Figure 15 is a graphical representation of equations 4–6.

The loss-over-deductible approach acknowledges that dwellings can be treated differently from mercantile and commercial structures in both insurance and governmental loss-estimation methods. It is a direct approach and, although the data remain inadequate, is

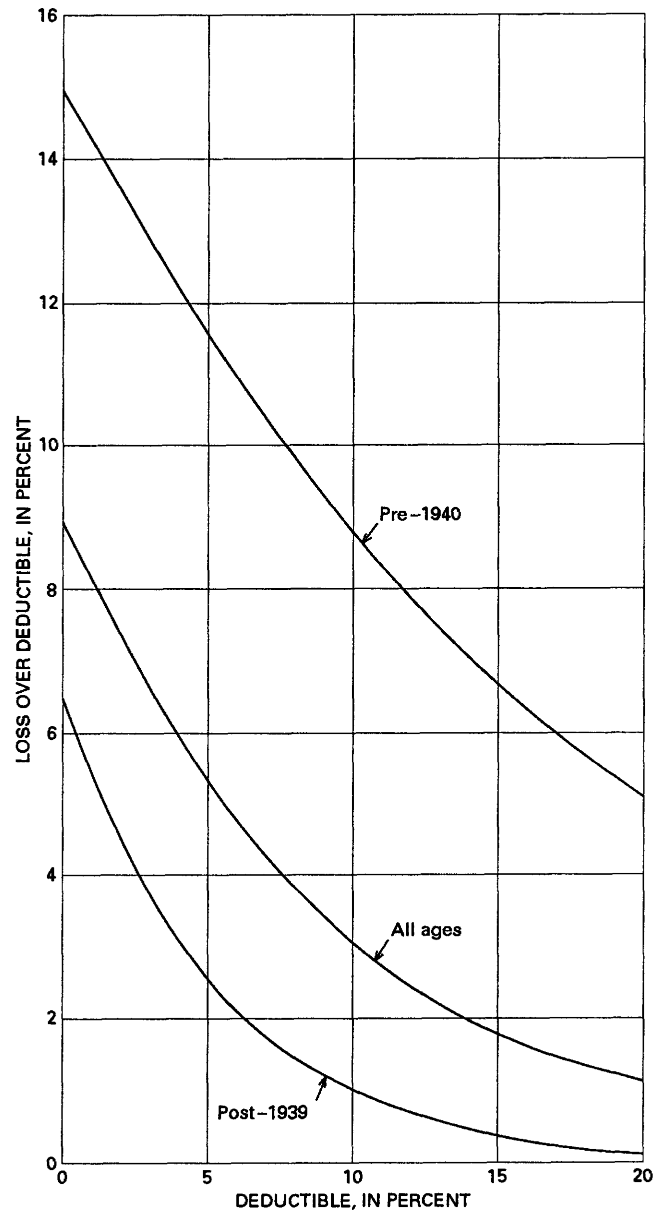

Figure 15. Graph showing recommended loss over deductible versus deductible, based on equations 4–6.

far better for use with dwellings than the approaches that are commonly used with non-dwelling structures. Finally, the readily changeable "uncertainty factor" is more easily understood and applied than is the "9 out of 10" PML definition.

For these reasons, we prefer the loss-over-deductible approach.

Applications to Simpler Methods

The California Department of Insurance uses a class PML that is applicable to all dwellings in each zone. The zones normally have political boundaries, which are influenced by major known active faults. The class PML does not directly recognize differences in soil conditions or distances from potential earthquakes. Exceptions are Zones A and B where subzones were established to consider partially the distance from potential earthquakes (Steinbrugge, 1982, chap. 9).

A better PML for dwellings can be established for each zone that has major known faults using a method based on an updated census inventory of dwellings and values. The maximum aggregate loss for the zone can be developed if the inventory data are processed by more sophisticated loss-estimation methods. These methods include variables such as the magnitude of the maximum credible earthquake, damage attenuation with distance, and soil factors. This maximum aggregate loss should equal the aggregate loss from the Department of Insurance's PML methods for each zone. It is possible for the Department of Insurance's percent PML for each zone to be changed so that the losses computed by each method are equal.

For a computational example, assume that the more sophisticated methods determined a $10 billion aggregate loss in a given zone that has no subzones. The aggregate losses are computed by the Department of Insurance by multiplying aggregate values in that zone by the Department of Insurance-assigned percent PML. Equating this $10 billion loss to this method:

$10 billion = (aggregate dwelling values, in billions of dollars) × (PML, in percent),

with the unknown being the PML. This PML is an average value for the zone and includes effects from soils and distances from faults. The PML can be applied to any other inventory of dwellings that is distributed in a manner reasonably consistent with the general housing throughout the zone. This is the normal case.

Other Findings

Older dwellings did not perform as well as did newer dwellings, with the dividing date being 1940. This decision was made in 1971 and has been maintained for the purpose of data consistency. The current validity of this 1940 dividing date was examined on a decade-by-decade basis for the 1987 Whittier Narrows earthquake using all the information from Insurance Source C:

Age Group	Number of dwellings	Percent loss
Pre–1920	92	0.74
1920–29	382	1.29
1930–39	534	0.70
1940–49	1526	0.24
1950–59	5994	0.23
1960–69	5440	0.21
1970–79	3996	0.07

The percent loss is the average for all dwellings in their respective age groups. We judge that the 1940 dividing date remains appropriate, that is, pre-1940 and post-1939 construction.

Structures with supported-wood first floors did not perform as well as did those with concrete slabs on grade if age was not a factor. However, performance was about equal among newer structures.

Recommendations

Overall, the available records of quantified loss experience for dwellings remain unsatisfactory. In addition, this experience is only from moderate earthquakes, and extrapolations to the maximum credible earthquake require major judgmental considerations for insurance purposes. These judgmental considerations need much more study. Isoseismal maps are the only recourse in some circumstances.

Appropriate data gathering after all damaging events should be conducted on a consistent and unified basis. The effort should include the public and private sectors. Gathered information should be made available in a prompt manner to all interested so that many investigators can study the losses. It may best be accomplished through an entity having this goal as one of their mandates. Funds possibly can come from some type of charge to financial institutions and others having a need to know. Logical entities can include state, Federal, and the insurance industry, among others. Data gathering should include much more than dwellings. The kinds of gathered information may be based on the California Department of Insurance's "Call for Data" for loss experience on the 1989 Loma Prieta earthquake ("San Francisco" earthquake).

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PROBABLE–MAXIMUM–LOSS BACKGROUND INFORMATION

APPENDIX

PROBABLE–MAXIMUM–LOSS BACKGROUND INFORMATION

Definition of Probable Maximum Loss

Probable maximum loss (PML) is a term commonly used in California earthquake-insurance loss estimation. The California Department of Insurance (1981, p. 6) defined PML in "California earthquake zoning and probable maximum loss evaluation program" as follows:

> The *probable maximum loss* for an individual building is that monetary loss expressed in dollars (or as a percentage of insured value) under the following conditions:
>
> (a) Located on firm alluvial ground or on equivalent compacted man-made fills in a probable maximum loss zone (defined later), and
> (b) Subjected only to the vibratory motion from the maximum probable earthquake, that is, not astride a fault or in a resulting landslide.
>
> The building *class probable maximum loss* (class PML) is simplistically defined as the expected maximum percentage monetary loss which will not be exceeded for 9 out of 10 buildings in a given earthquake building class under the conditions stated in the previous paragraph. The loss to the tenth building may be quite anomalous due to poor design or construction peculiarities, or to unusual earthquake motions and building response, or geologic hazards. *** Henceforth, when PML is stated in this report, class PML is the intent unless the context of the text is clearly to the contrary.

The California Department of Insurance (1981, and annually thereafter) report for 1989 states on page 24: "PML, for the purposes of this report, is defined as the average probable maximum insured loss which will be experienced by 9 out of 10 buildings (the atypical loss being excluded) in a given earthquake building class in a specified earthquake zone."

Further information may be found in Steinbrugge (1982, chap. 9). The 1981 PML definition, if applied to dwellings, must be considered in the context of its commercial/industrial origins, as discussed in the following section.

Zones used by the California Department of Insurance are practical applications of a geologic model. The California geologic PML zone applies to the maximum credible earthquake for insurance purposes on each insurance-important fault. Some insurance-important faults are the San Andreas, Hayward, Calaveras, Newport-Inglewood, Whittier, Elsinore, Malibu, Raymond, San Fernando, San Jacinto, Imperial, Arroyo Parida, and Rose Canyon faults, among others, all of which are insurance important due to being in heavily populated areas. The geologic zone boundary is defined as being 6 miles on either side of a strike-slip fault rupture such as found on the San Andreas fault. For other types of faults, the surface projection of the seismic energy modeled as a line source at depth replaces the surface rupture. The maximum credible earthquake on a major fault, which is implicit in the definition of PML, normally results in rupture of the surface. Where the geologic model does not apply, such as the central valleys of California, county boundaries are selected on the basis of area and population.

Origin of Wood-Frame-Dwelling Probable Maximum Loss

PML loss-estimation methods were developed over a period of years by the structural engineers of the Pacific Fire Rating Bureau. Applications were limited to commercial and industrial buildings on an individual risk basis. These dollar PML's were used by company underwriters to determine their lines and, for several companies, to determine their aggregate losses over deductible on an individual-risk basis.

Dwellings were included in the building classification system of the Pacific Fire Rating Bureau and its successor Insurance Services Office. As a consequence, a PML for wood-frame dwellings was also available; this was a secondary consideration because the underwriters of specific risks almost never asked for data on such dwellings. Although PML methods were widely known and used in California, most of this information was not published prior to the beginning of the California Department of Insurance's earthquake program in 1981.

The original concept of earthquake PML was patterned after fire whereby emphasis was placed on a single building or group of buildings at a specific site. This is an appropriate basis for a conservative loss estimate for a single risk in the event of a severe earthquake located in the near vicinity. Clearly, buildings situated miles away from the shock will experience lesser damage. It follows that 1,000 wood-frame dwellings spread over a large area would not experience the PML at each site if located on firm soil. Secondly, the "9 out of 10 dwellings having that PML loss or less," although reasonable for a single structure if underwritten on that basis, may become quite conservative for 1,000 dwellings that are scattered throughout an underwriting zone.

A 7 percent PML was established for dwellings on the basis of the 1933 Long Beach experience, which was the only data available at that time. Subsequent discussions in the 1970's asked if an 8 percent PML would be more appropriate, but no action was taken to apply the 1971 San Fernando experience.

The California Department of Insurance (1981) in its first report adopted the commonly used PML values for all classes of construction, including 7 percent PML for dwellings (at that time the deductible was 5 percent). This had the concurrence of the National Committee on Property Insurance. It was a reasonable decision for dwellings in view of the State budget constraints, time requirements for program implementation, companies' abilities to respond, and objectives of the program at that time. The common deductible has risen from 5 percent to 10 percent since then, and the latter value is usually given emphasis in this study.

Sensitivity: Loss Over Deductible versus Dwelling PML Changes

There is frequent confusion when using the term "percent PML." The commercial/industrial underwriters emphasize individual risks in their loss evaluations, whereas the personal lines underwriters emphasize large numbers of risks. Commonly stated, the percent PML minus the percent deductible is the percent loss over deductible. In a mathematical sense:

(percent PML) – (percent deductible) = (percent loss over deductible)

These terms may be re-arranged:

(percent PML) = (percent loss over deductible) + (percent deductible)

This latter form is used in the following discussion. The percent PML for wood-frame dwellings is not a fixed value because it is always in the context of a deductible plus the loss over deductible. For example, consider a damaging earthquake during which 1,000 wood-frame dwellings in a small area are subjected to the same severe ground motion. First, assume that two dwellings are total losses and the others have losses distributed between 0 percent and 100 percent. With a 10 percent deductible and using the current State of California's 1.5 percent loss over deductible, the result is a 11.5 percent PML. Next assume a highly improbable deductible of 95 percent. There still would be at least two dwelling losses greater than the 95 percent deductible. The percent PML for the 1,000 houses would therefore have to be the 95 percent deductible plus a very small loss over deductible to reflect the two total losses plus any other losses between 95 percent and 100 percent. In summary, the percent PML varies as a function of the percent deductible and may never be less than the percent deductible.

If the percent PML is close to the percent deductible, as in the case of wood-frame dwellings, the percent loss over deductible is very sensitive to any change in the percent PML. Consider a 10 percent deductible with a 11.5 percent PML for wood-frame dwellings. For $1 billion in wood-frame-dwelling liabilities, the loss over deductible would be 1.5 percent of $1 billion, or $15 million. However, should the maximum credible earthquake actually produce a 12.5 percent PML, instead of an 11.5 percent PML, then the loss over deductible would be 2.5 percent, or $25 million. In this case, a 1 percent increase in the percent PML creates a 67 percent increase in the aggregate dollar PML.

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