Insurance and the Mitigation of Earthquake Disasters

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Introduction

Natural disasters often instill a feeling of helplessness in those affected by them whether directly or indirectly. This is exemplified by English insurance parlance which puts earthquakes into the category of "Acts of God." However, it should be appreciated that although earthquakes may be acts of God, for instance, of God Seismos according to Greek mythology, most of their consequences on human society are certainly man made. This paper will offer some suggestions on how qualified insurers may assist in mitigating the impact of earthquake disasters. It will also show, probably to the surprise of some readers, that such help does not end with providing cover for some categories of loss or damage inflicted by earthquakes.

First of all, any insurer who deals with earthquake exposure in a modern professional way must be well informed about earthquake or shaking probability, (i.e. with earthquake hazard), in the respective regions. Secondly, he has to consider the vulnerability of a variety of elements and the corresponding probability distributions of damage (loss) associated with the existing hazard in the region. In insurance terminology elements at risk are, for instance, buildings, factories, plants, utilities, roads, bridges, vehicles, goods and stocks, business interruption, etc.* Finally, the insurer will have to apply the results of earthquake probability considerations and their insight into the loss or damage potential to specific insurance questions like rating of risks, determining which risks are acceptable and to what extent.

It is obvious that the results of such risk analysis may as well be used for risk optimization, i.e. assisting all parties and bodies concerned in what one may call "preventive medicine" aimed at timely earthquake disaster mitigation. This paper intends to provide a synopsis of such issues according to the sequence adopted above.

Event Probability

There are several ways to describe earthquakes and their effects. The non-instrumental macroseismic indicators of earthquake effects are represented by earthquake intensity scales like those now in use, i.e. MSK (Medvedev-Sponheuer-Kárník), MM (Modified Mercalli), JMA (Japan Meteorological Agency), or MCS (Mercalli-Cancani-Sieberg), RF (Rossi-Forel). All of them describe earthquake effects in a qualitative manner which may be influenced by the personal bias of the observer and even by a national one. Only few of them, the above list is far from exhaustive, produce indications which may be used with some confidence for general risk studies, like MSK, MM, and JMA. None of the scales classify the damage of specially designed high quality buildings nor of factories, plants, and utilities, i.e. nor the safety of the people living or working in such places. Further, cross-correlation between intensity assessments made by different observers using different scales is a difficult and uncertain matter, in particular if the personal bias of the original observer is unknown or if the "interpreter" is at a loss when assessing the effect of "national bias." Such a national bias is quite probable if the interpreter is not familiar with the standard of design or quality of material and workmanship in the country where the earthquake occurred. Also the mentality of the people matters: excitable minds will generally overstate the intensity, stoical ones will produce more reliable information.

Whereas the effects of earthquakes are described by individual degrees of macroseismic scales, the size of an earthquake is defined by the quantity "magnitude" which is proportional to the amount of seismic energy released at the source (focus). Instead of magnitude the term "Richter scale" is used by journalists because in 1935, C.F. Richter introduced the idea in the seismological practice. Magnitude is calculated using amplitudes of seismic waves recorded by seismographs and it is in fact not appropriate to speak about a "scale". Until now the magnitude concept has been much developed and different types of seismic waves are used for the calculations so that the size of an earthquake can be defined, e.g. by "local magnitude (M_L)," "surface wave magnitude (M_s)" or by "body wave magnitude (m_b)"; the values slightly differ for a particular event and this variety introduces factors of uncertainty

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*This terminology corresponds to definitions of hazard, vulnerability, risk, etc. as introduced by an UNDRO meeting in 1979 in Geneva. (See UNDRO publications.)

for persons not well acquainted with seismological practice.

It is also difficult to determine other earthquake parameters, e.g. the position of the focus of earthquakes in regions which are not densely instrumented. For many earthquake regions, reliable and fairly complete recording is available only for the last few decades. This may explain why earthquake probability estimates were so far left only to experts who had the data and tools required. As this is certainly not a satisfactory situation, a method was developed by the author which enables also government agencies, municipalities, architects and engineers, consultants, and insurance companies to perform earthquake hazard and risk assessments in an efficient and economic way.

The method is based on a Seismic Index Map (SIM) which expresses the seismicity of a place numerically. The seismic index considers earthquakes observed since 1897 and indicates the frequency of earthquakes within a certain area. Figure 1 shows the seismicity of part of Europe in a somewhat simplified version of our SIM. The range of seismic indices in this version (.014 to 20) is very much larger and therefore more instructive than a subdivision into relatively few zones like on most earthquake hazard maps.

The Seismic Indices (SI) may be used in obtaining, for instance, the average return periods of selected earthquake intensities, mean damage ratios for various classes of hazard, acceleration levels, or of earthquakes of selected magnitudes within a certain distance from the place under study.

One may also use the maps to scrutinize a region for seismic gaps, that is for places where a deficit in past earthquake occurrence is to be assumed.

With this model and its fairly straightforward and easy to apply formulas one may conveniently estimate the exposure covering the entire range from locally damaging small events to great earthquake catastrophes.

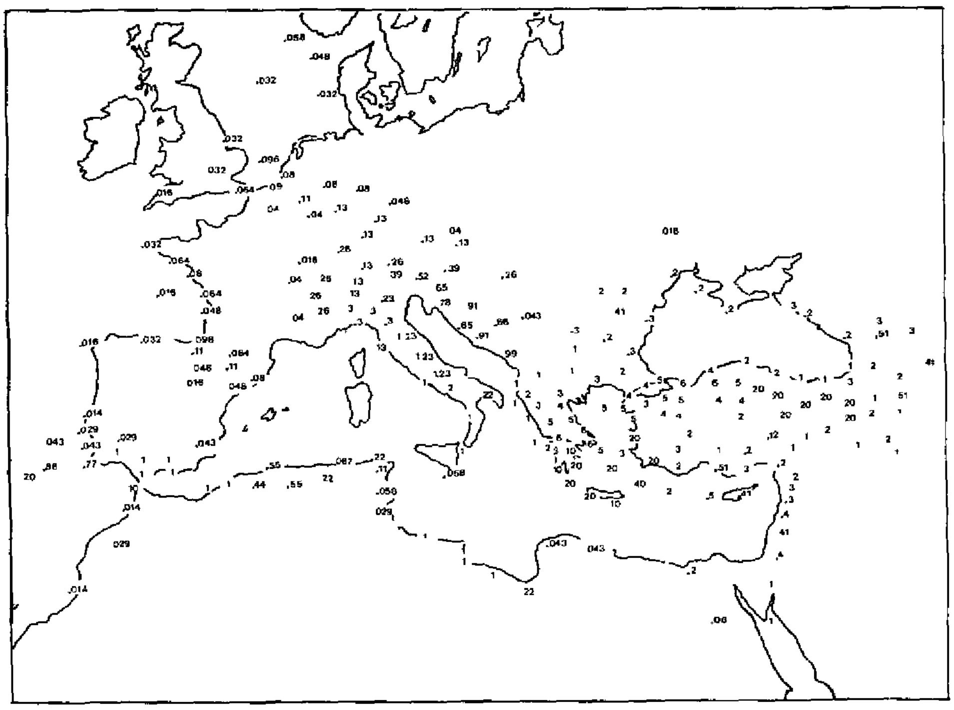

Fig. 1. *European part of a simplified version of our global Seismic Index Map. The indices show the seismicity of the respective place based on earthquake observations between 1897 and 1975. For instance, an earthquake of a selected magnitude is on the average ten times more frequent at a place having a SI of 1 as compared to one where the SI is only 0.1 The derivation of this map and some difficulties are explained in reference 1. In spite of the fact that a general version of the map is shown here, some seismic gaps are still visible like the one in the central northern part of Italy where the SI is substantially lower than at places to the east and west of it.*

Damage Probability Distributions

The second important type of information required relates to the average damage or loss to be expected at different grades of intensities or at different levels of ground motion, and to the probability that a certain percentage of elements experience lower or higher than average damage. Of the many parameters contributing to damage (cf., e.g. 2, 3, 4, 5, 6) one of the most important is the building quality. There are many examples in literature of the typically large difference between the performance of frail and of sturdy buildings. The potential for loss of life and injury is strongly correlated with building quality.

As soon as loss or damage levels have been established, one may estimate the probable "cost" of a selected earthquake resulting from the performance of individual elements at risk (villages, towns, industrial facilities) and also in terms of injury and loss of life. This information may not only be used for calculating insurance rates but to determine funds required for rehabilitation and reconstruction. Further fields of application are the study of the adequacy of building codes or cost-benefit analysis aimed at optimizing individual preventive measures for structures, settlements, or towns.

The method described here is also useful in educating the builders, engineers, architects, property owners, or officials who lack specialized knowledge but whose decisions exert an important influence on the vulnerability of structures and human lives.

Insurance and Disaster Mitigation

In order to illustrate the mechanics of providing earthquake insurance, let us first follow a project as it is realized and thereafter utilized.

During construction, erection, and testing, insurance protection against earthquake loss or damage is available under Contractor's All

Fig. 2. *Typical example of how buildings should not be built in earthquake zones. The picture shows some of the buildings in a large housing colony in El Asnam, Algeria, which were affected by the earthquake of about M 7.2 in October 1980. These buildings are top heavy and have a soft ground floor, the main reason for the extensive damage they suffered. This average damage amounted to 75 percent. Fortunately the buildings were still in the final phase of construction and had not yet been occupied.*

Risks (CAR) or Erection All Risk (EAR) insurance policies. They cover the physical loss caused by earthquakes to the work, material, and machinery incorporated into the project and, if desired, to the plant and the equipment of the contractors. Whereas such "All Risks" covers are freely available, others which extend to consequential losses resulting from earthquake, for example, due to delayed completion, are very rarely issued.

Once buildings, factories, plants, etc. are commissioned, earthquake insurance protection may be bought as an addition to conventional fire covers. It is mentioned in passing that this holds for tsunami exposure as well. Indirect losses, like business interruption, are covered under separate loss of profit policies which are extensions of the conventional fire cover.

It should be stressed that lack of insurance protection during the construction and operation of projects is nearly exclusively due to the failure of the parties responsible to buy such covers. It is not uncommon to find that only a small percentage of all projects and risks is covered. One might well debate, albeit not at this place, whether it is in the properly understood interest of a society or country for such utter carelessness to be rewarded by providing relief or aid after an earthquake.

For some elements at risk, such as roads, bridges, dams, irrigation canals etc., it is not customary to provide earthquake insurance cover after they have been taken over by the owner or put into use, although earthquake risks may have been covered under CAR earlier. As insurance coverage is generally not available for such projects after their completion, it is essential to apply a proper level of professionalism to planning design and construction. Such measures (which are often summarized under the heading "risk optimization") are particularly important if essential services like the supply of power, water, telephone, medical care, etc. would otherwise be jeopardized. A qualified insurer can, together with experienced international reinsurers, help the owner during the planning and construction phase in selecting economic protective measures. As such advice is based on international earthquake damage experience it will frequently provide information which is not available to the local communities of architects, engineers and contractors.

A very simple example may serve to illustrate risk reduction. For buildings which are as vulnerable as those shown in Figure 2 a mean damage ratio of about 75 per cent does not only represent a very high monetary loss but an extreme risk as regards loss of life. In addition one must consider that rather than one very damaging earthquake which may occur once every few hundred years, there may be a number of quakes of lower intensity which are still damaging to vulnerable structures. Taken together, smaller earthquakes may cost about three times as much as the comparatively rare catastrophic one.