

LOSS ESTIMATION FOR INSURANCE PURPOSES: UNITED STATES PRACTICES

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INTRODUCTION

The cultural and political environments in which insurance companies, their service organizations, and insurance regulators must exist will vary from country to country. Even within a nation such as the United States where regulation is on a state by state basis, laws governing the functions of regulators and responsibilities of insurance companies need not be the same in each of the 50 states.

Earthquake loss estimation practices vary within these environments. In some countries, overall insurance practices (fire and other perils) may have some of the aspects of a cartel. Where rates are semi-automatically set on an industry wide basis to reflect the previous year's experience, insurance service organizations and some companies may not have the same loss estimation incentives as those in other countries under more competitive conditions. This can be reflected in insurance rules and practices regarding building classification systems. For example, earthquake resistive design may or may not be included in the insurance rates and rules. Organizations may not have the technical competence to implement their own engineering and loss control rules. Other cases exist where the building classification system is so simple that loss estimation methods can not realistically use data from insurance field inspections. An overly competitive environment can have similar effects.

United States practices are not considered to be models for other countries, rather approaches to solutions which may be modified to suit the needs of others should similar conditions exist. Problems and limitations of United States practices are also examined in this presentation.

With this as a background, let us turn to United States practices having emphasis on those of the State of California.

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Monetary loss estimates related to insurance may be prepared from several viewpoints. Earthquake insurance premiums may not be the principal motivation in the assured's decision-making process when they, a multinational company may wish to upgrade the safety of their more vulnerable structures for a variety of reasons, one of which can be earthquake insurance. It often occurs that the costs necessary to earthquake retrofit a vulnerable structure are not cost-effective from solely an insurance premium standpoint, and other considerations then prevail.

A property-casualty insurance company will have economic constraints imposed by the amount of the earthquake premium and the overall business desirability of the account.

Reasonable monetary loss estimation methods are available from a number of sources, albeit with results which may differ widely. The user company may wonder about these discrepancies, since the practitioners are often engineers and scientists who understand earthquakes and use computers - therefore their results "must be correct".

First and foremost, loss estimation is by no means an exact science, rather a combination of art and science. The art exists in the experience plus the judgment capabilities of the consultant, or underwriter, or loss control person.

Before proceeding further, it is fair to state that the judgments of the qualified practitioners are generally very good; this observation is based on over 25 years experience during which some 20 to 30 loss estimation methodologies have been examined. A serious caveat; not all judgments are necessarily equally good.

Discussion is limited to direct damage, and not to workers compensation, ensuing fire, liability, and the like - any of which may equal or exceed the losses from direct damage.

CONSTRAINTS ON UNITED STATES
AND CALIFORNIA PRACTICES

The quality of the information received on each risk's construction characteristics greatly affects the quality of the loss estimation. There is currently a trend, for principally economic reasons, among the large majority of the property-casualty insurance companies and their service organizations to decrease their in-house structural and earthquake engineering capabilities. Costs involving the examination of construction drawings plus a detailed field inspection, which should be included in the insurance premiums, do not allow this for all but high value structures. Relying on the "law of large numbers", there is a growing tendency to group buildings by simple construction classes or other parameters identifiable by non-specialists.

Underway are the beginnings of a second growing trend whereby all field information received from the non-specialist in the field is directly processed by computer with minimal, if any, underwriting review. This has its greatest potential application with dwellings.

The final uses of this information are two-fold: (1) ratemaking which requires additional knowledge on earthquake recurrence intervals, and (2) loss estimation to determine company solvency after an earthquake. The latter of these is given considerable attention here.

ON BUILDING CLASSIFICATION

The earthquake classification system of the Insurance Services Office (ISO) is most commonly used by insurance companies, sometimes with minor modifications. Few exceptions exist where an individual company or group of companies have their own system for their special needs.

It is our experience that many newer earthquake resistive buildings are incorrectly or inappropriately classified in today's insurance practice. For an example of a classification problem, the field person must recognize that earthquake reinforced brick walls exist in the Los Angeles metropolitan area only in post-1933 construction as a consequence of changes in the building codes following the 1933 Long Beach earthquake. Certain visually obtained construction characteristics can assist in this determination for regions outside of the greater metropolitan Los Angeles area.

For another California example, damage characteristics of wood frame dwelling are functions of age, masonry veneers (if any), masonry chimneys, and other features requiring no significant technical knowledge for their identification. These are types of earthquake related characteristics which, if recorded by the non-engineer, allow the use of appropriate computer programs to develop adequate dollar and percent PMLs. The phrase "Probable Maximum Loss", or PML, is commonly used in earthquake insurance

(reference 1 : chapt. 9). Conventionally, PML can be expressed without a dollar or percent sign, and the context indicates which is meant. The trend is toward obtaining these kinds of dwelling characteristics, including field identifiable regional construction practices by age, mapped microzoned soil characteristics and fault locations, which can be related to building location using a suitable computer data base of fault locations.

For best data transferability among companies and to a regulator, any building subclassification system used should be compatible with the ISO classification system. These subclassifications can readily become modifiers and amplifiers to the ISO system. It is not always easy for engineers and scientists to accept simplified low cost classifications systems as being the economical solution.

COMMENTARY ON SPECIFICS OF
LOSS ESTIMATION METHODOLOGY

Computational methodology for California and other western states having seismic environments involve many factors, some of which are briefly reviewed here.

1. Earthquake Faults:

Most building damage is the consequence of ground vibrations resulting when sudden, rapid movement occurs along a fault. This movement and the resultant shaking constitutes the earthquake.

There are many, many faults on many, many fault maps. Without respect to time, any of them can be active again. From an insurance company solvency standpoint, it is the large earthquake in a large metropolitan area which may create a company solvency problem. For California, the wall-size "Fault Map of California with Locations of Volcanoes, Thermal Springs and Thermal Wells" may be considered to be the State's evaluation of the more important active faults (reference 2). The so-called "Special Studies Zones Maps" by the same agency are amplifications of the previously mentioned map, but their considerable detail usually makes them impractical for risk-by-risk use (reference 3).

The geographic coordinates of these faults can be placed in a computer file. The computer can then quickly determine the distance of any risk located by address to any fault in the computer data file.

Scientific knowledge on earthquake recurrence intervals is not very satisfactory from an insurance standpoint. Probably the best known are those for segments of the San Andreas fault system, and these have large uncertainty factors (reference 4). Recurrence intervals on lesser faults become somewhat speculative, especially when they are carried to three significant figures. Generally, the computational sophistication exceeds the quality of the data.

A supplementary approach which requires a probabilistic model considers the effect of all faults on a particular site. The relative effect at any site of an earthquake occurring on a particular fault is then the probability that an earthquake will occur on that fault in some period of time of interest (say 50 years). All known (or postulated) faults can be combined into a model which will provide an estimate of the ground motion at the site with, say a 90-95 percent probability in 50 years.

2. Magnitude, focal depth, and rupture length of earthquakes:

For company solvency purposes, the maximum credible earthquake on each fault is of interest as are the expected focal depth and rupture length.

There is reasonable consensus regarding the maximum credible earthquake on major faults. In the San Francisco Bay Area, an 8 1/4 Richter magnitude earthquake is generally assumed for the San Andreas fault, and a magnitude of 7.5 or less for the other two major faults (Hayward and Calaveras) in the heavily populated areas. In Los Angeles, the maximum magnitude usually ranges between 7 and 7.5 for faults such as the Newport-Inglewood.

The distance from the earth's surface to the point where the fault rupture first starts, or focal depth, averages about 10 kilometers (6 miles) throughout the state. This means that data from historic California earthquakes can be used elsewhere in the state when the other seismic parameters are similar.

This information is not always transferable to other states. In the Puget Sound region in the State of Washington, focal depths of damaging shocks can be over 40 kilometers, or over 24 miles (reference 5). Generally, the deeper the focal depth the less damage is to be expected. Damage patterns among building classes also change. Therefore, California loss estimation practices must be modified if used in Washington. Additionally, California practices cannot be directly applied to states east of the Rocky Mountains (reference 6). Companies should carefully examine those computer programs which claim to have universal application to determine if such programs are appropriate for evaluation of their risks.

The anticipated length of the fault rupture during an earthquake, although difficult to forecast, is an important parameter when determining the areas where damage is to be expected. Figure 1 shows the fault rupture with idealized encircling lines representing equal damage. Damage decreases with distance from the fault in a uniform manner if geological conditions are uniform (which, in the real world, they are not). The length and location of the rupture determines the location of the damage area. Magnitude determines the length of the rupture. Considerable world-wide data exist (reference 7). Judgments do vary regarding the best way to select among the available fault rupture information, but normally

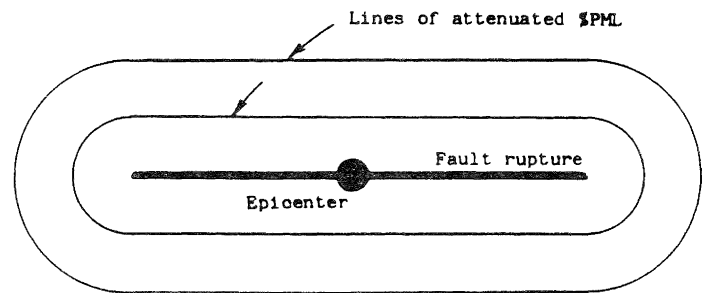


FIGURE 1 PLAN VIEW (MAP) OF IDEALISED ATTENUATED %PML.

this should not cause serious discrepancies in the aggregate loss estimates.

3. Loss Attenuation:

It seems that some of the greatest problems arise when establishing percentage PMLs by class of construction and then attenuating these with distance, that is, determining how losses decrease with distance from the fault rupture.

Most loss estimation methods use historic data expressed in the form of Modified Mercalli (MM) intensities. These intensities are mapped after they are gathered either by post earthquake field damage surveys or questionnaire mail surveys. The written description for each intensity is used to determine the percent PML for each intensity. The following is extracted from the Modified Mercalli scale for unreinforced brick bearing wall buildings having sand-lime mortar. Note the use of subjective terminology.

- MM VI: Damage slight in poorly built buildings...
- MM VII: Damage negligible in buildings of good design and construction, slight to moderate in well-built ordinary buildings, considerable in poorly built or badly designed buildings...
- MM VIII: Damage slight to structures (brick) built especially to withstand earthquakes... Considerable in ordinary substantial buildings... Cracked, broke, solid stone walls seriously....
- MM IX: Damage considerable in (masonry) structures built especially to withstand earthquakes... great in substantial (masonry) buildings, some collapse in large part....

Judgmentally assigned percent PMLs, for example, for "considerable" damage could vary over a very wide range and are never as reliable as actual field damage surveys by competent personnel.

Modified Mercalli data gathered via post card questionnaire forms and newspaper accounts is fraught with uncertainty. Even more difficult is the application of the Modified Mercalli scale to the constantly evolving earthquake resistive construction which now dominates building inventories in California.

One alternative or supporting mechanism is to make a theoretical mathematical analysis of each structure or of the building class. These analyses could then be compared with the meager quantified experience data from the 1964 Alaskan earthquake and 1971 San Fernando, California, earthquake, plus earthquakes with relevant construction types from elsewhere around the world.

Time and space constraints limit the discussion to California wood frame dwellings.

The first step is to develop an algorithm which relates dwelling damage to distance from the faulting using magnitude as a variable. The general shape of this loss-distance curve (attenuation curve) is a function of the ground shaking at the damage site. Ground shaking at numerous locations in many earthquakes has been recorded by instruments known as strong motion recorders. The general form of an attenuation curve derived from instrumental records is Figure 2 (reference 8). Attenuation curves such as that in Figure 2 have difficulties near fault ruptures since observed losses appear to become too high for structures when located on "firm ground". The top of the curve may be truncated by a horizontal line or other compensating relationship. In one model, the truncated horizontal distance from the fault rupture to the attenuation curve is taken to be the focal depth.

On applying this curve to California wood frame dwellings, one tentative relationship for a magnitude 8.25 event is:

$$(\text{Loss over } \% \text{ deductible}) = 9.0 e^{-0.105 X}$$

where X is the percent deductible. The complete algorithm must include modifying factors for a variable magnitude and for variations in local surficial geology (often termed "poor ground").

The general attenuation algorithm for all classes of buildings must additionally contain a relationship for so-called "long period" effects when the algorithm is extended to include high-rise buildings. The "long period" effects are taken to mean that, in general, as earthquake ground motion is attenuated away from the earthquake source, the long period (low frequency) ground motions die out relatively more slowly than the short period (high frequency) ground motions. Thus, tall buildings at a distance from an earthquake may be at risk relatively more than one story dwellings. Good examples of these phenomena are the high rise damage in Mexico City in 1985 and in Anchorage, Alaska, in 1964.

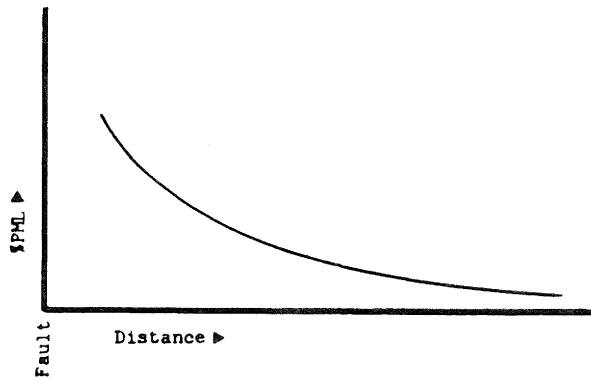


FIGURE 2 FORM OF %PML ATTENUATION CURVE FOR EACH BUILDING CLASS AND SUBCLASS.

It is desirable to evaluate the coefficients to the Figure 2 curve using actual dollar loss experience in place of the Modified Mercalli intensities. For this, we can use the actual California loss experience from 12,000 inspected dwellings after the 1971 San Fernando earthquake and all dwellings in Coalinga after their 1983 earthquake. Current studies are expected to include the insurance loss experience still being developed from the 1987 Whittier Narrows earthquake.

4. Influence of Surficial Geology on Damage:

"Poor ground" can have several interpretations, but in general it is used to indicate areas where intensified damage is to be expected. These areas are shown on maps, often called microzonation maps. Most microzonation maps use subjective terms such as "slight", "moderate", etc. for degrees of damage. The loss estimator needs some clairvoyance when interpreting these into monetary losses. It is further complicated when the design engineer has considered "poor ground" in his earthquake design.

Fortunately for California, the majority of its construction is not located in these hazardous areas. As a result, the impacts of poor judgmental interpretations in a major event may not be overly serious. This is not to say that spectacular damage may not occur in the high-rise sections of downtown San Francisco located on Bay Muds. Extensive damage may also occur along portions of southern California's coastline, including San Diego and Los Angeles.

A qualitative evaluation of poor ground or site response is possible using Modified Mercalli intensity data. Even though intensity data are subject to difficulties discussed earlier, it is an important qualitative guide to the evaluation of site response because of the large number of observations of intensity available. For example, in the U.S. Geological Survey data

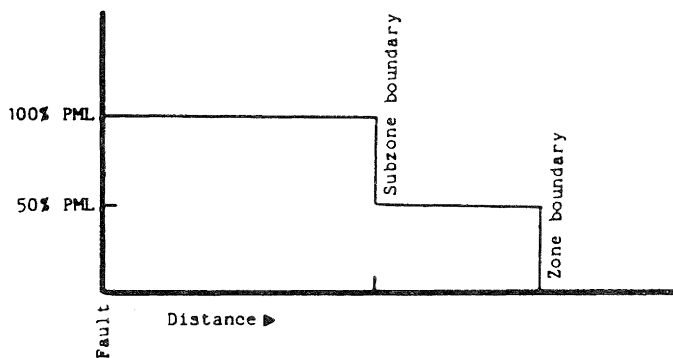


FIGURE 3 STATE OF CALIFORNIA %PML WHEN ZONES HAVE SUBZONES.

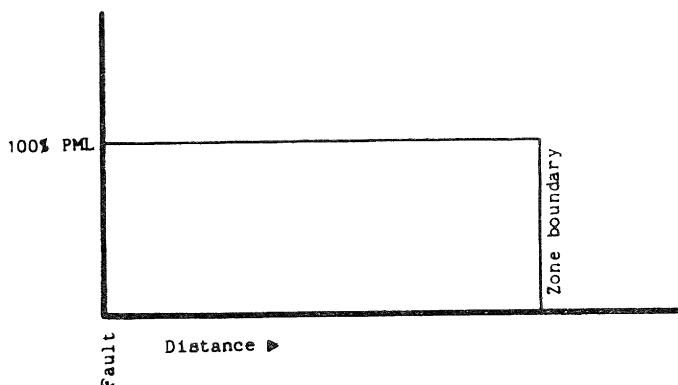


FIGURE 4 STATE OF CALIFORNIA %PML WHEN NO SUBZONES EXIST.

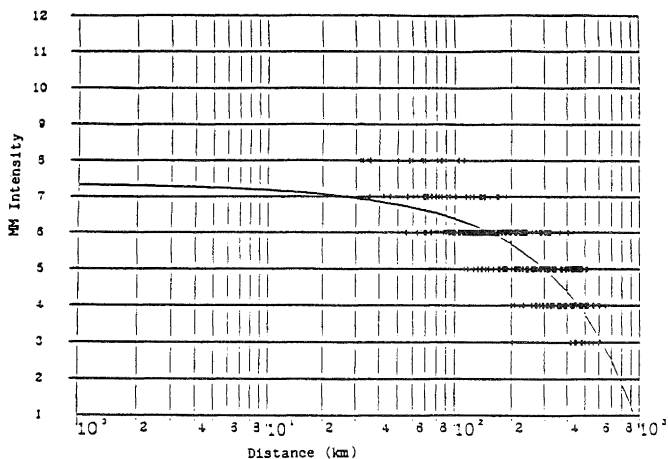


FIGURE 5 DISTRIBUTION OF INTENSITY WITH DISTANCE, KERN COUNTY, CALIFORNIA, EARTHQUAKE OF JULY 21, 1952. (Courtesy of S.T. Algermissen).

base, there are about 50,000 observations of Modified Mercalli intensity observed at approximately 3,900 sites in California. The effect of site conditions can be evaluated by comparing the difference in intensity actually observed at each site with a least squares curve or average curve of the decrease of intensity with distance. Such a curve, based on 644 intensity observations of the 1952 Kern county, California earthquake is shown in Figure 5. Clearly, many sites experienced higher and lower intensities than the average. Because of the manner in which the intensity data are collected, many of the intensity observations are observed at the same sites (or very near the same sites) and the distribution and mean of anomalously high (or low) ground motions at any particular site can be estimated. Even though the intensity data may be a relatively poor estimate of site response, the large number of observations tends to make the data statistically significant. Furthermore, the anomalously high or low intensities at each site can be compared with the surficial geology at the site and cautiously extrapolated to sites of similar geology where no historical intensity data are available. As a further step, the anomalous intensities can be compared with strong ground motion data where possible, thereby quantifying the evaluation of site response. Studies of this type are currently underway.

DWELLING AGGREGATE LOSSES -
RELATIONSHIPS TO CALIFORNIA DEPARTMENT
OF INSURANCE METHODS

The California Department of Insurance uses a simplified loss estimation methodology in their "California Earthquake Zoning and Probable Maximum Loss Evaluation Program" (reference 9). California is divided into 8 zones for companies reporting their loss estimates. Zone boundaries in the more seismically active areas were selected on the basis of the locations of major faults and their proximity to population centers. For practical reasons, zone boundaries were also boundaries of political jurisdictions; Los Angeles was one exception.

The same percent PML is applied to an entire California zone when no subzones exist (Figure 3). Figure 4 is representative when subzones exist. It is obvious that Figures 3 and 4 differ widely from Figure 2.

Loss computations based on Figure 2 concepts can be used to improve the PML percent losses shown in Figures 3 and 4. Dwelling counts from the 1980 Census can be updated to 1989 counts from California tax information. Updated dwelling values are obtainable through tax assessor's records and/or realtor oriented publications. Relationships exist between assessed values and insured values; see reference 9, page 38, for one such application. An alternate method uses relationships between market values and insured values.

It is evident that the aggregate dollar losses computed from Figure 2 methodology

obtained from Figures 3 and 4 methodology. Thus, the percent PML (ordinates) in Figures 3 and 4 can then be readily calculated for each State zone.

As a result, the state's reporting forms could have differing percent PMLs for each of its zones and subzones, and these would better reflect newer loss over deductible experience.

WHERE DO WE STAND AND WHERE DO WE GO

Discussions to this point have emphasized the uncertainties in loss estimation. In the hands of competent earthquake experienced loss estimation professionals, the overall damage patterns can be anticipated and reasonable aggregate PMLs determined. There are surprises after every earthquake since there remain many uncertainties. On the other hand insurance companies may not make use of all of the available knowledge. As a primary example, damage to Mexico City from their 1985 earthquake was predictable based on their 1957 earthquake experience. In 1957, the author examined the damage, mapped the damage area, and thereby predicted the damage patterns for future similar shocks.

The goal has not been reached whereby different professionals and scientists using the same inventory of building data will necessarily produce reasonably consistent loss estimates should there be, for example, a repeat of the 1906 San Francisco earthquake.

There is need to provide a framework of collaboration among interested parties in the United States. For a case in point, post-earthquake monetary loss data must be compiled on a consistent basis by construction class and by location (postal ZIP if not by address). This involves: (a) insurance companies collecting their loss experience on a basis useful by scientists and engineers; (b) Federal scientific agencies such as the U.S. Geological Survey and the National Science Foundation collaborating with the insurance industry on the gathering of loss data; and (c) state regulators making calls for post-earthquake data in a form compatible with the needs of all parties. To be most effective, this network should be in place now rather than after the event.

We urge that this becomes a conclusion and a recommendation to all nations attending this international conference.

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