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UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

WORKING GROUP ON THE ECONOMIC IMPLICATIONS OF EARTHQUAKE RISK

Paris, 23-26 August 1977

FINAL REPORT

1. INTRODUCTION

Earthquakes cause heavy losses of life and inflict damage which is conservatively estimated at several billion (thousand million) US dollars per year on the average. Despite the scientific and technological achievements of recent years and the hope that they offer of mitigating losses, the latter are still increasing steadily with time due to the growth of population, urbanisation and industrial development, particularly in the developing countries, and to the fact that progress in scientific and technical knowledge is not fully reflected in practice.

The Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk, held at Unesco Headquarters on 10-19 February 1976, adopted *inter alia* the following resolutions:

"Resolution 10.02: The Conference *recommends*:

(a) that Unesco encourage studies of probability distributions of different kinds of damage caused by earthquakes as a function of geophysical, engineering, economic and social factors. The Conference further *recommends* the use of the results of such studies in decision-making concerning the mitigation of earthquake hazard to all types of construction, including traditional housing;

(b) that appropriate international mechanisms be established under Unesco aupices to co-ordinate the aforementioned studies and implement their results through workshops and seminars."

"Resolution 10.1: The Conference *recommends* that Unesco, in co-operation with other United Nations bodies and relevant international organizations, gather experts from all countries with earthquake insurance programmes, together with interested experts from countries without such insurance programmes and from major insurance and reinsurance companies, seismologists, earthquake engineers, economists and social scientists, to consider the possibility of developing a workable general framework for the implementation of earthquake insurance and of initiating a long-term programme of studies on earthquake insurance problems."

The present working group, composed of experts in seismology, earthquake engineering, physical planning and insurance, was asked to advise Unesco on what action it might take to give effect to the resolutions of the Intergovernmental Conference quoted above, and more particularly resolution 10.1, concerning earthquake insurance. It had before it, among other documents, the report of the consultative meeting of experts on the Statistical Study of Natural Hazards and their Consequences, held at Unesco Headquarters in April 1972.

2. AGENDA

The meeting had the following agenda:

1. Review of report and relevant resolutions of the Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk.
2. Methodology for the statistical study of economic losses due to earthquakes as a function of:
   - 2.1 Geophysical and geological factors.
   - 2.2 Engineering factors.
   - 2.3 Economic and social factors, including physical planning.
3. Problems involved in the establishment of a general framework for earthquake insurance.
4. International co-operation in the study of the economic implications of earthquake risk and insurance.
5. Other relevant questions.
6. Adoption of report.

3. METHODOLOGY FOR THE STUDY OF ECONOMIC LOSSES RELATED TO EARTHQUAKES

The estimation of the probable economic losses associated with earthquakes involves: (1) the seismic hazard (probable intensity and spatial distribution of ground shaking, ground failure, etc.); (2) the value and location of buildings and other property exposed to the hazard; and (3) a vulnerability function, i.e. a set of coefficients defining the susceptibility of the property to damage by ground shaking or failure, fire following earthquake, etc. In addition to the more traditional techniques of risk estimation, the working group wishes to call attention to certain types of data, analysis techniques and results in geophysics, geology, engineering and planning that are considered significant.

3.1 Geophysics, geology and engineering

(a) Synthesis of geological, geomorphological and geophysical data with a view to determining earthquake-prone lineaments (surface traces of major discontinuties in the earth's crust). Special attention should be given to new sources of data (satellite observations, deep drilling, etc.)

(b) Construction of statistical models of:

(i) earthquake mechanism

(ii) earthquake occurrence with emphasis on the possibility of time-dependent models making use of new data available from geochronology, earthquake precursers, etc.

(iii) spatial distribution of ground shaking. Ground shaking depends upon the magnitude of the earthquake, type of earthquake mechanism, distance from the fault rupture and characteristics and geometry of the material between fault rupture and site. Ideally, ground shaking is best described by a complete time history of the ground motion. Unfortunately, at the present time, quantitative data on the characteristics of strong ground motion are very limited and shaking is commonly described by a single parameter (intensity, peak acceleration, etc.). Whenever possible, estimates of the spectral content of ground motion and some measure of the duration of shaking should be specified.

(c) Development of comparable hazard maps on a world-wide scale (preferably probabilistic descriptions of ground shaking and ground failure).

(d) Development of seismic zoning and microzoning maps. Seismic zoning and microzoning maps may, in some instances, be different from hazard maps because of the special requirements imposed for their effective use for design or in building codes. Research into techniques of microzoning should be encouraged. Microzoning includes estimation of the influence of shallow subsurface materials on ground shaking, which has proved to be particularly difficult to estimate. One useful method of microzoning is based on the measurement of the shear wave velocities in the surface materials and subsurface layers. The modification of ground shaking in the vicinity of any site may be estimated from the velocities and layering and through the use of multi-reflexion theory.

(e) Accumulation and statistical analysis of damage data. It is widely recognized that the type and age of structures and foundations greatly influence the vulnerability of a structure. The natural frequency and earthquake response of structures such as buildings, dams and bridges vary over a wide range. There are, in addition, many different structural types even in the same general category of structure (an example is the wide range of response characteristics of dams of various types). There are many different building categories, such as steel frame, steel frame reinforced concrete, reinforced concrete, plain concrete, mansonry (brick, stone, concrete block), wood, adobe, taquezal, stone and clay. The response of buildings varies over an enormous range and is, in addition, difficult to predict. Building age is significant for two reasons: on the one hand, there are purely aging effects; on the other, buildings of different age may have been constructed according to different design philosophies or building codes, and with the use of materials of different strength.

(f) Code revision to minimize loss of function in addition to preventing casualties. Past and present practice in earthquake engineering and building codes has aimed at minimization of casualties. Studies should be undertaken to determine optimal levels of damage control for favourable cost-benefit rates.

(g) Investigation of the various kinds of ground failure (surface faulting, landsliding, liquefaction, etc.). In many cases, damage to structures and other facilities is greatly increased by ground failure. Studies of ground failure have, up to the present time, been completed for only very limited areas.

(h) The following additional factors should be carefully considered in estimating potential earthquake damage to structures and other property:

  (i) design code and specifications, including structural and non-structural detail;

  (ii) method of design and structural analysis;

  (iii) quality of materials and testing methods;

  (iv) construction practice and performance;

  (v) degree of maintenance work;

  (vi) vulnerability of lifeline systems.

3.2 Physical Planning

Earthquake risks directly affect the physical planning process, i.e. the process of planning the spatial distribution of all economic and social activities, nationally, regionally or locally.

In the present context, the physical planner is basically concerned with two problems:

(a) preventing disasters by mitigating earthquake risk in areas already developed;

(b) mitigating or preferably eliminating earthquake risk to projected new developments.

For planning in areas of existing development, the physical planner requires, as a matter of priority, reliable information on (1) the probability of damage and (2) on the probable effects of such damage upon the economy. Without such information it is virtually impossible for planners to mobilise the political will that is required to effect the necessary modifications and adjustments to planning and building legislation and to take measures for risk mitigation particularly with reference to land use. Such information also serves to refine modifications at the technical level.

There are problems of scale. The scales of planning vary, and range from the distribution pattern of human settlements at the national level to the problems of locating individual buildings or activities on specific sites. The estimation of damage probability (loss potential) and its economic consequences at the national level differs from the same type of exercise at the local level. Whereas national data are of particular value for policy formulation, physical planners require more and better information about regional and local risks in order to be able to arrive at valid specific measures.

With respect to physical planning for new development, the planner is probably most interested in applying risk analysis techniques to economic, social and environmental goals. He requires risk data which may be easily and readily convertible into land use and building constraints. Although much work has been done in hazard analysis, too little is known about how to apply such analysis to comprehensive physical planning. The physical planner further needs to use risk analysis techniques to evaluate trade-offs between different types of development in an area of given risks, or conversely between alternative locations for a given type of development. Here also data for physical planning at the local level is most important, and the role of soil conditions (i.e. the total probable ground response) seems to be an important consideration.

It should be stressed that meaningful post-earthquake damage assessment (and the assessment of its indirect effects) presents major difficulties. There is no simple methodology to tackle the task, and an adequate data base is often lacking.

Finally, the working group wishes to emphasize the necessity of reinforcing disaster preparedness measures by assuring the adequate distribution to key locations of rescue and relief facilities, such as escape routes, fire fighting and ambulance services, access to power and water, etc. The planning process can also serve to reduce the vulnerability of these facilities to earthquake damage.

4. PROBLEMS INVOLVED IN THE ESTABLISHMENT OF A GENERAL FRAMEWORK FOR EARTHQUAKE INSURANCE

4.1 The effects of earthquakes on the insurance industry are one of the various consequences to the economy which have to be taken into account. The growing difficulty in providing adequate earthquake insurance cover makes it imperative to reconsider the present position. The overal damage caused by large earthquakes, even the damage to property only, may go beyond the resources of the insurance industry. Even if seismicity is not increasing (whereas some scientists believe that we may be entering into a period of increased seismicity), the overall commitments to be borne by the insurance industry are expanding. Despite efforts to mitigate its effects (land-use planning, earthquake engineering) higher losses have to be expected in the future, due to the general rise in world population, its increasing concentration in urban areas and the accompanying accumulation of values, the increasing wealth per capita in many countries, etc. It has been estimated that - for instance - a major earthquake in San Francisco or Los Angeles (USA) could lead to property losses of approximately US$ 50 billion, and in Tokyo (Japan) could exceed $100 billion.

4.2 The main problems facing the insurance industry in providing earthquake cover are:

- Lack of sufficient coordination of knowledge between scientists on the one hand and the insurance industry on the other, with respect to rating and risk assessment; there is a need to bridge the still-existing gap between developments in the geosciences, earthquake engineering and insurance practice.

- Insufficient coordination within the insurance and reinsurance industry on the national and international levels, despite great efforts being made in the last years to improve the situation.

- Insufficient coordination of ways and means to prevent and reduce losses between the insurance industry and governments or other public bodies (e.g. planning authorities), and unawareness among the general public.

- Lack of readily available statistical information on the location of risks, classes of buildings and their susceptibility to loss, breakdown of values at risk into buildings and contents.

- The fact that even the data available are not always fully used in premium rate calculation because of political, economic or social constraints.

- Constraints in insurance practice, often due to terms and conditions of insurance cover dating from periods when few coverages were granted and when earthquake losses could not seriously affect the overall property insurance portfolios, and partly to the difficulty of adjusting thousands of simultaneous losses in a relatively short time.

- The impact of inflation on insurance values and on investments of catastrophe reserves, taxation of the latter also presenting problems.

Insurance systems, even within the elaborate systems of world-wide reinsurance and retrocession with respect to earthquake cover, show a trend to reach a certain limit, where the finite financial resources may lead to a shortage of capacity - if the system is to remain solvent in the case of a large loss. Such a shortage is already occurring in some countries and the insurance industry has been forced to cover a smaller percentage of values. This may be lessened by appropriate measures with regard to insurance terms, premium rates and the taxation of catastrophe reserves.

5.2 For the general purposes of planning economic development in seismic areas, the following action is recommended:

(a) to improve and develop vulnerability analysis methodology for development planning purposes, especially physical planning (urban and regional) and, in particular, to develop means of translating scientific data on risk into practical planning concepts;

(b) to pay particular attention to vulnerability analysis for planning at the urban or local level;

(c) to encourage the organization of pilot projects in vulnerability analysis for investment programming and development planning purposes;

(d) to develop land-use programmes for mitigating earthquake risk.

5.3 A long-term programme of scientific studies on earthquake hazard and insurance should aim at providing the following information and data:

(a) Improved catalogues of historical events

(b) Probability distributions of earthquake severity

(c) Appropriate indices of earthquake shock severity for various classes of buildings and contents

(d) Earthquake hazard maps

(e) Geological information, with regard to secondary effects such as liquefaction, ground failure, etc.

(f) Relationship between seismological parameters and probable damage.

(g) Information on new methods of seismic zoning and hazard assessment, including corresponding algorithms and software.

5.4 In order to develop a workable general framework for the implementation of earthquake insurance, a step-by-step approach is recommended:

(a) Appropriate rating (appropriate to the risk) and a system of risk-orientated deductibles and partial self-insurance by the insured ("co-insurance") can provide motivation, by economic incentives, for the mitigation of damage due both to earthquake shock and to fire following earthquake, i.e. by the choice of better locations and by improved standards of earthquake engineering. These measures would contribute to an increase in available world insurance capacity, thus enlarging the insurance industry's service to national economies within the given international system of insurance, reinsurance and retrocession (re-reinsurance).

(b) By more transparency of insurance cover (information on liabilities assumed) and a solution to the problems of setting up catastrophe reserves and of their taxation, world insurance capacity would also be increased.

(c) Studies of the possibilities of improving physical planning techniques and building codes with a view to reducing material damage in addition to saving human lives.

5.5 In addition, the following specific proposals are made for action by Unesco in the near future:

(a) Establish a permanent interdisciplinary committee of experts to coordinate progress and the exchange of information on the economic and especially the insurance applications of earthquake studies.

(b) Convene an international conference or seminar on "Earthquake Hazard and Insurance" to be held possibly in Mexico in 1978 or early 1979. The purpose of this meeting would be to bring together a number of experts on a wide range of disciplines related to earthquake hazard and insurance, in order to broaden the scope of discussions on economic losses and on the role of earthquake insurance in abating earthquake risk.

(c) Organize a pilot study by scientists, engineers and the insurance industry of the possible effects of earthquakes on the economy of a given area. A possible choice might be the circum-Caribbean area.

LIST OF PARTICIPANTS

S.T. ALGERMISSEN
U.S. Geological Survey
Denver Federal Center
Box 25046 Stop 978
Denver, Colorado 80225
(U.S.A.)

W.O. BAUER
Departmental Manager
Munich Reinsurance Co.
107 Koeniginstrasse
D - 8000 Munich 40
(German Federal Republic)

G. BERZ
Munich Reinsurance Co.
107 Koeniginstrasse
D - 8000 Munich 40
(German Federal Republic)

D.G. FRIEDMAN
Research Department
Travellers Insurance Co.
1, Tower Square
Hartford, Connecticut 06115
(U.S.A.)

M. HEILBERG
Assistant Secretary
Earthquake and War Damage Commission
Wellington
(New Zealand)

V. KEILIS-BOROK
Soviet Geophysical Committee
Molodezhnaya 3
Moscow 117296
(USSR)

C. LOMNITZ
Instituto de Matematicas Applicadas
Ciudad Nacional Autónoma de México
Ciudad Universitaria
México 20 D.F. (México)

T. OKUBO
Director, Planning and Research
Administration Division,
Public Works Research Institute
2-28-32 Honkomagome
Bunkyo-ku,
Tokyo
(Japan)

P.-Cl. PERRENOUD
Swiss Reinsurance Company
50/60 Mythenquai
CH-8022 Zurich
(Switzerland)

UNDRO

L. VAN ESSCHE
Prevention and Planning Division

UNESCO

E.M. FOURNIER D'ALBE
Director, Division of Earth Sciences

K. KITAZAWA
Division of Earth Sciences