

EARTHQUAKE INSURANCE IN THE UNITED STATES - A REAPPRAISAL

By

P. G. Buffinton, Manager
Factory Mutual Rating Bureau

In considering earthquake insurance in the United States, it should be recognized that the insurance underwriter, the seismologist, and the engineer all have similar objectives - that of understanding more about earthquakes.

Although much has been learned by the seismologist in the last 50 years, only part of this knowledge is of use to the insurance underwriter and for this reason earthquake insurance rating as a science is much in need of further study and comprehension.

The problem of most insurance underwriters is that they do not possess sufficient knowledge to understand many of the technical aspects of seismology. On the other hand, the seismologist may not readily appreciate some of the problems of the underwriter, and this paper is directed at the objective of informing seismologists of some of our problems with the hope that we in turn will benefit from their analysis and advice.

FACTORS TO BE CONSIDERED IN ESTABLISHING EARTHQUAKE RATES

In general there are six factors which are considered in making fire and other property insurance rates:

1. Construction
2. Protection - both public and private
3. Occupancy
4. Exposure
5. Element of time - frequency of loss occurrence
6. Credibility of available statistics

The factors which must be considered in establishing earthquake rates are directly related to these factors, although they are often described in different terms. Each factor will be discussed below both in terms of its general significance in property insurance rate making and its special importance in determining earthquake insurance rates.

Construction

Construction has long been recognized as of major importance in determining earthquake rates and is sometimes referred to as the damageability factor or the relative resistance of various types of buildings to earthquake shock. Most earthquake rating schedules recognize 8 classes of construction ranging from the structural steel frame building which has been designed to resist earthquake shock to the poorer type of building constructed of tile, concrete block or adobe bearing walls. Bridges, reservoirs, dams, and brick stacks, as well as glass greenhouses and wood tanks on wood towers, also fall into the higher rated classification.

Other important factors which have been recognized include the natural period of vibration of the structure, its height, the type of ground upon which the building has been built, the presence of unanchored parapets or overhanging cornices, and the condition and type of cement mortar used in buildings of masonry construction.

The work of the late John R. Freeman in this important field is well known to most of you. Some of the important conclusions reached by Mr. Freeman are as valid today as they were in the late 1920's and early 1930's and are repeated here because of their significance to the overall problem of proper insurance underwriting.

1. A well designed and well built building of reinforced concrete having a rigidly braced steel frame and which is less than 100 feet in height, will resist an earthquake shock as violent as any that have occurred in the United States or Canada with only minor resulting damage.
2. Well designed and well built wood frame dwellings on good foundations will sustain only minimum damage in a major earthquake.
3. Structures of cement block although one or two stories in height are likely to be badly shaken and walls of adobe block have proved extremely weak in resisting earthquake shock. (It is significant that the recent major earthquake in Agadir has again proven the validity of this statement).
4. Ordinary brick veneer on wood framing will sustain major damage by earthquakes of even relatively moderate intensity, and hollow tile walls and partitions and ordinary brick chimneys are among the first parts of a building to be damaged.
5. Buildings on good concrete foundations invariably show less damage than those constructed upon piers or light footings.

Protection or the Resistance Factor

Although in the fire and allied lines field we generally think of protection as related to the presence or absence of automatic sprinklers and the degree of public protection available, protection is also recognized in earthquake insurance although perhaps it is more often thought of as the resistance factor or the fact that through the inclusion of special features buildings can be constructed which will safely resist earthquake shock.

Well informed managements always consider the need for automatic sprinkler protection when constructing new buildings because they are aware of the differential in fire insurance rates between a sprinklered and unsprinklered building and because sprinkler protection is of significant importance in reducing loss of life as a result of fires. Equally well informed managements building new

plants in earthquake areas should also recognize the need for earthquake resistant construction. Fortunately building codes on the west coast of the United States make such recognition mandatory in most areas. Unfortunately such requirements are far from universal and needless loss of life and damage will continue at places such as Agadir until better regulations are adopted.

Occupancy

In the United States separate building and contents base rates for fire insurance are developed for more than 100 different statistical classifications. Earthquake rating schedules are not as detailed but the kind of occupancy is important in determining earthquake contents rates. The earthquake insurance rules of the Pacific Fire Rating Bureau provide five classes of contents and the rates for classes most susceptible to earthquake damage are from 5 to 12 1/2 times as great as the rates for contents which are least susceptible depending upon the type of building construction involved. The Factory Mutual Fire Insurance Companies, who are insurers of large industrial risks, use their own earthquake rating schedule which has three classifications for contents. Contents rates provided by this schedule bear a constant relationship to the building rate for earthquake insurance and are 100%, 75% or 50% of the building rate depending upon the susceptibility of the contents to earthquake damage.

Present knowledge does not indicate the need for any further refinement of earthquake rating schedules insofar as occupancy is concerned. The major problem is related to exposure and frequency of loss occurrence and these subjects will now be discussed.

Exposure or Area Factor

Exposure is also recognized in establishing earthquake rates although it may be more generally thought of as the area factor or the territory within which damage occurs as a result of a single earthquake. From the standpoint of the fire risk, exposure is considered from three viewpoints, namely internal exposure from other risks in the same building, external exposure such as adjoining or nearby buildings, and conflagration exposure. The conflagration exposure from fire has been considerably reduced since the 1906 San Francisco disaster. Improvements in building design and fire fighting techniques have in fact, so reduced this exposure that it is very unlikely that we could have a conflagration today which would, for example, approach the damage sustained in the great Chicago fire of 1871.

Surveys are made of all large cities in the United States today and existing conflagration areas are mapped out and are used by underwriters in considering this exposure and most insurance companies limit their participation on risks in such areas.

In earthquake insurance we are not as fortunate in having such information and we need to know the areas over which violence may be sufficient to destroy structures or damage them in any single earthquake.

Studies made by John R. Freeman indicate that the area of destructive violence in any one earthquake has always been relatively small and it is highly probable that this area will never exceed 2500 square miles when considering earthquakes in the United States. Seldom have earthquakes caused important damage to structures at distances of more than 25-50 miles from the center of the disturbance and major damage is generally restricted to a narrow belt not more than 10 miles wide.

In the San Francisco earthquake of 1906 this belt was about 200 miles long, but the area of greatest intensity was still of modest size. The report of the California Earthquake Investigation Commission in connection with the 1906 San Francisco earthquake, indicated the following areas of intensity, (Rossi-Forel scale):

Zone X	- 400 square miles
Zone IX	- 3000 square miles
Zone VIII	- 9000 square miles

Another severe earthquake, the Santa Barbara earthquake of June 29, 1925, involved a much smaller belt approximately $1\frac{1}{4}$ mile wide and two miles long representing the area of severest intensity within which the major damage occurred.

The New Madrid earthquake of December 16, 1811, was also restricted to a fairly narrow belt perhaps 100 miles along the Mississippi River. The local severity of the New Madrid earthquake was intensified, however, by the peculiar circumstances of the geological and sedimentary conditions of the area involved.

The Assam, India, earthquake of 1897 was felt over an area of about $1\frac{3}{4}$ million square miles and yet reports indicate that the epi-central area of this earthquake was only about 200 miles long from east to west and about 50 miles in width. One report indicated that the maximum intensity of X Rossi-Forel scale extended for a distance averaging only about 70 miles from the epi-center.

It is unfortunate that the total area over which a major earthquake is felt is often misinterpreted as being directly related to the amount of damage which will result. It must be recognized that comparisons of relative damage of various earthquakes must take into account the type of construction involved and the type of ground upon which the structures have been built. These factors should not be confused with the area of major destruction or the area within which there is the possibility of major destruction.

Element of Time - Frequency of Loss Occurrence

In the property insurance field and particularly in fire insurance, it is recognized that loss trends do exist, but because of the usual frequency of fires and the large amount of insurance written, the extremes are not as great in fire insurance experience as they are in earthquake experience. Reference to the attached chart showing a comparison of the fire and earthquake loss ratios

for the period 1916-1957 shows that the fire loss ratio for the United States is generally contained within a range of ratios of from 40% to 60%. The absence of major conflagrations in the last 40 years has contributed to this result.

As would be expected, the earthquake loss ratio for the State of California for the same period shows a much wider range of fluctuation, having several minimums of 0 and a maximum of 118% representing the loss ratio for the year 1933 as a result of the Long Beach, California, earthquake.

Loss Ratios for extended coverage insurance (includes the perils of windstorm, explosion, riot, etc.) are more susceptible to fluctuation than fire insurance and although not shown on the chart, in the period 1940-1957, extended coverage insurance for the United States had a loss ratio range of from 21.8% to 63.3%. Extended coverage experience on a State basis, would produce greater fluctuations and has some of the problems of earthquake insurance inherent in its makeup although a much wider premium base exists.

A company writing dwelling insurance can foresee with reasonable accuracy the number of dwellings that will be subject to damage by fire and windstorm and can estimate within reasonable bounds what the loss ratio will be over a five or ten year period. We have already pointed out that the problem of conflagration is not serious today in most areas, and as long as the underwriter obtains a reasonable spread of risk, he need not be too concerned with this factor.

In extended coverage insurance a single windstorm may involve a wide area and losses of substantial proportion have occurred in recent years in various parts of the United States. Most companies, however, limit their insurance writings in areas susceptible to hurricanes and the spread of risk evens out the experience. Extended coverage insurance is widely purchased throughout the United States today thus providing a firm base for statistical analysis. It is significant to note, however, that the November 25, 1950, windstorm in the northeastern United States caused damage resulting in claims in excess of 200 million dollars, whereas the San Francisco earthquake of 1906 resulted in earthquake damage estimated at 90 million dollars when converted to the 1950 equivalent.

In earthquake insurance the frequency or infrequency of earthquakes in certain areas provides a serious problem for the underwriter. While he can see that reasonable underwriting based on well established principles will produce reasonable loss ratios for fire and extended coverage insurance over say the next five or ten years, he cannot know what the earthquake experience of his company will be over the next five years or even the next fifty years. Since most underwriters don't have a working span of fifty years, the problem is discouraging both to the individual underwriter and the company he represents. The Company also knows that any excess profits from a period of good earthquake experience will be eaten up by taxes, because no provision has been made for accumulating special earthquake reserves.

The problem of frequency, particularly of earthquakes of major intensity, is a matter of most concern to the underwriter and yet is probably the factor most difficult to predict at the present time. In the preparation of this paper the author spent considerable time compiling a list of earthquakes of various intensities for different regions of the United States. Reference was made to "Earthquake History of the United States - Part I Continental United States Exclusive of California and Western Nevada" - revised (1956) edition and "Earthquake History of the United States - Part II - Stronger Earthquakes of California and Western Nevada" revised (1951) edition. Reference was also made to the annual publication "United States Earthquakes" for the years 1951 through 1956 to provide an up-to-date record of the earthquakes in California and western Nevada.

Earthquake History of the United States - Part I provides information based on the Modified Mercalli scale whereas Earthquake History of the United States - Part II provides information based on the Rossi-Forel scale. All California earthquakes were converted to the Modified Mercalli scale in order to provide a comparable base. Table I shows the number and frequency of earthquakes of various intensities for the several regions of the United States.

The table indicates, for example, that earthquakes of intensity ten and over (Modified Mercalli scale) have a frequency of 1 in 13.3 years in California as compared to a frequency of 1 in 293 years in the eastern part of the United States with the other regions falling between these two extremes.

The chart also shows that in California for earthquakes of intensity 9 and over (Modified Mercalli scale) the frequency is 1 earthquake in 7.5 years; for intensity 8 and over, the frequency is 1 in 2.9 years; and for intensity 7 and over, the frequency is 1 every 1.35 years.

If this information is plotted using intensity as one scale and frequency as the other, it is possible to compare the areas represented by the curves for the different regions involved. The resulting relationships using California as unity are as follows:

California	-	1.00
Western Mountain Region	-	0.620
Northeast	-	0.097
Central	-	0.082
Washington-Oregon	-	0.056
Eastern	-	0.034

If these relationships are in any way valid insofar as the indication of the relative frequency and intensity of earthquakes in various areas of the United States, then it would appear, for example, that earthquake rates in the Northeastern United States should be about 1/10 of the rates charged in California. It is recognized that the above relationships are based on giving equal weight to earthquakes of various intensities which in reality, is probably not a fair assumption. Therefore, it was

Earthquake Insurance in the United States

decided to take the available information and compare the average damage in dollars for earthquakes of various intensities. Table II shows the results of these computations. If these figures could be accepted as valid, they would indicate that earthquakes of intensity 10 (MM) and above, would cause earthquake damage which was 26.5 times the damage caused by earthquakes of intensity 7 (MM).

It is recognized that the credibility of information available does not warrant any final conclusions. However, such study as the author has been able to make does indicate that the whole question of frequency and the relative damage caused by earthquakes of various intensities should be further investigated as a means of aiding the insurance underwriter and the insurance buyer. The seismologist can be of tremendous help in solving these problems.

Credibility of Statistics

The problem of the credibility of rate making statistics is well known to most actuaries and underwriters. Earthquake insurance statistics pose a particularly difficult problem and it has not received as much study and analysis as other types of property insurance.

In the field of fire insurance rate making certain credibility guides have been adopted and three of these will be mentioned to show the diversions of opinion and to point out some of the problems involved. The New York Insurance Department, for example, uses a credibility table as follows:

<u>5 Year Premium</u>	<u>5 Year Credibility - %</u>
\$6,000,000 and over	100%
4,860,000 - 5,999,999	90
3,840,000 - 4,859,999	80
2,940,000 - 3,839,999	70
2,160,000 - 2,939,999	60
1,500,000 - 2,159,999	50
960,000 - 1,499,999	40
540,000 - 959,999	30
240,000 - 539,999	20
60,000 - 239,999	10
0 - 59,999	5

The Texas State Board of Insurance has adopted a different credibility table for fire insurance as follows:

<u>Premium Volume (5 years adjusted earned)</u>	<u>Per Cent of Credibility</u>
\$1,000,000 and over	100%
900,000 to \$ 999,999	95
800,000 to 899,999	90
700,000 to 799,999	85
600,000 to 699,999	80
500,000 to 599,999	75
450,000 to 499,999	70
400,000 to 449,999	65

<u>Premium Volume (cont'd)</u>		<u>Per Cent of Credibility</u>
\$ 350,000 to	\$ 399,999	60%
300,000 to	349,999	55
250,000 to	299,999	50
200,000 to	249,999	45
150,000 to	199,999	40
100,000 to	149,999	35

The rules for the use of the Texas Credibility Table also provide that when a class or sub-class is not fully credible on its volume alone, then in addition and where applicable, the following may be considered:

- a. A longer than 5-year record
- b. Trends as disclosed in the record
- c. The loss potential, i.e., whether the units of experience are such that one loss may disrupt the whole record. This involves study of the nature of risks presented and units of volume insured.

The Factory Mutual Companies have given considerable study to this same problem, and for the specialized highly protected risk, which constitutes a major portion of their business, they have adopted a credibility table based on average amount of insurance in force. Using a ten year period, 100% credibility is reached when the average amount of insurance in force for any particular class reaches 500 million dollars. Converted to an equivalent earned premium volume, this would represent 100% credibility at approximately 2 1/2 million dollars earned premium for a ten year period or \$1,250,000 earned premium for a 5 year period.

It is thus obvious that even in the fire insurance field no fixed universal standards have been agreed upon regarding the minimum amount of premium needed for 100% credibility of statistics.

It is significant, however, that the 5 year earthquake premium writings in California are in excess of 26 million dollars, and all of the above credibility tables would indicate that full credibility would be reached when 5 year premium volumes reach 6 million and over.

Because of the relative infrequency of severe earthquakes, it would be unfair to compare the credibility problem of earthquake statistics to fire insurance statistics. However, the marked increase in extended coverage insurance premium writings in recent years have given the insurance companies statistical experience in a field which has many of the same problems as earthquake insurance. Whereas fire insurance premium writings have tripled in the period 1940-1957, extended coverage writings have increased 12 1/2 times, giving the companies a much broader base for statistical analysis.

The fact that extended coverage losses in excess of 200 million dollars have been paid in connection with one catastrophic

Earthquake Insurance in the United States

storm as compared to an estimated 90 million dollar loss for the 1906 San Francisco earthquake in terms of 1950 dollars, should provide an impetus for a reappraisal of the earthquake rating problem.

OTHER FACTORS TO BE CONSIDERED IN EARTHQUAKE INSURANCE

Certain other factors influence earthquake insurance to a greater degree than other fields of property insurance. Two of these are worthy of discussion, namely the attitude of the insurance buyer and the catastrophic nature of earthquake insurance.

Attitude of Insurance Buyer

If the reader will refer to the chart showing a comparison of fire and earthquake written premiums in the United States for the period 1916 to 1957, it will be recognized that certain trends exist. It is to be noted that fire insurance written premiums in the United States generally follow the economy and that in the period 1916-1929 a peak was reached followed by a sharp decline as a result of the 1929 stock market crash and the following depression years. Fire Insurance premiums leveled off in the early thirties and then started a gradual climb in the early forties, followed by a sharp increase as a result of the war years, reaching an all time peak in 1951.

During this period there has been a gradual downward trend in average fire insurance rates in the United States, and this is one reason for the apparent downward trend of premium writings for the period 1951 to date. In actuality, the amount of insurance at risk or the value of property insured has undoubtedly increased during this period, although premium writings have been reduced because of decreases in rates. Some of these rate decreases are the result of experimentation in the multiple peril field by both fire and casualty companies.

We also have a record of earthquake insurance written in the State of California for the same period of time. The figures for earthquake insurance written on a Nationwide basis are available for a shorter period of time, but unfortunately there are gaps in the published figures for the 1940's. However, California still represents more than 90% of earthquake written premiums in the United States and provides a good comparison of trends.

It is to be noted that the earthquake writings in California in 1916 were non-existent and the writings in the period up to 1924 were practically negligible. As a result of the Santa Barbara, California, earthquake in 1925, the premiums jumped to a substantial figure. This was followed by another downward trend which was reversed slightly as a result of the Long Beach earthquake of 1933 and the Imperial Valley earthquake of 1940.

It is interesting to note that the general shape of the California earthquake written premium curve follows closely the shape of the fire insurance premium curve for the United States indicating that the general economy still has an affect upon the writing of this type of insurance. The curve also shows without question that serious earthquakes have an affect upon the insurance buyers attitude with respect to earthquake insurance,

and that generally speaking, earthquake premium writings increased significantly after every serious earthquake. These increases have been less prominent in later years but still exist.

The general picture insofar as earthquake premiums are concerned is one which indicates that insurance buyers are not convinced of the need for earthquake insurance and are prodded into buying coverage only as a result of serious earthquakes or the requirements of mortgagees.

This same attitude can be further emphasized by studying the relationship of fire insurance premiums and earthquake premiums in California. The total fire insurance premiums written in California in 1956 amounted to approximately 115 million dollars and if we estimate an average rate of 35¢-40¢ per \$100 of insurance this indicates that the value of property insured is approximately 40 billion dollars. The 1956 earthquake written premiums in California were slightly in excess of 6 million dollars, and estimating an average earthquake rate of \$1.00 at 50% insurance to value, would indicate the value of property insurance against earthquake is 1.2 billion dollars or less. The conclusion, then is that less than 5% of the property in California insured against by fire is also insured against the peril of earthquake. On a nationwide basis the figure would be much less.

The Companies thus find themselves in a quandary. The present level of earthquake premium writings is not broad enough to justify significant rate decreases. On the other hand, if earthquake rates were reduced and earthquake insurance was written on a broad scale, the companies would be better off and the public better protected. Unfortunately, there is no guarantee that a reduction in earthquake rates would result in large scale buying of earthquake insurance.

Another peril which offers many of the same problems is that of flood. The Factory Mutual Fire Insurance Companies, as a result of serious floods in certain areas throughout the United States, have on several occasions made detailed surveys of the requirements of their insureds with respect to flood insurance. The response to these inquiries indicated in practically every case that the demand for flood insurance was almost non-existent. Those who did wish to purchase such coverage, if it was made available, had the greatest exposure to loss and even these prospective buyers would be willing to pay very little for the coverage afforded.

Earthquake Insurance - A Catastrophe Coverage

The attitude of the insurance buyer as discussed in the preceding paragraphs bears out the well established conclusion that earthquake insurance is a catastrophe type of coverage. As a catastrophe coverage, it is generally recognized that deductibles which require the buyer to assume a certain part of the loss are a necessity if insurance rates are to be within reach of the average buyer.

A mandatory deductible on buildings is needed to eliminate

Earthquake Insurance in the United States

arguments over the cause of minor cracking of plaster and other maintenance deficiencies which are not generally caused by earthquakes but are the result of building age, and are often caused by a slight settlement of the building itself.

The stock company schedules used for earthquake insurance on the Pacific Coast of the United States require a minimum deductible of 5% with higher deductibles for the poorer types of construction. It is significant to note that the Factory Mutual Companies permit lower deductibles under their rating schedule with a minimum of 1% on the best type of building. The Factory Mutual Companies are also willing to insure contents against the hazard of earthquake damage on a no-deductible basis if the buyer so desires.

TREND IN EARTHQUAKE RATES IN THE UNITED STATES

In 1916-1917 the Board of Fire Underwriters of the Pacific adopted an earthquake rating schedule for a straight earthquake policy (that is, a policy covering the peril of earthquake only as opposed to the more generally accepted method today of endorsing a fire policy to include the peril of earthquake). This schedule contained three building classifications with annual rates as follows:

Class A and B steel frame buildings	- 25¢
Class B buildings (frame construction)	- 35¢
All other	- 40¢

These rates were based on a 70% co-insurance clause subject to a 1% deductible with a minimum deductible of \$100 and a maximum deductible of \$1,000.

In 1921 the schedule was expanded to four classes as follows:

Class A buildings	- 20¢
Class B buildings	- 30¢
Class C buildings	- 40¢
All other	- 50¢

These rates were for 50% co-insurance with credits for higher amounts as follows:

60% Co-Insurance	- 10% credit
70% Co-Insurance	- 20% credit
80% Co-Insurance	- 25% credit
90% Co-Insurance	- 30% credit

In 1923, the co-insurance credits were increased to provide a 40% credit for 90% co-insurance with corresponding increases for other amounts, and in 1925, 6 classes of construction were adopted with rate ranges in the San Francisco area of from 14¢ to 125¢.

In 1928 a minimum mandatory deductible of 10% was adopted and rates were provided for 8 construction classifications as follows:

P. G. Buffinton

<u>Class</u>	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>	<u>VI</u>	<u>VII</u>	<u>VIII</u>
Rate	20¢	30¢	40¢	50¢	50¢	70¢	1.50	3.50
% Deductible	10	10	10	10	10	10	15	15

In August 1928 the deductibles for Classes I, II and III were reduced to 5%.

In January 1932, the Board of Fire Underwriters of the Pacific adopted rates for an earthquake assumption endorsement which provided earthquake coverage by endorsement to a fire policy. The schedule of rates for Zone 1, which includes San Francisco and Los Angeles were as follows:

<u>Class</u>	<u>I</u>	<u>II</u>	<u>III</u>	<u>IV</u>	<u>V</u>	<u>VI</u>	<u>VII</u>	<u>VIII</u>
Rate	15	25	30	35	35	40	75	2.50
% Deductible	5	5	5	5	5	5	10	15

It is interesting to note that this same schedule is still in effect today although the term factor for a three year policy was increased from 2 to 2 1/2 in 1947, affording a 25% increase in rate for most policies as of that date.

The trend in stock company earthquake rates can best be described as erratic when referring to the above schedules. In 1916 it was possible to buy earthquake insurance on a steel frame building at an annual rate of 25¢ subject to 70% co-insurance and a 1% deductible. Today the annual rate in Zone 1 for this type of building is still 25¢ subject to 70% co-insurance, but the minimum deductible is now 5%. A change in the term factor has also increased the cost of earthquake insurance during this period.

The Factory Mutual Fire Insurance Companies, who are the insurers of large industrial risks throughout the United States including California, have adopted their own earthquake rating schedule. These schedules were originally adopted based on the work done by the late John R. Freeman who was for many years President of the Manufacturers Mutual Fire Insurance Company of Providence, Rhode Island, one of the Factory Mutual group. Mr. Alton C. Chick, formerly one of Mr. Freeman's principal assistants, and today Vice President and Engineer of the Manufacturers Mutual, is chiefly responsible for much of the work done in preparing and maintaining these schedules.

Space does not permit a detailed comparison of the two schedules, but it is significant to note that reductions in the cost of earthquake insurance have been made by the Factory Mutual Companies in recent years.

In addition to making decreases in the cost of earthquake insurance, the Factory Mutuals now provide earthquake sprinkler leakage coverage in California without additional cost to most policyholders. Formerly a specific charge was made for this coverage.

SUMMARY AND CONCLUSIONS

In conclusion, I would like to summarize some of the more important factors which are in need of further investigation, in the opinion of the author, in connection with the general subject of earthquake insurance in the United States.

1. Of the several specific earthquake rating factors, two are in need of further investigation and study.
 - A. The area factor or the exposure to loss as a result of a single earthquake is of great importance to the underwriter. A comparison of the relative damage of earthquakes must take into account the type of construction and the type of ground upon which the building is constructed. The underwriter would be aided by more detailed information on individual earthquakes including specific information on the type of construction damaged, the type of ground upon which the building has been built, the total dollar damage, the estimate of property values in the high damage areas, thus providing a means of determining earthquake loss ratios, and the dollar damage and value of the more important buildings which have been damaged in the earthquake.
 - B. With respect to the frequency of loss occurrence we need further evaluation of the relation of intensity and frequency and better analysis of damage caused by earthquakes of various intensities. The relationship of earthquake rates for various regions of the United States should be re-examined in light of such information. In this connection an up-to-date revision of "Earthquake History of the United States - Part II - Stronger Earthquakes in California and Western Nevada" based on the Modified Mercalli Scale (similar to the recent provision of Part I of this publication) would be most helpful.
2. The attitude of the insurance buyer with respect to earthquake insurance should be re-analyzed. If buyer interest indicates earthquake insurance could be sold on a much wider scale at lower rates, earthquake insurance statistics indicate rate reductions would be justified. The fact that less than 5% of the value of property insured in California against fire is also insured against the peril of earthquake may be related to the fact that earthquake rates have generally been static in that State since 1932.

It is up to the insurance industry to solve the problem of the buyer's attitude and to further investigate the credibility of statistics. The seismologist, however, can be of great assistance to the insurance underwriter and the buying public by providing better information, particularly with regard to the relationship of earthquake frequency and intensity.

BIBLIOGRAPHY

- An Examination Into the Methods of Transacting Catastrophe Risks
prepared by an advance study group of Lloyd's
Underwriters, circa 1951.
- Bannister, Edward W., Rating Buildings for Liability to Earthquake
Damage, Engineering News Revised Volume 98, No. 26
June 30, 1927
- Berkey, Charles T., Memorandum on Zones of Earthquake Hazard,
New York, April 1930 (From files of Insurance
Society of New York)
- Chick, Alton C., Discussion of Fundamental Factors Involved in
the Underwriting of Earthquake Insurance, Bulletin
of the Seismological Society of America, Volume 24
No. 4 October 1934, P. 385.
- Crosby, Irving B., Earthquake Insurance Risks, The Standard
July 2, 1927
- Earthquake History of the United States - Part I - Continental
United States and Alaska Revised (1956) Edition,
Coast and Geodetic Survey, U.S. Department of
Commerce
- Earthquake History of the United States - Part II - Stronger
Earthquakes of California and Western Nevada
Revised (1951) Edition, Coast and Geodetic Survey,
U.S. Department of Commerce.
- Earthquake Insurance, from The Annals of the Society of Chartered
Property and Casualty Underwriters, Supplement
September 1957
- Earthquake Investigation in the United States Special Publication
No. 282 Revised (1958) Edition, Coast and Geodetic
Survey. U. S. Department of Commerce
- Freeman, John R., Earthquake Damage and Earthquake Insurance,
New York, McGraw-Hill Book Company, Inc. 1932
- Hodge, Edwin T., Earthquake Risks of the North Pacific Coast,
paper presented before 53rd Annual Meeting Fire
Underwriters Association of the Pacific, 1929
- Macelwane, J. B., Forecasting Earthquakes, Bulletin of the
Seismological Society of America, Volume 36,
No. 1 Pages 1-4, January 1946

Earthquake Insurance in the United States

Sheehan, Robert W., Casualty Company Aspects of the Southern California Quake, The Spectator March 16, 1933
P. 13.

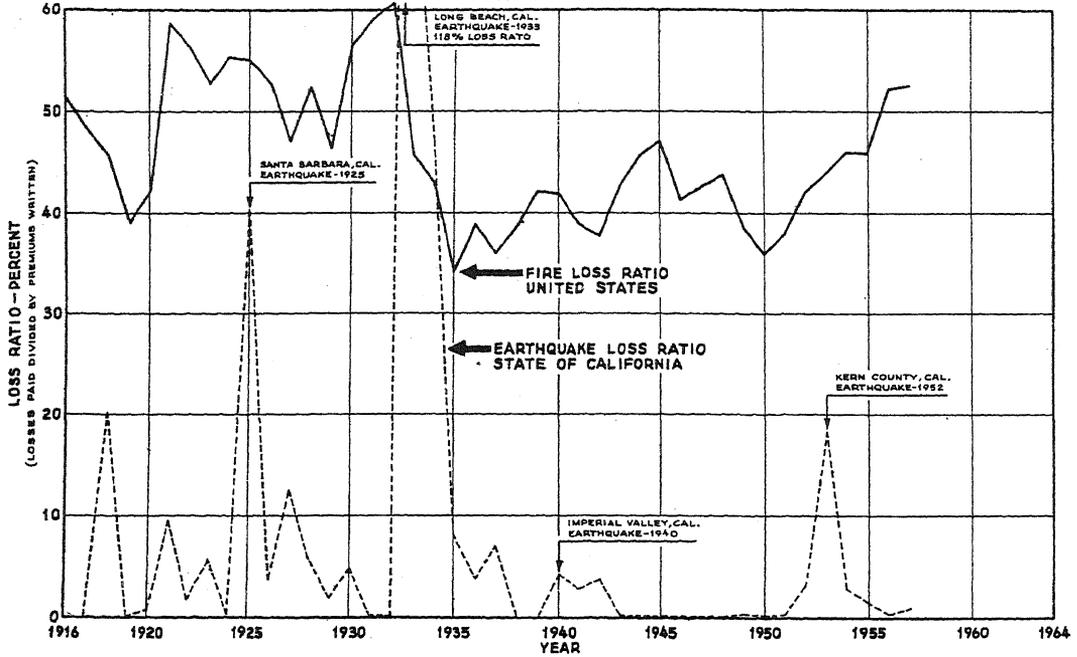
Statistics for Fire and Extended Coverage Insurance for the United States from the Fire Index published by the Spectator Company.

Statistics for Earthquake Insurance for California from the Annual Reports of the Insurance Commissioner of the State of California, 1916-1956

P. G. Buffinton

COMPARISON OF FIRE AND EARTHQUAKE LOSS RATIOS 1916-1957

P. G. BUFFINTON APRIL 1960



COMPARISON OF FIRE AND EARTHQUAKE WRITTEN PREMIUMS 1916-1957

P. G. BUFFINTON APRIL 1960

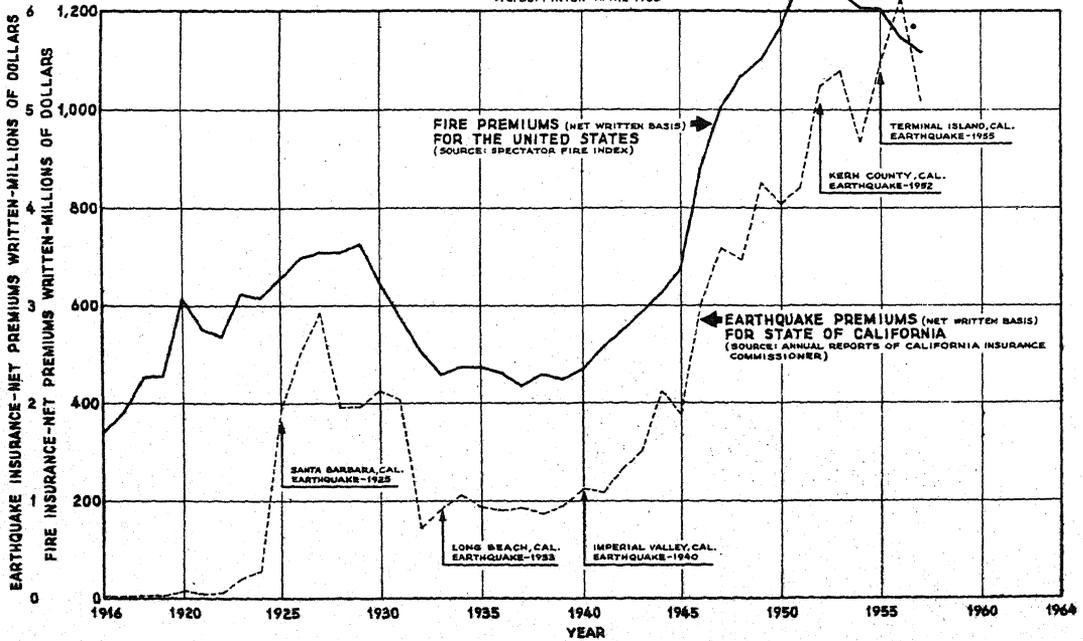


TABLE I
 FREQUENCY OF U.S. EARTHQUAKES 1638-1956

Region	Number of Years of Available Records	Intensity-Modified Mercalli Scale						
		10 and over Total	9 and over Total	8 and over Total	7 and over Total	Frequency No.	Frequency	
Northeast	318	2	2	159	12	26.4	25	12.7
Eastern	293	1	1	293	2	146.5	11	26.6
Central	257	1	1	257	5	51.4	24	10.7
Western	104	1	1	104	15	6.95	33	3.15
Mountain	115	0	0	0	1	115.0	8	14.4
Wash.-Ore.	187	14	25	7.5	64	2.9	138	1.35
California								

- Notes: (1) Information from Earthquake History of the United States - Parts I and II and United States Earthquakes 1951-1956 published by U.S. Coast and Geodetic Survey.
 (2) Frequency expressed as one earthquake for number of years shown.
 (3) Regions as defined in Earthquake History of the United States - Parts I and II.

P. G. B.
 April 1960

TABLE II

TOTAL EARTHQUAKE DAMAGE FOR EARTHQUAKES
OF VARIOUS INTENSITIES

Intensity MM Scale	Number of Earthquakes	Estimated Total Damage 1950 Dollars	Average Damage For one Earthquake
11	2	\$150,000,000	\$75,000,000
10-11	3	9,950,000	3,316,666
10	1	23,000,000	23,000,000
9	4	9,200,000	2,300,000
8-9	3	49,250,000	16,416,666
8	4	31,200,000	7,800,000
7	5	5,770,000	1,154,000
Summary:			
10 and above	6	182,950,000	30,491,666
8-9 and 9	7	58,450,000	8,350,000
8	4	31,200,000	7,800,000
7	5	5,770,000	1,154,000

- Notes: (1) Information from "Earthquake Investigation in the United States" Special Publication No. 282 Revised (1958) Edition
- (2) Damage based on 1950 evaluation of the dollar
- (3) Intensities from Earthquake History of the United States - Parts I and II and United States Earthquake Series.

P. G. B.
April 1960