9. ENGINEERING MEASURES FOR LOSS REDUCTION

9.1 Earthquake-resistant buildings

The session dealt with some of the most important problems connected with the earthquake-resistant design of buildings, with the salient characteristics of building codes formulated in the last few years, and with problems related to the implementation of building codes and research results.

In the presentation of the working paper (SC-76/SEISM/8) and in the discussion, the following significant features of modern codes were noted: a hierarchy of detailed and simplified methods of structural analysis, with more conservative design rules applying to simplified methods; explicit consideration of available ductility in the definition of reduced design spectra; probability-based criteria for superposition of response to three components of earthquake motions; redundancy requirements; explicit consideration of soil-structure interaction as regards its contribution to modifying natural periods of vibration and to introducing radiation damping; consideration of overturning moments for revision of stresses in columns, and of foundation capacity; special consideration of the design of joints and structural details so as to ensure that connexions are usually stronger than the members they connect. Special mention was also made of the convenience of expressing design requirements in the simplest terms and of adopting formats that lend themselves to easy updating.

In the same context, modal analysis was favoured with respect to supposedly more refined methods, such as step-by-step dynamic analysis, since the application of methods of the latter class to practical design does not seem justified at present, in view of the significant effects that they fail to account for. Definition of design spectra in given seismic zones by two parameters (effective peak ground acceleration and zero damping spectral velocity for intermediate periods) was deemed advisable.

The participation, in the drafting of building codes, of the various groups that will use them was considered as indispensable for their implementation.

Although it was recognized that uncertainty affecting ground motion parameters is significantly larger than that affecting structural parameters, important research efforts concerning the latter are justified in view of the wide applicability of the corresponding results.

Extensive discussion was devoted to the problem of the safety of low cost housing in rural areas of developing countries, and international co-operation for research and development in this field was strongly advocated.

The question of unification of building codes received special attention. The majority of participants felt that neither a general code nor a common code framework was feasible, however, the formulation of general guidelines on basic design principles was considered highly desirable.

The importance was stressed of making building codes consistent with the properties of locally available materials and with quality control standards.

The implications of earthquake resistance requirements for architectural concepts and the design process were recognized.

9.2 Utilities (railways, communications, pipelines, highways, etc.)

The discussion centred around working paper SC-76/SEISM/9. It was recognized that criteria for evaluating the safety of utility networks are still at an early stage of development. Problems of main concern are:

(a) Evaluation of relative displacements between different points, this will require the development of special measuring devices.

(b) Design of systems that allow significant deformation to take place mainly at pre-selected points (use of special joints).

(c) Special problems connected with the handling of fluids under high pressure.

In the evaluation of the reliability of life-line systems two groups of problems must be considered:

(a) Those associated with the performance of mains (trunk lines), where no redundancy is usually feasible.

(b) Reticulated systems within cities, where redundancy is feasible and desirable.

The necessity of adopting quantitative criteria for the design of anchorage for large pieces of equipment (mechanical, electrical, chemical, etc.) was emphasized.

9.3 Urban plans

The discussion covered problems of urban planning from the standpoint of measures to be taken for the purpose of reducing the possible consequences of earthquakes.

In the presentation of discussion paper SC-76/SEISM/10 and in the subsequent debate the following important points were raised:

1. The contrast between the ideal situation where planning can start from scratch and the real situation where only limited action can be taken: some actions taken in the United States of America and in Japan to describe quantitatively the existing hazard potential and to legislate effectively for its reduction were illustrated. Mention was made of the problems of relocating urban communities and the lack of any systematic analysis in this area. Experience reveals that there is often strong resistance to removal on the part of communities.

2. Hierarchies of factors requiring protection may vary from country to country and thus urban planning must be based, in each country, on the latter's assumed priorities.

3. Considerable weight was placed on the importance of defining accurately the different seismic risk levels within urban areas. Sound land-use policies should be a direct consequence of this assessment, and provide a basis for earthquake-resistant construction regulations. The convenience of basing planning criteria on comparative analyses of different kinds of risk, and of seismic risk in different areas, was extensively debated.

4. Recommendations were made to the effect that any regional or urban development project undertaken in seismically-active areas be preceded, from its very beginning, by engineering seismology studies defining microzones characterized by different risk levels.

5. The active participation of communities as a whole in all stages of decision-making in the urban planning process was deemed as indispensable for the successful implementation of planning strategies.

9.4 Special structures

Two main groups of special structures were covered under this heading nuclear reactors and large dams.

When dealing with the selection of earthquake design parameters, both types of structures require similar studies. The assessment of regional seismicity varies in accordance with the available information concerning seismotectonic conditions near the site: when faults are well defined and historical records of earthquakes are available, reasonably accurate estimates of seismicity are feasible, when such information is meagre, estimates of maximum intensities have to rely on studies of local and regional geology and on the known seismic activity of comparable zones of the earth's crust.

The validity of the usual one-dimensional shear-wave models for predicting the influence of local soil conditions on earthquake response was questioned, as these models do not account for vertical components of motion or for surface waves, which contribute significantly to the motion, at least at frequencies below 1 Hertz. Because experimental evidence is often in contradiction with the results of these methods, predictions should be based on comparison with motions recorded on similar ground conditions. It was recommended that motion be specified at the first competent layer beneath the site, rather than at the base-rock level.

Nuclear reactors

The analysis of the dynamic response of nuclear power plants poses special problems. It was stressed in the presentation of discussion paper SC-76/SEISM/12 and in the subsequent discussion that soil-structure interaction significantly affects the response; the usual criteria in the study of this phenomenon do not account for high-frequency energy loss at the foundation-soil interface. The application of finite-element methods to soil-structure interaction problems has significant drawbacks. Comparative studies of records obtained simultaneously at foundations and in the free field were strongly recommended. The step-by-step analysis of non-linear structural response is often carried out, but the very significant interaction among responses due to different components of ground motion is usually neglected. Equipment mounted on the main structure is designed on the basis of floor-response spectra, that fail to account for the reduction in response entailed by equipment-structure interaction.

Design regulations were reviewed, with emphasis on the two intensity levels usually advocated and on the influence of stress levels on the damping values to be adopted. The requirement that the intensity of the operating basis earthquake be equal to one-half that of the safe shutdown earthquake was criticized, and it was mentioned that the question is now being analysed.

Some problems connected with the specification of design spectra were discussed optimum safety criteria can be shown to lead to design spectra whose shape differs from those consistent with fixed reliability criteria; moreover, uncertainty in natural periods precludes taking full advantage of the decrease in spectral ordinates occurring in the high-frequency range.

Scarcity of strong-motion data in the near field was pointed out. The significance of small magnitude earthquakes originating beneath given sites in regions of low seismicity was recognized. Comments were also made on the difficulty of applying strong-motion data to conditions differing from those of the original recording sites, and on the need to account for local conditions and source mechanisms when trying to correlate magnitude and intensity. Some discussion was also devoted to the possibility of isolating structures from earthquake waves and from fault displacements.

Large dams

As in the case of nuclear power plants, emphasis was placed in document SC-76/SEISM/11 and in the discussion on the convenience of deploying arrays of instruments in the vicinity of the construction as well as at its foundation and at several locations in the superstructure.

Some problems specific to large dams deserve special attention, such as the formulation and calibration of two-phase models for representing the behaviour of soil-water systems in rockfill or earthfill embankments; consideration of tridimensional interactions as well as of travelling wave effects on the dynamic response; adoption of improved compaction-control procedures aimed at avoiding non-uniform embankment settlements, installation of arrays of instruments prior to construction in order to detect induced seismicity, if any; protective measures against gradual and sudden relative displacements along faults; radiation of energy through foundation and abutments.

It was stressed that seismic design criteria of embankment dams should be based on crest settlement restrictions rather than on stress limits.

When geological conditions suggest the possibility of induced seismicity, it must be assumed that earthquakes of the maximum regional magnitude may be generated.

Attention was drawn to the interest of the International Commission on Large Dams (ICOLD) in receiving and distributing information concerning the seismic design and behaviour of dams. Comments were made on the observed satisfactory performance of some dams subjected to moderate earthquakes.

There was some discussion of the load combinations to be assumed in design. The suggestion that one should design for the simultaneous occurrence of maximum flood level and of the largest regional earthquake occurring beneath the dam was exhaustively debated but was not considered applicable by the majority of delegates. The study of regional tectonic stresses was regarded as highly desirable for the assessment of induced seismicity.

In view of the difficulties tied to fault displacement predictions, use of self-healing non-cohesive materials in cores of embankment dams was recommended.

The possibility of waves being generated by slope failure in the reservoir underlines the need for extremely careful studies of local geology.

9.5 Strengthening of existing and of damaged buildings

The problem of repair and strengthening of buildings was discussed from the standpoints of technical requirements and implementation policies. It was pointed out that repair means at best restoration of the original structural resistance, whereas strengthening means improvement of the structure's ability to withstand earthquake forces. Warnings were given of the possibility that repair works may in reality weaken structures.

It was recognized that the detailed recommendations contained in discussion paper SC-76/SEISM/13 apply mainly to the specific conditions for which they were developed, and that different conditions may call for different solutions. The problem should receive the attention of local authorities and engineers, because the present shortage of dwellings and its probable persistence during the next few decades require action to make the surviving buildings safe.

Some delegates insisted on the need to improve the present damage-based intensity scales. However, it was concluded that discussion of this topic should not be pursued, because of the already large number of existing scales and of its loose connexion with this item of the Agenda.

Observations of the behaviour of actual structures should be applied to develop improved design and construction practice. Hence, the performance of structures damaged by earthquakes should be analysed in an attempt to understand and to describe quantitatively the reasons for failure. The introduction of new structural systems and building technologies leads to new failure modes and this makes exchange of information on seismic damage an issue of utmost importance.

The special problems posed by the strengthening of monuments were discussed, and it was agreed that the general recommendations adopted under this item should be considered applicable to them.

RESOLUTIONS

RESOLUTION 9.11

Because investigation of the behaviour of buildings subjected to strong earthquakes is of great importance for checking and improving criteria and methods of design and construction, the Conference recommends that analysis of buildings undamaged, damaged or destroyed by strong earthquakes be continued by Unesco field missions.

RESOLUTION 9.12

Recognizing that building codes play a key rôle in the reduction of seismic risk, the Conference recommends that Unesco support the interchange of relevant ideas and guidelines for the development of general principles involved in the formulation of building codes.

RESOLUTION 9.13

Theoretical and experimental investigation of basic static and dynamic properties of structural materials, elements and systems is required in order to develop simple methods for designing different types of structures, especially masonry and prefabricated buildings. The Conference recommends that Unesco seek co-operation with the appropriate international organizations in formulating criteria for resource allocation to research and in preparing aids to designers, such as guidelines and handbooks, based on optimum criteria for earthquake-resistant design.

RESOLUTION 9.14

The Conference recommends that seismologists and engineers work together in the field of seismic design, the former to define the hazard and the latter to determine the way in which the hazard is to be taken into account in design.

RESOLUTION 9.15

The Conference recommends that Unesco invite the International Union of Architects to encourage its members to collaborate with earthquake engineers in the planning and design of buildings and facilities in earthquake-prone areas, from the very early stages of projects.

RESOLUTION 9.16

The Conference recommends that Member States that have not yet adopted mandatory minimum standards and codes for materials and construction do so.

RESOLUTION 9.17

Noting the requirements for an increased flow of data relating to the near field of earthquakes, and for observations of the behaviour of many types of structure under severe conditions,

The Conference invites Member States, with the assistance of Unesco, to establish Earthquake Experimental Areas in regions of high seismicity and low population density. Within each area, simple basic facilities and access in the form of a network of signposted trails should be established. The host country would be asked to facilitate the entry and exit of visitors with their supplies and equipment, and to provide any other assistance within its power.

RESOLUTION 9.2

Recognizing (a) that the present state of technology in the earthquake-resistant design of utility systems is in the developing stage, and (b) that seismic damage to utility systems poses great hazards to modern community life,

The Conference recommends that Unesco provide assistance to existing co-operative governmental programmes in this area that have been established for exchanging information and personnel.

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RESOLUTION 9.31

Recognizing the importance of Habitat: United Nations conference on human settlements for efforts on the global, regional and sub-regional levels to improve human settlements, the Conference recommends that Unesco take appropriate steps to ask Habitat to include on its agenda consideration of human settlements in earthquake-prone areas.

RESOLUTION 9.32

Noting that in future planning or urban development, factors such as seismic microzoning and socio-economic implications of earthquake hazard are very important, the Conference recommends that Unesco take appropriate action to provide, on request, technical assistance in promoting the international exchange of information on these subjects.

RESOLUTION 9.33

The Conference recommends that every regional and urban development project undertaken with the participation of Unesco, covering seismically active areas, be carried out with participation of experts in seismic zoning, microzoning, seismic risk and earthquake-resistant design, as early as feasible.

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RESOLUTION 9.41

The Conference recommends that Member States pay special attention to the selection of sites for construction of nuclear power plants in earthquake-prone regions. Extensive research on seismic characteristics of the region and comparison of different sites, taking into account social and economic criteria, should be carried out before initiating planning and design of each nuclear power plant.

RESOLUTION 9.42

The Conference recommends to Member States that the International Commission on Large Dams (ICOLD) be made aware of all observations of existing dam behaviour, as also the results of research leading to improvements on (a) estimation of ground motions for design, (b) behaviour of materials under dynamic load, and (c) methods of computation of both strain and stress in large concrete or embankment structures.

RESOLUTION 9.43

Noting (a) that chemical plants, nuclear power plants, large dams, and similar facilities could extensively endanger the lives of neighbouring people if these facilities were subjected to strong earthquakes without meeting adequate design standards; and (b) that the International Atomic Energy Agency (IAEA) is proposing international safety guides to protect nuclear power stations against earthquake disaster,

The Conference recommends:

(1) that each Member State make available its complete aseismic regulations or codes for these facilities, together with information on seismicity and related technical background; and

(2) that in formulating suitable codes or regulations, all Member States co-operate, with assistance from Unesco and IAEA.

RESOLUTION 9.44

The Conference recommends that Member States intensify the acquisition of strong-motion seismograms: (1) by the use of Earthquake Experimental Areas, if possible; (2) by deploying more strong-motion instruments both in nuclear reactors and in the free field, in regions where strong earthquakes are expected; and (3) by deploying close networks of strong-motion equipment in the aftershock regions of major earthquakes.

The experiments should be designed to give data on wave propagation as a function of source mechanism and distance from the source, site amplification, and soil-structure interaction.

RESOLUTION 9.5

The Conference recommends:

(1) that Unesco support international co-operation and research to devise practical ways for reducing the risk of earthquake damage in (a) rural residential dwellings built by the residents themselves using locally available materials, and (b) non-engineered dwellings, i.e. dwellings built without the application of engineering principles and for which socio-economic factors preclude participation of engineers or qualified technicians. Measures should include:

   (i) the development of practical solutions, drawing on specific experiences and experimental research;

   (ii) the preparation of simple graphic material that can be easily understood by ordinary houseowners and craftsmen;

   (iii) the training of houseowners and craftsmen in the practical implementation of devised solutions;

(2) that Unesco act as a centre for the collection and distribution of documents and technical reports it judges to be of importance, describing experiences and methods adopted in various countries in the field of strengthening and repair of structures, when such documents are not generally available,

(3) that a set of unified guidelines for describing damage caused by earthquakes be prepared by Unesco, with the assistance of a working group appointed ad hoc;

(4) that Member States devote special attention to the strengthening of hospitals, theatres, schools and other buildings that may house a large number of people. These facilities should be inspected and their safety thoroughly checked periodically and just after a damaging earthquake;

(5) that Member States give specific consideration to the safeguard of historical monuments against earthquake damage and their proper repair and strengthening, since this poses sometimes engineering problems which are fundamentally different from those of ordinary structures of a limited lifetime. These problems have rarely been considered in the light of modern technology and deserve special attention.

10. IMPLICATIONS OF EARTHQUAKE RISK

10.1 Economic implications of earthquake risk

The discussion paper SC-76/SEISM/14 was introduced by the Secretary-General of the Conference, who emphasized the importance of economic considerations in the overall social implications and the necessity of analysing the problems of insurance against earthquake risk.

The delegate of Switzerland, co-author of the discussion paper, then outlined the significant points in the paper, stressing.

(1) the necessity of realizing that when an earthquake occurs, consequential losses - for example, those from fire or interruptions to production - are often more important than direct losses but are more difficult to assess and control;

(2) that from the insurance and reinsurance point of view, earthquake risk was like a stowaway creeping into insurance life. The main problem was to gain a clear idea of the loss potential of earthquakes.

With earthquakes, the premium calculation should be considered only as a third priority, after the assessment of the maximum commitment by insurance companies and the assessment of an adequate catastrophe reserve.

The basic numerical data required by insurance companies to quantify loss potential and to assess an adequate catastrophe reserve can be defined by asking:

(a) Where are the geographical accumulations of insurance risks and how large are the total sums insured?

(b) What is the average frequency of shocks of a given intensity in a given area - the average return period? and

(c) What may be the average degree of damage from a shock of a given intensity in a given area?

Several delegates described the principles governing the functioning of insurance schemes in their respective countries, and discussed the relative merits of private and national earthquake insurance programmes. The Conference noted that in a number of countries, such as New Zealand, Japan, the Union of Soviet Socialist Republics and the United States of America, there exist workable insurance schemes covering earthquake risks. A study is under way at the University of Pennsylvania (U.S.A.) to determine among other matters the reason why people purchase or do not purchase earthquake and flood insurance available in the United States. It was mentioned that insurance companies could assist considerably in mitigating the earthquake hazard by scaling their rates to ensure the application of current knowledge in design and by ensuring that this design is implemented during construction. However, in many countries earthquake insurance is being practised in a rather simplistic way and serious efforts are needed to provide this insurance on a reasonably scientific basis.

The Conference examined the methodological approach to the study of the probability distributions of different kinds of earthquake damage, using data from geophysics, engineering and economics, developed in the USSR as a guide to insurance decision-making. It took note of the offer by the Academy of Sciences of the USSR to make available information on this methodological approach and on the relevant computer software.

10.2 Human implications of earthquake risk

The Secretary-General of the Conference presented discussion paper SC-76/SEISM/1 on the social dimensions of human response to earthquake risk. He underlined the importance of these problems and the need for the knowledge and skill accumulated by science to be implemented in practice.

During the discussion that followed on the human implications of earthquake risk the main attention of the delegates was paid to the following points:

(1) Consciousness among individuals of the earthquake problem:

(a) Research to discover the reactions of individuals to earthquake disasters in specific country or regional locations.

(b) Practical measures to stimulate this consciousness.

(c) Examples of practical educational measures which include use of the mass media, films, etc. These measures must be factual and not sensational as the latter may prove to be counter-productive.

(d) Examples of administrative and legislative measures which include preparedness training, national and local laws, volunteer efforts and the provision of co-ordinating mechanisms for the effective implementation of the preparedness plan.

(2) Behaviour and response of individuals to earthquake occurrence and threat:

(a) The study of the conditions conducive to possible panic.

(b) Practical measures to counteract the onset of panic; for example, engineering solutions such as the avoiding of excessive flexibility of buildings, the design of quick and safe exit facilities, education of the public, etc.

(c) The study of the conditions under which mental health problems arise, and of practical measures to counteract these problems.

(d) Attitudes of individuals to frequent and infrequent earthquake threats.

(3) The absence or presence of institutionalized post-disaster assistance.

The delegates drew attention to the practical problems faced by individual Member States in connexion with the human and social implications of seismic risk. One delegate pointed out the need which exists in countries without adequate standards for earthquake-resistant construction, for information on the most effective means of promoting awareness of earthquake risk. Without such public awareness legislation does not follow.

Some countries have areas with earthquake-resistant construction. These require a different form of legislation to promote the most effective individual and community action against earthquake risk, and may benefit from information obtained from other countries with similar problems.

It was noted that human response to the earthquake hazard is a complex phenomenon related both to individual and situational constraints. Psychological and social science research is needed to reveal the conditions of human behaviour during and after disasters, including the social psychology of stress situations leading to anxiety and panic.

10.3 Social implications of earthquake risk

Discussion paper SC-76/SEISM/16 on the social implications of earthquake risk was presented, in the absence of its author, by the Rapporteur of Commission C.

The attention of the delegates was drawn to the principles of the organization of a special emergency relief or civil protection service as a response of society to the earthquake hazard.

Information was given on methods of coping with disaster. It was noted that in the United States of America, two government organizations exist to provide assistance in times of disaster, one of which, the Federal Disaster Assistance Administration is specifically concerned with natural disasters. This institution provides assistance in the form of public facilities and individual assistance, including housing, unemployment, food and loans and grants.

It was noted that disaster preparedness measures also exist in some other countries, for example New Zealand, Japan and the Union of Soviet Socialist Republics.

Mention was made of the value of voluntary efforts in disaster, especially that provided by the League of Red Cross Societies.

The representative of the United Nations Disaster Relief Co-ordinator outlined the work of his Office and supported the general conclusions of the discussion paper. He stated that his Office had two main functions: (1) the co-ordination of relief; (2) the organization of disaster prevention. He stressed the impact that natural disasters have on developing countries and concluded that vulnerability studies of major projects in these countries were essential, if only to avoid heavy investment in high risk areas.

The Conference discussed a range of possible measures which should be considered in regard to the mitigation of seismic risk. It was suggested that necessary attempts to find an optimum set of these measures for effective mitigation, were desirable. Some descriptions were given of the approaches to such optimization developed in the Union of Soviet Socialist Republics, Mexico and other countries.

RESOLUTIONS

RESOLUTION 10.01

The Conference, recognizing the value of research done in recent years into the human, social and economic aspects of earthquake and other disasters, recommends that Unesco encourage further research into their social and economic aspects in order to provide the understanding required for the use of seismological and earthquake engineering findings for the mitigation of such disasters.

RESOLUTION 10.02

The Conference recommends that Member States, in seeking to mitigate seismic risk, adopt optimal combinations of the following measures: (a) rules on land use, (b) building codes; (c) educational and other measures for the improvement of non-engineered buildings not covered by building codes; (d) tax policies and other economic incentives; (e) insurance; (f) planning of emergency action; (g) planning of relief; (h) relevant research.

These measures should be taken at the international, national, regional and local levels.

RESOLUTION 10.03

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 auspices to co-ordinate the aforementioned studies and implement their results through workshops and seminars.

RESOLUTION 10.04

The Conference recommends that Unesco's earthquake reconnaissance missions include experts from appropriate branches of economics and the social sciences.

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.

RESOLUTION 10.21

The Conference recommends that Unesco promote among Member States research at the local level of traditional awareness and response to earthquake risk. The Conference further recommends that where necessary this traditional awareness and response be incorporated into the national mitigation effort or be utilized to provide innovative solutions at the local level.

RESOLUTION 10.22

The Conference recommends that Unesco encourage Member States (a) to study the extent of awareness of earthquake risk at the individual and community level in order to determine the requirements for educational material, and (b) to disseminate such educational material through appropriate media in conjunction with a continuous monitoring process to evaluate the success of this effort.

RESOLUTION 10.3

The Conference recommends to Member States the formulation, adoption and appropriate updating of plans for the implementation and regulation of emergency measures following an earthquake, according to local needs. The Conference further recommends rehearsals of emergency measures at the community level in addition to nation-wide programmes and practices, in areas of high seismic risk.

11. GENERAL TOPICS

11.1 Earthquake parameters for engineering design

The presentation of discussion paper SC-76/SEISM/17 was oriented towards criteria for selecting design parameters and intensity levels. Rational engineering design calls for optimum decision-making, and the required information must be consistent with this approach. It does not suffice to have point estimates of expected values of largest magnitudes and intensities. It is also necessary to assess the degree of uncertainty attached to such estimates.

An analysis was made of the problems encountered in the process of converting geological, seismotectonic and historical information into the quantitative values required for engineering decisions. Two groups of problems were considered those defined by the response of individual structures at a given site, and those related with the response of spatially extended systems. The first group includes, for instance, seismic design of buildings, whereas the second includes, among others, the design of lifeline networks or the estimation of the probability distribution of the maximum global loss caused by an earthquake in a given region.

Problems in the first group may be dealt with by means of seismic probability maps which, in their simplest form, consist of plots of the values of single parameters having given return periods. Because different parameters are more strongly correlated with the seismic response of different systems, sets of seismic probability maps showing different parameters (such as peak ground acceleration, velocity, or ordinates of response spectra for various natural periods and damping values) should be prepared, and in fact have been prepared in some countries. These maps contain information in a form suitable for decision-making and provide the basis for seismic zoning maps, whose coefficients and spectra for routine design are specified.

When the response of spatially extended systems is of interest, models of the earthquake generation process and of intensity attenuation as a function of location relative to the source are required.

Engineering decisions have been shown to be sensitive to the probabilistic models of seismicity, and this calls for further research. The main difficulties envisaged are tied to the scarcity of statistical information and to the need to formulate conceptual models of the process of energy accumulation and release in given areas.

As in other sessions, much attention was devoted to the convenience of developing instruments capable of recording directly particle ground velocities.

The most significant uncertainty attached to intensity assessments for given sites is that associated with geophysical and geological evaluations. Use of Bayesian analysis criteria does not add new data, but provides a rational framework for its analysis.

Some discussion was devoted to the problem of studying further the correlations between modified Mercalli intensities and instrumentally recorded parameters.

As a corollary to the conclusions concerning the ways of presenting information for engineering decisions, attention was again given to the convenience of enlarging the number and extension of seismic instrument networks and of taking measures that will ensure proper servicing and maintenance as well as data reduction and interpretation.

11.2 Field studies of earthquakes

The discussion was based on discussion paper SC-76/SEISM/18. The author emphasized that knowledge relevant to the assessment and mitigation of earthquake risk must be based on the growth of a body

of reliable observational data. This can only be achieved through the field study of earthquakes and cannot be obtained simply from lectures or by reading reports.

Since 1962, nineteen earthquake disasters have been considered by Unesco to justify the dispatch of missions. These caused the death of about 94,000 people and damages of approximately $1,800 million.

It was noted that, unfortunately, it frequently took several weeks for Unesco missions to gain entry to the disaster-stricken countries. This was considered to be a serious delay and it was suggested that Unesco should:

(a) offer the country concerned the dispatch of a reconnaissance mission; and

(b) immediately send a special consultant who should reach the country in which the earthquake has taken place within 72 hours.

It was stressed that the composition of a Unesco mission of not more than four specialists should be tailored to the particular disaster; earthquakes occurring in urban settings obviously will require a different team from those in rural areas. It was emphasized that the reconnaissance mission is general in nature and that specialized missions may be required at a later date.

There was considerable debate about the composition of field missions. Some delegates stressed that experts from earthquake-prone regions should be included in missions to other countries. Other delegates, while accepting this, also stressed that local experts should be included in Unesco missions. It was also suggested that the participation of young research students should be facilitated.

The Conference was informed of a swarm of earthquakes that had recently occurred in Iceland. Some of the unusual features of these events were described.

The representative of the Inter-American Development Bank described the activities of his Organization in the reconstruction phase following earthquake disasters in Central and South America.

11.3 Interdisciplinary education and training

Discussion paper SC-76/SEISM/19 on this subject was presented by a delegate of Japan. The main theme of the paper was that specialization leads to lack of contact and mutual understanding between the various specialists, and that efforts must be made specifically to bridge these gaps by promoting interdisciplinary studies.

Discussion began with a call from delegates for a multilingual glossary to help to establish a common terminology. It was proposed that three different levels of interdisciplinary training be defined: firstly, long-term studies at the post-graduate level; secondly, seminars of a few weeks' duration for practising engineers to bring them up to date with new techniques; and thirdly, short seminars aimed especially at government technicians and legislators. With regard to the intermediate-length and short seminars, it was suggested that each of these should concentrate on one region and its particular problems. These seminars should be given jointly by foreign specialists and local counterparts.

In response to a question over the stage at which education in earthquake risk should begin, it was illustrated that in some countries this normally begins in secondary schools, whereas in others no attempt is made to introduce the subject except at a specialized, post-graduate level. In the field of adult education, it was learnt that booklets aimed primarily at craftsmen and small builders were being produced by one national group in order to illustrate, with the aid of diagrams, the use of new building materials which, in many parts of the world, are rapidly replacing traditional materials.

Attention then moved to the possibility of setting up new international training centres, particularly in view of the fact that certain of the existing centres had recently lost some of their international character. The general opinion was that the revival of existing international institutions would be preferable to the creation of new ones. It was agreed that Unesco should attempt to support two main kinds of interdisciplinary education, i.e. post-graduate training at international centres, and shorter courses to concentrate on regional problems.

RESOLUTIONS

RESOLUTION 11.11

The Conference recommends to Member States that research into the correlations between earthquake intensity and physical parameters be intensified, co-ordinated and the results published.

RESOLUTION 11.12

In view of the importance of particle ground velocity in determining the index of severity of strong ground motion, the Conference recommends that Unesco provide technical advice and encouragement for the development and design of appropriate inexpensive instruments.

RESOLUTION 11.13

The Conference recommends that Unesco continue its endeavours to ensure that existing and future strong-motion records in the world be collected, together with corresponding macroseismic data when possible, and be made publicly available for the purpose of improving the evaluation of earthquake design parameters.

RESOLUTION 11.14

The Conference recommends that Unesco encourage the development of easy-to-operate and durable engineering seismology instrumentation, to be available to all Member States. Together with regional or national centres having similar objectives, Unesco should co-operate in the necessary technical training for operators of these instruments.

RESOLUTION 11.15

The Conference recommends that Unesco organize a working group with the task of preparing instructions to be used in the organization and operation of national networks of strong-motion instruments, and in the reduction and interpretation of recorded data.

RESOLUTION 11.16

The Conference recommends that Member States use, wherever possible, seismological networks for improving earthquake detection capabilities, and for estimating earthquake parameters, and stresses the importance of the participation and co-operation of national and regional agencies in allocating telecommunication resources for the transmission of seismic signals.

RESOLUTION 11.2

Earthquake reconnaissance missions play an important part as the first stage in the field study of earthquakes. Such missions should be dispatched as soon as possible (preferably within 72 hours) after the disaster occurrence.

The Conference therefore urges that Unesco and Member States take all feasible measures to facilitate the entry of mission members and appropriate instrumentation. Such measures might include simplifying border regulations for field missions sponsored by both Unesco and bordering States.

The Conference recommends that reports of field missions be distributed as widely and rapidly as possible.

The Conference also recommends that Unesco, in consultation with Member States, prepare an up-to-date list of experts for earthquake reconnaissance missions. The missions should include experts from countries with frequent earthquakes.

RESOLUTION 11.31

The Conference recommends that Unesco assist in establishing short training courses in seismology and earthquake engineering with the co-operation of established centres, and suggests that host countries contribute with counterpart lecturers, translations and dissemination of lecture notes.

RESOLUTION 11.32

The Conference recommends that Unesco, in co-operation with other competent international organizations, organize a working group to compile a glossary in the interdisciplinary fields of seismology, engineering seismology, geophysics and seismotectonics in the languages which Unesco uses.

RESOLUTION 11.33

The Conference recommends that Member States in active earthquake areas place emphasis on the improvement of the educational systems in universities and technical institutes which combine seismological, geophysical and geological sciences with earthquake engineering.

RESOLUTION 11.34

Noting that deeper mutual understanding and better exchange of information are needed among seismologists, geologists, earthquake engineers and urban planners on earthquake disaster prevention, the Conference recommends that Unesco and its Member States support training and education in the field of seismology, engineering seismology and earthquake engineering by the provision of experts for short-term seminars on the subjects of interest in different countries and for international training and research centres (such as the IISEE).

RESOLUTION 11.35

Noting the need to provide training in relevant subjects in countries having earthquake risks, the Conference recommends that Unesco establish mobile groups of experts in subjects relevant to earthquake risks, to promote training and research for the minimization of earthquake hazards in countries which are less conversant with advancements and achievements in these fields. These groups could be invited to give advice and guidance in laying the foundations of basic training in the fields of earthquake engineering and seismology.

RESOLUTION 11.36

Recognizing the great value of public awareness in the mitigation of seismic risk in earthquake-prone countries, the Conference recommends that Unesco co-ordinate with Member States concerned the dissemination of present scientific and technical knowledge in ways suitable for use in general education and training of the public, both in schools and in adult education.

12. IMPLEMENTATION

12.1 Interdisciplinary research on the mitigation of earthquake losses

At the invitation of the Chairman, the Convenor of the Working Group on Interdisciplinary Research presented the report of this Working Group (document SC-76/SEISM/WG/1). The Secretary-General invited the Conference to consider this report as its working paper on this item of the agenda and suggested that, if it agreed with the proposals put forward by the Working Group, it should expand and amplify them somewhat in order to provide guidance to Unesco on the action that it felt should be undertaken on each of the problems that the Group had identified as calling for an interdisciplinary approach. He suggested that in some cases concrete proposals might be made for research programmes to be undertaken on a world-wide or regional basis.

One delegate proposed the following addition to the list of problems put forward by the Working Group.

"Evaluation of seismic risk

This interdisciplinary problem will involve the estimation of probability distributions of different kinds of damage from earthquakes for specific territories and periods of time, based on joint analysis of all relevant data - geophysical, economic, social and engineering. Such distributions may be used as a base for practical decision-making aimed at the mitigation of earthquake hazards."

With reference to the choice of design earthquake ground motions, the delegates of Bulgaria, Greece, Romania, Turkey and Yugoslavia proposed jointly the initiation of a project for the mitigation of earthquake risk in the Balkan region, with the following objectives:

(i) Utilization of the data from the previous "Survey of the Seismicity of the Balkan Region" for improving knowledge in earthquake engineering and physical planning;

(ii) Documentation of methodology for the design of engineering structures and utilities, and the implementation of the results of the above-mentioned research to practical problems of disaster prevention and preparedness;

(iii) Training and research programme by establishing an international institute in Skopje with participation of related institutions of countries in the region.

This regional co-operation initiated by Balkan countries would be open to the participation of other neighbouring countries and it would be hoped that the results of this project would be beneficial to all countries suffering from earthquake hazards.

On the same problem, the delegates of Iran and Turkey proposed that a regional study of the seismicity and seismotectonics of the Anatolia-Zagros-Hindukush-Himalaya ranges would provide a good opportunity for regional co-operation.

With reference to the problem of induced seismicity, the delegate of Greece stated that steps would be taken to arrange for interdisciplinary studies of induced seismicity to be made by international teams at the sites of existing and future reservoirs in Greece.

RESOLUTIONS

RESOLUTION 12.11

The Conference recommends that Unesco encourage and assist the projects mentioned in its report on this item of the agenda and sponsor a series of regional and international workshops, symposia, and interdisciplinary working groups to study and report on specific subjects related to regional and/or general topics.

Some of these meetings may be organized, under the sponsorship of Unesco, by international non-governmental organizations such as the international scientific unions and associations. The organization of others, especially regional workshops and seminars, requires the strong support of Member States.

Participants should include selected groups of younger, active research workers.

The following interdisciplinary problems are considered to be of the highest priority:

(i) Choice of design earthquake ground motions

Among the items that will contribute to the understanding of this problem are: seismotectonic studies, instrumental and historical data on seismicity (seismic zoning), local geological and soil conditions (microzoning) and relevant strong-motion data.

(ii) Specification of engineering design criteria

This will require consideration of the following topics: acceptable risk, economic factors (e.g. cost-benefit studies), architectural-engineering considerations, availability of local materials, and methods of construction.

(iii) Induced seismicity and its social impact

In the present state of knowledge, this important problem calls for co-operative efforts of experts in tectonics, rock mechanics, hydrology, seismology and engineering, as well as the attention of social scientists.

(iv) The interpretation of historic and archaeological records of earthquakes

The searching out and assessing of historical events demands the interdisciplinary co-operation of historians, archaeologists and earth scientists, as well as the participation of scientists engaged in absolute age dating.

(v) Consequences of earthquake prediction

Social and economic effects are of concern here, as well as the problem of issuing predictions in the most effective terms.

(vi) Interdisciplinary research for the improvement of the earthquake resistance of non-engineered indigenous dwellings and buildings

This major problem, of particular importance for developing countries, needs the attention of architects, engineers, social anthropologists and economists.

(vii) Economic and social implications and insurance relating to the mitigation of earthquake disasters

This will involve the co-operation of economists, applied mathematicians and insurance specialists as well as of seismologists and engineers familiar with problems of risk analysis.

(viii) Evaluation of seismic risks

The estimation of probability distribution of different kinds of earthquake damage based on multidisciplinary analysis of all relevant data will form a practical basis for decision-making aimed at the mitigation of earthquake hazards.

The Conference agreed that, if established, the proposed Advisory Committee on earthquakes would be an appropriate mechanism for planning the implementation of the interdisciplinary research identified in the eight points above.

RESOLUTION 12.12

The Conference urges Member States to recognize the need for interdisciplinary efforts in their own countries with regard to the assessment and mitigation of earthquake risk. Special efforts should be devoted to interdisciplinary training at university level.

12.2 Mechanisms of international co-operation

At the invitation of the Chairman, the Convenor of Working Group II submitted its report on this item of the agenda to the plenary session of the Conference.

The ensuing discussion centred on the question of whether the resolutions of the present Conference would be better and more effectively implemented by means of a non-governmental advisory committee, or alternatively, by an intergovernmental body. The Secretary-General pointed out that this was a fundamental issue which should be decided before examining any proposals in detail. The Chairman invited the Conference to indicate whether it wished to vote on this question. The delegate of the United Kingdom stated that, in his opinion, no such vote was necessary and suggested that the Conference pass to the examination of the draft resolution proposed by the Working Group.

At the invitation of the Chairman, the Conference then examined, paragraph by paragraph, the draft resolution contained in the report of the Working Group (document SC-76/SEISM/W1/1).

The delegate of China, while recognizing the importance of international meetings such as the present Conference, expressed the opinion that the composition and functions of the Committee proposed by the Working Group were not clear enough, and that it was premature at present to form such a committee. He explained the position of his Government with respect to those international non-governmental organizations which had not yet responded to resolution 6.51 adopted by the General Conference of Unesco at its eighteenth session, and stated that his delegation would not therefore take part in the vote on this proposal.

With regard to paragraph 1 of this draft resolution, the delegate of the USSR proposed the replacement of the phrase "in general, ... earthquake risks" by the words "on preparation for a long-term interdisciplinary research programme to be undertaken as a joint venture of Unesco and UNDRO for the promotion of international co-operation in this field".

The delegates of Iraq, Sweden and the USSR proposed amendments to the text of the draft resolution which were accepted by the Conference.

With regard to paragraph 2 of the draft resolution, the delegate of Turkey proposed an amendment tending to replace the proposed committee of specialists and observers representing international non-governmental organizations by a committee composed of representatives of 20 Member States elected by the General Conference of Unesco. This amendment was rejected by 17 votes against, 8 in favour and 6 abstentions.

Paragraph 1, as amended, was adopted unanimously, paragraph 2, as amended, was adopted by 24 votes in favour, 2 against and 7 abstentions, paragraph 3 as amended was adopted by 23 votes in favour, one against and 7 abstentions, paragraph 4 was adopted by 28 votes in favour, none against and two abstentions. The resolution as a whole, incorporating the approved amendments, was adopted by 21 votes in favour, none against and 6 abstentions; its text is as follows:

RESOLUTION 12.21

The Conference,

Desirous of ensuring as far as possible that its recommendations are put into effect by Unesco, its Member States, and other international organizations as appropriate,

Recognizing that the implementation of many of its recommendations will entail concerted action by several international organizations (both governmental and non-governmental) and by Unesco and UNDRO in particular,

Aware that its recommendations will call for a wide degree of interdisciplinary co-operation in the natural, human, social and engineering sciences,

Attaching great importance to the creation and establishment of a suitable mechanism of international consultation and co-ordination for this purpose,

Recommends·

1. That Unesco, in consultation with UNDRO, set up an international committee, to be known as the "Joint Committee on the Assessment and Mitigation of Earthquake Risk", to advise Unesco and UNDRO on the implementation of the recommendations and resolutions of this Conference, and on preparation for a long-term interdisciplinary research programme to be undertaken as a joint venture of Unesco and UNDRO for the promotion of international co-operation in this field;

2. That this Committee be composed of· (a) specialists (not more than 10 in number) selected by Unesco and UNDRO in consultation with Member States, with due regard to the need for ensuring equitable geographical representation; (b) observers representing selected international non-governmental organizations;

3. That the Committee operate according to Unesco's regulations for such advisory committees, as applicable; in particular, Member States and Associate Members of Unesco would have the right to send observers to meetings of the Committee;

4. That, in addition to the advice mentioned in paragraph 1 above, the Committee be ready to advise Unesco and UNDRO, and through them the Member States, on how best to engage the wide range of relevant disciplines and how to achieve the most effective combination of scientific and administrative action, in a concerted attack on the problem of earthquake risk and its mitigation. In particular, the Committee should consider and advise on what intergovernmental machinery would be desirable.

The following resolution, proposed by the delegates of the German Democratic Republic and of Iceland, was adopted unanimously with one abstention

RESOLUTION 12.22

The Conference,

Noting that in the last decade enormous progress has been achieved on a world scale towards avoiding losses due to earthquakes and that further progress is expected,

Aware that knowledge is already at hand for saving human lives and mitigating the serious economic consequences of earthquakes,

Noting that this knowledge is not yet implemented in practice in great parts of the world which are in danger of earthquake catastrophes,

Recognizing the pressing need of internationally co-ordinated efforts to achieve further progress in assessing and mitigating earthquake risk,

Emphasizing the usefulness of the broad exchange of opinions and experience on recent developments in seismology, earthquake engineering and related subjects at the intergovernmental level,

Taking into account the timely initiative of Unesco in promoting interdisciplinary research by convening this Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk,

(1) Commends the activities of Unesco in this field,

(2) Proposes that the nineteenth session of the General Conference of Unesco include the continuation and expansion of the activities of Unesco in promoting interdisciplinary scientific and technological research in seismology, earthquake engineering and related subjects in the Unesco programme for 1977/1978; and

(3) Recommends that the governments of Member States, in which earthquake losses may be expected, put increased resources into investigations on subjects related to earthquake risks.

THE EARTHQUAKE OF 4 FEBRUARY 1976 IN GUATEMALA

At its opening plenary session, the Conference stood in silence for one minute, in memory of the men, women and children who lost their lives in the disastrous earthquake of 4 February 1976 in Guatemala.

The following telegram was addressed to General Kjell Langerud, President of the Republic of Guatemala by the Chairman of the Conference·

DELEGADOS CONFERENCIA INTERGUBERNAMENTAL SOBRO EVALUACION Y DIMINUCION RIEGOS SISMICOS REUNIDOS HOY 10 DE FEBRERO EN SEDE DE LA UNESCO OBSERVARON MINUTO DE SILENCIO EN MEMORIA DE LAS VICTIMAS DEL TERREMOTO DEL 4 DE FEBRERO EN GUATEMALA Y RENOVARON SU DETERMINACION DE HACER TODO LO POSIBLE PARA EVITAR REPETICION DE EVENTOS TAN TRAGICOS RESPECTUOSAMENTE

JAI KRISHNA PRESIDENTE CONFERENCIA

The following reply was received:

PROFUNDAMENTE AGRADEZCO SU EMOTIVO MENSAJE DE CONDOLENCIA Y SOLIDARIDAD CON EL PUEBLO GUATEMALTECO EN ESTOS MOMENTOS CRUCIALES POR LOS QUE ATRAVIESA ATENTAMENTE

KJELL EUGENIO LANGERUD GARCIA
PRESIDENTE DE GUATEMALA