MEDITERRANEAN ACTION PLAN
PRIORITY ACTIONS PROGRAMME

UNITED NATIONS ENVIRONMENT PROGRAMME

LAND USE PLANNING IN EARTHQUAKE ZONES
SEISMIC RISK REDUCTION IN THE MEDITERRANEAN REGION

Documents produced in the first and second stage of the Priority Action (1984-1986)

AMENAGEMENT DU TERRITOIRE DANS LES ZONES SISMIQUES
REDUCTION DU RISQUE SISMIQUE DANS LA REGION MEDITERRANEENNE

Textes rédigés au cours de la première et de la deuxième phase de l'action prioritaire (1984-1986)

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This volume is the seventeenth issue of the Mediterranean Action Plan Technical Report Series.

This Series will collect and disseminate selected scientific reports obtained through the implementation of the various MAP components: Pollution Monitoring and Research Programme (MED POL), Blue Plan, Priority Actions Programme, Specially Protected Areas and Regional Oil Combating Centre.

Ce volume constitue le dix-septième numéro de la série des Rapports techniques du Plan d'action pour la Méditerranée.

Cette série permettra de rassembler et de diffuser certains des rapports scientifiques établis dans le cadre de la mise en oeuvre des diverses composantes du PAM: Programme de surveillance continue et de recherche en matière de pollution (MED POL), Plan Bleu, Programme d'actions prioritaires, Aires spécialement protégées et Centre régional de lutte contre la pollution par les hydrocarbures.

PREFACE

The United Nations Environment Programme (UNEP) convened an intergovernmental Meeting on the Protection of the Mediterranean (Barcelona, 28 January - 4 February 1975), which was attended by representatives of 16 states bordering on the Mediterranean Sea. The meeting discussed the various measures necessary for the prevention and control of pollution of the Mediterranean Sea, and concluded by adopting an Action Plan consisting of three substantive components:

- Integrated planning of the development and management of the resources of the Mediterranean Basin (management component);
- Co-ordinated programme for research, monitoring and exchange of information and assessment of the state of pollution and of protection measures (assessment component);
- Framework convention and related protocols with their technical annexes for the protection of the Mediterranean environment (legal component).

All components of the Action Plan are interdependent and provide a framework for comprehensive action to promote both the protection and the continued development of the Mediterranean ecoregion. No component is an end in itself. The Action Plan is intended to assist the Mediterranean Governments in formulating their national policies related to the continuous development and protection of the Mediterranean area and to improve their ability to identify various options for alternative patterns of development and to make choices and appropriate allocations of resources.

The Priority Actions Programme (PAP), a component of the integrated programme of the Mediterranean Action Plan (MAP), promotes the exchange of experience in the fields of integrated planning and management of resources in the Mediterranean coastal areas.

The starting point of the PAP activities is the awareness that the protection and sound management of the environment can only be implemented by means of a rational development which translates into an optimum exploitation of natural resources. The notion itself of environment in a broader sense and especially in the Mediterranean context is at the same time the most precious resource of the Area.

Within the framework of the definition of the PAP activities, the representatives of the Mediterranean Governments, the Contracting Parties of the Barcelona Convention, have established the following priorities for the PAP:

- human settlements
- water resources management
- soil protection against erosion
- tourism
- aquaculture
- renewable sources of energy

In the abovementioned areas, the following activities are being completed:

- directories of Mediterranean institutions and experts
- water resources management
- integrated planning and management of Mediterranean coastal zones
- protection and rehabilitation of historic settlements
- land-use planning in earthquake zones
- soil protection against erosion
- solid and liquid waste management, collection and disposal
- development of tourism harmonised with the environment
- aquaculture
- renewable sources of energy
- environmental impact assessment
- balance between the hinterland and the coastal zones

The United Nations Agencies, many international organisations and almost all Mediterranean countries take active part in all these activities.

This volume, which is the 17th in the Mediterranean Action Plan Technical Reports Series, contains selected documents concerning the Priority Action entitled "Land-Use Planning in Earthquake Zones", and covers its first phase, from 1984 until the end of 1986.

PREFACE

Le Programme des Nations Unies pour l'environnement (PNUE) a convoqué une réunion intergouvernementale sur la protection de la Méditerranée (Barcelone, 28 janvier - 4 février 1975) à laquelle ont pris part des représentants de 16 Etats riverains de la mer Méditerranée. La réunion a examiné les diverses mesures nécessaires à la prévention et à la lutte antipollution en mer Méditerranée, et elle s'est conclue sur l'adoption d'un Plan d'action comportant trois éléments fondamentaux:

- Planification intégrée du développement et de la gestion des ressources du bassin méditerranéen (élément "gestion");
- Programme coordonné de surveillance continue, de recherche, d'échange de renseignements et d'évaluation de l'état de la pollution et des mesures de protection (élément "évaluation");
- Convention cadre et protocoles y relatifs avec leurs annexes techniques pour la protection du milieu méditerranéen (élément juridique).

Tous les éléments du Plan d'action étaient interdépendants et fournissaient le cadre d'une action d'ensemble en vue de promouvoir tant la protection que le développement continu de l'écorégion méditerranéenne. Aucun élément ne constituait une fin à lui seul. Le Plan d'action était destiné à aider les gouvernements méditerranéens à formuler leurs politiques nationales en matière de développement continu et de protection de la zone de la Méditerranée et à accroître leur faculté d'identifier les diverses options s'offrant pour les schémas de développement, d'arrêter leurs choix et d'y affecter les ressources appropriées.

Le Programme d'actions prioritaires (PAP), partie du plan intégré du Plan d'action pour la Méditerranée (PAM), a pour but de promouvoir des échanges d'expériences dans les domaines de la planification intégrée et de la gestion des ressources des zones côtières méditerranéennes.

Le point de départ des activités du PAP est la connaissance que la protection et la promotion de l'environnement ne peuvent être réalisées que grâce à un développement raisonné qui se traduit par une exploitation optimale des ressources naturelles. La notion même de l'environnement, conçue dans un sens plus large, et tout particulièrement dans des conditions méditerranéennes, constitue en même temps la plus précieuse ressource de la région.

Dans la phase de la définition des activités du PAP, les représentants des Gouvernements meditérranéens, Parties contractantes de la Convention de Barcelone, ont précisé les domaines prioritaires du PAP, notamment:

- établissements humains
- gestion des ressources en eau
- protection des sols contre l'érosion
- tourisme
- aquaculture
- sources d'énergie renouvelables

Dans les limites des domaines précités, les actions suivantes sont en voie d'achèvement:

- répertoires des institutions et experts méditerranéens
- gestion des ressources en eau
- planification intégrée et gestion des zones côtières méditerranéennes
- protection et réhabilitation des sites historiques
- aménagement du territoire dans les zones sismiques
- protection des sols contre l'érosion
- gestion, collecte et élimination des déchets solides et liquides
- développement du tourisme en harmonie avec l'environnement
- aquaculture
- sources d'énergie renouvelables
- évaluation des impacts sur l'environnement
- interrelation côte - arrière-pays

A toutes les actions prennent part les organismes des N.U. et de nombreuses organisations internationales, y compris la participation active de presque la totalité des pays méditerranéens.

Le présent volume, le 17ème de la Série des rapports technique du PAM, englobe un choix de documents relatifs à l'action prioritaire intitulée "Aménagement du territoire dans les zones sismiques", couvrant sa première phase de 1984 jusqu'à fin 1986.

EDITORIAL

This Technical Report has been prepared in the framework of the Priority Action "Land-Use Planning in Earthquake Zones". It is based on the documents produced in the course of the Priority Action itself. The principal aim of this Technical Report is to describe concisely the results obtained, the methods and techniques used and briefly review the state of the art in this field.

Within the framework of this Priority Action "Land-Use Planning in Earthquake Zones", a set of national reports, studies and other documents was produced between 1984 and 1986, reflecting the state of experience of the participating countries in the field of physical and urban planning in earthquake-prone areas, in seismic hazard mitigation and emergency management.

National reports have also shown how earthquake-prone the territory of most Mediterranean countries is; a long series of disastrous earthquakes has occurred in the far and recent past. They have taken a heavy toll of human lives and caused tremendous property damage, material, cultural and other social losses.

The studies prepared and experience gained have shown that only a comprehensive approach of hazard mitigation, through improved physical and urban planning and design, through the appropriate aseismic design and construction procedures, proper detailing and strict quality control as well as through adequate emergency management, may lead to considerable reduction of potential losses.

In this regard, it is necessary to point out that this report could only include parts of particular national reports and studies. We endeavoured to include those segments which, severally and as a whole, would best reflect the intention of the authors as expressed in the titles of the various reports. We must ask for the indulgence of both authors and readers if, in their view, we did not wholly succeed in achieviing our goal.

The main activities carried out before the preparation of this paper are described in the Introduction. The documents produced in the course of this priority action are presented chronologically and mostly in their original form, or in such a way as to describe clearly and concisely their basic subject. Because of the large number and volume of documents produced, and bearing in mind the kind of paper this is, some documents are presented partially (some even only in summary form), others in their entirety. The Report is divided in seven chapters according to subject, distributed in two global parts relating to the Cetinje and Genoa Seminars.

PAP/RAC Split can to be sure put at the disposal of interested readers the complete documentation on a particular topic; readers can also turn to the authors of particular papers for further assistance.

Despite the very specific character of such an edition and its possible shortcomings, we sincerely hope that this book will reach all those who have an interest in the field, from experts and decision makers to the general public. We also hope that it will promote the objectives of this Priority Action through the consolidation of efforts for the reduction of seismic risk in the Mediterranean Region.

Bozidar S. PAVICEVIC
Co-ordinator of the Priority Action on
Land Use Planning in Earthquake Zones

AVANT-PROPOS

Le rapport technique que voici a été élaboré dans le cadre de l'action prioritaire intitulée "Aménagement du territoire dans les zones sismiques". Il repose sur les documents établis au cours de cette action elle-même, et il vise avant tout à exposer succintement les résultats obtenus, les méthodes et les techniques utilisées, ainsi qu'à faire le point des connaissances dans ce domaine.

Dans le cadre de ladite action prioritaire, un ensemble de rapports nationaux, d'études et autres textes ont été rédigés entre 1984 et 1986; ils reflètent les enseignements des pays participants en matière d'aménagement des villes et du territoire dans les zones exposées aux séismes, de même qu'en matière d'atténuation des risques sismiques et de gestion des situations critiques.

Les rapports nationaux ont en outre montré à quel point le territoire de la plupart des pays méditerranéens est exposé aux séismes ; une longue série de tremblements de terre catastrophiques a jalonné l'histoire de la région, de la plus haute antiquité jusqu'à nos jours, et elle s'est soldée par un lourd tribut en vies humaines et par d'énormes dommages matériels, culturels, sociaux et autres.

Les études préparées et les enseignements acquis attestent que seule une approche globale de l'atténuation des risques peut conduire à une réduction considérable des pertes potentielles par une série d'actions parallèles : conceptions nouvelles en matière d'aménagement des villes et du territoire, règlementations parasismiques et procédés judicieux de construction, contrôle rationnel, minutieux et rigoureux de la qualité, gestion avisée des situations critiques.

A cet égard, il convient de souligner que le présent document n'a pu englober que des parties seulement des rapports nationaux et études spécifiques. Nous nous sommes néanmoins efforcés à ce que ces parties, prises isolément ou dans leur ensemble, reflètent le mieux possible l'intention des auteurs telle que celle-ci s'exprimait dans les intitulés des divers textes communiqués. Nous sollicitons l'indulgence des auteurs comme des lecteurs s'ils estiment que le résultat final n'est pas pleinement à la hauteur de nos voeux.

Les principales activités menées avant l'établissement du présent rapport technique sont exposées dans l'introduction. Les documents élaborés au cours de cette action prioritaire sont présentés par ordre chronologique et le plus souvent sous leur forme originelle, ou bien de telle manière qu'ils exposent avec clarté et concision leur sujet principal. En raison du nombre et du volume importants des textes, et compte tenu de la nature du rapport d'ensemble destiné à les rassembler, certains rapports n'ont été repris qu'en partie (ou même sous une forme abrégée), alors que d'autres le sont intégralement. L'ensemble du rapport est divisé en sept chapitres abordant chacun un thème précis et qui s'agencent successivement autour des deux grands axes d'étude et de réflexion constitués par les séminaires de Cetinje et de Gênes.

Le CAR/PAP de Split peut, bien entendu, mettre à la disposition des lecteurs intéressés la documentation complète sur tel ou tel sujet ; les lecteurs peuvent aussi s'adresser directement aux auteurs des communications s'ils souhaitent obtenir d'eux des éclaircissements ou d'autres renseignements.

En dépit de son caractère spécifique et de ses imperfections éventuelles, nous espérons très sincèrement que cette publication atteindra tous ceux qui se sentent concernés par le sujet, qu'il s'agisse des experts, des décideurs ou même du grand public. Nous espérons aussi qu'elle contribuera aux objectifs de l'action prioritaire dans laquelle elle s'intègre, raffermissant ainsi les efforts visant à la réduction du risque sismique dans la région méditerranéenne.

Bozidar S. PAVICEVIC
Coordonnateur de l'action prioritaire
sur l'aménagement du territoire
dans les zones sismiques

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1. INTRODUCTION

1.1. PRIORITY ACTION "LAND-USE PLANNING IN EARTHQUAKE ZONES"

by Bozidar S. Pavicevic, Civil Engineering Faculty, University of Titograd, Titograd

A. General

It is a well-known fact that most of the territory of the Mediterranean countries is an earthquake-prone area exposed to a relatively high level of seismic risk.

Bearing in mind the nature and characteristics of the earthquake phenomenon and the limited possibilities of protection from its destructive effects, it is inevitable not only to expect the occurrence of earthquakes (on the basis of probabilistic forecasting determined by natural seismo-geological and tectonic conditions), but in addition to assume an increase of the seismic risk due to a permanently developing process of an ever faster growth of settlements and concentration of population, production systems and other social assets oriented mostly to seismically active areas.

The consequences of disastrous earthquakes in the future can be kept under a controlled level only if appropriate approaches, regulations and measures are taken. They must be incorporated into all development plans and other policies concerning land-use, urban planning, aseismic design and building construction in seismic areas as well as emergency management.

All this should be based on the definition of the acceptable level of seismic risk, assessed with economically and socially justified criteria.

It is therefore understandable that the Mediterranean countries are so interested in the implementation of common efforts, aimed at the coordination and harmonization of activities carried out by individual countries in hazard mitigation and seismic risk control.

For all these reasons, the Mediterranean countries - Contracting Parties to the Convention on the Protection of the Mediterranean Sea from Pollution - have decided to include the issues of mitigation of seismic hazard into the Priority Actions Programme (PAP) which is one component of the Mediterranean Action Plan (MAP).

B. Objectives of the Priority Action: Land-Use Planning in Earthquake Zones

The objectives of this Priority Action can be summarized as follows:

- to analyze the problems related to land-use planning in earthquake zones of the Mediterranean Coastal Region;
- to prepare case-studies on selected subjects and review them in a seminar;
- to prepare a comprehensive survey of experiences pertaining to the professional treatment of aseismic protection through physical and urban planning policies, and of experiences gained in the field of adequate overall earthquake preparedness;

- to propose recommendations for land-use planning in earthquake zones aiming at seismic risk reduction in the region;
- to propose a follow-up for the exchange of experience and further cooperation among Mediterranean States on the subject, through the collaboration of experts and institutions.

C. Advancement of the Priority Action and its main results

In the first phase of the Project, the countries were asked to prepare their national reports, providing all relevant information; Algeria, Egypt, Cyprus, Greece, Italy, Morocco, Turkey and Yugoslavia actively responded and participated in the Project. The national reports are presented in the form of a synthesis report.

In addition to the national reports, a certain number of selected case-studies was prepared by national experts and institutions, nominated by PAP National Focal Points and appointed by PAP/RAC Split.

In April 1985, a working meeting of experts was organized in Split, in order to review the national reports and selected case-studies, to discuss the relevant issues and problems resulting from the national reports, as well as to establish the objectives and programme for the Cetinje Seminar.

The seminar was held in Cetinje, Montenegro, Yugoslavia between 28 and 30 June, with the participation of nine countries (Algeria, Cyprus, Egypt, Greece, Italy, Turkey, Yugoslavia, France and Tunisia); the coordinator of MAP and the representatives of UNDRO/Geneva and UNCHS (Habitat) Nairobi also participated.

The Cetinje Seminar discussed inter alia future cooperation among Mediterranean countries in this field. The Seminar agreed on the thematic framework for future activities and suggested that a number of immediate activities be undertaken as the basis of the conceptual framework and outline for future work.

The Seminar strongly expressed the urgent need and unanimous readiness to establish, on a permanent basis, the cooperation already initiated in the most comprehensive and efficient way possible.

Adequate attention was paid to the conclusions and recommendations of the Cetinje Seminar by the Fourth Conference of the Contracting Parties to the Barcelona Convention on the Protection of the Mediterranean, held in Genoa, September 9-12, 1985, where it was pointed out that the programming, organization and implementation of activities envisaged should be carried out in the framework of a special cooperative project.

The next step was a seminar held in Genoa, Italy (October 16-18, 1986), with the participation of eleven countries, as well as the coordinator of MAP/UNEP and representatives from UNDRO, UNCHS (Habitat) and UNESCO.

The basic objective of the Genoa Seminar was to examine the demonstration studies and other technical documents prepared on the basis of the Conclusions and Thematic Framework adopted by the Cetinje Seminar.

In this context, the Seminar reviewed and assessed the Project Document Proposal of the Cooperative Programme and adopted the Conclusions and Recommendations relative to seismic risk reduction in the Mediterranean Region, including proposals for the follow-up of the Action.

Finally, it seems appropriate to point out the broad response for participation and involvement in this Priority Action, not only by the Contracting Parties to the Barcelona Convention, but also by almost all interested United Nations Agencies and Organizations.

1.2. SEISMIC RISK REDUCTION AS A COMMON OBJECTIVE OF THE MEDITERRANEAN COUNTRIES

by Bozidar S. Pavicevic, Civil Engineering Faculty, University of Titograd, Titograd

A synthesis of issues raised in the national reports and other preparatory documents

A. A brief review of national reports

National reports contain relevant information in this field within the following framework:

- General information;
- Exposure to seismic risk and experience in connection with earthquake consequences;
- Investigations carried out for the needs of planning and construction under seismic conditions;
- Physical development and urban planning for seismic areas as well as planning for earthquake preparedness; and
- Proposals and recommendations regarding exchange of experience, including possible technical assistance.

National reports were prepared by the following countries:

- Algeria, by Mohamed Benblidia, Agence Nationale pour l'Aménagement du Territoire - ANAT;
- Cyprus, by Ioannis P. Neophytou, Cyprus Seismological Station - Geological Survey Department, Nicosia;
- Greece, by John C. Drakopoulos, Department of Geophysics, University of Athens, Athens;
- Egypt, by Ezzeldin M. Ibrahim, Department of Seismology, Helwan Institute of Astronomy and Geophysics, Helwan - Cairo;
- Italy, by Giulio Rossi Crespi, ITALTECHNA S.p.a., Rome, with Pier Luigi Matteraglia, Giampiero Amori and Antonella Belliazzi, consultants;
- Morocco, by Mohamed Ramdani, Centre National de Coordination et de Planification de la Recherche Scientifique et Technique, Rabat;

- Turkey, by Octay Ergünay, Earthquake Research Institute, Ankara; and
- Yugoslavia, by Bozidar S. Pavicevic, Civil Engineering Faculty, University of Titograd, Titograd.

The synthesis of these national reports was prepared by B.S. Pavicevic, Coordinator of the Priority Action.

Algerian Report: Aménagement du territoire dans les zones sismiques

The report gives a comprehensive review of the most essential data pertaining to seismicity and to the level of seismic risk in the country.

There is a very concise description of the earthquake which struck the region of El Asnam (Ech Chlef) on October 10, 1980. With its dramatic consequences, it was a brutal reminder and proof that Algeria is permanently exposed to a very high level of seismic activity.

It also sets forth the measures that are taken which aim at seismic risk mitigation, both those that are currently implemented and those that will be carried out in the future, particularly as concerns the land-use planning activities and relevant legislation. It is recommended that seismicity and seismic risk reduction become a constituent part of all physical development planning; they have already been incorporated into regional development and urban planning after the 1980 earthquake. Seismic risk reduction has become the concern of all those involved in land use and the design and construction of buildings and other structures. There is a very detailed explanation of the new Code for the Design of Buildings under Seismic Conditions, which sets up an advanced and modern approach to the relevent seismic parameters, in order to define the influence of the dynamic characteristics and types of structures and even of the quality of construction work.

The disastrous earthquake of October 1980 made people at all levels aware of a permanent danger of seismic risk in the northern parts of the country. This factor was taken into consideration not only in the planning approach to further development of these regions, but also in the development plans of the whole national territory as well.

Studies prepared for the Chlef region and for other regions in Algeria represent a general and valuable experience which could be applied in other Mediterranean countries, also exposed to a similar seismic hazard.

Cyprus Report: Land-use planning in earthquake zones

The report gives a rather concise and clear review of the existing state of current activities in the field of earthquake engineering and construction in seismic conditions. It is particularly emphasized that the country has no direct experience in the field of land-use planning in earthquake zones.

From the data on seismicity of this island country, it seems important to point out that the most seismically prone area is that around the capital, Nicosia (intensity 8-9+, according to MKS scale), especially since that is the zone with the highest population density, where over 80% of the development projects is situated, (accumulation lakes, retaining dams and infrastructure systems, as well as various types of buildings).

Seismo-tectonic analysis and mapping have not yet been started. However, a geotechnical map of Nicosia, containing local seismic hazard assessment, has recently been completed.

Concerning aseismic planning and construction as well as relevant legislation, the report points out that practically none of the buildings was specially designed to resist earthquakes, except for major water retaining dams and very few general utility buildings. In fact, no regulations for aseismic design have been enforced so far, but on the basis of this report it can be stated that Cyprus is taking certain measures and formulating programmes in the field of seismic risk management.

Finally, the report makes some proposals and recommendations for the exchange of information and technical assistance in this field, following the PAP objectives.

Egyptian Report: Seismic activity in the various tectonic provinces of Egypt (Information Document)

The document elaborates, as is evident from the title, the current seismic activities in the various tectonic provinces of Egypt, comparing them with other active earthquake prone areas and regions of the world, especially with those in southern Europe. It provides general information on the natural characteristics and geographic position of the country as well as its geological structure which is presented in detail.

The document reviews the seismicity of Egypt, mainly through earthquake occurrences and spatial distribution inside Egypt itself and its near vicinity. Owing to the fact that these areas of the world have the longest documented history, some information on earthquakes can be traced as far back as the year 2800 B.C.

In conclusion, it is pointed out that the main objective of the information document is to describe the geological and geophysical studies carried out in Egypt as the basis for a more adequate approach to regional and urban planning in that country.

Greek Report: National report on land-use planning in seismic zones

The report describes the activities of Greek institutions in the field of seismotectonic engineering, seismology and earthquake engineering. Its immediate objectives are clearly to summarize existing knowledge and expertise, and to identify gaps in the current state of the art, highlighting thus the need for a synthesis, through cooperation at Mediterranean level, of knowledge gained so far.

The author underlines the exposure of Greece to the highest seismic activity in Europe, with about 2% of the world's seismic energy release, and describes the seismotectonic model of the area as well as numerous studies which have been produced on this particular subject.

The report states that the assessment of losses due to earthquakes must be based on the derivation of relationships between the degree of damage to structure (by class or type of building) and the intensity of ground shaking. It points out that the cumulative damage of earthquakes of moderate to maximum intensity (VII - VIII) is greater than the cumulative damage caused by greater earthquakes. The report embarks in detail upon the construction practices in Greece and the behaviour of structures (per type of building material) during recent catastrophic earthquakes. It points out the importance for existing structures to be systematically evaluated in order to determine their actual strength and response and the need for establishing adequate strengthening procedures where necessary.

The report warns that any successful programme of earthquake risk reduction must involve scientific, political, social and economic decisions. It is stated that since earthquakes do not respect national boundaries, losses and earthquake risk reduction are of common interest to all Mediterranean countries.

There are also recommendations on the preparation of guidelines for a unifield model code for the Mediterranean countries. In this context, it is also pointed out that the development of building codes is inseparable from land use zoning studies. Suggestions are given for the establishment of national earthquake preparedness plans in all Mediterranean countries and it is proposed that Governments should be responsible for developing a disaster planning unit in each country where the incidence of earthquake hazard is high.

Italian Report: Earthquake hazard and seismic emergency management in Italy

This report has been prepared in cooperation with the Italian Ministry for Coordination of Civil Defence, thus ensuring that it conforms in all respects with the present government activities in this field. The report contains the following:

1. Notes on the seismic character of the Italian territory;
2. Suggestions for the upgrading of programming and managing techniques to deal with emergencies in the Mediterranean environment;
3. The institutions of the Italian Government for emergency management and research; and
4. Proposals for an Italian contribution to international cooperation in civil protection activities.

Bearing in mind the fact that the Italian urban and rural areas (like the whole of the Mediterranean) have predominantly historic and traditional characteristics, the following issues are dealt with in detail:

- Vulnerability, understood as an essential component of the conditions of seismic risk considered in its structural aspects and in correlation with the settlement network system as a whole;

- Planning criteria and protection techniques aimed at providing safety in emergency situations, which is especially significant when planning for settlements of historic value;

- Problems and guidelines for the implementation of emergency plans, and the need to define the institutional and technical planning instruments which will coordinate and facilitate the implementation of emergency measures.

Within the framework of the system of government institutions for emergency management and research, the following actions are considered for future development: relevant research activities; monitoring; intervention; prevention; and functioning of the Operational Centre of the Ministry for Civil Defence, which acts as the "relay station" for an effective coordination of the various operational agencies involved.

This report, in one of its key points, calls for the establishment of an international organization in charge of rescue and assistance operations under earthquake circumstances. In accordance with this plan, all Mediterranean countries could gradually adhere to an agreement aiming at the coordination of all national civil protection organizations.

Moroccan Report: Aménagement du territoire dans les zones sismiques (Rapport sur les données Marocaines)

The report presents general information on the location and population of the country, its geology and seismicity and the current activities on seismic risk mitigation. It is pointed out that throughout its history Morocco has been exposed to very violent earthquakes. However after the disastrous earthquake that struck Agadir on February 29, 1960, Morocco went through a very painful experience, which prompted the country to take the necessary measures and carry out research on its seismicity. In this context the report gives some basic information on the seismic risk reduction programme in Morocco. Immediately after the Agadir earthquake, the codes regulating aseismic design and construction were enforced (1967); furthermore, recently new regulations taking into account the results of seismological investigations in Morocco were put into effect.

The report also gives information on future projects, especially on the Project for evaluation and mitigation of seismic risk in Arabic countries (PAMERAR), and its objectives as they relate to Morocco.

The main objectives of the PAMERAR programme are:

- Modernization and extension of seismological networks;
- Training of professionals as to the requirements of construction of earthquake resistant structures;
- Consideration of the seismic risk, within the framework of both socio-economic planning and land-use planning; and
- Support to the states to organize civil protection in order to meet earthquake emergency situations.

Elements of the project referring to Morocco are being dealt with in detail.

Turkish Report: Earthquake hazard and mitigation programme in Turkey

The report gives general information on the natural characteristics and population of the country and it states that Turkey is greatly exposed to various kinds of natural hazards which have been causing substantial losses of lives and property. Earthquakes have the largest share among all natural disasters: the average annual losses caused by earthquakes in the last 60 years constitute about 0.8% of the total Gross National Product (GNP), whereas all other natural disasters combined claim only 0.2%.

It is stated that 92% of the total surface and 95% of the population of Turkey live in seismic hazard zones. Studies concerning the preparation of an earthquake hazard zoning map of Turkey first appeared after the big Erzincan earthquake in 1939. They were updated in 1963 and again in 1972. Particular attention is paid to the experience relating to seismic resistance and vulnerability of existing buildings. The development of the seismic risk mitigation programme in the country is described and it is pointed out that a series of earthquakes between 1955 and 1959 have again called for the improvement of disaster preparedness; consequently the Law for Public works (Urbanization) and the Law for Natural Disasters were passed. In this context a disaster fund, to be used for natural disaster preparedness, has been established as a continuous and legally supported resource allocation for the rehabilitation and resettlement of people in areas struck by earthquakes.

The Natural Disaster Law also provides for the establishment of a government institute to carry out research, information campaigns and the coordination of all national efforts aiming at mitigation of natural disasters.

The ongoing seismic risk mitigation programme can be summarized as follows: pre-earthquake preparedness and planning; emergency management; post-earthquake activities, especially temporary and permanent population resettlement and rehabilitation of affected areas. Certain experiences acquired within each of the above phases are also discussed in the report.

Finally, the report also takes note of the results obtained on the basis of which the Turkish experience in seismic risk mitigation calls for the following considerations to be taken into account when action is being planned or implemented:

- Disaster mitigation efforts and appropriate measures should be considered within the framework of the overall national development goals and integrated in all physical and urban planning decisions;

- Public awareness and education activities should constitute an essential part of the overall seismic risk mitigation schemes and plans; they should target all sections of society and population groups;

- Emergency assistance and rescue operations should be the task of specially trained permanent teams and organizations. Volunteer organizations and *ad hoc* actions of civil defence cannot adequately function under emergency circumstances;

- Temporary and permanent resettlement of people in affected areas should be based on previously prepared long-term plans;

- A general strategy of disaster mitigation should not rely upon short-term political considerations or on the funds available. The responsible organizations and implementing agencies should be clearly defined.

Yugoslav Report: Seismic hazard and seismic risk control within the framework of physical and urban planning in Yugoslavia

This report examines problems and the experience relating to seismic risk mitigation in Yugoslavia, primarily through physical development and urban planning, but also, other relevant aspects of seismic risk reduction.

Particular attention is paid to experience gained after the disastrous earthquakes which struck the Montenegrin coast in 1979 and Skopje in 1963. It is emphasized that each of these catastrophes represents to a certain extent a radical change in the establishment of a broader scientific approach and more advanced social and legislative context for a more appropriate seismic risk management.

The report makes clear that, owing to United Nations technical assistance, it has been possible to achieve results of broader significance and interest.

In accordance with the main objectives of the Priority Action, the report gives first of all general information on the geographical and other natural characteristics of the country. Geological evolution, relief and general seismicity of the terrain are also examined. The report discusses the Yugoslav long-term research programme in earthquake engineering, seismology and seismic zoning, the definition of methodology for the reduction of seismic risk through physical and urban planning, as well as the connections to relevant research and international projects carried out in the Balkan region, after the Montenegro earthquake in 1979.

Activities on the elaboration of the overall and complex seismic macro- and micro-zoning of the country are underway at present: this task has nearly been completed for the SR Montenegro (conducted actually within the framework of the Project "Physical Development Plan of the Republic and Master Plans of the Communes)".

After the Montenegro earthquake (1979), an interest was shown for the definition of a methodological approach to seismic vulnerability assessment and seismic risk reduction through land-use planning. The conclusions of large-scale studies and the summarized results of the damage and usability inspection after the earthquake (covering over 64,000 buildings, according to function, structural type and the type of material used), served as a solid basis for it.

The report also describes the approach and identifies the main principles of physical development and urban planning policies; it discuses earthquake preparedness and emergency management on the basis of the experiences gained after the Montenegro earthquake. It is pointed out that the strategy of earthquake protection and seismic risk mitigation must become an integral part of all development strategies. The formulation of a rational strategy of protection from seismic risk calls for the understanding and implementation of the statutory character and legislative role of physical development and urban planning in the framework of an integrated approach, i.e. seismic risk management.

Finally, strong support is given to the objectives of this Project, as well as to proposals for the consideration and establishment of adequate forms of long-term and permanent mutual cooperation among Mediterranean countries in all relevant components and segments of these Project objectives. In this context, the involvement of other United Nations agencies having an interest in the programmes of seismic hazard mitigation and risk reduction (like UNDRO, UNCHS, UNESCO, UNIDO) should be considered very important and indispensable.

B. Case-Studies and other preparatory documents (Summary)

In the framework of the preparation of the Cetinje seminar, the following case-studies and other documents were elaborated:

The Algerian case-study: "Aménagement régional et sismicité - la région d'El Asnam (Chlef)", by M. Benblidia. This study of macro- and micro-zoning prepared after the last (1980) earthquake of Chlef was used as the basis for developing a scheme of long-term planning for the area.

The scheme met the major objective of the national land-use planning policy that was to control and reduce the rate of urbanization along the coast, a high-risk zone. Within the urban context, this study served for the elaboration of master plans as well as for the reconstruction of towns affected by the earthquake.

It is stated that an extension of the macro- and micro-zoning study to other regions of the country is in process, indicating thus that the land-use planning policy in Algeria considers seismic risk reduction as a major planning parameter. Finally, it is suggested that the studies carried out after the catastrophe of Chlef (micro-zoning, physical planning, recovery standards, regulations for aseismic construction etc.) might serve as the elements for an exchange of experience and cooperation with other countries of the Region.

The Italian case-study: "Emergency assistance and reconstruction - experiencing community rehabilitation techniques after the 1980 earthquake in Southern Italy", by G. R. Crespi, A. Beliazzi, M. Lonciano, B. F. Lapadula and P. L. Matteraglia.

The study illustrates the experience gained from recovery and reconstruction activities in the Basilicata and Campania regions struck by earthquake in 1980. It describes the institutional, legislative and operational measures adopted for the reconstruction of more than one hundred rural settlements and of that section of the metropolitan area of Naples which was damaged by the earthquake.

The study also comments on the recent establishment of the Ministry for Coordination and Civil Protection and on the creation of a national Department entrusted with operational responsibilities. The study concludes with the need for a strong appeal to the national authorities of other Mediterranean countries for unified research and operational procedures.

The Yugoslav case-study: "The Montenegro experience in physical development planning for seismically menaced areas", by R. Bakic, M. Vukotic, B. Milic and V. Radulovic.

The case study concerns the experience of Montenegro in physical and urban planning for earthquake prone areas gained after the disastrous earthquake that struck Montenegro in April 1979. It illustrates the characteristics of this earthquake and its consequences, the work done on survey and analysis of losses, the actions undertaken by the Government for the relief and accommodation of the population as well as for reconstruction. The study also presents the methodology and measures adopted for long-term planning and development at all levels. Special attention is paid to the description of the character and the pioneering results of the Project "Physical Development Plan of the Republic and Master Urban Plans of the Communes in Montenegro" (UNDP/UNCHS/UNDRO Project YUG/79/104) which proved to be extremely significant and was implemented after the earthquake with the technical assistance of the United Nations.

The document "Physical Developemnt Plan of the SR Montenegro and Prevention of the Seismic Risk in the UNDP Project Yug/79/104 - a Methodological Review" by P. Radogna, V. Djurovic, S. Furman, J. Lazarevic, T. Michalak.

This document highlights the main objectives of the strategy of physical development of the Republic of Montenegro on the basis of seismic risk reduction at the local and urban levels. Strict control of development and urbanization is given as the basic measure for seismic risk reduction.

The document "A Synthesis of Methodological Approaches to Earthquake Vulnerability and Seismic Risk Analysis for the Need of Physical and Urban Planning" by J. Petrovski and Z. Milutinovic.

This synthesis illustrates the experience achieved through the damage and vulnerability assessment after the Montenegro earthquake. Examples of applied methodology at the communal and local levels are demonstrated as well. The need for further development of the methodology, for a unified methodology on data acquisition and processing, as well as for the establishment of a broader data basis with the exchange of data is also underlined.

C. Synthesis of issues raised

On the basis of the national reports and other documents presented, one gets a comprehensive idea of the exposure of Mediterranean countries to a very extensive seismic activity, and their relatively high vulnerability level. It is also possible to a certain extent to predict the level and trends of future development of the system and thus to adopt measures for seismic protection and hazard mitigation in different countries, both general and through controlled physical development and urban planning. All this makes possible certain comparisons of the situations in the various countries and of the acquired experience in seismic risk mitigation planning; thus a common belief can be arrived at and proposals can be formulated for the improvement of earthquake protection, both at national level and at Mediterranean level, through cooperation among the various States.

Some of the main points which aim at a more comprehensive approach to seismic risk reduction and which are raised in the reports are the following:

- The reports give a lot of information on the influence and effects of seismic hazard on the areas exposed to strong earthquakes, and the readiness of the countries to take the measures necessary for seismic protection and hazard mitigation.

- All national reports emphasize that physical development and urban planning, based on appropriate studies, are very important for adequate seismic risk reduction and protection from the possible undesirable earthquake consequences. Furthermore, the reports of the countries exposed to a higher degree of seismic hazard emphasize that, on the basis of the experience gained, the overall social, administrative, legislative and institutional organization has to be based on a broad and rational concept.

- The strategy of earthquake protection must be an integral part of the overall social and physical development goals of each country; it must therefore be a part of an adequate integrated planning system. Concerning adaptation to seismic hazard, it is stated that analyses of vulnerability and assessment of the acceptable seismic risk based on socially and economically justified criteria, are becoming leading factors in the approach to seismic protection. The role of scientific research in earthquake engineering, geology, seismology, geotechnology, economics etc., and of an adequate earthquake preparedness are also discussed in detail.

- The protection of the physical environment and the cultural and historical heritage of the Mediterranean require in many cases a very specific and subtle approach. The vulnerability assessment of existing structures, the land-capability analyses, and the land-suitability analyses of areas proposed for construction are all matters of primary importance for an effective seismic protection. The most concentrated and densely populated urban agglomerations, the historical settlements, various monuments of historical value etc. are almost all located in areas with very high seismic activity. It is therefore reasonable to propose that earthquake preparedness and emergency management be the main field for cooperation among the countries of the Mediterranean.

Special emphasis is given to the following:

(a) Development of methods for seismic risk assessment in larger urban agglomerations; problems referring to the specific treatment of rural settlements exposed to seismic hazard.

(b) Identification of conditions and instruments for adequate implementation of plans and measures (legislative, technical, other).

(c) Provision of an adequate informational and institutional system for the establishment, implementation and improvement of the seismic risk mitigation programme.

(d) Clear identification and establishment of permanent forms of close coordination of all persons and agencies in charge of planning, implementation and monitoring the seismic risk mitigation programme at national level.

Monitoring of the plan implementation cannot be achieved solely by passing adequate legislation. The effectiveness of seismic protection depends, to a large extent, on adequate control to ensure that regulations are adhered to, especially during the plan implementation and building construction phases.

The raising of social and public awareness and public educational activities should be an integral part of the seismic risk mitigation programmes and should target all segments of the administrative and social organization of the country and all population levels, especially decision-makers.

(e) On the basis of the questions raised and the proposals made in this synthesis and in the national reports, as well as those that might be formulated in the meantime, it appears both reasonable and necessary to prepare an adequate programme of cooperation among the countries of the Mediterranean Sea on appropriate short-term and especially long-term objectives of seismic risk reduction in the Region.

2. CONCLUSIONS AND RECOMMENDATIONS OF THE MEETING OF EXPERTS, Split, April 1-2, 1985

Representatives from Algeria, Italy and Yugoslavia as well as representatives of UNCHS and UNDRO participated in the meeting.

The objectives of the meeting were: (a) to review the completed national reports and the Synthesis Report; (b) to identify common and specific problems in the field of seismic risk mitigation in the Mediterranean; (c) to define the objectives and the programme structure of the Seminar to be held in Cetinje; (d) to propose case-studies which would be presented to the Seminar; and (e) to consider activities following the Seminar.

The meeting discussed common and specific priority problems in the mitigation of seismic risk and land-use planning as the basic tool for achieving these goals and identified a number of important issues and statements, summarized in its Conclusions and Recommendations, as follows:

- A considerable part of the Mediterranean coastal zone is seismically active and highly vulnerable to seismic hazards. Coincidentally, this same area, because it is the cradle of many civilizations, rich in cultural heritage and with abundant natural and man-made riches, has been under constant pressure of intensive development and periodic migrations generating a permanent urban growth.

- The activities undertaken so far for seismic risk mitigation and the results achieved in individual Mediterranean countries differ, due to the specific conditions prevailing in each country.

- The considerable activity of specialized agencies and organizations (UNDRO, UNCHS, UNESCO, PAMERAR, etc.) in the Mediterranean has yielded a number of plans and projects on seismic mitigation. However, the possibilities for developing regional and/or multilateral cooperation are far from being fully used.

- Knowledge and experience accumulated so far in seismic risk mitigation are a good scientific basis for the promotion and intensification of the activity in each country and in the Region as a whole. The accent therefore should be on the exchange of expertise.

- Mitigation of seismic risk requires an integrated and interdisciplinary approach both at national and regional levels.

- In addition to departing from conventional frameworks, physical planning in earthquake areas requires a thorough knowledge of seismic risk based on geoseismic investigations, geoseismic regionalization for larger areas and micro-zoning for urban areas.

- Development objectives, policy and plans must inter alia take into account the nature and degree of identified seismic risk which requires appropriate information at all levels (policy making, managerial, professional and general public).

- Results of seismic macro-regionalization are the basis for determining the physical and socio-economic development concepts for a given area, whereas micro-zoning is essential in defining land-use, distribution of uses, choice of structure types and standards of construction.

- Respect for the outcome of geo-seismic studies is vital in planning infrastructure systems for larger areas and towns to make them adaptable and functioning in emergency situations.

- Specially emphasized is the need for the knowledge on seismic risk to be incorporated in the development plans of rural settlements and the protection of agricultural land which has been neglected up til now.

- Mediterranean historic settlements and urban cores must be given priority; a special approach must be used for their protection from earthquake hazards.

- Numerous methods and procedures used in seismic investigations have not been either fully verified or harmonized, something that would be necessary in order to minimize earthquake disasters and to develop international cooperation in the field.

- Existing and future structures of high economic or other value should be dealt with separately and treated with special care in the preparation of land-use plans.

- Each country exposed to seismic risk should develop a monitoring system oriented to the investigation of seismic phenomena. Experience already gained in this report shows that the monitoring network can be used simultaneously both in programming and modelling earthquake effects. The possibilities for establishing Mediterranean cooperation in this field should also be explored.

- High frequency of earthquakes in the Mediterranean demands a special approach to the problems pertaining to the formulation and implementation of pre-earthquake preparedness programmes. There is some emergency management in all Mediterranean countries; some countries have used the most advanced methods in compiling and processing relevant data, in modelling and preparing earthquake scenarios, as well as in organizing immediate, short-term and long-term restoration activities.

- Many countries have developed the necessary procedures for post-earthquake activities and, unfortunately, had the opportunity to test them in practice. Some of these procedures, such as post-earthquake damage inventory and vulnerability analysis, are of particular importance.

- In some cases of devastating earthquakes, the analysis after the earthquake revealed the inadequacy of post-earthquake interventions. In this connection, the cooperation of Mediterranean countries based on experience gained may greatly contribute to the upgrading of efficiency in cases of catastophe.

- Laws, regulations and standards governing mitigation of earthquake risk differ in scope, level of elaboration and conformity with the most advanced knowledge in the field. It is to be assumed that some of them are inadequate. Therefore a survey of the legislation on earthquake mitigation existing in Mediterranean countries may prompt the analysis, appraisal and eventual improvement of such legislation.

- Experience of past destructive earthquakes clearly indicates that inadequate construction and poor quality workmanship is frequently the major cause of damage on buildings and heavy losses of life. Therefore, strict and active control measures covering design and construction are greatly needed in seismically active areas.

- Newly acquired knowledge in the field of seismic risk mitigation makes clear the need to re-evaluate existing physical plans and/or to revise them where necessary.

- The need to train professionals, specialists in geoseismic studies, physical planning and emergency management in earthquake conditions is emphasized.

- It is felt that MAP and PAP within their respective framework should stimulate mitigation activities in each member country; furthermore, that they should initiate, facilitate and promote in the field Mediterranean cooperation at government level or at the level of professional institutions.

- This particular PAP project should contribute to the exchange of relevant information and expertise, and to the training of professionals and managers. To secure efficiency, the project should concentrate on specific selected subjects which will enable a direct exchange of experience, verification and harmonization of applied methods with a view to arriving at relatively simple and less costly methods.

3. MAJOR STATEMENTS AND DOCUMENTS ADOPTED BY THE SEMINAR "LAND-USE PLANNING IN MEDITERRANEAN SEISMIC ZONES", Cetinje, 27-29 June 1985.

A. General

The objectives of the Seminar were in correlation with the objectives of the Priority Action itself, namely: to analyze the problems related to seismic risk reduction through physical and urban planning and to seismic risk management in the Mediterranean Region; to consider the national reports as well as to review the case-studies prepared on selected subjects; and to promote the follow-up for further exchange of experience and cooperation among Mediterranean countries in this field.

Representatives of the following Mediterranean countries took part in the meeting: Algeria, Cyprus, Egypt, France, Greece, Italy, Tunisia, Turkey and Yugoslavia.

The representatives of UNDRO and UNCHS as well as the Coordinator of MAP also attended the Seminar.

B. Conclusions and Recommendations of the Seminar

1. The meeting discussed the matter of future cooperation and formulated the following general conclusions:

- The Mediterranean is a major earthquake zone where a number of countries are regularly affected by earthquakes resulting in loss of life and destruction of housing and infrastructure.

- Seismic risk is an element of the Mediterranean coastal environment which must be taken into account in land-use planning as an integral part of national development policies.

- The objective of seismic risk prevention in coastal areas may promote a policy of preventing excessive concentration of population and development activities in coastal areas which is pursued by many Governments.

- Such a policy constitutes an important element of the longer-term efforts to reduce pollution of the Mediterranean Sea from land-based sources.

- The Mediterranean Coastal States have accumulated an extensive expertise in dealing with earthquakes.

- The willingness to cooperate and to exchange experience has been clearly expressed by the meeting and by the international organizations represented.

- Developing countries are relatively more vulnerable to earthquake damage and within each country the poor are more heavily affected.

- Historic centres, which are essential to the Mediterranean identity, are particularly vulnerable to earthquakes and should receive special attention and programmes.

- Based on the previous general conclusions the meeting recommended that cooperation should and could be expanded.

2. The participants in the Seminar agreed on the thematic framework for future activities which is contained in Section 3.3 of the report.

3. The participants furthermore agreed on the following possible outline for future cooperation among Mediterranean countries:

- Application of the thematic framework for the assessment of seismic hazard, vulnerability and risk of the single elements at risk at the various levels of physical and urban planning.

- Selection of social and economic parameters and their use in the assessment of consequential losses due to earthquakes.

- Application of land capability analysis to specific cases through the preparation of the land-use environmental factors matrix and land capability maps.

- Construction of scenarios on the impact of selected earthquakes upon the existing development at regional and urban levels.

- Definition of the seismic vulnerability of the existing urban areas and their use as planning parameters in the planning and programming process at regional and urban levels; use of field surveys for their assessment; and guidelines for the definition of the acceptable seismic risk.

- Formulation of a comprehensive methodology for the assessment of models of urban development in the preparation of master plans designed to incorporate seismic risk; and definition of needed seismic data base.

- Formulation of the methodology for the comparative analysis of the costs of development programmes and investment projects according to alternative locations designed to incorporate seismic risk; and its application to specific cases.

- Guidelines and criteria for the formulation, design and implementation of investment projects designed to reduce seismic vulnerability and risk in existing urban areas; and their application to specific cases.

- Comparative analysis of models of distribution of population, functions and networks of infrastructure at the regional level based on alternative values of concentration and densities as a function of seismic vulnerability and risk.

- Models of contingency plans at the national, regional and local levels; and their application to specific cases.

- A uniform conceptual and lexical basis for research and operational procedures in the prevention, emergency management and recovery stages based on the full cooperation among institutions and scientific organizations in the different countries.

4. It was agreed that on the basis of the conceptual framework and outline for future action a number of immediate activities could be undertaken, among which:

- Development of conceptual framework and definition of terms.
- Listing of relevant institutions and projects.
- Exchange of information with a view to establishing a common data base.
- Preparation of a limited number of case studies and one synthetic case study; arrangements for a review of the studies.
- Consideration of possible initiatives in the field of technical cooperation, training and the exchange of information.

5. The meeting underlined the need for a close cooperation among UNEP, UNCHS, UNDRO and other interested agencies and organizations which should be based on their specific expertise and capabilities. The agencies represented at the meeting provided the following indication of their expertise and capabilities:

- UNEP in the field of environmental management and networking, acting as a promoter and focal point for action and the collection and dissemination of information and the generation of funds;
- UNDRO in the field of servicing and providing expertise with respect to seismic risk assessment (prevention) and emergency planning (preparedness), as an input to the activities of countries and agencies;
- UNCHS in the field of integrated physical planning in connection with the need to reduce seismic risk and the preparation, management and implementation of programmes and projects in that field.

6 It was suggested that cooperation among the above mentioned agencies be arranged and finalized within the context of the proposal for future cooperation with a view to providing technical assistance to the cooperation among Mediterranean countries for the priority action of land-use planning in seismic-prone zones and that it be based and draw upon the conclusions and recommendations of the Seminar.

7. In anticipation of future cooperative arrangements PAP/RAC should undertake to:

(a) establish a network of national institutions, in cooperation and consultation with Governments and interested agencies and international organizations, with a view to promoting information exchange, training and research activities in the field of land-use planning in earthquake-prone Mediterranean zones, including reduction of seimic risk, emergency planning and management;

(b) act as a clearing house for the identification and financing of programmes and projects in land-use planning in seismic zones;

(c) seek and intensify the collaboration and involvement of UNDRO, UNCHS and other interested agencies and organizations, particularly UNESCO and UNIDO and specific projects such as PAMERAR, in the development and implementation of relevant programmes and projects in accordance with their specific expertise and capabilities.

8. The Seminar participants strongly underlined the need for an early implementation of the conclusions and recommendations of the Seminar. They urged the Contracting Parties to initiate and/or support the respective activities proposed, in particular the preparation of a proposal for future cooperation.

C. Thematic framework for future cooperation

Proceeding from the proposals given through the national reports and case-studies prepared, as well as on the basis of direct consideration of relevant issues, the Seminar has in the framework of its conclusions and recommendations also adopted a special thematic framework for future joint and coordinated activities of the Mediterranean countries in the field of seismic risk mitigation in the Region.

The thematic framework itself covers a wide range, starting from studying the phenomenon and assessing the seismic hazard itself, through vulnerability analysis considering the engineering and urban aspects of earthquake effects, with regard to seismic risk assessment and reduction, and earthquake preparedness and emergency management in the widest sense of the word.

This thematic framework of future activities is given in its entirety; it was presented through the report of the Cetinje Seminar, as follows:

1. The study of seismic phenomena

Hazard Analysis (seismologists, geologists and related professions)	- research in seismology; - seismotectonic studies/maps; - observation of seismic phenomena (instrumental networks and monitoring); - seismic hazard analysis; - seismic hazard mapping (macro- and micro-zoning);

2. Seismic effects on buildings, structural systems and lifelines

Vulnerability analysis (civil/earthquake engineers) Risk Assessment and Reduction	- damage analysis; - vulnerability analysis *per se*; - repair and strengthening; - seismic building codes; - building regulations, methods and supervision. N.B. Reference is made to structural systems (typology), settlements acting as a system, lifelines, and not least, historical monuments, settlements and property.

3. Physical planning and socio-economic development

(Architects, engineers physical planners economists)	- comprehensive planning; - application of seismic hazard zoning maps for risk reduction to development (locational criteria as a function of hazard and vulnerability); - detailed urban and rural settlement planning, using seismic micro-zoning maps/information.

4. Legislation

Risk Mitigation (legal, administrative and political functions)	- legislation with respect to long-term prevention and protection; - legislation with respect to emergency management and relief; - legislation with respect to reconstruction and long-term post-disaster relief action.

5. Earthquake emergency planning and management (Disaster Preparedness)

Mitigation (civil protection personnel with technical support from professions as listed above)	- preparation of emergency and contingency plans; - training of personnel; - emergency management and post-disaster support from recovery/rehabilitation; - design, equipment programmes and implementation of operational structures.

6. Information and training

- public information;
- public education;
- training of specialists in prevention and preparedness.

4. SELECTED TOPICS AND EXAMPLES OF STUDIES (EXCERPTS FROM NATIONAL REPORTS AND CASE-STUDIES)

4.1. GREEK NATIONAL REPORT CONCERNING LAND-USE PLANNING IN SEISMIC ZONES

by John Drakopoulos, Department of Geophysics,
University of Athens, Athens.

Foreword

Earthquakes have always been regarded as one of the most formidable natural threats to human life and property. Unlike other rapidly occurring natural hazards, earthquakes usually strike without warning or regard to time of day or season of the year. They can kill, injure and cause property damage thousands of kilometers from their point of origin.

Earthquakes are natural phenomena that cannot be controlled, but the severity and nature of future damaging ground motion may be estimated with some confidence. Thus, appropriate mitigating measures, through engineering design based on seismic zoning, can be taken to minimize the losses. Seismic zoning maps delineate areas of similar seismologic, geologic and tectonic characteristics. When combined with engineering input on earthquake resistant design, these maps become an essential and practical tool for the implementation of a seismic building code.

In view of the rather high level of seismic activity in the Mediterranean area seismic studies are necessary for continued social and economic development in the Mediterranean countries. They will give needed information which will help the public appreciate the level of earthquake hazard and provide the engineering community with the information it needs to mitigate the damage by using appropriate engineering design. Thus, combined seismic studies (hazard, vulnerability and rik analysis) will help prevent disastrous loss of life and property in the future when severe earthquakes occur in Mediterranean countries.

The Mediterranean countries which have similar earthquake characteristics, have led a similar way of life for so many centuries and use similar construction methods, may expect from this collaboration a great benefit from the combined efforts of their experts in the fields of seismology and earthquake engineering.

The information provided by the present national report is limited to the major activities of Greek Institutes in the fields of Seismotectonics, Engineering Seismology and Earthquake Engineering without reference to special scientific or detailed organizational items covered by each Institute.

The aims of this report in the framework of the RAC/PAP Project are, firstly to identify existing knowledge and expertise which may be applied directly towards prevention of earthquake disasters, particularly in Mediterranean countries and, secondly, to identify the gaps in current knowledge which require concerted action by the international community.

Introduction

Greece has the highest seismic activity in Europe with about 2% of the whole world's seismic energy release. This is accomplished within an area amounting to only 0.09% of the total area of the world, truly a "vast seismological laboratory" as many investigators put it.

Most of the largest earthquakes in Greece occur along well defined belts that coincide with plate boundaries. Relatively little deformation occurs in most of the interiors of plates.

Subduction of the Mediterranean lithosphere under the Aegean sea occurs along the Hellenic trench. The tectonic setting of the Hellenic subduction zone has been discussed most recently by McKenzie (1978) and Le Pichon and Angelier (1979). The convergence rate is estimated to increase from 2 cm $year^{-2}$ in the west to 5 cm $year^{-2}$ in the east. These rates are far higher than the rate of the Europe-Africa collision because of the NS spreading in the Aegean. This is the reason for the very high seismicity rate in the circum-Aegean area, which exceeds by an order of magnitude all other earthquake activity in Europe and North Africa.

On the other hand, in the neotectonic map of Greece many major and innumerable minor faults exist which may have the potential for damaging earthquakes. Some large shallow earthquakes are associated with ruptures along faults which have been, or could have been, identified as capable faults.

The long documented seismic history of Greece reports many catastophes due to earthquakes (Galanopoulos 1961, Lomnitz 1974), so seismicity studies are important for Greece.

The fact that the number of victims in Greek earthquakes is generally low for the event magnitudes is an equally remarkable and fortunate circumstance emphasized by some investigators. The exact reason for the relatively low death figures compared to other countries in the same earthquake belt (Italy, Yugoslavia, Turkey) is not quite clear but we can speculate on the following factors:

1. More appropriate constructional style of houses;

2. Intermediate seismic activity in southern Greece;

3. Population distribution in relation to the earthquake damaging zones. It has to be emphasized that some strong earthquakes have their foci under the sea and far from densely populated areas.

Even though the number of deaths is comparatively modest, the material damage from earthquakes has been considerable in recent years.

To the purely material damage must be added the direct and indirect economic consequences: abandonment of towns and villages, forced unemployment, production losses and additional cost of health and other social services.

We also want to emphasize at this point that one of the reasons that recent shocks have caused greater damage than older ones of the same magnitude is due to the fact that we construct buildings with a larger natural period, in other words taller buildings that are affected from shocks of some distance. A good proof of this is to compare the damages to Athens from the Corinth area earthquakes in 1928 and 1981 (50-60 km from the epicentre).

Revised map of maximum observed intensity

The map in Fig.5 shows the isolines of maximum observed intensity over the period 1700-1984. It was based on the maximum values of intensities of particular earthquakes as well as on the proper evaluation of existing isoseismal maps.

In the majority of isoseismal maps of Greece, one can generally observe an elongation in a NNW - SSE direction. There is also the same trend for a similar elongation of different zones of isoseismals in the map of maximum observed intensities. This may indicate the existence of one main direction of seismic energy i.e. NNW - SSE, or more probably this tendency reflects the general pattern of geological conditions in Greece and is related to the main direction of the Hellenides.

As concerns the precision of the isoseismal lines presented in the map, we believe that it varies between 5 and 10km, depending mainly on population density in the different parts of the country. In general the limits of the areas with different intensities, as portrayed on the map, do not show any strong correlation with local surface geology. It is likely that the main features are controlled by the focal depth of the strongest earthquakes in a given area. However, some minor details are probably related to the thickness of soils and to surface geology. In this regard, we may say generally that the more competent the in situ materials, the lower the intensity of earthquake motion at the site. Landslides can take place on steeper slopes. On the other hand, landslides have an effect on maximum earthquake intensity which is higher in landslide terrains.

It must be mentioned that at least one (if not more) intensity I_0VI has been observed over practically the whole territory. There are very few exceptions to this general rule. These apparently immune earthquake regions are: the Aegean block which includes the south-eastern parts of Attica and Euboea and some of the Cycladic islands. The block formed by north-eastern Greece and southern Bulgaria (Thrace) is also well defined. A third aseismic region is in the northern part of central Greece i.e. in the Kozani-Ptolemais basin. This apparently quiescent seismic region is almost of cyclic type with a radius of the order of 70 km. Since, on the basis of geological and tectonic criteria, this region is not expected to be seismically quiescent, one may assume that the return period of shocks there is rather long. In the three above mentioned quiescent seismic regions maximum intensity has not exceeded the level of VI in the specified period of time. While these areas have not experienced any significant shocks they should not be totally discounted on the basis of seismic history alone.

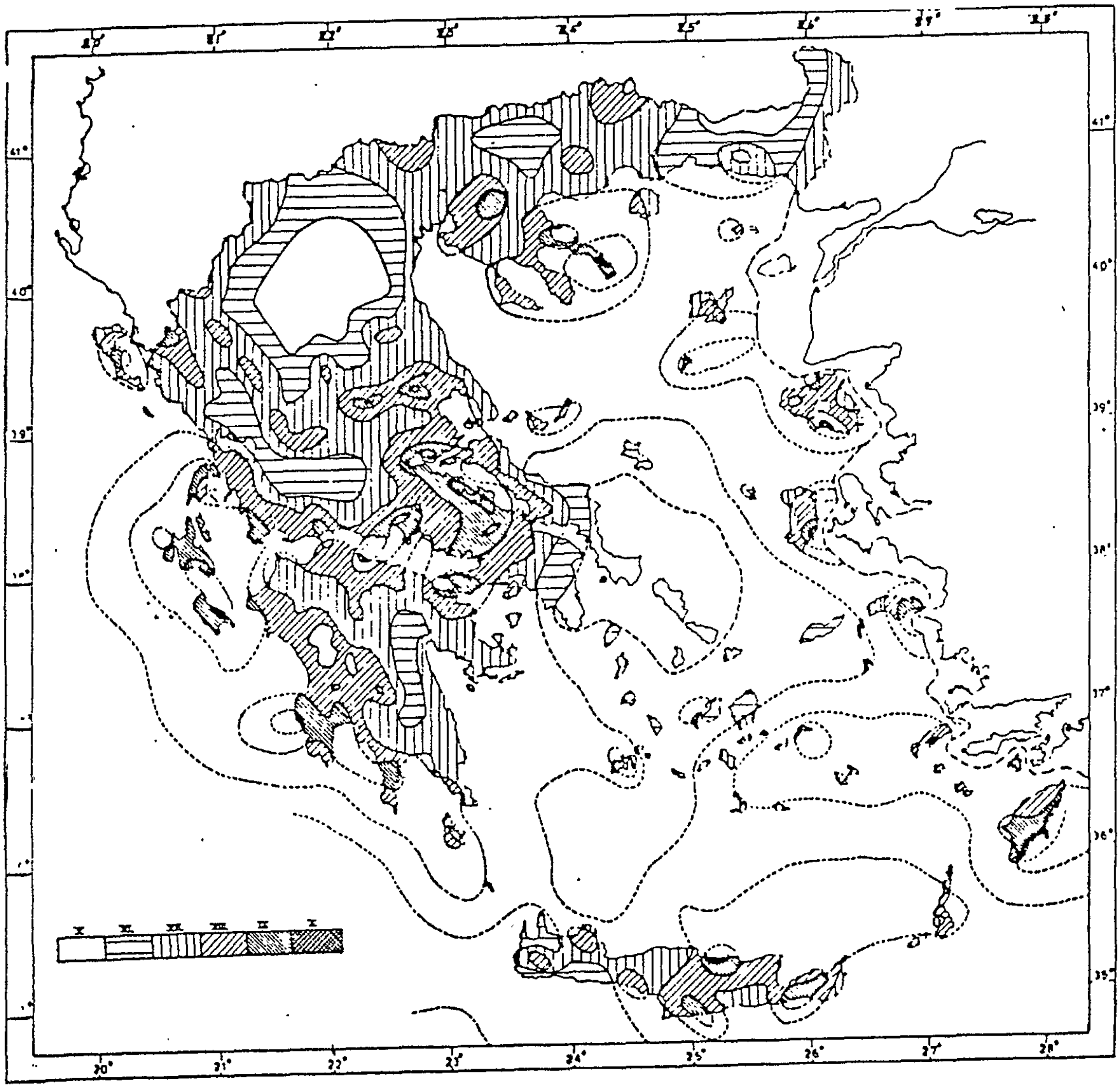

Fig. 5 Generalized Map of maximum observed intensities
(period 1700-1983, Drakopoulos - Makropoulos, 1983)

In this map we can also distinguish centres of higher observed maximum intensities i.e. of high earthquake risk. One zone is in the islands Leukas - Cephalonia - Zante where the maximum observed intensities are I_0 IX. Another centre of higher observed intensities is in the south-western part of the Peloponnese where the maximum observed intensities are higher than IX. A third centre of high maximum observed intensities covers some special areas of Dodecanese - Crete. As is well known, there is a large fault zone in this area which is responsible for earthquake activity but this zone is of sub-crustal origin, so there are only a few cores with maximum intensities I_0 IX in Crete and in the eastern part of Rhodes and Kos islands. Another part of the country with high maximum observed intensities is the Eastern Sporades (Lesbos, Chios, Samos).

There are many other regions in northern Peloponnese and central Greece where the maximum observed intensity during the period 1700 - 1984 was higher than IX. In the northern part of the country the only region with a higher than IX observed intensity is eastern Chalcidice and a core near Volvi.

The high level of seismological activity and the sufficient number of observed earthquakes guarantee that the estimation of maximum observed intensities for Greece is realistic. This map defines in a reliable way the most seismically active regions in Greece and for this reason it contributes to research on seismic zoning.

The main disadvantage of such a map is that it cannot be directly used by earthquake engineers since for special structures, velocity and acceleration spectra are required. Nor can we determine from maximum observed intensity maps at each site the return period of a particular intensity. Thus it is impossible to calculate from such maps for any level of probability the maximum intensity of shaking in a given number of years at a certain site.

In conclusion, it should be pointed out that regionalization involving intensities should rather be applied to the design and location of ordinary buildings. However, for large and complex constructions intensities are insufficient especially when the consequences of large and long-period earthquake motion are to be taken into account.

Seismic origin zones in Greece

The seismic origin zones in Greece are indicated in Fig.8. The map was drawn on the basis of neotectonic and seismological criteria. The more important seismic sources (zones) are the following:

1. The Hellenic trench subduction zone, which starts from the Ionian islands-Southern Crete and finally trends NE with a maximum expected earthquake magnitude of 7.5 and mainly shallow foci. Focal mechanism results and geologic information show that this region is affected by compressional stresses.

2. An extended wide zone along the Aegean Arc (2 on the map with M^{max} = 8.0. Along the outer Aegean Arc indermediate shocks with depths of 70-100 km dominate (2a on the map) while along the inner volcanic arc deeper shocks (130 - 180 km) are more common (2b). Between these subregions of the same zone we have another sub-zone with intermediate shocks and focal depths of 100-130 km (2c).

3. NW Greece and Albania with M_{max}=6.8. The compressional stresses associated with the Hellenic trench are thought to extend inland into northwestern Greece and Albania.

4. Corinth Gulf zone with expected maximum earthquake magniture 7.2. Data suggest east-west normal faulting with a significant dip-slip component. This tends to be supported by focal mechanisms indicating extensional stresses trending north-south.

5. A zone trending N - S in Central Peloponnese with expected M_{max}=6.8. This zone is not well defined. The relatively diffuse seismicity in the Peloponnese coupled with the multiple rift orientations makes this area particularly difficult to analyze for capable faulting. The Peloponnese may consist of several blocks perhaps each with its own stress field and different M_{max}.

6. Corinth - Central Euboea zone with shallow activity and extension by normal faulting trending N-S.

7. Atalanti fault system with expected M_{max}-7.2 and very shallow activity. The Locris - Euboea region bears a strong resemblance to the eastern Gulf of Corinth. The major faults bounding pre-Pleiocene formations trend WNW. It is likely that the Pleiocene deposits in the Renginion valley have been uplifted by motion on the normal fault near Kamena Vourla, which is part of a large fault system on the south side of the Gulf of Atalanti that last moved in the earthquake of 1894.

8. A zone from Ambrakikos Gulf to Patras Gulf which trends parallel to Hellenides. The activity is shallow and the expected M_{max}=6.8.

9. Transcontinental zone. A very large zone which starts from Turkey-North Aegean and crosses Central Greece up to the Ionian islands. In Central Greece the expected M_{max}=7.0 and we have shallow activity and tensional stress field trending N-S.

10. Volvi - Eastern Chalcidice - N. Aegean zone (Serbomacedonian) with shallow activity and expected M_{max}=7.6. The previous two zones 9 and 10 strongly suggest that in North Aegean region two large fault zones running NW-SE and NE-SW have been active in recent years. Seismological and geological data seem to indicated that the motion on the NW-SE running fault zone is left lateral and throw on the northeastern side. The motion on the other zone running in a NE-SW direction is right lateral and down throw on the north side.

    The whole picture gives the impression of a bending conjugate system. The places of maximum bending i.e. the places where the stress changes direction abruptly and the areas around these places are among the most active centres in Greece. This is also valid for the Ionian sea and the region close to Rhodes. In the Northern Aegean area we have the predominance of horizontal T axes trending N-S (extentional field).

11. Two well defined zones in Eastern Sporades trending parall and in E-W azimuths with expected M_{max}=7.2 and shallow foci (11a in Lesbos and 11b in Chios).

12. Eastern Crete - Rhodes area (parallel to the trench and particularly between Gavdos and Pliny trench). The activity there is shallow and intermediate and the expected $M_{max}=7.6$.

13. A NW - SE zone along Western Crete with mainly intermediate shocks along W. Crete (13a) and shallow activity under the sea south of Crete (13b).

    Contemporaneous normal and thrust faulting have been observed in close association near Crete (Jackson et al., 1982) presumably as a result of topographically induced stresses above the subducting plate. Local changes to normal or reverse faulting as a result of strike-slip motion are also common in Crete (Zones 1, 12 and 13) and have been observed seismically (Drakopoulos and Delibasis, 1982).

The above mentioned origin zones were delineated mainly on the basis of historical seismicity, stress field information and an evaluation of available neotectonic and geological evidence suggesting recent earthquake activity. However, research in this field should be pursued and the proposed framework must be considered preliminary.

8. Physical and economic aspects of earthquake effects. Examples from Greece.

The assessment of losses due to earthquakes is based on the derivation of relationships between the degree of damage to structures by class or type of construction and the intensity of ground shaking.

Intensity is related to the degree of shaking at a specific place. It is a numerical index that describes the effects or degree of damage of an earthquake on man-made structures.

Total damage D, that is the total number of residential houses destroyed or rendered uninhabitable, and maximum intensity Io are not all that closely related and therefore epicentral intensity alone is not a good predictor of total damage. This is obvious since two normal shocks of different magnitude may produce the same epicentral intensity but the larger of the two will release more energy that will affect a larger mesoseismal area and consequently cause greater total damage.

A good predictor of total damage for shallow earthquakes is magnitude. Fig. 9 shows a plot of the surface wave magnitude M_s versus total damage D for events of shallow depth with epicentral areas entirely on land in Greece and Turkey (Ambraseys and Jackson, 1982 with data from 1902 to 1981).

As far as the physical aspect of earthquake effects is concerned, it has been found that the cumulative damage of earthquakes of moderate maximum intensity (VII - VIII) is greater than the cumulative damage caused by greater earthquakes. This of course is a result of the greater number of moderate earthquakes. It has also been found that losses from ground shaking predominate by far, if compared with losses due to surface faulting and landslides, in California (Algermissen et al., 1972) and Greece (Drakopoulos and Tassos 1983).

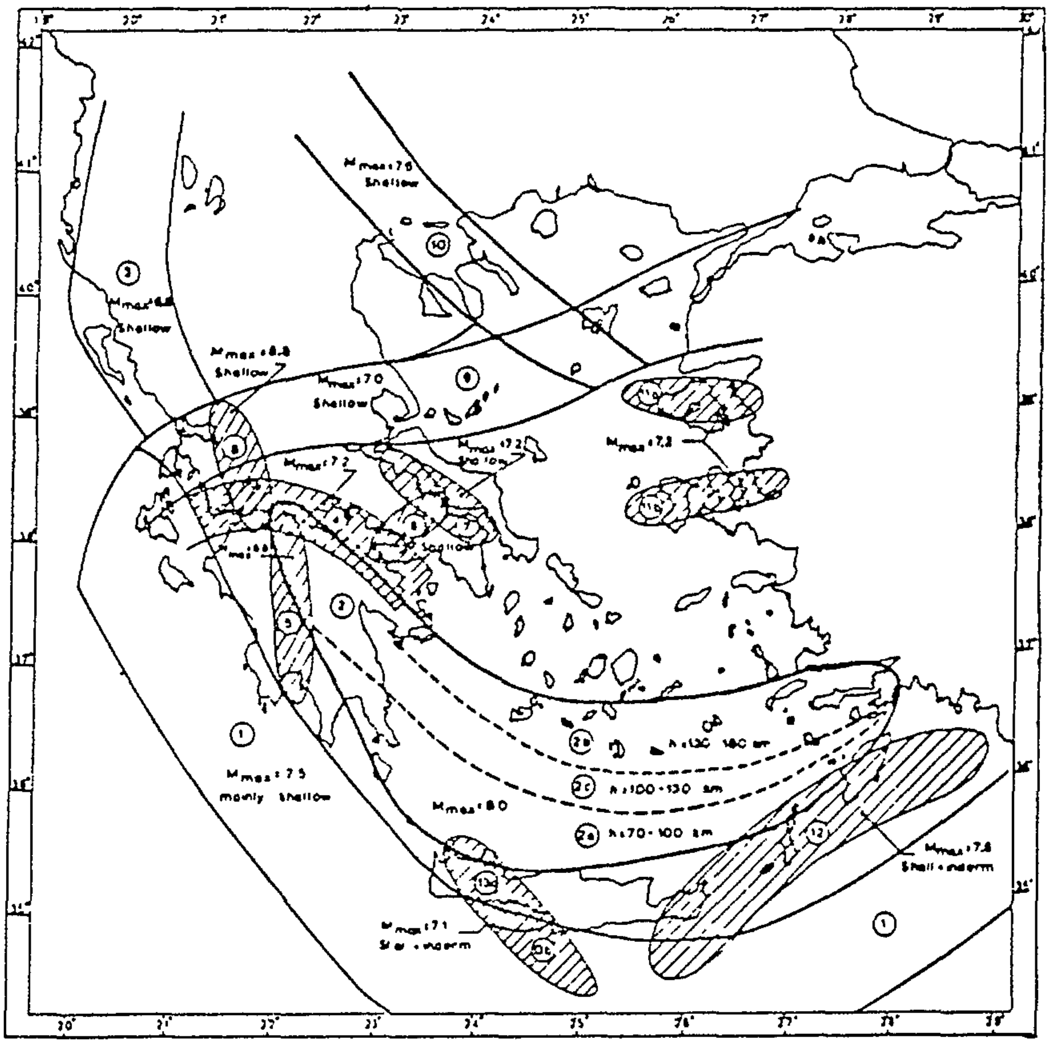

Fig. 8 Map of seismic origin zones in Greece

Results of recent shocks in Greece (The Corinth region, February 24-25, 1981; Boeotia, March 4, 1981; Salonica, June 20, 1978) have clearly shown that even in the same event the cumulative damage due to intensities VII and VIII on the Mercalli scale is much greater than the total damage that occurred in the epicentral areas shaken with an IX degree intensity. This is due to the fact that the total area shaken with a certain level of intensity is much larger than the area shaken with an intensity of one degree higher (Fig. 10).

Late December 1981 statistics from the district of Attica (Greece) show that out of 79,000 houses, which were affected by the February - March 1981 earthquakes, 4% had to be demolished; 7% could be repaired at some considerable expense; 47% suffered minor structural damage and 42% slight damage. In the district of Corinthia the corresponding percentages for a total of 22,000 houses affected are 26%, 17%, 26% and 31%.

The direct loss from this sequence is estimated at 50 billion drachmas with an expected additional cost of 6 billion drachmas for relief services and temporary housing. In all 12,000 houses were destroyed or damaged beyond repair, requiring demolition.

Even these few statistical data make crystal clear the economic impact of earthquake phenomena in disaster-prone countries.

Damage statistics are often distorted by the inclusion in the sums of damaged or destroyed building structures other than houses, such as barns, stables and sheds or, in large villages and towns, of more than one housing unit, flat or apartment in one building. Indirect damage, caused by secondary non-vibrational effects, such as landslides, rockfalls, ground slumping and liquefaction, often distort damage statistics (Ambraseys and Jackson 1982).

Review of the Greek code for earthquake aseismic structures

General characteristics of the code

The Greek code for aseismic structures reflects the existing older codes as well as the long experience on the response of buildings gained after the catastrophic earthquakes of Corinth 1928, Hierissos 1932, Larissa 1941, Lefkas 1948, Cephalonia-Zante 1953 and Sophades-Karditsa 1954. From 1954 till 1959 most of the articles of the code were implemented throughout Greece as informal recommendations. The code was finally introduced in June 1959 and is obligatory for all structures erected in Greece regardless of their use, location, type of building, material used etc. This code is still in force without any substantial changes. The fact that the code is based on construction practice, design capabilities and building materials existing in Greece before 1954 constitutes its main disadvantage; for example, before 1955 no architectural needs for large structural spans were apparent. The need for an open and/or high story was rather small. Partitions were continuous down to the groundfloor level. The quality of building materials and especially that of reinforced concrete as well as construction technology were quite low. The result was rather stiff structures. The behaviour of ductile frames was not well understood at the time.

In the existing code, the relevant article dealing with general design concepts recommends the use of R/C walls, while other articles stipulate the need for an aseismic design study of ordinary structures if symmetrical and adequate shear walls are used in both directions. If the required walls are missing, or the construction is asymmetrical, the code stipulates that the columns and beams should "function as frames" without any other provision for the design of an earthquake resistant structure.

The code specifies the application of equivalent horizontal seismic forces at each level throughout the height of the structure. These forces are equal to the product of the sum of the dead plus full live load concentrated at the respective level of the structure by a seismic coefficient.

The code specifies in brief the design seismic loads which are always statically applied, the analysis methodology, the resistant stresses of the structure and soil and a few structural details. The code deals with masonry (artificial or natural stone and brick walls) and reinforced or unreinforced concrete as load carrying systems. Some attention is paid to the details of the non bearing partitions.

It must be pointed out that a few changes were made in the code (1985) after the recent experience on the response of buildings gained during the catastrophic earthquakes of Salonica (1978) and the Corinth-Athens area (1981). These changes constitute a good revision of the Greek code.

Concluding remarks about the response of buildings during recent strong earthquakes in relation to the Greek provisions

The response of buildings during an earthquake is the combined result of many parameters; nevertheless among the most important is the implementation of the code provisions and the design and construction of buildings which are governed by a network of related laws.

The Greek aseismic code was formulated around 1959 and reflected the experience on the response of buildings gained after earthquakes which struck major Greek cities. The type of buildings constructed in Greece up to 1959 was rather stiff and low rise. Therefore the response of this type of building, if designed and constructed according to the code, was quite satisfactory as shown during recent earthquakes; older and newer buildings constructed of masonry, reinforced or unreinforced concrete which however complied with the code stood the test of earthquakes quite well. This is all right for a limited level of the earthquake forces developed in this kind of structure, but serious problems may arise if the seismic forces increase, because this type of structure is rather brittle because of the absence of even the word "ductility" in the code; thus damage can be exceptionally high.

Modern structures erected recently are not covered by the provisions of this code. Other codes related to design and construcion, but lacking any provision concerning earthquake proofing, have contributed to this, as for example the code on reinforced concrete srtuctures. Modern structures have large open spaces, and modern high strength materials are used; these produce rather flexible systems with large displacements and rather small damping. For such a structure to be earthquake resistant not only sound design, but very good construction as well, are needed. Difficulties are proportional to the flexibility of the structure. The construction of buildings with a flexible reinforced concrete skeleton demands a careful aseismic design.

Damages to contemporary structures in recent strong earthquakes are often due to few, basic and repeated errors in the concept of the structural system, ommissions and bad workmanship in the construction being beyond the explicit provisions of the codes. Most of the damage is typical and has been repeatedly observed.

The current Greek code is based on observed intensities which give a measure of the severity of ground shaking; however, the fact is that they are mainly based on structure response. It is very difficult, if not impossible, to separate the various components that contribute to the seismic response of a structure, namely the severity of the earthquake in the bedrock, the influence of local soil conditions and the dynamic and strength characteristics of the structure. This difficulty is increased by the fact that the structures on the response of which the above mentioned distribution of intensities is based are old and were not designed or constructed by engineers. Because construction spread beyond the limits of the old villages and cities, severe problems of seismic load assessment have been encountered.

There are also other problems contributing to damage; they are related to marginal parameters other than pure engineering design and practice; such problems may concern architecture, town planning or the change of use of a building. The destruction or heavy damage of many old buildings, as well as the open free space on the ground floor, the addition or subtraction of the non-bearing brickwalls from structures, are all facts confirmed time and again after recent earthquakes (Carydis, 1983).

A very common problem is the inappropriate assessment of type of soil at the site of construction in order to apply the relevant seismic coefficient specified by the code. In most cases the soil category for the application of the seismic coeffiecient is assessed as higher than it actually is, although for the foundation and bearing capacity, soil quality is generally correctly assessed. This is almost the rule for sites belonging to the worst soil category (c) where the seismic coefficient should be doubled and additional measures taken (stiffer structure-foundation system etc.)

It was observed that similar structures in the towns and villages behaved differently. Damage was greater in the countryside because of lack of adequate engineering support (design and supervision), improper foundation in bad soil and finally because of additions and renovations to existing structures and lack of maintenance.

Buildings that were constructed before 1959, when the code for earthquake resistant structures was put into effect, and buildings erected in regions where higher seismic coefficients are foreseen depending on the design of the structure (Carydis, 1983) should be redesigned.

Existing codes appear to address the types of problems likely to affect structures in a seismic zone, but they are not specific enough to prevent some of the detailing and conceptual problems seen after recent earthquakes. Seismic codes must be continually revised to avoid such problems and engineers must be informed of those revisions. In addition, existing structures need to be systematically evaluated to determine their actual strength and response, as opposed to their anticipated behaviour when designed. Where necessary, strengthening procedures should be undertaken.

Earthquake effects on cultural monuments in Greece

The Parthenon. Because of the great historical interest of the Parthenon, we briefly describe the damage caused by the 1981 earthquakes.

The monument is founded on two different types of soil. Limestone is under the northern part and earthfill under the southern part. The Acropolis hill of Athens consists in its upper part (between elevations of 118 and 156m) of upper cretaceous limestones, usually thick, platy and in places very fractured with obvious karst and erosion features.

The 1981 earthquake produced relatively small permanent displacements in certain parts of the monument. The northern part of the monument displaced westward, while the southern part displaced eastward.

The most severe displacements and damage were observed on the eastern side, where many marble chips fell. The eastern top beam at the north end displaced westward about 4 cm in relation to the ground.

The west side suffered much smaller displacements, concentrated near the bottom end of the pillars. This difference in the deformation of the pillars between the east and west sides may result from the fact that the east side has no horizontal connections between the inside and outside pillars, while the west side has more horizontal supports along the span (Carydis et al., 1982).

Salonica. In the city of Salonica there are numerous monuments; still standing and dating from the Roman period is the Arcade of Galerius, memorial of his victory against the Persians in 297 A.D. and the Rotonda, erected at about the same time. Many other monuments were built in more recent times. Most of these buildings had already suffered some damage during previous earthquakes. The damage during the series of earthquakes of 1978 was in most cases serious, and this proves that if not repaired carefully after each earthquake the damage to monuments is cumulative.

Part of the main structure of the Rotonda has since the fifth century been used as a church dedicated to Saint George; another part has been used as a museum; between 1430 and 1912 the monument was a mosque (the minaret can be seen in the foreground). During the 1978 earthquake the monument suffered extensive damage. Afterwards strengthening and restoration repairs were carried out according to a detailed study.

The White Tower in Salonica is a masonry monument of the fifteenth century A.D.; in the past it was used as a prison and later as a fortification tower of the Salonica harbour. Its location also indicates the southeastern limit of the old city. After the main shock of 1978 four of the ramparts at the top of the Tower were toppled.

Loss reduction studies

The disastrous effects of earthquakes can be mitigated in several ways, but a successful programme of earthquake risk reduction must involve a complex interplay of scientific, political, social and economic decisions. Earthquakes do not respect national boundaries; in Europe therefore such decisions must be taken by organizations with not only the requisite international authority, but the confidence and the respect of the individual European peoples as well.

The overwhelming majority of deaths, injuries and economic losses due to earthquakes arises from the collapse of or damage to structures erected by humans (such as houses, dams, etc.). It is clear therefore that, by improving the resistance of these structures to earthquakes, considerable reduction in the hazardous effects of these disasters can be gained independently of any other developments in earthquake risk reduction. Many inhabitants of earthquake prone regions live in inadequate housing from the point of view of earthquake resistance. Considerable effort should be expended in all countries to improve these conditions. Support should be given to research and development programmes designed to provide cheap, earthquake resistant structures and to upgrade the resistance of existing buildings.

For ordinary structures of relatively short life the earthquake risk may, under certain conditions, prove to be economically acceptable. However, for special structures whose failure or damage during an earthquake may lead to uncontrollable disasters, this attitude is not acceptable. To determine what is an acceptable risk for a particular project, a considerable amount of informed judgement, detailed technical evaluation of the structures and great caution must be employed in the selection of earthquake design parameteres (Ambraseys, 1981).

Thus loss reduction studies for the Mediterranean countries cover a broad spectrum of interests and involve more than one discipline all of them aiming primarily at the assessment of earthquake risk and its minimization.

Examples of vulnerability analysis in Greece

A case study on vulnerability analysis was made of the effects of the earthquake which struck the Perahora village on 24 and 25 February 1981. We present a review summary of this study (Mouzakis, 1982). The geological and surface soil conditions are described and a classification of buildings is presented. The construction practice, the condition of the structures and their history of previous seismic loading are all taken into account when discussing their behaviour during the earthquakes. Next the methodology of damage evaluation is described and some general economic data are given. The figures illustrate the seismological and geological setting and show the geographic distribution of damage. Damage histograms for various classes of buildings are also given.

Ground motion is expressed in this study by isoseismals of MCS intensities. The damage degree is estimated by means of a method used for the assessment of MCS intensities with a calibration from 0 to 1. The buildings investigated are divided into four classes according to criteria of material age and degree of engineering.

The vulnerability characteristics are expressed in the form of damage degree histograms for the village of Perahora as a whole. The cost evaluation also refers to the village as a whole.

A very good and systematic work on Vulnerability in the Northeastern Mediterranean was published by Ambraseys and Jackson (1982). Their results based on case studies lead to some useful conclusions regarding the different vulnerabilities of various structural systems and throw light on certain weaknesses to be avoided. The conclusions of their work are in this respect of obvious interest for engineering practice.

V-analyses were based on individual buildings. On the other hand it must be noted that the vulnerability of other structures and works, as well as whole urban systems and regional networks, represents a subject of the highest social importance which to date has not been specifically taken into consideration in Mediterranean countries.

The recent V-studies in Greece have pointed out some features of the vulnerability of buildings that may be taken directly into account in practice, even without a more sophisticated risk analysis. Some causes of high vulnerability are highlighted by the observations on damage distribution. The negative impact of unsuitable sites, the use of weak materials and the lack of appropriate engineering are confirmed. Lack of dynamic symmetry, a high degree of stiffness and strength discontinuities, strength that is too low, insufficient ductility etc., are to be avoided. More attention should be paid to appropriate dimensioning of strength and ductility and consequently to detailing in all kinds of buildings of reinforced concrete, whether they are of the flexible or of the rigid type (UNDP/UNESCO rep. W.G.B.).

The vulnerability to earthquakes of different categories of structures, facilities, public works etc., which depends inter alia on their nature, soil and foundation conditions, constituent materials, design criteria, quality of design and construction, can be derived from the systematic and statistical analyses of damage caused by recent earthquakes in the Mediterranean.

The information required in order to identify the structural vulnerability to houses should include a classification not only according to their type of construction and building materials, but also according to their state of repair. It is obvious that in highly seismic regions such as Greece and Italy, both urban and in particular rural houses, have during their lifetime, suffered considerable damage from near and distant earthquakes as well as from improper repairs, alterations and ageing (Ambraseys and Jackson 1982).

The use of seismic risk assessment in urban and regional planning

Decisions about land use, town planning and structural design in regions exposed to seismic hazard must be based on quantitative and qualitative models describing the risk, or the probability distribution of the damage that may occur to the elements or systems exposed to the hazard during given time intervals.

Physical planning is conditioned by three main factors:

- the degree and spatial variation of seismic hazard;
- the life expectancy of constructions;
- the rate of change and growth of areas subject to development and the direction of such change.

It must also be emphasized that for town planning and urban design the results of microzoning studies as well as risk assessments of total expected physical losses for given earthquake intensities are also needed.

In conclusion the general methodology in this field must be the following:

- Seismologists and engineers must provide the data that planners need, in a summary and possibly a qualitative form.

- Planners must design alternative scenarios, taking into account all the variables they usually deal with (social, economic, administrative, demographic etc.), plus the seismic hazard factor.

- For each scenario, the engineers have to calculate the residual risk; from this the added costs of development can be calculated until an optimal scenario is arrived at, balancing cost and acceptable risk. This process is continuous, since planning scenarios change in response to changing conditions.

Preparation of guidelines for a model seismic code in Mediterranean countries

The development of building codes is inseparable from land use zonation studies and involves the assessment of risk, which has a highly subjective component. At what point, that is, does the cost of constructing earthquake-resistant buildings become prohibitive in the light of the likely lifetime of the structures, the number and severity of earthquakes they are likely to experience and the cost to communities of likely deaths and injuries? Decisions on these points should not be reached in an arbitrary or bureaucratic way but must be subject to discussion, control and revision in local communities, which after all bear the brunt of earthquake damage.

The safety of human life in the event of a severe earthquake is the paramount consideration in the design of buildings. With this in mind the provisions and principles embodied in any building code should provide an up to date basis for regulations ensuring that most buildings:

- resist minor earthquakes without damage;
- resist moderate earthquakes without significant structural damage though perhaps with some non-structural damage;
- resist major or severe earthquakes without major failure of the structural framework of the building or its component members and equipment, and without risk to life.

It has become clear that the development of a detailed model code ready for implementation is not possible as an output of a Mediterranean project. A thorough study will be needed in each Mediterranean country before a detailed model code can be formulated. Thus at the present stage few general guidelines and related objectives can be presented for the development of a model code.

Detailed guidelines must be prepared by both PAP/RAC and individual countries for subsequent discussion; detailed codes by European countries individually or collectively can then be formulated.

Suggestions for the establishment by Mediterranean countries of national earthquake preparedness plans

In countries where the incidence of earthquake disaster is high it seems important that the government set up a disaster preparedness planning unit. The legislation establishing the disaster preparedness planning unit should clearly outline its power and duties.

The author believes that the preparedness plan must be under the responsibility of the government. Cooperation among Mediterranean countries could consist in the exchange of preparedness plans and of experience gathered from previous earthquake rescue operations in each country.

In Greece we have developed our own preliminary earthquake preparedness plan. On the basis of this experience the author can suggest the following items to Mediterranean countries to be taken into consideration:

1. Earthquake preparedness plans can only be formulated on the basis of realistic scenarios for probable earthquakes in Mediterranean areas designated as being at risk. Such scenarios must be based on the identification of seismic origin zones, the determination of magnitude - frequency relationships and attenuation laws, and the resulting expected intensity of a possilbe earthquake.

   All earthquake preparedness plans must provide complete operational guidance. Portions of the plan have to concern national, regional and local responsibilities . These must be clearly defined and co-ordinated through the appropriate administrative and governmental mechanisms.

2. Inventories of equipment, personnel and resources needed for rescue and relief operations from earthquake damage must be established by the responsible governments in earthquake countries where the incidence of earthquake disaster is high (Greece, Italy, Yugoslavia).

3. Training and organization of rescue teams must be the responsibility of each government. In an international seminar on earthquake preparedness (Athens, 1983) some suggestions were adopted by all experts; the following are additionally proposed for adoption by Mediterranean countries.

4. Damage classification should be part of a general national preparedness plan designed to deal with the emergencies created by an earthquake. The primary purpose is to classify buildings according to their continued usability in order to reduce the incidence of death and injuries to the occupants of buildings that have been weakened by seismic activity. Such buildings are likely to be subjected repeatedly to earthquake aftershocks during the first few days or weeks following the initial shock. There is therefore an urgent need for early post-earthquake inspections at national level.

5. Urban plans should be elaborated by Mediterranean countries on the basis of reliable seismic hazard data and on models of vulnerability and acceptable risk for all categories of buildings and public works.

6. Emergency shelter is required for two categories of people, the homeless and those who will continue to use their houses, except for sleeping (responsibility of the government). The shelter requirements for both categories of people will be modified according to climate and the prevailing weather conditions.

Experience has shown that the most effective response is to encourage rapid reconstruction of permanent housing. Emergency shelters such as tents may be of use for limited periods. Their climatic unsuitability and relatively poor physical properties are factors that should discourage over-dependance on such items. We also submit the following proposals to the Regional Activity Centre/PAP:

(a) The term critical facilities is used to describe those facilities in an area whose function during or immediately after an earthquake can play a critical role in coping with the emergency (hospitals, fire and police stations, communication centres, power plants, electricity and water distribution networks etc.). Thus, one of the basic elements of earthquake preparedness is to take steps that will ensure the uninterrupted functioning of such facilities immediately after a damaging or catastrophic earthquake (responsibility of the government).

(b) It is important that in each Mediterranean country a long-term and consistent programme be developed to inform the public by all appropriate means (newsmedia, posters, brochures, teaching at schools etc.) of the nature of the earthquake risk and of the measures that can be taken, both individually and collectively, to minimize damage and loss of life in the event of an earthquake. Simple instructions should be prepared and distributed to every home, office and factory, telling people how best to protect themselves when an earthquake occurs and what precautions to take for their survival and recovery after the disaster.

4.2. EARTHQUAKE HAZARD AND MITIGATION IN TURKEY
by Octay Ergünay, Earthquake Research Institute, Ankara

A. Introduction

The Republic of Turkey is located within the sector bounded approximately by the latitudes 36°-42°N and longitudes 26°-44°E, occupying an area of 779.452 square kilometres, of which 755.688 square kilometres lie in that part of Asia known as Asia Minor or Anatolia, and 23.764 square kilometres in that part of Europe known as Eastern Thrace.

The two continents, Europe and Asia, are separated by the straits, consisting, from southwest to northeast, of the Canakkale Bogazi, Marmara Sea and Bosphorus. The Republic's territory is roughly in the shape of a rectangle measuring 550 km. from north to south and 1565 km from east to west, at its widest points.

Turkey's borders are very long and have various characteristics. Its land borders cover 2753 km and its sea borders are 6000 km. long. Turkey's border with Syria is 877 km long. Its border with Iraq 831 km, with Iran 454 km, with the Soviet Union 610 km, with Greece 212 km and Bulgaria 269 km.

It is a country of high elevation with an average altitute of 1130 metres. Mountain ranges extend from west to east along the northern and southern coasts of the country. There are however a good many plains, plateaus, highlands and basins. Topographically, Turkey is divided into five regions of North, Soutn, East, West and Central Anatolia, all of which display different characteristics.

According to the results of the 1980 census, the population of Turkey was around 45 milion, but now exceeds 48 million. Population density is around 58 per km^2; it is much higher in urban centres while it declines in areas with unfavourable living conditions, such as south of Tuz-Gölü in Central and Eastern Anatolia.

The annual average population growth rate was 2.2% between 1975 and 1980. The rate of increase is much higher in the urban areas. It was around 4.2% in urban areas in the same period. The difference between these two rates can give us some idea about net migration of rural population to urban areas. Today rural/urban ratio is around 57/43 and will be around 30/70 in 1995. This development will create many new problems such as infrastructure, housing, public services, environmental pollution and will increase the existing earthquake risk, because 70% of the cities in Turkey is located in or near active fault zones.

As a result of her orogenic system, geology, seismicity, topography and climate, Turkey is exposed to various types of natural hazards causing substantial losses of life and property.

The total number of houses damaged by natural disasters in Turkey in the last 60 years is indicated in Table I.

Table I

Number of houses damaged by natural disasters in the last 60 years in Turkey.

Type of natural disaster	Number of houses damaged	Percent of the total number %
Earthquakes	333.935	65.4
Floods	78.047	15.3
Landslides	54.930	10.8
Rock falls	36.600	7.2
Storms, rain, hail	5.640	1.1
Avalanches	1.274	0.2
	510.426	100

We should point out that, especially after the 1960's, the flood, landslide and rock fall hazards as well as the vulnerability from such hazards have been decreasing through river course regulation and land use planning; however earthquakes will be the natural disaster affecting Turkey in the future. As far as the casualties and other economic losses caused by natural disasters are concerned, earthquakes claim the lion's share among natural disasters. Again the statistics of the last 60 years reveal that the average annual earthquake disaster related losses constitute about 0.8% of the total gross national product whereas all other natural disasters claim only 0.2%. The natural disaster mitigation programme in Turkey essentially means the mitigation of earthquake disaster.

B. Seismic hazard and risk in Turkey

1. Seismotectonics

Turkey lies within the Mediterranean sector of the Alpine-Himalayan orogenic system. The Alpine orogeny is produced by compressional motion between Europe and Africa, the Himalayan orogeny has resulted from the collision of India and Asia.

The main active fault zones, illustrated in Fig. 1, are:

-North Anatolian Fault (NAF) and the Anatolian Trough.

The North Anatolian Fault is a morphologically distinct and seismically very active right-lateral strike slip fault. It runs about parallel to the Black Sea coast throughout Anatolia (Ketin, 1968). The Anatolian Trough is the westward continuation of the northern strand of NAF. In the east, it divides into several branches which continue toward lake Van. This zone is characterized by a vertical fault plane which is repeatedly displaced en echelon. It has a well developed surface expression for most of its length of about 1000 km. In the landscape it occurs as a chain of depressions, contained by river valleys, lakes or sag ponds. It is accompanied by thermal springs, locally also by minor basaltic eruptions. The basement rocks are mylonitized in a belt several kilometres wide.

-East Anatolian Fault (EAF);

The East Anatolian Fault is an active left-lateral strike slip fault which extends from Antakya to Karliova, the eastern terminal of the North Anatolian Fault. It is a fault zone which is about 2-4 km wide, and links into the rift system of the Dead Sea fault. It can be traced clearly via Binjöl to the Hazar lake south of Elazig, in which a displacement by 15 to 25 km may have occurred since the end of the Tertiary period. (Seymen and Aydin, 1972).

-Western Turkey Graben Complex;

This is an area of intense seismic activity which is related to the east-west trending graben complexes in the Aegean region. Seismically, the earthquakes are normal faults and partly wrench faults with movement planes of a mean strike of N $50o_E$.

The sea of Marmara, Izmit-Sapanca, Gemlik-Iznik, Edremit, Bakircay, Bergama, Simav, Gediz, Buyuk Menderes, Kücük Menderes and Alasehir grabens are typical examples of these graben complexes. The grabens close eastward and also terminate westward shortly after the western coastline of Anatolia. McKenzie (1978) however argues that the graben systems of western Turkey extend beneath the Aegean as troughs.

A catalogue of the large ($M \geqslant 5.9$) and damaging events (epicentral intensity ($I_0 \geqslant VII$) is given in Appendix A for the period 1900-1983. In Fig. 2 the macroseismic locations of these large and damaging events are plotted together with tectonic features. As can be seen, the tectonic features of Turkey correlate well with the distribution of macroseismic epicentres.

2. Seismic hazard and risk

As is well known Turkey has experienced devastating earthquakes for centuries. Therefore a long discussion about the significance of earthquake hazard for Turkey is hardly needed. A few statistical data will suffice to illustrate this fact.

On the basis of the currently applicable official seismic hazard zoning map of Turkey (Fig. 3) and the results of the 1980 census, 92% of the total surface area and 95% of the population of Turkey are in various seismic hazard zones. Table II summarizes the exact situation.

Table II

Distribution of population, land area, industry and hydraulic dams with respect to the seismic hazard zones.

Earthquake zone	Population (percent)	Surface area percent	Big industrial centres (%)	Hydraulic dams (percent)
First degree hazard $I_o \geqslant IX$	22	15.0	24.7	10.4
Second degree hazard $I_o = VIII$	29	28.4	48.8	20.8
Third degree hazard $I_o = VII$	24	29.0	12.0	33.3
Fourth degree hazard $I_o = VI$	20	19.6	12.6	27.1
No hazard zone $I_o \leqslant V$	5	8.0	1.7	8.4

Table III shows the earthquakes with $I_o \geqslant$ VIII MSK that occurred in Turkey within the last 60 years and the total losses they caused. According to this Table about 1100 people are killed and about 5600 buildings are destroyed annually in Turkey.

The need for the preparation of an earthquake hazard zoning map for Turkey first became apparent after the big Erzincan Earthquake of December 26, 1939. The first official zoning map was prepared in 1945. This map was based on geologic and tectonic maps and historical earthquake data. Subsequently, new earthquake catalogues were prepared, some new data about the tectonics of Turkey were obtained and new criteria for the preparation of hazard zoning maps were developed through international cooperation. On the basis of these new data the Ministry of Reconstruction and Resettlement prepared in 1963 a new map which divides Turkey into the following four zones:

1st degree hazard zones : $I_o \geqslant$ VIII MM
2nd degree hazard zones : $I_o =$ VII MM
3rd degree hazard zones : $I_o =$ VI MM

No hazard zone : $I_o \leqslant$ V MM or zones that show no seismic activity.

In this 1:2,000,000 scaled map, the hazard zone boundaries of the earthquake zones were established according to maximum observed intensities. However, these boundaries were changed later in order to be consistent with administrative boundaries of cities and provinces for practical purposes. However, because of these changes, some disparities appeared on the map, such as a first degree hazard zone neighbouring a no hazard zone. These very sharp disparities gave rise to practical problems. A new revised hazard zoning map was thus prepared by the Earthquake Research Institute in 1972.

According to this currently applicable official earthquake hazard zoning map (Fig. 3), Turkey is divided into the following five zones:

1st degree hazard zones : $I_o \geqslant$ IX MSK
2nd degree hazard zones : $I_o =$ VIII MSK
3rd degree hazard zones : $I_o =$ VII MSK
4th degree hazard zones : $I_o \leqslant$ VI MSK

No hazard zones : I_o V MSK or zones that show no seismic activity.

Studies related to the preparation of the earthquake zoning map are based mainly on earthquake catalogues, tectonic and seismotectonic maps, observed and expected maximum intensity maps and earthquake epicentre maps.

The new map was prepared by using the deterministic approach. However, since the location, time of occurrence, magnitude and other characteristics of future earthquakes are uncertain, the appropriate tools for the evaluation of seismic hazard are the principles of probabilistic forecasting and decision making. During the last few years increasing interest has been shown in the application of probabilistic theories in the quantitative evaluation of seismic hazard in Turkey. Yarar _et al._(1980) and Erdik _et al._ (1982) have prepared such hazard maps for Turkey.

The key research steps and the parameters of a probabilistic seismic hazard assessment can be summarized as follows:

- Compilation of all available earthquake data, (historic, macroseismic and instrumental);
- Preparation of a seismotectonic map;
- Preparation of a seismic sources map;
- Assessment of the maximum magnitudes for each source zone;
- Assessment of the attenuation laws for each source zone.

Table III

List of destructive earthquakes which occured in Turkey
from 1925 to 1984

No.	Place	Date	Local time	Ms	I-MAX	Number of Heavy Damage	Number of Death	Death Heavy Damage
1	Afyon-Dinar	1925. 8. 7	8h46m	5.8	IX	2043	3	0.001
2	İzmir-Torbalı	1928. 3.31	2h29m	7.0	IX	2000	50	0.025
3	Sivas-Suşehri	1929. 5.18	8h37m	6.1	VIII	1357	64	0.047
4	Denizli-Çivril	1933. 7.19	22h07m	5.7	VIII	200	20	0.100
5	Erdek	1935. 1. 4	18h20m	6.7	IX	600	5	0.008
6	Kırşehir	1938. 4.19	12h59m	6.7	IX	3860	149	0.039
7	Izmir-Dikili	1939. 9.22	2h36m	6.5	IX	1235	60	0.049
8	Erzincan	1939.12.26	1h57m	8.0	X-XI	116720	32962	0.282
9	Kayseri-Develi	1940. 2.20	-	6.7	VIII	530	37	0.070
10	Van-Erciş	1941. 9.10	23h53m	6.0	VIII	600	194	0.323
11	Bigadiç-Sındırgı	1942.11.15	19h01m	6.1	VIII	1262	7	0.006
12	Niksar-Erbaa	1942.12.20	16h03m	7.0	IX	32000	3000	0.094
13	Adapazarı-Hendek	1943. 6.20	17h32m	6.6	IX	2240	336	0.150
14	Tosya-Ladik	1943.11.26	0h20m	7.2	IX-X	25000	2824	0.113
15	Bolu-Gerede	1944. 2. 1	5h22m	7.4	IX-X	20865	3959	0.190
16	Gediz-Uşak	1944. 6.25	6h16m	6.2	VIII	3476	21	0.006
17	Ayvalık-Edremit	1944.10. 6	9h28m	7.0	IX	1158	27	0.023
18	Adana-Ceyhan	1945. 3.20	9h58m	6.0	VIII	650	10	0.015
19	Kadınhan-Ilgın	1946. 2.21	17h43m	5.6	VIII	509	2	0.004
20	Varto-Hınıs	1946. 5.31	5h12m	6.0	VIII	1986	839	0.422
21	Karaburun-Izmir	1949. 7.23	17h03m	7.0	IX	865	2	0.002
22	Karlıova	1949. 8.17	20h44m	6.7	IX	3000	450	0.150
23	Kurşunlu	1951. 8.13	20h33m	6.6	IX	3354	52	0.016
24	Hasankale	1952. 1. 3	8h03m	5.8	VIII	701	133	0.190
25	Yenice-Gönen	1953. 3.18	21h06m	7.4	IX	1750	265	0.151
26	Kurşunlu	1953. 9. 7	5h58m	6.4	VIII	230	2	0.009
27	Söke-Aydın	1955. 7.16	9h07m	7.0	IX	470	23	0.049
28	Eskişehir	1956. 2.20	22h31m	6.4	VIII	1440	1	0.001
29	Fethiye	1957. 4.25	4h25m	7.1	IX	3100	67	0.022
30	Bolu-Abant	1957. 5.26	8h33m	7.1	IX	4200	52	0.006
31	Köyceğiz	1959. 4.25	2h26m	6.0	VIII	775	0	0.000
32	Çınarcık	1963. 9.18	18h58m	5.9	VIII	230	1	0.004
33	Malatya	1964. 6.14	14h15m	6.0	VIII	678	8	0.012
34	Manyas	1964.10. 6	16h31m	7.0	IX	5398	23	0.004
35	Denizli-Honaz	1965. 6.13	22h01m	5.7	VIII	488	14	0.030
36	Varto	1966. 3. 7	3h16m	5.6	VIII	1100	14	0.013
37	Varto	1966. 8.19	14h22m	6.9	IX	20007	2394	0.120
38	Adapazarı	1967. 7.22	18h56m	7.2	IX	5569	89	0.016
39	Pulümür	1967. 7.26	20h53m	6.2	VIII	1282	97	0.076
40	Amasra-Bartın	1968. 9. 3	10h19m	6.5	VIII	2072	29	0.014
41	Alaşehir	1969. 3.28	3h48m	6.6	VIII	3702	41	0.011
42	Gediz	1970. 3.28	23h02m	7.2	IX	9452	1086	0.115
43	Burdur	1971. 5.12	8h25m	6.2	VIII	1542	57	0.037
44	Bingöl	1971. 5.22	18h45m	6.7	VIII	5617	878	0.156
45	Lice	1975. 9. 6	12h20m	6.7	VIII	8149	2385	0.293
46	Çaldıran-Muradiye	1976.11.24	14h22m	7.2	IX	9232	3840	0.416
47	Erzurum-Kars	1983.10.30	7h13m	6.8	VIII	3241	1342	0.356
					TOTAL	315935	57914	

- Development of a mathematical model of earthquake occurrence (Poisson, Markov, Bayesian etc.)
- Preparation of a seismic hazard map on which hazard is expressed in terms of ground accelerations or velocities with various probabilities other than periods of time.

A probabilistic seismic hazard map was prepared for Turkey by the Middle East Technical University with the cooperation of the Earthquake Research Division of the Ministry of Public Works and Resettlement. Figs. 4, 5, 6 and 7 show some steps of these maps (Erdik et al., 1983).

Seismic hazard in Turkey as a whole can be illustrated by Fig. 8 which plots the annual number of occurrences of earthquakes of a given magnitude or higher within the entire territory of Turkey. The data base covers all the earthquakes of the last 60 years. Assuming a Poissonian behaviour of the data one can argue that there exists a 63% probability of having one earthquake of a 6.3 magnitude and above or ten earthquakes of magnitude 4.8 and above every year in Turkey. Similar probability levels are also valid for one earthquake of 7.3 magnitude or above occurring every 10 years. However, it should be noted that not all earthquakes take place in regions where potential damage is likely. For this reason the curve in Fig. 9 indicating the annual number of occurrences of an event of a given intensity level or above in all of Turkey is a better descriptor of seismic hazard. A comparison of Figs. 8 and 9 indicates that only about 50% of earthquakes in Turkey take place in areas where damage can be caused.

Seismic risk in the form of annual number of occurrences of the total number of heavily damaged or collapsed rural houses or of the percentage of the annual national budget spent for rural reconstruction is provided in Fig. 10. Again assuming Poissonian behaviour of the data, there exists a 63% probability of spending 0.07% of the national budget per year or 1.4% of the national budget for every 10 years for rural post-earthquake reconstruction purposes. Fig. 11 shows seismic risk in terms of the total annual number of lives lost in all of Turkey. Similarly one can expect a 63% probability of losing to earthquakes about 10 lives every year or about 800 lives every 5 years or about 8000 lives every 5 years in rural areas with adobe and stone masonry building stock. As can be seen the losses in areas with wooden frame buildings are much lower.

3. Seismic resistance and vulnerability of the existing buildings in Turkey

Estimation of damage probability of buildings from an earthquake must take account not only of the size and location of the future event, but also of the population density and the types of buildings. Experience from past destructive earthquakes indicates that the major cause of life loss and injury was the collapse of existing weak structures which were not adequately constructed to resist earthquakes. Therefore one of the important problems of earthquake engineering is to observe and predict the seismic resistance and vulnerability of existing buildings. There isn't one method of vulnerability and risk assessment that can be applied in all cases; thus case studies are needed to develop appropriate methodologies for different sets of circumstances. UNDRO (1979) proposed a uniform terminology and definition of terms, such as "vulnerability meaning the degree of loss to a given element at risk or set of such elements resulting from the occurrence of a natural phenomenon of a given magnitude and expressed on a scale from 0 (no damage) to 1 (total loss)". But in practice, there is a large variety of different circumstances to be considered.

Sandi (1982) stated that vulnerability is the observed or expected degree of damage inflicted or to be inflicted by an earthquake of parameter X to a facility. If vulnerability is related to post-earthquake observation of the actual earthquake effects, then it may be called observed vulnerability. If it is related to prediction of future earthquake effects, then it may be called predicted vulnerability. In order to evaluate predicted vulnerability, it is essential to collect all available data related to observed vulnerability of existing buildings especially old rural buildings.

Structures in rural areas built with local materials and tradition without any external engineering input are classified as rural structures. Approximately 50 percent of the total dwelling inventory in Turkey can be classified as rural structures amounting to about 4,600,000 units in 1984. About 76 percent of all rural buildings are load bearing masonry (stone, adobe, brick, concrete block etc.). The classification of rural buildings in Turkey with respect to structural systems is given in Fig. 12. The regional distribution of various types of rural buildings is given in Fig. 13. As can be seen from Fig. 13, in the economically less developed, eastern and southeastern parts of Turkey stone and adobe masonry are the dominant rural building type due to the abundance of the local building material and also to lack of economic means for substitute material and construction technology with better earthquake resistance characteristics.

Damage statistics of rural structures pertaining to earthquakes since 1966 are indicated in Table IV. The data were obtained from the official damage assessment reports of the Earthquake Research Institute. Only intensity areas of VII MSK or larger have been considered.

These Tables indicate that for site intensities of VIII MSK or greater about 45 percent of the adobe structures collapse or experience heavy damage, 37 percent experience medium damage, and 18 percent experience light or no damage. The respective figures for stone masonry structures are 70, 22 and 8 percent. Although the number of adobe and other structures involved in the earthquakes is quite limited and some of the adobe structures have timber roofs, one can say in general that the earthquake performance of the adobe structures is better than that of the stone masonry structures. It should be noted that a considerable percentage of stone masonry rural structures includes rubble stones with mud mortar.

The casualty statistics also endorse this finding. Unpublished studies of the Earthquake Research Institute indicate that, on the average, 5 lives are lost per 100 collapsed and/or heavily damaged wooden frame structures and 11 lives are lost for adobe structures with flat earth roofs. The respective figure for stone masonry with mud mortar and flat earth roof is 26.

Seismic vulnerability of the rural housing stock can be illustrated by Fig. 14. This Figure gives the percentages of heavily damaged dwellings with adobe and stone masonry, and that of wooden frame Turkish rural building stock for given levels of MSK intensities.

TABLE IV

Earthquake damage statistics of rural structures
August 19, 1966 Varto Earthquake (MS = 6.9, I_o = IX MSK)

T.S.	T.P	C.P.	M.D.P.	L.D.P.
Stone Masonry	85%	75%	20%	5%
Adobe Masonry	10%	50%	40%	10%
Other	5%	70%	25%	5%

July 22, 1967 Adapazarı Earthquake (MS= 7.2, I_o =IX MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Wooden Frame	85%	55%	30%	15%
Adobe Masonry	5%	65%	20%	15%
Other	10%	20%	25%	55%

March 28, 1970 Gediz Earthquake (MS= 7.3, I_o = IX MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Wooden Frame (Hımış)	40%	80%	18%	2%
Wooden Frame (Bağdadı)	50%	10%	40%	50%
Adobe Masonry	5%	30%	50%	20%
Other	5%	40%	35%	25%

May 12, 1971 Burdur Earthquake (MS= 6.2, I_o= VIII MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Stone Masonry	40%	55%	30%	15%
Adobe Masonry	50%	35%	35%	30%
Other	5%	40%	40%	20%

May 22, 1971 Burdur Earthquake (MS= 6.9, I_o= VIII MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Stone Masonry	80%	75%	20%	5%
Adobe Masonry	15%	40%	50%	10%
Other	5%	40%	45%	15%

September 6, 1975 Lice Earthquake (MS=6.9, I_o= VIII MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Stone Masonry	85%	65%	30%	5%
Adobe Masonry	10%	50%	40%	10%
Other	5%	-	60%	40%

November 24, 1976 Çaldıran Earthquake (MS= 7.2, I_o= IX MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Stone Masonry	75%	75%	15%	10%
Adobe Masonry	20%	60%	30%	10%
Other	5%	25%	25%	50%

October 30, 1983 Erzurum Earthquake (MS= 7.1, I_o= VIII MSK)

T.S.	T.P.	C.P.	M.D.P.	L.D.P.
Stone Masonry	95%	50%	30%	20%
Adobe Masonry	2%	30%	40%	30%
Other	3%	20%	30%	50%

Legend : T.S: Type of Structure
T.P: Percentage of the Type in $I \geqslant$ VII MSK area
C.P: Percentage of Heavily Damaged Collapsed Structures
M.D.P: Percentage of Medium Damaged Structures
L.D.P: Percentage of lightly DamagedStructures.

C. Earthquake mitigation programme in Turkey

1. History and development of the earthquake mitigation programme in Turkey

There is indisputable archeological evidence for the damage caused by earthquakes during the time of the ancient Anatolian civilizations. It is known that the city-state Hierapolis was erased from the map after a devastating earthquake. There is also ample evidence that, from very early times, human settlements were repaired or rebuilt after earthquakes by the people living in them, sometimes assisted by neighbouring communities or the administration. A well documented historical example is the reconstruction after the September 14, 1509 Great Istanbul earthquake. After the earthquake the Ottoman rulers declared a state of emergency and instituted mandatory labour for reconstruction for one male person from each household, brought in 40,000 masons and carpenters from other parts of the empire and provided financial assistance to each affected household thereby providing for the total reconstruction of Istanbul in about 6 months. The administration also prohibited stone masonry house construction allowing only timber framed type construction, a decision influenced by the greater number of casualties found in masonry houses. Although this decree is probably one of the first decisions in history concerning earthquake disaster mitigation through intervention relating to construction types, it was changed in later years due to the increased fire disaster vulnerability. Thus, in Turkey, disaster mitigation programmes have a comparatively long history.

After the first World War, from the foundation of the modern Turkish Republic till the early 1940's post-earthquake disaster assistance has been provided by the Turkish Red Crescent Society usually in the form of first aid, shelter, clothing and food assistance in the short run and in the form of financial assistance for reconstruction and rehabilitation in the long run.

The toll of 43,319 people killed and 75,000 injured and of the 200,000 collapsed houses caused by the disastrous earthquake sequence of 1939-1944 (starting with the December 26, 1939 Great Erzincan earthquake (MS=8.0) and continuing with short intervals with the Niksar-Erbaa (MS=7.2), Adapazari-Handek (Ms=6.8), Tosya-Ladik (MS=7.5) and Bolu-Gerede (MS=7.5) earthquakes) has convinced the authorities that earthquake disasters cannot be prevented just by post-earthquake reconstruction efforts and prompted the enaction of the "Law Concerning the Pre- and Post-Earthquake Measures" in 1944. In general terms, this law required: the assessment of hazardous zones in Turkey; the determination of the appropriate building types, construction techniques and specifications in each of these hazard zones; the preparation of the emergency aid and rescue programmes in each province; the planning for temporary housing by the provincial administration and the Red Crescent Society and the undertaking by the municipalities of geological surveys for new settlement areas. This law also established the rules and procedures during and after earthquake disasters stipulating the mandate and responsibilities of each administrative office. The post-earthquake reconstruction and the permanent settlement issues were not included in this law and were left to be decided on a case by case basis depending on the prevailing socio-economic conditions. This law, very modern in its spirit, also empowered the Ministry of Public Works to inspect the structural capacity of public buildings, hospitals, city halls, schools and religious centres located in the first degree hazard zones and to take the necessary measures for their condemnation or repair and stengthening.

As required by this law, the first earthquake hazard zoning map and the mandatory earthquake resistant design and construction specifications were issued in 1945. The earthquake hazard zoning map distinguished the zones of certain earthquake hazard and probable earthquake hazard on the basis of the observed historic activity. The earthquake resistant structure design regulations followed those of the 1940 Italian code with minor modifications. The authority for the enforcement of these regulations was given to the provincial governments for villages and to the mayors of municipalities. The municipalities were also required to conduct geological investigations prior to land use decision making. Furthermore, after this law was enacted in 1944, new financial resources were allocated to the Red Crescent Society to strengthen its provincial level organization and new regulations were passed for emergency management, first aid assistance and temporary housing.

This 1944 disaster mitigation law was strictly enforced initially. However, towards the mid-1950's its enforcement weakened somewhat since it could not cope with the fast rate of urbanization and industrialization, and since it originally excluded other natural disasters from its field of application. Due to budgetary restrictions, most of the plans for public education, repair and strengthening and organization of emergency assistance were shelved and the whole earthquake disaster prevention programme was almost reduced to post-earthquake reconstruction and resettlement activities. The close sequence of earthquake and flood disasters experienced between 1955 and 1959 again kindled the flames for disaster preparedness; in 1956 the Law for Public Works (Urbanization) and the Law for Natural Disasters were enacted.

The 1956 Public Works Law is an attempt to regulate urbanization and urban construction. The currently applicable 1959 Law for Natural Disasters (Law 7269) has expanded the field of application of the previous 1944 Law by covering also the natural disasters created by floods, landslides, rock falls, storms and avalanches, in addition to earthquakes and also the manmade disaster of fire. The new law also stipulated the type and extent of government assistance for resettlement of disaster victims and held the government directly responsible to provide the victims with new settlement areas and houses. To finance these important activities a new disaster fund was established. The resources allocated to this fund comprise allocations from the general budget, 3% of the annual profits of government enterprises and banks, and mortgage payments of the tenants of the post-earthquake houses. In 1971 the resources going to the disaster Fund were further strengthened by the addition of a special excise tax on government monopoly commodities, i.e. strong liquor, tobacco and tea. Thus with this law and the disaster fund there is continuous funding of natural disaster preparedness, mitigation and post disaster resettlement activities. The annual income of this fund is about US$ 20 million. Another aspect of this Natural Disaster Law is the establishment of a government institute to carry out research, public education and coordination of all national activities concerning natural disaster mitigation. It was thus that the Earthquake Research Institute in Turkey was established.

The most important stipulations and the subsection titles of this law are given in Appendix B.

2. Current mitigation programme

The ongoing earthquake and other disaster mitigation programmes in Turkey can be summarized under the subheadings of: pre-earthquake preparedness and planning; emergency management and post-earthquake temporary and permanent settlement and rehabilitation.

a. Pre-earthquake preparedness and planning

Determination of the measures to be taken, enforcement and application of laws and regulations, and the related education, planning and training activities towards mitigation of the effects of natural disasters are among the primary responsibilities vested in the Ministry of Public Works and Settlements.

The Ministry conducts these activities with the funding coming directly from the special Natural Disaster Fund (i.e. separate from the general budget) under the Division of Earthquake Research and the General Directorate of Disaster Operations.

The main responsibilities and functions of the Division of Earthquake Research can be summarized as follows: establishment and maintenance of the national strong and weak ground motion recording arrays, preparation and development of seismic hazard zoning and earthquake resistant design regulations, determination of the essentials for post-earthquake damage assessment, repair and strengthening, undertaking public awareness and public education programmes and carrying out earthquake prediction investigations. The General Directorate of Disaster Operations has the responsibility for the determination of appropriate measures for the mitigation of other disasters as well, such as floods, landslides, rock falls and avalanches. The General Directorate also plans for the temporary and permanent resettlement of victims and oversees their implementation.

Under this scheme, the provisional governments and the municipalities play an important role in the enforcement, application and control phases of the appropriate laws and regulations.

The Earthquake Research Division conducts public education programmes jointly with the Universities. These programmes which started effectively in 1974, are now included in the five-year development plans of Turkey and target the following groups of people:

- rural masons, carpenters and foremen;
- civil engineers acting as supervisors of structural design and construction;
- structural designers;
- civil engineers and architects who may act as post-earthquake damage assessors;
- provincial government officials and civil defence officers in charge of earthquake disaster management;
- city planners;
- politicians;
- high school and primary school teachers;

These educational programmes use the following means to convey their message:

- radio and television programmes;
- wall posters and handbooks;
- seminars, conferences and round-table meetings;
- technical bulletins and periodicals;
- on-the-job training for rural masons and carpenters.

In addition to these public education programmes the related education efforts of the Universities and professional societies are supported by the Government. Also supported are the various research and development activities in earthquake engineering carried out by the national Universities.

It is believed that in developing countries especially, public education programmes constitute the most important long term measure for the mitigation of earthquake disasters. Without such programmes no law, rule or regulation will be functional or serve its purpose.

The main reason for the fact that in Turkey earthquake mitigation has not been as effective as it should, even though there is a thorough understanding of the problem, is not financial shortcomings but rather the indifference of the inadequately informed people at different levels of decision making.

In Turkey, because of the very large experience concerning earthquake disasters and the existence of laws and regulations passed in the last 40 years, there are detailed manuals and documents ranging from zoning maps to design codes, from physical planning operations to emergency management and from bureacratic procedures for temporary housing to the responsibilities of the damage assesor. Yet, due to the following reasons, one cannot claim that the availability of these documents has substantially contributed to the mitigation of earthquake disasters or to the improvement of post-earthquake settlements.

- In Turkey there has not been a stable state policy on earthquake disaster mitigation, unaffected by political decisions and in consistence with the development, industrialization and urbanization policies.

- The fast rate of industrialization and agricultural mechanization have accelerated the rate of rural migration to the urban areas creating uncontrolled shanty towns with very low seismic vulnerability.

- The earthquake resistant design rules and regulations cannot be brought to the level of the rural population due to accessibility difficulties.

- An effective mechanism to control adherence to the earthquake resistant design rules cannot be established. Although some control exists for structural design, it is almost non-existent at the construction level.

- Economic conditions have prohibited the allocation of funds toward condemnation or repair and strengthening of existing weak structures.

- City planners are still mostly ignorant of the essentials of land use planning for disaster mitigation.

- As is the case in almost all developing countries, decision makers are sometimes forced by the circumstances to accept the short-term save-the-day type responses over the invest-for-the future type long-term ones.

- There still do not exist adequate numbers of qualified professionals trained in earthquake engineering.

b. Emergency management, rescue and first aid assistance

The organizational chart of the Emergency Condition Committees is given in Fig. 15. As can be seen from it where there is an emergency a Natural Disaster Central Coordination Committee is formed to provide the inter-ministerial coordination and contacts with foreign assistance sources. The actual field operations are conducted under the direction of the Provincial Emergency Assistance and Rescue Committees.

By law each province in the country has to prepare its own disaster management plans and submit them to the Ministry of Public Works and Settlement. But these are not based on well developed scenarios. In the event of actual disaster these plans cannot be easily and automatically put into effect due to bureaucratic problems and the unfamiliarity of the administration with disaster conditions.

The main deficiencies observed at this phase can be summarized as follows:

- An emergency state requires the actions of well trained, disciplined and organized teams. It is almost impossible to carry out effective emergency assistance and rescue operations with untrained personnel.

- More specifically, rescue and first aid operations require well trained specialists equipped with special instruments. One cannot say that each and every physician and fire fighter is so equipped.

- Volunteer assistance groups and civil defence personnel are ineffective, unless they are accompanied and directed by specialists.

- Emergency management requires experienced and trained administrators. One cannot expect each and every local administrator to fulfill this job adequately.

c. Temporary and permanent settlement activities

Post-disaster short and long-term settlement planning is under the responsibility of the Red Crescent Society, the General Directorate of Disaster Operations and the Provincial Governments. In general, it can be claimed that both short and long-term settlement programmes have been quite successful or at least have fulfilled their expected goals. The most successful examples in this regard belong to the 1966 Varto, 1970 Gediz and 1983 Erzurum earthquakes.

After the 1966 Varto earthquake, within a period of four months, 65% of the 210,000 people was temporarily settled in the locally built prefabricated houses and the remaining 35% was temporarily settled in nearby towns. Similarly, after the 1983 Erzurum earthquake, within one month, a total of 25,000 people were temporarily housed in prefabricated houses and government buildings.

However there also exist unsatisfactory post-disaster settlement cases, such as those associated with the 1971 Bingöl and 1975 Lice earthquakes. The main causes of failure can be summarized as follows:

- Permanent settlement planning requires substantial investigations and expertise. The objective should not be the provision of immediate shelter, but rather, the socio-economic rehabilitation of the disaster victims. This fact escaped several planners.

- Settlements should not be moved to new locations unless absolutely necessary for technical and environmental reasons.

- The architecture of the permanent settlements should be in conformity with the environment, traditions and socio-economic lifestyles of the recipient community.

- The construction materials, elements and techniques should allow for subsequent adoption by the community for its future construction activities.

D. Results

The existing laws and regulations in Turkey concerning mitigation of earthquake disasters are well formulated and quite satisfactory at least on paper. However as was pointed out several times in this report, their application has been inadequate. The Turkish experience in earthquake mitigation dictates the following considerations for the disaster mitigation efforts in developing countries:

- Developing countries should have a general disaster mitigation strategy in accordance with their development and urbanization plans. This strategy should be kept free of short term political considerations; funding sources, organizations responsible and implementing agencies should be clearly indicated.

- Disaster mitigation efforts should be considered as having a national development dimension and should be included in all physical and land use planning decisions.

- Public awareness and education activities should constitute an essential part of the overall disaster mitigation schemes; they should target each and every section of the population.

- Construction control cannot be solely achieved on the basis of laws. The viability and effectiveness of compulsory earthquake insurance remains to be tested in developing countries to achieve the goal of self-control in construction.

- Emergency assistance and rescue operations should be left to the specially trained permanent organizations. Volunteer organizations and temporary civil defence efforts cannot adequately function by themselves under emergency conditions.

- Temporary and permanent settlement activities should be based on previous long-term plans. Imported building technologies seldom present a viable solution. Solutions should be sought in locally available means and technologies.

- The objective of permanent housing programmes should not be the swift provision of a shelter, but rather the socio-economic rehabilitation of the recipient.

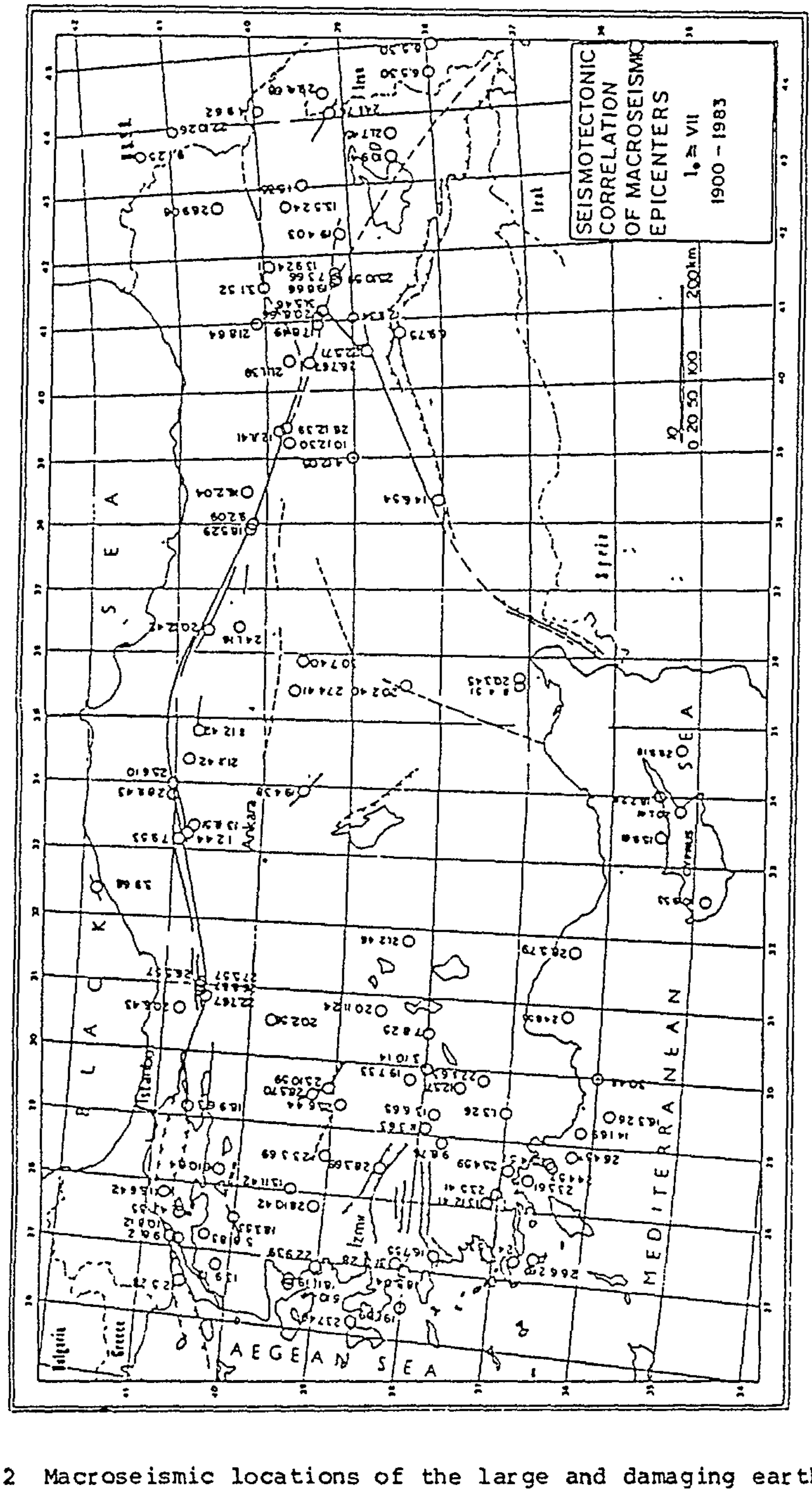

Fig. 2 Macroseismic locations of the large and damaging earthquakes in Turkey (listing is provided in Appendix A)

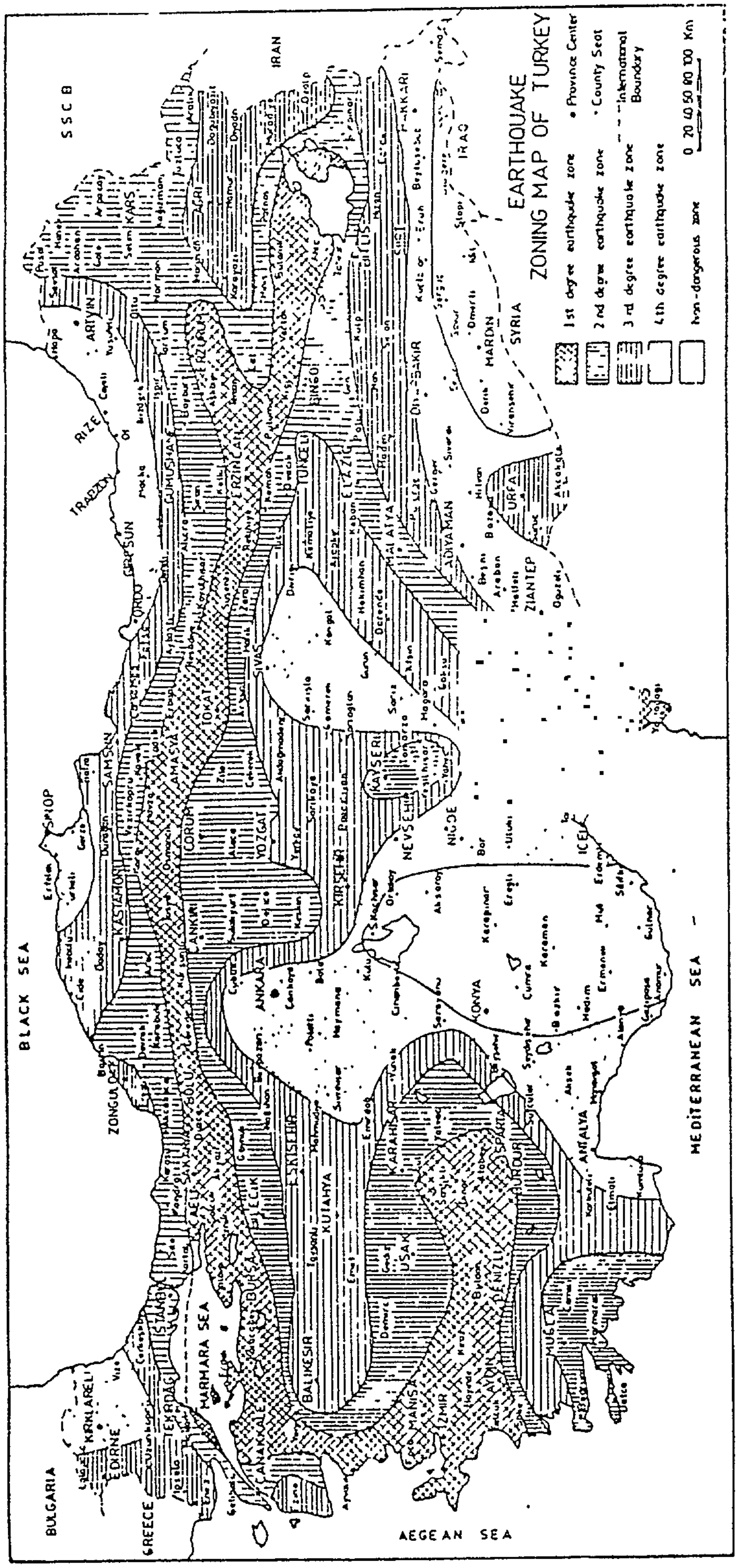

Fig. 3 Official earthquake zoning map of Turkey

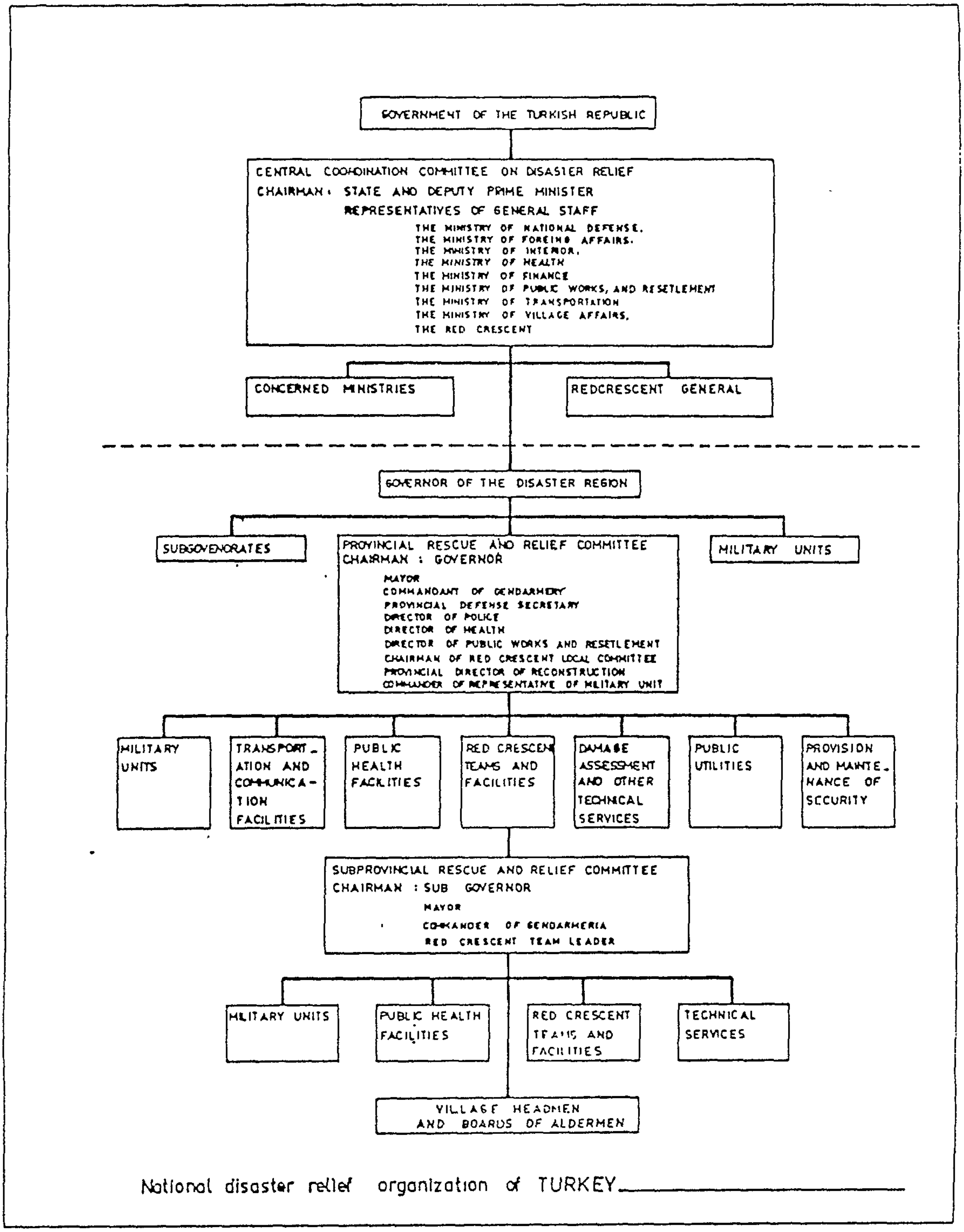

Fig. 15 National disaster relief organization of Turkey

4.3. SEISMIC HAZARD AND SEISMIC RISK CONTROL WITHIN THE PHYSICAL DEVELOPMENT AND URBAN PLANNING IN YUGOSLAVIA

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A. Introduction

This report has been designed in accordance with previously given guidelines based on the main objectives of the Project. Very briefly it will be recalled that the basic principle of this project is to collect and process knowledge, and to exchange experience among the Mediterranean countries for the elaboration of integral, regional physical plans and master urban plans for the earthquake prone areas and with particular consideration to applied methodologies and specific elements which have to be built into the integral plans in order to mitigate the adverse consequences of possible seismic disasters.

The above is due particularly to the fact that most of the Mediterranean countries are located in an area exposed to a high seismic hazard and in which a whole series of catastrophic earthquakes has been recorded to date, in the recent and far past, taking a heavy toll of human lives and causing enormous material and other social losses. In addition, there also exists an implicit interest of those countries from the region which have been spared the catastrophe so far to learn from the experience of those countries which have been primarily and to a greater degree exposed to it.

It is however evident that the consequences of catastrophic earthquakes can in the future be reduced to the lowest i.e. controlled level only if adequate measures and regulations are formulated in a coordinated fashion and built into all development plans and relevant documents which regulate spatial organization and building construction in seismic-prone areas; this would imply definition of the acceptable level of seismic risk, i.e. economically justifiable criteria for its determination.

In connection with the above it can be said that the global experience of each country, together with the experiences gained after each earthquake, in particular after recent ones give as a rule new dimensions to the scientific, professional and social treatment of the earthquake phenomenon and to the mitigation of earhtquake impact, as well as to overall earthquake preparedness. This is the context within which the experience of Yugoslavia gained in the last two decades should be viewed, particularly the experience gained after the 1963 Skopje earthquake and the Montenegro 1979 earthquake.

B. General information

The territory of Yugoslavia is located in the northern peripheral earthquake area of the Mediterranean, which ranges among the seismically most active areas on earth. This is a consequence of the tectonic instability of the Adriatic and Pannonian basins, and numerous faults along which the ground is susceptible to motion. All parts of Yugoslavia are in fact potentially exposed to earthquakes, although the danger is not equal everywhere. According to the available records on past seismic activity, most imperilled are the coastal areas. The oldest records on earthquakes in the territory of Yugoslavia date back to the years 306 (Opuzen), 361 (Zadar) and 518 (Duklja).

Since then nearly a hundred disastrous earthquakes have been recorded, striking most heavily and most frequently Duklja, Dubrovnik, Zadar, Ljubljana, Skopje, Kotor, Budva, Herceg-Novi, Split, Trogir, Livno, Banja Luka etc. Most recently a whole series of severe earthquakes have occurred, among which most disastrous were those which struck Skopje in 1963, Banja Luka in 1969 and the Montenegrin Coast in 1979.

On the basis of the exhibited seismic effects and the follow-up activities it is possible to distinguish, as especially characteristic, the following areas:

- Skopje epicentral area, with the Berovo, Valandovo, Debar and Ohrid areas;
- Banja Luka epicentral area;
- Epicentral area of the Montenegrin Coast, as well as Dubrovnik and Skadar Lake areas.

In addition, account has also been taken of the importance and exposure to disaster of other seismic-prone zones and areas in the country (Posocje, South Dalmatia, the area of Zagreb, Slavonia, Kopaonik etc.); the most exposed to this kind of disaster are the largest cities in each Republic, including Belgrade itself.

Data on the strongest earthquakes recorded to date

In connection with the earthquakes which have struck our country there is a relatively large amount of data available.

The most comprehensive compilation, systematization and analysis of information on seismicity of the terrain in Yugoslavia have been carried out within the international project: "Investigation of the seismicity of the Balkan Region", implemented from 1971 to 1976 through cooperation among the Balkan countries and with the technical assistance of the United Nations. Within this project, and taking into account the data available at that time and the perspective needs for seismic zoning as the basis necessary for the elaboration of design and building codes for seismic-prone areas, the following basic studies have been elaborated for the entire Balkan area (including Yugoslavia):

- a catalogue of earthquakes until 1970, with a 6°MCS intensity or above, covering the entire territory of Yugoslavia;
- maps of earthquake epicentres;
- an atlas of the observed (macroseismic) intensities of earthquakes (isoseist maps);
- a set of maps as the basis for seismo-tectonic analysis; a seismotectonic map; a map of focal areas according to the maximum magnitudes expected;
- maps of seismic zones according to the intensity, velocity and acceleration expected.

Although it is obvious that significant results have been achieved through this project as a valuable basis for further, more detailed investigations and monitoring of seismicity in each country, a number of shortcomings has become apparent among which most notable are: insufficient scope of data, inadequate instrumentation, low personnel and institutional preparedness, as well as unsatisfactory communication system.

Due to the character of this report, we present here a short review of the most severe earthquakes recorded to date which occurred mainly in the southern part of the Adriatic basin (Table I), as well as a review of a number of very severe earthquakes which have occurred in other areas of the country in the last 100 years (Table II).

Table I

No.	Date, year	Approximate location	Intensity °MCS
1.	361	Adriatic Sea	(10)
2.	518	Duklja, Skopje	10
2a.	1237	Drac	9
3.	1343	Zadar	9
4.	1444	Ulcinj	(9)
5.	1451	Dubrovnik	9
6.	1471	Dubrovnik	9
7.	15.02.1482	Dubrovnik	9
8.	7.12.1504	Dubrovnik	9
9.	6.05.1516	Dubrovnik	(10)
10.	28.07.1516	Dubrovnik	(9)
11.	17.05.1520	Dubrovnik	9
12.	22.07.1530	Dubrovnik	(9)
13.	24.01.1559	Kotor	9
14.	13.06.1563	Kotor	10
15.	14.05.1608	Kotor	9
16.	25.07.1608	Kotor	9
17.	15.09.1608	Boka Kotorska	10
18.	02.1631	Boka Kotorska	(8)
19.	1632	Herceg-Novi/Kotor	9
20.	28.07.1639	Dubrovnik	9
21.	16.04.1667	Dubrovnik	10
22.	21.09.1780	Boka Kotorska	(9)
23.	03.07.1855	Skadar	9
24.	16.07.1855	Skadar	8
25.	1.06.1905	Skadar	9
26.	3.06.1905	Skadar	8
27.	12.10.1926	Ivangrad	8
28.	27.08.1948	Skadar	8
29.	3.09.1968	Ulcinj	7/8
30.	15.04.1979	Montenegrin Coast	9/10
31.	15.04.1979	Budva	8
32.	24.05.1979	Budva	8

Table II

No.	Date, year	Approximate location	Intensity °MCS
1.	9.11.1880	Zagreb	9
2.	14.04.1895	Ljubljana	9
3.	4.04.1904	Berovo (Yug./Bulg.border)	9
4.	6.04.1904	Berovo	10
5.	2.01.1905	Zagrebacka gora	8
6.	11.02.1911	Ohrid Lake	8
7.	18.02.1911	Ohrid Lake	10
8.	20.02.1911	Ohrid Lake	8
9.	6.02.1923	Tihaljina (Kljuc)	8
10.	15.02.1923	Tihaljina (Kljuc)	9
11.	7.03.1931	Valandovo	9
12.	8.03.1931	Valandovo	10
13.	21.08.1950	Banja Luka (Drugovici)	8
14.	7.01.1962	Biokovo (Middle Dalmatia)	8
15.	11.01.1962	Biokovo	9
16.	26.07.1963	Skopje	9
17.	13.04.1964	Slavonski Brod	8
18.	26.10.1969	Banja Luka (Slatina)	8
19.	6.05.1976	Tolmin (Yug./Ital.border)	8
20.	18.05.1980	Kopaonik	8

The data presented clearly indicate that a considerable part of the country is exposed to a relatively very intensive activity. This can practically be expressed with the statement that strong earthquakes with a 7-degree intensity (according to the MCS scale) occur every year on an average, the destructive ones every fifteen, while catastrophic earthquakes with a 9-degree instensity occur every forty years.

It can, inter alia, be pointed out that particularly interesting and significant are the data and analyses on the seismic activity manifested during the 1979-1980 period in the Montenegrin Coast, as well as certain important and specific experiences gained after Montenegro earthquake (1979) with regard to further improvments of the modern and integrated approach to seismic risk reduction in general.

C. EXPOSURE TO SEISMIC RISK AND INVESTIGATIONS RELATED TO ITS MITIGATION

Investigations on the definition of methodology for the reduction of seismic risk through physical and urban planning

By their nature and characteristics, both physical and urban planning, i.e. the respective plans as legislative documents, incorporate in themselves the possibilities for the establishment and effective implementation of a rational policy for the mitigation and reduction of seismic risk in the areas exposed to earthquakes.

The studies for the definition of a physical planning methodology in seismic conditions include the interpretation of concepts and methods for the definition and analysis of seismic hazard, seismic vulnerability and seismic risk; definition of relevant principles and elements of the policy within the scope of physical planning; studying of all natural conditions and man-made factors, from the aspect of their adequacy for physical planning, development and land use in seismically active terrains, and their impact on long-term development policy.

In this connection we present here only some crucial issues, statements and definitions, whereas somewhat more detailed considerations are presented separately, in Chapter 5 which gives a concise interpretation of the approach used in the treatment of seismic hazard and seismic risk control in the Physical Development Plan of SR Montenegro.

It is worth pointing out that physical planning, land use and development are a legal obligation of each socio-political (territorial) community in Yugoslavia.

In view of such an obligation and bearing in mind the experiences and the consequences of the Montenegro earthquake in 1979, as well as the interests of the wider social community, the international Project "Physical Development Plan of the Republic and Master Plans, SR Montenegro", (UNDP/UNCHS Project YUG/79/104) was undertaken. The Project Document envisaged, as one of the Project's main objectives, an authentic design and elaboration of a physical planning methodology for seismic-prone areas, among which the territory of the Republic represents a most distinct example for the Mediterranean conditions. As the Contractor for the elaboration of the Physical Plan of SR Montenegro, with UN technical assistance (UNDP/UNCHS/UNDRO), the Republic Institute for Town-Planning and Design, Titograd, was engaged in the definition of the working methodology and the contents of physical and master urban plans for earthquake-prone areas. This work is carried out in close cooperation with the Institute for Earthquake Engineering and Engineering Seismology (IZIIS), Skopje, as an institute cooperating in the analysis and definition of vulnerability and acceptable seismic risk for the needs of the Project, as well as within the scope of cooperation on the previously mentioned Yugoslav scientific research macro-project.

Methodological basis for vulnerability analysis and definition of acceptable level of seismic risks for the Physical Development Plan of SR Montenegro

The preliminary investigations and other geological, geophysical, seismological and geotechnical investigations and the correlations among them lead to the conclusion that the results obtained, together with the data collected from the classification of damage, degree and usability of buildings and the data from the registered ground movements during the 1979 earthquake, offer a unique possibility for defining a consistent empirical vulnerability model, with outstanding conditions on the basis of which characteristic theoretical models of expected vulnerability and acceptable level of seismic risk are developed, i.e. within the framework of investigations for the direct needs of the Physical Plan of the Republic as well as for other physical and urban planning in Montenegro.

In this connection, in order to provide adequate urban planning and rational designing of structures resistant to earthquakes, it is necessary to clarify the basic requirements and treat the relevant parameters, especially those from the fields of geology, seismology, construction, economy and social development policy.

The problem can simply be formulated in two basic requirements, which must be respected in urban planning and designing of structures in seismic conditions: the first requirement is that in each earthquake the loss of lives, injuries and material and other damage be reduced to the smallest possible extent; second, that the cost of reparation and rehabilitation not exceed the cost of designing, construction and financial investments through which it would have been possible to prevent damage, destruction, injury and loss of life caused by them. It may be said that in essence the very concept of acceptable seismic risk (1) lies in these two requirements.

Relationship with other studies and projects in the wider region

As is known, the Balkan region is situated in one of the most active seismic zones in the world. This fact has stimulated in the past and especially after the Montenegro 1979 earthquake, a number of research activities and studies in the field of seismology and earthquake engineering, on a separate as well as on a cooperative basis among the countries in the Region.

In this sense, of particular importance and contribution certainly were the regional projects which were or are under implementation with the assistance of the United Nations Development Programme (UNDP).

It is worth mentioning in particular the 1970 project: "Investigations on the Seismicity of the Balkan Region" (UNDP Project RER/70/172 and REM/74/009) which after six years of very intensive cooperation activities resulted in the acquisition of very valuable knowledge about the degree of seismic hazard in all the areas of the region.

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(1) The classification and meaning of some terms in this field have been used according to the concepts and definitions adopted by UNDRO (Geneva, July 1979) and UNEP (Nairobi, January 1980) and adopted also through the UNDP/UNESCO Project RER/79/104 - Project on Reduction of Seismic Risk in the Balkan Region (Herceg-Novi, April 1981, and Skopje, January 1983).

After the disastrous earthquake in Montenegro in 1979, two new regional projects supported by UNDP were established: "Reduction of Earthquake Risk in the Balkan Region" (UNDP/UNESCO Project RER/79/014) with the participation of six Balkan countries (Yugoslavia, Romania, Bulgaria, Greece, Turkey and Albania), and "Building Construction under Seismic Conditions in the Balkan Region" (UNDP/UNIDO Project RER/79/015), with the participation of five Balkan countries (Yugoslavia, Romania, Bulgaria, Greece and Turkey), and Hungary. The implementation of these projects was concluded by mid-1984.

However, with regard to the obvious need and the agreement already reached among all participants in these Projects, the common activities and the cooperation in certain fields will continue even after the termination of these projects by unifying the two Projects and establishing a Permanent Coordination Committee for the Reduction of Earthquake Risk in the Balkan Region. In this way further planning on a programme basis, coordination and implementation of cooperative activities of all the countries in the Region needing earthquake risk reduction will be provided. The basis of this programme of future activities in the Region is made up of the recommendations commonly adopted at the level of the Coordinating Committee of the two Projects, during the sessions in Skopje, January 1983 and Ankara, April 1984; it was then decided that each country will undertake the necessary activities in the development of its own projects using as far as possible the results of the common activities in the region.

In connection with further cooperation based on the above mentioned Projects, it was specifically concluded that the coordination of activities connected with physical and urban planning in seismic conditions will be assumed by SR Montenegro.

D. SOME EXPERIENCES IN CONNECTION WITH RECENT EARTHQUAKES IN YUGOSLAVIA

This review presents briefly some basic data on the characteristics and consequences of the major disastrous earthquakes which occurred in Yugoslavia during the last two decades, i.e.

- earthquake in Skopje — 26 July 1963
- earthquake in the Montenegrin Coast — 15 April 1979

Earthquake in Skopje

The main shock of the Skopje earthquake with an intensity of I=9 (MCS), had a magnitude M=6,1; depth h=5 kms.; it is assumed that it reached the intensity of a maximum expected earthquake in the Skopje epicentral area. In this connection, and due to the concurrence of other circumstances, the consequences of the earthquake appeared not only as vast material losses, but also as a heavy loss of human lives: more than one thousand were killed, and approximately 75% of the buildings were severely damaged. Skopje, as the capital of SR Macedonia, was in a rapid development process as an important industrial and administrative centre and had at the time of the earthquake nearly 200,000 inhabitants. The total loss was estimated at approximately, 1,500 billion dinars.

The reconstruction of the town and the activities undertaken after the earthquake represent in many respects an unprecedented example in our country. It happened that the further development of Skopje was neither interrupted nor considerably slowed down; on the contrary, through the solidarity of the community, development was now based on the advanced principles of urban planning through the elaboration of a new urban master plan with UN technical assistance and particularly through the designing of buildings in seismic conditions; the latter was also strongly supported through international cooperation. Considering the conditions in Yugoslavia at the time, it can be stated that this meant a radical change in the area, resulting in the strong incentive to improve regulations, practice and scientific research in the areas of seismology and earthquake engineering. The experiences and results of this earthquake were multiple and varied: for the first time in our country there was organized monitoring of aftershocks, by means of a network of local seismological stations, establishment of a wider network of instruments for the monitoring of more intensive earthquakes, behaviour studies of various types of structures (in conjunction with local ground conditions), and the involvement of research institutions at the highest level. On all of these aspects and experiences there is a large amount of materials, data and literature available.

Earthquake in the Montenegro Coast, 1979

The disastrous earthquake of 15 April 1979 was one of the strongest earthquakes that occurred not only in Montenegro but in Europe. As is known, the magnitude of the main strike was I=9/10 (MCS) in intensity and M=7.2 in magniture and was followed by a great number of series of strong after-shocks, of which the strongest of M=6.1 magnitude occurred on 24 May 1979.

The earthquake and the numerous after-shocks caused enormous damage to the Montenegro littoral and to a large number of communities in the territory of SR Montenegro.

The earthquake was registered in an area covering 50,000 km^2 in the territory of Yugoslavia; at the same time it struck the areas of Skadar and Lesha in the SPR Albania. This earthquake and the stronger after-shocks were registered by instruments for registration of strong earthquakes (three-component accelerographs and seismoscopes), installed in the epicentral zone of the Montenegro littoral and beyond. Thus, a great number of readings was obtained (over 350 high quality records) which represents the greatest number of records ever registered in a seismogenic zone in the world.

Of special interest and importance are the registrations made in the epicentral zone and for different magnitudes of earthquakes, in different soil surface conditions as well as of the bedrock. The records obtained are very valuable for the study of the mechanisms of earthquake centres, the distribution of seismic waves, the influence of terrain topography, and local soil conditions vis-à-vis modifications due to ground motions during strong earthquakes, for the determination of the dynamic reaction of the construction of buildings, and other aspects of research on earthquake effects.

The maximum values of acceleration registered during this earthquake were: for the vertical component 49.3%g (Ulcinj); for the horizontal component N-S 45.9%g (Petrovac) and the horizontal component E-W 37.1%g (Bar).

Concerning the level and total volume of damage (both direct and indirect), it can be mentioned that they were such that it was difficult to quantify them even approximately; it is probable that certain effects of the earthquake and the lost dynamics of development will never be overcome and restored, especially within the framework of a complex and depressed economic situation, the duration and consequences of which can hardly be predicted.

It was estimated that the total damage caused by the Montenegro earthquake amounted to 8-10 percent of the total national income of Yugoslavia for the year 1979, i.e. not less than about 4 billion US dollars.

The very high volume of damage was primarily due to the vibrational effects of the earthquake; however, it was also due to the instability of the surface layers of the soil (with characteristic manifestations of liquefaction, landsliding, intensive soil depressions, rock-sliding etc.) which had a strong negative impact on the stability of structures with shallow foundations.

The instability of the surface layers of the soil, even at accelerations of lower value, had a significant often even decisive impact in the areas of the coastal communities of Bar, Budva, Tivat, Kotor and Herceg-Novi.

It is of interest to mention that after the earthquake a great number of systematic investigations was carried out on these and other effects; they have already been used or will continue to be used for various scientific, professional and other socially useful purposes.

In this sense, the data from the Montenegro earthquake constitute a very precious documentation basis, not only for assessing priority post-earthquake tasks in determining the usability of structures and later for damage assessment but also for current research on vulnerability and seismic risk. A classification of damages on high-rise buildings, carried out immediately after the earthquake, and covering over 64,000 buildings in the twelve coastal and central communities has been used for the needs of physical and urban planning.

On the basis of the classification results according to the degree of damage and usability, it was concluded that 58% of structures can be used in the future, 20% can be restored and strengthened, while for 22% it was estimated that their reparation and strengthening were technically and economically neither justified nor acceptable.

Major principles and elements of physical and urban planning policies for seismic risk mitigation

Measures for the mitigation of seismic risk by are in essence complementary to the regulations aiming at the protection of the physical environment. In any case, only a system of physical planning which comprehensively combines both development and risk mitigation will be acceptable.

It is clear that the measures for risk mitigation vary to a certain degree depending on the nature and level of natural disasters, then on the level of physical and urban planning; and, of course, their implementation depends to a certain extent on the socio-economic and other conditions of the given area and/or country as a whole.

The main planning steps consist in finding a compromise between zones of different risk levels and programmes with different intensity and type of development. Development and risk levels should be at an inverse ratio.

E. PROPOSALS AND RECOMMENDATIONS

In connection with the objectives of the Project and in accordance with the terms of reference of the present report, it is believed appropriate to present, inter alia, the following proposals and recommendations for the next stages of Project implementation:

(a) In regard to the exchange of experience with other countries there is the interest and readiness for such an exchange in each of the areas referred to in this report as well as in land-use planning and design under seismic conditions.

(b) As far as technical assistance to other countries is concerned it can, on a very competent basis, include the entire cycle of activities - research, preparation of seismo-geological base maps, elaboration of studies on seismic risk, preparation of master urban plans and aseismic design of all kinds.

(c) In addition to the above it is believed that the Mediterranean countries should establish adequate forms of technical cooperation in specific segments of this field; this cooperation would include multifold programmes, both short and long-term, with the appropriate coordination of subregional and national efforts aimed at improving the system as well as measures in the field of mitigation of earthquake disaster.

The following can be considered as fields of initial cooperation:

- establishment of an appropriate organization system for mutual cooperation and coordination;

- determination of a minimum programme for exchange of information and expertise (scientific data, methods, application of methods to land-use planning, socio-economic planning) by the countries having more experience;

- identification of related issues of common interest and consolidation of efforts in dealing with them (some methodological aspects, manuals, relevant norms and standards in the area of aseismic planning and design, especially as concerns the appropriate treatment of existing structures, with special reference to cultural-historic monuments and old towns; also earthquake preparedness plans, etc.);

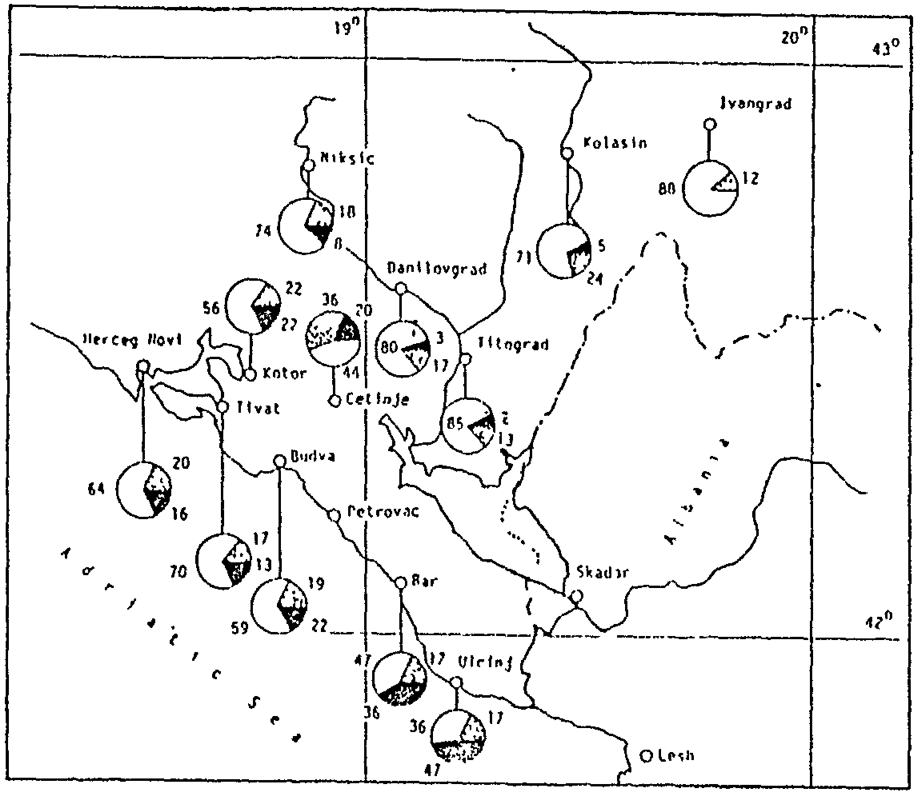
- study of the above mentioned issues from a global point of view.

(d) in all forms of future cooperation, one should understand as irreplaceable the coordination role of UNEP, as well as the involvement of the other United Nations agencies having an interest in the programmes of reduction and mitigation of seismic risk (UNESCO, UNIDO, UNDRO, UNCHS).

Table A.5

Summarized classification of buildings according to property, function and structural type for 12 municipalities of SR Montenegro with summarized presentation of damage caused by the Montenegro earthquake (April 15, 1979)

CLASSIFICATION		MUNICIPALITY																								Total	
		Ulcinj		Bar		Budva		Tivat		Kotor		H Novi		Cetinje		Niksic		Titograd		Danilov Grad		Ivangrad		Kolasin			
		No. ins. struc.	%	No. ins. struc	%	No ins. struc	%	No. ins. struc	%	No. ins struc	%	No. ins struc	%	No. ins. struc	%	No. ins struc	%	No ins struc.	%	No ins struc	%	No ins struc.	%	No ins struc	%	No ins struc	%
Number of inspected bldg.		6729	100	10357	100	2609	100	2962	100	6482	100	5737	100	6937	100	3315	100	5026	100	5237	100	735	100	717	100	57610	100
Property	private	6290	94	9550	91	2240	95	2590	87	5793	88	4895	85	6277	91	2623	81	5195	89	4859	93	585	80	637	89	51548	89
	social	430	6	792	9	369	14	372	13	779	12	842	15	657	9	622	19	631	11	370	7	150	20	80	11	6102	11
Function	housing	4829	72	8805	85	2160	82	2389	82	5072	77	4434	77	5225	75	2565	77	5479	94	4410	84	652	59	629	88	46769	81
	cater.-turist.	40r	7	200	2	155	4	127	4	144	2	187	3	40	1	14	1	6	0	11	0	2	0	3	0	1373	2
	industrial	135	3	261	3	70	3	79	8	184	3	232	4	139	2	105	3	181	4	188	4	34	5	5	1	1672	3
	agricultural	262	9	346	3	49	2	5	0	381	6	458	[illegible]	710	10	246	7	17		355	7	2	0	27	4	3223	5
	other	622	9	702	7	186	7	313	11	798	12	426	8	833	12	408	12	339	2	272	5	45	6	53	7	4795	8
Structure	masonry	6175	92	8872	85	2022	80	2776	95	5851	91	5264	92	6458	94	3080	95	5454	93	5050	97	695	97	625	87	52322	92
	reinf. concrete	309	5	735	8	295	12	44	2	362	6	289	5	270	4	68	2	216	4	124	2	10	3	6	3	2728	5
	steel	25	0	36	0	22	0	5	0	8	0	42	0	8	6	7	0	17	0	18	0	-	0	-		168	0
	wooden	120	2	156	2	40	2	42	1	24	0	91	2	31	0	103	3	16	0	36	1	4	0	4	0	669	1
	other	97	1	417	5	164	6	65	2	154	3	51	1	113	12	-		139	3	9	0	6	0	82	12	1297	2
I Usable	undamaged	1252	19	2006	22	872	14	1204	43	1918	30	1808	32	839	12	425	13	1417	24	1599	30	69	9	73	10	13542	23
	damaged without struc. damages	684	10	1306	13	378	15	391	13	779	12	845	15	963	14	1040	31	1825	30	1351	26	224	31	134	19	9024	17
	with slight struc. damage	488	7	1283	12	246	10	304	13	824	14	948	16	1153	17	1025	30	1723	29	1257	24	350	46	291	40	10090	16
	total I	2424	36	4595	47	1496	59	2049	69	3621	56	3601	63	2955	43	2490	74	4971	83	4207	80	619	88	493	69	33556	58
II Temporary nonusable	with struct. damage	576	9	990	10	26[illegible]	10	309	10	759	12	722	13	1262	18	437	13	622	11	627	12	70	10	135	19	6770	12
	with consider. struct. damage	543	8	897	7	235	9	217	8	666	10	499	0	1109	17	183	5	269	4	242	5	14	2	49	7	5003	8
	total II	1119	17	1887	17	496	19	526	18	1425	22	1221	21	2451	45	620	10	891	17	[illegible]069	17	81	12	184	26	11773	20
III Nonusable	heavily damaged	1598	24	2020	18	292	11	237	8	770	12	511	9	1237	18	231	7	92	2	121	2	1	0	25	4	7135	13
	partly damaged	919	13	1158	11	205	8	103	3	503	8	325	0	292	4	44	1	23	0	54	1	1	0	0	1	3642	6
	compl. failed	666	10	692	7	60	3	65	2	156	2	79	1	27	0	1	0	1	0	6	0	-	-	1		1763	4
	total III	3183	47	3870	36	565	22	406	13	1435	22	915	16	1556	22	276	8	116	2	181	3	2	0	45	5	12540	22



severely damaged buildings (red)
moderately damaged buildings, to be repaired (orange)
slightly damaged and undamaged buildings (green)

Fig. A.4 Discrete Distribution of Damage in the Communes of SR Montenegro due to the Earthquake of April 15, 1979

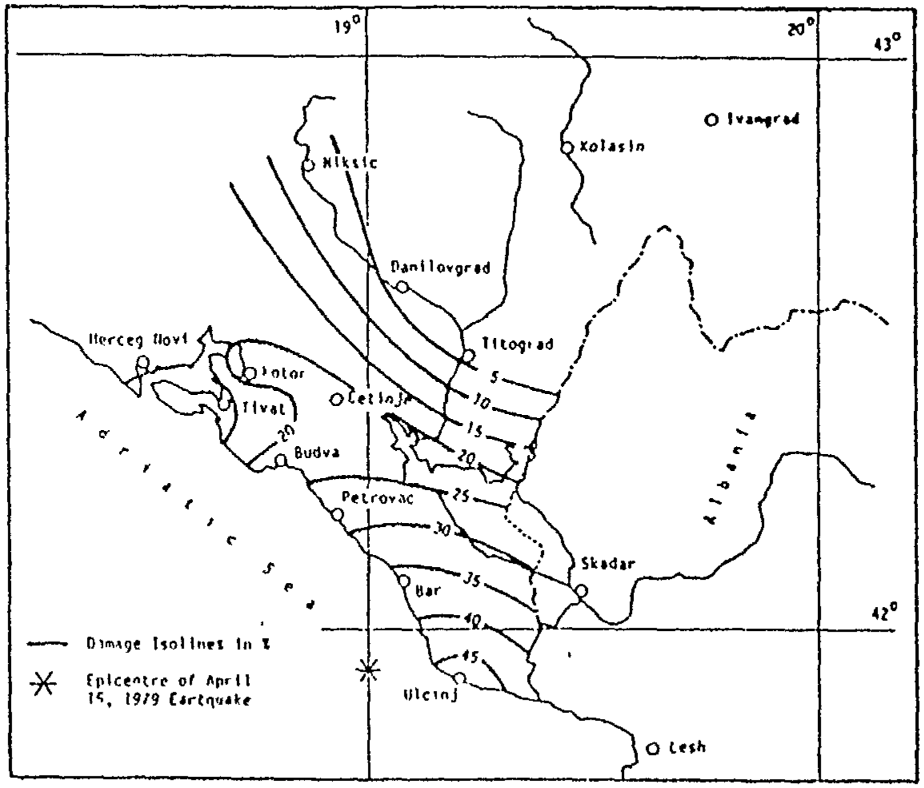


Fig. A.5 Spatial Distribution of Heavily Damaged Buildings-Red (in Percent of Total Number of Classified Buildings) for the Territory of Montenegro due to the Earthquake of April 15, 1979

4.4 AMENAGEMENT REGIONAL ET SISMICITE - LA REGION D'EL ASNAM/CHLEF

par Mohamed Benblidia, Agence Nationale pour l'aménagement du territoire - ANAT, Alger

A. Considérations générales sur la sismicité en Algérie

Contexte géodynamique

L'évolution de la Méditerranée est liée au mouvement relatif des deux grands blocs: l'Eurasie au nord et l'Afrique au sud. Entre ces deux grands blocs, il existe plusieurs zones frontières. La distribution des séismes dans la région ouest de la Méditerranée tend à montrer que la séismicité se concentre à partir de la dépression du Chéliff suivant une ligne sensiblement O.E., située à une cinquantaine de kilomètres au sud de la côte algérienne. La limite des plaques se trouve en Algérie, à peu près le.long du parallèle 36°N. Les études récentes, en particulier de néotectonique, ont permis de confirmer le mouvement du sud vers le nord de l'Afrique par rapport à l'Eurasie. Les deux plaques Eurasie et Afrique se rapprochent par un mouvement relatif approximativement perpendiculaire à la frontière commune. Le phénomène de contact est donc principalement de compression.

Le bloc continental africain affronte, le long de la côte algérienne, les fonds océaniques du bassin de la Méditerranée occidentale, solidaires du bloc Eurasie. La vitesse de rapprochement est de l'ordre de 0,5 cm/an.

Entre ces deux limites extrêmes, la sismicité suit les grandes lignes structurales du pays: le Tell (au nord) fortement sismique et l'Atlas présaharien de moindre activité encadrant la zone aséismique des Hauts Plateaux. Plus à l'est, là où l'Atlas Saharien rejoint les chaînes montagneuses du Tell, la sismicité est forte dans toute la zone comprise entre la flexure Sud Atlassique et le littoral.

B. Considérations sur la région d'El Asnam du point de vue de la sismicité

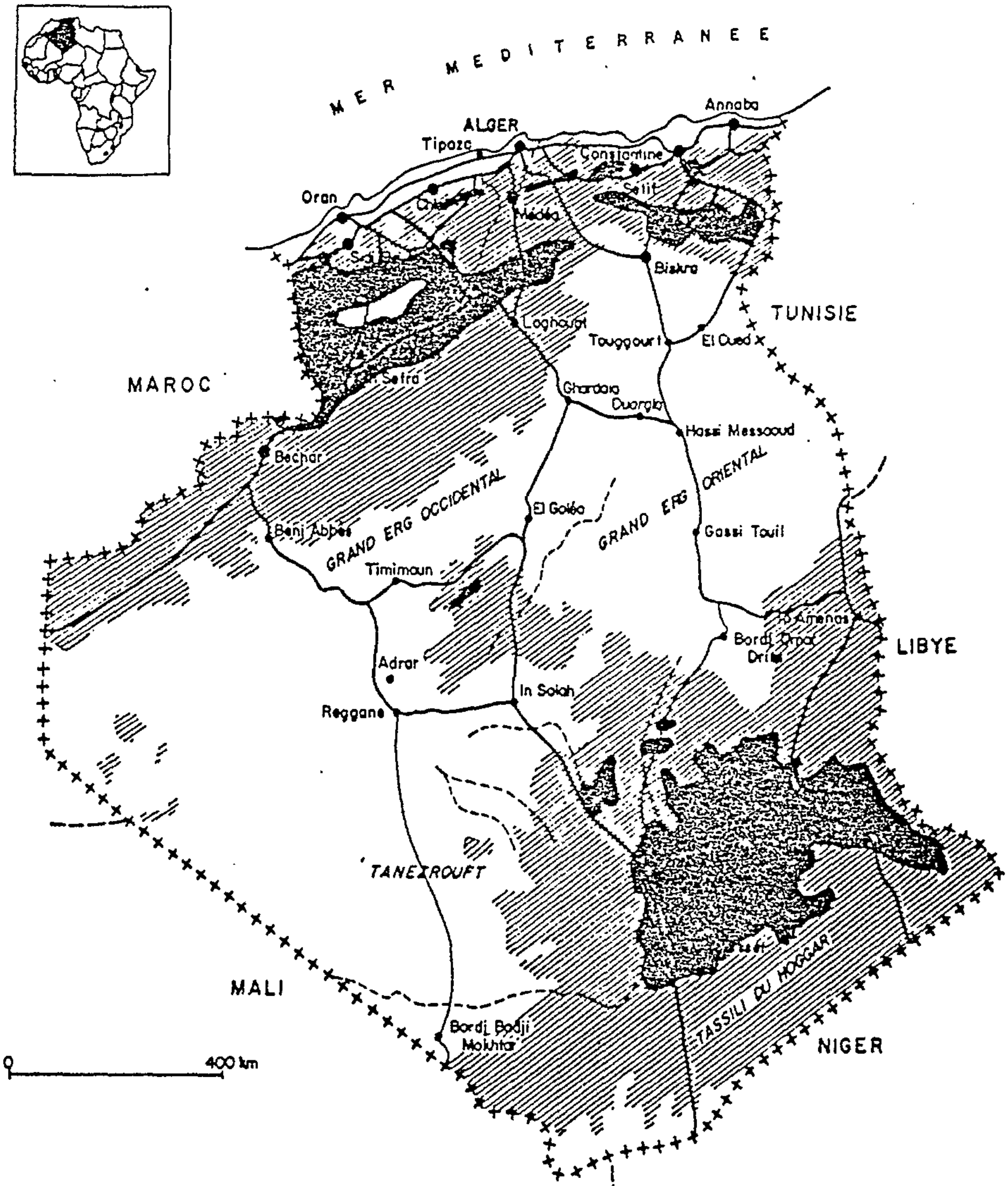
La région de Chlef* a connu de tout temps une activité sismique importante. De 1853 à 1973, on avait dénombré 481 secousses principales ressenties par l'homme.

L'analyse des données existantes montre que les secousses de magnitude supérieure à 5 sont assez fréquentes dans la région; les principales sont:

- El Asnam : 1853, 1867, 1876, 1922, 1934, 1954, 1957, 1980.
- Tenes: 1872, 1831, 1905.
- Gouraya: 1831

---

* Chlef, El Asnam - Orléansville sont les noms successifs de la même ville. Orléansville désignait la ville avant 1962 (Indépendance); El Asnam a été utilisé de 1962 à 1981 - Chlef est le nom actuel.



L'ALGERIE EN CHIFFRES

- Superficie : 2 381 millions de km² dont 3 % de terres cultivables
- Population : 21 millions d'habitants, dont la moitié a moins de 16 ans
  Taux annuel de croissance démographique : 3,2 %
  Population en l'an 2000 : 35 millions d'habitants.
  Population active : 3 400 000 habitants (dont 30 % dans l'agriculture et 32 % dans l'industrie)
  Principales villes : Alger : 2 500 000 h. – Oran : 690 000 h.
  Constantine : 450 000 h. – Annaba : 300 000 h.

Fig. 1 L'Algérie en chiffres

En ce qui concerne la période de retour, les secousses s'inscrivent dans des périodes de crises qui sont principalement:

- la crise de 1867 à 1876
- 15 ans plus tard, la crise de 1831
- 14 ans après celle-ci, la crise de 1905
- 12 ans après le séisme de 1932, soit en 1934, nouvelle série de secousses
- de 1954 à 1957: nouvelle période de crise.

Un séisme violent a encore frappé la région (le 10 Octobre 1980) suivi de nombreuses répliques. La magnitude du séisme principal a atteint M= 7,3.

Les deux derniers grands séismes ont été particulièrement meurtriers et destructeurs.

En 1954, (séisme de magnitude de 6,7) on eut à déplorer la mort de 1243 personnes et la destruction de plus de 20.000 maisons.

En 1980, le séisme a provoqué la mort de 3000 personnes et a détruit ou endommagé près de 70% des constructions dans la région proche de l'épicentre.

C. <u>La région d'El Asnam (Chlef) - population et démographie</u>

Avec 830.464 habitants (au recensement de 1977), la Wilaya de Chlef représentait 4,33% de la population algérienne et occupait le 4ème rang dans le pays. En 1983, la population était estimée à 996.750 habitants. En 1966 (précédent recensement), elle occupait le 3ème rang et représentait 5,16%.

La structure de la population de Chlef est la même que pour l'ensemble du pays:

- une population jeune: 50% ont moins de 15 ans
- une répartition par sexe à peu près égale:
  . masculin : 411.739 - 49,58%
  . féminin: 418.725 - 50,42%

Il s'agit d'une population essentiellement rurale qui vit en majorité en zone éparse.

Les indicateurs démographiques portent la marque de la ruralité:
- une taux de natalité très élevé: 48°/oo

Ce mouvement se structure de la façon suivante:

- un pôle économique et administratif (Chlef et Khémis);
- autour duquel gravitent des communes - relais (Ouled Farès - Oued Fodda - Arib - Miliana - El Attaf - Ain Defla) où les migrants ne font qu'une étape avant de quitter la Wilaya ou rejoindre le pôle principal;
- des communes réserves de main d'oeuvre:
  Bouzghaia pour Chlef et Ténès
  Sendjas pour Chlef
  Djendel, Djelida, Tarik Inb Ziad pour Khémis Miliana.

Cette description sommaire des caractéristiques physiques et humaines permet d'avoir une vue d'ensemble de la situation de la région à la veille du séisme du 10 Octobre 1980.

D. Les orientations générales de l'aménagement du territoire en Algérie

Les axes principaux de la politique d'aménagement du territoire

Ces axes ont été déterminés dans trois textes principaux:

- les objectifs de la Charte Nationale en matière d'aménagement du territoire (1976);
- "Le Rapport Général du Plan Quinquennal 1980 - 1984" dont les objectifs ont été présentés au IIIe congrès du FLN (15-19.06.80);
- le projet de Schéma Directeur d'Aménagement du Territoire - M P A T 1982.

Bref rappel des objectifs de la Charte Nationale en matière d'Aménagement du Territoire:

(a) équilibrer les niveaux de développement entre les différentes régions du pays;

(b) réaffecter les moyens de développement dans l'espace;

(c) réorienter la croissance des pôles d'accumulation vers les poches de stagnation;

(d) concevoir une armature urbaine harmonieusement répartie sur toute la surface du pays.

Le Schéma Directeur d'aménagement du territoire reprend ces objectifs et fixe plus précisément pour la région nord du pays les quatre objectifs suivants:

1. Sauvegarde des terres et développement de l'agriculture liés au ralentissement de l'urbanisation et de l'industrialisation dans les grands centres urbains de la côte.

2. Mobilisation des ressources en eau.

3. Réorientation du développement et de la croissance des populations.

4. Préparation des régions nord à assurer:
   - le transfert de population
   - le transfert des resssources hydrauliques
   - une politique d'urbanisation compétitive avec la nécessaire sauvegarde des terres agricoles.

On constate que ces objectifs généraux de la politique d'aménagement du territoire coincident avec la recherche de la réduction de la vulnérabilité sismique : en effet, on cherche à freiner l'occupation de la région nord qui est en même temps la plus exposée aux risques de tremblements de terre; on développe l'occupation des Hauts Plateaux et du sud du pays (considérés comme moins ou peu sismiques) et enfin on favorise l'urbanisation dans les petites villes où les conséquences de secousses telluriques sont évidemment moins grandes et moins graves pour les habitants et pour l'économie nationale que dans les grandes agglomérations urbaines.

Application à la région de Chlef

La Wilaya de Chlef est concernée par les objectifs fixés à la région nord - elle est dotée:

- de plaines agricoles à sauvegarder
- de piémonts agricoles à mettre en valeur
- d'une armature urbaine déséquilibrée, avec une croissance des villes de la plaine à ralentir et un nécessaire développement de villes petites et moyennes à mettre en oeuvre, accompagné d'un développement de la PMI
- de zones de montagnes à désenclaver
- de ressources en eau à mobiliser

La réalisation de ces objectifs est la condition du développement de la région, la lutte contre les disparités à l'intérieur de la Wilaya passant aussi par la satisfaction des besoins sociaux (habitat - équipements sanitaires et scolaires, électricité etc...).

De la même façon qu'au niveau national, il y a parfaite coincidence entre la recherche de la diminution de la vulnérabilité aux séismes et la cohérence du développement socio-économique de la région.

En effet, la vallée du Chélif est à la fois la zone la plus urbanisée, la plus peuplée, la plus riche en terres agricoles et la plus exposée au risque sismique.

E. Le séisme du 10 octobre 1980

Le 10 octobre 1980 à 13H 26 (heure locale) s'est produit un séisme particulièrement violent dans la région.

Il a été suivi par une autre forte secousse à 16 h 30.

L'ensemble de ces deux secousses telluriques constitue un des évènements sismiques les plus importants de l'Algérie du Nord au cours du dernier millénaire. It était nettement plus fort que celui qui avait frappé la même région en 1954. On estime que la quantité d'énergie libérée en 1980 était environ 8 fois supérieure à celle de 1954.

Caractéristiques du séisme et de ses répliques

	Choc principal	Réplique principale
Date:	10.10.1980	10.10.1980
Heure locale	13 h 25 mn 23,7	16 h 39 mn 09,8
Latitude (N)	36,143	36,210
Longitude (E)	1.413	1.632
Magnitude (Ms)	7,3	6,0

La profondeur moyenne de 10 Km déterminée instrumentalement est conforme avec celle donnée par la formule de Gutenberg pour une intensité comprise entre IX et X et un rayon macrosismique de 250 km. environ. Aucun accélérogramme n'a été enregistré lors des deux séismes majeurs du 10 octobre 1980. Les 4 accélérographes installés dans la région sur des barrages n'ont pas fonctionné par négligence et manque d'entretien.

Les informations ainsi perdues sont inestimables. On a été réduit à évaluer par des méthodes indirectes la nature et le niveau des accélérations de ces séismes. On a pu conclure que les accélérations au sol dans la région épicentrale ont varié de 0,25 g à 0,70 g. Par ailleurs, et c'était une particularité du séisme du 10 octobre 1980, la composante verticale de l'accelération était très élevée; (M. Deysperoux l'estima à certains endroits à 1% g).

Quelques jours après le séisme, plusieurs missions étrangères (Yougoslavie, Grande Bretagne, France) ont installé un réseau de sismographes dans la région épicentrale.

Les épicentres des répliques jalonnent la faille principale avec une certaine orientation aux extrémités nord-est et sud-ouest où elles ont atteint jusqu' à 600 par jour à El Abadia et 130 à Sendjas.

Au total quatre vingt (80) répliques ont été enregistrées entre le 21 octobre et le 7 décembre 1980 avec une accélération maximale variant de 1,0 à 31,0% de l'accélération de la pesanteur. Tous ces enregistrements ont donné une composante verticale de valeur élevée du même ordre de grandeur que la composante horizontale.

<u>Conséquences du séisme</u>

La catastophe de 1980 a provoqué de nombreuses pertes en vies humaines, des destructions d'habitations en grand nombre et des dommages importants à des infrastructures de liaison et à des équipements publics.

Au total pour la Wilaya de Chlef, on a dénombré:
- 2 633 morts
- 8 369 blessés
- 348 disparus
- et 6.778.948 sinistrés.

Le taux de destruction des localités a atteint 71% pour la ville de Chlef (ex. El-Asnam, ex-Orléansville), 19% à El-Abadia et 16% à Oued Fodda.

- 212 édifices publics ont été totalement détruits
- 785 édifices publics endommagés
- 29.747 logements totalement détruits
- 24.609 légèrement endommagés
- 307 locaux commerciaux endommagés.

Les communications ont été sérieusement atteintes et trois ponts gravement endommagés.

F. Les mesures prises après le séisme

Les opérations de secours commencèrent immédiatement après la première secousse avec les moyens locaux d'abord et les moyens dépêchés par les régions voisines.

Suite à la catastrophe, le Gouvernement a pris des décisions se traduisant par des actions concrètes et nécessaires à la réhabilitation et à la normalisation dans la région sinistrée, selon un plan en trois phases:

Les trois phases

Phase I :

- sauvetage des personnes sinistrées;
- récupération des biens matériels, des services et des archives;
- fourniture d'abris provisoires sous forme de tentes pour une majorité des populations sinistrées;
- approvisionnement des populations en moyens de subsistance (nourriture, eau potable, vêtements, soins);
- réfection des infrastructures de base de communication (routes, chemin de fer, téléphone, réseaux d'énergie et distribution de combustibles);
- rétablissement des conditions de sécurité publique et des structures administratives;
- régularisation de la situation scolaire et sanitaire par l'ouverture des écoles primaires (sous tentes) et des services de soins mobiles;
- répartition des personnes sinistrées, en particulier des écoliers, dans les régions voisines;
- reprise des activités agricoles et commerciales;
- évaluation des dégâts sur l'immobilier (sous le pilotage de l'Organisme National de Contrôle Technique de la Construction CTC) permettant le recensement du patrimoine récupérable et de celui définitivement perdu;
- évaluation de la situation des travaux arrêtés par le séisme, pour en définir les modalités de reprise éventuelle d'une part et en préciser les préjudices subis par les opérateurs (dossier contentieux) d'autre part.

Phase II:

- amélioration progressive de la situation des populations sinistrées;
- recensement généralisé à l'ensemble du territoire sinistré afin d'évaluer avec précision les pertes en vies humaines, les dégâts matériels, ainsi que les mouvements de populations enregistrés;
- construction de logements préfabriqués légers, adaptés aux conditions locales, pour l'ensemble des populations sans-abri, aussi bien dans les agglomérations que dans les campagnes;
- la réalisation de ce programme doit être très rapide (une année);
- construction d'écoles, de lycées, de locaux commerciaux, de centres de santé et d'hôpitaux dans les mêmes conditions (préfabriqué léger et délai court);
- remise en fonctionnement normal de toutes les activités économiques de la région: agriculture, industries, bâtiment et travaux publics, commerces.

Phase III:

- réparation des bâtiments endommagés mais récupérables;
- reconstruction des centres urbains détruits;
- programme de développement économique et social de la région.

La phase III nécessite au préalable des études permettant de mieux localiser et réaliser les constructions futures en fonction du risque sismique.

G. Les recommandations de la Commission interministérielle

Dans son rapport de juin 1981, la Commission interministérielle formulait des recommandations et proposait un plan d'actions à engager: en matière d'études d'aménagement, d'urbanisme, de connaissance et d'évaluation du risque sismique, en matière de réglementation de construction parasismique:

- en matière de formation
- en matière d'information et de sensibilisation de la population
- en matière de prévention
- en matière d'organisation post-catastrophe.

La Commission interministérielle a notamment recommandé de situer toutes les actions futures dans le cadre d'un schéma d'aménagement et de développement socio-économique à long terme pour la région, schéma intégrant le risque sismique et ayant pour but la réduction de la vulnérabilité aux séismes.

H. Elaboration du schéma d'aménagement régional

Conformément aux recommandations de la Commission interministérielle, cette étude a été élaborée par l'Agence Nationale pour l'Aménagement du Territoire (ANAT), organisme national d'études dépendant du Ministère de la Planification et de l'Aménagement du Territoire.

Les travaux ont été menés en liaison étroite avec les autorités de la région et avec l'assistance du Centre des Nations Unies pour les Etablissements Humains (CNUEH) de Nairobi.

L'étude a permis de définir et de proposer les orientations principales du développement planifié économique et social pour la région, en intégrant le paramètre de l'aléa sismique.

L'analyse de la situation, la prise en compte des contraintes qui pèsent sur le développement futur régional - en particulier la contrainte du risque sismique - la nécessité de sauvegarde des terres agricoles riches de la région, ont permis de dresser une série de schémas et de plans d'organisation économique et sociale pour le futur de la région.

Les contraintes sont essentiellement:

- la sismicité
- la disponibilité des terres, compte tenu de l'érosion
- l'approvisionnement en eau
- la pression démographique

I. Les études de microzonation dans la région de Chlef

Conformément aux recommandations de la Commission interministérielle, des études de microzonation sismique ont été réalisées sur 9 agglomérations de la région sinistrée: Chlef, Oued Fodda, El Abadia, El Attaf, Oued Sly, Boukadir, El Karimia, Sendjas et Ouled Ben Abbelkader. La carte de la Fig. 16 p.75 donne la situation de ces villes dans la région.

Ces études ont été confiées à l'Organisme National de Contrôle Technique de la Construction (CTC). Le CTC a sollicité l'assistance de l'UNESCO pour la constitution d'un groupe de consultants spécialistes de renommée internationale, pour suivre, conseiller le CTC dans la conduite des études de microzonation et d'aléa sismique. Ce groupe de consultants a notamment donné ses avis sur la méthodologie adoptée, sur les clauses des contrats d'études et sur les résultats des études.

Un bureau d'études (Woodward - Clyde Consultants - WCC) a été sélectionné après une analyse technique très minutieuse des offres faites par plusieurs groupements de bureaux d'études.

Plus de trente scientifiques et ingénieurs ont participé en commun à la réalisation de ces études de microzonation sismique: géologues, hydrogéologues, sismologues, géotechniciens, ingénieurs de structures et de génie sismique, urbanistes, aménagistes.

Les différentes parties de l'étude de microzonation

L'étude de microzonation sismique de la région de Chlef se décompose en trois étapes:

(a) établissement et développement d'un modèle régional d'aléas sismiques

(b) établissement de cartes de microzonation sismique pour les sites urbains choisis

(c) recommendations pour les réglementations de construction parasismique, et l'aménagement urbain dans la zone.

Le diagramme de la figure 17 représente les principaux points de repère de l'étude de microzonation - l'objectif final est la limitation des risques humains et matériels au cours des séismes futurs, cette limitation devant s'obtenir avec le minimum de dépenses.

J. Utilisation des études de microzonation urbaine

Les cartographies de microzonation sismique dans les neuf agglomérations étudiées servent actuellement à deux usages:

1. Choix des bâtiments endommagés (orange) à détruire ou à conforter. Pour les bâtiments à conforter et à réparer, les calculs tiennent compte du nouveau règlement parasismique (RPA 81) et des caractéristiques de la zone considérée (fournies par l'étude de microzonation).

Etape 1

Etude d'aléa sismique régional:

- modèle tectonique
- détermination probabilistique de l'aléa sismique

Fournir une explication sur la localisation des séismes, leur magnitude, et leur fréquence

↓

Etape 2

Cartographie de microzonation sismique:

- cartographie géologique
- investigations géotechniques et hydrogéologiques
- aléa des mouvements vibratoires du sol
- ruptures du sol induites par séisme:
  - liquéfaction
  - glissements de terrain
  - rupture de faille en surface
- inondations induites par séisme
- cartes de synthèse et de microzonation

définir les emplacements, où un potentiel d'aléa sismique existe pour les zones urbaines d'étude, qui doivent être considérées dans le code de construction, les études du choix d'un site, la conception et la construction des structures, et le plan d'aménagement des sols

↓

Etape 3

Codes de construction
Règles de construction
Plan aménagement des sols urbains:

- coefficients des forces pour la conception
- exigences du code de construction mises à jour
- règles recommandées pour la construction para sismique
- méthodes pour la détermination des capacités du terrain et pour l'aménagement des sols

éviter des dégats matériels et des pertes humaines inacceptables aux cours des séismes futurs en fournissant une conception adéquate pour les structures et/ou en localisant les structures en dehors des zones à risques sismiques élevés

Fig. 17 Diagramme des études de réduction des risques sismiques

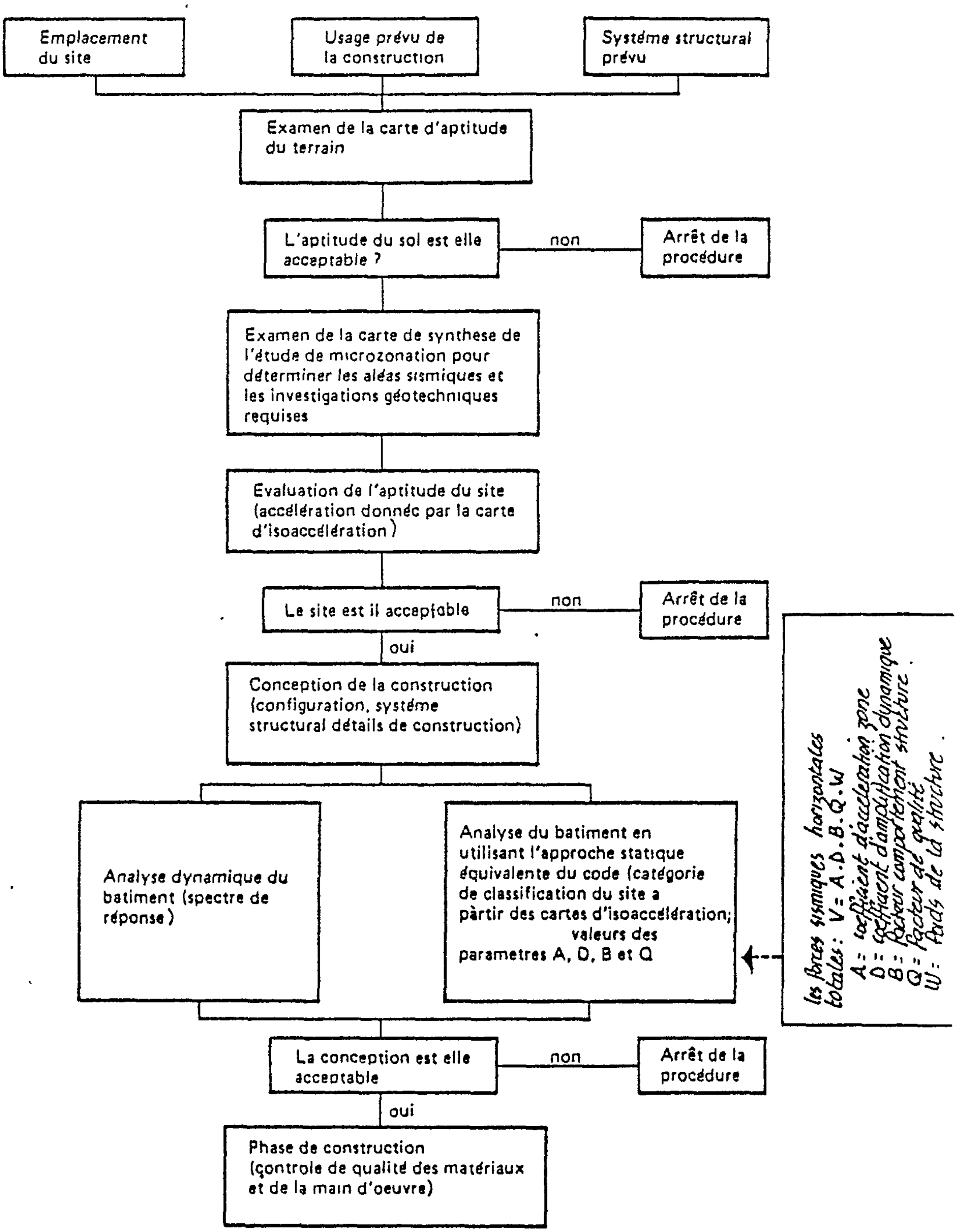


Fig. 29 Schéma d'utilisation des études de microzonation

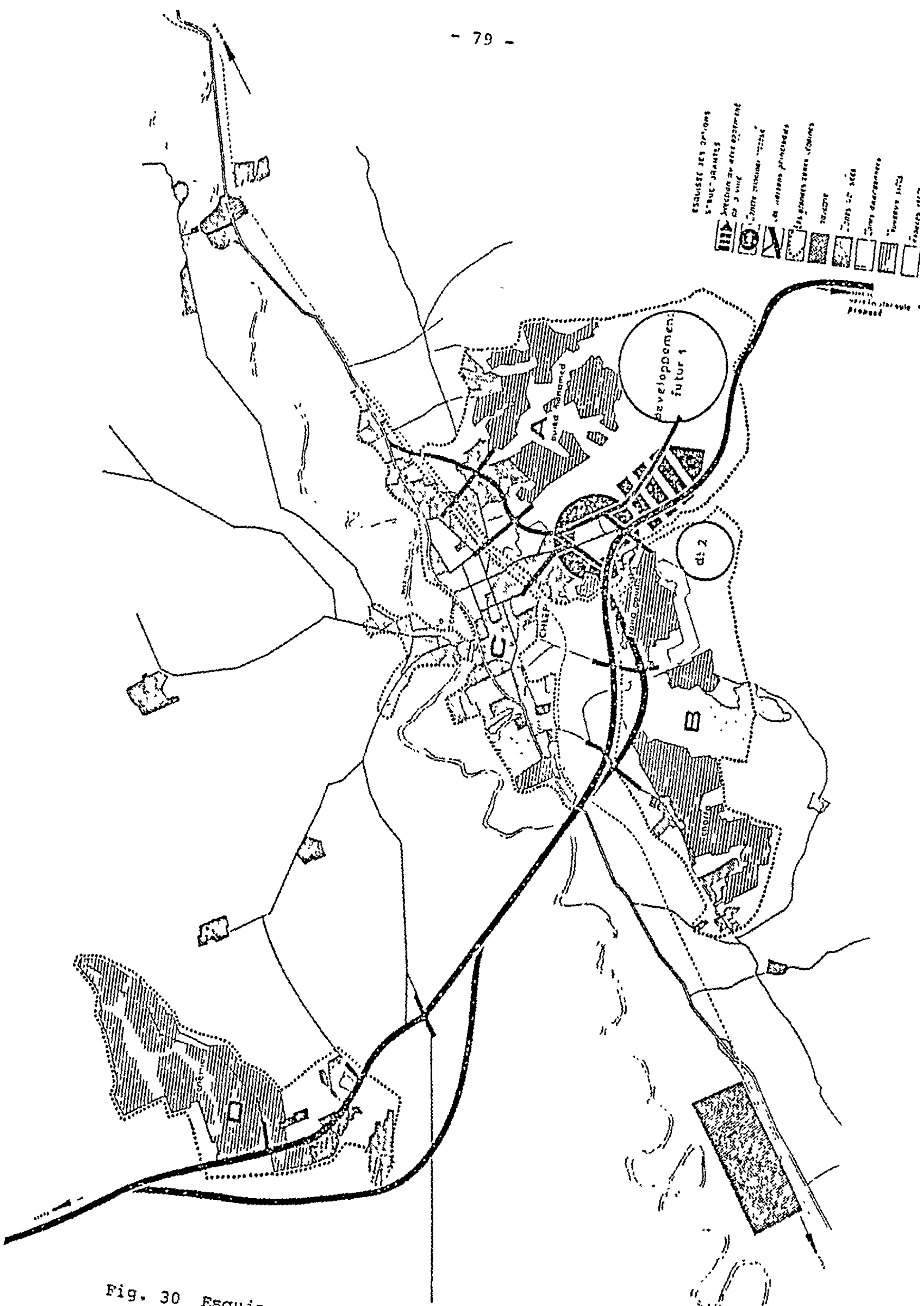


Fig. 30 Esquisse des options structurantes

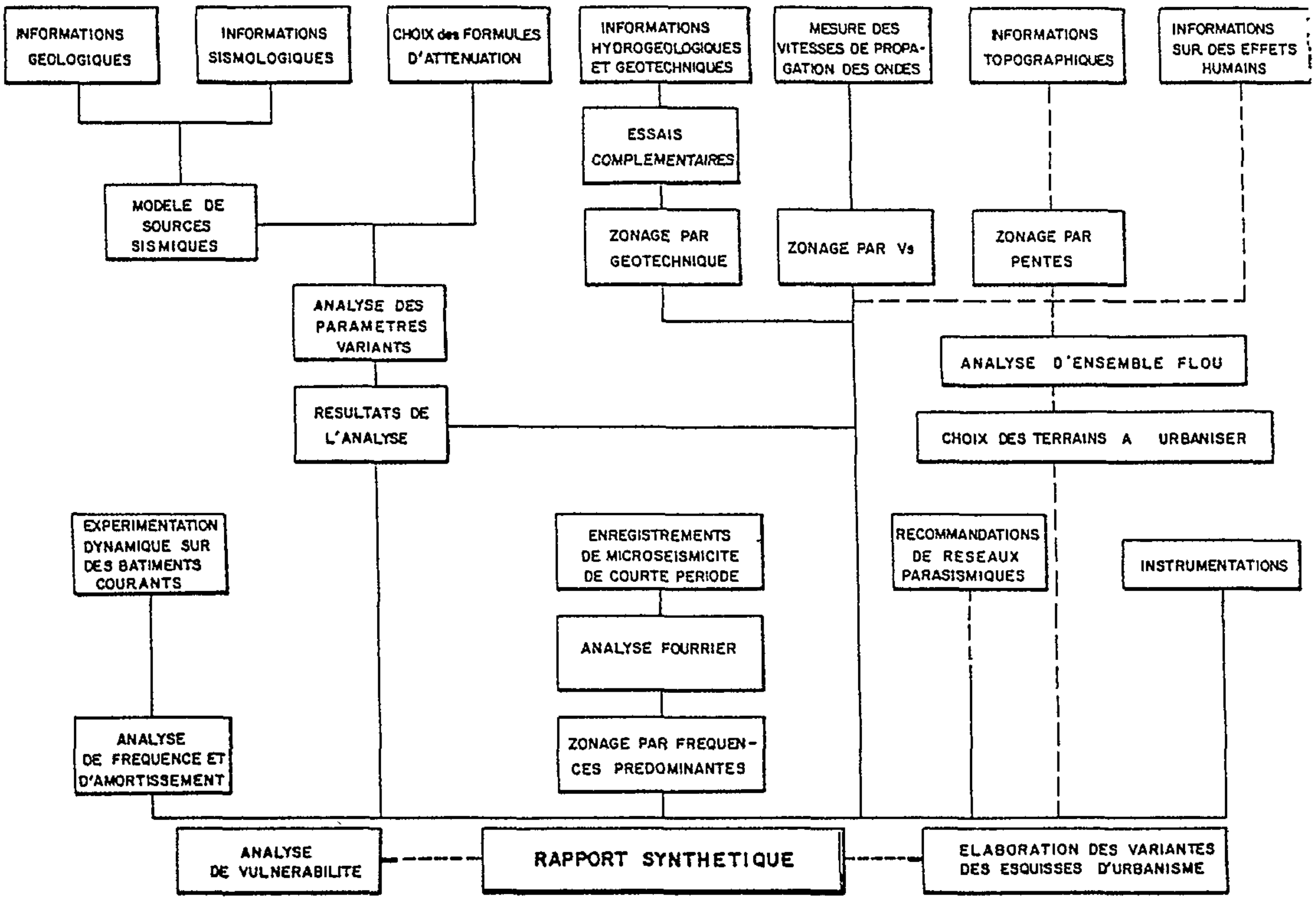


Fig. 31 Organigramme de la méthodologie de microzonation sismique adoptée

2. Elaboration des nouveaux plans directeurs d'urbanisme. Dans une première phase, la carte de microzonation est utilisée pour donner une indication sur les zones à proscrire pour l'urbanisation.

   Dans une deuxième phase, elle permet de dresser le plan de développement urbain à long terme.
   Le cas de la ville de Chlef est intéressant à cet égard.

<u>Cas de la ville de Chlef</u>

La ville de Chlef est actuellement formée de la "juxtaposition" de secteurs urbains à caractère hétérogène - le passé et notamment les deux grands tremblements de terre qu'elle a subis expliquent cette caractéristique de ville "éclatée", caractéristique aggravée par la création des sites d'habitats préfabriqués (voir carte page 50 Fig. 11).

En vue de corriger cette situation, la stratégie d'aménagement adoptée est basée sur les principes fondamentaux suivants:

1. Intégration des différentes composantes de la ville.

   - maximalisation des opportunités de contact entre les habitants des différents quartiers;

   - systèmes de liaisons efficaces;

   - création et développement d'un nouveau et véritable "centre principal".

2. Choix d'une direction où le développement de la ville sera encouragé.

   Cette direction est le sud en raison de:
   - l'établissement de la plupart des nouveaux sites en préfabriqué au sud de la voie de chemin de fer;

   - la meilleure qualité des sols du point de vue géologique et sismique - (que confirme l'étude de microzonation);

   - l'absence de contrainte de préservation de terres agricoles.

Les orientations du développement urbain ont été établies et insérées dans un schéma directeur d'urbanisme qui s'appuie sur: (voir Fig. 30).

- la priorité accordée au développement de la ville vers le sud et l'équipement adéquat et la mise en valeur des sites en préfabriqué;

- l'intégration de ces sites entre eux et dans la nouvelle ville et la réutilisation progressive de l'ancien tissu urbain en fonction des résultats de l'étude de microzonation.

<u>Mise en oeuvre des plans d'aménagement régional et d'amenagement urbain</u>

Le schéma d'aménagement régional est adopté. Les plans de développement économique et social tiennent compte des recommandations du schéma, notamment dans le choix des types d'investissements planifiés et de leur localisation dans la région.

L'application du schéma devra être périodiquement évaluée afin de procéder aux correctifs nécessaires.

Les plans d'urbanisme sont en cours d'élaboration à partir des résultats des études de microzonation. Il tiennent compte également d'améliorations dans la conception et le calcul de la résistance des bâtiments au séisme.

En effet, l'analyse des dommages dûs au séisme du 10 Octobre 1980, a apporté des enseignements qui ont été mis à profit pour:

- d'une part, l'élaboration des recommandations et dispositions techniques pour la réparation et le confortement des bâtiments endommagés;

- d'autre part, la mise au point du nouveau règlement de construction parasismique (RPA 81).

Le séisme de 1980 à Chlef a fait prendre conscience au niveau des autorités politiques du pays de l'importance du risque sismique dans le nord de l'Algérie et de la nécessité d'en tenir compte dans l'aménagement du territoire et le développement urbain.

Parmi les décisions prises par le Gouvernement, soulignons:

- la création du Centre National de Génie Sismique;

- l'organization d'une Commission interministérielle chargée de la prévention et de la lutte contre les catastrophes naturelles et technologiques.

4.5 EMERGENCY ASSISTANCE AND RECONSTRUCTION - EXPERIENCING COMMUNITY REHABILITATION TECHNIQUES AFTER THE 1980 EARTHQUAKE IN SOUTHERN ITALY

by Giulio Rossi Crespi, Italtechna S.p.a., Roma, with: P. L. Matteraglia, G. Amori and A. Belliazzi, consultants

A. Earthquake of November 23, 1980

Among the many earthquakes which have struck Italy in recent years, the one that struck Irpinia in 1980 represents a case in point in recent emergency management experiences in Italy. In particular:

- The earthquake, of remarkable intensity, embraced a very extensive area and struck a wide section of the population;
- The special geographic characteristics and the social and economic configuration of the affected area induced greater damage than that which would be caused by the destructive capacity of the earthquake alone, and caused very serious human and material losses;
- The magnitude of the event called for the participation of rescue forces at national and extra-national level, submitting a still too vulnerable civil protection organization system for a country like Italy (often struck by natural calamities) to a gruelling test. However, the system's shortcomings and weak points provided elements for reflection and valuable suggestions for improving the civil protection organization, whose structure has been expanded and consolidated over the last few years.

Description of the event

The earthquake, which occurred at 7.34 p.m. on November 23, 1980, reached, in the epicentral zone an intensity of the 10th grade on the Mercalli scale (6.8 magnitude), causing 2,570 dead, 8,800 injured and rendering about 300,000 homeless.

The epicentre was located between the towns of Lioni, Laviano and Oliveto Citra, on the Apennine ridge between the Campania and Basilicata Regions. A wide area in southern Italy, measuring about 20,000 km^2, was profoundly disturbed, suffering perhaps irreversible damage to its architectural heritage and its socio-economic system. (Fig. 1)

More than seventy per cent of the area is mountainous, with elevations ranging between 500 and 1,500 m a.s.l., with a complex orography, which brought about an altogether irregular seismic-wave pattern.

The time series of the events which occurred in the zone, confirm its high level of seismicity, falling between the 7th and 10th degree of the Mercalli scale; in 1930, an earthquake of the 10th grade in the Mercalli scale had caused the death of 1,400 persons (Fig. 3).

The special nature of the upper stratum, consisting of sedimentary rocks with sharply inclined layers tends, under the effect of the seismic wave, to cause landslide occurrences, which on the occasion of the November 1980 earthquake, contributed to making the situation even more critical in some places and adversely affected the efficiency of land communications.

The road network crossing the area is based on a single main line of communication, to which a minor road network is connected. The "feeder" road network is characterized by sharp differences in level, twisting alignments and narrow carriageways, all of which made rescue operations difficult in the crucial period.

The special meteorological situation, the time and the day on which the event occurred were additional crisis factors: a thick mist and the night time darkness impeded first air reconnaissance; the bad weather and the snow made work difficult; the day of the event, a Sunday, and the time at which it occurred, meant that many were surprised by the tremor in their homes or in the places of worship.

Survey and assessment of the damage

All in all, the boundaries of the affected zone included 640 "comuni" (municipalities) within the Campania and Basilicata Regions and partly, in Apulia, involving a population of 4.7 million inhabitants (including the municipality of Naples).

The zone concerned has particular socio-economic features as well: the internal area of Campania and Basilicata is, in fact, a "classic" depressed area, with poor agriculture; farm income does not reach the regional average. Housing resources consist of historical centres and rural buildings which have never been restored and which therefore already had a substratum of damaged or particularly vulnerable buldings. To this already precarious situation must be added the city of Naples, a metropolitan area of complex nature, in which the earthquake, even if with attenuated intensity, superimposed itself on an already existing state of urban degradation.

From the point of view of settlement structure, the affected territory has a differentiated residential density: in the epicentral zones, with low average settlement density (70 inhabitants km^{-2}), systems are encountered with a clear-cut preponderance of scattered houses and nuclei in other zones; density increases in other areas and there are urban systems with high concentration rates; finally, there is the coastal system, with an average density of more than 10,000 inhabitants km^{-2}.

For damage assessment, an Interministerial Committee was appointed in the days following the earthquake to make a survey in order to evaluate the extent of the damage and to prepare the legal procedure necessary for reconstruction. A survey was thus made of the damages caused to the building resources, through an investigation schedule at the level of buildings or of single housing units (Fig. 4).

The survey concerned a significant sample of all the housing resources in the stricken area, comprising 57,000 housing units, 257,000 rooms, the analysis of 32 million m^3 of building space and a population of about 146,000 inhabitants. The survey, conducted by 1,000 army technicians under the direction of the headquarters of the Defence Ministry, made it possible to estimate the total damage at about 9,800 billion Italian lire (Tables I and II).

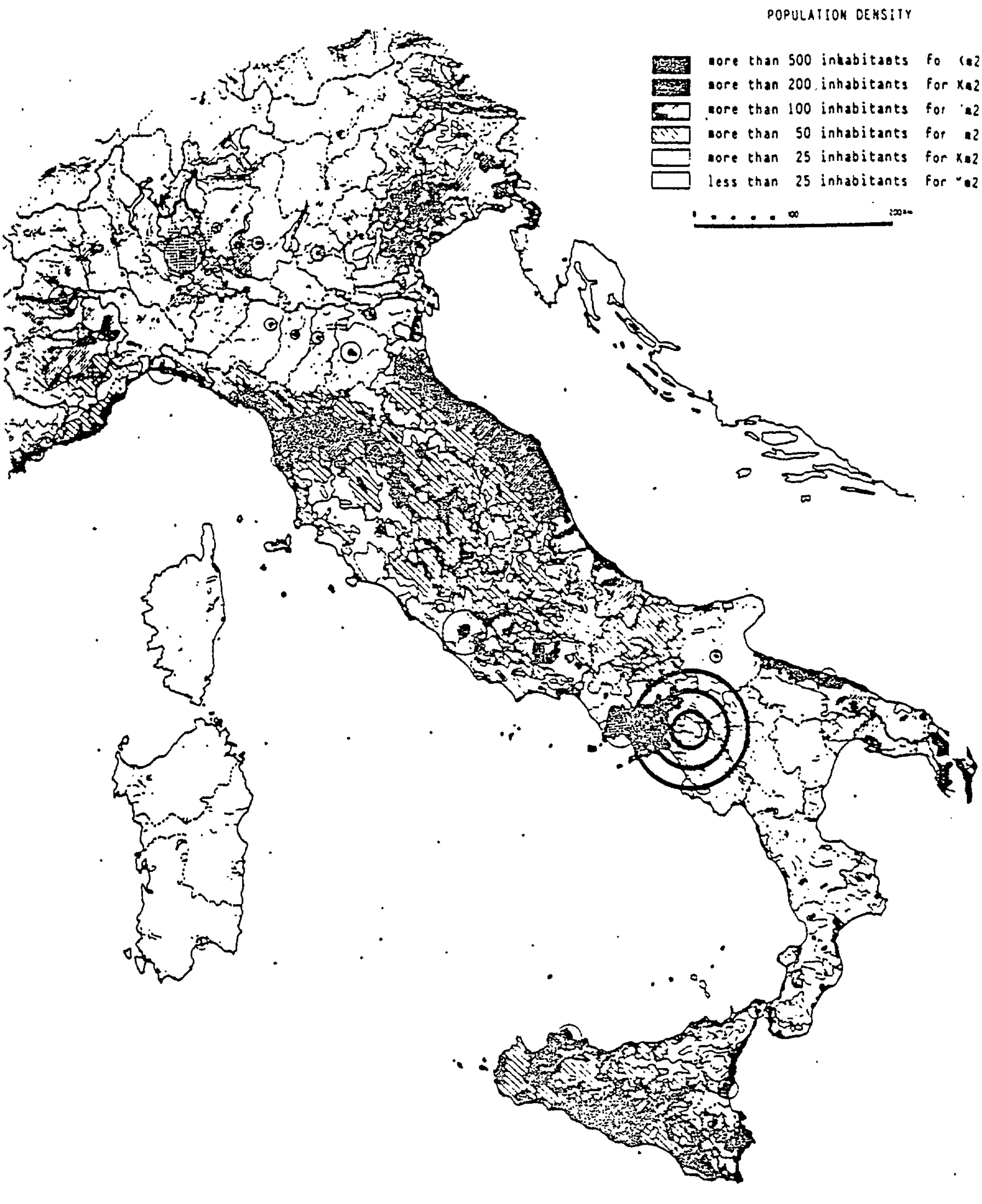

POPULATION DENSITY
more than 500 inhabitants fo Km2
more than 200 inhabitants for Km2
more than 100 inhabitants for Km2
more than 50 inhabitants for Km2
more than 25 inhabitants for Km2
less than 25 inhabitants for Km2

Fig. 1

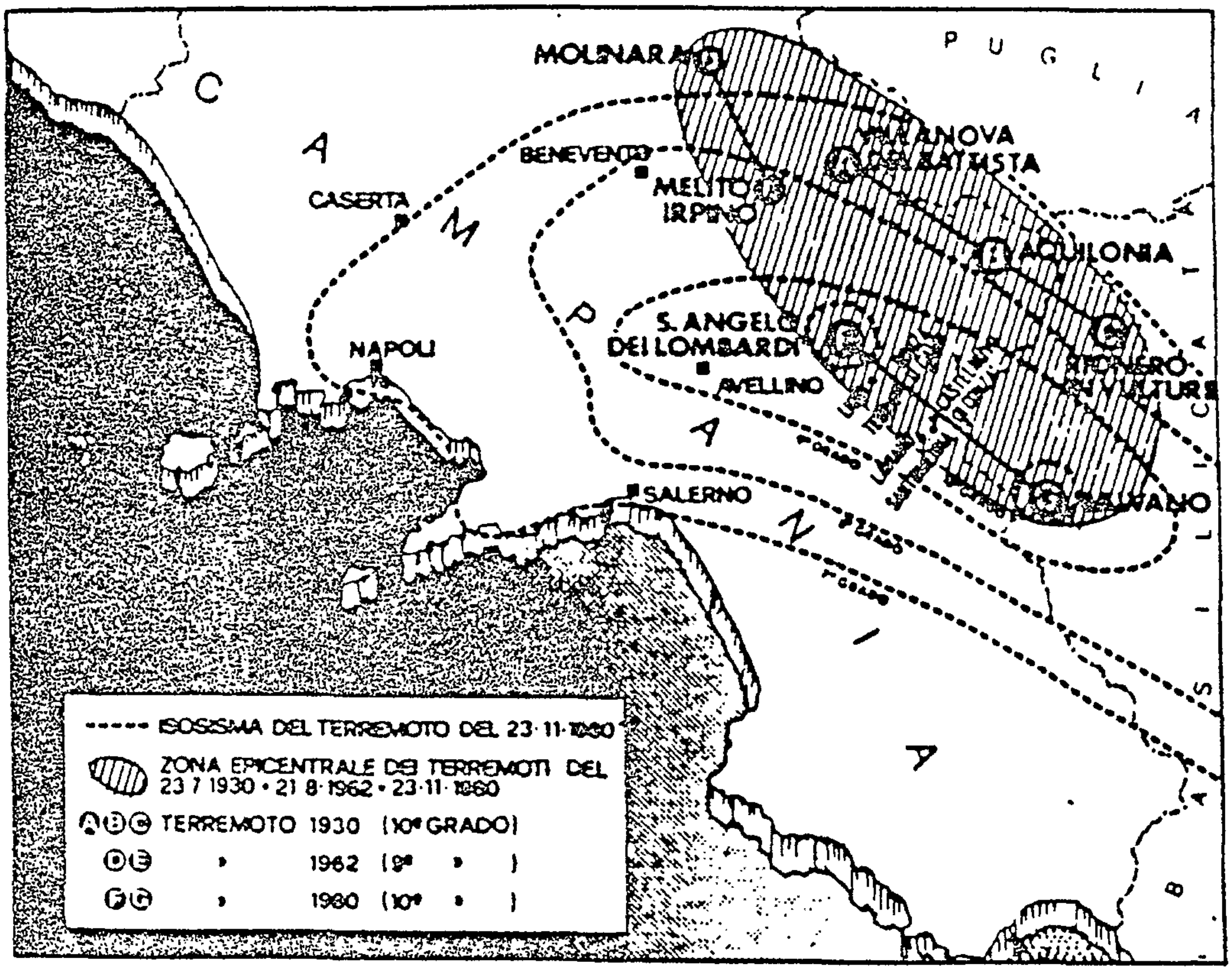

MOLINARA
BENEVENTO
CASERTA
NAPOLI
MELITO
IRPINO
S. ANGELO
DEI LOMBARDI
AVELLINO
SALERNO
AQUILONIA
C A M P A N I A
P U G L I A
B A S I L I C A T A
----- ISOSISMA DEL TERREMOTO DEL 23·11·1980
ZONA EPICENTRALE DEI TERREMOTI DEL 23·7·1930 · 21·8·1962 · 23·11·1980
ABC TERREMOTO 1930 (10° GRADO)
DE » 1962 (9° »)
FG » 1980 (10° »)

Fig. 3

Table 1

Outline table of the damage in the "crater" (1) zones and in external zones (serious and slight damage)

AREA	Total Inhabitants	DWELLINGS			
		Destroyed	Seriously damaged	Slightly damaged	Unharmed
1 - *Basilicata*					
1 1 - Crater	30 750	2 663	3 443	3.075	1 069
1 2 - Outside crater	432 334	1 655	28 366	43 233	70 875
TOTALS	436.084	4,318	31 809	46 308	71 926
2. - *Campania*					
2 1 - Crater	77 717	6 730	8 699	7 771	2 705
2 2 - Outside crater	4 121 966	16 447	248 357	412 357	696 988
TOTALS	4 199.683	23 177	257 056	419 968	699 693
3 - *Apulia*					
3 1 - Crater	-	-	-	-	-
3 2 - Outside crater	44 530	132	3 153	4 453	7 107
TOTALS	44 530	132	3 153	4 453	7 107
Totals					
Crater	108 467	9 393	12 142	10 846	3 774
Outside crater	4 598.830	18 234	279 876	459 883	774 950
GRAND TOTALS	4,707,197	27 627	292 018	470 729	778 724

(1) The term «crater» defines the area close to the epicentre which has been more seriously damaged

Table 2

Overall table of the reconstruction and repair costs (in billions of Italian lire)

AREA	Inhabitants	COSTS			
		Reconstruction	Repairs		TOTALS
			Serious	Slight	
Basilicata					
Crater (1)	30 750	143 20	120 35	6 92	270 47
Outside crater	432.334	59 46	765 39	97 27	922.12
TOTALS .	436.084	202 66	885 74	104 19	1,192 59
Campania.					
Crater	77.717	356 00	300 42	17 48	673.90
Outside crater ..	4 121 966	573 49	6 384 19	927 44	7 885 12
TOTALS .	4,199.683	929 49	6,684 61	944 92	8,559 02
Apulia					
Crater . .	-	-	-	-	-
Outside crater ..	44 530	4 80	83 18	10 00	97 98
TOTALS .	44,530	4 80	83 18	10 00	97 98
Totals					
Crater .	108.467	499 20	420 77	24 40	944 37
Outside crater	4 598.830	637 75	7,232 76	1,034 71	8 905 22
GRAND TOTALS	4 707 197	1 653 53	7,653 53	1 059 11	9,849 59

2. Organization of the first rescue operations

Rescue operations during the first hours after the earthquake were obviously directed towards saving the greatest number of human lives, arrangements being made, at the same time, for providing assistance to the survivors, for clearing the rubble and for the recovery of victims.

Appointment of the extraordinary commissioner

In order to ensure coordination of activities at all levels and to optimize the utilization of the intervening forces, the Government, on November 24, appointed an Extraordinary Commissioner in the person of the Hon. G. Zamberletti, at present Minister of Civil Protection.

In this regard it is necessary to make clear that at the time of the earhquake the duties of Civil Protection were entrusted to the Ministry of the Interior. It was not before 1982 that the Civil Protection Department was set up by the Presidency of the Council of Ministers, with the task to coordinate rescue operations relating to Emergency and to carry out Forecasting and Prevention activities (cf. Chapter 4).

The operational first-aid plan drawn up by the Commissioner, in the very first phase, dealt with the implementation of an integrated command system for the rescue forces, through the establishment of Operational Centres at various levels:

- "Centro Operativo Commissariale" (C.O.C.) with command and coordination activities over all the stricken territory, made up of the representatives of all the civil and military authorities called upon to take part in rescue operations.

- "Centri Operativi Provinciali" (C.O.P.), with duties of direction and command of the operations on the provincial territory and consisting of the representatives of the authorities concerned and of the intervening forces.

- "Centri Operativi di Settore" (C.O.S.), with jurisdiction over a certain number of municipalities.

In addition to these Centres, which ensured a direct link with the stricken populations and made the action of the rescue teams more effective, the office of the Government Commissioner integrated staff and appointed several officials of the Interior and Foreign Affairs Ministries (the latter for international relations) and a Fire Brigade squad to run a Technical Secretariat.

Personnel and equipment involved in the emergency phase

At the time of the earthquake the forces available in the stricken area amounted to about 8,000 men, from the military and security forces and 900 firemen. Within twenty-four hours the contingent had risen to about 22,000 men; within forty-eight hours to 27,000, to reach a maximum of 47,000 rescue units, to which must be added 980 men made available by foreign countries (Table III).

Table III

Personnel and equipment involved in the emergency phase

	First 24 hours	First 48 hours	Maximum strength
Army	6,350	8,171	19,648
Navy	190	412	2,000
Air Force	2,400	3,300	5,400
«Carabinieri»	6,260	6,448	8,929
Public Security	3,390	4,150	4,311
Firemen	2,665	3,759	4,792
Excise Forces	612	675	1,217
Forestal Police			633
Foreign units			983
TOTAL	21.867	26.915	47,943

In addition, to improve the liaison between the central command and the field, an army officer was assigned to each of the 160 mayors of the most severely affected municipalities, to organize the flow of applications for help and the assistance activities whereas, in order to streamline the volunteer action of the Regions and of the Local Authorities, a plan of cooperation was implemented, which linked each Italian Region with a clearly demarkated area, on which assistance and rescue operations were focused.

Operation plans were also drawn up:

- to accommodate the homeless in tents and to arrange for the distribution of food and clothing;
- to set up an integrated communications system via radio and telephone;
- to coordinate the inflow of help and to set up appropriate collection centres;
- to restore the road and general lifeline systems along with the essential public utilities and services. This task was mainly carried out by the Corps of Engineers which managed to restore 120 km of road, 90 km of railway track, and to set up 8 bridges, in addition to demolishing 2,640,000 m^3 of unsafe buildings and clearing rubble and landslides.

Concerning assistance to the homeless, action was taken in various stages:

- temporary accommodation, in the first emergency phase, through the installation of 10,000 tents, for an overall 200,000 beds, and the provision of 1,230 railway carriages;
- accommodation during the winter period in caravans (32,000, for 110,000 inhabitants), in schools or in other public buildings (22,000 inhabitants); (Tables IV and V).
- resettlement of the population, through the use of light prefabricated houses and/or containers, and through financial support for the restoration of the dwellings.

Twenty five thousand prefabricated housing units, and 1,400 "monobloc" houses were erected; criteria for allocation were the following: the light prefabricated units were given to the municipalities in the epicentral zone, where the greater damage required longer periods for a return to normality; the "monobloc" houses and the containers, which were more mobile and consequently easier to remove when the emergency had passed, to the extra-epicentral zones. (Table VI).

For the implementation of the plan for light prefabricated units, an Advisory Technical Committee was set up to evaluate the temporary settlement projects, requesting municipalities to choose, through the "concessionary" system, the most appropriate solution to meet local requirements within specified levels of per capita area (10 m^2) and an average cost per m^2.

Some overall remarks

The rescue forces encountered a series of difficulties, which often slowed them down.

In particular:

- the prompt action of the rescue forces coming from the north of the country was certainly not facilitated by the mountainous nature of the stricken area and by the resulting length of the road network;

- the geological nature of the soils, the consequent landslides and the quantities of rubble, often made it hard to reach many of the towns and villages within the first forty-eight hours;

- the damage caused to the telecommunications system, the interruption of electricity supplies, the meteorological conditions considerably delayed a rapid reconnaissance, the dissemination of information and the immediate identification of the more severely stricken centres to be assigned priority.

Nevertheless, despite the difficulties encountered, the results of the emergency operations and of resettlement may be considered positive, thanks also to the unified direction assumed by the Commissioner and the organizational system used, which made possible a flexible and non-bureaucratic management of operations.

C. Reconstruction

Law for post-earthquake reconstruction

On May 14, 1981, with a modification of the previous Law 75 of March 19, 1981, Law 219 relating to the concerted measures for "the reconstruction and development of the territories affected by the earthquakes of November 23, 1980 and of February 1981..." came into force (cf. Annex 2).

The norms promulgated, as had already been the case for other earthquakes (Belice and Friuli), were not contained in a consolidation act but in various laws, which have followed one another, with relative frequency, up to the present.

The new Reconstruction Law, apart from containing provisions regarding emergency measures, sets up norms on:

- the repair and reconstruction of dwellings;
- urban planning;
- urban development projects;
- special measures for the City of Naples;

For reference, the norms can be divided into three large groups:

(a) Norms governing a temporary exemption from fulfilment of obligations to the State, Public authorities, and private individuals; also norms for carrying out urgent work which cannot be postponed (clearing of rubble, demolition, execution of work for shoring up unsafe buildings etc.) and the preparation of temporary accommodation, with emergency occupation if necessary of areas needed for the installation of shelters etc.;

(b) norms for the transition period, i.e. before the start of the reconstruction as such (repair of buildings, measures for occupation, costs of temporary accommodation etc.);

(c) norms for the reconstruction proper (urban plans, reconstruction activities, regional development projects). To these norms must be added those concerning the conurbation of Naples.

Annex 2 describes in detail the institutional aspects and framework of the technical regulations of Law 219 on reconstruction. We shall attempt in the following pages to shed light on and evaluate the results obtained from the application of Law 219 in concrete cases. More specifically, programming and coordination experience gained in the Basilicata Region is described in Chapter 4.2, while Chapter 4.2.2. deals with the recuperation and development programmes in the Comune of S. Angelo dei Lombardi.

Furthermore, Chapter 4.1 deals with a characteristic aspect of the law, and one concerning point c) above, in which the focal point is that of restructuring the production systems, understood as the supporting framework for the development of the areas affected by the earthquake.

Urban reconstruction programmes

One of the most significant improvements which the law made possible is certainly in the area of town-planning, where reconstruction of the ruined or damaged centres used ordinary instruments, activating them however with accelerated procedures. One of the objectives of the law is that of equipping, within twelve months, all the Municipalities stricken by the earthquake with an overall Master Plan.

Contents of Urban Plans

The damage categories into which the Municipalities affected by the earthquake are divided are as follows:

(a) Catastrophically damaged Municipalities

(b) Seriously damaged Municipalities

(c) Damaged Municipalities

The procedures which are described below are compulsory for the Municipalities classified as "catastrophically damaged" and optional for the others, even if later most of the municipalities found it advisable to update their own programmes and urban plans in order to have access to reconstruction funds.

In this respect, it is perhaps useful to give some of the provisions of Art. 28:

"Within 12 months from the coming into force of the present law, the stricken municipalities shall adopt or modify the general master plan or update the reconstruction plan provided under Law 1431 of October 5, 1962, in compliance with the guidelines of regional development laid down by the Region.

"To provide for the immediate needs of reconstruction, the municipalities themselves shall adopt or confirm the following plans, where necessary:

(a) the Zonal Plan (1) drawn up in compliance with Law 167 of April 18, 1962, and subsequent modifications, formulated on the basis of the requirement of urban areas for the construction of residential buildings destroyed or unreconstructible in situ;

(b) the Plan for production installations (1) as per Article 27 of Law 865 of October 22, 1971, which governs the need for urban areas to construct buildings intended for production activities, including those of commerce and tourism;

(c) the Recuperation Plans (1), as per heading IV of Law 457 of August 5, 1978, and subsequent modifications, which govern the reconstruction in situ of the buildings demolished or to be demolished, the reconstruction of those seriously damaged and the laying out of the areas of ruins of buildings demolished or those to be demolished which cannot be re-erected in situ".

and again:

"Where the "Recuperation Plan", as in c) above concerns centres of historical and artistic interest, the competent Office of the Superintendent must be consulted before its adoption; he shall take the necessary steps within 30 days from the date of application".

On the expiry of this term, the opinion is taken as favourable.

To those persons who are not able to reconstruct the buildings destroyed or those to be demolished in situ, there is direct provision or with delegation as per Article 8, d) above for the construction of accommodations and of production plants in the areas along with primary utilities and services... the areas themselves shall be granted in ownership even beyond the reservation of communal property and independently of the possession of the requisites".

Law 219 sets up norms regarding the implementation of reconstruction activities on the basis of annual programmes. Art. 6 of the law establishes:

"The "comune", the mountain communities, the provinces and the other public authorities, by June 30 of each year, shall define and transmit to the region their programmes of action for reconstruction and repair.

The Region, by September 15 of each year, shall approve and transmit a programme of action, including the programmes of its own sphere of competence, to the CIPE (1).

In the event of the term established not being kept, the Region will replace them for all and every purpose".

For the elaboration of the first plans, priority was given to the more immediate housing problems; these concerned chiefly the homeless families, accommodated through particularly difficult temporary arrangements. In the immediately subsequent phase, plans were prepared for the resettlement of the families lodged in prefabricated housing units. It is obvious that the implementation plans had to allow for the complex case-study method provided for in the law for the private settlements (repairs and re-construction depending on the drawing up of recuperation plans, on integrated inverventions delegated by the owners to the "Comune", on the granting of areas to private ownership for the construction of houses to be built in situ, on the elaboration of programmes to facilitate construction for homeless tenants etc.). In this respect, we should note that for the "Recuperation Plans" a modification was brought to Law 219 on the basis of Law 187 of 1982, for the enlargement of the urban reference boundaries (see Chapter 4.2), which in the regulations then in force had referred exclusively to urgent interventions in the historic centres proper.

A general criterion was that reconstruction must be made in the place where the built-up area already stood, unless there were impediments of a geological, technical or social character; in the event of this not being possible, reconstruction might be carried out in another zone provided it fell within the territory of the same "comune"; in any case communal authority was fully entitled to decide the matter. The sole limitation set by the law was that reconstruction must safeguard the pre-existing social and cultural characteristics:

"This means that in the work of reconstruction it is necessary to keep constantly in mind the features belonging to each community, its history, its *traditions, its customs, in other words everyting that contributes towards* giving that community its own historical identity.

"Essentially therefore, the "comune" provided with a general urban instrument (General Master Plan or Reconstrucion Plan) must proceed with a verification of the needs for areas for the erection of new buildings for housing and for production purposes and with a check on the buildings which can be reconstructed or restructured if seriously damaged, in order to draw up the plans we have just mentioned.

"These are operational plans and, therefore, once approved, come immediately into effect" (1).

---

(1) According to Italian Law the municipalities can on their own or combined in consortia draw up Plans of the Areas to be assigned to production installations, within the framework of Urban Plans and with the approval of the Regions.

Reactivating and strengthening the production systems

Law`219, in addition to the reconstruction of the settlement structures which have been damaged, also proposes repair and strengthening of the production structures, in order to contain above all the exodus which the effects of the earthquake would have made more acute.

To face up to this situation, Law`219 granted to the industrial enterprises which had plants in the Basilicata and Campania Regions and in the Municipalities of Apulia a contribution of 75% (Art. 21) of the costs needed for:

- the repair or reconstruction of the plants and of all the equipment needed in order to carry out production;
- the improvement and functional upgrading of the plants;
- the purchase of land in the same municipality, should seismic reasons or urban-environmental constraints make a reconstruction in situ not possible.

In a first phase, the jurisdiction had been assigned to the Ministry of Industry, but Law`187 transferred it to the Prime Minister. The latter was to modify the procedures - judged in the course of implementation as being somewhat complex - which provided for the forwarding of an application to the competent Ministry and to a Provincial Commission, along with the permit or concession to build (issued by the mayor) and with a sworn expert opinion (drawn up by a technical officer). Moreover, it must be evident, inter alia that the number of persons previously employed by the firm remained the same.

Along with this system of broad measures, which aimed at putting back together the pre-existing industrial tissue, Law`219 (Art.`32) provided for programmed interventions (which still enjoy a 75% outright grant) for new areas. In this case the task of identifying these areas for the purpose of "stimulating industrial installations of medium and small size, as well as commercial ones in a supra-communal environment" (within the context of their territorial development guidelines, and on the proposal of the Mountain Communities) was assigned to the Campania and Basilicata Regions.

These programmed measures are given maximum importance locally and the implementation of Law`219, Art.`32 is considered an important contribution to the widening of the production and occupational base.

In putting Art. 32 into effect, the Mountain Communities identified the areas within the time frames provided for in the Law and the Regions subsequently approved these locations.

The second Law, 187 of 1982, helped clarify a situation which the complexity of the procedures and the great number of initiatives risked jeopardizing. The responsibility was delegated by the Prime Minister to the Minister of Civil Protection. The funds appropriated by CIPE (900 billion), to which were added EEC-EIB funds, were distributed as follows: 31.1% for repair and reconstruction investments, 55.6% for investments in programmed areas, 11.1% for cooperative efforts and 2.2% for the contribution of the guarantee funds.

D. Putting Law No. 219 for reconstruction into effect

The following paragraphs set forth the results obtained with the application of Law 219; they will be commented upon and compared with the actual reconstruction experiences. In particular, frequent references will be made to two especially significant situations:

(a) The coordinating role that the Basilicata Region played in the reconstruction and urban improvement of its municipalities. Basilicata, in effect, was able to carry out the functions provided for by Law 219 without the conditioning factors which the coastal and metropolitan conurbations of Campania had to cope with when drawing up their regional administrative strategies and procedures.

(b) The urban and district planning in S. Angelo dei Lombardi, for the reconstruction of a centre which in some ways assumed a symbolic value among towns and villages hit by the earthquake (Table I). S. Angelo was in fact among the settlements most drastically damaged by the earthquake and not only in terms of lives and material damage; S. Angelo had facilities which had served a vast subregional district (hospital, magistrates' court, law courts, prison, various public offices) which gave it a key role despite its small size. These facilities were destroyed by the earthquake and the reconstruction targets had, of necessity, to take into account the need to restore these functions and provide the residents with an occupational structure which would be in keeping with their customs and qualifications.

Naturally, these two examples will be referred to in correlation with the more general context in which they are situated.

It must be noted *inter alia* that the work team which drew up these documents had worked on both the above cases, so that the information and comments reported here stem from the direct experience gained through the technical development of the plans and above all from comparisons with the competent administrative (and political) bodies.

Reorganization of the urban settlement systems

The November 1980 earthquake struck a particularly vulnerable urban structure. This had to do with building techniques: most of the buildings in the historical centres had been built with rough-hewn stones cemented with lean lime mortar, which had become powdery with the passing of time; the horizontal structures were often not connected together. Of even more decisive effect in causing catastrophic situations was however the vulnerability of the settlement systems seen from the point of view of urban organization.

The uneven landform, the siting of the towns on hills (hill towns) and consequently their difficult accessibility, due also to the marked instability of the slopes on which the links between the various centres run; the shortage of open spaces or public buildings which, on account of their size and functions could rapidly be transformed into shelters for the victims; the winding alignments of the street network in the settlements: all these are typical features, common to almost all the historical towns of southern Italy, which inter alia, is hit by earthquakes of catastrophic magnitude with impressive regularity. It may be said that a resident of that area has been present at minimum two very important seismic events in his lifetime - provided, of course, he survives the first.

It is therefore surprising that the attitude of the residents of the inland zones of southern Italy towards the need for a progressive adaptation of the residential structures to the objective situation of risk in which they live should be so lax. The "earthquake culture", as is called, which in Japan has had a deep effect on the criteria with which the city and the dwelling houses are recollection of the catastrophe fades rapidly; it is probable that only a cyclical rhythm characterized by an imminent "period", as is the case in Japan, will manage to make the phase of being on the alert coincide with the phase of emergency, in order that the behaviour of citizens change. In the south of Italy, the 40-year cycle of serious seismic events seems only to have the effect of paralyzing the processes of reaction and making the decisional capacities of the local authorities even more sclerotic.

Reorganization of urban management procedures

Indeed, the November 1980 earthquake found a very inactive, if not actually lethargic, situation in the functional and administrative life of the urban system. For example, the team of technicians called in to assist the Basilicata Region in organizing and coordinating the documentation required for reconstruction, was confronted with the fact that out of 79 stricken municipalities, despite the specific prescriptions of the Italian law, only 11 were provided with a General Master Plan, 57 were provided only with the so-called Building Programme and 11 had no operational urban planning instruments whatsoever.

Concerning the so-called executive plans , 60% of towns and villages did not have any plans for low-cost public housing; 80% were without the Production Installation Plans (PIP) and only 9 out of 79 municipalities had drawn up Recuperation Plans for the Historic Centres.

Immediately after the earthquake and on the basis of the provisions of Law 219, the Communal Authorities undertook an intense but disorderly planning action; one year after the earthquake, out of the 79 municipalities in Basilicata indicated above, 35 had drawn up the Recuperation Installation Plans. Only 8 however had submitted the General Master Plans for Regional approval (Law 219 in fact required that the towns without Master Plans should prepare documents from which the general guidelines of the Plan, to be prepared within a year, would be drawn). But many documents submitted by the towns for regional approval were objectively devoid of the minimum elements required for approval.

It should be recalled that the smaller towns of the inland areas had for decades based their urban policies on the use of the Building Programme: a document with an outdated and static normative structure, exclusively limited to the areas subject to building development, and almost always drawn up on the basis of rudimentary and stereotyped analysis. Every planning document which was based on an extension or detailed definitions of the Building Programme (as in fact were most of the final plans submitted in the very short periods initially imposed by Law 219) proved to be unacceptable and scientifically unreliable.

The technical assistance teams which the Basilicata Region put into action (having recourse as provided for by the law to employing outside professional forces) resumed the task of the reorganization of the procedures for drawing up the Plans.

To meet the shortage of basic research and scientific specialities in the various disciplinary sectors which, at the technical-structure level of the communal authorities, had proved indispensable for implementing the Law for Reconstruction, the Basilicata Region requested that the technical assistance structure be based on various specializations:

1. Town-planning: mainly for methodology definition and to assist the Communal Technical bodies in putting together the basis for the analytical and design phases.

2. Engineering: consolidation, repair and reconstruction of the buildings damaged or destroyed by the earthquake; aseismic techniques in general.

3. Legal-administrative: interpretation of Law 219, for the processing of applications to obtain contributions, for drawing up agreements etc.

4. Technical-administrative: structures, requisites, preparation procedures and administrative management of urban planning documents.

5. Geology: criteria and techniques for geognistic soundings for the preparation of seismic microzoning maps.

6. Informatics: guidelines for the elaboration of computer programmes for financial and administrative management.

Assistance was based geographically on working groups operating out of the premises of the Regional Offices at Potenza and located at Communal headquarters lying in a central position with respect to areas characterized by a certain homogeneity of damage and settlement typology.

In line with the spirit of the law for reconstruction, the main control function of the Regions consisted in analysis and approval of the general and executive urban instruments prepared by the municipalities, and in the provision of funds for the activities provided for in the plans themselves.

In performing these tasks, the Regions had to frame them in an overall action of control (with the possibility of taking the place, if necessary, of the defaulting towns) for defining priorities considered within a general framework of regional development so as to draw up a scheme of harmonious development, the aim being to avoid two types of imbalance:

- that which could stem from spontaneous phenomena already in progress (e.g. the imbalance between the stronger contractual and political power of the coastal municipalities and that of the weaker inland areas);

- the imbalance emanating from the process of more rapid functional reorganization of the less severely stricken towns vis-à-vis those catastrophically damaged, whose decision making structure had remained - as it were - paralyzed by the seismic event.

Urban development and recuperation of historic towns

As concerns the historic towns destroyed or damaged by the earthquake, the requisites of the Recuperation Plan included in the urban planning legislation in force had to be adjusted to meet reconstruction needs.

Methodological guidelines for the recuperation measures

Within a unified plan, the parts of the built-up area struck by the earthquake, whose repair and reconstruction had to be carried out under emergency procedures, and those subject to degradation, due to natural causes, like most historic towns in the area, had to be indicated clearly and included in systems of differentiated interventions.

But apart from its technical aspects, the subject of "recuperation" in the area struck by the earthquake had to be set within a framework of the combination of actions aiming at the rehabilitation and functional reactivation of the urban systems. For example, among the reconstruction objectives of the historic centre of S. Angelo dei Lombardi was that of revitalizing the most ancient part of the city with the safeguarding of its social structure, and with the introduction of public, commercial and handicraft services. In the majority of cases, the intention was to reconfirm the principle of urban restoration, already tried out for example in the town of Venzone (Friuli), according to which the laws of growth of the building organism constitute the principal point of reference; the rehabilitation would be based on processes which, of themselves, would guarantee the overall morphological recomposition.

With the objective of the reconstruction of the urban tissue by modules equipped with the functional requisites, the operation of launching the recuperation process of the traditional historical structures was, in the majority of cases, based on the following phases:

(a) Architectural and static inventory of buildings: identification of the building; ground plan; photographic documentation; architectural and functional characteristics; architectural features of historical or artistic importance; survey of the real-estate units with identification on the land registry records; amenities and sanitary and public health conditions. With the static inventory, a survey of the damages suffered by the buildings was obtained concerning their structural characteristics and insfrastructure, with a survey of the vertical and horizontal elements and of the foundations; checks on buildings collapsed or demolitions subsequent to the first interventions, for the purpose of supplying the town with supporting documentation for drawing up an urban plan, but above all in order to provide a basis for comparison with the repair projects implemented in the emergency phase.

The implementation of the Recuperation Plan for historic towns was conditioned by the structure of the building organisms and by the articulation and fragmentation of property. This is the reason why the following criterion was generally applied:

(b) To identify the Minimum Units of Intervention (MUI), understood both as structural elements and as functional aggregations, one had to bear in mind the parallel development of reconstruction and repair, as well as aseismic adaptations for adjacent (common wall) and/or overlying properties. The reconstruction of the whole block, i.e. many properties, must occur contemporaneously. From this stemmed the need for the owners to form consortia for planning and executing the work.

(c) In accordance with the legal stipulation to permit a unified design of the Minimum Units of Intervention, the right was granted to owners' consortia to delegate if necessary the planning and implementation activities to the municipality.

In any case, the Communal Authorities had to make sure that the intervention on the individual MUI respected building volumes, the conservation or restoration of the environmental values of the building profiles and of urban facilities.

Points to be considered when formulating a Recuperation Plan
Example: S. Angelo dei Lombardi

Each of the Minimum Units of Intervention (MUI) included a number of buildings with various types of damage and with, at times, very complex property structures (Fig. 3).

The choice of such ample MUIs originated from the need to frame initiatives which, because of their dimensions and structure, would maintain the morphological unity of the blocks. Meanwhile an attempt was made to encourage the delegation of powers to the "comune", which would be able, better than individuals, to operate with integrated systems and to guarantee public supervision of the reconstruction phases.

The measures envisaged by the Plan (Fig. 4) are divided into four categories:

Restoration A1: concerning the most architecturally significant buildings; their original value as well as their architectural and ornamental features, such as portals, external staircases, plaques etc., would have to be restored;

Restoration A2: measures limited to the reconstruction of some nuclei of complexes of historic and/or architectural value outside the historic centre proper:

Restoration A3: concerning buildings wholly or partly renovated in the recent past, of which the volumetric characteristics alone would have to be preserved.

Restoration B1: concerning the sites of the destroyed building units: the reconstruction would have to observe the limits of the foundations as shown in the land registry ground plans and follow building typologies similar to those prevailing in the site.

With the aim of recreating the urban set-up which had become fragmented and disjointed, extensive zones were envisaged for safeguarding the environment and for afforestation, as a veritable protective boundary.

In addition, care was taken to keep the layout of the road system, reconfirming the linking function of the network of squares, including (within the boundary of the historic centre) the concerted expansion of three suburbs adjoining the Centre proper (S. Rocco, S. Maria and Piaggio).

E. Organizations responsible for managing emergencies in Italy

Over the last thirty years, the Italian government has had to take action to cope with a pressing sequence of seismic emergencies.

The events referred to can be classified in two categories: the major ones which affected areas of vast dimensions (Irpinia 1962; Belice, in Sicily, 1956; Friuli, 1976; Irpinia, November 1980) and those which, although not disastrous nevertheless seriously damaged important towns (Tuscany 1971, Ancona 1972; the "swarm-type" seismic activitiy still in progress in the "Campi Flegrei", at Pozzuoli-Naples).

During the same historical period, the State often has also had to take measures to assist the populations of vast areas struck by floods, forest fires and industry accidents (e.g. Seveso).

The decision had been maturing during the course of these experiences to establish a State agency for the coordination of all civil protection measures. On the occasion of the Friuli earthquake, the government set up a Special Commission to manage the emergency phases of the earthquake in 1980; in 1982 a Department was finally set up under a Minister for Coordination of Civil Protection.

The Minister is responsible for the activities of preventive planning and coordination of the measures to be taken for various types of emergencies, the management of equipment and the training of both hired personnel and volunteers.

The internal technical structures of the National Department directed by the Minister are the "Forecasting and Prevention" and "Emergency" Services; liaison functions with other State organizations and with the local administrations are assigned to an "Operations Room"; scientific assistance is provided by the "Major Risks Committee" (Comitato Grandi Rischi) made up of experts in various disciplines with advisory functions, which meets either at regular intervals or in the event of a calamity. The measures to be taken are finally decided upon within the sphere of a summit executive committee (EMERCOM) in which the Minister of Civil Protection and those in charge of the institutions involved when necessary (other Ministries, local authorities etc.) take part.

The almost simultaneous coming into force of Law 219, the setting up of the National Department and the appointment of the Minister responsible for coordinating Civil Protection operations is obviously no coincidence.

In effect, Law 219 despite its evolutive setting and its orientation towards the principles of reconstruction in a dynamic sense remains a legislative document drawn up a posteriori to make up for organizational and institutional shortcomings.

The conceptual structure of Law 219 will remain a framework within which to outline the objectives and strategies of Government action in the event (deprecable, but not unfortunately improbable) of future emergencies; however, it is precisely the operational methods and procedures provided for by the Law which have proved less satisfactory in recent experiences.

The events in Irpinia, struck by earthquake, have finally drawn attention to the need to adapt the criteria and techniques of urban and regional planning - as well as building design - to the objective of safety in crisis or "stress" situations; the need to design but above all to manage in a dynamic way systems of preventive "immunizaton" and programmes of emergency action on the basis of predetermined models.

The National Department and the Ministry which oversees it have the duty to develop appropriate preventive methods and techniques for the more exposed areas of our Country, but above all to provide them with the means (materials, men and equipment) necessary both to reduce the threshold of vulnerability of the settlement systems and to operate effectively in case of need.

Current equipment and operational possibilities of the National Department of Civil Protection

At the present time, the National Civil Protection Department has at its disposal an Operations Room located in the premises of the Department itself, which, in emergency situations, constitutes the headquarters of the Executive Committee (EMERCOM).

The equipment of the Operations Room is progressively upgraded; it is expected that in the near future the Operations Room will have equipment to allow fully automated techniques for the reception of messages and for data processing.

Meanwhile, the programmes and software have already been made ready; when computerization is put into effect, a data bank (numerical and cartographical), already prepared as support "inputs" for EMERCOM's activities, will be made available to the Operations Room personnel.

In particular, the procedures developed (i.e. the evaluation and forecasting "modes") make it possible to identify and classify, by typology, the risk conditions predictable in the country's territory; the definition of the "risk areas" can be made by taking into account, in addition to geographic location, those factors which determine cyclical or evolutive temporal variations (e.g. seasonal ones).

Hypotheses for putting into effect a system of fully equipped territorial "strong points"

All the elements described above constitute for the Department an effective instrument for programming and coordinating the distribution of means, equipment and competencies over the national territory, in relation to the requirements estimated on the basis of technically and politically defensible criteria.

The hypothesis (to be verified analytically, but convincing in its general aspects) follows the setting up of a system of Zonal Centres, located near the bary-centres of areas with homogeneous characteristics of vulnerability (and of potential hazard); the information available at the technical service of the department will allow, through the Informatics System described, the calculation of the equipment to be supplied to the various Centres taking into account temporal fluctuations as well.

The structure of the Zonal Centres may thus be considered the cornerstone for the implementation of a protection strategy for the national territory. The Zonal Centres can be used as territorial "strong points", which apart from the functions of collection and distribution of personnel and equipment can assume the role of a link between central and peripheral decision-makers on the subject of assistance, but above all be the centres for prevention, monitoring and training of the operators responsible for Civil Protection.

It is important to note that the Zonal Centres must be considered as centres of a system equipped with great dynamic capacity. The flows of material, personnel and communication messages among the various Centres must respond to the continuous variations of the conditions of risk integrated in the operating models at the Department, in order to avoid tie-ups in the system.

The National Centre, at this point, should not be involved in functional or management coordination (which would be reserved to the Operations Room), but should act solely as an "expansion chamber" for the system.

Thus, the National Centre will maintain and redistribute the equipment to ensure flexibility:

- to the procedures of renewal and updating of the material (turnover);
- to the operations of routine and extraordinary maintenance (mechanical assistance, storage, spares, painting and fittings etc.);
- to the disposal (not least through sales to private individuals and Italian and foreign bodies) of any surpluses of equipment to be replaced;
- to the accumulation and redistribution of equipment and supplies coming from national or foreign suppliers on the occasion of emergency situations or operations for the renewal of stocks.

Functions of the peripheral "strong points"

Some considerations on the functional nature of the system of Centres in full operation or in emergency conditions are set out below.

To the Zonal Centres may be delegated:

(a) The setting up and management of the monitoring network;

(b) Training programmes for the personnel and preparation of scenarios to activate periodic practical exercises;

(c) The organization of operation control boards in coordination with the Operations Room of the Ministry of Civil Protection and the initiation of the pre-alarm and alarm procedures in relation to the "safety threshold" determined in advance.

(d) The management of equipment and the local coordination of assistance activities under emergency conditions.

With regard to the last item, it must be pointed out that the Zonal Centres will manage the offer of specialized entrepreneurial structures (i.e. companies producing prefabricated buildings, containers, mobile health units, construction equipment generally); they will also promote the development of modes of communications through a system based on national or local telematics networks, to assist for example in a progressive integration between government procedures and public opinion.

International coordination among structures of emergency operations

It must be recalled that the size and technological effectiveness of the equipment for intervention in an emergency must inevitably be matched with the predictable requirements in the event of major calamities.

Bilateral or multilateral agreements among bordering countries would make it possible to intervene in the event of a calamity not only through rescue teams but also through the immediate, "automatic", help of Civil Protection organizations of other States. The advantages are obvious: from prompt intervention with rescue personnel and means to match the needs, to the economic advantages stemming from the more frequent utilization of the means prepared. Moreover, each country's equipment could be placed at the disposal of other countries [1].

If these proposals were adopted, the countries of the whole Mediterranean area could gradually adhere to an agreement aiming at unifying and coordinating the national Civil Protection Organizations.

From the procedural and organizational aspect, the range of problems to be tackled is very vast: very specific ones - such as the preparation of catalogues of materials and medical equipment produced by various countries; the definition of ways in which to use the professional and specialized skills from other countries and the development of strategies at international level for the management of assistance to be given from one State to another.

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(1) A proposal upheld at recent international congresses; in particular by the French Secretary of State for Civil Protection, M. Tazieff, in Geneva (Engineering 84)

The Zonal Centres, with the Coordination of the Operations Room of the National Department of Civil Protection, could play a decisive role in managing the exchanges with the corresponding structures in other countries, assuming *inter alia*, the (delegated) responsibility for streamlining procedures and solving any problems that may arise.

4.6 EXPERIENCE OF MONTENEGRO IN PHYSICAL DEVELOPMENT PLANNING FOR SEISMICALLY MENACED AREAS

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A. The earthquake of April 15, 1979.

The characteristics of the earthquake

Undoubtedly, the greatest devastation in Montenegro in recent times was caused by the series of earthquakes, which had their epicentres offshore of the Montenegrin coast and along the coastline itself and occurred during 1979. This series of earthquakes began with a shock on April 9, 1979 and lasted almost two years. However, the earthquake which caused the greatest devastation was the April 15, 1979 earthquake which had the following characteristics:

1.	Hypocentral time	15.04.1979, 06h, 19'40,0''
2.	Magnitude	7.1 Richter
3.	Intensity	IX° MCS scale
4.	Epicentre latitude	41°55'2''
5.	Epicentre longitude	19°0,06'
6.	Hypocentre depth	17 km

The devastation of this earthquake manifested itself much more in a southeast - northwest direction (viewed from the epicentre), i.e. along the sea coast, than in the direction transversal to this, i.e. from the southwest towards the northeast, in which direction its force diminished faster. This is due to the geological composition of the territory of Montenegro. The muffling of seismic force along the strike of the Dinaride structure is lower than in the direction transversal to it. This was the regional manifestation of the earthquake of April 15, 1979. In addition, this earthquake activated numerous faults, some along the Dinaride strike, some transversal and diagonal to them. Along these faults there occurred particularly devastating effects of the earthquake, with considerable deformations of the ground and demolition of practically all buildings along these faults.

The consequences of the earthquake

This earthquake caused ground deformation, demolished a great number of buildings from Skadar to Dubrovnik, bringing about extensive damage to the whole territory of Montenegro and further causing the loss of 101 human lives. The total loss caused by this earthquake is estimated at approximately four billion U.S. dollars.

The April 15, 1979 earthquake caused devastation along the Montenegrin sea coast including Crmnica and the hinterland and covering not only the area to Niksic and Titograd, but also the whole territory of Montenegro.

On the sea coast and in the hinterland, the Crmnica and Zeta depressions, the earthquake caused: big waves on the sea and on Lake Skadar, a temporary change in the coastline, a mud-drying of surface and underground waters, a drying up and pulsating of springs, the activation of old and new landslides, rock-falls, liquefaction, considerable destruction and demolition to structures (houses, hotels, schools, hospitals, roads, bridges, docks, buildings along railways, waterlines, sewerage facilities etc.). Practically the whole housing stock was destroyed, leaving approximately 80,000 inhabitants without a roof over their heads. 250 municipalities were heavily damaged. Approximately 30,000 workers were practically left without employment as a result of damage to industrial and other economic facilities.

Particularly considerable devastation occurred to cultural and historic monuments and particularly to urban and rural entities, monastery complexes, fortifications and single buildings of sacred and profane architecture as well as to other structures of cultural importance.

The classification of damaged buildings

One of the first measures taken after the shock was the recording of all the damaged structures on the basis of a uniform methodology. The classification of the damaged buildings was carried out so that an evaluation of the damage could be made in the initial phase which would later serve as a documentational basis in the phase of physical planning, for the evaluation of the vulnerability of constructions.

B. Long-term measures of reconstruction and development in the earthquake area

The conditions for the effective and successful meeting of the goals of the Programme of continuing reconstruction and development of the afflicted area were set down with the implementation of the Temporary Programme for Reconstruction and Development through the provision of the necessary funds and the appropriate regulations in all segments of social activities. In order that all further activities be conducted in a planned and rational manner, the Long-term Programme of Reconstruction and Development of the Afflicted Areas was drawn up, in which all questions of vital importance for the future organization of life and work in this seismically menaced area were defined.

The conception of continuing reconstruction and development in accordance with the resolutions decided upon was harmonized with the socio-economic development of Montenegro; thus the reconstruction of the damaged and destroyed material and cultural values and goods at the expiration of the period of reconstruction and development was supposed to make up the lost tempo and to create the conditions for further development of the afflicted area. As a result, the process of reconstruction and development required effective and harmonious performance of all the social factors.

The Programme established and defined the following basic directions and goals of reconstruction and development:

- that, in accordance with development possibilities the reconstruction and development be assured at a modern technical and technological level,

- that, at the expiration of the period of reconstruction and development, the tempo of development lost as a result of the earthquake be compensated,

- that reconstruction and development be uniform, continuous and in accordance with both needs and possibilities.

- that effectiveness of investment and rational use of finances be assured in the reconstruction and development,

- that reconstruction and development be conducted in accordance with the contemporary requirements of the economy,

- that reconstruction and development be conducted in accordance with the contemporary requirements of science for construction in seismic areas,

- that reconstruction and development be set to and adapted to the requirements of physical planning and land use, and

- that reconstruction and development be complementary with the requirements and possibilities of development of the Republic as a whole.

The goals set within the framework of the Long-term Programme of Reconstruction and Development were coordinated with the Plan for the use of finances provided exclusively for this purpose.

Physical and urban planning

Up to the catastrophic earthquake of April 15, 1979, which struck most heavily the Montenegrin sea coast and its immediate hinterland, Montenegro had two regional physical plans. The regional physical plan "The South Adriatic" (adopted in 1969) and the Regional Physical Plan of Northern Montenegro (adopted in 1971); the whole area of the Republic was thus covered by these plans. Both plans were drawn up with a projection of development up to the year 1990. In accordance with the solutions included in both of these physical plans, the master plans of Ulcinj, Bar, Budva, Boka Kotor (Kotor, Tivat and Herceg Novi), Cetinje, Titograd, Danilovgrad, Kolasin, Mojkovac, Bijelo Polje, Ivangrad, Plav, Rozaje, Zabljak and Pluzine were drawn up.

On the basis of these plans, several master plans and urban desings were drawn up, in which solutions from the higher-level plans were closely defined and developed. The majority of these plans were not elaborated on the basis of microseismic investigation data; thus they did not include the components of seismic hazard and risk as preconditions for the physical distribution of structures, nor for aseismic planning and construction.

This gap in the plans was the decisive factor for the large number of buildings demolished or damaged in that earthquake.

The existing geoseismic bases

The first seismic regionalization of the whole territory of Montenegro was carried out in 1950, within the framework of the published Seismological Maps of FNR Yugoslavia at 1:1,000,000 and on the basis of the distribution of isoseists of earthquakes from 360 to 1951. This map was an integral part of the Preliminary Technical Regulations for Building under Seismic Conditions. According to this map the seismically most active areas were isolated areas in the vicinity of Ulcinj, Bar, Budva and Boka Kotor Bay, as well as in the hinterland of Titograd. These regions were distinguished into areas of up to and including IX° MCS scale.

Seismic microregionalization of urban areas in Montenegro

After the Skopje earthquake of 1963, at the end of the seventies and at the beginning of the eighties, certain seismological investigations were carried out on the basis of which maps of seismic microregionalization of the urban areas of Ulcinj, Bar, Budva, Herceg Novi and Titograd were drawn up. The consequences of the 1979 earthquakes confirmed the seismic parameters defined in the maps of seismic regionalization of the above mentioned urban areas.

In Montenegro, immediately after the earthquake of 1979 the elaboration, revision and implementation of a project of seismogeological investigations was started, with the aim of collecting the indispensable seismological data for the elaboration of the seismogeological work documents with seismic microregionalizations of the terrains of urban areas, for all of the communes on the territory of Montenegro. Such bases have already been elaborated for the urban areas of Ulcinj, Bar, Budva, Tivat, Kotor, Herceg Nov, Cetinje and Niksic, while for the other communities investigation is under way or will soon begin.

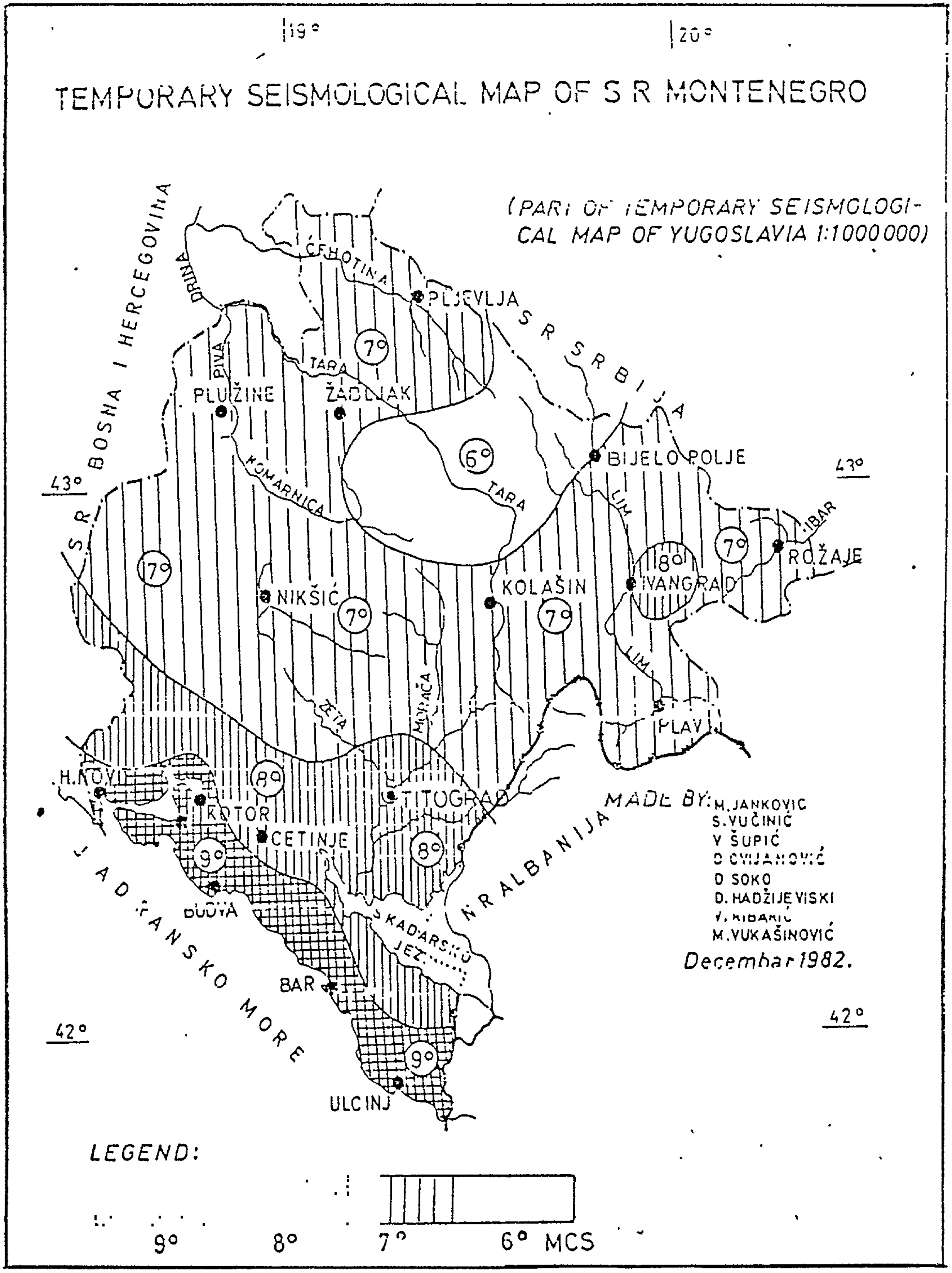
The seismological bases of seismic microregionalization for urban areas of communities on the territory of Montenegro, (topographical bases on a 1:5,000 scale) are crucial for the elaboration of master plans. These bases contain, besides maps of seismic microregionalization, hydrogeological, geo-engineering maps, morphometrical maps, maps of ground stability and maps of ground stability for urbanization in addition to geological criteria. These bases give not only all the indispensable geological data for the elaboration of master plans; they also provide guidelines for land use in many zones of urban areas.

After the 1979 earthquake new projects were launched, or old ones revised for the collection of all necessary data for the rehabilitation and revitalization of old towns (Ulcinj, Bar, Kotor, Toplica, Budva, Savina, Herceg Novi) as well as industrial, cultural, educational and other buldings. This investigation was conducted and completed through complex geological and other methods of investigation and it entailed such voluminous work, that in addition to maps of seismic microregionalization at 1:1,000, hydrogeological, geo-engineering, morphometrical maps and maps of ground stability at 1:1,000 were also drawn up.

These bases were the foundation for the drawing up and adoption of detailed plans for the rehabilitation and revitalization of the buildings for which they had been drawn up.

Revision of existing physical plans

The consequences of the catastrophic earthquake of 1979 hastened the need for reviewing the bases on which the existing physical plans were drawn up. Accepting the newly originated circumstances and the unavoidable fact that development, especially physical and urban development, must be set on a new basis, and accepting the recommendations of the United Nations officials and the Mission of UNESCO experts, which visited Montenegro immediately after the earthquake, the Assembly of the Socialist Republic of Montenegro, on June 25, 1979, came to the decision to set in motion the procedures for the Review of



SEISMIC ZONING MAP OF THE SR MONTENEGRO (1:1,000,000):
BASIC DEGREE OF SEISMICITY (MCS) IS RELATED TO THE MINIMUM SOIL CONDITIONS

the Physical Plan of the Republic while, at the same time, defining the basic tasks in the revision process, as well as obliging the communes, to ensure coordination with the Physical Plan of the Republic by joining in the revision process or by elaborating their own master plans.

Technical aid for the revision and elaboration of these physical plans was offered by the United Nations through the Development Programme (UNDP); at the end of 1979, the Project Document was drawn up and officially accepted and signed in the first half of 1980 by the United Nations and the Government of Yugoslavia under the title "Physical Planning in the SR of Montenegro" (YUG/79/104). The Project covered the revision of the Physical Plan for the SR Montenegro and a revision and elaboration of master plans for all the communal centres.

In accordance with the Decision of the Assembly of the SR of Montenegro and the Project Document, the revisions of the Physical Plan of the Republic were to be conducted in accordance with the system of social planning and modern scientific and technical achievements in this field.

For such complex tasks, the Project Document defines the fundamental methodological framework which, due to the pioneer undertaking mainly in the field of aseismic physical planning and with the engagement of experts of varied profiles both Yugoslav and international, must be continually updated so that it shall take its final form with the completion of the Project.

Global methodological targets given in the Project Document cover: the phase of plan elaboration (information, documentation and analysis with the evaluation of physical data, base studies* and the evaluation of the current situation, the elaboration of the Plan Bases, Draft and Suggestions), integrated planning, the simultaneous elaboration of physical plans at various levels, the creation of an information system within the Project and the inclusion of Yugoslav experts in the teams of experts of the United Nations in the process of plan drafting.

Within the methodological aspects of the Project, a particular role is given to aseismic physical and urban planning, which is developed to the level of in-depth study of the physical characteristics and the definition of seismic hazard and seismic risk with the intent of arriving at preventive measures of protection through physical plans, by which a safer life and the protection of material goods within the territory of Montenegro are ensured.

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* For the needs of reviewing the Physical Plan of the Republic the following studies were conducted: Economic Development (general study), Industry, Tourism, Agriculture, Naval Economy, Energy, Hydrotechnical System, Transport, Population, Settlement Network, Tertiary Activities, Sociological Aspects, Nature Preservation, Preservation of Landscape, Hydrological and Climatic Characteristics, Hunting and Fishing, Forestry, Pedological Characteristics, Land Use and Land Policy, Vulnerability and Seismic Risk, Heating, Mineral Resources and other reports of smaller scope.

Activities of Project Implementation YUG/79/104

Planning the work in Project YUG/79/104 started in September 1981.

The revision of the Physical Plan of the Republic was entrusted to the Institute of the Republic for Town Planning and Design - Titograd, while the revision and elaboration of the master plans of communal centres to well-known planning institutions from Montenegro and other Republics of Yugoslavia.

As coordinator of these activities, the Project Administration consisted of the Committee of the Republic for Town Planning and Civil Engineering, as an auxiliary body of the Executive Council of SR Montenegro.

The executive agency for the implementation of technical support of the United Nations in this Project was HABITAT - Nairobi, while UNDRO - Geneva was associated with the project.

In order to include as fully as possible local institutions and experts, to make use as rationally and effectively as possible of the specialist potential which was engaged in the Project, particularly United Nations experts, and in order to ensure greater possibilities of acquaintance with the specific characteristics of the individual environments, the revision and elaboration of master plans were organized in ten centres grouped on a subregional basis.

For specialized direction, particularly of the complex tasks at the level of the Project, an Expert Staff, Coordination Body and Specialized Commission were formed. All these bodies had precisely defined responsibilities and tasks in the revision of the Physical Planning of the Republic, as well as in the revision and elaboration of master plans.

Planning activities for all plans were carried out by the specially created work teams; research and the drafting of working papers, general studies and base studies in individual fields were carried out by numerous specialized institutions from throughout the country. There was synchronization of individual activities among the work teams and the researchers.

The specialized support by United Nations experts was directed towards defining research and planning programmes, applying modern research to the methodology of physical and urban planning and in choosing the optimal model for physical development.

A special contribution to the solving of specific open questions, which occurred during the implementation of the Project, was made by a group of high-ranking United Nations experts engaged within the scope of Project YUG/79/003 "The International Consultative Board",in collaboration with distinguished Yugoslav experts.

The results obtained within the framework of the United Nations Regional Project REP/79/014 "Reduction of Seismic Risk in the Balkans" and REP/79/015 "Construction under Seismic Conditions in the Balkan Region", were of exceptional help to the planning teams, particularly in solving problems in the field of earthquake engineering and engineering seismology.

Financial resources and technical conditions for the implementation of such an extensive and complex Project were ensured by Montenegro and the United Nations Development Programme (UNDP).

Measures taken for the implementation of aseismic physical planning

In order to carry out the goals set forth in the Project, especially concerning the introduction of seismic hazard and seismic risk as essential elements in the elaboration of physical and urban plans for seismically threatened regions in Montenegro, numerous, large-scale investigation activities were carried out.

For the accomplishment of these undertakings, three programmes were set up:

- the programme for regional geological, geophysical, hydrogeological, geotechnical, geo-engineering, seismological and seismo-engineering investigations for the needs of the Physical Plan of the Republic;

- a research programme to complete the seismo-geological data bases necessary for the revision and elaboration of master plans; and

- a research programme for the restoration of old towns and selected monastery complexes and other cultural and historical monuments.

Within the scope of the programme for completing the necessary geoseismic bases for the Physical Plan of the Republic, geoseismic data bases were elaborated taking the form of a working paper on seismic regionalization of Montenegro with maps at 1:100,000 (compilatory geological tectonic maps, hydrogeological maps, epicentre maps, seismo-tectonic maps, seismic hazard maps, maps of land protection and underground waters, maps of the distribution of maximal components of summary accelerations, engineering geological maps, mineral resources maps, maps of seismic regionalization, geomorphological maps, neotectonic maps, maps of contemporary tectonic movements etc.

In order to complete the geoseismic data bases, working papers of seismic microregionalization for every urban area of Montenegro with maps at 1:5,000 were drafted (morphological maps, hydrogeological maps, geo-engineering maps, terrain stability maps, terrain load maps, maps of seismic microregionalization, maps of land suitability for urbanization, maps of liquefaction potential and others). Such complex research led to a precise definition and classification from a seismological point of view of terrains without limitations for urbanization, terrains with minor limitations for urban development, terrains with limitations for urban development and terrains unsuitable for urban development.

For the needs of rehabilitaton of old urban towns, similar research was carried out, except that the results were given in 1:1,000 scale maps.

On the basis of these activities and the results obtained, the conditions were created for the elaboration and revision of physical plans with well defined zones of seismic hazard (according to intensity) and on the basis of which the function of the physical unit would be determined, so as to minimize seismic risk in the future.

Within the scope of the investigation for defining the anticipated vulnerability and the acceptable seismic risk in the area of Montenegro, as a result of repeated occurrences of catastrophic earthquakes, special studies of anticipated vulnerability and acceptable seismic risk were carried out for the needs of the revision and elaboration of master plans*. Their importance in physical planning is particularly emphasized by the impact of the high level of seismic hazard on the economic development and financial investment in the Montenegro.

This investigation was conducted on the basis of the analysis of data on the buildings damaged in the April earthquake; the data were obtained in the process of classifying the damage and the degree of usefulness of the buildings (depending upon the type of construction, material used in the construction, the intended use of the building and the type of foundations); data were also obtained from the analysis of seismic hazard according to intensity and maximum acceleration of the ground and the occurrence of liquefaction.

On the basis of these analyses, methodological studies were carried out in order to define the empirical and theoretical models of vulnerability and acceptable seismic risk; others were used as the basis for the elaboration of maps of physical distribution of buildings and infrastructure for a return period of 50 and 200 years, in order to revise the Physical Plan of the Republic as well as those of the urban areas.

Because the specialists and experts participating in this research did not have the necessary previous experience, since this type of research was used for the first time to cover the needs of physical and urban planning, it was indispensable that specialists be trained, particularly physical planners. In this connection and during the implementation of the Project two Yugoslav symposia and one workshop were organized, at which besides the specialists engaged in this field within the Project, specialists from other countries participated through UNDRO.

C. Summary

Montenegro is a coastal Republic of SFR Yugoslavia. Its sea coast is the closest of the Yugoslav sea coast to the Straits of Otrant, and thus its southernmost part. With a mild Mediterranean climate and a coast protected from the effects of strong winds, particularly in the Boka Kotor Bay, it has always been attractive for settling purposes and for developing human activities. As a result, we find old settlements with specific urban and architectural characteristics.

During the last few decades, the Montenegrin sea coast developed intensively from an economic, physical and urban point of view. Tourism and sea trade have developed as the major economic fields. A strong regeneration is also seen in the central part of the Republic and to a certain extent its northern part, where there has been a more intensive development, particularly in industry and the social services, while Titograd and Niksic have grown into the biggest urban centres of Montenegro. Because of the development of these two economically most advanced parts of the Republic there has also been development in transportation as well as infrastructures in general.

From previous investigations and generally from the knowledge of the geological-tectonic structure of the terrains of Montenegro, as well as from previous occurrences of earthquakes, it was known that this is a seismically hazardous area, particularly the Montenegrin sea coast, the basin of Skadar and the area of the valley of Ivangrad. The earthquake of April 1979 confirmed this knowledge and devastated the area of the Montenegrin sea coast and its hinterland.

Within the scope of this paper, a review was given of the seismic regionalization of Montenegro, the basic characteristics of the catastrophic earthquake of 1979, the extent of its consequences, the course of action taken immediately after the catastrophy, the most important short-term and long-term measures taken and particularly action carried out for the revision and elaboration of the physical planning documents for this highly active seismic area.

Particular emphasis was given to how the Project "Physical Planning in the SR of Montenegro" (YUG/79/104) came to be formulated, which institutional and specialized potentials participate in its implementation, while at the same time light was shed on the considerable importance of the participation, engagement and contribution of the international experts engaged through HABITAT and UNDRO. However, the greatest emphasis was put on the specific methodology applied in the Project - its pilot role for seismically threatened regions and the results from its application during Project implementation. In the Project and for the first time in the world (for such a vast territory and at several levels), an attempt was made to introduce a methodology of aseismic physical planning; in the course of Project implementation, valuable knowledge and results of considerable importance have been obtained thus far; this is the reason why it is felt that this work should be critically reviewed, evaluated and internationalized. At this point, it must be emphasized that the Project is still in the implementation phase, that the elaboration of the physical plans is still going on, that all of the experience has not been gained as yet.

This paper stressed the fact that experience to date was gained in work on plans at various levels (the Republic, the territory of the communes, the towns, smaller settlements and old urban centres) so that the results should be fully studied and evaluated after the completion of the Project.

The authors believe that the experience to date from the Project "Physical Planning in the SR of Montenegro" (YUG/79/104) is very valuable and as such can be a solid and reliable basis for the establishement of a methodology of aseismic physical planning for all the seismically menaced areas. As a result this paper should be interpreted as a first initiative for studying more fully and even for creating this methodology. In this sense, valuable expert support should be extended by all project participants, especially the HABITAT and UNDRO experts involved. The Institute for Geological Investigation of Montenegro, the Seismological Institute of the Republic - Titograd, the Institute for Earthquake Engineering and Engineering Seismology of Skopje and other Yugoslav and Montenegrin institutions all contributed to this complex and specific accomplishment.

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* This study was carried out by the Institute for Earthquake Engineering and Engineering Seismology of the "Kiril and Metodij" University - Skopje.

Finally, the authors believe that in addition to the theoretical elaboration of a methodology of aseismic physical planning, it would be of exceptional importance, on the basis of the experience of Montenegro, to consider the methodology used for the revitalization of old urban entities, especially in elaborating plans for other old towns. Examples can be had from the urban plans elaborated for Old Kotor, Old Budva, Old Herceg Novi, Old Bar and Old Ulcinj. Moreover, due to the number and importance of the cultural and historical monuments located in the area, the complexity of the urban structures, the accomplishments already attained and certain particularly important seismic characteristics, the urban centre of Old Kotor would be an example for the formulation of recommendations for the revitalization of old towns.

The experience described in this work concerning the activities and the results to date from the physical and town planning activities in Montenegro at several levels was presented according to the sequence and scope defined in the methodology for the implementation of the Project and the global themes set out for the elaboration of this material.

4.7. THE PHYSICAL DEVELOPMENT PLAN OF THE REPUBLIC AND PREVENTION OF SEISMIC RISK IN THE FRAMEWORK OF PROJECT YUG/79/104, SR MONTENEGRO: A METHODOLOGICAL REVIEW

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FOREWORD

The paper complements the two papers presented at the Cetinje Seminar:

(a) Yugoslav National Report: Seismic hazard and seismic risk control in physical development and urban planning in Yugoslavia, by B.S. Pavicevic.

(b) Yugoslav Case Study: Experiences of Montenegro in physical planning for seismically threatened regions, by R. Bakic, M. Vukotic, B. Milic, V. Radulovic.

Its purpose is to present a short review of the way the issue of prevention of seismic risk has been handled in the preparation of the Physical Development Plan of the Republic in connection with the other plans in Project YUG/79/104, namely the urban master plans.

Because the preparation of the final stage of the Plan of the Republic is now nearing its completion, the review intends to give the balance of this pioneer planning exercise so far, namely accomplishments on one side and on the other problems which have not been solved as yet and which therefore require further research and planning, possibly in the context of a technical and scientific cooperation among the seismic-prone countries of the Mediterranean.

PART I: GENERAL INFORMATION

A. Montenegro and the earthquake - April 15, 1979

Montenegro, a seismic-prone area which faces the Adriatic sea and is located in southern Yugoslavia, is the smallest of the Socialist Republics of the Federation. It covers an area of about 13,812 km^2 with a population of about 584,000 (1981); its territory is mostly mountainous with peaks reaching 2,500 m; the landscape is quite impressive. Montenegro, proverbial for its traditions and strong identity, with a great historic and cultural heritage, belongs to the part of the country which, from the point of view of economy and infrastructure, is less developed. It is one of the most seismic areas in the Mediterranean.

On April 15, 1979 a disastrous earthquake struck the coastal belt and, to a lesser degree, the inland territory of Montenegro. The intensity in the epicentral area was 9 degrees in the MCS, while the magnitude was 7.2 RS. Ninety-eight inhabitants lost their lives, 1,700 were injured. Vast destruction and damage were caused to the urban and rural settlements, historic-cultural monuments, to infrastructure and the production activities, especially tourism and industry. Eighty thousand inhabitants were left homeless, 30,000 lost their work; nearly 42,000 buildings as well as 1642 historic-cultural monuments were destroyed or damaged. The value of the direct losses only has been estimated at US$ 4 billion, at 1979 prices, which corresponds to about 10% of the national income of Yugoslavia and is 4 times the national income of Montenegro.

While emergency measures were taken for the immediate relief of the population, laws were passed at the federal level for the mobilization and allocation to Montenegro of about US $ 2.8 billion, at 1979 prices, needed for its reconstruction; the funds were provided through the solidarity of the other Republics and Provinces of Yugoslavia. The Republic Fund for reconstruction and development was set up in order to administer such resources in conformity with a ten-year time-schedule, covering the period between 1979 and 1989.

B. Project YUG/79/104, SR Montenegro and its organization

Meanwhile, according to the resolutions voted by the Assembly of the Socialist Republic of Montenegro in June 1979, the previously prepared and adopted regional and urban plans had to be totally revised in order to take full account of the seismic risk component and other factors and in order to address the objective of the reduction of seismic risk in a comprehensive manner. Highly qualified national and international research and professional institutions had to be engaged in the planning process in order to provide the most advanced scientific knowledge and expertise.

Project YUG/79/104 was launched as a joint initiative by the Federal Government and the Socialist Republic of Montenegro through the Republic Committee for Town Planning as the Implementing Agency, the United Nations Development Programme and its Executive Agency UNCHS/HABITAT (United Nations Centre for Human Settlements, Nairobi) along with the Associated Agency, UNDRO (United Nations Disaster Relief Office of the Coordinator, Geneva) in order to implement the resolutions mentioned above. The responsibility of UNCHS and UNDRO is to give technical assistance in the areas of physical and urban planning and earthquake science to the government bodies and national institutes which have the responsibility of preparing the plans. The Project started in 1981 and is still continuing, but nearing the final stage of the proposal in several plans, including the Physical Development Plan of the Republic.

The immediate objectives of Project YUG/79/104, which were decided upon by the Montenegro Government, are the simultaneous preparation of the Physical Development Plan of the Republic, the master plans of the major urban settlements in the twenty communes of Montenegro, the physical development plans of the communes on the coast, in connection with the reduction of seismic risk; the training of local planning staff for the preparation of those plans; the establishment of a network of planning centres in the Republic for the management of a permanent planning process as the follow-up of the Project; and the establishment of an automated information system. About 40 plans are under preparation within the Project.

Besides UNCHS and UNDRO, the Project has cooperated with several international projects located in Montenegro or in the Balkan region, in particular the International Consultative Board for the reconstruction of the region affected by the earthquake, Project YUG/79/003; the UNESCO Project for the Reduction of seismic risk in the Balkan region, Project RER/79/014 and the

UNIDO Project for Construction in the earthquake-prone areas in the Balkan region, Project RER/79/015 should also be mentioned. All these projects were initiated after the 1979 earthquake.

C. <u>The planning system in Yugoslavia and Montenegro</u>

The constitution, the institutional machinery and the planning laws of Yugoslavia and SR Montenegro form the setting of Project YUG/79/104 and the methodological framework for its operation. In this connection the following three principles should be recalled:

(a) Self-management which underlies the whole system of social, political and economic relationships.

One aspect of this principle, particularly relevant here, is the autonomy of the Communes as sovereign subjects in the process of the development and planning of their territories.

(b) Participation, as a right and a duty, in the planning process for the elaboration of the Physical Development Plan of the Republic by the Workers and the Citizens of the Republic and more specifically by the Communes, self-managing Organizations and Republic Bodies.

Such participation is formally carried out through the institute of public debate, for each of the major stages of the preparation of the Plan (basis, draft and proposal), as the democratic forum where possible conflicts are negotiated and agreements reached.

(c) Simultaneity and continuity in the planning process, namely the simultaneous and continuous preparation, updating and mutual adjustment of the physical and socio-economic plans at the Republic and Communal levels.

These principles explain the broad scope of Project YUG/79/104, the complexity of its organization and the highly demanding task of the coordination of the Plan of the Republic with the Communal Plans in the Project and the Plan of the Socio-Economic Development of the Republic up to the year 2,000, which is not included in the Project but is being prepared according to a procedure parallel to that of the Physical Development Plan of the Republic.

At the end of 1984 the Assembly of SR Montenegro adopted the draft of the Physical Development Plan of the Republic after a long and thorough public debate which recorded the active participation of all local authorities, working organizations, republic bodies and scientific and cultural institutions.

In accordance with the principles mentioned above the draft of the Plan of the Republic defined the long term strategy of the physical development of Montenegro taking into consideration the self-government prerogatives of the Communes and their role in the process of development. Consequently the Plan provides the necessary reference framework for the lower level physical and urban plans in their design of land use patterns and land management policies. Furthermore, the strategy of the physical development of the Republic is closely linked with the Plan of long term socio-economic development (up to the year 2,000), as a general basis for the five year development programmes and the investment projects.

As far as the federal level is concerned, the long term Socio-Economic Plan has not been developed yet, while physical planning is a subject still awaiting appropriate legislation. However, the Programme of economic stabilization, 1983 marks a new approach to the problems of regional development and planning in Yugoslavia and includes important guidelines for the Republics, Provinces and Bodies at the federal level. The Physical Development Plan of the Republic, SR Montenegro has taken this programme as one of its bases.

PART II: THE STRATEGY AND THE POLICIES OF DEVELOPMENT

D. The major physical features of Montenegro and the problems of its development

In the past forty years Montenegro has undergone a great social, economic and physical change due to industrialization (based mainly on the production of aluminium and steel, and hydro-electric energy), the development of tourism and the construction of a modern network of transportation infrastructure (port of Bar; railway between Bar, Titograd and Belgrade; roads of interrepublican linkage). The living standard was raised substantially and the urban population grew very fast. Titograd, the town designated as the capital of the Republic after the last World War, located at the foot of the Dinaric Alps, has emerged as the most important industrial, agricultural, cultural, political and administrative centre of Montenegro (100,000 inhabitants in 1981), while the smaller towns of the coast, due to their long history and culture, mildness of climate and beauty of scenery constitute one of the most attractive holiday areas in the Mediterranean. Montenegro, which was isolated and rural in the past, has become an area undergoing intensive industrialization and urbanization.

Isolation has been and continues to be a problem not only for Montenegro, but for the whole Southern Adriatic coast as well. Already in the late sixties and early seventies the Southern Adriatic Project, a joint initiative by the Government of Yugoslavia, the Governments of several Republics including SR Montenegro, and the United Nations Development Programme, had proposed the concept of the development of the whole Adriatic coast as a new axis of development which should balance and integrate the traditional axis of development of the economically stronger areas of inner Yugoslavia, along the plains of the rivers Sava, Drava, Danube, Morava, Vardar from which historically the Adriatic coast had remained detached.

The problem then is the structural disparity between Montenegro and the economically more developed areas of other socio-political entities in Yugoslavia. In spite of the large investments carried out so far, (with the help of the other Republics and Provinces), such disparity is still strongly marked in terms of active population, employment, industrialization, social product, productivity, living standard, etc. and it explains why Montenegro is an emigration Republic (between 1961 and 1981, 47,000 people left Montenegro).

The participation of Montenegro in this axis of development had to take into account the specificity and sensitivity of its territory, with its intricate and broken relief, made up of high mountains, highlands, canyons, valleys, rivers, plains, lakes and seashore which together create a fascinating, wild and at the same time delicate natural environment. Any intervention which is out of scale and in contrast with the physical features and any conflict among sectors in the development process can easily have a negative impact. The loss of part of the fertile agricultural land, which is very scarce in Montenegro, is a good example of this problem, others being the uncontrolled urban land development, water and air pollution, aggression against the landscape, the degradation of forests and soil erosion.

Although the urban population of Montenegro increased by 150,000 inhabitants between 1961 and 1981, there are still 1,060 human settlements, over a total of 1,239, which have fewer than 500 inhabitants. The total corresponding population in 1981 was 168,000 which is highly dispersed over the rural areas in the whole territory of Montenegro, particularly in the karst plateaux and mountains. Generally, Montenegro has been losing people due to the rather low living standards, shortage of job opportunities and difficult access. Only two towns (Titograd and Niksic), where a total of 146,000 inhabitants lived in 1981, enter the category of towns over 20,000 inhabitants and only four towns are included in the category between 10,000 and 20,000 inhabitants, with a total of 55,000 people in 1981. That points out the very limited extent of development of the medium size towns, as an intermediate category between villages and larger towns.

Taking into account both the natural conditions and the level of socio-economic development, the territory of the Republic can be divided into three geographical areas: the coastal, the central and the northern, which respectively had populations of 116,000, 240,000 and 229,000 inhabitants in 1981. Each of these areas has a different economic structure and a different pattern of physical development. The coastal area, densely populated, has an economy based on tourism, maritime activities and trade and it is the most prosperous in the Republic. The central area contains the largest share of industrial development of Montenegro, the best agricultural land and the main centres of tertiary activities, including culture. Here we find the highest level of population concentration in towns. Although the largest investments have been carried out just in this area of the Republic, the social product per capita is lower than that on the coast since investments have been directed to the basic, capital intensive industry. The northern area, which is the largest of the three, is in the early stage of urbanization and industrialization, has an insufficient level of tertiary activities, reveals the abandonment of traditional agricultural activities and a very low level of exploitation of its large potentials of pastures, meadows, forests, mineral resources and hydro-electric production. This area of the Republic has the lowest social product per capita and the lowest living standard.

Such a marked disparity in the distribution of development and the neglect of agriculture have heavily affected the distribution of population in the Republic. In addition to the net emigration out of Montenegro already mentioned, the coastal and the central areas gained respectively 12,500 and 4,300 inhabitants, while the northern area lost 63,800 inhabitants between 1961 and 1981. In particular, only the town of Titograd and the towns of the coast were net immigration urban centres. Imbalance between job distribution and population distribution in the Republic represents one of the most serious problems in the management of the physical structure.

The shortage of jobs, not only in the rural areas but also in the towns, and their unbalanced distribution in the Republic should be seen in connection with the development of capital-intensive industry, dominated by raw materials and energy production complexes; the very limited exploitation of the agricultural potential and other natural resources; the insufficient use of the existing stock of infrastructure and productive capacities; the lack of functional integration among branches in the economic and productive structure and other factors.

E. The inputs of seismic hazard and risk in physical planning at the level of the Republic

The territory of Montenegro is exposed to a high level of seismic hazard which is of tectonic origin. The whole territory is seismically active: the sea coast which is the most active, the Zeta depression (the central area), the Lim valley (the north-eastern part) and to a lesser degree the Cehotina valley (the north-eastern part). The regional ruptures of the first order, seismically active, are located along the sea coast and the Zeta depression (where Titograd and Niksic, the largest towns of Montenegro, are located) while a less active rupture of the first order is located in the northern area. The intensity of the seismic hazard for a 100-year return period varies from a level of over 9 degrees MCS along the coast to 6 degrees in the north-western part of Montenegro. Isoseismal lines are distributed according to a pattern of parallels to the coast. The seismic hazard for a 200-year return period presents the same features, but its level is about 0.5 degrees higher than the 100-year one. The acceleration of ground motion expected in a 200-year return period, which shows a pattern of distribution of the isoseismal lines similar to that of the intensity, varies from more than 0.40g (gravity acceleration) in the south-eastern tip of the coast to 0.06g in the north-western part of the Republic. The values of the acceleration of the ground motion over a 100-year return period are slightly lower than those for the 200-year period.

The distribution of population, settlements and man-made resources within the territory of the Republic looks quite contradictory to the distribution of the seismic hazard described above. This applies particularly to the existing trends. Most of the elements at seismic risk are concentrated in the areas of high seismic hazard. The most densely populated coastal part of the Republic, with its historic towns, tourist development and the port of Bar, is also the most seismically hazardous area. Seismic hazard is also high in the central part of the Republic, in particular in the zones of Titograd and Cetinje, where there is a high concentration of the population working in the main industrial complexes and other social, economic and cultural activities. It is therefore necessary to conclude that the general pattern of the physical development of the Republic today increases the seismic risk to which it is exposed, regardless of the seismic vulnerability of the single building structures.

The maps on seismic hazard, scale 1:100,000, together with other geological-seismological maps on the same scale, have been the necessary tool for the preparation of the Physical Development Plan of the Republic and specifically for the critical evaluation of the existing state of the physical structure and for the definition of strategy for the development of the Republic, which is briefly described in the next chapter.

Three remarks should be made in this connection. First, the terminology of seismicity applied to Project YUG/79/104 fully reflects the concepts and definitions adopted by UNDRO, UNEP and HABITAT (1979 and 1980) and applied also to the UNDP/UNESCO Project RER/79/014. Second, seismic microzoning maps at the level of urban settlements, scale 1:5,000, which were prepared for the communes of the coast and other communes in the interior and are under preparation or completion for the rest of Montenegro, are the necessary tools for the preparation of master plans. The strategy of Development of the Republic and land-use planning at the local level are the two planning instruments for the prevention of seismic risk. Third, the maps of seismic hazard and the other seismo-geological maps, scale 1:100,000, were finalized for the preparation of the map of seismic macro-zoning of the Republic, scale 1:100,000. This map, along with the seismic micro-zoning maps, scale 1:5,000, shall be adopted by the SR Montenegro as the normative basis for the application of the building code and will supercede the temporary seismic map of Yugoslavia, as far as Montenegro is concerned. It will therefore represent a basic instrument for the preparation of feasibility studies and economic calculations for all development programmes and investment projects.

As was mentioned in the Foreword, studies on the methodology for assessing seismic vulnerability and risk have been elaborated by the specialist institutes in order to provide the needed input to physical and urban planning in Montenegro; they are now being finalized. So far they have not been either tested or applied systematically in the Project. However, a tentative assessment of the risk of the existing housing stock of the Republic points out quite clearly the implications of the different degrees of exposure to seismic hazard of the coastal, central and norther regions and, in particular, the high comparative advantage in economic terms, apart from any other consideration, of the northern region vis-à-vis the coastal region and, to a slightly lesser degree, to the central region as far as the above mentioned risk is concerned. Even on the basis of aseismic reconstruction and strengthening of all the buildings affected by the earthquake of 15 April 1979, the losses as percentages of the existing housing stock in the coastal region are three to six times higher than those in the northern region with reference to return periods respectively of 50 and 200 years. Such ratios would be slightly lower when comparing the losses in the central region with those in the northern one.

The main transportation infrastructure in the coastal and central regions is highly vulnerable to seismic hazard because of the instability of the soil. However, the vulnerability of the network as a whole in the coastal and central regions is reduced by the redundancy of single trunklines, which allows alternative circular itineraries in the case of interruptions. Such is not the case, because of the great difficulties determined by the relief, in the northern region where railway and highway are laid down along the same corridor connecting coastal and central Montenegro with Serbia. Such a corridor is highly vulnerable because of its crossing of active ruptures and because of soil instability.

F. Outline of the strategy of the physical development of the Republic up to the year 2000

The Physical Development Plan of the Republic has adopted the following major objectives for the physical development of the Republic up to the year 2000:

1. Better use of all existing natural, man-made and human resources and raising of the employment level.

2. Consolidation of the physical components in an overall integrated structure at the level of the Republic.

3. Promotion of equal conditions for development through the whole territory of the Republic and reduction of the territorial disparities in the quality of life and job opportunities.

4. Prevention of seismic risk.

5. Preservation and upgrading of the ecological balance.

6. Protection and revitalization of the historic-cultural heritage.

The physical development strategy of the Republic has addressed these objectives in the following way:

Total population will grow from 584,000 in 1981 to 692,000 in the year 2000 (population growth index equal to 118). Active population shall increase from 34.0% of the total population in 1981 to 40.0% in 2000. The number of jobs is expected to increase from 167,000 in 1981 to 268,000 in the year 2000 (employment growth index equal to 160), which means the creation of a number of 101,000 new jobs. This will help reduce outward migration, which was equal to 47,000 in the 1961-81 period, to 20,000 people.

In order to achieve this employment objective it will be necessary to create a new economic structure which is based on several priorities, namely the production of energy, food and raw materials, on manufacturing and tourism; and a diversified small business network which should complement the major economic activities and make the creation of new jobs faster.

The protection of agricultural land, agricultural land reclamation and development, management of agricultural production in the framework of the different climatic and environmental conditions in the various areas of Montenegro and their functional links, the promotion of fisheries and aquaculture, the upgrading and management of forests and soil conservation should all be underlined as measures which mark the new approach to the problems and the recovery of the primary sector, to the economic support of the rural areas and the adjustment of the balance of payments of the Republic. This will allow employment in the primary sector in the year 2000 to be kept at the same level as in 1981.

Great importance has been attached to the role of the manufacturing industry in the creation of a large number of new jobs and the additional industrialization of the northern region. However, capital-intensive investments will also be needed for further developing the existing production of hydro-electric energy and raw materials, also in view of their necessary functional linkage with the manufacturing industry. The secodary sector will provide about 51,000 new jobs between 1981 and 2000.

Tourism will be further developed and its designated areas protected, on the coast, in its immediate hinterland, in the mountains and the rural areas. Tertiary activities, including tourism, will contribute to the creation of about 50,000 new jobs in the Plan implementation period.

Between 1981 and 2000 the primary, secondary and tertiary sectors will change respectively from 20 to 12, from 31 to 38 and from 49 to 50 per cent of total employment.

The social, economic and physical development of the Republic is conditional upon the move from a pattern of fragmented and dispersed local economies and single human settlements to a new pattern based on aggregation, progressive consolidation and final integration at the level of the whole territory. Such a process relies first on the actions which will be carried out by the Communes as to their own territories in order to create a functional relationship between towns and rural areas; second, on the cooperation among Communes for the creation of sub-regional and regional structures; and third, on the integration of regional structures at the level of the Republic.

As regards the first level, it will be necessary: to strengthen the sub-communal centres, to have a higher concentration of the population in a smaller number of rural settlements, to stimulate the growth not only of agriculture, but also of small scale industry, crafts and rural tourism and to develop local technical and social infrastructures. These measures will stop or reduce the exodus from the rural areas.

Sub-regional cooperation among Communes in areas with common problems and interests (the Boka Kotorska and Budva, the southern coast, the valley of Zeta-Bjelopavlici, the Cetinje field, the old Montenegrin plateau and the Niksic field, Mount Durmitor, the upper streams of the Lim, Tara and Ibar rivers and the river basin of Cehotina) which furthermore contain one or more strategic zones is also foreseen (the Plan has defined the basic criteria for the development of these zones and the control of existing or potential conflicts).

Regional cooperation concerns the creation of social, economic and physical entities which at the moment have only a geographical connotation: the coastal, central and northern areas. The coastal region will develop several sectors, namely tourism, maritime economy, agriculture and, to some extent, industry. The central region will develop industry, agriculture, services to production activities, cultural-scientific and socio-political activities. The northern region will develop the production of minerals, coal and hydro-electric energy, the manufacturing industry, agriculture and animal breeding, forestry and tourism.

The leading role of urban settlements and their polycentric network (intercommunal centres are Titograd, Niksic, Cetinje, Bar, Kotor, Bijelo Polje, Ivangrad and Pljevlja) in this process of aggregation, consolidation and integration should be highlighted. Urban population will grow from 315,000 in 1981 (54.0% of total population) to 469,000 in 2000 (68.0% of total population), but its rate of growth will be lower than in the previous period, 1961-81; meanwhile, the rural population will decrease from 269,000 in 1981 to 223,000 in 2000 (index equal to 83).

In particular, urban population in the settlements of up to 5,000 inhabitants will decrease from 11.3% to 8.9% of total urban population; in the settlements between 5,000 and 20,000 from 42.3% to 24.35%; in the settlements between 20,000 and 50,000 it will move from zero to 24.1% and in the settlements over 50,000 it will move from 46.4% to 42.75%. Two major policies should be underlined: the development of medium size towns (Bijelo Polje, Ivangrad and Pljevlja in the north and Bar on the coast) which is the prerequisite of the whole development process; and the control or limitation of urban development in the two major towns in Montenegro: Titograd and Niksic.

The integration of the territory at the level of the whole Republic will be supported by the contruction of further technical and, particularly, transportation infrastructure (Titograd-Matesevo-Ivangrad for the connection with Serbia; and Titograd-Pluztne-Foca for the connection with Bosnia).

Between 1981 and 2000, 8,700, 19,000 and 22,900 new jobs will be created in the secondary sector in the coastal, central and northern regions respectively. The number of new jobs for every new inhabitant in these three regions will be equal to 0.46, 0.81 and 1.69 respectively. Such figures point out the willingness of the government to promote a faster development of the northern region, which is also based on the development of the urban areas of medium size (Bijelo Polje, Ivangrad, Pljevlja), within existing possibilities. Consequently net emigration from the northern region will be reduced to 33,200 people in the period between 1981 and 2000, while net immigration in the coastal region and net emigration from the central region will be equal respectively to 18,500 and 5,300 inhabitants.

Population in the coastal, central and northern regions in 2000 will be 154,000, 289,000 and 249,000 inhabitants respectively with a corresponding growth index between 1981 and 2000 equal to 134, 121 and 109 respectively (total population growth index equal to 118). Such indices should be compared with those of the 1961-81 period and are equal to 140, 141 and 105 respectively (total population growth index equal to 123).

The above data show that the territorial disparity between the northern region on the one hand and the coastal and central regions on the other will be reduced substantially during the period of implementation of the Plan, but not eliminated altogether; they also show that strong control should be exerted upon the development process of the central region, in particular in the towns of Titograd and Niksic.

As far as the prevention of seismic risk is concerned, the information presented above clearly indicates that the strategy of physical development of the Republic in the long term should include at the level of the Republic measures addressing this objective, along with other objectives. These measures are:

1. Faster development of the northern region.

2. Control of urban growth of the larger towns, Titograd and Niksic.

3. Polycentric model of urban development.

4. Development of agriculture and support of rural areas.

Such measures provide the conditions for the reduction of seismic risk connected with the pattern of physical development which would occur if the existing trends were not corrected by the Plan). The conditions would be achieved by:

(a) either diverting future development from the areas which are exposed to the highest seismic hazard to those exposed to the lowest in the territory of the Republic;

(b) or limiting the degree of concentration in the distribution of population in the territory of the Republic.

The premise of the Plan is that there is no conflict necessarily between development and environmental protection. The real problem is the attitude people have towards life and the environment. Therefore, the strategy of physical development is focused on the preservation of the ecological balance and on the arrangement of a natural matrix of blue and green (sea, inland waters, forests, mountains), which incorporates and links all the most important components of the ecosystem through ecological corridors. Within this matrix reserves, national and regional parks for outdoor recreation, conservation of wildlife and scientific research have been proposed for final adoption.

The reconstruction of historic centres ranks as top priority among those adopted by SR Montenegro soon after the earthquake of April 15, 1979. Historic centres proved highly vulnerable to earthquakes. After a period of decay and abandonment in the past few decades the historic centres have now justly become the symbol of the renewed commitment of the Republic in the process of reconstruction and development. The Plan also focuses on protection and revitalization of the so-called "minor" historic settlements and villages in the rural areas and the preservation of the historic-cultural monuments within their landscape and environmental setting.

G. The policies of the physical development plan of the Republic for seismic risk prevention

In the framework of the policies of the Physical Development Plan of the Republic seismic risk prevention is a task for all Communes, Working Organizations and Republic Bodies engaged in physical planning and development process at the various levels. Such policies have a general character and are complemented by the guidelines to the plans of the Communes which are reviewed in Part III of this paper. The major contents of such policies are the following:

Seismic risk prevention is a basic objective in physical planning. All physical development plans (Plan of the Republic, Plans of the regions (two or more communes), Plans of the communes, Master Plans of urban settlements, Plans of special areas) must include the appropriate planning measures (land use pattern, level of concentration, density, layout of technical infrastructure etc.) to control or reduce seismic risk and to ensure the necessary level of safety of people and structures on the basis of economic criteria.

Full use has to be made, in the preparation of physical development plans, of all the information on seismicity made available to the Planning Teams. Other information should be prepared on the basis of further analysis of data already collected and made available to the Planning Teams without delay. Necessary actions should be undertaken in order to complete the collection of data still lacking in some communes of the Republic.

The development policies of the territory of the Republic shall correlate the distribution of population and economic activities to the pattern of distribution of seismic hazard, whose level decreases from the south to the north of the Republic.

The consideration of seismic risk has to be introduced into physical planning. The following information, mostly available to the Planning Teams, is needed for the assessment of seismic risk of each type of structure in each seismic zone:

(a) regional seismic hazard maps showing macro-seismic intensities or ground accelerations at given levels of probabilities for given time periods.

(b) local micro-zoning maps showing expected macroseismic intensities or ground accelerations modified by local subsoil and soil conditions, for the same probabilities, levels and time periods.

(c) probability distribution functions of macroseismic intensity or ground acceleration for each locality under study.

(d) vulnerability functions relating degree of damage to macroseismic intensity or to ground acceleration for each structural type of building found in the locality.

The above information makes possible an assessment of the cumulative losses due to all the earthquakes likely to occur in a given zone and in a given time period with a given probability level.

The above assessment of seismic risk refers only to the probability of losses caused directly by ground shaking. It should also include the secondary losses (due to events or chains of events triggered by the earthquake like landslides, soil liquefaction, subsidence, coastal floods etc.) and the consequential losses (of human, social, economic life).

Land capability analysis is also recommended. It is a method for the aggregate evaluation of several environmental factors that affect land stability and its capacity to support various land uses and the appropriate structures.

The Yugoslav building code for aseismic construction has to be applied strictly, with adequate on-site inspection, in all cases of design and construction of new buildings.

Costs of construction in accordance with the building code for aseismic construction and seismic risk have to be included in every economic analysis of the costs of realization and operation of development programmes and investment projects, comparing alternative locations in the territory of the Republic.

High concentrations and densities of population and activities must be avoided. Buildings and facilities which are highly sensitive in terms of their function must be located in the safest sites in a given area. They should be designed to resist earthquake ground motion one degree of intensity higher than normal for the site. Redundancy is the criterion for planning and design of networks of technical infrastructure in order to ensure the operation of lifelines in the event of disaster.

Existing development shall be evaluated with regard to the seismic risk it is exposed to. All existing highly sensitive buildings should be examined and tested to determine their vulnerability; if necessary, they must be strengthened to conform with the code requirements specified above.

Physical development plans have to be complemented by pre-disaster provisions and measures, as a component of the preparedness plans, at regional level (inventory of physical infrastructure, maps of ground instability areas, maps of preparedness resources) and at the local/urban level (inventory and maps of all urban services and linkages likely to be critical during emergencies).

PART III: GUIDELINES FROM THE PHYSICAL DEVELOPMENT PLAN OF THE REPUBLIC TO BE USED IN PHYSICAL DEVELOPMENT AND MASTER URBAN PLANS OF THE COMMUNES

H. THE DEVELOPMENT FRAMEWORK BY COMMUNES AND SECTORS

The Plan of the Republic has defined the basic guidelines and parameters of development between 1981 and 2000 for each of the twenty Communes of Montenegro. The framework of development by communes and sectors adapts the physical development strategy of the Republic to the local level; it is the necessary planning instrument for the preparation and coordination of the physical plans of the Communes. Its great importance, as a link between the Physical Development Plan of the Republic and the Communal plans, is revealed by two considerations: first, land use planning is the specific competence of the Communes; second, Communes are the sovereign subjects in the process of development of the Republic, as already mentioned.

The information presented in the framework of development by communes and sectors includes: degree of control of the process of development, major functions of development (agriculture, industry, tourism, tertiary activities, transportation, etc.) of the communes, conditions they have to comply with, population growth in the period for which the plan is developed, urban population in the capital towns of the Communes and economic structure by employment in the various sectors.

Protection of the environment and overcoming existing or potential conflicts among sectors arising in the process of development are the key criteria for the definition of the policies of development in each of the Communes. Such definition is based on the comprehensive analysis of many factors, according to the methodological approach included in the concept of strategic zones.

One of the main factors of this type of analysis is the exposure of single urban areas to seismic risk in the territory of the Republic, expressed in descriptive terms, along with an assessment of the possible planning measures which aim at reducing such an exposure.

I. METHODOLOGY FOR THE PREVENTION OF SEISMIC RISK IN THE COMMUNAL PLANS AND THEIR INPUT ON SEISMICITY

The geo-seismic macrozoning maps, on a 1:5,000 scale, which were prepared for the master plans of urban settlements in the Project, include a set of maps indicating the suitability of land for urbanization. Four categories are identified: land without limitation, land with minor limitations, land with considerable limitations and land unsuitable for urbanization.

The four categories of suitability were determined on the basis of six factors (slope of land, depth to water table, composition of the bed rock, stability, soil bearing capacity, earthquake intensity).

These maps are very useful in assisting planners when making decisions as to which areas are most or least favourable for development and, in particular, in identifying those types of ground failure that can be induced by seismicity. However, the experience acquired by Planning Teams in the Project has shown that the usefulness of those maps could be increased if two additional steps were taken in their general interpretation, namely the correlation of specified land-uses to each suitability category and the adoption of a procedure allowing more detailed information on the six factors mentioned above.

To develop a correlation of land-uses with the various suitability categories (more sensitive types of land uses demand stabler conditions) the cumulative judgement of experienced professionals from several fields (as a minimum, geology, structural engineering, planning) is required. In this manner a list of land uses can be produced permitting the planner to make direct use of suitability maps. As far as the second aspect is concerned, the planner should be able to review the input maps related to the six factors mentioned above in order to evaluate the feasibility of solutions proposed even if not recommended in the maps for a given area.

A more complicated land suitability system may be employed; it is the extension of the first approach indicated above. Two basic tools are used: the land use - environmental factors matrix and the land suitability maps.

The matrix correlates environmental factors with land uses which in turn are correlated with structural types and the latter's occupancy. Ratings and weights are used to measure the capability of the factor being considered to support the corresponding land use option as well as its relative importance for the same land use option. Land suitability maps, where the weighted capabilities are scaled into broad categories, are then prepared on the basis of this matrix.

A general remark on the use of land capability analysis is that limitations on land use as a method of mitigating risk are appropriate where land values are comparatively low or fit normal practices; whereas as land values increase it becomes more feasible economically to mitigate the risk through engineering solutions (apart from the cases where hazards may be beyond any reasonable engineering solutions).

Such considerations bring us to the economic aspects of land use planning. In this connection a comprehensive methodology for the assessment of models of urban development in the preparation of master plans based on cost-benefit analysis and designed to incorporate the seismic risk reduction factor has been formulated and its introduction into the Project has been proposed. This proposal concerns the new urban development, rather than the recovery of the existing one.

According to such an approach, studies on seismic hazard, vulnerability and risk should include the inputs needed on the basis of this methodology and which should be correlated with the inputs reflecting other important factors of urban development.

The premise on which the proposal is based is that a constant level of acceptable seismic risk, as defined in the building code, can be maintained through different land use models in the urban plans, but at different levels of cost. The best use of land according to its suitability minimizes the cost of land preparation, construction and cumulative losses from future earthquakes. However, other costs should be included as well - costs referring to the use of agricultural land and loss of its production, development of technical infrastructure, new development of obsolete urban areas as well as other non-economic costs. Therefore the problem is the minimization of the overall cost or, better, the maximization of the effectiveness of the model. This has also been confirmed by methodological studies carried out at the local level.

Such an approach to the assessment of urban development models assumes the adoption of a range of different procedures, from the simpler and descriptive to the more sophisticated and quantitative, according to environmental conditions and the dimensions of the development programmes.

As has already been indicated in the chapter on policy, such comprehensive methodology should be applied in the economic analysis of development programmes and investment projects, which are the instruments of implementation of social and physical planning in the long term.

It is assumed that the study on the applied methodology for the assessment of earthquake vulnerability and risk based on the earthquake of 15 April 1979 in Montenegro, a study prepared jointly by the Institute of Earthquake Engineering and Engineering Seismology (IZIIS), Skopje and the Republic Institute for Town Planning and Design (RZUP), Titograd will be finalized and made available to the Project soon.

J. RECOMMMENDED PLANNING AND DESIGN MEASURES FOR SEISMIC RISK PREVENTION AND PREPAREDNESS IN THE PLANS AT THE URBAN LEVEL

The Yugoslav building code defines the level of acceptable seismic risk of single structures. This code must be strictly followed in all design and construction work. However, the building code does not include physical planning and urban design measures to mitigate vulnerability of settlements as a whole and their components and control related seismic risk. Consequently the Plan of the Republic recommends planning and design measures which should be applied for seismic risk prevention and preparedness in the physical (development and regulatory) plans at the urban level. Their contents are as follows:

All physical plans at the urban level must be based on seismic micro-zoning maps and land suitability maps in connection with land stability under seismic conditions. Scale of the basic maps, to be selected according to local requirements, will range from 1:10,000 to 1:500.

The basic rule in the seismic-prone areas is to avoid the concentration of important urban functions within one zone because it increases the vulnerability of the whole system and to encourage a spatial distribution according to an open, polycentric model. The levels of development density should be in reverse proportion to the level of seismic hazard and in direct proportion to the level of land capability. Values of parameters are not recommended because they depend on specific cases.

Land use pattern should be closely correlated with land capability. Uses of higher sensitivity should be located on the more stable land. A list of land uses by categories of sensitivity (highest, high, medium, low) is presented (sensitivity depending on the potential secondary and consequential losses).

Criteria are given concerning the definition of the plot index (ground coverage by buildings), according to building height, in order to ensure sufficient free space between buildings.

Open, green spaces should be used as screen belts against possible chains of disaster, for emergency approach, evacuation zones and first emergency accommodation. Their distribution should be a function of their easy, fast access from residential and central urban areas.

Transportation links should be designed according to criteria of redundancy and safety in order to ensure their operation as lifelines in case of disaster. Basic criteria are given also in respect of feeders.

As far as buildings are concerned, planning and design criteria are recommended for their location in connection with their degree of sensitivity, for their mutual distances, direct exits, shapes and layouts.

All buildings in the seismic-prone areas shall have obligatory insurance coverage against earthquake damage.

Contingency plans, integrating the resources provided by administrative, logistical, technical and social support, equipment and relief supplies, information and education on earthquakes, etc. shall be prepared for every urban settlement. They must be periodically revised and updated and be operational at all times. Nuclei of permanent staff are needed at different levels of the federal, republic and local administration. Local preparedness is of the utmost importance, although some elements of the contingency plans can only exist at the federal and republic levels because they are the most specialized and costly to maintain (specialist rescue teams, specialist services for damage assessment, specialist medical care and logistical support etc.).

Disaster preparedness plans consist of three components, namely predisaster provisions and measures, relief and rescue operations and measures for recovery and rehabilitation. A fourth component, reconstruction, falls back into the field of prevention.

The recommendation to include the predisaster provisions and measures in the physical development plans at the local level has been referred to in connection with the seismic risk prevention policies in the Plan of the Republic.

The objective of disaster relief and recovery operations is to shorten to the maximum extent the relief and rehabilitation period, so as to engage as quickly as possible in reconstruction, thus saving on the costs (social and economic) of protracted "temporary" solutions. However, fast reconstruction should not take place without adopting the appropriate risk reduction planning measures already indicated.

The importance of two actions, linking preparedness and prevention, should be duly stressed. First, the systematic survey and recording of the condition of buildings for different occupancy and structural types. A detailed vulnerability analysis of the existing building stock and infrastructure network must be carried out designating those buildings and critical facilities urgently requiring repair and strengthening. Second, the preparation of earthquake scenarios in which estimates are made of deaths, injuries and damage for earthquakes of varying intensities and probabilities of occurrence. Unless such scenarios are provided, preparedness plans have nothing to go on and prevention obviously cannot be implemented for lack of social perception of risk.

PART IV: CONCLUSIONS

The plans formulated in project YUG/79/104 are still under preparation and the proposals of many of them are now being finalized for adoption. This paper does not propose to review to what extent policies, methodologies, planning and design measures being recommended by the Physical Development Plan of the Republic have been applied to date at the local level. Work for the preparation of the basic maps and studies on seismicity has been carried out and adequate consideration of the seismic risk factor has been given by workshops, conferences and other activities in the framework of Project management. All this work is recorded in the bibliography attached as an Appendix to this paper.

Further, the ongoing reconstruction of the historic centres of the coast is a very specific chapter which deserves a separate presentation and cannot be treated in this paper.

Prevention of seismic risk in land use planning requires pioneering work which, in most of the seismic-prone countries, is almost in its infancy. Whatever the results of the physical plans contained in Project YUG/79/104, a lot of ground must still be covered. The methodological review presented in this paper has pointed out achievements, but also problems awaiting solutions. The setting-up of the necessary data base; interdisciplinary work of geologists, seismologists, structural engineers and planners; initiation of planners in the consideration of the seismic risk factor; the complexity of organizational arrangements are all factors explaining some of the difficulties in the Project. It appears that the Project should be linked to the establishment of a permanent planning system in SR Montenegro which will allow not only the management of the development process through the plans but more specifically, the development of ongoing research and planning activities in areas of seismic risk as well as its prevention.

On the basis of the above, possible cooperation among Mediterranean countries in land-use planning in seismic-prone areas appears extremely important and would be warmly received. Actually, such cooperation, based on the exchange of information and aggregation of available resources, would enable the joint efforts of the Mediterranean countries to be directed towards major targets in the prevention of seismic risk and preparedness like:

(a) the acquisition and consolidation of existing scientific knowledge and planning experiences.

(b) the build-up, demonstration and extension of methodologies.

(c) the development of theoretical premises and planning instruments.

(d) the comparative evaluation of systems and procedures applied in the process of plan implementation.

On the basis of the methodological review presented in this paper, which underlined accomplishments and problems in the planning process of Project YUG/79/104, the following major issues are proposed here as a contribution to setting-up the platform for possible future cooperation among the Mediterranean countries:

1. Application of the methodology for the assessment of seismic hazard, vulnerability and risk of single elements at risk at the various levels of physical and urban planning.

2. Selection of social and economic parameters and their use in the assessment of consequential losses of earthquakes.

3. Application of the land capability analysis to specific cases through the preparation of the land use-environmental factors matrix and land capability maps.

4. Elaboration of scenarios on the impact of selected earthquakes on existing development at the regional and urban levels.

5. Definition of seismic vulnerability and risk of the existing urban areas and their use as parameters in the planning and programming process at the regional and urban levels; use of field surveys for their assessment; and guidelines for the definition of acceptable seismic risk.

6. Formulation of a comprehensive methodology for the assessment of models of urban development in the preparation of master plans designed to incorporate seismic risk; and definition of the needed seismic data base.

7. Formulation of the methodology for the comparative analysis of the costs of development programmes and investment projects for alternative locations designed to incorporate seismic risk, and its application to specific cases.

8. Guidelines and criteria for the formulation, design and implementation of investment projects aimed at reducing the seismic vulnerability and risk of existing urban areas, and their application to specific cases.

5. COOPERATIVE PROGRAMME FOR SEISMIC RISK REDUCTION IN THE MEDITERRANEAN REGION*

A. General

Results previously obtained within this Action have clearly shown the extent to which the whole Mediterranean region is seismically exposed, and how a number of Mediterranean countries have advanced in the area of scientific research, earthquake engineering, planning and management in the field of seismic risk mitigation, and also how great the needs are to share such knowledge and experiences with other Mediterranean countries. However, these issues, particularly with regard to their comprehensive treatment and adequate systematic application to planning and management, represent a very demanding task which cannot be carried out without difficulty by any single country.

In this sense and on the basis of the Conclusions and Recommendations of the Cetinje Seminar, the representatives of UNDRO, UNCHS, UNESCO, UNIDO and UNEP-PAP/RAC have prepared a Project Document Proposal: Cooperative Programme for Seismic Risk Reduction in the Mediterranean Region.

The basic objectives of the proposed Project are as follows:

- to provide a comprehensive and interdisciplinary synthesis of existing knowledge in the various fields concerned;

- to guarantee optimal use of resources and expertise through the cooperation agreed upon by the various Agencies;

- to ensure efficient and properly coordinated implementation;

- to avoid repetition and duplication by taking into account the achievements of past projects and activities in seismic hazard assessment and seismic risk reduction;

- to serve as test project of interest to other regions and non-participating countries.

A summarized version of the Project Document Proposal will be presented in the following sections.

B. Project Document Proposal: Cooperative Programme for Seismic Risk Reduction in the Mediterranean Region

PART I THE PROJECT AND ITS BACKGROUND

a. The Premises of the Project and the development objectives and strategy for Seismic Risk Reduction in the Mediterranean Region

1. The Mediterranean Region belongs to one of the more active seismic zones in the world. A number of countries are frequently and regularly affected by earthquakes which cause a heavy toll on human lives,

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* Proposal elaborated jointly by UNCHS, UNDRO, UNEP/PAP RAC, UNESCO and UNIDO in 1986.

destruction of settlements and infrastructure, and losses to national economies. The exposure of settlements and development to earthquake disaster is continuously rising due to the growing process of industrialization and concentration of population at very high densities in large, vulnerable metropolitan areas. Consequently effective and systematic actions for the reduction of seismic risk have become imperative and urgent, as the recent Mexico earthquake has shown.

2. Since the earthquake in Skopje in 1963, and particularly after the earthquakes which struck Montenegro in 1979 and El Asnam in 1980, several projects for seismic risk reduction were undertaken through the UN system at the regional and national levels by governments and regional institutions (such as PAMERAR). Other damaging earthquakes in Greece, Italy and Turkey should not be forgotten (Friuli, Lice, Van, Thessalonica, Corinth, Basilicata, Erqerum).

The projects include the Survey of Seismicity in the Balkan Region (REM/70/172 and REM/74/009); Earthquake Risk Reduction in the Balkan Region (RER/70.014); Building Construction under Seismic Conditions in the Balkan Region (RER/79/015); several national projects in Romania (ROM/77/003, ROM/77/004 and ROM/77/009) and Yugoslavia (YUG/68/010, YUG/75/008, YUG/77/103 and YUG/79/104). At the same time numerous actions at the national level were undertaken by governments and local authorities in the Mediterranean countries for the reduction of seismic risk. Activities were also carried out by several UN agencies in the areas of research, planning, training and relief.

All these projects and actions in the last few years have marked an important advance in scientific knowledge and research, technical co-operation among countries, operational procedures in the areas of planning, building, preparedness and training in order to control seismic risk and protect existing and future development.

3. The Priority Actions Programme of the Mediterranean Action Plan was set up in 1979 within the framework of the Barcelona Convention which came into force in 1978.

A seminar of the Priority Action Programme, Land-use Planning in Earthquake Zones, was organized by PAP/RAC/UNEP in co-operation with UNDRO and UNCHS/Habitat in Cetinje, Yugoslavia, in June 1985. The purpose was to review problems of land-use planning and emergency management in seismic-prone areas of the Mediterranean Region.

The Seminar's conclusions showed the extent of seismicity of the Mediterranean Region. They also provided evidence that knowledge and experience in seismic risk management exist, and that they should be strengthened and disseminated further to reduce seismic risk in the Region.

4. Development Objectives:

Thus, it can be stated that the aim of the Project within the institutional framework provided by the Mediterranean Action Plan is to contribute to the reduction in loss of lives, community identity, income and property (social, economic and environmental) caused by earthquakes;

and consequently, to the rational development, protection and enhancement of the Mediterranean coastal environment. This development objective will be achieved through the establishment of a permanent co-operation programme and a permanent system of information and exchange of experience among Mediterranean countries. The development objectives are to:

(i) Formulate appropriate national policies and programmes in seismic risk reduction based on existing and available knowledge/experience;

(ii) Develop multidisciplinary and comprehensive approaches to seismic risk research, assessment and management;

(iii) Develop seismic risk reduction projects as integral parts of physical planning and building;

(iv) Strengthen and develop disaster preparedness;

(v) Create public awareness of seismic risk

b. <u>Strategy of the Project, its contribution to the achievement of development ojectives and the mechanisms necessary for its implementation</u>

1. The strategy of the Project may be summarized as follows:

(i) To ensure continuity with the regional and national projects and actions for seismic risk reduction mentioned in point 1.2; to consolidate their results and findings; to ensure their adoption as the necessary foundation of the Project;

(ii) To consider the Mediterranean Region not only as the geographic area where countries share common problems of seismic disaster, but also as an environmental, historic and cultural unity in which countries can best engage themselves in a common effort to reduce seismic risk through policies and measures at the national and regional levels;

(iii) To produce a limited number of final outputs ensuring, in this manner, their wide applicability in well-defined areas. These outputs are addressed to the:

- decision-makers
- professionals
- public

These outputs should be tied to the completion or extension of a number of existing national projects undertaken by countries in recent years or projects which are now being implemented.

(iv) To initiate a co-operative programme, as well as a system of information and exchange of experience among Mediterranean countries, with a view to their permanent establishment.

(v) To provide the framework for further bilateral or multilateral co-operation in related or parallel areas.

2. The implementation of the Project is based on the following:

(i) Co-ordination and management of the Project as a shared responsibility of the Mediterranean countries. Countries will assume responsibility for co-ordinating and implementing selected components of the programme;

(ii) Transfer among Mediterranean countries of scientific knowledge and experience in planning, implementation and management which constitute the existing state of the art in seismic risk reduction;

(iii) Holding of workshops/seminars as well as round-tables for decision-makers as the basic instruments of co-operation, exchange of information and co-ordination;

(iv) Case studies on the application of methods of assessment, planning methodologies and procedures, management systems etc., to be reviewed and discussed in workshops and seminars by national institutions and experts;

(v) Fellowships and group training programmes to reinforce the effectiveness of national policies and programmes;

(vi) The production of guidelines, manuals and specific documents for practical use by decision-makers, professionals and institutions;

(vii) Bilateral or multilateral technical co-operation for the implementation of national projects on the basis of the results and findings of the project.

3. U.N. Agencies UNEP-UNDRO-UNCHS will:

(i) Provide a supportive role in technical co-operation on specific issues;

(ii) Contribute to the transfer of experience and knowledge acquired to date in regional and national projects;

(iii) Contribute to the preparation and co-ordination of workshops and seminars;

(iv) Contribute to the implementation of technical co-operation projects among countries, and the dissemination of results and findings;

(v) Co-operate among themselves and with other UN agencies and operate in the Project according to their mandates, expertise and capabilities as follows:

(a) UNEP in the field of environmental management and networking, acting as promotor and focal point for action and collection and dissemination of information;

(b) UNDRO in the field of seismic risk assessment and preparedness;

(c) UNCHS in the field of integrated physical and urban planning, to reduce seismic risk.

4. Actions Planned:

The following actions are organized around the thematic framework established by the Cetinje seminar (June 1985). This framework provides a logical and sequential scheme for analysis and action:

(i) Hazard:

- Observation of seismic phenomena (instrumental networks and monitoring;
- Seismological and seismotectonic studies/maps;

  Seismic hazard assessment;

  Seismic hazard mapping (macro and micro-zoning);

(ii) Vulnerability:

- Damage analysis;
- Vulnerability assessment of structures and systems, including lifelines;

(iii) Risk reduction and management:

(a) Physical planning:

- comprehensive physical planning (regional and local);
- settlement planning, including land-use planning and detailed urban development planning;
- design of earthquake scenarios for economic and social planning and disaster preparedness;
- revision of regional economic and development plans as a function of such scenarios

(b) Legislation:

- planning legislation for mitigation and reconstruction
- seismic building codes
- building regulations and controls
- codes for repair and strengthening

(c) Planning, building and engineering aspects of disaster preparedness (emergency planning):

- rescue
- shelter and related services
- access and evacuation
- demolition and clearance

(d) Public awareness of earthquake hazard, vulnerability and risk:

- public information and education
- simulation based on earthquake scenarios, with special reference to access, rescue and evacuation

(iv) Synthesis of project results for the benefit of national programmes and Mediterranean co-operation (decision-making level).

Immediate Objectives

1. To promote a systematic approach to seismic hazard, vulnerability and risk assessment for physical planning and building (development objective i).

2. To promote applied research in seismic risk reduction (development objective ii).

3. To provide methods and procedures to incorporate seismic risk reduction in the physical planning and building process (development objective iii).

4. To promote the adoption and practice of risk management systems and to ensure the linkage of risk management organisms to planning organizations (development objective iii).

5. To promote education and training in planning and management for seismic risk reduction (development objective iv).

6. To promote public information on seismic hazard, vulnerability and risk and basic measures for seismic risk reduction (development objective v).

7. To synthesize knowledge in a usable and practical form for national governments at the decision-making level (for the formulation and implementation of relevant national seismic risk reduction policies and programmes, and for the development of permanent co-operation in the Mediterranean in this area) (development objective vi).

ANNEX I

LEGAL CONTEXT

1. Reference to the Barcelona Convention of the Mediterranean countries and other Contracting Parties to the same Convention for the environmental protection of the Mediterranean Region through the Mediterranean Action Plan.

2. Reference to the Assistance Agreements between the Governments of the Mediterranean countries and the United Nations Development Programme.

3. Reference to Memoranda of Agreement between the UN Agencies.

ANNEX 2

SPECIAL CONSIDERATIONS

The premises of the Project being to contribute to the reduction of loss of lives, community identity, income and property (social, economic, cultural and environmental) caused by earthquakes, the Project will actively and directly contribute to the following two global achievements:

1. Preservation and improvement of the physical environment: through the mitigation of seismic risk the Project will promote the rational development, protection and enhancement of the Mediterranean coastal environment.

2. Co-operation among countries: in this respect the Project will contribute:

   (i) to the establishment of permanent co-operation among the Mediterranean countries in the fields of planning and management for seismic risk reduction, and

   (ii) to the establishment of a permanent system of information and exchange of experience on the subject among those countries.

ANNEX 3

INSTITUTIONAL FRAMEWORK

1. NETWORK:

The Project: "Seismic Risk Reduction in the Mediterranean Region" will be developed as a regional network of national institutions in the areas of research, planning, implementation and management in view of the establishment of a permanent process of technical co-operation, information and exchange of experience among the Mediterranean countries for the reduction of seismic risk.

2. CO-ORDINATING COMMITTEE:

As the Programme is co-operative in nature, co-ordination and management of the Project must be a shared responsibility of the countries in the Mediterranean Region. Consequently a Co-ordinating Committee of the Project will be set up. It will have the responsibility to plan, implement and evaluate the technical co-operation programme among the Mediterranean countries, and in particular, to develop and conclude existing national projects, to transmit the experience derived from them to the Mediterranean Region as a whole and to promote new national projects and highly specialized services for seismic risk reduction at the regional level.

Participating Mediterranean countries will nominate their representative in the Co-ordinating Committee. Representatives will have the right to vote. So will the representatives of other Contracting Parties to the Barcelona Convention. The UN agencies will be represented in the Co-ordinating Committee, but with no voting right.

The Co-ordinating Committee will meet twice a year at least. The Chief Technical Adviser will act as secretary of the meeting.

3. UN AGENCIES PARTICIPATING IN THE PROJECT:

The UN agencies, UNDRO-PAP/RAC-UNCHS, will provide support in the form of technical assistance on specific professional items.

The Project will be executed by one of the UN agencies involved. It will be posted in a selected host country of the Mediterranean Region or in the UNDP Regional Office, Geneva, in the implementation phase of the Programme.

The Programme Staff will consist of the Chief Technical Adviser and the host country Project Manager and the administrative support personnel and will employ a multidisciplinary team of scientists and professionals - phisical urban planners, seismologists, engineers, civil protection specialists, jurists etc. This team will work on specific assignments in the Mediterranean countries.

4. LEVERAGE OF SPECIFIC TECHNICAL CO-OPERATION PROJECTS BY THE PROGRAMME:

Parts of the Group Training Programme will take place in different countries participating in the Project. Contributions in national currencies are expected to cover a part of the related expenses.

ANNEX 4

MONITORING, EVALUATION AND REPORTS

1. MONITORING REVIEWS:

The Project will be subject to periodic reviews in accordance with the policies and procedures established by UNDP and in keeping with those established through the Barcelona Convention within the framework of the Mediterranean Action Plan.

2. EVALUATION:

The Project will be subject to evaluation after 18 months of operation in accordance with the policies and procedures established by UNDP. Terms of reference of the evaluation and its organization will be decided by consultations between the Co-ordinating Committee, UNDP and the UN Executing Agencies.

3. REPORTS:

The Chief Technical Adviser and the Host Country Project Manager will prepare the periodic reports and the terminal report. A schedule of reports at six months intervals should be established from the date of inception of the Project.

ANNEX 5

DEVELOPMENT OBJECTIVES	IMMEDIATE OBJECTIVES	OUTPUTS	ACTIVITIES
	1. To promote a systematic approach to seismic hazard, vulnerability & risk assessment, & to assure its incorporation in physical planning	1.1 State of the art in assessment	1.1.1 Collection of methods/techniques
		1.2 Practical use of assessment	1.2.1 Ad Hoc meeting to define method
			1.2.2 Preparation of studies
			1.2.3 Gen. workshop to review studies
			1.2.4 Preparation of final studies
			1.2.5 Gen. seminar to review final studies
		1.3 Methodology	1.3.1 Dissemination of report
To develop interdisciplinary and comprehensive approaches to seismic risk assessment and management	2. To promote applied research in seismic risk assessment for physical planning & building	2.1 Inventory of institutions	2.1.1 Assemble inventory
		2.2 Data & information	2.2.1 Ad Hoc expert group to identify inputs/needs
			2.2.2 Preparation of material
			2.2.3 Gen. workshop to review material
		2.3 Classification	2.3.1 Dissemination of report
	3. To provide methods & procedures to apply risk assessment to planning & building	3.1 Overview of planning experience	3.1.1 Review of planning projects
		3.2 Preparation of plans & projects	3.2.1 Ad Hoc expert group to define approaches
			3.2.2 Preparation of plans & projects
			3.2.3 General review workshop
			3.2.4 Preparation of final studies
			3.2.5 Seminar on final studies
		3.3 Planning methodology	3.3.1 Dissemination of report
		3.4 Glossary of concepts & terms	3.4.1 Preparation & review
			3.4.2 Publication & dissemination of glossary

ANNEX 5 (cont.)

DEVELOPMENT OBJECTIVES	IMMEDIATE OBJECTIVES	OUTPUTS	ACTIVITIES
o incorporate seismic risk eduction in all physical planning nd development projects	4. To promote the adoption & practice of risk management systems, and to assure their ties with planning at the professional and institutional levels	4.1 Risk management systems 4.2 Normalized systems	4.1.1 *Ad Hoc* expert group to identify methods, needs & approaches 4.1.2 General review workshop 4.2.1 Dissemination of report
o strengthen and develop lisaster preparedness	5. To promote training & education in all aspects of seismic risk	5.1 Training programme 5.2 Fellowships	5.1.1 Prepare fellowships programme 5.2.1 Programme implementation
o promote public awareness of seismic risk	6. To promote public awareness of seismic risk and counter-measures	6.1 Public awareness programme 6.2 Information & education	6.1.1 Programme preparation 6.2.1 Programme implementation
o formulate appropriate national policies and programmes for seismic risk reduction based upon existing knowledge and experience	7. To synthesize knowledge in a practical form for Governments at the decision-making level, for policy-making & programming and to establish a permanent Mediterranean co-operation	7.1 Synthesis of knowledge and guidelines for national policies 7.2 Guidelines for decision-makers 7.3 Summary of Project results	7.1.1 Synthesis programme formulation 7.1.2 Programme implementation 7.1.3 Round tables for decision-makers 7.2.1 Preparation of guidelines 7.3.1 Preparation of summary 7.3.2 Final conference at the decision-making level

6. CONCLUSIONS AND RECOMMENDATIONS OF THE SEMINAR ON SEISMIC RISK REDUCTION IN THE MEDITERRANEAN REGION, Genoa, October 16-18, 1986

A. General

Cyprus, Egypt, France, Greece, Israel, Italy, Morocco, Syria, Tunisia, Turkey and Yugoslavia were represented at this seminar as well as UNCHS, UNDRO, UNESCO and the Co-ordinating Unit of MAP.

The basic objectives of the Genoa Seminar, the second one held in the framework of this Priority Action, were as follows:

1. Consideration, discussion and appraisal of selected and elaborated case-studies and other technical documents prepared on the basis of the Conclusions and Recommendations as well as the Thematic Framework adopted by the Cetinje Seminar;
2. Review and appraisal of the Co-operative Project Proposal for seismic risk reduction in the Mediterranean;
3. Formulation of proposals and recommendations relative to seismic risk reduction in the Mediterranean Region, addressed to the Governments of the coastal States, including proposals for the follow-up of the Action.

It is understood that dealing with these objectives and other relevant issues significant for the future co-operation of the Mediterranean countries in this field should be considered in the scope of all conclusions of the Cetinje Seminar, in connection with the further development of this Priority Action, including a more direct linking with essentially equal and/or mutually linked fields of other priority actions in the framework of PAP/MAP, and particularly with PA "Integrated Planning and Management of Mediterranean Coastal Zones".

As is evident, the objectives and thematic structure of the Genoa Seminar have been defined and oriented in such a way as to contribute to a most complete identification of issues and to the provision of appropriate conditions for a common and co-ordinated approach to seismic risk mitigation in the Mediterranean, through the promotion of the proposed Mediterranean Co-operative Project and other possible initiatives and forms such as technical co-operation, staff training, exchange of information with a view to establishing a common data basis etc.

This Section presents only the major conclusions and recommendations of the Seminar. Certain selected topics and examples of studies relating to seismic risk reduction in the form of experts' reports from the demonstration studies prepared for the Seminar itself and for further exchange of experience in this very field are presented in the next chapter.

B. Conclusions and Recommendations

Conclusions

Following the ideas put forward at the Cetinje seminar, the meeting concluded the following:

1. National reports, demonstration studies and papers as well as the thematic framework presented at both the Cetinje and the Genoa seminars provide the basis for the exchange of experience and information in the field of planning and building in seismic-prone Mediterranean coastal areas.

2. The involvement of UNCHS, UNDRO, UNIDO and UNESCO has substantially contributed to past efforts in the reduction of seismic risk in the Mediterranean.

3. Further continuous efforts are needed to improve seismic instrumentation networks, data base, training and implementation of earthquake technology for the management of seismic risk through the process of survey, assessment and planning.

4. The project proposal "A Co-operative Programme for Seismic Risk Reduction in the Mediterranean Region" is a sound basis for immediate action. This implies a synthesis of knowledge in various disciplines for practical application in physical planning and construction; the training of experts; public information and education; increasing awareness among decision makers; and exchange of experience among the countries of the region.

5. Previous results of the PAP action and the deliberations of this seminar have stressed the need for establishing a permanent Mediterranean co-operation in the field of seismic risk reduction and preparedness.

<u>Recommendations</u>

1. It is recommended that:

   (a) In the project follow-up action priority be given to the creation of the necessary conditions for the immediate implementation of the Mediterranean co-operative project, for the identification of the host country, the participating countries and their possible professional inputs;

   (b) all Mediterranean countries join the co-operative project and recommend it to national, regional and other organizations for their support;

   (c) the existing co-operation of relevant UN agencies be maintained and that co-operation with other interested organizations and programmes which have not been involved so far be initiated;

   (d) PAP/RAC proceed with examining the possibilities and modalities of future permanent co-operation between Mediterranean countries in the field of seismic risk reduction, such as:

      - establishing a permanent system of data acquisition, training, and exchange of information and experience in the assessment of seismic hazard, vulnerability, seismic risk and earthquake disaster management;

- setting up a Mediterranean data bank and a centre for the planning of seismic risk management and mitigation;

- promoting co-ordinated research programmes;

- improving and harmonizing legislation, codes and standards specific to land-use planning, aseismic design and building;

- establishing inter-country post-earthquake emergency assistance.

2. It is recommended that a firm linkage with other PAP actions, particularly with "Integrated Planning and Management of Coastal Zones" and "Rehabilitation and Reconstruction of Mediterranean Historic Settlements" be established.

7. SELECTED TOPICS/EXCERPTS FROM FIVE DEMONSTRATION STUDIES PRESENTED AT THE GENOA SEMINAR

7.1 SEISMIC HAZARD ASSESSMENT AND LAND CAPABILITY ANALYSIS IN ECH-CHELIFF, ALGERIA

By Tebbal Farouk, El Foul Djamal, Boudiaf Azzedine, C.T.C., Algiers

A. Introduction

Algeria has had a long history of damaging earthquakes. Past studies of the seismicity and tectonics of Algeria have shown that 70 percent of the northern part of the country is very active seismically. Recently the Ech-Cheliff (formerly El Asnam) 1980 earthquake damaged buildings and lifeline systems in the region and killed 2,700 people.

Algeria is situated in the African tectonic plate and at its north the Eurasian plate collides with the Africann plate. As a result, a wide belt of folded mountains (the Atlas Mountains) and a zone of crustal shortening about 400 km wide have been created along the collision zone. A broad zone of seismic activity extends along the northern margin of the African plate.

In Algeria, destructive earthquakes have occurred in coastal areas where seismic activity is concentrated. The Ech-Cheliff region lies in a particularly exposed zone. This region has experienced moderate to large earthquakes at least a dozen times in the past 250 years. The most notable recent ones occurred in 1922, 1934, 1954 and 1980. The major earthquake (Ms=7.3) which struck the Ech-Cheliff region on October 10, 1980 was the largest earthquake known to have occurred in Northern Africa. It caused damage to buildings and lifeline systems over an area of about 1,000 km2 and affected to a lesser extent an area of about 10,000 km2. The epicentre of this event was about 10 km east of Ech-Cheliff on the Oued Fodda fault, an active reverse fault that has about 47 km of surface faulting. The mainshock, although not recorded on a strong motion accelerograph, may have generated peak ground accelerations exceeding 0.5 g.

For the planning of reconstruction and development of the Ech-Cheliff region, the planners had to answer the main question that faces authorities concerned with land-use planning in seismic prone areas in other regions of the world; that is how urban development should be planned in order to protect the population and what it values most (i.e. houses, roads, industries, power plants, etc.). To achieve this goal, the first step is to undertake a seismic risk mitigation program through appropriate land-use planning, enforcement of aseismic building codes and the setting up of effective civil defense.

Since the primary objective of such a programme is to reduce the human and economic losses caused by earthquakes, two main alternatives should be considered:

- Avoid the recognized hazard by building and living in an area where the probability of occurrence of an earthquake is lowest, or

- Remain in the hazardous area and try to reduce the risk through a safety planning programme developed on the basis of a seismic hazard assessment.

Before trying to reduce seismic risk, it should first be evaluated by assessing the degree of exposure of individuals and structures to a given seismic hazard. This is done by comparing the defined hazard with the distribution of population, the existence or not of important facilities, the size of the city and its vulnerability to its particular hazard.

Following the magnitude 7.3 earthquake that damaged the Ech-Cheliff area on October 10, 1980, a seismic microzoning study was initiated in order to evaluate the earthquake hazards of ground shaking, surface faulting and earthquake-induced ground failures in the region, the objective being to define the regional and local (urban scale) seismic hazards so that appropriate actions to reduce seismic risk could be taken.

Seismic microzoning, the division of an urban area into zones expected to experience the same relative severity of ground shaking, surface faulting, tectonic deformation, or earthquake-induced failure, started in May 1983. This study had to answer the following questions:

(1) Where have earthquakes occurred in the past?

(2) Why do they occur?

(3) How often do they occur?

(4) What are the earthquake-induced hazards the area is likely to experience, how severe can they be and how often can they occur?

(5) What are the actions to be taken towards improving land-use and earthquake-resistant design to mitigate the risk in the area?

The workplan described below in terms of general tasks consisted of three phases:

Phase 1: Evaluation of seismic hazards on a regional scale:

This phase of the microzoning study established the physical parameters of the region and included the following tasks:

- Compilation of a historic seismicity catalog and map.

- Performance of neotectonic studies (mapping, age dating and trenching) to extend the recurrence of information derived from the historical seismicity data.

- Preparation of a photogeology map.

- Preparation of a seismotectonic map showing acting faults.

- Preparation of a map showing seismic source zones, specifying the maximum earthquake and the frequency of occurrence for each source zone.

- Specification of near-field ground-motion characteristics (peak amplitude and spectral composition).

- Specification of regional seismic attenuation laws, including their uncertainty.

- Preparation of probabilistic ground-shaking hazard maps in terms of peak ground acceleration.

- Creation of regional data bases (for example seismicity, aerial photography, hydrogeology, lineament maps and drill logs) and documentation of computer programmes for the analysis of data.

Phase 2: Microzoning of urban areas in the Ech-Cheliff region:

This phase of the microzoning study integrated the information acquired in the regional study with site-specific data acquired in each of the 9 selected urban areas to produce microzoning maps. The primary technical tasks included:

- Acquisition of existing and new geological, geophysical and geotechnical data to characterize the soil and rock in the Ech-Cheliff region in terms of their physical properties and the response expected under various levels of the earthquake ground-shaking hazard.

- Estimation of empirical soil transfer functions with consideration of the amplitude, frequency composition and level of peak ground acceleration.

- Preparation of probabilistic ground-shaking exposure maps for each urban area in terms of peak ground acceleration and exposure times that can be correlated with the Algerian building code.

- Specification of the dynamic amplification factor for typical soil columns in each urban area.

- Preparation of a map showing the potential for surface fault rupture in each urban area.

- Preparation of a map showing the potential for liquefaction in each urban area.

- Preparation of a map showing the potential for landslide in each urban area.

- Preparation of a map in each urban area showing potential secondary effects (for example flooding).

- Preparation of a map in each urban area that synthesizes all of the potential seismic hazards in terms of their relative probability of occurrence.

- Evaluation of the distribution of damage from the 1980 Ech-Cheliff earthquake.

Phase 3: Recommendations for land-use, building codes, construction practices and other related matters.

This phase of the microzoning study required the analysis and synthesis of the primary data and the maps prepared in the above tasks to be applied in terms of specific recommendations. The tasks included:

- Evaluation of the building code currently used in Algeria, focusing on possible modifications to reflect the lessons learned from the 1980 Ech-Cheliff earthquake.

- Evaluation of regional urban land-use practices in Algeria, identifying possible alternatives to current practices.

- Evaluation of construction practices for new buildings in Algeria, specifying possible alternatives to current practices.

- Evaluation of the practices used in Algeria to repair and strengthen existing buildings suggesting possible alternatives to current practices.

B. GEOLOGICAL AND SEISMOLOGICAL STUDIES

Seismological network

It was not possible to determine with precision the location of the 1980 earthquake focus due to the fact that the closest seismological stations to the epicentral area (Oued Fodda and Relizane)were equipped with short period seismographs. The focus of the main shock and the epicentres of the principal aftershocks were localized on the basis of data gathered from the world seismological network. To monitor the seismic activity better in the future, the Algerian "Centre de Recherche en Astrophysique, en Astronomie et en Géophysique" acquired recently a telemetred network which is in the process of being installed throughout the country.

Assessment of the characteristics of the complex earthquake ground motions and the quantification of key ground motion parameters for earthquakes are essential for engineering applications. Without a good understanding of these characteristics and the factors that affect them, no realistic evaluation of the seismic hazards is possible and no procedures that can be utilized to address these hazards can be adequately developed. These considerations (combined with the fact that valuable seismic information was lost concerning the 1980 earthquake because no strong motion record was obtained for that event) led Algeria to deploy a national strong motion accelerograph network. For this purpose, 90 SMA-1 instruments were purchased. So far 70 have been installed throughout northern Algeria.

The objective of this network is to collect basic ground motion data as rapidly as possible in order to improve the understanding of earthquake ground motions in the country through the evaluation of the factors affecting the parameters of these motions. Such factors are:

- the characteristics of the seismic source
- the duration of shaking
- the regional seismic wave attenuation relation, and
- the frequency dependent effect of soil and rock on ground motion.

Aftershock studies

Hundreds of aftershocks (up to 600^{-y} of Ms 2) were recorded right after the mainshock; 50 had a MS 4 and were recorded between October 10, 1980 and January 31, 1981. Most of these events were localized by the "Centre Sismologique Europeo-Méditerraneen: CSEM" and the "United States Geological Survey: USGS" on the basis of recordings from worldwide stations.

In order to determine precisely the relative positions of the epicentres of the mainshock and those of the aftershocks, a local network of 14 seismological stations was installed by French and Algerian seismologists. This local network was completed with 10 instruments obtained from the United Kingdom. The records obtained show that the activity is diffuse without a clear relation to surface rupture. This feature is even more outstanding in the north-eastern end of the fault rupture.

During the same period, the seismicity observed in the central region of the fault break decreased and numerous events were recorded at both ends of the fault (300 events per day in the northern part and 23 events per day in the southern part).

The greatest number of recordings in the northern part in comparison with those in the southern part might be due to either:

- The geometry of the network installed that allowed solely the recordings of the events in the northern part, the events 1.5 MS and 2.5 at the southern end not being recorded; or

- The depth of the form due to the velocity model used (Up = 5.5 kms), the largest southern aftershocks being relatively deep and thus recorded. Consequently a correlation coefficient study of the histograms should be recommended.

Another phenomenon was observed during this monitoring period; it is the migration of seismicity in both directions between the northeastern and the southwestern ends. A specific study concerning this problem is necessary to get a better understanding of this phenomenon.

C. REGIONAL SEISMIC EXPOSURE STUDY AND URBAN MICROZONATION

Seismotectonic setting

Tectonic activity and the associated seismicity in North Africa are the result of the interactions between the African and Eurasian plates. Based on the spreading rates and orientations of fracture zones in the Atlantic to the north and the south of the Azores triple junction and on the slip vectors along the Azores-Gibraltar Ridge, Mc Kenzie in a re-evaluation of the tectonics of the Mediterranean concludes that east of Gibraltar, the African plate is moving northwards with respect to Eurasia. The calculated direction and rate of convergence are N20 W, 16 mm per year near Gibraltar and N7 W, 23 mm per year near Sicily (Fig. 1). The rate near the study region is about 18 mm per year. As a result of this motion, the Atlas/Alpine orogenic belts are undergoing a northwest-southwest compression that is responsible for the crustal shortening, folding and reverse faulting within the Atlas zone.

A broad zone of shallow seismic activity extends along the north African part of the plate margin. In Algeria, seismic activity is concentrated in coastal areas and associated with the structural features of the Atlas Mountains (Fig. 2). Three zones of destructive earthquakes in Algeria have been noted: 1) a zone delineated by the towns Oran-Mascara-Relizane, 2) a zone extending from the Massif de Dahra, near Ech-Cheliff, to the Mountains of Hodna and Aures, and 3) a zone corresponding to the line Kherrata-Constantine-Guelma. Destructive earthquakes have occurred in all three zones.

The Ech-Cheliff region lies within the Atlas Tellien near the northern boundary of the African plate. The earthquake sources of the region coincide with two major belts. The southern belt includes the Oued Fodda and Lower Cheliff Valley fault zones and consists of a group of north-east striking north-west dipping reverse faults. The second belt that is interpreted to lie just offshore at the north of the Ech-Cheliff area is apparently the mirror image of the structures observed along the southern belt. Reverse faults are the dominant structures in the region and trend east-west to east-northeast, parallel to the plate boundary and normal to the direction of convergence. The epicentre of the 1980 Ech-Cheliff earthquake was about 10 km east of the city of Ech-Cheliff on the Oued Fodda fault, an active reverse fault that has about 47 km of surface break.

Hazard assessment

Seismic hazard analyses were conducted for 106 sites located throughout the study region on a 10 km grid. At each site, the results of the exposure analysis were used to obtain the levels of peak ground acceleration at different return periods. The resulting acceleration values were then contoured to provide isoacceleration maps for the region for return periods of 50, 200 and 500 years. The isoacceleration maps are shown in Figs. 10 and 11. The range in computed acceleration values throughout the study region is:

Return Period (Years)	Range at Peak Ground Acceleration Firm Soil Site Conditions (g's)
50	0.05 - 0.18
200	0.09 - 0.39
500	0.13 - 0.54

The isoacceleration contours generally delineate two areas of higher accelerations, one running along the coast, parallel to the inferred offshore fault zone, and one encompassing the interior faults along the Chelif valley. The pattern of the contours reflects the general northeast-soutwest trend of the geologic structures and the areas of highest exposure coincide with Area Source I, which has the highest level of seismic activity and contains all of the mapped active faults in the study region.

The confidence intervals about the estimated ground motion levels for the specified return period were evaluated by computing the seismic hazard for each branch of the logic trees developed for the seismic sources. The confidence intervals represent the uncertainty in the estimated ground motion levels due to uncertainties in interpreting the available geological and seismological data. These evaluations indicate that 68 percent confidence interval about the estimated ground motion levels represents a variation of approximately plus 20 percent to minus 25 percent of the values shown on the isoacceleration maps.

Seismic microzonation of urban areas

A series of earthquake hazard and seismic microzonation maps have been prepared for each of the nine selected urban sites of Ech-Cheliff, Oued Fodda, El Abadia, El Attaf, Oued Sly, Bou Kadir, El Karimia, Sendjas, and Ouled Ben Abdelkader (Fig. 12). The main purpose of the seismic microzonation of urban areas in the Ech-Cheliff region is to delineate the seismic hazards that could affect these areas and to present and synthesize the results of the study in the format that will be useful to government agencies, city planners, and the construction industry.

The three primary sources of data used to compile the maps are (1) geologic mapping of the urban areas; (2) the results of the geotechnical and hydrological investigations and (3) the results of the regional seismic exposure study.

Synthesis of earthquake hazards and seismic microzonation

The synthesis and microzonation maps provide both a synthesis of the individual earthquake ground failure hazards and microzonation of each urban area into zones having a similar overall degree of hazard and similar requirements for geotechnical investigations for building. The hazards that are synthesized on the maps include liquefaction potential, landslide potential, surface fault rupture potential and potential for compaction (settlement) of loose man-made fill or young sandy alluvium. Fig. 16 shows such a map for the city of Sendjas. The areas presenting these hazards were delineated using the geotechnical maps (to delineate areas of fill and alluvium with potential for compaction) and the ground failure maps (to delineate areas of potential for liquefaction, landsliding and surface fault rupture). Three zones, I, II and III, were defined and used for microzonation mapping of the urban areas. Within each zone, a similar overall severity of hazard was judged to exist, based on a subjective evaluation of the combined effects of the hazards within a given area. Zone I comprises conditions that generally pose significant earthquake-related ground failure hazard to ordinary buildings; zone III comprises conditions that generally do not pose significant hazards; and zone II comprises conditions that are intermediate between those in zones I and III.

The legends of the synthesis and microzonation maps provide guidance for an appropriate degree of geotechnical investigation to assess earthquake hazards in the microzonation zones. The most comprehensive investigations are needed in zone I. In contrast, investigations in zone III would generally be only those required by ordinary building practices, without special consideration of hazards due to earthquake-related ground failure. The potential for strong ground shaking needs to be considered in designing buildings in any location of the urban areas.

The microzonation maps provide the type of information needed in taking urban and land-use planning decisions. The use of maps in urban planning is discussed by Mader and Thiel and Woodward-Clyde Consultants. The maps also serve as a "red flag" to builders and regulators that at some sites geologic hazards may exist and require investigation and consideration in foundation design. These maps are not intended to replace the need for site-specific studies; they provide a framework and guidance for planning site-specific studies and they will aid in evaluating the results of such studies.

D. LAND CAPABILITY ANALYSIS WITH A REVIEW OF SELECTED CASES AND REGIONAL PLANNING AFTER THE SEISMIC HAZARD STUDY

The microzonation study was intended to provide the local authorities of Ech-Cheliff with results to be used directly for:

- The improvement of construction practice through the use of seismic hazard and a better understanding of the structural behaviour of constructions submitted to dynamic loading;
- The improvement of construction regulations, namely the aseismic design code (RPA-81);
- The implementation of appropriate urban and regional planning.

The third item proved to be the latest to begin since all construction was frozen in the damaged area until the completion of the microzonation study, i.e., from October 1980 to the end of 1984. The first step for the reconstruction and redevelopment of the damaged area was the laying out of a proper urban and regional planning based on the evaluation of seismic risk which is related to the seismic hazard exposure defined for the area.

The seismic microzonation study accomplished by CTJ and Woodward-Clyde Consultants identified potential ground failure hazards induced by earthquakes in this area. A land capability analysis methodology was then proposed for the purpose of evaluating these hazards and deriving statements as to land use after establishing a matrix of natural factors. For the illustration of this methodology a portion of the city of Ech-Cheliff was chosen on which the approach was tested (Figs. 17, 18 and 19).

At present, the local urban planning offices are following the same pattern in the other cities. We give maps of the proposed urban plan for the city of Sendjas (Fig. 20).

It should be pointed out that most of the material for the first part of this section is derived from the CTC-WCC microzonation study report.

In the second part of this section, we shall comment briefly on some recommendations for regional planning in this area.

Land capability analysis

As part of the study, seismic microzonation maps were prepared for nine urban sites within the area, Ech Cheliff, Oued Fodda, El Abadia, El Attaf, Oued Sly, Bou Kadir, El Karimia, Sendjas and Ouled Ben Abdelkader. The potential for ground failure, liquefaction (l), landsliding (h), consolidation of man-made and natural fill (t) and faulting (f), was investigated and assessed for each of these communities. Synthesized earthquake hazard maps, called microzonation maps, were prepared. They integrated the ground failure hazards for each community. Fig. 20 shows an example of the type of maps produced for Ech Cheliff. Each of the identified zones represents an area of similar severity of hazard: Zone I comprises conditions that generally pose significant earthquake-related ground failure hazards to ordinary buildings for which specific seismic geotechnical investigations are recommended prior to design or construction; Zone III comprises conditions that generally do not pose a significant earthquake hazard and do not warrant special earthquake site investigations beyond those carried out in normal geotechnical practice; and Zone II is intermediate between the other two. The subscripts reflect the source (g) of the problem and are consistent with the notation given in parentheses above. A prime (') indicates a lesser hazard.

A land capability analysis is recommended as a method for integrating the seismic microzonation study into Algerian urban and regional planning. This type of analysis evaluates collectively environmental factors that affect capability of land areas to support land uses. The seismic microzonation maps for each of the nine urban areas in the Ech Cheliff region rate areas in terms of three general levels of seismic hazard (I, II and III) and also provide data as to specific hazards. These maps do not, however, attempt to correlate the seismic hazard areas with particular land uses. It is the purpose of the land capability analysis to go this next step and establish a methodology for correlating land uses with mapped seismic hazards.

For illustration purposes, a land capability analysis has been applied to a portion of the city of Ech Cheliff. The land capability classifications in the example are illustrative only and are not intended as recommendations. It is recommended, however, that Algerian planning agencies use the methodology to develop the land capability classifications they believe are appropriate.

Land-use environmental matrix

The Land-Use Environmental Factors Matrix is the fundamental part of a land capability analysis. This matrix correlates environmental factors with land-use categories. Each part of the matrix is described below.

a. Environmental factor

The environmental factor is the mapped information. Listed on Table I are four environmental factors included on the microzonation maps: potential for fault rupture, potential for landslides, and potential for liquefaction. In addition to seismic factors many other factors are often used in a land capability analysis, such as:

- Agricultural value of land
- Slope of land
- Existing regulations
- Soil percolation rates
- Flooding
- Distance to circulation facilities
- Availability of utilities
- Aesthetic qualities
- Ownership patterns
- Existing land-use

Factors chosen should be those planners find important in taking land-use decisions. For illustrative purposes, however, the factors included in Table I include only these four which are on the microzonation maps.

b. Map designation

The map designations are taken from the categories shown on the seismic microzonation maps.

c. Land-use categories

Three land-use categories are selected for illustrative purposes: Dwellings, Moderate Density; Commercial, High Occupancy Use; and Essential Buildings or Facilities. Since land uses are normally composed of both structures and occupancies, it is appropriate to define land-uses in terms of both structural types and occupancies. In a microzonation study, these attributes are particularly important.

The illustration considers new structures of the types listed in Table II. Each of these types is understood by structural engineers to have certain structural attributes and to be appropriate for certain types of land uses. Although the illustration example is limited to new structures, it could be extended to existing construction, including damaged or repaired constructions.

To correlate structural types with occupancies or uses, a list of five types of land-uses with several sub-categories is shown in Table III. Structural types are taken from Table II. The X's indicate the types of structures that are suggested as possibly appropriate for each type of land use. Then, when judging the appropriateness of different land uses for various seismic conditions, the types of structures that are being considered and the types and levels of occupancies are easily understood.

d. Capability rating

Capability ratings are noted in Table I in the columns headed "C". A capability rating indicates the capability of land with a particular map designation, such as "f", to support a particular land use. A rating scale of 10 to 0 is used. A value of 10 indicates that land is excellent for the land use, a capability of "1" indicates that land is poor for the land use. A rating of "0" indicates the land has no capability of supporting the use. If a capability of "0" is given, the land use option is ruled out of the particular map designation. The assignment of a "0" does not mean, however, that it is necessarily impossible to build on a particular site.

e. Weight

The weight column on Table I is headed "W". A scale of 10 to 0 is used. If an environmental factor is critical with respect to land use, it is assigned a weight of 10. If it is of minimal importance, it is assigned a weight of 1. If it is of no importance, it is assigned a 0. For weight, a "0" does not remove the land-use option from consideration. The weights are also based on the judgement of knowledgeable professionals.

f. Weighted capability

The weighted capability of Table I is the product of multiplying the "Capability Rating" times the "Weight". It therefore represents the relative importance of the environmental factor for the land-use option being considered, as well as the capability of the factor to support the same land-use option.

g. Land capability maps

Once the Land-Use Environmental Factors Matrix, as illustrated in Table I, is completed, the next step is to use the matrix in the preparation of land capability maps. For the purpose of this illustration, a portion of the seismic microzonation map for Ech-Cheliff has been selected. Also, for illustration purposes, three land capability maps have been prepared which correspond to the three land-use categories shown on Table I.

Table I. LAND USE - ENVIRONMENTAL FACTORS MATRIX

		Land Use Categories								
		1.B. Dwellings Moderate Density			2.B. Commercial High Occupancy Use			5. Essential Buildings or Facilities		
Environmental Factor	Map Designation	C	W	WC	C	W	WC	C	W	WC
Potential for Surface 1/	Potential (f)	1 2/		8	0		0	0		0
Fault Rupture	Blank (Little or none)	10	8	80	10		100	10	10	100
Potential for Compaction 1/	Potential (t + Note 4)	1		8	1		4	0		0
	Potential (t)	4		32	3		12	1		15
	Some Potential (t')	7	8	56	7	4	28	6	5	30
	Blank (Little or none)	10		80	10		40	10		50
Potential for Landslides 1/	Potential (g)	0	10	0	0	10	0	0	10	0
	Blank (little or none)	10		100	10		100	10		100
Potential for Liquefaction 1/	High (l) 1	1		7	0		0	0		0
	Moderate (l')	5	7	35	4	9	36	3	8	24
	Blank (little or none)	10		70	10		90			80

Legend:

C = Capability Rating
10 - Excellent
9
8
7
6
5 - Fair
4
3
2
1 - Poor
0*-No Capability

*0 Capability rules out the land use category

W = Weight (Relative Importance of factor for land use being considered)
10 - Critical
9
8
7
6
5 - Significant
4
3
2
1 - Minimal
0 - No importance

WC = Weighted Capability

Weighted capability = Capability Rating x Weight

1/ From seismic microzonation maps.

2/ Assumes the development of an area, not all of which is subject to high potential for surface fault rupture.

3/ The designation "Note 4" refers to a note that is shown on the seismic microzonation map for Ech Cheliff, Map 6, Sheet 2 of 4.

Table II. STRUCTURAL TYPES

S1. - Reinforced concrete frame - not to be permitted in Seismic Zone III and above.

S2. - Structural steel rigid frame.

S3. - Reinforced concrete frame and shear walls with details providing reasonable ductile performance.

S4. - Complete shear and bearing walls with details providing reasonable ductile performance.

S5. - Non engineered 1/ 1 or 2-storey reinforced concrete frame with cement block infill walls and details providing reasonable ductile performance.

S6. - Non engineered 1/ 1 or 2-storey masonry structures

a. inspected
a'. not inspected2/

S7. - Elevated water tanks.

S8. - Silos, bins, etc.

1/ Non-engineered structures must meet the requirements of the building code but do not require a professional engineer to calculate loads and resistances.

2/ Not permitted by Proposed Revision RPA '81 and would only be permitted in Seismic Zone I.

TABLE III. LAND USE CATEGORIES AND STRUCTURAL TYPES

Land Use Categories			Structural Types S1	S2	S3	S4	S5	S6	S7	S8
1. Dwellings	A.	Low density, 1-2-storey and 1-4 unit	X		X	X	X	X	X	
	B.	Moderate density, 2-3-storey and/or 4-12 unit	X		X	X	X	X		
	C.	High density, 4+ storey	X		X	X	X	X		
2. Commercial	A.	Low to moderate occupancy use	X	X	X	X	X	X		
	B.	High occupancy use, or mixed use - moderate commercial occupancy and dwelling use	X	X	X	X	X	X		
3. Industrial	A.	Facility contains low to moderate hazard uses and/or storage	X	X	X	X	X			
	B.	Facility contains high hazard materials or processes that pose a substantial threat to adjacent populations	X	X	X	X				
4. Special Purpose										
	A.	Non-essential services e.g. silos, bins								X
	B.	Essential services buildings e.g. natural gas storage, electrical switch gear, elevated water tanks	X	X	X	X			X	
5. Essential Buildings or Facilities		- hospitals and clinics - schools - mass assembly buildings: sports stadia, mosques - governmental emergency facilities: fire and police stations, emergency communications centres - facilities whose operation is vital to post-earthquake public life	X	X						

h. Weighted capabilities for each land-use

Before preparing capability maps, it is useful to prepare tables for each land-use which contain the total weighted capabilities for each combination of environmental factors shown occur on the map under consideration. Tables IV, V and VI illustrate this step by providing weighted capabilities for the three land-uses. The first column on each table, entitled Designation of Seismic Microzonation Map, lists all ten map designations shown on the selected map. Columns 2 through 5 of each table indicate the weighted capabilities for the four seismic environmental factors under consideration. The weighted capabilities are obtained by selecting them from Table I. The total weighted capabilities are shown in column 6.

i. Land capability map preparation

Land capability maps graphically portray the relative capability of different areas to support a given land-use. To illustrate how land capability maps are prepared, we will prepare a land capability map for our selected area in Ech Cheliff for the land-use category "Dwellings, Moderate Density" (Fig. 17). First, the boundaries from the microzonation map are delineated and shown on Fig. 17. Next, the weighted capabilities from Table IV are added to the map near the designations from the microzonation map. They are also listed in the scale under "Weighted Capability". The scale has a maximum of 330 points for this land-use, the highest rating possible. The scale then extends downward in increments of 10 units to include the lowest rating given, or 247. Next, classifications are prepared which arbitrarily break the index into ranges of 90-100 percent, 80-90 percent, and less than 80 percent. The terms high, moderate, and low are then assigned to these groupings down to a weighted capability of "0". The Weighted capability of "0" is given the classification of "No Capability". Figs. 18 and 19 are prepared in the same manner.

Since the illustrations include only the four factors shown on the microzonation maps, flooding, which is very important in part of the Ech Cheliff area, is not included. Obviously, flooding, as well as many other non-seismically-related environmental factors, should be included in a complete land capability analysis prepared by Algerian agencies for Ech Cheliff.

The total weighted capability scores fall within rather narrow ranges due to the fact that all four environmental factors considered are of relatively high importance and therefore have high weights. If the capability analysis were extended to include a wide variety of factors, some of which would be of varying importance for the land-use alternatives, the spread of the weighted capability scores would increase.

Table IV. WEIGHTED CAPABILITIES FOR LAND USE CATEGORIES

Designation on Seismic Microzonation MAP (1)	1.B. Dwellings, Moderate Density Weighted Capability				
	Fault Rupture (f) (2)	Compaction (t+Note 4,t,t') (3)	Land-slides (g) (4)	Lique-faction (l, l') (5)	Total (6)
I g	80	80	0	70	0
I l	80	80	100	7	267
I t, g	80	32	0	70	0
I t, l'	80	32	100	35	247
I t, g, l	80	32	0	7	0
II t+note 4*	80	8	100	70	258
II t	80	32	100	70	282
II l'	80	80	100	35	295
III t'	80	56	100	70	306
III	80	80	100	70	330

Table V. WEIGHTED CAPABILITIES FOR LAND USE CATEGORIES

Designation on Seismic Microzonation MAP (1)	2.B. Commercial, High Occupance Use				
	Fault Rupture (f) (2)	Compaction (t+Note 4,t,t') (3)	Land-slides (g) (4)	Lique-faction (l, l') (5)	Total (6)
I g	100	80	0	90	0
I l	100	80	100	0	0
I t, g	100	12	0	70	0
I t, l'	100	12	100	36	248
I t, g, l	100	12	0	0	0
II t+note 4*	100	4	100	70	274
II t	100	12	100	90	302
II l'	100	80	100	36	316
III t'	100	28	100	90	318
III	100	80	100	90	370

Note: Whenever a weighted capability of "0" occurs in columns (2)-(5), the Total in Column (6) is "0".

* The designation "note 4" refers to a note that is shown on the seismic microzonation map for Ech Cheliff, Map 6, Sheet 2 of 4.

Table VI. WEIGHTED CAPABILITIES FOR LAND USE CATEGORIES

Designation on Seismic Microzonation Map (1)	5. Essential Buildings or Facilities Weighted Capability				
	Fault Rupture (f) (2)	Compaction (t+Note 4,t,t') (3)	Land-slides (g) (4)	Lique-faction (l, l') (5)	Total (6)
I g	100	50	0	80	0
I l	100	50	100	0	0
I t, g	100	15	0	80	0
I t, l'	100	15	100	24	239
I t, g, l	100	15	0	0	0
II t+Note 4*	100	0	100	80	0
II t	100	15	100	80	295
II l'	100	50	100	24	274
III t'	100	30	100	80	310
III	100	50	100	80	330

Note: Whenever a weighted capability of "0" occurs in columns (2)-(5), the Total in Column (6) is "0".

* The designation "note 4" refers to a note that is shown on the seismic microzonation map for Ech Cheliff, Map 6, Sheet 2 of 4.

j. Primary applications of the land capability maps

There are three primary ways to use these maps:

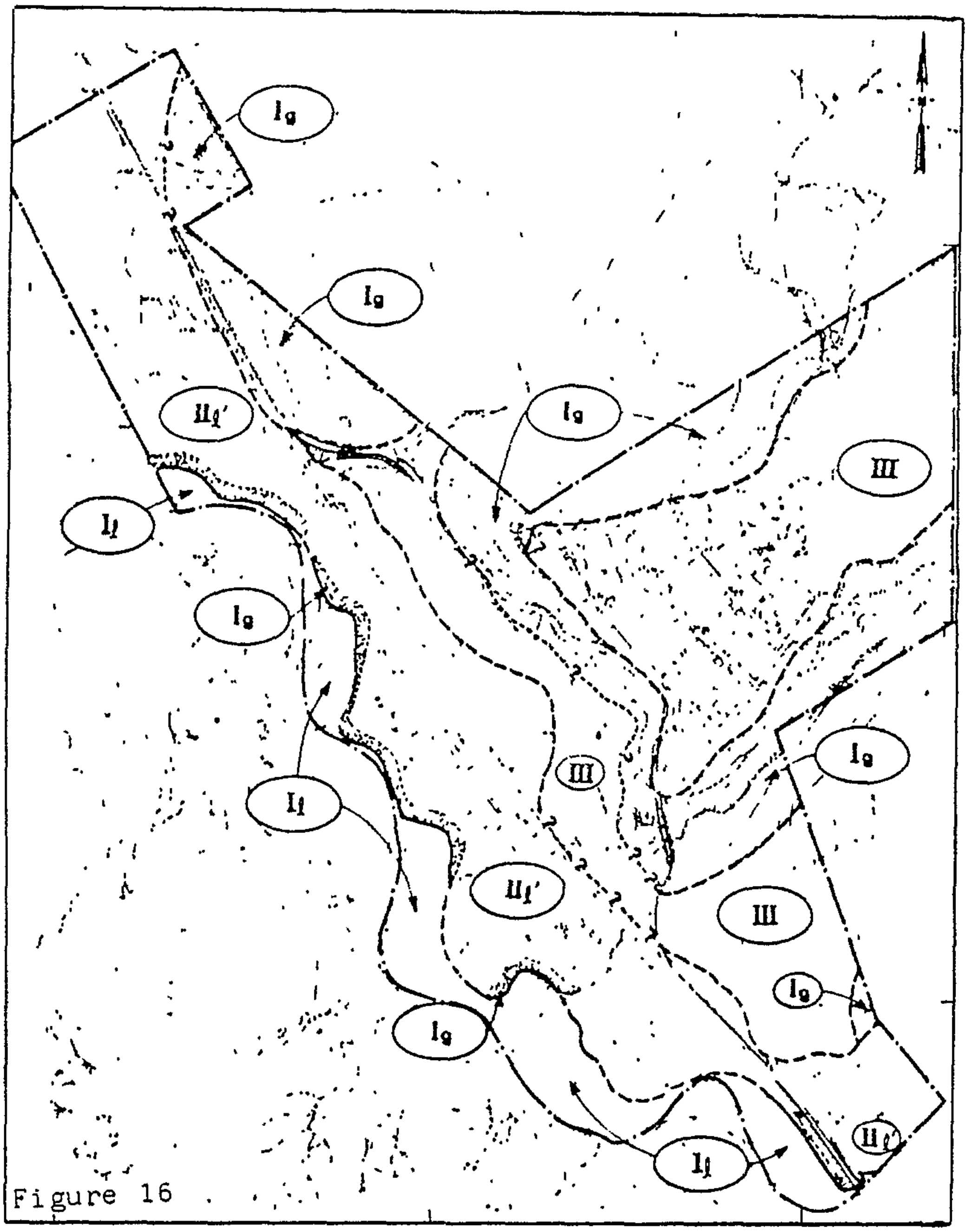
(1) Best site for a single land-use: In order to establish the best site for a particular land-use, taking into consideration only the four seismic factors included in the analysis, it is first necessary to select the map that addresses that land-use. Take Map 1, for instance. Four areas are shown as having high capability. These would then be the preferred areas for residential use. It is also possible to look within the high capability category to see if some areas have higher capability that others. It is seen, for instance, that three of the areas have the highest rating of 100 percent, while one area has a lower rating of 93 percent.

(2) Ranking of sites for a single land-use: a second use is to rank sites according to capability for the same use. It can be seen on Fig. 17 that areas are designated moderate, low and no capability. If the best sites are not available for land use, then the lower ranking sites can be considered. Such considerations should include the understanding that some seismic problems will be present and will result in increased risk or cost for solving problems, or both.

(3) Comparison of different land uses for the same site: since the scales for each land use are based on the percent, the weighted capability is of the maximum possible for that land use, it is possible to compare different uses for the same site. The land use which comes closest to maximizing the possible capability rating should have priority for the particular site; for instance if one looks at the area in the lower left hand corner of Figs. 17, 18 and 19, one can see that "Dwellings, Moderate Density" has a rating of 75 percent, Commercial, High Occupancy Use" has a rating of 67 percent, and "Essential Buildings or Facilities" a rating of 77 percent. Thus, priority consideration should be given to "Dwellings, Moderate Density".

k. Guidelines for use of land capability maps

It would be useful now to reflect on the meaning of land capability ratings. The ratings indicate areas where few problems are expected, areas where problems are significant and areas where problems are so severe that users should be prohibited from building. The ratings are based on certain assumptions as to geotechnical and structural measures. In general, they represent abnormal practices. Thus, the map indicates ratings based on normal, not abnormal construction practices.



Remarques:

1. Cette carte fournit, pour la zone urbaine de Sendjas, une synthèse des aléas d'effondrements du terrain et la microzonation en zones possédant un degré global semblable des aléas d'effondrements du terrain. Les informations obtenues par cette carte peuvent être utilisées dans l'analyse des aptitudes d'aménagement des sols, dans l'évaluation initiale des aléas de ruptures du sol pour un site spécifique, et dans la détermination des exigences pour les investigations géotechniques d'un site.

2. Les *niveaux estimés* des mouvements vibratoires du sol sont relativement uniformes pour l'ensemble de la zone urbaine. On se reportera à la carte d'isoaccélération 7—3 pour les données sur les caractéristiques des mouvements vibratoires à Sendjas.

3 *Le potentiel d'inondation dû aux déformations* tectoniques ou à une subsidence est négligeable comparé au risque d'inondation dû aux crues naturelles. De ce fait, le potentiel d'inondation lié aux séismes n'est pas indiqué. On se référera à la section 7 du volume II de l'étude de microzonation pour un commentaire de l'aléa d'inondation.

4. Dans l'objectif de la détermination d'un programme d'investigations géotechniques, les exigences indiquées sur la carte pour les différentes zones de la microzonation sont applicables aux sites de *bâtiments ordinaires* (groupe d'usage 2 dans le *RPA*) *Pour* des bâtiments essentiels ou critiques (groupe d'usage 1 dans le RPA), des investigations géotechniques, qui comprennent une évaluation des aléas d'effondrements du sol, doivent toujours être conduites quel que soit l'emplacement des bâtiments à *l'intérieur de la zone urbaine.*

5. On se référera à la section 8 du volume II de l'étude de microzonation pour un commentaire de l'approche utilisée dans la préparation des cartes. On se référera également à la section 16 du volume II *pour un résumé des résultats de la cartographie de synthèse et de microzonation de Sendjas.*

6. La cartographie a été effectuée uniquement à l'intérieur des limites de la zone urbaine

0 50 100 200 300 400

Fonds topographiques fournis par
l'Institut National de Cartographie Hussein Dey Alger

Carte de synthèse et de microzonation sismique
(Synthesis and Seismic Microzonation Map)
SENDJAS

Fig. 16 Synthesis and Seismic Microzonation Map

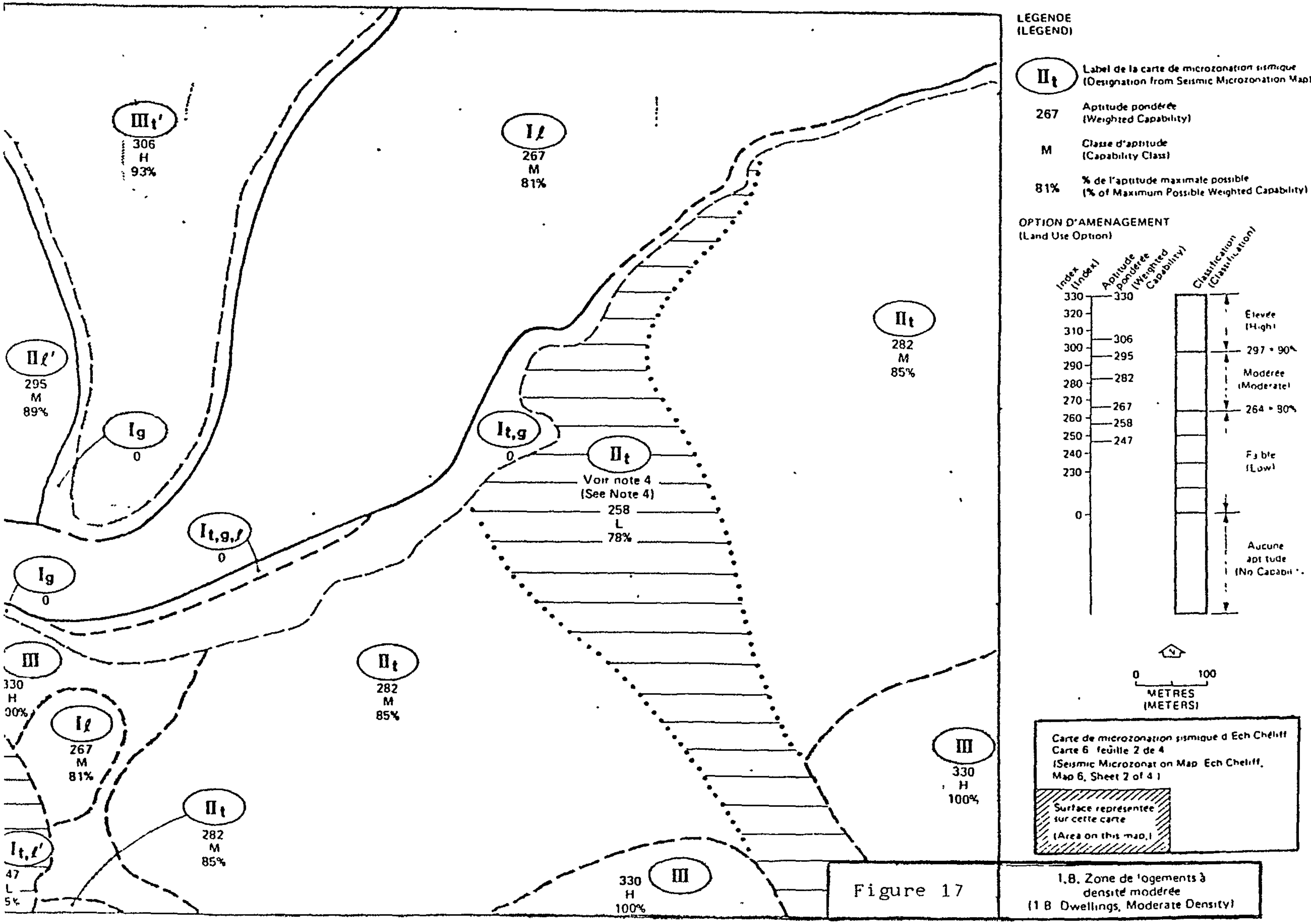
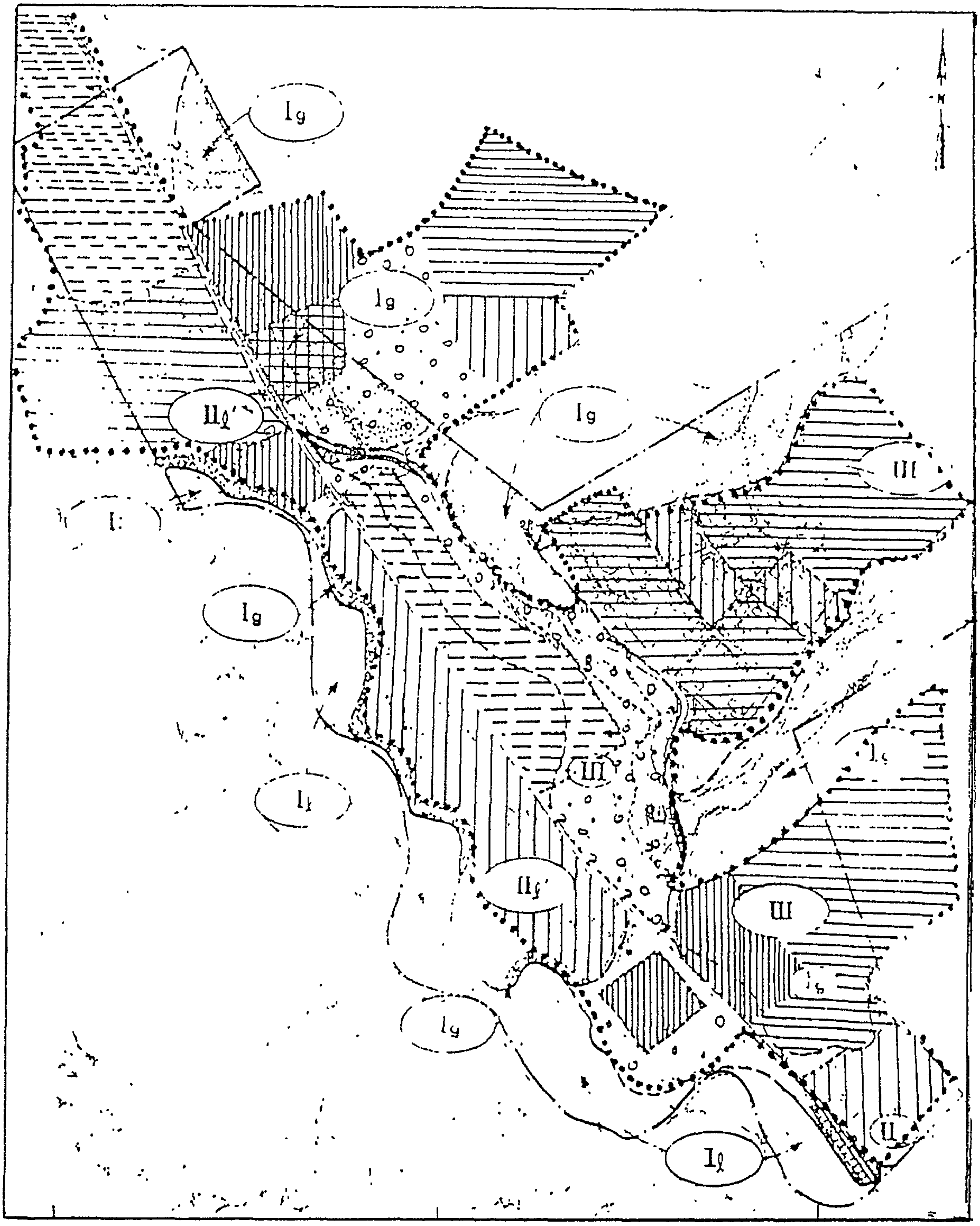


Figure 17

1.B. Zone de logements à densité modérée
(1 B Dwellings, Moderate Density)



Dwellings, moderate, density | Administrat. Services | Prefabricated houses
Schools | Dwelling high density | Green areas

Fig. 20 Sendjas - Provisional Urban Plan

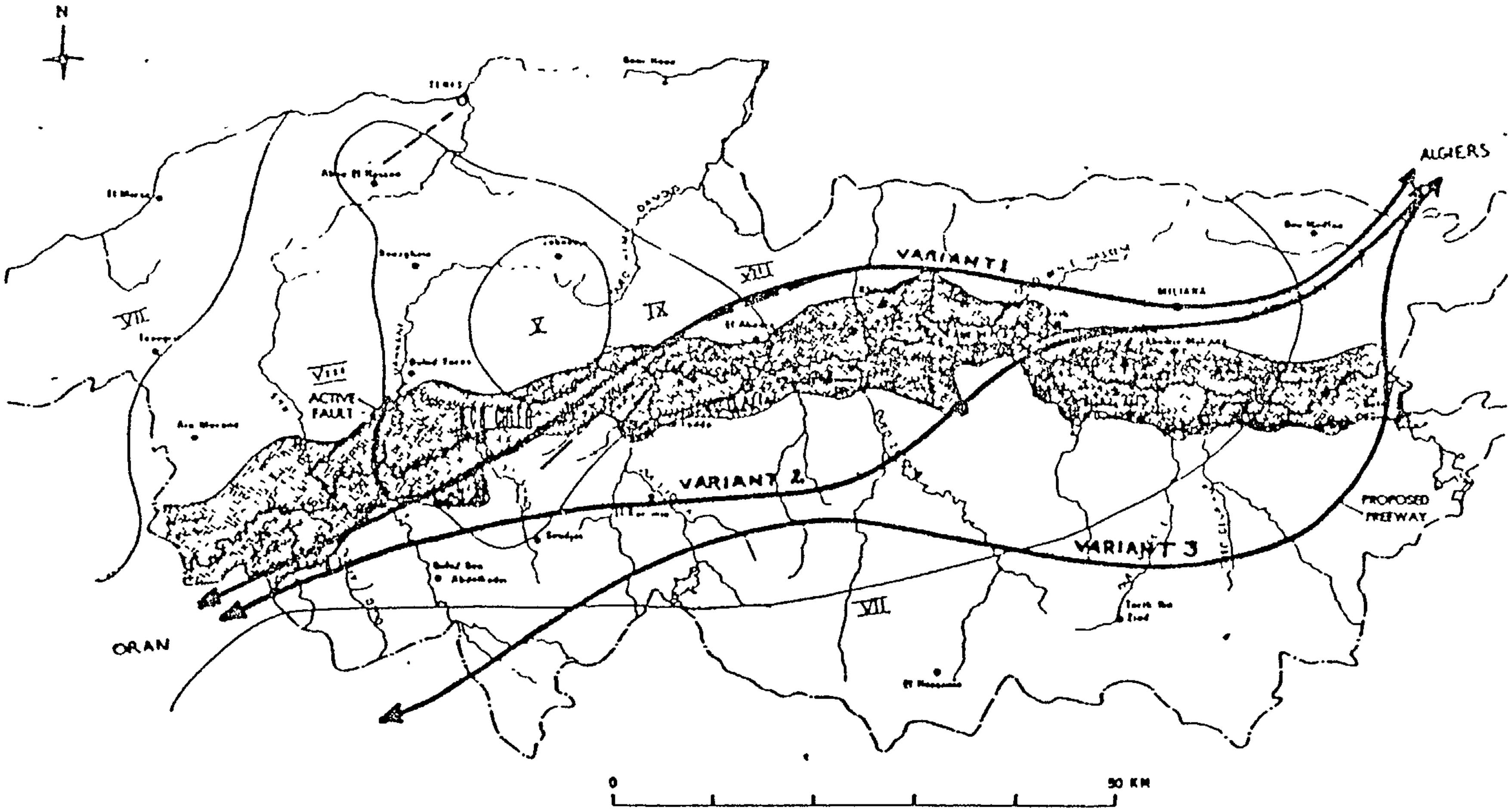
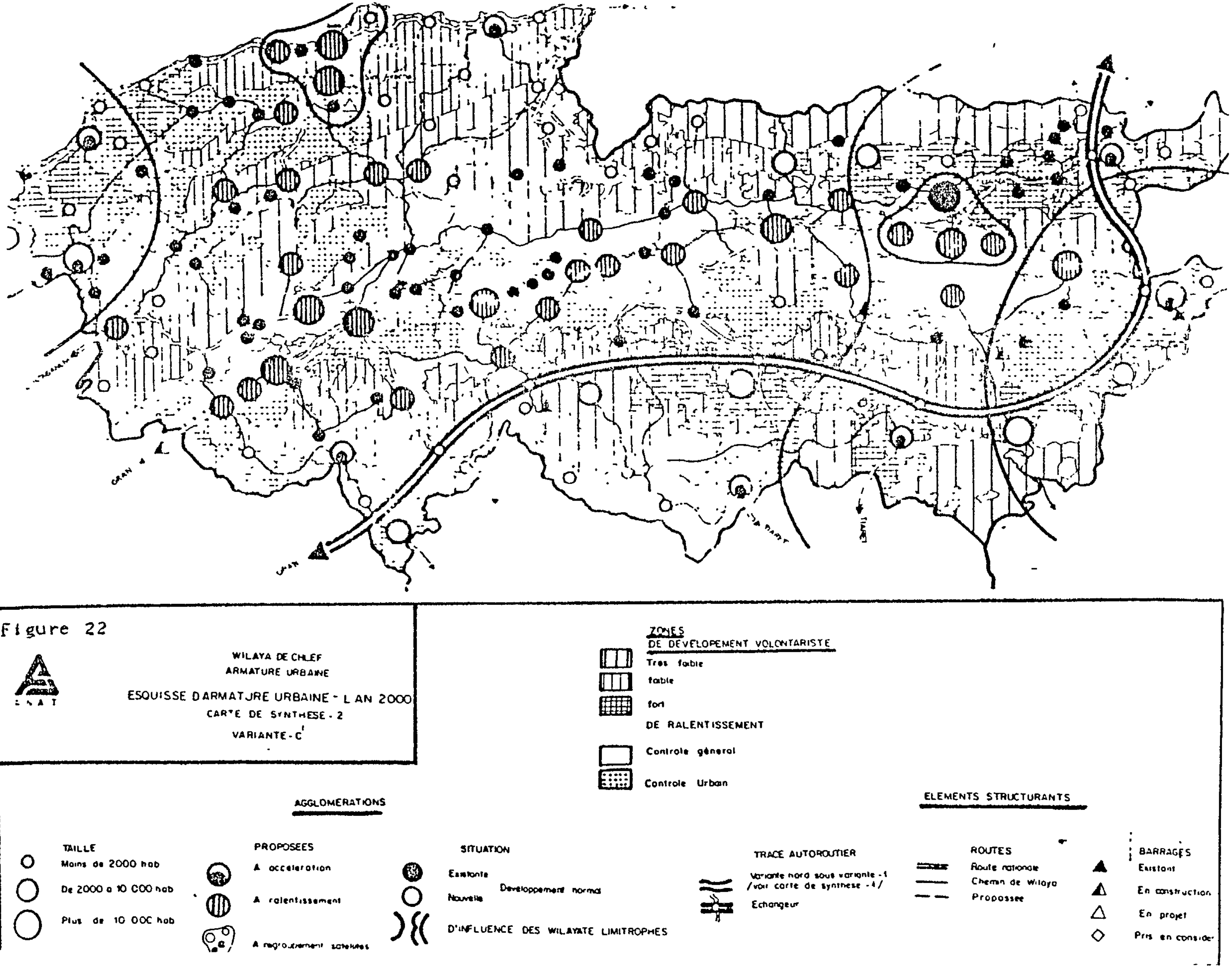


Fig. 21 Map showing the proposed freeway routes. The seismicity information is also shown.


WILAYA DE CHLEF
ARMATURE URBAINE
ESQUISSE D'ARMATURE URBAINE - L'AN 2000
CARTE DE SYNTHESE - 2
VARIANTE - C'
ZONES
DE DEVELOPEMENT VOLONTARISTE
Tres faible
faible
fort
DE RALENTISSEMENT
Controle général
Controle Urbain
AGGLOMERATIONS
TAILLE
Moins de 2000 hab
De 2000 a 10 000 hab
Plus de 10 000 hab
PROPOSEES
A acceleration
A ralentissement
A regroupement satellites
SITUATION
Existante
Nouvelle
Developpement normal
D'INFLUENCE DES WILAYATE LIMITROPHES
ELEMENTS STRUCTURANTS
TRACE AUTOROUTIER
Variante nord sous variante -1
/voir carte de synthese -4/
Echangeur
ROUTES
Route nationale
Chemin de wilaya
Proposee
BARRAGES
Existant
En construction
En projet
Pris en consider
TIARET
ORAN
Figure 22

L - CONCLUSIONS AND RECOMMENDATIONS

Information should be exchanged among the earthquake prone countries of the Mediterranean Region on experience gained and advances made as to how earthquake hazards are evaluated and their impact mitigated. Indeed, national programmes which aim at reducing the earthquake risk would certainly benefit from this exchange of information. The Mediterranean countries should encourage such a cooperation inter alia in order to:

- Exchange (1) information on earthquakes of large magnitudes (Ms 4) and (2) data concerning the physical causes of earthquakes, their social and economic effects as well as their impact on engineered structures;

- Develop a regional strong motion data bank along with procedures to facilitate access to copies of records from this bank;

- Develop regional strong motion attenuation functions for use in countries having similar tectonic and geological settings;

- Exchange information on the assessment of seismic exposure and subsequent hazards related to local soil conditions, as well as on the actions taken by physical and urban planners for the reduction of seismic risk;

- Create a Mediterranean earthquake catalogue that should be (1) purged from most of the errors through the resolution by Mediterranean scientists of differences in the location of earthquakes as they appear in various national catalogues, and (2) enriched by new data through the cooperation of Mediterranean historians and seismologists in the search and interpretation of historical records of past earthquakes;

- Plan to (1) facilitate activities of inter-Mediterranean agencies to provide assistance following an earthquake, and (2) exchange specialists to gather experience in each other's country and collect post-disaster information when an earthquake occurs;

- Create a board of experts which would be provided with secretarial services. The main missions of this board would be to orient the efforts made by the specialized groups (i.e. strong motion, seismotectonics, land-use planning, etc.), to ensure that the common actions taken are coherent with the orientations, and to contribute to the raising of the technical level of the countries engaged in this joint effort.

F - SUMMARY

Earthquakes are inevitable, but their damaging effect can be greatly reduced. Land-use planning and management based on a microzonation study can be particularly effective in reducing loss of life, as well as injury and property damage from earthquakes.

Effective local planning to reduce seismic risk is based on an evaluation of the nature and degree of risk, risk being defined as a function of the nature, severity, and frequency of seismic hazard and of the exposure of persons and property to those hazards.

Following the destructive magnitude 7.3 Ech-Cheliff earthquake which occurred on 10 October 1980, the Algerian authorities decided to integrate seismic risk reduction plans into the general planning programme for the reconstruction of the devasted area.

The method includes: consideration of seismic hazard in analyzing capability, formulation of land-use policy and regulations consistent with seismic risk, and the establishment of project review procedures in order to ensure the consideration of seismic hazard in land-use decisions and land development practices as well as in building practices.

The first step taken within the framework of the adapted plan was to launch a seismic microzoning study in order to evaluate the earthquake hazards of ground shaking, earthquake inducted ground failure and surface fault rupture.

As a result of the detailed seismic geology investigations carried out for the microzoning study, and a review of historical seismicity, the seismic source model for the Ech-Cheliff region has been extensively revised; the revised model provides a better understanding of (1) where potentially damaging earthquakes can occur, and (2) how big they can be and how often they occur. The seismic source model includes both fault specific sources and area sources to account for the smaller magnitude earthquakes that have occurred and cannot be associated with the mapped faults. This study included mapping of nine urban areas to delineate the seismic hazards they are exposed to.

The hazard due to the strong ground shaking is relatively high in the nine selected areas, but highest for those cities closest to the Oued Fodda fault. In addition to the ground shaking hazards there is also the potential for liquefaction of saturated sandy soils, landsliding and surface fault rupture.

Land capability analysis was employed as the method for integrating the results of this study. This type of analysis made a global evaluation of the environmental factors that could affect the capability of land areas to support land-use. The maps for each of the nine urban areas in the region rate areas in terms of three general levels of seismic hazard (I, II and III) and also provide data concerning specific hazards.

The Algerian aseismic regulations ("Règles parasismiques algériennes") and the Algerian building practices were assessed on the basis of experience from the Ech-Cheliff region.

7.2 PRINCIPAL ISSUES IN DETERMINING SEISMIC VULNERABILITY AND THE ACCEPTABLE SEISMIC RISK IN YUGOSLAVIA

by Jakim Petrovski and Zoran Milutinovic, IZIIS - Institute for Earthquake Engineering and Engineering Seismology, Skopje

A. Introduction

During the last two decades, natural disasters, and earthquakes in particular, have tended to become increasingly destructive as they affect an ever larger concentration of material property and population. An orderly industrial development of seismic regions accompanied by urban expansion and increased population growth, becomes prohibitive unless investments in infrastructure, housing and other public and social activities are protected against loss at all stages of their development.

Significant efforts have been made toward a better assessment of seismic hazard and mitigation of its possible consequences. In spite of this, major earthquakes have continued to cause enormous damage to the economy of the affected regions and of entire countries in the Mediterranean. For example, the direct economic losses, caused by the Montenegro earthquake of April 15, 1979 (Yugoslavia), alone were estimated at about 10 percent of the gross national product (GNP) of Yugoslavia for 1979, which was four times the GNP of Montenegro itself. A similar event, the 1963 Skopje earthquake (Yugoslavia) cost the national economy about 15 percent of GNP for 1963. Taking into account other earthquakes that took place in Yugoslavia from 1963 to 1984 (Petrovac 1966, Debar 1967, Ulcinj 1968, Banja Luka 1969 and 1981, Kopaonik 1980, 1982, 1983 and 1984), the penalty paid has been estimated at an average of more than 1.5 percent of the GNP per annum.

The year by year development of earthquake engineering has enabled many countries exposed to high seismic hazard to decrease the overall seismic risk to populated regions. Traditionally, the engineering response to the problem has almost solely been structural, i.e. (1) to demolish the highly vulnerable building and replace it with a modern one, designed and built according to the aseismic regulations, standards and codes in force in the country, or (2) to repair and strengthen it in order to improve its seismic resistance and overall safety. Although the method is very effective in the case of isolated buildings, the amount of capital resources to be allocated in advance when the building class is considered becomes so high that only few countries can afford it. Earthquake damage can also be reduced by a proper land-use policy, which should be implemented gradually through the processes of general, physical and urban planning. To decrease earthquake damage, the urbanization pattern (land occupancy, adopted structural typology, distribution of material property and its density concentrations etc.) should comply with the level and the spatial distribution of the expected seismic hazard.

The urban planner rarely has the opportunity to designate a new urban area. The current land-use (the existing building stock designed and built without consideration of the seismic regulations, standards and codes) must be respected and incorporated properly in the new land-use plans without an increase in the overall seismic risk. Based on a trade-off between structure-replacing and structure-reinforcing capital inputs, a decision must be made whether or not the replacement of the existing hazardous building classes with modern building types is economically feasible.

Post-earthquake opportunities allowing more freedom in urban and land-use planning (as for example in Skopje after the 1963 earthquake) are rarely seized. It should be pointed out that the "Characteristic of most cities that have undergone disaster-induced reconstruction is that rebuilding follows roughly the same patterns that existed previously... The reason is found largely in the continuation of the pre-disaster property rights as well as in the desire to rebuild rapidly" - (Douty, 1979). A typical example is Mexico City, Mexico D.F. The major damage contours of the 1985 catastrophic earthquake outline approximately the same region as did those after the earthquakes of 1957 and 1979.

Even without the "opportunity" of post-earthquake reconstruction, mitigation of seismic risk through land-use planning is viable, especially when one considers the rapid and enormous growth of cities and the extent to which this growth might be controlled by local government and city authorities, in cooperation with specialized and authorized land-use planning agencies.

B. Elements of seismic risk

Following the definitions proposed by UNESCO (1976, 1977 and 1979) seismic hazard is defined as a probability that seismic intensity I will be exceeded in a certain period of time. Under the term seismic intensity, any qualitatively or quantitatively defined parameter related to earthquake magnitude M as a measure of seismic phenomena can be employed. Hazard parameter I may be modified Mercalli intensity (MM), response spectra (RS), peak ground acceleration (PGA), equivalent acceleration (EQA), effective response spectra (ERS) or any other parameter of engineering significance. For the region of interest it is a function of seismicity, i.e. probability of earthquake occurrence and attenuation (loss of seismic energy from the earthquake source to the site under consideration).

Vulnerability is defined as probability or degree of loss to a given element at risk, or set of such elements under a pre-specified level of seismic intensity. However, information on vulnerability of various elements at risk is less plentiful and less reliable than information usually available on seismic hazard since various categories of data are required (related not only to the physical damage, but also to the degree of economic and social disorganization that may ensue). Therefore, there is still a need to collect, classify and publish as much information as possible, on damage to various elements at risk which occurred in past earthquakes.

Seismic risk is a quantification of vulnerability of a given element at risk (or set of such elements) under the pre-specified level of seismic hazard defined as a probability of loss. It is a quantification of possibe consequences of natural phenomena, or a quantification of the capital investments allocated in advance in order to mitigate the total penalty caused by seismic disaster.

An integrated model to assess the expected seismic risk of the region considered should involve the following basic steps:

- evaluation of seismic hazard;

- identification of elements at risk;

- derivation of the appropriate vulnerability functions for the identified element at risk, which define the interrelation between the specific loss and seismic hazard;

- evaluation of the specific seismic losses per element at risk and its participation factor in the existing volume of properties;

- evaluation of the total seismic losses and risk for the region considered.

Out of the three factors which determine seismic risk: value of the elements at risk, their vulnerability (i.e. their specific loss potential) and seismic hazard, only the first two are under human control. They can be controlled through proper land-use development policies and pre-disaster risk mitigation and prevention programmes. Although the values of elements at risk might be efficiently controlled by relocating earthquake sensitive elements at risk to regions of lower seismicity, there is still a need to provide economically justified practical measures to protect other elements at risk, which, due to favourable natural conditions, have to be located in regions of higher seismicity. In the latter case and depending on the level of economic development of the region considered or the entire country, a level of acceptable risk should be estimated and defined through the level of expected vulnerability.

If we consider an earthquake as a sudden phenomenon occurring beyond any human control and bringing significant economic losses, it is necessary to qualify the exposed vulnerable elements at risk, or in other words, to define a loss model of the region considered.

A direct loss model, Fig. 1., usually refers to physical damage expressed in terms of human casualties and injuries, damage to local infrastructure (road and river system, water and gas supply etc.), residential and other types of building structures or any other property or material goods owned by the state or enterprises which were lost or damaged during, or immediately after, an earthquake event.

In addition to the physical damage and functional disorder caused by an earthquake there are also several categories of indirect effects of earthquakes which can be generally classified as economic and social damage (Fig. 2.). Stagnation of industrial activities, decrease in industrial production and regional revenue as well as additional expenditure for immediate rehabilitation of the stricken region/urban area: these are all classes of typical indirect economic losses. On the other hand, interruption of transportation, water and electricity supply systems, a decrease in civil and information services as well as adverse publicity concerning the damaged areas can be considered as classes of typical social damage.

In order to estimate correctly the type of possible disaster as well as the level of capital pre-investments for mitigation of earthquake consequences or post-disaster capital investments payed as penalty by the whole society for the earthquake occurrence, it is necessary to formulate a model of the long-term effects of earthquake losses. It can be efficiently done (Fig. 3.) by combining the direct loss (Fig. 1.) and the models of indirect effects (Fig. 2) through the interrelation and time-series estimation of economic effects induced by direct losses. An adjusting mechanism between the unaccelerated supply of productivity due to earthquake-induced damage and the accelerated investment demands for repair and reconstruction of the stricken region should also be formulated and incorporated in the modelling.

In order to achieve the stated goals - i.e. the development of a model for earthquake losses including various elements at risk and the assessment of the total seismic risk at regional/urban level we must depend on damage data from past earthquakes. Particular attention should also be payed to the derivation of vulnerability functions (relations between the specific loss and the seismic intensity descriptor) since they are the most sensitive step of any seismic risk assessment procedure.

C. Methods and procedure for earthquake damage assessment

During the last two decades natural disasters, and earthquakes in particular, have tended to become increasingly destructive as they affect ever larger concentrations of population and material property. Industrial development of earthquake-prone regions which is ordinarily accompanied by urban expansion and increased population becomes prohibitive unless investments in infrastrucure, housing and other public and social activities are proteted against damage at all stages of their development.

Although significant efforts have been made toward a better assessment and mitigation of the possible consequences of existing seismic hazards, major earthquakes which occurred in this period induced enormous damage to the economy of the regions stricken and of entire countries. Moreover, due to the rapid development and high concentration of material property in seismically active regions a significant increase of damage may be expected in future major earthquake events.

The objective of this Chapter is to present a uniform methodology and procedure for earthquake damage assessment of buildings (inspection, classification and reporting) in urban and/or rural regions, establishment and organization of data bases on damage due to earthquake effects; furthermore to discuss the methodological highlights of damage data analysis necessary for a reliable estimation of physical, functional and economic losses. The principal reason for developing this methodology and procedure for earthquake damage assessment is to ensure, primarily, an adequate volume of data to cover the following needs:

- To reduce incidents of death and injury to occupants of buildings which have been seriously weakened or damaged by a strong seismic event and which are likely to be exposed to a series of aftershocks immediately after the main shock;

- To obtain realistic information on the disaster magnitude in terms of the number of usable, damaged and dangerous buildings; the purpose here is to protect human lives, to provide citizens with shelter and housing and to revitalize as quickly as possible the basic life and social activites;

- To create a data base which would serve for the uniform estimation of economic losses and the development of appropriate rehabilitation programmes for the reconstruction and future development of the affected region on the basis of improved seismic design regulations, codes and construction standards;

- To create a data base for the prediction of the consequences of future earthquakes in the affected regions and other seismic areas;

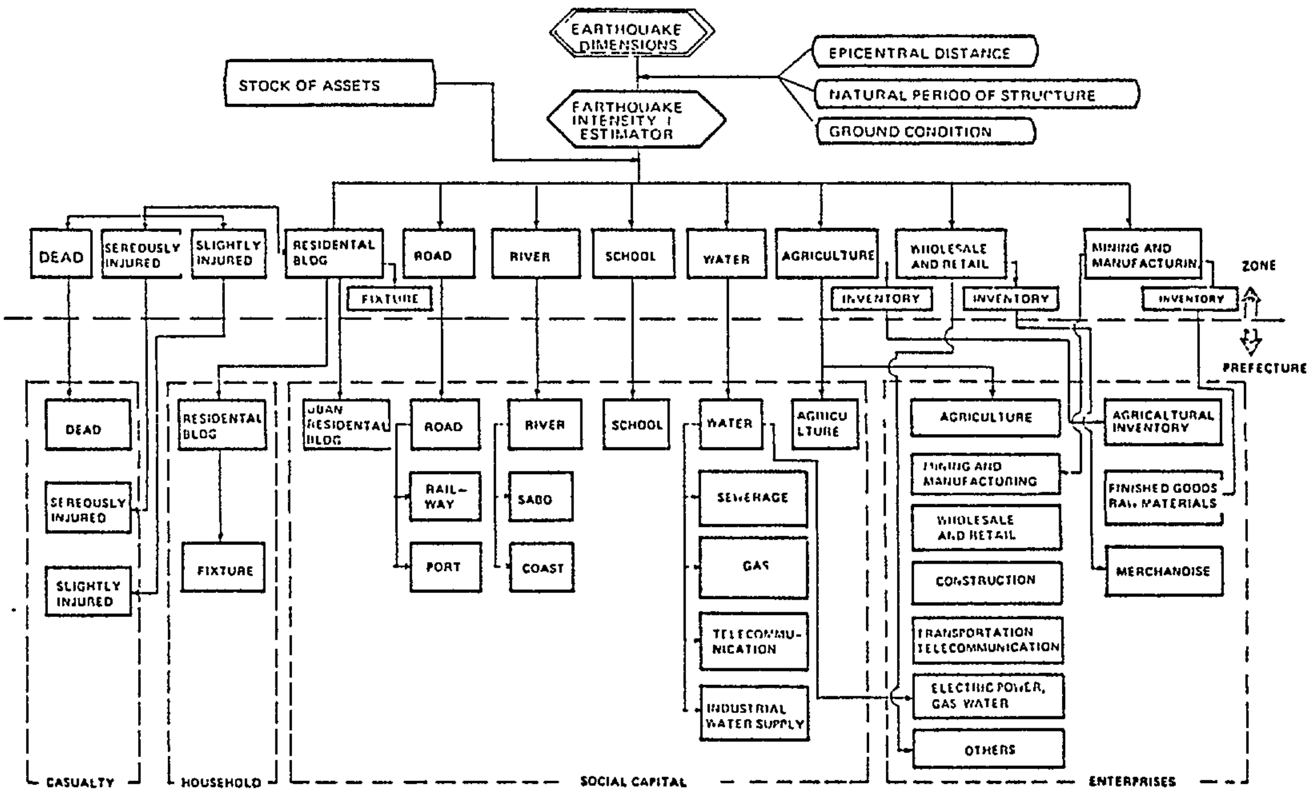


Fig. 1 Direct loss estimation

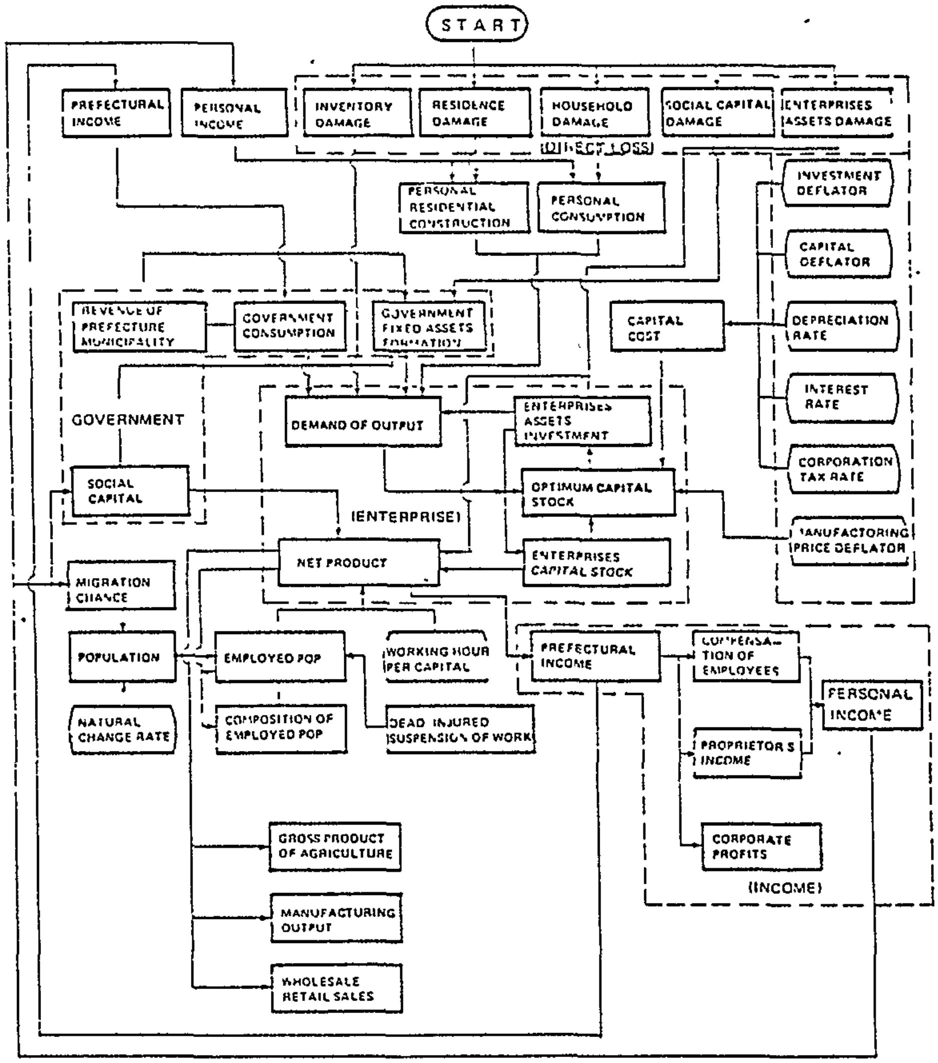


Fig. 2 Indirect effect model

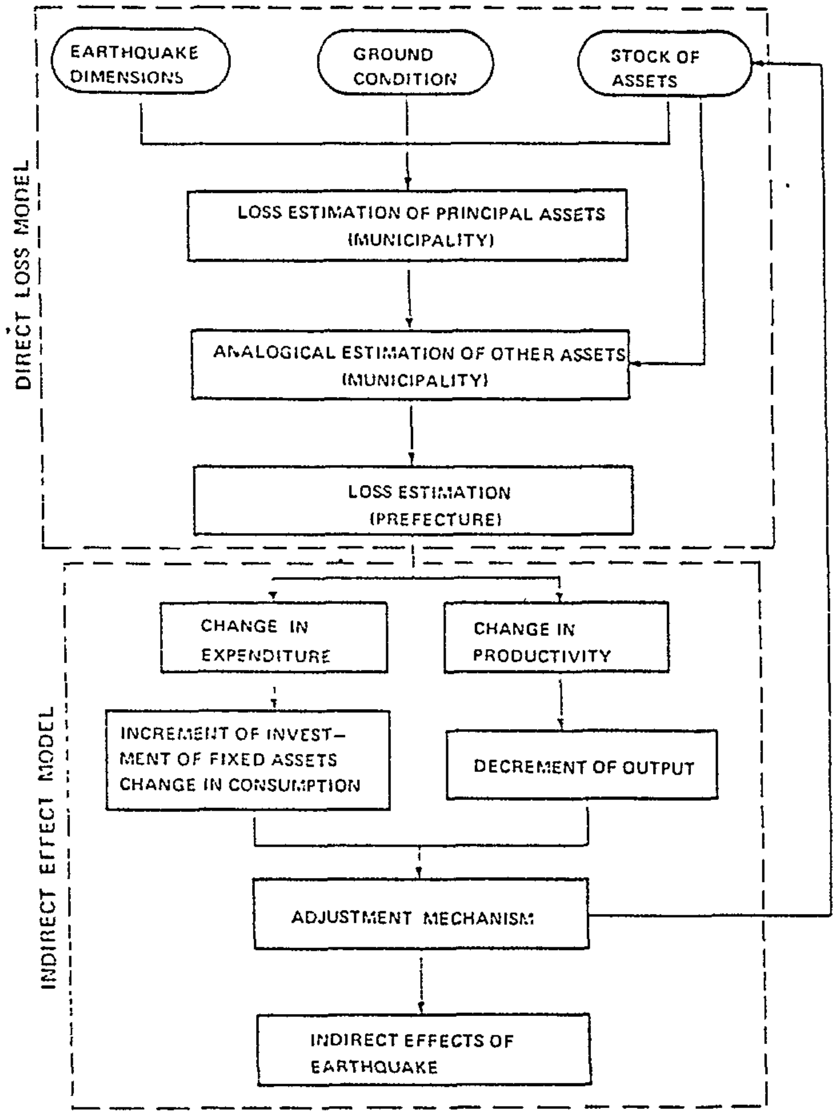


Fig. 3 Structures of direct loss model and indirect effect model

- To provide data to serve as a basis for planning and organizing a civil defence system, through the elaboration of rescue operation plans, staff training, organization of emergency supplies etc.;

- To record and classify damages to plan and carry out repair and strengthening of damaged buildings;

- To identify the principal elements of earthquake damage and to develop vulnerability relationships for different building categories which are indispensable for planning and carrying out both short and long-term priority actions for the reduction of earthquake consequences as well as for pre-earthquake assessments;

- To improve seismic design and construction codes and regulations, as well as design and construction practices; and finally

- To improve the scientific basis for physical, urban and general planning which aims at reducing earthquake consequences and mitigating the risk of seismically active regions.

Post-earthquake damage evaluation and classification must be carried out by means of a systematic methodology and a rapid procedure in order to provide local and national decision making authorities with essential information on the basis of which the latter will take economically justified and technically consistent measures for the uniform reduction of earthquake consequences over the entire country.

Principal elements incorporated in the uniform methodology for earthquake damage assessment such as damage and usability projections and classification of earthquake induced damage to buildings, method and organization of damage data collection, earthquake damage data analysis, organization of damage data bases, etc. as presented in the following chapter are derived from experience gathered from earthquakes that occurred during the last two decades, in Yugoslavia and other countries located in seismically active regions in the world. The methodology and procedure for earthquake damage assessment, which was originally proposed by ISIIS-Skopje and later accepted by other Balkan countries will provide, it is believed, more reliable data which will form the basis for the practical elaboration of efficient pre-disaster risk mitigation and for management of post-disaster reconstruction and revitalization programmes.

D. Vulnerability functions based on building damage data from the 1979 Montenegro earthquake

a. General

The estimation of losses resulting from an earthquake requires that for each building class the relationships (vulnerability functions) between the intensity of ground shaking and damage degree be known or developed.

Potential earthquake damage to structures, human beings and personal property has been the scope of numerous studies. Different approaches have been employed so far to estimate earthquake casualties and damage. These approaches have combined in various ways the important input or determinant factors, including data from relevant historical and recent damaging earthquakes, the theoretical background of seismological and geological phenomena and the opinion of structural engineers. For example, under the UNDP/UNESCO project for earthquake risk reduction in the Balkan region (RER/79/014), the vulnerability of buildings is assessed in the following manner:

- Data on damage suffered by individual buildings in the region during recent earthquakes (Skopje, Yugoslavia, 1963; Adapazari, Turkey, 1967; Gediz, Turkey, 1969; Vrancea, Rumania and Bulgaria, 1977; Montenegro, Yugoslavia and Albania, 1979; Corinth, Greece, 1981) have been compiled and reduced to the standard format;

- The damage state of each building is expressed on a standard scale;

- Buildings are classified according to structural (principal load carrying system) type and materials used; and

- Vulnerability functions, relating damage degree to the intensity of ground motion, are derived for each building class.

The same methodological approach has been adopted in this study to develop proper physical vulnerability functions. They are derived on the basis of damage data from the Montenegro earthquake of April 15, 1979 compiled by structural classes and damage categories (as defined in Appendix B) and assessed values of average effective response spectra (Milutinovic and Kameda, 1983 and 1984, detailed briefly in Appendix A) calculated from instrumental records taken during the same earthquake. The records obtained from this earthquake make possible to relate percent damage (physical vulnerability), loss of function (functional vulnerability) or value loss (economic vulnerability) to one more physical parameter of ground motion than what the information on peak ground acceleration, or any other seismic hazard estimator derived from macroseismic compilation of earthquake data allows.

b. Development of Vulnerability Functions

The development of vulnerability functions based on empirical data (loss versus average effective response spectra relationships) entails three basic steps: (1) examination of losses experienced in the April 15, 1979 Montenegro earthquake (Yugoslavia) and statistical processing of damage data in accordance with the prevailing structural classes, the site-soil conditions and the identified damage degrees; (2) determination of average site-dependent effective response spectra ($\bar{S}$ or ERS) from the same earthquake for every settlement for which there is a building damage inventory and statistical processing of damage data; and (3) synthesis of (1) and (2) into vulnerability functions through a correlation of the observed losses with the calculated ERS's.

Modelling Vulnerability

Vulnerability functions are developed for four building classes (for details see section B.3 or Table B.2, in Appendix B) which largely comprise urban Montenegro and Yugoslavia as a whole as well. The three-level damage rating scheme as described in section B.2 and presented in summarized form in Table B.1 of Appendix B is used.

General Strategy for Evaluation of Economic Earthquake Losses

With respect to the level of seismic protection of buildings, each region generally comprises two types of structural systems: (1) old, traditional structural types designed and constructed to withstand the effects of gravitational loads only, and (2) new, seismically resistant structures and groups of structures designed and built to withstand both gravitational and seismic loads.

It is unrealistic to expect that the class of seismic resistant structural systems will not be vulnerable in the case of a major earthquake event. Damage to non-structural and structural elements will undoubtedly occur; this would require proper repairs in order to bring damaged structures to their former, pre-earthquake stage. The loss estimates, therefore, should include only the repair costs since the principal load carrying system is already designed and constructed to withstand seismic loading.

For non-aseismic structural types, in addition to the repair costs, the loss estimate should also incorporate expenditure necessary for strengthening the principal load-carrying system in order to increase its seismic resistance and meet the specific safety requirements stipulated by the code.

The principles which govern estimation of economic losses apply only when damaged structures are classified in D&U categories I or II.

The VF function labelled I (Fig. 4) cannot be considered a true vulnerability function within the physical vulnerability context, since it represents the percentage of total number of buildings, or total gross area, without the damage. However, within the economic vulnerability context it is a true VF because the extent of damage associated with damage category I (Table B.1) will also cause some economic losses.

These concepts of vulnerability, specific and economic losses apply only when a large population of buildings of the same kind is exposed to some level of seismic hazard. The proposed model can predict physical damage in terms of the numbers of undamaged, damaged and destroyed (usable, temporarily and permanently unusable) buildings, or in terms of corresponding gross areas. Through the application of proper damage-cost factors it can estimate the economic losses to each element at risk, or the cumulative economic losses if more than one element at risk are considered in the analysis.

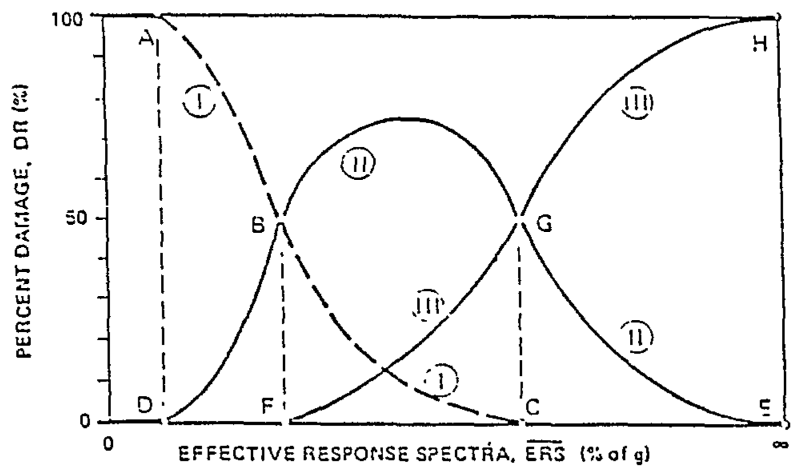


Fig. 4 Physical (Functional) Vulnerability Functions
for Adopted Damage/Usability Categories

c. Vulnerability Functions by Structural Types of Low-Rise Buildings

Based upon damage records from the April 15, 1979 earthquake, physical and functional vulnerability models for SM, BM, STM and RCFS building classes are developed for D&U-C-II and D&U-C-III by taking into consideration: (1) the variation in site-soil conditions of a site where buildings exist and (2) the number of storeys if the data is large enough to give such information. For any building class the following three types of vulnerability functions (models) are developed:

- Generalized vulnerability models: they consider as independent variable only the type of contruction (SM, BM, STM and RCFS) and the average site-independent S. They will be referred to as XX-i-ES, where XX^{eff} identifies the building class and "i" denotes the D&U category.

- Generalized site-dependent vulnerability models: they consider three independent variables, i.e. (1) type of construction, (2) site-soil condition of location where the building is situated and (3) average site-dependent Seff values. They will be referred to as XX-i-SS, where SS denotes vulnerability function for rock (SS=R) and diluvial-alluvial (SS=DD) site-soil conditions.

- Site and number of storey-dependent vulnerability models for one, two and three storey buildings: they consider the number of storeys as an additional parameter that influences building vulnerability. These, four-variable vulnerability models are dervied for only the SM and STM building classes since data samples of adequate size cannot be established for the other two building classes.

The vulnerability functions for the SM, BM, STM and RCFS building classes are developed on the basis of damage data samples on 14,476, 703, 2,617 and 180 buildings respectively. The size of data sets for masonry building classes was large enough to enable derivation of generalized and site-dependent vulnerability functions. However, the complete set of number of storey-dependent vulnerability functions could only be developed for the SM building class. Due to the limited number of data in the data samples for two and three-storey STM buildings, both these data sets (for two and three-storey buildings) were used as a single data set; only two number of storey dependent vulnerability functions are derived; the first assessing the vulnerability of one storey buildings, and the second describing the vulnerability of two and three-storey STM buildings.

The above vulnerability models, however, do not take into account some critical factors concerning structure such as age, building layout, construction details and innovative construction techniques, design level and changes in the construction codes. If we incorporate them into the analysis, data scatter substantially decreases and accuracy and reliability increases accordingly.

For the SM, BM, STM and RCFS building classes, the generalized and generalized site-dependent vulnerability models are presented in Figs. 6 and 7. They are developed on the basis of data scattergrammes constructed by using low-rise building damage data classified into 3 damage/usability categories, similar to those presented in Fig. 5.

A significant influence of site-soil conditions upon vulnerability was found for weak structural systems (SM and BM) decreasing substantially for seismic resistant classes (STM) as shown in Fig. 6.

The same conclusion is derived with regard to the number of storeys: with increasing seismic resistance, the influence of the number of storeys upon vulnerability decreases. With increasing number of-storeys, vulnerability generally increases for diluvial-alluvial, whereas for rock site-soil conditions it decreases; more rapidly for SM and BM than for STM buildings.

Although the influence of site-soil conditions and number of storeys upon the vulnerability is evident (Fig. 6), it was found that construction type (Fig. 7) plays the most important role. The highest vulnerability was found for the SM building class, decreasing significantly for the BM, STM and RCFS classes. This high damage potential of the SM buildings may be explained in terms of the dependence of the damage threshold on S_{eff}. Defining it as the lowest S_{eff} capable of causing damage or destruction to a particular building class, for highly vulnerable structures of the SM type this threshold is so low, that at 10% g S_{eff} a 62% of SM buildings is damaged and ruined. If we increase S_{eff} to 40%g, 84% of buildings will be damaged and ruined; this gives only a 22% difference for a 30%g increase of S_{eff}. Considering that the relatively low S_{eff}' of, say, 10%g will affect a much larger area than that which corresponds to the threshold of less vulnerable classes, the total damage of low threshold building classes will be significantly larger; this can be clearly observed in Figs. 6 and 7.

Due to a lack of data, the tail behaviour of the proposed vulnerability models is not investigated in the low S_{eff} range. Because damage will most likely be insignificant for S_{eff} less than 5% of g and the maximum S_{eff} will never be higher than 50%g (for the Montenegro region) and if we consider also that the damage data base ranges from about 18% g to 43%g S_{eff}, the models proposed are subject to restrictions: the upper boundary of S_{eff} must equal 45%g, and the lower 5%g.

The developed vulnerability models may be considered either as physical or functional models. As physical models they allow the estimation of physical losses in terms of numbers of buildings to be damaged to damage level II or III. As functional they help us estimate the number of buildings which have lost function either temporarily or permanently. However, the sum of vulnerabilities for both D&U categories should be considered only as functional vulnerability since it allows us to calculate the number of buildings that lost their function immediately after an earthquake event. These models can be used, as will be shown in the following pages, only to estimate the immediate or short-term earthquake effects on the function and serviceability of the building stock exposed. If other structures or facilities are taken into account, the above considerations do not apply, because there are other types of functional damage that should be related to physical damage.

On the basis of the detailed response analysis of the 104 buildings of different structural types selected for the five expected levels of PGA and using the criteria of strength (shear base coefficient) and deformability capacity (interstorey drift), the theoretical vulnerability functions were derived for aseismic structures and presented in Fig. 9. A detailed cost estimate analysis for repair and strengthening of the same 104 buildings of different structural types gave the functions of cost for repair and strengthening per unit floor area (Fig. 8).

E. Prediction and estimation of regional/urban seismic losses Physical and urban aspects of seismic risk reduction

a. General

Rapid development and urbanization, especially of earthquake prone regions, will rapidly increase their vulnerability and seismic risk if no appropriate measures are taken for protecting human lives and property. The process of pre-disaster seismic risk mitigation, reduction and management should start at the level of physical and urban planning and be implemented at all development stages.

Urbanization, as a complex social process, represents a predominant characteristic of the development of regions, towns and human settlements. Spatial distribution and density of material property (industry, enterprises, human settlement systems etc.), life-line systems, population density and other factors are usually controlled by socio-economic development regardless of the level of seismic hazard they are exposed to. Ultimately, society accepts a compromise between exposure to hazard and economic and social necessities.

Planning is, unfortunately, a long term activity highly vulnerable to conflicting priorities and demands, especially if these are economic. Buildings, for example, have relatively long economic lives ranging from 50 to 100 years. To move an existing settlement of any significant size is, without exception, prohibitively expensive and unrealistic both in social and economic terms. One is left with fairly limited possibilities of modifying what exists, while calling the attention of decision makers to the potential consequences of prevailing seismic hazards when the urbanization of a new region, town or even a new settlement is planned.

In order to plan new developments or post-earthquake reconstruction, for earthquake preparedness, insurance and for decision-making, what is needed is quantitative seismic risk assessment for different building classes in various locations. In the following pages we will discuss state-of-the-art mapping of spatial distribution of specific losses and seismic damage of various elements at risk and the quantification of cumulative seismic losses.

b. An Integrated Prediction Model for Estimation of Regional/Urban Seismic Damage - Methodology and Outputs

Only recently have efforts been made in the development of quantitative loss prediction procedures. Two decades ago, almost no predictive estimates of damage that might result from earthquakes existed. The development of various procedures for the estimation of earthquake losses has been prompted by the increased loss potential due to rapid development and the concentration of material property in seismically active regions. However, the development of a single damage prediction methodology is not feasible at present because of the complexity of the problem and the lack of data.

Loss evaluation is currently made with varying degrees of rigour. However, in all theoretically or empirically based models which have been proposed for predicting seismic losses in an urban area there is the need to perform a series of complex procedures requiring extensive computations and the proper acquisition and manipulation of building data. A systematic approach is necessary; the problem of prediction and estimation of regional/urban seismic losses should therefore be approached through the following basic steps:

- Zonation of the region/city and classification (with inventory) of material property (elements at risk) within each zone (inventory methodology);

- Identification of the effects of local site-soil conditions on the severity of the event at a given location;

- Prediction of the ground motion parameters, in this particular case the effective or average effective response spectra, affecting the earthquake damage potential for each zone (effective response spectra prediction methodology); and

- Prediction of losses to any individual element at risk for each zone, as well as prediction of cumulative losses for all considered elements at risk in the entire region/city (loss prediction methodology).

The above sequences, indispensable for a systematic approach to the problem of predicting loss potential for a region or an urban area, should consistently be implemented and coupled into an integrated prediction model (Fig. 10) for the calculation of regional/urban seismic damage.

The first step in predicting earthquake losses is to inventory structures (Inventory methodology, Fig. 11 that may be subjected to significant ground motion. An urban region usually comprises many types of structures, facilities, life-line system networks etc., sensitive to various damage modes and levels of vulnerability. Typically, most structures are buildings; out of those the vast majority is low-rise (1 to 3-storey) structures; however, most affected regions will also have many other types of structures. It is a tremendous and time consuming task to predict and calculate damage level and the associated losses to each structure. In order to decrease the work load, it is obvious that on a regional/urban level structures should be categorized and proper structural classes established. Furthermore, these structural classes can also be broken down into smaller classes in accordance with their physical and mechanical characteristics such as principal load carrying system, architectural components and materials of construction, age of structure, etc.

The second step toward regional/urban damage prediction is to estimate the site-dependent seismic hazard parameters. In the early stages of earthquake engineering development, the main focus was on peak ground acceleration (PGA) on the assumption that it played the major role in controlling the damage level of structural systems. Nowadays, it is generally recognized that damage potential of ground motion is more likely to be related to the response spectra, power spectra, or other descriptors of the joint effect of the amplitude and frequency content of the ground motion than hust to the PGA alone.

On the basis of these considerations the concept of Equivalent Acceleration - EQA (Kameda and Kohno, 1983; Milutinovic and Kameda, 1983; 1984) has been coupled with the concept of Inelastic Response Spectra (Milutinovic and Kameda, 1983; 1984) to form the concept of Effective Response Spectra - ERA (Milutinovic and Kameda, 1984; Milutinovic, Petrovski and Kameda, 1985 and 1986) in order to provide: (1) en equivalent static acceleration level pertinent to seismic load design, and (2) a seismic hazard parameter that can be conceived as a direct measure of the destructiveness of earthquake ground motions. The ERS concept takes into consideration the effects of ground motion intensity and duration, as ground motion parameters, the natural period of vibration and damping, as parameters describing the dynamic properties of the structure, and the ductility and number of load reversals, as representatives of the group of parameters related to structural capacity. It also includes the PGA as a site dependent seismic hazard parameter because it takes into consideration the local soil conditions of a site.

Fig. 12 gives a schematic description of the methodology for predicting effective response spectra (outlined in Appendix A) and shows how the ERS methodology is related to the general loss prediction methodology presented in Fig. 13.

The third and final step in predicting regional/urban losses is to forecast the damage potential of a structural group. For damage evaluation of a large number of structures (regional/urban building stock) one should first draw up inventories and define the appropriate building classes and subclasses and then derive the vulnerability functions for each category/subcategory. By establishing structural categories and subcategories and then putting structures in groups, we introduce greater variety which leads to more accurate results in the final evaluation of damage.

The model shown in Fig. 10, can be used to simulate either urban or regional damage and to provide regional and urban planners with the following outputs:

- Regional/urban specific loss maps for selected elements at risk;

- Regional/urban damage distribution maps for each element at risk and superimposed maps of the cumulative damage for all elements at risk;

- Cumulative figures on regional loss-producing potential of building classes adopted in urbanization (old urban cores and new developments);

- Estimates on total physical and functional losses the region/city will suffer in the event of an earthquake of predetermined magnitude or according to a seismic hazard scenario justified by the level of economic development;

- Estimates on the vulnerability of groups of existing structural systems adopted in modern housing and/or new developments;

- Information on convenience, applicability and needs for improving of existing construction standards, regulations, codes, etc.

It is clear that the layout and distribution of human activities, as well as development planning at the regional or local levél must be decided on the basis of a compromise between exposure to seismic hazard and economic and social needs.

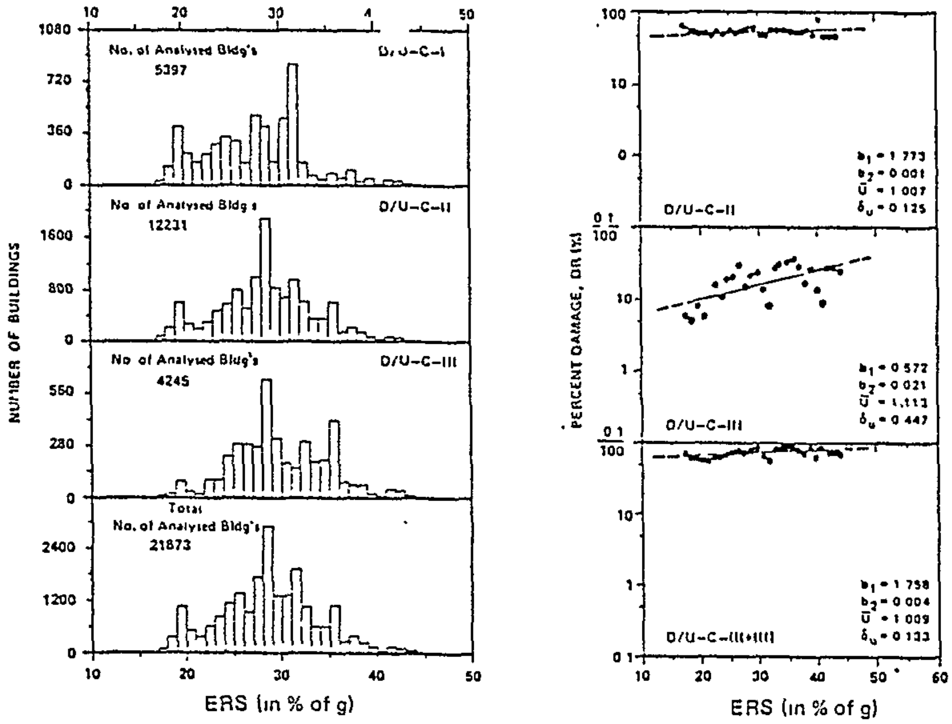
F. Socio-economic aspects and legislative basis of seismic risk management

a. Basic Criteria for Defining the Acceptable Level of Seismic Risk and Institutional Organization

Earthquake-resistant design can be defined as one that provides at an acceptable cost adequate safety against injury and loss of life, minimum damage to property and ensures continuity of vital services. However, it is a well known fact that to provide complete protection against earthquakes is not economically feasible. It is generally accepted that earthquake-resistant design criteria should satisfy the following conditions:

- To resist minor earthquakes, without damage;

- To resist moderate earthquakes without structural damage but with some non-structural damage; and



a) Analysed Building Population

b) Data Scattergram and Regressed Vulnerability Functions

Fig. 5 Generalized Physical (Functional) Vulnerability Functions and Data Scattergrammes for STONE MASONRY (SM) Buildings

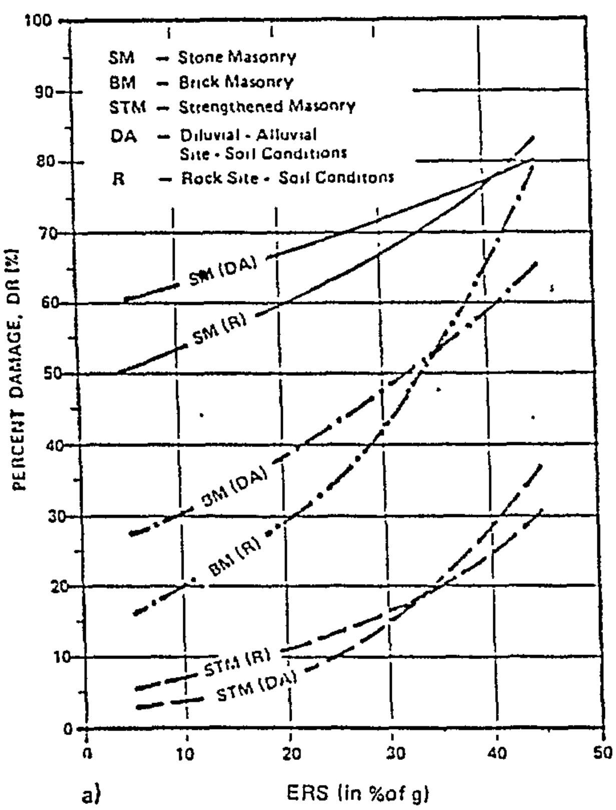


Fig. 6 Site-dependent Vulnerability Functions for D/U-C(II + III)

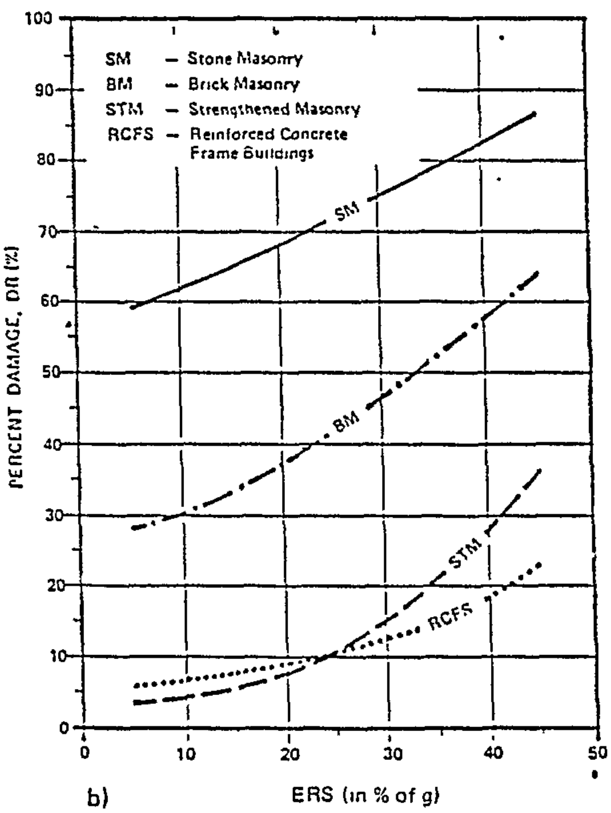
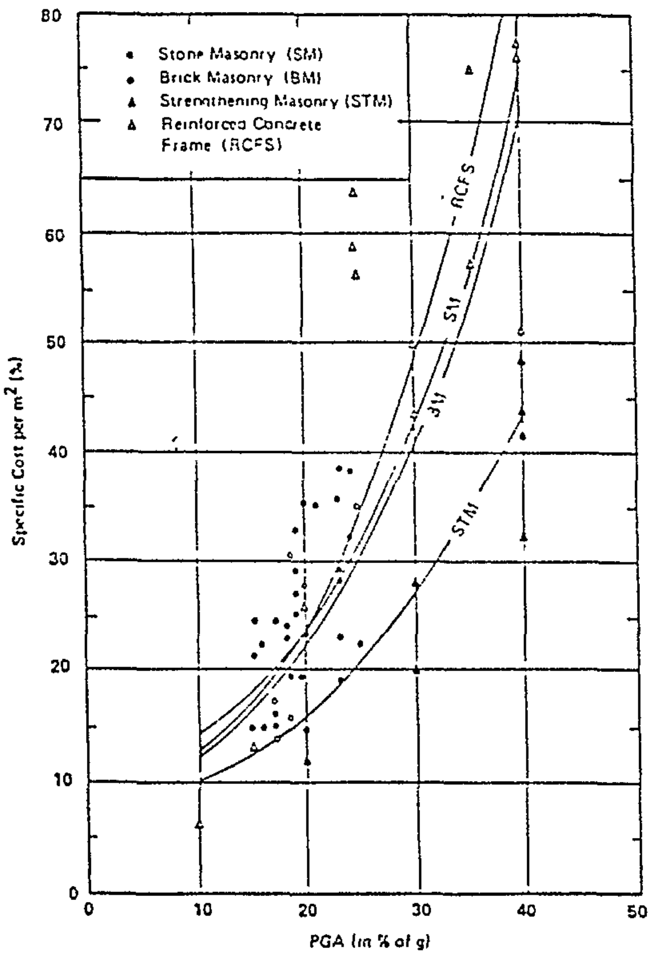


Fig. 7 Generalized Vulnerability for D/U-C(II+III)



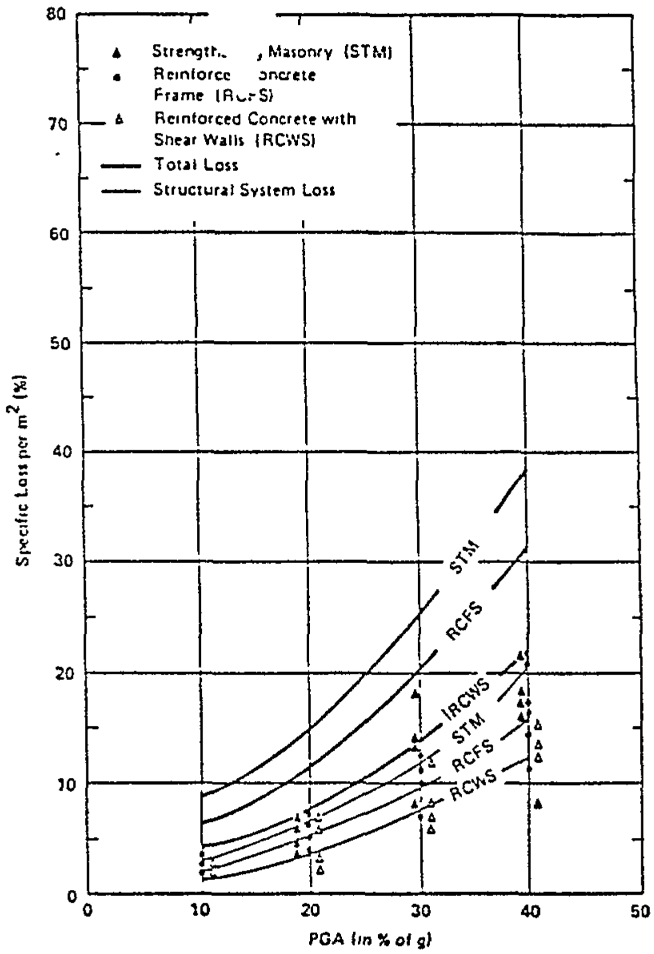


Fig. 8 Functions of Cost for Repair and Strengthening of different building classes

Fig. 9 Vulnerability Functions of Structural Systems for Modern Aseismic classes

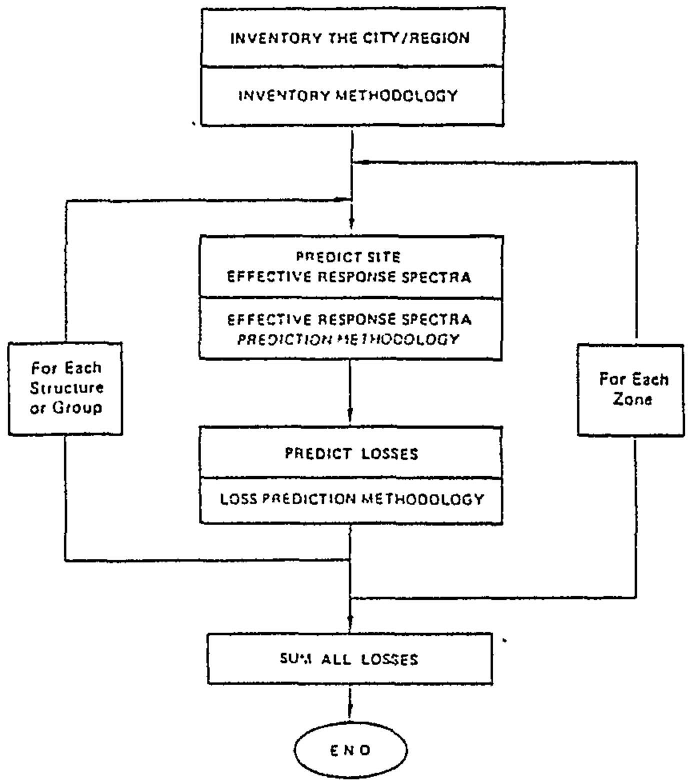


Fig. 10 General Earthquake Loss Prediction Methodology for a City/Region

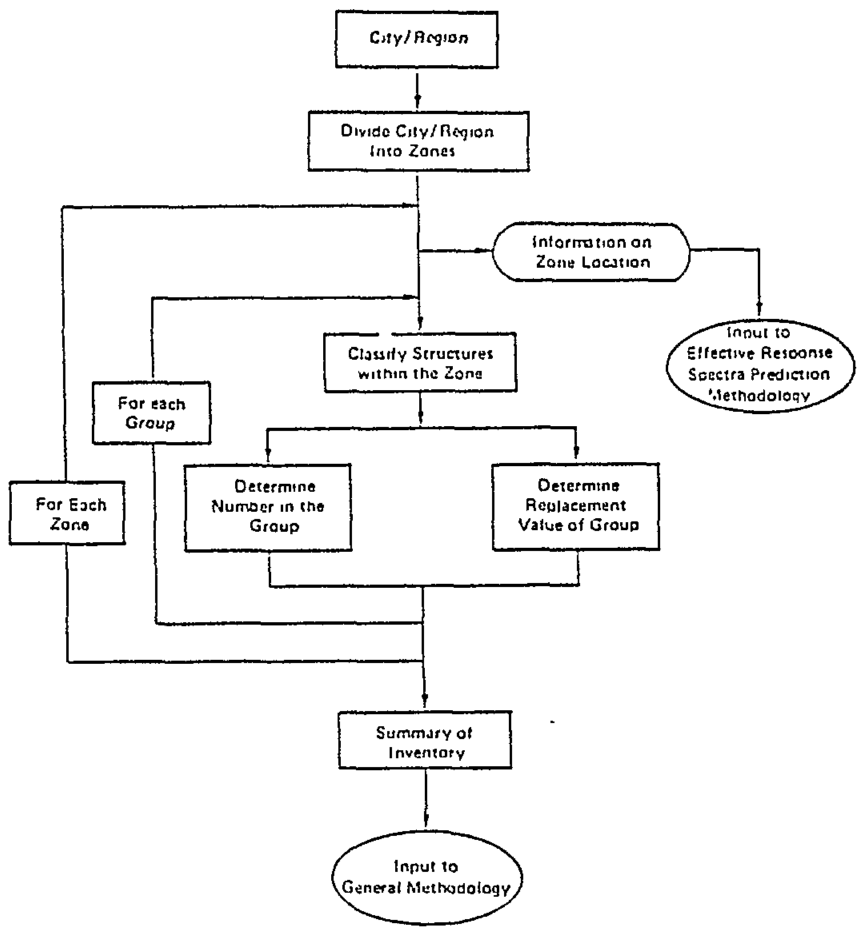


Fig. 11 Inventory Methodology for a City/Region

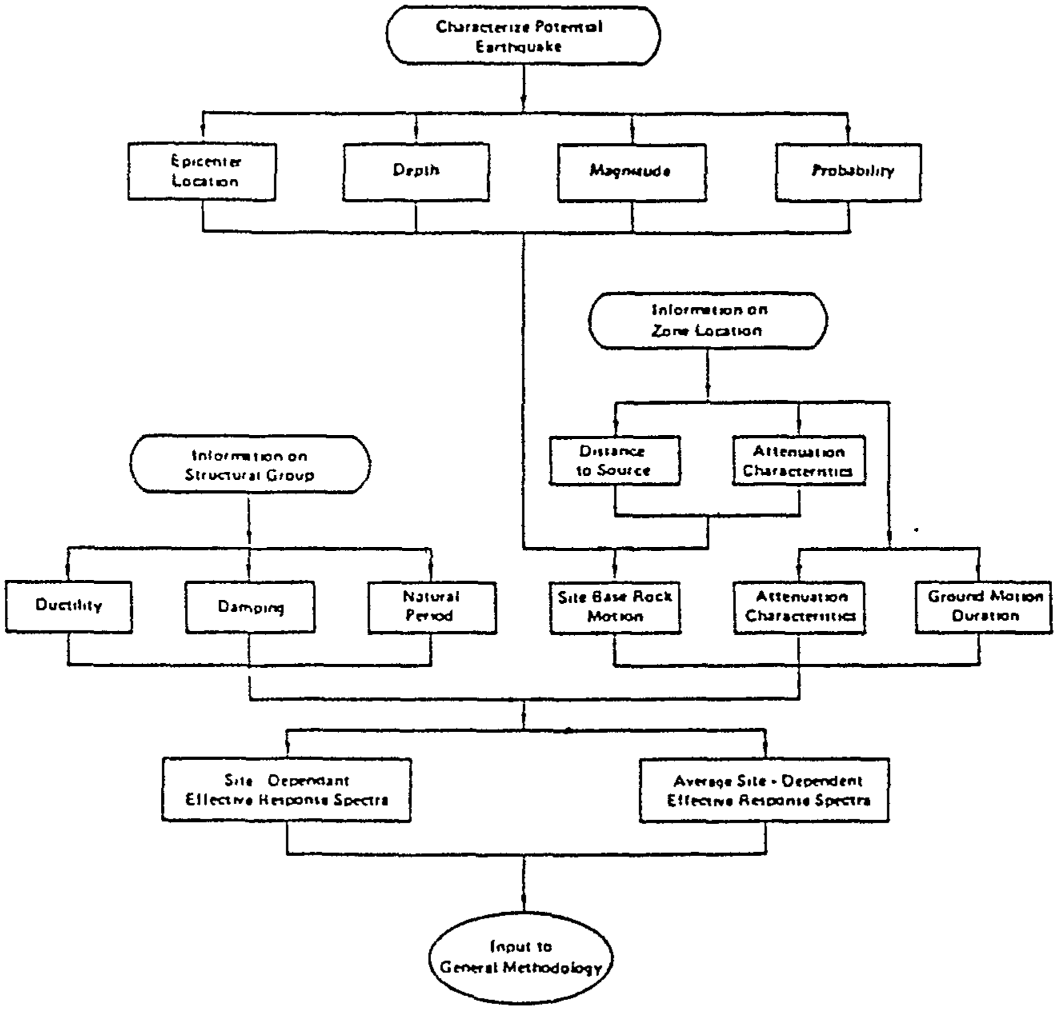


Fig. 12 Site Effective Response Spectra Prediction Methodology

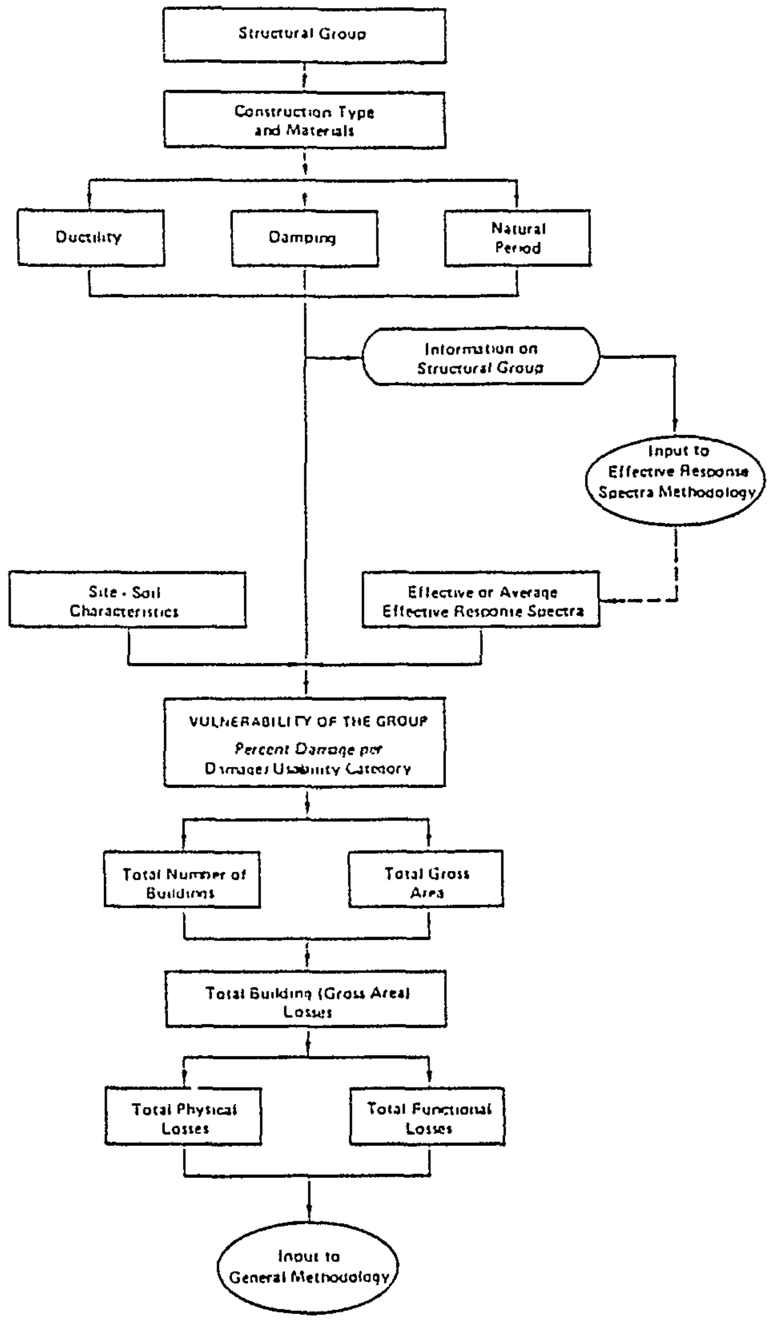


Fig. 13 Loss Prediction Methodology for Group of Structures

- To resist major earthquakes of intensity and severity of the strongest experienced in the area, without collapse, and with limited structural and vital non-structural damage, even in a major earthquake, which is limited to repairable level.

In order to achieve acceptable earthquake-resistant design criteria, one needs an understanding of how structures deform under the action of earthquake shaking, and how the construction materials will behave when subjected to these deformations. Several levels of understanding are required. The first is the elastic response of structures during which the earthquake vibrations do not produce any structural damage or any plastic deformations. The second is the large-amplitude non-linear vibrations of structures when plastic deformations, cracking and other types of damage may be sustained, but not to the degree that the structure is near to the point of collapse. The third is the very large-amplitude vibration with increased damage to the point of collapse.

The consideration of elastic structural vibration is required in order to understand how structures will behave when subjected to minor and moderate ground shaking that should cause no structural damage. This is the most probable ground shaking that structures will experience. However, very strong shaking may occur during the life of a structure, even though the probability is low; in this case the ground shaking may be so severe that the structure suffers damage.

Economic considerations require that ordinary structures be designed for controlled damage when exposed to very strong ground shaking. Life safety considerations require that ordinary structures be designed so as not to collapes in the event of a maximum credible shaking but, on the other hand, economic considerations show that it is not feasible to design ordinary structures to resist such intensive ground motions without damage. The percentage of structures that will experience such intense ground shaking during their lifetime is quite small and most will never experience such a strong shaking. Therefore, it is economically desirable to reduce the design for structures in general, even though some structures will require damage repairs.

On the other hand, special structures, because of cost, potential hazard, the need to maintain operations etc. require special consideration. For example, attention should be paid to how various structures and facilities will perform during future earthquakes; what is acceptable infrequent damage; how much should be invested in providing earthquake resistance. Such questions are certain to arise when designing high-rise buildings, large dams, nuclear power plants, long-span bridges, oil refineries, LNG storage facilities, offshore platforms, chemical process facilities, port and harbour facilities, and other similarly complex and costly installations. It is very important that correct earthquake engineering decisions be made for such projects, from the standpoint of safety as well as of cost.

All social goals incorporate values that must be weighed against the costs of achieving various objectives. Several factors must therefore be considered in defining "acceptable risks" to life and property in relation to the costs and outlays required. There is no uniform level of acceptable risk. Acceptable safety levels vary with time, place, frequency of natural disaster occurrence. They must be related to costs and are influenced by socio-economic and technology development factors and applied practice.

Considering the above in the establishment of criteria to define the acceptable level of seismic risk for ordinary buildings and structures as well as for special structures of vital importance for the economy of each country and bearing in mind the existing conditions in the Mediterranean region, for the purpose of earthquake risk reduction, a continuous process of studies, measures and actions as described below should be carried out.

- Elaboration of laws and regulations for earthquake protection;

- Performance of seismic hazard studies and elaboration of seismic zoning maps of each country;

- Elaboration of seismic microzoning maps of major urban areas;

- Evaluation of expected vulnerability and acceptable seismic risk levels with the requirements for protection against earthquakes;

- Elaboration of a model code and a national code, instructions and manuals for aseismic design and construction of buildings and structures;

- Improvement and development of design and construction control organizations;

- Development of research and training centres in the field of earthquake engineering and urban planning, and long term cooperation among the centres in each country;

- Establishment of regional and local effect - strong motion instrumentation arrays;

- Strong motion instrumentation of buildings and structures; and

- Training of specialists for the needs of each country in the fields of seismology, earthquake engineering, seismic risk mitigation, physical and urban planning.

The above ten proposals for earthquake risk reduction should be implemented through the combined efforts of all Mediterranean countries in close cooperation with one another. Activities should be focused on the components of highest priority and of common interest to all countries. The following components could be considered for specific development in the future:

- Elaboration of model laws and regulations for protection against earthquakes;

- Elaboration of instruction materials for seismic hazard studies, for seismic zoning and microzoning maps, and for a case study for training purposes;

- Evaluation of expected vulnerability and acceptable seismic risk levels in close cooperation with other countries; and

- Elaboration of a model seismic design and construction code, instructions and manuals for the improvement of existing design and construction practice.

- Development of national research and training centres in the field of earthquake engineering and urban planning;
- Establishment of regional and local-effect strong-motion arrays;
- Training of specialists in aseismic planning, research, design and construction; and
- Elaboration of standards and instructions for strong-motion instrumentation of buildings and structures.

A number of components specified below could be developed by each country separately as follows:

- Elaboration of national laws and regulations for protection against earthquakes;
- Elaboration of seismic zoning maps of each country;
- Elaboration of seismic microzoning maps of major urban areas;
- Carrying out detailed studies on vulnerability and levels of acceptable seismic risk by taking into consideration the specific level of existing and planned economic development;
- Elaboration of a national code for seismic design and construction and its continuous improvement, dependent upon levels of economic development of the country;
- Establishment and development of a national design and construction control organization with a specialized section in earthquake engineering and engineering seismology;
- Close cooperation among the Mediterranean countries in performing cooperative research programmes and training of specialists;
- Operation, maintenance and data collection of regional and local-effect strong-motion arrays and earthquake damage data; and establishment of a standardized earthquake damage and ground motion data bank; and
- Continuous strong-motion instrumentation of buildings and structures, instrument maintenance, data collection and analysis.

It is essential that each country consider the development of specialized centres in earthquake engineering and urban planning within existing civil engineering institutions, design and construction control organizations, departments of civil engineering and architecture at the universities, in close cooperation with seismological, geophysical, geological and other organizations and institutions.

b. Legislative Basis for Seismic Risk Management and Integral Approach to Planning of Seismic Risk Reduction

Developing and developed countries in the Mediterranean region must face the fact of how important it is to protect from earthquakes industrial, power, transportation and other structures of vital importance which, due to high seismicity and frequent earthquake occurrence, are permanently exposed to damage and disastrous destruction. However, bearing in mind the size of additional investments required, we are led to the conclusion that efficient earthquake protection should correspond to the level of development and economic possibilities of the country. Conservative design may bring with it serious economic penalties.

In order to meet all the above mentioned requirements for economic development and aseismic design, systematic theoretical and applied research should be carried out in order to evaluate seismic risk, define economically justified and technically consistent design criteria and improve the structural systems so that they withstand the expected earthquake effects. Thus, earthquake prevention is the best means of protection of both social goods and human lives, as long as it corresponds to the development of the country and its future requirements.

As a result of recent catastropic earthquakes in the Mediterranean region (Yugoslavia, Algeria and Italy), a large number of residential buildings, schools, hospitals and other public, administrative and industrial buildings, as well as other local and regional infrastructure facilities, has been severely damaged. Most of the damaged buildings were in an unfit state for use before adequate repairing and strengthening of the basic structural system, the non-structural elements and installations. In order to ensure that the damaged buildings will be safe and function normally, it is important to recognize that they will be exposed in the future to a large number of small and moderate earthquakes; we should also bear in mind that there is a probability of catastrophic earthquakes with large magnitudes similar to those of the past.

Thus it is essential that an adequate legislative basis for seismic risk management and integrated planning of seismic risk reduction be developed and implemented in the stage of general physical and urban planning in all Mediterranean countries.

The purpose of this legislative basis is to protect the life and property of the citizens from earthquake induced hazards through the intensification of earthquake disaster prevention measures concerning the designation of seismic areas, the establishment of a seismological and strong motion observation system, and other measures relating to the establishment of an earthquake disaster prevention system, to preserve social order and secure public welfare.

Due to the expected high frequency of occurrence of large scale earthquakes in the Mediterranean region, it will be of particular importance to implement short-term prevention measures against earthquake disaster by establishing headquarters for earthquake disaster prevention and issuing earthquake and related effects warning statements when an earthquake can be predicted. Earthquake disaster prevention arrangements are also long-term: permanent governmental and professional activities are needed in order to establish a consistent scientific basis and for the practical applications in reduction and mitigation of seismic risk. Earthquake disaster prevention arrangements could best be achieved with continuous implementation of the following activities: permanent recording of earthquakes by seismologiccal and strong motion observation systems in the entire Mediterranean region; strong motion instrumentation of buildings and structures; continuous earthquake data analysis and studies of earthquake phenomena for the needs of general, physical and urban planning, seismic design and construction of new structures and prevention of existing structures and utilities; continuous improvement of seismic zoning maps of the region and microzoning maps of the urban areas, as well as seismic design and construction codes and regulations; continuous education and upgrading of the level of knowledge of scientists, engineers and planners.

The principles on which the legislative basis for seismic risk reduction should be developed are in our opinion the following:

- Designation of areas within the region under intensified measures against earthquake disaster, by carring out deterministic and probabilistic seismic zoning studies of the region and seismic microzoning studies of the larger and more significant urban areas and zones with high seismic hazard;

- Improvement of existing and development of contemporary seismological and strong motion observation systems, through the establishment of telemetred and computerized seismological observatories in the region amd micronetworks for the areas of highest seismicity for the purpose of continuous recording and rapid seismological data analysis; combining seismological instrumentation with other types of instruments for the purpose of short-term earthquake prediction; development of a strong motion instrumentation network in the region and strong motion instrumentation of typical and important buildings, structures and utilities; establishment of a data bank for seismological and strong motion earthquake records; preparation in a format suitable for dissemination and direct use in basic and applied studies of seismic hazard, dynamic response of soils, buildings, structures and utilities as well as evaluation of expected vulnerability and seismic risk;

- Establishment of a long-term observation and research programme on earthquake prediction;

- Establishment of medium and long-term research programmes for studies of seismic hazard, vulnerability and seismic risk;

- Continuous integration of verified findings from the studies of seismic hazard, vulnerability and seismic risk into the process of physical and urban planning at regional and urban levels, improvement of seismic design and construction codes and regulations, preparation of manuals for practicing engineers and control of design and construction practices;

- Establishment of headquarters for earthquake disaster prevention within the existing system of civil defence and territorial units within the region and the entire country for the elaboration of earthquake disaster prevention plans, training of the population, systematic data selection of observed damage for appropriate estimation of vulnerability and earthquake losses as well as short-term and long-term planning for reduction of earthquake effects, and other short-term prevention measures against earthquake disaster;

- The above mentioned activities could be approved, organized, financed and implemented by the National Committees on seismic risk reduction in each country and through the various governmental or other competent institutions and bodies;
- The planning of activities could be done by competent national institutions and organizations for each five year period and submitted for approval to the National Committees on seismic risk reduction; and
- The cooperative efforts of the Mediterranean countries could be coordinated by a permanent intergovernmental body under the auspices of the UN specialized agencies and organizations (UNEP, HABITAT, UNDRO).

G. Conclusions and recommendations

a. Assessment of the Applied Approach, Results obtained and Highlights of Major Pending Problems

The presented method and procedure for assessment of regional/urban seismic losses provides basis, essential data and assistance for elaboration of physical development plans and urban master plans. It was shown that earthquake risk reduction is only one aspect of an overall hazard reduction programme that should be synchronized with other communtiy cocerns.

The techniques presented herein are an attempt to resolve a major problem of land-use planning in seismic regions, that of using seismic hazard data and data on existing and/or planned urban patterns. The approach and results presented provide regional/urban planners, public and social policy makers, scientists, engineers and other competent authorities with the following outputs: (1) regional/urban specific loss maps for any element at risk, (2) regional/urban seismic loss maps for each element at risk, and (3) regional/urban seismic loss maps superimposed for all elements at risk which are taken into consideration. These maps provide information and help in the elaboration of physical amd master land-use plans and the principal strategy of urbanization policy. Thus, technically consistent and economically justified measures for risk management can be undertaken through balancing pre-disaster capital investments, necessary for achieving the required seismic protection levels and the value of damaged or lost property. On this basis uniform pre-disaster tools for developing and elaborating effective disaster mitigation, management, and civil protection programmes as well as uniform post-disaster assessment tools including the rehabilitation and revitalization of economic and social activities can be obtained. Vulnerability and expected losses of the existing volume of elements at risk as well as new developments can be identified, providing information on the effectiveness and possible need for improvement of the codes, regulations and standards in force.

Vulnerability and related regional/urban loss-producing potential concepts refer to classes of buildings rather than to individual buildings. This is possible through the adoption of three level damage/usability categorization schemes (Table B.1); vulnerability functions are developed for two damage/usability levels, the D&U-C-11 and D&U-C-III. The degree of losses inherent to existing or planned regional/urban land-use, as quantitative measure of existing or potential seismic risk, might be expressed through physical losses (percent of damaged or lost buildings/building gross area) or loss of function. This procedure allows the development of regional, D&U category-dependent loss-of-value functions which can further be synthesized into a single, building-class dependent, regional loss-of-value function (economic loss). To achieve this, an appropriate damage cost factor must be applied to physical vulnerability functions. Through this hitherto unimplemented approach we can estimate the level and degree of specific losses both to the existing building stock and to future development, by obtaining sound information on building classes. This approach can also provide information on prevailing quality of design, materials and workmanship, as well as efficiency and possible needs for improvement of codes, regulations and standards in force.

Empirical damage data on 39,830 (5,634,088 sq.m. gross area) one to three-storey Montenegro buildings have been processed in order to derive generalized, site- and site-and-number-of-storey dependent vulnerabbility functions for SM, BM, STM and RCFS building classes. More than any other variable involved in the analysis, construction type was identified as the main parameter which controls damage level and loss producing potential. The specific loss potential of SM building class was isolated as the highest, ranging from 52% to 56% (D&U-C-II) and from 7% to 29% (D&U-C-11) for an S_{eff} increase from 10% to 45% g. For the same S_{eff} range, the BM building class specific losses range from 19% to 53% (D&U-C-11) and from 3% to 13% (D&U-C-III), and about 5% to 17% (D&U-C-II) for the S_{eff} increasing from 10% to 45% g.

Specific loss potential is identified for different site-soil conditions and number-of-storeys. With an increasing number of storeys, the vulnerability of SM and STM buildings generally decreases for rock, whereas it increases for dilivial-alluvial site-soil conditions. This is expected since the high frequency content of rock-site ground motions creates resonant conditions for stiffer structures while, on the other hand, the frequence content characteristic of diluvial-alluvial sites would affect more flexible structures.

The vulnerability functions proposed for assessing the level and degree of regional/urban specific losses are the basic tool for the prediction and calculation of regional/urban seismic damage. While of wide practical significance, the vulnerability models presented in this study should not be directly employed in other regions since it is unrealistic to expect that the building typology and seismic environment will be the same as in Montenegro. The models should therefore be verified first and, if necessary, adjusted and calibrated in accordance with the specific conditions, and only then implemented for assessment of loss in the region of interest.

A word of caution should also be mentioned here. The vulnerability assessments based on damage observations from a single earthquake event can in some cases prove unreliable and even misleading. Therefore, data on damage from as many past earthquakes as possible must be collected, uniformly compiled and reduced to standard format. The improvement of the statistical volume of data with damage data from different scale earthquakes and different regions in the world will make possible the elaboration of more reliable and widely applicable vulnerability relationships.

The general long-term aspect of an overall regional earthquake risk reduction programme is analyzed and presented by means of a case study of a particular region. Two urban forms comprising the same regional, communal and zonal gross areas, but differing in the building typology, are studied for seismic hazard levels related to two specific return periods of 50 and 200 years. By replacing the prevailing highly vulnerable SM building gross area by BM (30%) and STM (70%), we found that overall physical loss production potential decreases by 63.7% (D&U-C-1l, SH-50), 59.8% (D&U-C-III, SH-50), 54.1% (D&U-C-II,SH-200) and 65.1% (D&U-C-III, SH-200).

The risk to an urban region/town/settlement is far greater than the sum of the risks to the individual elements. Besides the direct physical damage and functional disorder caused by earthquakes, there are also categories of indirect earthquake effects which can be generally classified into economic and social damage. Stagnation of industrial activities and production, loss of regional revenue and additional expenditure for immediate rehabilitation in the stricken area, are all typical indirect economic losses. Interruption of transportation, as well as water and electric power supply systems, disruption of public services and information systems, as well as bad publicicity for the damaged areas are all classes of typical social damage.

The correct calculation of the size of possible disaster as well as the required level of pre-disaster capital investments necessary for mitigation of earthquake consequences should be based on a loss model capable of incorporating long-term effects of earthquake losses. This can efficiently be achieved by coupling the direct-loss model, implemented in this study and the indirect effect models through interrelation, and time-series estimation of economic effects induced by direct losses. This area is identified as a natural continuation of this study and a topic for further research.

The principal advantage of the methodology presented here is that it provides simple and ready access to integrated seismic risk assessment irrespective of whether or not seismic activity has occurred. The model is flexible enough to incorporate any kind of a consistently derived set of vulnerability functions irrespective of whether they are developed empirically or theoretically for vulnerability assessments of existing traditional or modern, seismic resistant buildings. Even though the methodology proposed was developed on the basis of the effects of the Montenegro earthquake, it has the added advantage that the data compiled and results derived can be transferred to countries of seismic activity in the entire Mediterranean region (because of the similiary among structural types for which the vulnerability functions derived herein are applicable). In general, empiricald or theoretical vulnerability functions should be adjusted and verified in accordance with the specific conditions of the region under consideration in respect of the actual quality of material and workmanship.

b. Specific Issues and Topics of Common Interest to All Mediterranean Countries

It is no exaggeration to say that all facets of the above investigations and analyses require additional research. However, certain aspects are more obvious than others, including:

- Improvement of the damage/usability inventory and classification of damaged buildings in order to create a uniform data base for the development of reliable vulnerability models of widespread applicability;

- Collection and exchange of damage data from other regions and different scale earthquakes, their uniform processing and reduction to standardized format. If this is combined with strong motion data from the same earthquake events, it will significantly improve the statistical volume and usability of data needed for the establishment of a ground motion and earthquake damage data bank;

- Evaluation and comprehensive analysis of S_{eff} from data from various earthquakes and different seismic environments in order to improve modelling patterns and decrease modelling uncertainty. By improving the strong motion data bank, we obtain widely applicable magnitude and source to site dependent S_{eff} relationships;

- Efforts must be made to incorporate the concepts of EQA and ERS within the framework of current design formats since they have a capacity of implementing the effects of: (1) ground motion intensity and duration as ground motion parameters; (2) fundamental period of building and damping as parameters describing the dynamic properties of a structure; and (3) ductility and number of response reversals as representatives from the group of parameters related to structural capacity. Because of lack of rational techniques to obtain these effects, a lot of strong motion data accumulated up to now cannot be used for the direct evaluation of seismic design loads;

- The seismicity model of a region of high seismic activity has great influence upon the final results - the effective response spectra. The existing data on source mechanisms, the reasons and conditions under which large earthquakes occur, as well as the time period for which reliable data exist are not sufficient to allow forecasting and a comprehensive calculation of the posssible consequences of future earthquakes;

- A mathematical model of seismic hazard is one of the possible solutions to the problem. It involves many theoretical and practical issues which should be taken into account, on the basis of specific studies on the region (geological, tectonic, neotectonic, seismic and so forth); the model should be verified on the basis of existing experience and accumulated instrumental data;

- The vulnerability models presented were developed on an empirical basis. They should be synthesized and improved by taking into consideration the large volume of existing theoretical and experimental studies;

- The empirical models presented assess the vulnerability of low-rise buildings only. Considering that an urban area is an aggregate of many building types with a varying number of storeys, similar models should be theoretically developed for mid- and high-rise buildings, and verified on the basis of damage data obtained from past earthquakes;

- The damage induced by ground shaking is one form of earthquake-induced losses. There are other forms of hazards due to earthquakes, such as ground failure, surface faulting and flood effects, fires etc., which should be incorporated in a loss prediction methodology;

- This study dealt only with the building stock. For the final decision making, regarding urban layout and land-use, life-lines, civil engineering structures, communication and transportations systems etc., which are of vital importance for an undisturbed pre-earthquake life and the post-earthquake rehabilitation and reconstruction of an urban region, should also be included in the analyses of regional/urban loss producing potential; and

- Finally, it should be noted that in assessing the interaction between disaster and regional development, the direct physical losses, i.e. loss of function or investment is not the only disaster-related criterion to take into consideration. There are chains of indirect and secondary effects which in the long run can lead to unrecoverable national economic damage. These indirect and secondary losses require proper definition and examination in terms of physical damage. At present, this task can be handled only in an approximate manner, or on the basis of subjective judgements. To define it more rationally multi-disciplinary studies must be carried out.

It is obvious then that there is an urgent need to incorporate a rational and effective methodology for the assessment of vulnerability and seismic risk in all regional and urban planning; the areas listed above could thus be considered as a basis for the development of future cooperation in the field of seismic risk mitigation planning in the Mediterranean region.

7.3 ALEA SISMIQUE ET CENTRE HISTORIQUE - LE CAS DE MARSEILLE, FRANCE

par Gilles Delfosse, C.N.R.S. et Daniel Drocurt, l'Atelier du Patrimoine, Marseille

La région qui entoure la ville de Marseille dans un rayon de 100 km présente un bilan de sismicité historique non négligeable. Le Bureau de recherches géologiques et minières a établi en 1976 une esquisse sismo-tectonique de la Provence occidentale et centrale qui montre l'occurrence dans le passé de deux séismes d'intensité IX, quatre séismes d'intensité VIII, dix séismes d'intensité VII et d'une soixantaine de séismes d'intensité inférieure à VII. La région est sillonnée de nombreuses failles plus ou moins actives ; la zone sismique la plus active est située dans la chaîne de la Trévaresse, à 40 kms à vol d'oiseau de Marseille. Elle a été responsable du séisme catastrophique du 11 juin 1909 d'intensité IX qui fit 50 morts et détruisit les villages de Lambesc, Saint-Cannat, Rognes et, partiellement, la ville de Salon-de-Provence. La secousse fut largement ressentie à Marseille où elle provoqua des fissures dans un certain nombre de bâtiments, ainsi que la chute de cheminées. D'autres grands tremblements de terre ont secoué la région de Marseille dans le passé ; citons les séismes d'Aix-en-Provence d'intensité X qui fit 5.000 morts en 1227 et celui de Manosque (1708) d'intensité IX.

La ville de Marseille est affectée par les séismes qui se produisent dans la région environnante du fait que les ondes à grande période issues des épicentres trouvent une direction de propagation préférentielle vers Marseille. Témoin cette secousse du 19 février 1984 de magnitude 4 dont l'épicentre était situé dans le bassin de Gardanne et qui a mis en émoi une partie de la population marseillaise, en même temps qu'elle occasionnait des fissures à certains bâtiments.

L'activité sismique de la région marseillaise est surveillée par la station séismologique de Cadarache, dépendant du Commissariat à l'énergie atomique, et qui enregistre environ 3.000 micro-séismes par an.

Le microzonage de la région n'a pas été effectué, si bien qu'il n'est pas possible à ce jour de tenir compte des effets de site dans l'appréciation de l'aléa sismique local.

A. Comportement aux séismes des immeubles existants. Evaluation de la vulnérabilité

Les immeubles du noyau historique de Marseille sont construits, pour la plupart, en maçonnerie de pierres non appareillées liaisonnées au mortier de chaux et montées sur une assise en pierre plus dure. Les cloisons intérieures le plus souvent sont en briques pleines minces de 2,5 cm d'épaisseur, appelées communément "crottes". Les planchers sont constitués par des solives en bois avec revêtement en tomettes ou carreaux hexagonaux en terre cuite de 16 cm de côté. Les toitures sont en tuiles "canal" demi-rondes posées sur carreaux de couvert en terre cuite et charpente en bois. Des variantes existent qui utilisent des planchers de cave sur voûtains en briques et des toitures en tuiles canal posées sur voliges en bois.

Un exemple type est constitué par un groupe de deux immeubles situés au n° 17 de la rue Puits-du-Denier et au n° 18 de la rue des Pistoles et qui datent de la fin du 19ème siècle début du 20ème siècle, avec un socle plus ancien. Ce premier immeuble comporte quatre étages sur rez-de-chaussée, tandis que le second n'en comporte qu'un. Les figures 1, 2, 3 et 4 extraites de la référence (1) montrent les façades, plans et coupes du groupe. Les fondations sont constituées par une assise en pierres froides surmontées, par endroit, d'un soubassement en pierres appareillées. Les murs de façade et les murs mitoyens sont en pierres non appareillées liaisonnées au mortier de chaux. Les cloisons intérieures sont en crottes liaisonnées au mortier de chaux. Les encadrements et les linteaux de fenêtres sont en pierres appareillées. Les planchers sont constitués par des solives en bois scellées dans les murs mitoyens et supportant un revêtement en tomettes posées sur ravoirage au mortier. Le plancher du rez-de-chaussée est posé à même le sol par l'intermédiaire d'un hérisson en pierres et d'une forme en mortier ; il reçoit un carrelage en terre cuite. La toiture est en tuiles canal, tuiles de courant et tuiles de couvert, installées sur carreaux de couvert en terre cuite et charpente en bois portées par les murs mitoyens.

Le mode de construction des bâtiments du noyau historique et leur état de vétusté les rend particulièrement vulnérables à l'action d'un séisme. On peut recenser sept points importants qui conditionnent la vulnérabilité de ces immeubles.

1. La faiblesse du contreventement. Ce dernier est assuré par les murs en maçonnerie de moellons non appareillés hourdés avec un mortier de chaux. Un tel type de maçonnerie manque totalement de cohésion et en eût-il suffisamment qu'il ne pourrait résister aux efforts de traction importants introduits par un séisme. L'absence quasi générale de refends accroît encore l'insuffisance du contreventement.

2. La faibless des liaisons. Liaison des murs entre eux et liaisons des pièces de bois avec les murs. La faiblesse de la liaison des murs entre eux procède de la même raison que ci-dessus : les murs en moellons non appareillés ne permettent pas la réalision de jonctions résistant en traction à la faibless de l'ancrage des pièces de bois dans les murs, ce qui tient, pour une part, à l'insuffisance de la longeur d'ancrage et, pour une autre part, à la moississure des parties ancrées dans les murs.

3. Toitures lourdes et vétustes. Ainsi que nous l'avons vu, les toitures sont constituées de deux lits de tuiles (tuiles de courant et tuiles de couvert) posées sur une sous-toiture en carreaux de terre cuite ; l'ensemble est supporté par une charpente de bois le plus souvent de grande section. Une telle toiture constitue une masse importante concentrée au sommet de l'immeuble ; il en résulte une élévation du centre de gravité et un accroissement du moment de renversement.

4. Absence de rigidité des planchers dans l'une des directions horizontales. L'ossature des planchers est constituée de solives en bois portant entre les murs mitoyens. Le manque quasi général d'entretoises dans la direction perpendiculaire rend le plancher inapte à la transmission des effets horizontaux dans cette direction.

5. Tassement fréquent du sol de fondation. Le sol de fondation est fréquemment constitué par des alluvions, voire des remblais. Au cours du temps, les infiltrations d'eau de pluie ont créé des tassements sous les fondations et peu à peu rongé les pierres d'assise en calcaire. Il en est résulté des affaissements et des fissures dans les maçonneries, qui compromettent un peu plus la stabilité de l'ensemble.

6. Fragilité du second oeuvre. Les cloisons en briques creuses de 2,5 cm d'épaisseur ou crottes manquent de stabilité et sont, en outre, insuffisamment accrochées aux murs porteurs.

7. Absence de joints de séparation entre bâtiments de types ou de hauteurs différents. C'est le cas par exemple pour les deux bâtiments présentés plus haut dans lesquels la variation brutale d'inertie en élévation introduisait des dommages importants.

Les faiblesses de construction énumérées ci-dessus ont une incidence importante sur la courbe empirique de vulnérabilité qui peut être dressée.

Si, pour un bâtiment historique, on définit la vulnérabilité comme le montant des travaux à effectuer après séisme rapporté à ce que coûterait à neuf l'ensemble du bâtiment, on obtient une courbe variant de 65% pour un séisme d'intensité VII à 95% pour un séisme d'intensité X, la moyenne se situant autour de 80% (Fig. 12). La vulnérabilité est élevée dans tous les cas.

Renforcement des immeubles historiques

Il est banal de dire que les bâtiments historiques font partie du patrimoine culturel d'un pays ; cette constatation entraîne cependant une conséquence majeure, à savoir que le caractère architectural de l'immeuble doit être préservé à tout prix au cours des travaux de renforcement. Un bâtiment ancien est, comme un vieux livre, l'expression d'une pensée venue du passé et il faut prendre garde de ne pas l'altérer gravement.

Le maître du projet doit être un homme de culture qui sente l'histoire inscrite dans la pierre et ne permette pas qu'on l'efface. L'utilisation des matériaux modernes tels que le béton, l'acier ou le plastique sont certes nécessaires au renforcement de la structure ; il convient cependant de veiller à ce qu'ils ne restent pas apparents et qu'au contraire, ils soient comme fondus dans la maçonnerie de l'immeuble.

Cet impératif de maintien du caractère architectural des bâtiments historiques rend évidemment beaucoup plus difficile leur renforcement parasismique. En l'état actuel de la technologie, on peut considérer qu'il existe deux niveaux de protection dont l'effet est de diminuer substantiellement la vulnérabilité de l'immeuble ou du groupe d'immeubles. Le premier niveau concerne le renforcement de la structure, le second niveau l'insertion d'un système d'isolation à la base.

Premier niveau de protection parasismique

Le premier niveau de protection concerne l'accroissement de la capacité de résistance de la structure et la description qui suit est un catalogue des dispositions qui doivent être prises pour conférer à la structure une résistance minimale aux forces latérales.

1. Constitution d'une ossature générale en béton armé formée d'éléments horizontaux (chaînages, planchers) et d'éléments verticaux (poteaux, voiles) ; les premiers sont destinés à assurer la transmission des efforts horizontaux d'une rive à l'autre de la construction, dans les deux sens ; les seconds sont chargés de renforcer les murs existants, voire de les compléter, pour obtenir la résistance latérale souhaitée.

   Les planchers sont constitués par une dalle pleine en béton armé, représentant une rigidité du même ordre de grandeur dans les deux sens ; ils remplacent purement et simplement les planchers existants sur solives. Au cours du montage de ces derniers, le carrelage en tomettes est soigneusement récupéré pour être réemployé avec le nouveau plancher.

Les voiles, poteaux et chaînages sont fréquemment incorporés dans la maçonnerie existante ; le béton doit être soigneusement vibré, non seulement pour lui donner sa résistance optimale, mais aussi pour lui permettre d'épuiser entièrement la cavité ménagée dans la maçonnerie. La retombée des chaînages sous dalle ne sera pas inférieure à 20 cm.

Les poteaux en béton armé sont obligatoires aux angles, à la jonction des murs et en bordure des piles de croisées ; dans ce dernier cas, on constitue, en fait, des encadrements en béton armé dont le but est d'empêcher la dislocation de l'ouverture pendant le séisme. La plus petite dimension d'un poteau ne sera pas inférieure à 25 cm. Dans le cas des étages de grande hauteur, on instituera avec profit un ou deux chaînages intermédiaires de 20 cm de hauteur incorporés dans la maçonnerie et liaisonnés aux poteaux d'ossature.

2. Liaisons et ancrages

La liaison des éléments résistants entre eux et leur ancrage dans la structure générale est un problème capital pour les structures destinées à résister à des efforts sismiques.

La liaison des éléments entre eux concerne essentiellement les nouveaux éléments en béton armé qui ont été construits ; elle s'opère essentiellement à l'aide des armatures longitudinales dont les recouvrements ne doivent jamais être inférieurs à 50 diamètres. Mentionnons, au passage, l'importance particulière en protection parasismique des armatures transversales (cadres et étriers) dont le rôle essentiel est d'empêcher le flambement des armatures longitudinales. La plupart des règles parasismiques en vigueur dans le monde imposent une quantité d'armatures transversales plus importante qu'en statique. On soignera particulièrement la liaison des poteaux et des chaînages nouvellement construits, du point de vue des armatures et de la qualité du béton ; de leur solidarité effective au droit des noeuds de jonction dépend souvent l'état d'endommagement de l'immeuble après séisme.

L'ancrage des éléments dans la structure concerne les parties et dalles en béton armé et la charpente de toiture. Les dalles en béton armé formant planchers doivent être ancrées aussi profondément que possible dans les murs porteurs et être reliées aux chaînages par le biais des armatures supérieures ou chapeaux. Le coulage simultané du plancher et de son chaînage crée un ensemble monolithe très résistant. Les poutres en béton armé doivent être encastrées dans les murs par l'intermédiaire de semelles de répartition du même matériau ; leurs armatures comporteront

les crochets ou équerres nécessaires à leur bon ancrage. Les pannes de la charpente de couverture doivent présenter une longueur d'ancrage suffisante et exempte de moisissures. Cette disposition est capitale pour éviter un effondrement catastrophique de la toiture. L'ancrage peut se faire avantageusement à l'aide de tiges filetées passant à travers les pièces de bois au droit des murs et reprises dans une semelle de répartition en béton armé. La disposition idéale consiste à installer suivant le rampant du pignon un chaînage continu sur lequel sont ancrées les pannes de la charpente.

3. Reprise des cloisons

Les cloisons en crottes sont d'épaisseur suffisante et sont mal accrochées aux murs porteurs. Il en résulte un manque de stabilité qui représente un risque sérieux pour les occupants. La solution consiste à les remplacer par des cloisons de même matériau, mais ayant une épaisseur d'au moins 10 cm. Des potelets en béton armé sont incorporés dans la maçonnerie au droit des portes et à la jonction avec les murs porteurs un chaînage d'au moins 20 cm. de hauteur, liaisonné aux potelets, couronne la cloison.

L'ancrage de la cloison aux murs porteurs ou au poteaux en béton armé incorporé dans ceux-ci est assuré par les armatures transversales des potelets d'extrémité de la cloison. L'enduit sur les cloisons est avantageusement armé par un treillis métallique, ou encore renforcé à l'aide d'un adjuvant augmentant sa résistance en traction.

4. Reprise des fondations

Il arrive fréquemment que les tassements du sol sous le bâtiment entraînent la construction de fondations plus larges et plus résistantes que les fondations anciennes ; les nouvelles fondations doivent, en outre, être calculées pour s'opposer aux moments de renversement qui interviennent pendant un séisme. La reprise se fait de façon classique, par longueurs d'environ 4 mètres en constituant sous le mur en maçonnerie une semelle rectangulaire avec partie de tête en béton armé. On utilisera avec profit une colle à béton à base de résine époxy pour assurer la jonction des différents tronçons au droit des reprises. Dans le cas où le terrain a été très affouillé par les infiltrations d'eau et présente une résistance insuffisante, il est bien souvent nécessaire de forer jusqu'au bon sol des petits pieux de part et d'autre de la fondation pour apppuyer la semelle.

5. Joints de séparation

Des joints séparant les immeubles sur toute leur hauteur doivent être créés dans au moins un cas. C'est celui où un ou plusieurs immeubles sont accolés à un immeuble de moindre hauteur. C'est le cas du groupe d'immeubles dont il a été fait mention plus haut. La variation brusque d'inertie en hauteur entraîne une concentration des contraintes au droit de l'immeuble le plus bas et est responsable de dommages importants pendant le séisme. Il est un autre cas où il est conseillé de ménager un joint entre les immeubles, même lorsqu'il n'y a pas variation soudaine de hauteur ; c'est celui où la longueur de l'ensemble est supérieur à 2,5 fois la largeur du bâtiment.

Ce rapport dimensionnel favorise un mode de torsion appelé torsion accidentelle et qui résulte de la probable hétérogénéité du sol suivant la dimension prépondérante. La largeur d'un joint est calculée comme la somme des valeurs absolues des déplacements attendus pour les immeubles de part et d'autre ; elle ne saurait être inférieure à 5 cm en l'absence de système d'isolation à la base.

6. Consolidation des éléments libres

Par éléments libres, nous entendons les appendices tels que les souches de cheminées, les corniches, les garde-corps etc. et d'une façon générale, tous les éléments dont une extrémité est libre et l'autre plus ou moins encastrée. Ces parties isolées entrent souvent en résonance avec l'une des périodes propres de la structure et sont alors soumises à des efforts hors de proportion avec leur résistance intrinsèque. Il convient donc de les consolider par des renforts en béton ou en acier et d'assurer leur mode d'ancrage au bâtiment afin d'éviter leur chute.

Figure 1. Groupe-type de deux immeubles historiques à Marseille. Façades.

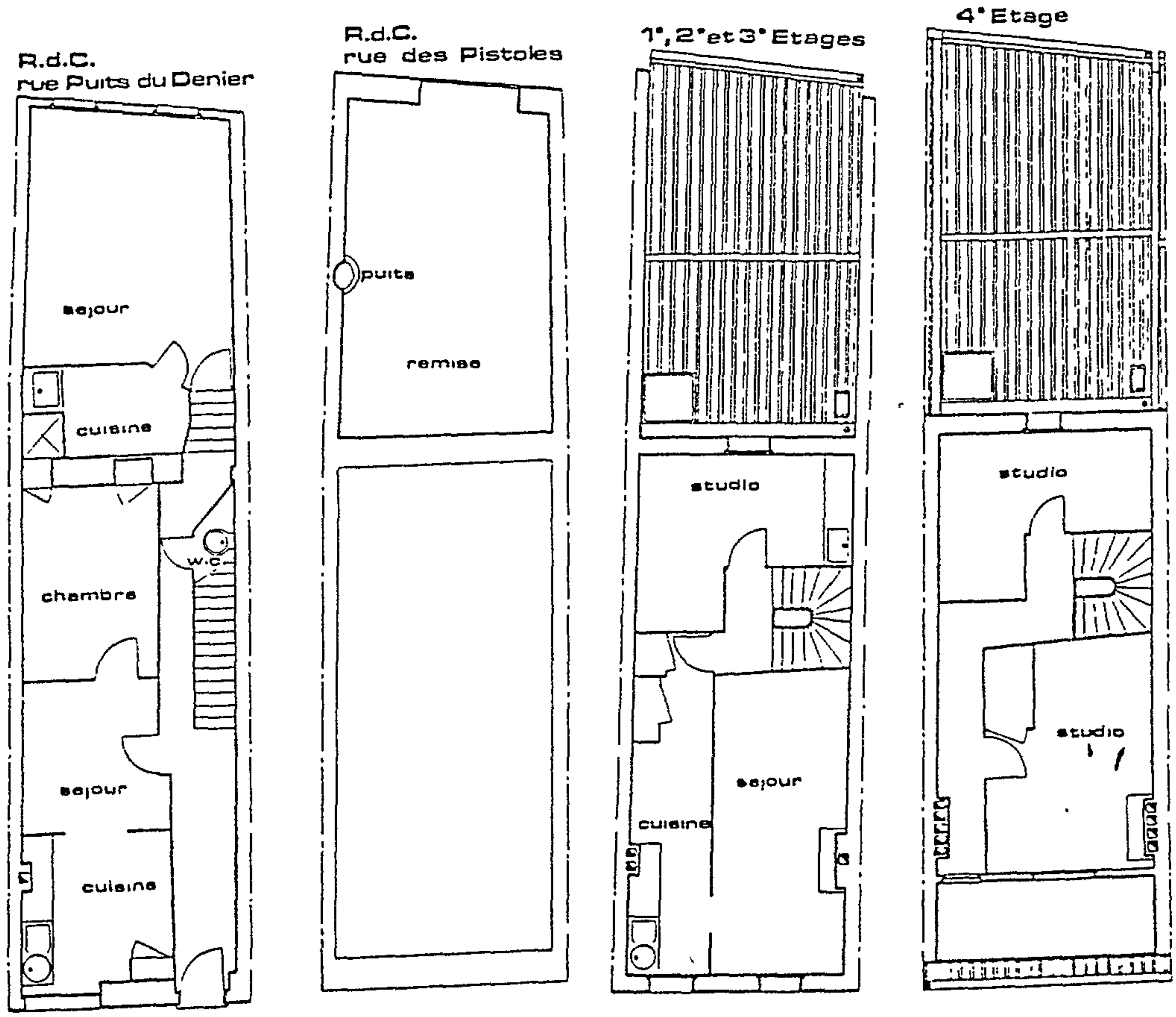


Figure 2. Groupe-type de deux immeubles historiques à Marseille. Vues en plan.

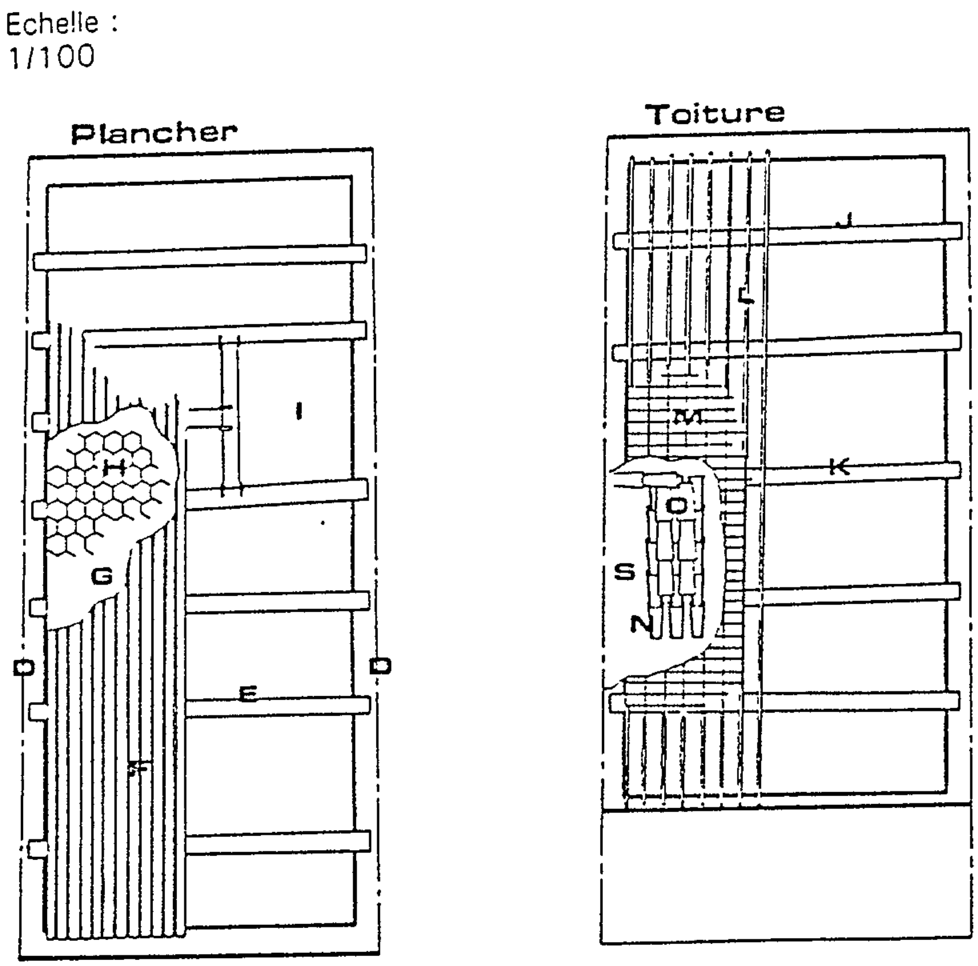


Figure 3. Groupe-type de deux immeubles historiques à Marseille.
Vues en plan d'un plancher courant et de la toiture.

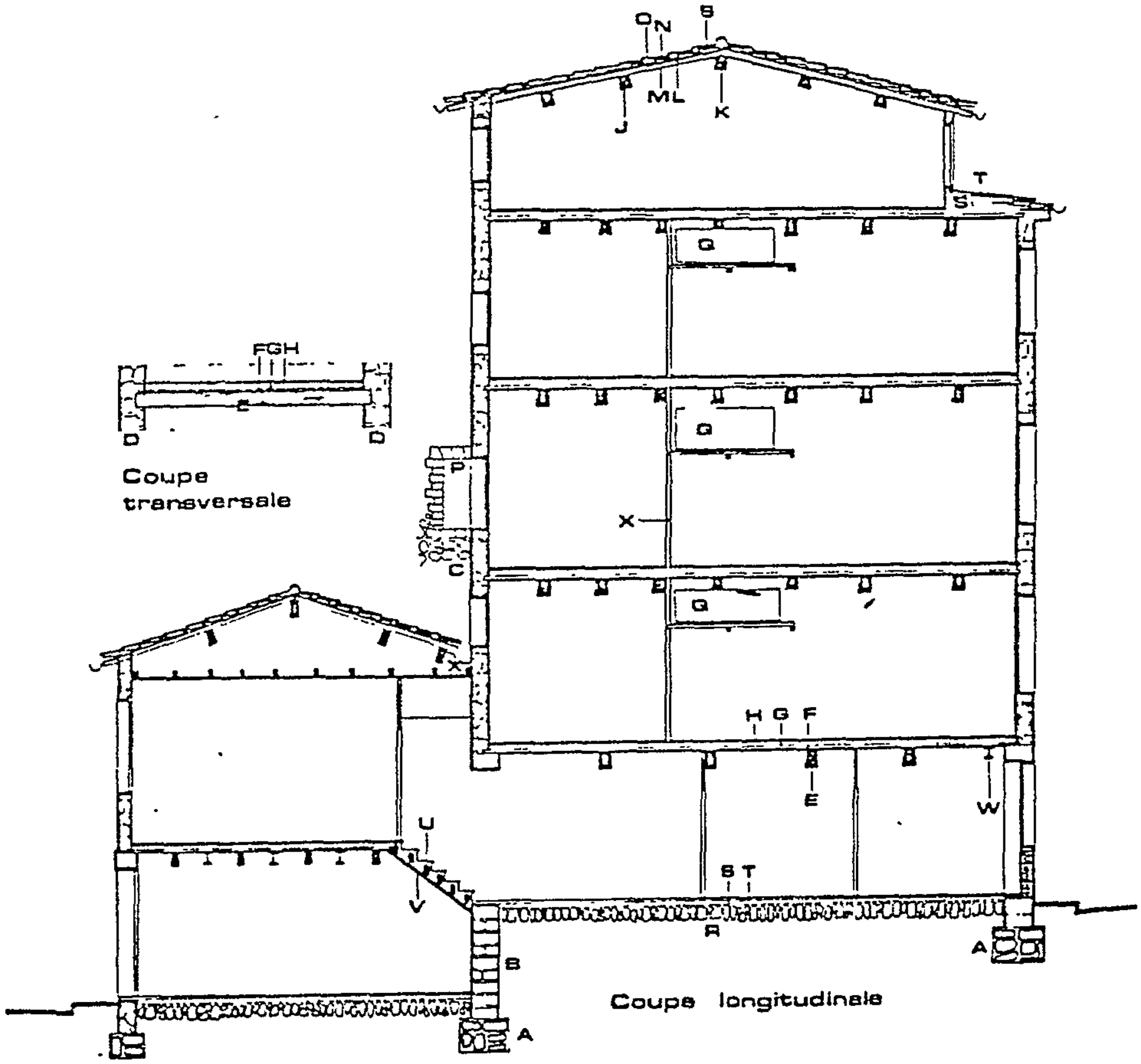


Figure 4. Groupe-type de deux immeubles historiques à Marseille.
Coupes longitudinales et transversale.

7.4 ORGANISATION DES ACTIVITES DE LA PROTECTION CIVILE: LE CAS ITALIEN

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A. SISMICITE ET ORGANES DE CONTROLE EN ITALIE

Le chapitre 1 concernant la vulnérabilité sismique du territoire national traite tout d'abord des aspects généraux pour procéder ensuite à une description des dommages occasionnés par les séismes et des organismes chargés de la surveillance de la sismicité.

Les facteurs de vulnérabilité des zones métropolitaines des centres historiques, des systèmes d'établissements ruraux et de villes comme Naples et Pozzuoli sont pris en considération.

a. Vulnérabilité du territoire italien

La fragilité des systèmes territoriaux est notamment illustrée par les événements sismiques des dix dernières années.

Le rapport rappelle tout d'abord qu'au cours des deux derniers millénaires l'Italie a enregistré 160 tremblements de terre de forte intensité qui ont fait jusqu'à 500.000 morts.

Les tremblements de terre de 1976 et de 1980 ont causé respectivement 1.000 et 3.000 morts et coûté plus de 5.000 milliards de lires pour les seules opérations d'urgence.

Le haut niveau de vulnérabilité des systèmes des anciens centres urbains est souvent associé à de mauvaises pratiques en matière de construction : une enquête menée dans une commune à forte sismicité de l'Italie du Sud a mis en évidence après un tremblement de terre destructeur qu'un échantillon d'édifices en béton armé avait enregistré des écroulements correspondant à 47% du volume bâti, alors que 19% restaient indemnes.

b. Surveillance de la sismicité

Le territoire italien est doté d'organismes de surveillance des événements sismiques, qui opèrent en liaison avec les structures de la protection civile. A l'heure actuelle, la situation peut être considérée comme satisfaisante.

L'Institut national de géophysique gère, entre autres, un réseau sismique comprenant plus de 50 stations de télétransmission, avec élaboration centrale en temps réel des paramètres les plus importants de l'événement en cours, de la première estimation des dégats prévus de l'évolution probable du phénomène. Ce service fonctionne en permanence 24 heures sur 24. L'Institut a pu avoir recours à des financements de la protection civile, ce qui lui a permis d'occuper dans ce domaine, grâce à son réseau sismique, une position de pointe.

Un autre organisme qui collabore directement avec la protection civile est le Groupe national pour la défense contre les séismes du Conseil national des recherches. Il organise, coordonne et finance des études visant à la détermination et à la réduction du risque sismique. Les grands axes d'étude prévus concernent la subdivision en zones et le reclassement sismique, la prévention des dommages encourus par les édifices et la stratégie de réduction du risque.

Il y a en outre d'autres organisations scientifiques comme l'ENEL et l'ENEA, qui disposent d'un réseau accélérométrique, et le ministère des Travaux Publics comprend un service sismique qui s'occupe de l'établissement des normes techniques et du classement sismique.

B. EVOLUTION DE LA LEGISLATION; STRUCTURES INSTITUTIONNELLES, DESIGNATION DU MINISTRE ET CREATION DU DEPARTEMENT DE LA PROTECTION CIVILE

Le chapitre 2 concerne l'histoire et l'évolution de la protection civile en Italie vers un régime juridique stable. Les activités de l'Etat relatives à la protection civile remontent au tremblement de terre de Messine de 1908. Les dispositions législatives qui ont suivi ont réglementé d'une manière organique les activités de premier secours. La compétence relève du ministre des Travaux Publics, qui assume également la direction des opérations. D'autres lois engagent la responsabilité de plusieurs ministres, chacun d'eux selon ses attributions, mais les fonctions les plus importantes et délicates par leur caractère d'urgence reviennent toujours au ministre des Travaux Publics. Un Commissaire extraordinaire est également prévu. Replacé dans le contexte de cette période historique, on peut considérer que le dispositif en question était efficace ; il suffit de penser que dans une gare de Rome, un train chargé du matériel nécessaire aux premières opérations de secours était prêt à partir à tout moment, avec le moteur de sa locomotive allumé.

a. Historiques des institutions de la protection civile

La loi 996 de 1970 attribue compétence en la matière au ministère de l'Intérieur (Direction générale de la protection civile et des services contre les incendies) et aux préfets. Cette loi, comme les précédentes d'ailleurs, reflète une situation désormais périmée du fait de la création des régions dotées d'une autonomie administrative et du développement des organisations bénévoles. En fait, ces dix dernières années, la loi a surtout permis d'instituer le poste de Commissaire extrordinaire pour la gestion des situations critiques, ce qui a entraîné, presque automatiquement, la création du ministère de la Coordination de la protection civile. La loi de 1970 est encore en vigueur à l'heure actuelle.

b. Remarques sur la situation actuelle

Les opérations de secours, réparation et reconstruction à l'occasion des tremblements de terre d'Ancône, du Frioul, de Campanie et de Basilicate et du bradyséisme de la région des Champs Phlégréens pendant la période comprise entre 1972 et 1983 sont ensuite exposées en détail. A ces occasions, on a pu enregistrer la participation active du ministère de l'Intérieur, des régions, mais surtout des Commissaires extraordinaires et des ministres de la protection civile. Les aspects les plus important de cette forme institutionnelle concernent par exemple une évolution progressive des procédures vers des schémas souples de décision. Tout en restant dans le cadre de la loi 996, cela a été rendu possible grâce à l'attribution au Commissaire extrordinaire du pouvoir de prendre des arrêtés, pouvoir attribué également plus tard au ministre de la Protection Civile et qui, en permettant certaines dérogations, assure une efficacité immédiate. Lors de ces séismes "historiques", on a constaté que les lois ordinaires comme celle sur les habitations et sur l'aménagement du territoire restent le cadre fondamental pour les opérations de réparation et reconstruction ; que les normes techniques parasismiques ont dû par contre faire l'objet de révisions appropriées pour répondre aux situations critiques ; que le processus même de reclassement sismique a été réexaminé entièrement avec la contribution essentielle du CNR (Projet Visée Géodynamique). De cette manière une convergence progressive s'est dégagée entre planification ordinaire et planification d'urgence. Et c'est justement pour ces raisons que les interventions de la protection civile ont pu respecter certaines prescriptions géologiques et hygiéniques sanitaires, de même que la concession des travaux permet des délais bureaucratiques très réduits. Nous ne citerons à cet égard que quelques chiffres, d'ailleurs très révélateurs :

- parmi les interventions d'urgence et les programmes de reconstruction en Campanie et Basilicate au cours de ces années, on a eu recours à des financements représentant un montant d'environ 20.000 milliards de lires;

- à Monteruscielle (la nouvelle zone résidentielle de Pozzuoli), 4.000 logements ont été réalisés en moins de deux ans depuis la décision politique d'agir pour prévenir le danger de bradyséisme.

c. <u>Perspectives en matière de législation nouvelle</u>

Nous avons remarqué que la loi qui confie au ministère de l'Intérieur les fonctions de protection civile est encore en vigueur, mais il convient d'ajouter que le pouvoir exécutif tout d'abord et le Parlement ensuite ont dégagé de nouvelles voies vers une modernisation de la législation.

On a pu le vérifier en 1981 quand le Commissaire extraordinaire en Campanie et Basilicate, M. Zamberletti, a été nommé ministre de la Coordination et lorsqu'en 1982 le Parlement a approuvé la loi instituant un fonds à la disposition du nouveau ministère.

Il s'agit là d'un progrès dont on ne peut méconnaître l'importance et qui ouvre des domaines nouveaux à la protection civile en la faisant relever du système collégial du gouvernement coordonné par un ministre nommé à cet effet et gérer de concert avec les régions.

En même temps, au cours de ces années, les études du CNR, le réseau sismique et les normes techniques du ministère des Travaux Publics enregistrent des progrès décisifs. Le bénévolat aussi se développe. Les organisations bénévoles sont au nombre de 2.500 environ et couvrent divers domaines d'ordre sanitaire, technique/logistique, de vulgarisation et d'autres domaines. Quelque chose est donc en train de bouger dans notre pays, même si nous somme encore loin du million et plus de personnes bénévoles de l'Allemagne fédérale, des principes d'organisation des équipes yougoslaves de premiers secours, de la conscience civique de secteurs importants de la population japonaise qui prennent une part active aux exercices de protection civile, comme l'illustre un appendice du présent rapport.

Avant de procéder à l'examen des propositions opérationnelles dans le cadre des travaux de ce Congrès, il est opportun de fournir quelques indications sur la structure actuelle de la protection civile italienne.

Ce qui nous manque sans doute est un "service" national de protection civile qui puisse agir sur une base de routine pour tous les problèmes liés aux risques encourus sur le territoire.

Le projet de loi de la IXe législature, intitulé "Institution du Service national de la protection civile" est le résultat final de plusieurs contributions et propositions développées ces cinq dernières années, et il a été soumis à l'examen du Parlement. Ce projet - sans prévoir un ministère "ordinaire" - esquisse un service ayant des fonctions de coordination, capable d'assumer des fonctions de prévision des événements et de prévention et d'assurer les secours ainsi que la reprise de la vie économique et sociale des populations frappées par un séisme.

L'Etat s'acquitte de toutes les obligations de protection civile, mais en même temps sont affirmés le droit et le devoir de chaque citoyen et de chaque association à l'autoprotection. Il s'agit du droit fondamental qu'un individu a de défendre sa propre vie et ses biens et du devoir de chaque citoyen d'offrir sa propre contribution tant individuellement que collectivement dans le cadre des organisations bénévoles au profit de la communauté nationale en cas de nécessité, conformément aux prescriptions de la constitution du reste.

Les fonctions de coordination du ministre dans le respect de l'autonomie administrative des services publics centraux, régionaux et locaux, la coopération récemment instituée entre communauté scientifique et pouvoirs publics, l'introduction de fonctions tout à fait nouvelles de prévision et prévention des sinistres majeurs, la promotion du volontariat et la sensibilisation du public en matière de protection civile, sont les caractéristiques les plus importantes du futur service national.

Le projet de loi est sur le point d'être adopté par le parlement mais le sort réservé dans le passé à des lois de cet ordre ne doit pas inciter à trop d'optimisme. L'interêt porté à ces problèmes, qui heureusement reste vif dans notre pays, a cependant remédié à ces lenteurs tout en convainquant le gouvernement de créer, dans le cadre de la Présidence du conseil des ministres, un département de la protection civile placé sous la direction du ministre de tutelle.

d. <u>Structures du département de la protection civile</u>

Le département tel qu'il est organisé aujourd'hui peut être de toute façon considéré comme une anticipation partielle, fonctionnelle et opérationnelle, du futur service national.

Le département de la protection civile comprend le cabinet du ministre, le bureau législatif, le service des situations critiques, le service de coordination des activités de prévision et prévention, le service des travaux publics d'urgence et le service du bilan et des affaires administratives.

Pour le compte du ministre travaillent la <u>Commission technique</u> scientifique "Grands risques", le Comité opérationnel pour les situations critiques (EMERCOM) ainsi que des assistants et des conseillers.

Dans le cadre du service des situations critiques travaillent le Centre opérationnel aérien unifié (C.O.A.U.), le Centre opérationnel pour les situations critiques en mer (Procivilmare), le Centre d'application d'études informatiques (C.a.s.i.) et le Centre Situations (CE.SI.).

Le Service Prévision et Prévention comprend des bureaux spécialisés pour les différents risques :

PROCIVILSISMA pour le risque sismique
PROCIVILINDECO pour le risque industriel et écologique
PROCIVILMAGMA pour le risque volcanique
PROCIVILIDRO pour le risque hydrogéologique
PROCIVILFUOCO pour le risque résultant des incendies et des activités ménagères.

La Commission Grands Risques s'articule elle aussi autour des secteurs spécifiques aux différents risques. Dans ce cadre ont été pris également en considération le risque des transports et le risque nucléaire.

C. ADAPTATION DES ENTREPRISES, DES TECHNIQUES ET DES STRUCTURES PROFESSIONELLES

La thèse développée en conclusion du troisième chapitre concerne la nécessité d'une adaptation systématique des technologies, des entreprises et du cadre professionnel, afin d'élaborer les dispositifs de prévention et de mise en oeuvre des interventions d'urgence.

Pour l'étude de ces problèmes, le département est en train de créer un Comité de haute consultation technologique composé de représentants d'institutions nationales et des structures des entreprises les plus importantes de notre pays.

Au chapitre 3 on s'est efforcé - sur la base des éléments exposés au chapitre 2 - de souligner combien les procédures et les organes nécessaires au contrôle de la vulnérabilité du territoire urbanisé et rural doivent être considérés comme de mieux en mieux intégrés aux techniques courantes de gestion et d'aménagement du territoire : le souci de la sécurité de la vie civile a un rôle et une portée de plus en plus spécifiques comparables à ceux qui, au cours des siècles passés, justifiaient la construction d'ouvrages défensifs contre les invasions.

L'importance d'une réorganisation des entreprises et d'une adaptation technologique ressort des expériences faites au cours des dernières années par les structures opérationnelles du département ; ces expériences répondent essentiellement aux types de situation suivants :

- catastrophes sismiques majeures comme celle de Campanie/Basilicate (1980);

- situations créées par l'interférence progressive de phénomènes sismiques qui se répètent dans un contexte urbain rendu vulnérable par l'encombrement des services et infrastructures (bradyséisme et séisme de dimension moyenne à Pozzuoli et dans l'aire métropolitaine de Naples).

a. Technologies visant à assurer la défense et l'équipement du territoire aux phases de prévention

Pour mener une politique d'innovation, de prévention des établissements et de gestion des situations critiques, il est nécessaire de développer le concept de vulnérabilité, en le reliant globalement aux systèmes territoriaux, entendus au sens de structures intégrées et complexes ; les programmes de prévention revêtent donc le caractère de vastes opérations d'équipement du territoire. Ceci demande évidemment de la part des responsables de la gestion des situations critiques une base de données qui doit être constamment tenue à jour.

Pour coordonner ces fonctions, le centre opérationnel du ministère de la Protection Civile a commencé à mettre en place un système informatique ; mais sur le plan opérationnel, il convient, de toute évidence, d'instaurer des systèmes couvrant l'ensemble du territoire national. D'où l'idée d'aménager, de concert avec les services administratifs périphériques et avec les organisations bénévoles, un système de "centres de défense équipés", situés à proximité des barycentres de zones présentant des caractéristiques de vulnérabilité et de risque potentiel homogènes, en vue de :

(a) la mise en place et la gestion des réseaux de surveillance;

(b) la formation du personnel et l'établissement de "scénarios" servant à effectuer périodiquement des exercices pratiques ;

(c) l'organisation de dispositifs de contrôle opérationnels coordonnés avec le centre opérationnel du ministère de la Protection Civile et l'amorce des procédures de préavis et alerte en fonction de "seuils de mise en garde" préétablis;

(d) la gestion des équipements et la coordination locale des activités d'assistance en cas de situation critique.

Mais outre la surveillance, le contrôle et l'alerte, les fonctions d'un "centre de défense" comprennent également la mise en place et la gestion de systèmes d'équipements répartis selon les nécessités et le degré d'exposition au risque des différentes zones.

Les organes techniques du département pourront effectuer - grâce au système informatique - le calcul des besoins en équipements à fournir aux différents "centres de défense ou garnisons", en prévoyant également les fluctuations temporelles.

La structure des "centres de défense ou garnisons" devient l'élément vecteur et essentiel pour mettre en oeuvre une stratégie de prévention du territoire national. Il s'ensuit donc qu'il incombe d'amorcer et de coordonner une ample gamme d'initiatives importantes de la part des chefs d'entreprise afin :

- de fournir et renouveler périodiquement le matériel (depuis les résidences et services d'urgence jusqu'aux équipements mécaniques ou aux services de haute technologie, communication, assistance sanitaire etc.);
- d'assurer l'entretien ordinaire et le dépannage (assistance mécanique, stockage, pièces de rechange, peinture, ameublement);
- d'écouler (notamment par la vente à des particuliers ou à des organismes italiens et étrangers) les "surplus" éventuels d'équipements à remplacer;
- de rassembler et répartir les équipements provenant de fournisseurs nationaux ou étrangers à l'occasion de situations critiques ou d'opération de renouvellement des stocks.

Toujours dans le domaine de la mise à jour technologique et de l'adaptation des entreprises, il faut remarquer que les réseaux des centres de défense sont reliés aux systèmes de communication centrale ; du point de vue de l'équipement, outre les moyens conventionnels (voitures-radio, télégraphes etc.), il faudra prévoir l'emploi étendu de techniques permettant l'utilisation de réseaux nationaux de télévision et de réseaux privés reliés avec les réseaux téléphoniques (relais territoriaux pour les systèmes du type VIDEO TEL VIDEOTEX etc.).

b. Techniques de prévision, de formation des opérateurs, de vulgarisation et de sensibilisatiion du public en matière de séismes

1. Les modèles de prévision:

L'élaboration des données concernant la sismicité, les caractéristiques géodynamiques des établissements, les infrastructures, la composition sociale des populations - données intégrées dans le système informatique du département - a permis de dresser des cartes du risque et de mettre au point des modèles de prévision des dommages qui sont utiles pour :

- évaluer ou vérifier la cohérence des données relatives aux dommages survenus pendant des événements que l'on a pu effectivement constater, de manière à corriger et rectifier l'information toujours confuse provenant des zones frappées par un séisme;

- établir des programmes d'intervention et mettre en place des moyens d'intervention adéquats et conformes aux besoins prévisibles dans les zones à plus fort risque.

Les appendices au présent document indiquent les données relatives aux estimations de dommage effectuées récemment à l'occasion de l'organisation des interventions d'assistance aux populations frappées par deux séismes de magnitude moyenne et faible, qui ont eu lieu en avril et mai 1984 en Ombrie et dans les Abruzzes. Des modèles, mis au point d'après les prévisions d'événements sismiques plus importants (par ex. zone de Calabre méridionale - Sicile orientale), sont en cours de préparation.

2. Les exercices:

Aux cours des dernières années, les ministres compétents dans ce domaine (Protection Civile, Intérieur, Défense) ont programmé et effectué des exercices de protection civile pour tester les dispositifs, le degré d'efficacité des divers services, le rendement des technologies nouvelles, l'état de préparation technique et administrative des cadres supérieurs, la capacité de coopération entre les diverses institutions, dans l'optique la plus large possible et avec la conscience que dans l'exercice tout comme pendant le sinistre réel on teste d'une manière incontestable un nouveau mode de gestion de la protection civile.

Mais aussi les occasions offertes par les sinistres récents d'ampleur restreinte ont été utiles pour tester l'efficacité des services et la réponse des populations.

Le cas du tremblement de terre de Garfagnana (Toscane, 1985) qui s'est avéré comporter des caractéristiques considérées par les experts comme potentiellement prémonitoires d'un événement plus grave a donc servi à expérimenter des procédures d'évacuation et des techniques de préparation des systèmes d'urgence.

3. Formation et activités de vulgarisation

Le Groupe Tremblements de Terre (GNDT) du CNR a également parmi ses buts celui de promouvoir et de coordonner des activités de recherche sur l'enseignement et l'information en matière de séismes.

Par exemple, voici quelques années, il a été financé la préparation d'un cours de formation pédagogique qui a été suivie de sa réalisation concrète. Le cours a été réalisé par l'Institut pour les techniques pédagogiques du CNR avec la contribution de sismologues et géologues du Groupe national pour la défense des tremblements de terre. Il se compose de brochures, d'un manuel récapitulatif, de diapositives et de vidéocassettes. Un premier essai a porté sur environ 10.000 élèves de 3 régions et le résultat a montré que ceux-ci ont beaucoup apprécié l'expérience et que les professeurs l'ont trouvée aisée à réaliser.

Il s'agit en même temps d'un véritable cycle de leçons, donc d'une méthode traditionnelle et d'une série d'animations qui pourraient être aussi bien utilisées par les mass media. Le matériel de ce cours est en vente libre depuis 1984.

En ce qui concerne la défense civile, la défense individuelle et les comportements de groupe dans le cas de sinistres, les règles de comportement élaborées par le GNDT et indiquées aux appendices du présent rapport sont tirées - avec des modifications adéquates imposées par les conditions différentes de la réalité italienne - des normes adoptées en d'autres pays, tels que les USA, l'Allemagne fédérale, le Japon et la Yougoslavie.

La diffusion des normes de comportement ne nécessite pas d'études et de projets particuliers ni même l'intervention de structures nouvelles pour les répandre et les vulgariser ; elle relève seulement de l'administration courante ; en effet, elle ne demande qu'un financement modeste : cependant, on peut affirmer en général que, bien que l'Italie ait de lourds antécédents sismiques, il n'y existe pas encore de mécanismes courants ou d'initiatives de sensibilisation et d'information efficaces du public.

c. Hypothèses opérationnelles pour la réduction de la vulnérabilité des habitats italiens

Pour répondre à une demande de prévention sismique qui ne cesse d'augmenter dans le pays, le Groupe Séismes du CNR a mené des enquêtes en collaboration avec le département de la protection civile, saisissant l'occasion précieuse offerte par les régions de Toscane, d'Emilie-Romagne et par d'autres régions qui ont amorcé, de concert avec le GNDT, des programmes d'évaluation de la vulnérabilité des systèmes urbains. Les premières études ont montré la nécessité d'interventions pour l'adaptation aux normes parasismiques des édifices situés dans des zones à fort risque. Des hypothèses d'intervention ont été formulées pour tout le territoire national (20 millions de personnes exposées au risque) et pour quelques zones particulières : Sicile orientale, Calabre, Garfagnana (4,5 millions de personnes exposées).

Les interventions dans tout le pays et sur l'ensemble des bâtiments, prévues sur un délai de 10 ans pour le secteur privé et de 5 ans pour le secteur public et productif, coûteraient environ 20.000 milliards de lires par an, soit un million de lires par personne.

Les interventions sur les bâtiments et les établissements de propriété domaniale ou publique privilégient cependant les édifices d'importance stratégique, ceux qui "doivent" rester debout pendant un séisme : les préfectures, les mairies, les casernes, les hôpitaux, les écoles etc.

Pour le secteur privé, on devrait prévoir des subsides de l'Etat pour les usagers concernés, sur la base des lois relatives aux logements subventionnés. Il est évident que l'initiative à l'égard des particuliers est étroitement liée à la sensibilisation du public aux problèmes en jeu, celle qui devrait l'inciter à investir son argent dans le renforcement des logements.

d. Considérations sur l'ampleur et sur les problèmes d'organisation des activités de rétablissement et reconstruction

(a) Phase de rétablissement. C'est la phase très délicate qui intervient au bout des 72 premières heures et se poursuit jusqu'à la fin des opérations de récupération fonctionnelle du système.

De la coordination correcte de cette phase dépendent l'efficacité des solutions logistiques, la fourniture des services essentiels et le rétablissement progressif des activités interrompues.

Les expériences récentes de rétablissement dans les zones frappées par le séisme de 1980 en Campanie et Basilicate prouvent qu'il est très important de procéder à l'exécution de plans préétablis qui mettent en jeu les autorités politiques, administratives et les entreprises concernées pour répondre aux besoins grâce à des procédures irréprochables au point de vue institutionnel et technique.

En l'absence d'un programme d'action et d'organes adéquats, les frais de gestion augmentent démesurément et la communauté nationale doit consentir des sacrifices énormes.

En Campanie et Basilicate, les services du Commmissaire extraordinaire ont dû faire face à un besoin de résidences temporaires (préfabriqués légers, containers) pour 40.000 habitants environ, auxquels il fallait ajouter les contributions (10 millions de lires par logement) accordées en vertu d'un arrêté de l'Etat, pour faire face aux frais de réparation des logements qui en étaient justiciables et à tous les frais d'équipement en infrastructures et services essentiels.

Il s'agit là d'engagements que l'administration publique doit respecter pour assurer au moins le redressement des fonctions essentielles à la vie de la collectivité : ce sont donc des coûts directs et il est bien évident qu'il faut absolument en contrôler le montant et la rentabilité.

(b) Reconstruction. Pendant les phases de restauration et de reconstruction, l'activité des organes responsables de la protection civile s'intègre dans les fonctions des organes administratifs responsables de la gestion ordinaire et dans celles des autres organismes de l'Etat.

Cependant, c'est justement pendant cette phase qu'il faut aborder quelques problèmes particulièrement importants en vue d'une réorganisation de la structure sociale et productive : en effet, les organes qui gèrent la phase de reconstruction ont pour tâche de mettre au point des stratégies pouvant associer les capacités intérieures et extérieures en vue du rétablissement de la production.

C'est alors que se pose la nécessité d'amorcer une politique judicieuse, tant pour rétablir les secteurs productifs stratégiques à l'échelon local ou "exportation" (pour employer un terme d'économie élémentaire) que pour favoriser la mobilité de la main d'oeuvre.

Par exemple, pour la mise en oeuvre des articles 21 et 32 sur le rétablissement des industries frappées par le séisme de 1980, l'investissement global des initiatives qui bénéficiaient de la contribution de l'Etat se montait à 1.750 milliards de lires, avec une contribution de 1.025 milliards (58%) et l'emploi de 7.960 employés, soit 220 millions de lires d'investissement par personne et 129 millions de lires de contribution par personne. Mais tout aussi importants sont la réorganisation et le renforcement des fonctions urbaines et de l'habitat. Par exemple, l'ensemble des interventions vise à assurer une redistribution de la population dans le territoire municipal prévu à la suite de la décision de créer le nouveau centre de Monteruscielle à Pozzuoli, par la création d'un nouvel ensemble résidentiel pour environ 90.000 habitants.

Le nouveau projet de loi prévoit le logement d'environ 37.000 habitants dans la commune de Monteruscielle, une réduction très importante du nombre des habitants au centre de Pozzuoli (8.000 contre 27.000 actuellement) et dans la zone de Solfatara (8.500 contre 10.300).

Sans vouloir aborder plus en détail le problème de la rentabilité de ces choix sur le plan urbanistique (à propos desquels un débat reste ouvert en Italie) nous tenons cependant à dire que l'exemple de Monteruscielle est très significatif quant à l'efficacité des procédures institutionnelles adoptées, l'ampleur et les conséquences de cette initiative.

D. HYPOTHESES EN VUE D'UNE ACTION A L'ECHELON MEDITERRANEEN

Si l'on décide d'attribuer au contrôle de la vulnérabilité des établissements le rôle de composante essentielle lors des processus courants d'aménagement, il convient tout d'abord d'amorcer un renouvellement progressif des méthodes de conception et de gestion des systèmes d'établissement. De ce point de vue, le processus d'adoption des choix opérationnels (surveillance, information, décision) doit devenir périodique et souple, conforme aux critères de la programmation continue.

Les aires géographiques liées aux facteurs de vulnérablité s'étendent bien au delà des territoires concernés : pour les sujets qui nous concernent, on a pu constater au cours des expériences évoquées au 3ème chapître que la suppression des conditions de risque sismique d'une zone déterminée dépend en grande partie de l'organisation de services et systèmes d'équipements ayant une portée interrégionale ou nationale.

Il s'agit là déjà d'une première raison incitant à identifer les domaines où peut s'opérer une action coordonnée entre les pays riverains de la Mediterranée ; en effet, si on considère les situations critiques entraînées par la pollution, la préparation de systèmes de surveillance de l'environnement, les critères de gestion des ressources physiques, et le déclenchement des plans d'urgence en cas de catastrophe sismique, il importe, de toute évidence, que les divers Etats prennent sans délai des initiatives.

L'autre raison justifiant l'instauration d'une collaboration entre les pays du Bassin méditerranéen tient à la demande sans cesse croissante en équipements et personnel pour faire face à des situations critiques.

C'est ainsi que s'est créé un marché dont la taille est devenue aujourd'hui importante. Par conséquent, il semble raisonnable de favoriser et de soutenir le développement de technologies et par conséquent d'entreprises (qui se caractérisent par leur articulation et leur importance économique) auxquelles il faudra confier la réalisation et l'octroi de services et équipements et la formation de cadres spécialisés.

Cette extension des activités de protection civile d'un niveau productif et professionnel élevé dépend de la possibilité de réaliser une harmonisation soigneuse :

- au point de vue politique, cette action devra être confiée, selon toute probabilité, à des organes relevant de plusieurs Etats à l'intérieur desquels on décidera la répartition des tâches en fonction de l'estimations de l'étude des capacités et spécialisations des secteurs de production de chacun des pays concernés;

- au point de vue scientifique et opérationnel, il sera nécessaire d'implanter des structures de recherche et d'étude pour mettre au point les "règles du jeu", à savoir des cahiers des charges définissant sans équivoque :

  (a) la conception fondamentale du système des "centres de défense ou garnisons";

  (b) les conditions techniques, les normes, les types de fournitures;

  (c) les modalités de distribution et de renouvellement des équipements;

  (d) les volumes de production;

  (e) les procédures financières, fiscales, douanières.

Il s'agit de thèmes qui ont servi de repères à plusieurs réunions d'experts et d'administrateurs des différents pays, mais qui n'ont été jamais développés systématiquement avec de véritables intentions opérationnelles. Il est cependant raisonable de penser que les conditions nécessaires pour amorcer des initiatives plus concrètes sont en train de mûrir.

7.5 LEGISLATION AND INSTITUTIONAL FRAMEWORK RELATIVE TO THE REDUCTION OF SEISMIC RISK IN TURKEY

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The planning system in Turkey can be reviewed on two planes, "Economic and Social" and "Physical", each corresponding to two levels of planning, namely national and local.

In this part of the report we give an overview of these components and provide a brief historical perspective so that the current approach to planning is appreciated more fully.

A. Economic and Social Development Planning in Turkey

The requirement for a rapid and balanced national development under a planned discipline was felt soon after the proclamation of the Republic in 1923. A strategic plan entitled "Economic and Social Programme" was initiated in 1930. This programme soon faced major difficulties and obstacles, and the situation was aggravated by insufficient capital accumulation. The State was forced to intervene in the economy in a dominant way. "The First Five-Year Industrial Plan" was initiated in 1934 and implemented with success. The next "Five-Year Industrial Plan" coincided with World War II and could not be put into effect. Instead, yearly development programmes were implemented. In the post-war years, the idea of centralized planned development gained popularity again and two plans, one written by Turkish experts and other by World Bank experts, were prepared during 1949-50. In 1950, political power changed hands and the new liberal economic outlook did not provide the necessary climate to put these plans into effect.

Comprehensive and multifaceted social development was given the appropriate framework by the new constitution of 1961; the State Planning Organization (SPO) established in 1961 quickly prepared a 5-year plan for 1963-67. Five-year plans have been regularly prepared and implemented ever since. These plans are legal briefs which enjoy mandatory powers for the public sector and are viewed as guidelines for the private sector.

The conceptual framework of planning at the national level is the promotion of all sectors of the economy in such a way as to be compatible with the social development of the society as a whole. However, the most distinctive characteristic of the national development plans in Turkey has always been their sectoral approach towards economic development. In other words, the plan models aim at securing an optimum distribution of resources among various sectors of the economy, disregarding the spatial dimension which would help ensure the social objective.

Regional Planning

The First National Development Plan (1963-67) defined regional planning as the level at which the reconciliation of economic goals with human welfare would be possible. Within this framework, regional planning was attributed the function of both determining the regional potential and facilitating an interregional comparison of economic sectors.

The Second Five-Year Development Plan (1968-72) further regarded regional planning as the instrument for the comparison and evaluation of projects that would be harmonized with regional studies to provide a spatial dimension to national development plans.

The responsibility for regional planning was entrusted to two organizations - the State Planning Organization (SPO) and The Ministry of Reconstruction and Resettlement. During this period, either separately or in collaboration, these institutions conducted studies of a number of regions. However, neither of these sets of plans has been implemented. This was due to the fact that regional planning lacked the operational tools and legal basis for implementation. The lack of a corresponding level of management for regional planning was also responsible for this state of affairs. In recent years, regional planning has been discarded from Turkish planning terminology, to be replaced by "regional development" which implies a less comprehensive approach, conceived as planning for priority areas. Nevertheless, the concept of regional planning reappears in the fifth Five-Year Development Plan (1985-89), introducing the drafting of "regional development schemes" which depend on regional potentials, and which will determine the appropriate areas for the location of different sectoral developments.

B. Physical Planning

The need for a national physical planning in Turkey was first spelled out at the end of the 1960's. National Physical Planning is defined as the level at which decisions can be taken relating to location and timing of investments, the total capacities of which are determined by the economic development plans.

Preliminary studies for a national physical planning had been initiated within the Ministry of Reconstruction and Resettlement. However, the idea was later abandoned due to the immense scale and cost of the project, as well as the difficulties encountered in the gathering of adequate meaningful data.

In Turkey, physical planning of urban or regional settlements dates back to the second half of the 19th century. Possibly the first legal document promulgated in this connection is the "Building Regulation" of 1848.

Recent Legislative Changes

In Turkey the 1970's witnessed a strong anticipation of decentralization of decision making powers, maximum opportunities for public participation, better involvement in local matters and effectiveness and efficiency of the government machinery as a whole.

In fact, although local authorities were given diversified responsibilities such as the provision and operation of urban services, implementation of physical plans and development control, the decision making powers were exercised mainly by the central authority through the approval of physical plans, development regulations and programmes and finally through financial instruments.

The shortcomings of such a system have been increasingly felt over the years as the rate of urbanization accelerated and Turky reached the 1980's with half of its population living in urban areas. The centralized planning system meant that the competent Ministry had to cope with an unmanageable daily workload. Almost 20,000 proposals for plan amendments had to be investigated annually. Furthermore, the centralized system allowed for little initiative on the part of local authorities, inevitably impairing the development of local administrative mechanisms.

The first step taken towards the decentralization of decision making powers was to strengthen the financial viability of local authorities through a new legislation on municipal finance enacted in 1981. Through later amendments to this law, the contribution to municipalities from the national budget increased to 10 percent. The municipalities also enjoy flexibility in determining the tariffs of local taxes, since now the central government imposes only upper and lower limits. The most recent development on local finance is the transfer of property taxes hitherto collected by the central government to local authorities.

The second action towards decentralization was the establishment of metropolitan authorities in three major cities and transfer of decision-making powers in physical planning to these authorities. The new administration with the additional funds supplied by the new Act aims at providing supervision and coordination of functions. The effect of this transcends the boundaries of the individual municipalites within the metropolitan area. This was followed by the delegation of physical planning powers to all local authorities in 1985, through the new legislation on settlement planning.

Concomitantly, a similar reorganization scheme has been put into effect within the central government. Following the decentralization process, the functions of the central authority were redefined and reorganization of the present administrative structure to increase efficiency through merging of different institutions carrying out the same or related functions and thus improving coordination and minizing the bureacratic steps, was undertaken. Within this framework, the Ministry of Reconstruction and Resettlement was merged with the Ministry of Public Works to form a new Ministry to be named the Ministry of Public Works and Settlement. The setting of national guidelines, research for planning standards and helping train municipal staff are some of the duties of this new Ministry.

Current Legislation on Physical Planning

The Settlement Planning Act and regulations are the most important legal documents on physical planning in Turkey.

The main features of the new Act which was put into effect in November 1985 can be summarized as follows:

1. Settlement plans are classified as regional plans and urban development plans. Urban development plans are designed at two stages as Master Plans and Implementation (detailed) plans.

2. Regional plans will be prepared by the State Planning Organization, if necessary.

3. Settlements with a population of over 10,000 must have an urban development plan consistent with the regional plan, if one exists.

4. Urban development plans can be prepared by the competent local authority either directly or through tendering or it can be prepared or be tendered out by the Bank of Provinces if authorized by the competent local authority.

   Planners are classified according to a set of criteria. The Ministry is responsible for the issuing of planning licenses to individual planners.

5. The base maps on which the plans are drafted are approved by municipalities or provincial authorities depending on whether the area mapped is inside or outside municipal boundaries.

6. The physical plans of settlements within municipal boundaries are ratified by the municipalites concerned; for settlements outside municipal boundaries the relevant organization for ratification is the provincial authorities.

7. Minimum space requirements for social and technical infrastructure as well as design norms are specified and all plans have to conform to these standards.

8. The Ministry of Public Works and Settlement retains the prerogative of preparing and ratifying plans relating to:

   - Public buildings, disasters, collective housing and implementation in compliance with the Law on Squatter Housing.

   - Settlements where more than one local authority exist.

9. Development programmes prepared for a 5-year period and in conformity with ratified physical plans are approved by the local authorities concerned.

10. Municipalities are eligible to receive credits for some of the technical and social infrastructure projects.

11. Parcellation plans prepared prior to implementation of the plan are approved by the local authority concerned.

12. All buildings with the exception of those which comply with the provisions of a valid urban development plan and have less than 1,000 m^2 of construction area and are not higher than two storeys are subject to construction permits issued by either the relevant municipality or provincial authority or by a private architecture and engineering office the establishment and operation conditions of which are determined by the Ministry of Public Works and Settlement.

13. All buildings are subject to occupation permits issued by the above mentioned bodies.

    Nine regulations have been prepared by The Ministry of Public Works and Settlement in 1985. These regulations are as follows:

a. Regulation for the Principles of Licensing of Responsible Persons or Establishments which Will Undertake Preparation of Current Maps and Application of Work for Delineation of Land Boundaries and Parcel Outlines.

b. Regulation for Determining the Competence of Persons or Establishments which Will Prepare Construction Plans.

c. Regulation for Principles of Preparation of Construction Plans and Their Modification.

d. Construction Regulation for Use within Areas without Plans Inside or Contiguous to Municipal Limits.

e. Regulation for Principles of Land and Parcel Boundary Delineations to be Worked out in Accordance with Article 18 of Construction Act No. 3194.

f. Regulation for Certified Private Architecture/Engineering Bureaus in Conformity with Construction Act No. 3194.

g. Regulation Concerning the Authority, Duty and Responsibility of Technical Persons other than Engineers, Architects and City Planners Enumerated in Article No. 38 of the Construction ACt.

h. Standardized Construction Regulation for Municipalities Outside the Scope of Act No. 3030 Concerning the Establishment, Duty and Responsibility of Metropolitan Municipalities.

i. Carpark Regulation

This brief review of the Construction Act clearly displays the distance taken from a highly centralized structure towards a more local one. In fact, the integration of planning and implementation powers within the local authority can be considered as a major step towards the fulfillment of the need of residents. On the other hand, the inclusion of specific guidelines in the Act reflects the concern for a harmonized course of action over the whole country; it is also a compensatory mechanism for the lack of prior experience and trained staff of local authorities in this field.

C. Legislation on Environmental Protection

One of the primary objectives of balanced economic and social planning is to ahcieve a high total production and corresponding increase in the standard of living, while creating conditions in which the social values and culture of a society can be best expressed. The achievement of this dual objective, however, depends on the national location of the different means of production, consumption and services in an efficient, healthy, comfortable and pleasing environment. Physical planning consequently involves the development and change of the physical environment so as to permit the proposed economic and social development to take place.

Environmental Healtn Protection

The earliest legislation on environmental protection in Turkey is the Law on Environmental Health dated 1930.

This Law classifies industries in terms of the negative effect they may exert on human health and imposes environmental protection zones of varying dimensions around them.

The same legislation also envisages protection belts around sources of drinking water. To the same effect, a protocol was signed in 1976 between the Ministry of Health and Social Welfare, General Directorate of State Hydraulic Works and the Ministry of Reconstruction and Resettlement. The protocol established four levels of protection zones: absolute (0-300 m.), short (300 m-1 km.), medium (1-2 km) and long-range zones (the catchment area of the water source). Within these protection areas, varying degrees of control are exercised raning from total prohibition of activities to the control of waste by-products.

The most recent and comprehensive legislation on environmental proection is the Environment Act, dated 1983. The main principles of the Act are as follows:

1. The "polluter pays" principle is adopted.

2. Preventive rather than curative approach is essential. Thus, environmental protection should in the first place be secured through national land-use decisions.

3. To avoid or mitigate environmental pollution, the most appropriate technology will be adopted in economic activities.

4. Measures related to environmental protection will be evaluated in terms of their effect both in the short and long-run on human health and economic development.

5. All institutions and firms, the planned activities of which may cause environmental problems, have to prepare an Environmental Impact Analysis Report, specifying the measures that will be taken to alleviate the harmful effect of wastes and residuals.

6. Establishment and operation permits will not be issued to those firms which have not individually or collectively established waste treatment systems.

The Environment Act established a "Supreme Commission" at the national level and "Local Commissions" at the provincial level. The Commissions are entrusted with developing programmes for environmental protection. The Act, however, is not in full operation, since the related environmental standards that it depends on are not specified yet.

Protection of the Natural Environment

Another aspect of environmental protection is the preservation of natural property. The National Parks Act of 1983 identifies four devices for the conservation, development and management of areas which have esthetic and scientific value. These devices are as follows:

1. National Parks are those segments of land with natural and cultural value at the national and international scale, and a high recreational potential.

2. Natural Parks are those pieces of land which at the national and regional scale have rare characteristics in terms of vegetation and wild life.

3. Natural Monuments are those pieces of land which have special characteristics caused by natural phenomena.

4. Conservation Zones are those which have vanishing ecosystems and wildlife species.

In all the above mentioned areas, activities which may impair the natural and ecological balance and the ecocystem are either restricted or totally prohibited.

D. Protection of Cultural and Historic Monuments, Ancient Settlements and Other Man-Made Values

It is widely accepted that structures which display the social, economic and cultural status of communities should be transferred to future generations. The conservation and maintenance of historic and cultural entities has long been a special concern in Turkey. The earliest attempts of preservation of such wealth date back to the early years of the Republic, when a commission was formed to develop policies and measures for the preservation of works of art in the country. The Commission identified 3,500 monuments between the years 1933-35 and prepared reports for their restoration. As part of these activities, the museums and the foundations were reorganized in 1934 and 1935 respectively.

In 1944, an Advisory Commission on Antiquities and Museums was established to conduct studies on the subject. In order to solve the problems caused by the high rate of urbanization in the 1950's, the Supreme Council of Antiquities and Monuments was established in 1951. However, until the enactment of the Reconstruction Act in 1956, preservation was carried out on the scale of individual monuments. The Reconstruction Act facilitated preservation both at the monument and settlement scale. The concept of Natural/Archeological/Urban Sites introduced by the Law of Antiquities, enacted in 1973, further stressed the preservation of towns or quarters as a whole.

The most recent legislation in this field is the "Preservation of Cultural and Natural Entities Act" enacted in 1983 which replaced the previous act of 1973. According to both of these documents the first step of preservation is the identification studies carried out by the Ministry of Culture and Tourism with the cooperation of universities and other competent public bodies. The objects identified are then registered by the Supreme Council on Cultural and Natural Entities. The Regional Councils on Cultural and Natural Entities also established by the Act of 1983 are responsible for the delineation of preservation zones which will secure the maintenance of these objects in harmony with their immediate environment.

The Regional Council also determines the level and types of construction activities that can be permitted within the prevention zones. The owners of structures registered in conformity with the provisions of this law are eligible for credits and technical aid for the maintenance and restoration of their buildings. On the other hand, the designation of an area as a "Site" by the Supreme Council terminates the implementation of the existing physical plan of that area. The Supreme Court, within 3 months following this decision, has to determine the conditions according to which construction activities can be carried out during a maximum transition period of 2 years. A new preservation plan should be prepared within this period, as an integral part of the physical plan of the settlement concerned as whole.

E. Legislation on Seismic Loss Reduction in Turkey

Background

Available historical information tells us that since the beginning of written history, Anatolia has witnessed major earthquake disasters causing the relocation of important centres of habitation or, as in the case of Hierapolis near Denizli, their total abandonment. In retrospect, relocation or resettlement of large populations must have been governed by decrees or other regulating decisions taken by whichever authorities governed at that time.

A sustained chain of disastrous earthquakes occured between 1939-44 starting with the 26 December 1939 event in Erzincan (M_s=8.0). With an average period of 7 months between events, major earthquakes in Niksar-Erbaa (M_s=7.2), Adapazari-Hendek (M_s=6.8), Tosya-Ladik (M_s=7.5) and Bolu-Gerede (M_s=7.4) killed 43,319 persons, injured 75,000 others, and destroyed 200,000 homes. This astonishing sequence had the sobering influence on governments of making it evident that rebuilding collapsed houses did not constitute an adequate form of battling earthquake losses. It was realized that legal and physical preparedness was the essential ingredient in this matter and a law entitled "Measures to be taken prior to and after ground tremors" was passed on 22 July 1944.

The 1944 law covered earthquakes only. During the 1955-1958 period other disasters such as floods and landslides took a heavy toll of property in the country, and it became clear that a more comprehensive law was required. The "Civil Defence Law" was promulgated in 1958, and with it civil defence teams responsible for rescue and relief on the scale of the entire country were established. This law was complemented in 1959 with the promulgation of a more comprehensive legislation entitled "Measures and Assistance to be put into effect regarding Natural Disasters Affecting the Life of the General Public" which superseded the 1944 Act. This Law, No. 7269, henceforth referred to as the "Disaster Law", is still in effect. A descriptive translation is provided in Appendix B.

As the title implies, other forms of natural disasters such as floods, landslides, avalanches, rockfalls as well as man-made occurrences are covered. A new feature of this law is that permanent resettlement is now a responsibility of the state, and clear guidelines are defined for terms and conditions of assistance to be implemented regarding affected persons. Article 5 of the law foresees the establishment of "Research Institutes" affiliated with the Ministry of Reconstruction and Resettlement (coalesced in 1983 with the Ministry of Public Works to be renamed the Ministry of Public Works and Settlement) so that the hazards of earthquakes and other disasters are abated by identifying counter-measures on a national scale, determining the basic policy, and coordinating scientific, technical and administrative works. The institute would also be responsible for converting scientific and technological developments into legislation, regulation, bylaw, or code format and for providing training. The "Earthquake Research Institute" was created in 1970 as a consequence of this article.

Another novel feature of the law was the creation of a "Disaster Fund" in addition to the component within the general State budget in order to underwrite the hazard reduction activities before and after the natural events. Expenditures from the fund can easily be allocated.

A major revision of the law was made in 1968 when 7 additional articles were inserted in the text for clarification purposes. In 1971 significant new funds were made available to the Disaster Fund when a part of the revenues obtained from the sale of alcoholic beverages and tobacco were channelled into it. This way, with or without the actual occurrence of a natural disaster, there is always the financial means of meeting expenditures required for contingency planning, rescue and relief, temporary shelter and permanent rehabilitation.

A number of statutes or regulations have been enacted to assist in the implementation of Act No. 7269. These are continually reviewed and updated so that current requirements can be met. Their titles are:

1. Regulations for Procedures of Expenditures from the Disaster Fund.

2. Criteria to be used in identifying individuals to be assisted.

3. Reduction of the cost of buildings or the sum of indebtment of affected persons.

4. Emergency aid organization and programmes related to natural disasters.

5. Regulation for construction in disaster areas.

Act No. 7269 provides regulatory requirements and coordination between the central and the provincial governments. These are elaborated further in affiliated regulations, statutes and instructions. Still, certain deficiencies were noted during the earthquake in the Erzurum area on 30 October 1983. In response, a "State of Emergency Law" was put into effect in 1984 with two regulations that bear directly on its implementation:

1. Establishment, Duties and Responsibilities of the Council and Bureaus for State Emergency; Determination and Disbursement of Payments to Deserving Parties.

2. Directive Regarding the Principles to be Implemented when a State of Emergency is Declared because of Natural Disasters.

The above historical perspective describes the legislative action for the mitigation of damage from earthquakes and other natural disasters. We have not touched upon other laws and regulations concerning civil defence and tax incentives, for example, because they have no direct bearing on the subject.

Current Legislation on Seismic Loss Reduction

Legislation on Building Construction, Control and Materials

The principal items of legislation on building construction, control of such construction and construction materials have been based on codes, regulations and standards required by Law no. 7269 on Natural Disasters and Law no. 3194 on Construction, which were referred to in Part I. In Appendix C we give a list of the titles of all standards pertaining to some aspect of building construction.

The map of seismic areas currently in effect describes 92 percent of the country's land area as exposed to some level of earthquake hazard. This means that all construction in these areas must conform to the Code. Control of conformity is delegated to municipalites (where they exist) or to the offices of the governors. The procedure for control has been described in the parent laws and in the regulations thereto. Accordingly, any individual who wishes to construct a new building or to renovate an existing one within a municipality or "contiguous" areas must engage an architect/engineer to draw up the design blueprints and get a construction permit. After the Engineer's Office of the municipality approves them, it is a legal requirement that such designs be prepared by engineers or architects. During the control and approval phases, it is the responsibility of the municipality to ensure that the proposal conforms to the city's construction plan and other special regulations. For construction to begin after the permit has been issued, the municipality should be informed of the identity of the engineer who will supervise the construction and will be responsible for its architectural, structural and material qualities. This engineer is charged with informing the municipality of any defects in construction under his supervision. An occupancy permit must be received after the completion of the building when it is inspected. Gas, water and electricity may then be supplied to the building. All forms of construction completed without a permit or which do not conform to the architectural and structural drawings or to the earthquake code shall not be issued occupancy permits, and shall in fact be demolished if the deficiencies can not be removed. The new Construction Law No. 3194 which went into effect in 1985 does not in fact require a building permit for buildings of 2 storeys or less with floor area not more than 1000 m^2 but conformity to the earthquake code is still required. The functions of municipalities are assured by the governors in areas outside the boundaries of municipalities.

Requirements for design and construction of all types of buildings and their materials are prepared by the Turkish Standards Institute with recommendations submitted by the Ministry of Public Works and Settlement, the Ministry of Industry and Trade and the appropriate professional bodies. Mandatory standards are promulgated in the Official Gazette. In Appendix C, mandatory standards are shown with an asterisc. In all cases the Earthquake Code requirements supersede standards in case of discrepancy.

Legislation on Contingency Planning and Preparedness

The Natural Disaster Law No. 7269 summarized in Appendix B and the regulations attendant to it contain protective and preventive measures as well as activities to be undertaken during and after natural disasters. Article 4 of the law and a regulation entitled "Emergency Aid Organization and Programme Related to Natural Disasters" contain detailed descriptions on how governors, offices or ministries will plan and organize during earthquakes, their responsibilities, powers and means of coordination. The same article makes it mandatory that every province shall prepare a "Provincial Rescue and Relief Plan" and provide prior training and preparatory work as well as exercise it when the need arises. Experience has indicated that even with the most perfect legislation there is often a lack of coordination and communication between the central government and the provincial authority. This fact was evident once again during the 30 October 1983 earthquake near Erzurum, and the "State of Emergency Law" was promulgated in 1984 as a response to it.

Both Laws No. 7269 on Natural Disasters, and 2985 on State of Emergency give extraordinary powers to provincial governors in case of natural disasters. For these powers to be exercised, however, it is a constitutional requirement that the Council of Ministers convene under the chairmanship of the president, and declare the state of emergency in a region or the whole country. This period may not exceed 6 months.

When a state of emergency is declared following a natural disaster, a "Coordination Council for a State of Emergency" is constituted under the chairmanship of a minister of state. Members of this council are the deputy Ministers of the Interior, Public Works and Settlement, Justice, National Defence, Foreign Affairs, Finance and Customs, Communications, Labour and Social Security, Health and Social Welfare, Agriculture, Forestry and Rural Affairs, Industry and Trade, Energy and Natural Resources, the President of the Red Crescent Society and the Secretary General of the National Security Council. Functions of the Council are to issue government-level directives. Execution of these directives is left to a "State of Emergency Sub-Commission" chaired by one of the assistant deputy ministers of Public Works and Settlement and attended by a director general level employee from the organizations listed. The Sub-Commission serves as the executive arm of the Council, and also as the link between "Provincial State of Emergency Bureaus" and the Government. The following groups constitute the provincial bureaus:

1. Communication and transportation services

2. Services of preliminary hazard assessment, temporary shelter, distribution of food and other requisites

3. First aid and health services

4. Relief and debris removal services

5. Security services

6. Electricity, water and sanitation services

7. Impoundment, rent or procurement services

8. Agriculture, animal husbandry and rural services

9. Red Crescent Society.

The personnel for these groups is borrowed from the provincial offices of the ministsries, municipalities and even the armed forces. A similar organization is put into effect in smaller townships under the chairmanship of the local appointed administrators. Training and equipping of these groups fall under the responsibility of the Ministry of Public Works and Settlement, the Ministry of the Interior and the General Directorate of Civil Defence.

In practice, all expenditures for emergency aid, rescue and relief, temporary shelter and the like are met from the "Disaster Fund" established by Law No. 7269. Sums requested by provincial governors are made available to them immediately.

When families lose their only homes as a result of some type of natural disaster, it is the responsibility of the Ministry of Public Works and Settlement, by virtue of Article 29 of Law No. 7269, to ensure that a new house is built for them. Depending on the economic conditions of the affected region, these houses are made available for families on no-interest loans of a 20 or 30-year repayment period. The Council of Ministers is authorized to write off 50 percent of the loan. When the affected building is a commercial establishment the period of indebtment is from 5 to 15 years, but the loan is again at no interest.

Experience shows that standard design dwellings for different social and climate conditions are feasible. In rural areas single storey houses of 60 to 110 m^2, and in urban centres 3-5 storey, 60 to 90 m^2 houses have been developed. In this regard, the following three methods of indebtment and construction are offered as alternatives to claimant families:

a) Aided Self Help

This envisages the cooperation of the individual and the State. The person who is determined to deserve assistance is expected to provide the labour; he in turn is provided with technical and administrative assistance and his credit is disbursed in installments depending on the rate of progress of construction.

b) Construction of Prefabricated Houses

The General Directorate of Disasters within the Ministry of Public Works and Settlement has a number of plants capable of producing 5 timber and lightweight concrete units per day. When claimant families choose this option, the Ministry provides labour to erect these units which vary between 45 and 62 m^2. It usually takes 3 foremen and 6 labourers 3 days to finish one of these units which may be employed for long-term shelter.

c) Construction Bids

When claimants want the Ministry to bid their houses to contractors and have them delivered in a ready condition, the Ministry advertizes for tenders and provides control services with its own personnel.

An interesting feature of Law No. 7269 is that the cost of infrastructure of post disaster houses (roads, water distribution, electricity) and their social complements (schools, parks, etc.) is met by the State, and these costs are not reflected in the indebtment of individuals.

Legislation on Research for Seismic Hazard Reduction

Article 5 of the Natural Disaster Law charges the Ministry of Public Works and Settlement with the responsibility of protecting human life and national welfare, reducing losses of natural disasters and establishing cooperation with other public institutions including universities and instituting training and publishing facilities for these purposes. The law stipulates research institutions for achieving this purpose. The Ministry established the General Directorate of Disaster Affairs as a consequence of this legal mandate as both a research and an implementation body. Later in 1970, the Earthquake Research Institute was established with the realization that earthquake research should be separated from daily policy implementation and from other forms of natural disasters such as floods, landslides and rockfalls. A number of organizational changes have been put into effect since then; planning and research on disasters different from earthquakes are the responsibility of the General Directorate of Disaster Affairs while earthquakes fall into the area of responsibility of the Division of Earthquake Research which is now part of the General Directorate of Technical Research and Implementation.

The primary duties of the Division of Earthquake Research are the following:

1. Establish the principles and priorities of the national policy in earthquake loss reduction, prepare plans and programmes for this purpose, orient national activities to this common goal by cooperating with universities and other establishments, coordinate and support such activities.

2. Study intensively occurrences and causes of earthquakes, analyze data and synthesize them, examine seismicity of Turkey, prepare earthquake catalogues and earthquake maps and update them.

3. Execute local geotechnical investigations at sufficient detail required for regional, urban and industrial plans or significant constructions such as nuclear plants, dams and the like, facilitating land use decisions through microzonation maps and local earthquake hazard schemes.

4. Establish design and construction requirements for all buildings in earthquake zones, issue regulations, codes and instructions for this purpose and ensure that they are continually updated.

5. Operate and expand the strong motion network in Turkey to meet the national needs, investigate the feasibility of building it locally.

6. Organize training and publicity programmes to educate the public at large on earthquakes, as well as provide technical backstopping to builders, administrators, cooperate with universities and establish joint programmes, support training and research activities.

7. Organize national and international research programmes and work on earthquake prediction, coordinate existing efforts.

8. Participate in international, national and bilateral programmes aimed at the reduction of earthquake risk, represent Turkey in such programmes.

9. Monitor continually the rapidly advancing earthquake resistance construction technology, perform experimental verification of emerging techniques, establish theoretical and experimental research programme with universities or support such programmes.

10. Serve as founding member and executive office for the Turkish National Commission on Seismology and Earth Physics as dictated by the constitution of the Turkish National Association for Geodesy and Geophysics.

In carrying out these functions, the Division benefits from the financial assistance of the general budget as well as the Disaster Fund established by Law No. 7269. Article 36 of the law permits expenditures from the fund for research aimed at the reduction of earthquake hazard. In pursuing its enumerated duties, the Earthquake Research Division has established cooperation with all universities, the Minerals Research and Exploration Institute, the Scientific and Technical Research Establishment of Turkey and the Turkish National Committee on Earthquake Engineering. Its general policy is to determine the required topics of research and development and encourage and support the appropriate universities to work in that area.

F. System and Mechanism of Integrated Physical and Urban Planning at all Levels

In Part I of this report we mentioned that the conceptual framework of the approach in Turkey toward physical planning at the national and regional levels was entrusted to the State Planning Organization (SPO) and the Ministry of Public Works and Settlement. With regard to actual implementation, however, it must be underlined that physical planning was considered at the metropolitan and urban levels from the beginning. This fact may be attributed to the traditional understanding of healthy and liveable cities, and the assumption that physical problems related to urban settlements can best be solved by physical measures taken in the immediate environment.

A rigidly centralist frame of mind concerned with urban planning principles alone pervaded the Construction Act of 1956 as well as its amended version of 1972. This fact was naturally reflected in regulations and statutes attached to the parent act. The powers and responsibilities of different institutions involved in urban planning within the framework of the Construction Act of 1956 were as follows:

1. The Ministry was entitled to determine the zoning principles and planning standards which the local authorities had to comply with when preparing their plans.

2. Local plans could either be prepared or contracted out by local authorities themselves or they could be prepared or subcontracted by the Bank of Provinces if authorization was granted by the local administration concerned.

3. Local plans and their revisions could acquire validity following the approval of the Municipal Council and ratification of the Ministry.

4. The base maps on which the plans would be drafted were subject to the ratification of the Ministry.

5. Development programmes which the municipalites ought to prepare to implement their plans had to be approved by the Ministry. Municipalities were eligible to receive credits for some of the technical and social infrastructure projects designated in their development plans and programmes.

6. Infrastructure projects of local authorities were subject to Ministry approval.

7. The appointment of the technical staff of Municipalites was within the domain of the Ministry. The Ministry had the exclusive right to prepare and ratify metropolitan plans and those plans relating to disasters or the implementation of the Squatter Housing Law.

8. The Ministry carried out its planning functions through both its central organization and local meetropolitan planning offices established in 6 cities. Besides metropolitan plans, the Ministry also prepared "regional plans" with the objective of ensuring a balanced physical development in those areas which were under the pressure of competing land use demands such as agriculture, industry and tourism.

In Act No. 3194 promulgated in 1985 and regulations attendant to it (cf. Section 2.4) physical planning at the national level is not considered. Instead, regional scale planning activities are entrusted to SPO when such plans are called for. No clarity exists as to the precise conditions on preparatory work for this purpose. With regard to urban physical plans, the same general principles as in the 1956 Act are followed but acceptance and approval powers are now transferred to the local municipalities or governors' offices. The Ministry is responsible for setting the rules and principles for planning in the form of regulations.

It has become increasingly evident that in Turkey, as in all other developing democratic countries where strong trends continue in rapid population increase, agricultural mechanization and rural to urban migration, it is not possible to bring effective solutions to the physical problems of cities through standardized, centralized and difficult to change rules and regulations. The common denominator that defines societies in developing countries is their dynamism, and a dynamic planning process is the only viable means of responding to their requirements. Active popular participation in planning decisions is the most desirable process, and involving popularly elected municipal councils in physical decisions encourages this democratization trend. In keeping with this view, Act. No. 3239 passed in 1985 redefined the apportionment of the State's tax revenues to municipalites and provincial private enterprise administrations (which provide capital from the general budget to stimulate local economies); municipalities now receive 9.25 percent of general revenues. The law also provides for municipalities to assess and collect local property taxes. Act No. 2464 passed in 1981 also contains provisions for channelling extra tax revenue into the local administrations by accepting the principle that persons who profit from such infrastructure services as roads, waste and sewage systems should be required to meet one-third of the cost of such facilities through increased local taxes.

In brief, from 1981 onwards a series of legal changes have been put into effect in Turkey whereby preparation of physical plans and their implementation have been placed under the responsibility of local administrations whose financial and legal powers have been broadened. The central administration now assumed responsibility for training, supporting and guiding activities in planning.

G. CONCLUSIONS

In the previous section of this report we have summarized the planning concept and approach in Turkey and the historical perspective regarding the legal principles and applications in earthquake hazard mitigation. We have outlined three case studies, ranging from the earliest to the most recent one. In this section we give an appraisal of the experience gathered during the last 45 years, and point out some remedies for improving the conditions for better response towards hazard abatement. We complement these observations with suggestions for interregional cooperation.

Overall Evaluation

Without intending to turn a blind eye towards what has been accomplished in the mitigation of earthquake hazard in Turkey in the institutional and legislative spheres, we point out some areas where further work is still required.

1. In Turkey reduction of earthquake hazard was for a long time not handled on a national scale. This fact is reflected in the time lag with which preventive and protective measures were incorporated into development and physical plans at all levels.

2. The process of rapid but unplanned industrialization and agricultural mechanization accelerated the domestic migration towards cities. This made it difficult to prevent unauthorized construction of settlements around urban nuclei which lacked the necessary infrastructure for sanitation and proper living conditions. Political motivations ruled the kinds of services made available to these areas and encouraged such construction.

3. In the legislative domain, efforts were made to regulate settlements and construction by means of acts and regulations on disasters, construction, environment but implementation of these in rural areas is admittedly not widespread. Turkey is a large, mostly mountainous country with numerous sparse settlements so it should come as no surprise that urbanization can not be fully regulated by centralized means.

4. Of the housing stock, 3 million units are older than 40 years, and predate the first earthquake code. It is estimated that 1.5 million of these units is in active earthquake zones, but their immediate replacement is not feasible.

5. An effective building construction supervision has not become institutionalized for lack of adequate trained personnel. Similarly, a sufficient number of persons trained in earthquake engineering and seismology is not available.

6. In spite of the abundance of natrual disasters of one form or another, no effective network of rescue and relief teams of adequate number and personnel training has been established.

7. The comprehensive plan put into effect after the earthquake in the Erzurum-Kars area after the earthquake on 30 October 1983 represents a significant step forward in addressing the problems enumerated above.

Thoughts on Interregional Cooperation

There are many similarities among the various legal measures for earthquake hazard mitigation in the Mediterranean countries. The same holds for building materials and practices. This points to a significant number of interfaces where regional cooperation can be initiated in the Mediterranean area. We point to a few of the more feasible areas of joint studies:

1. In varying degrees, countries lack the necessary trained personnel in adequate numbers. One way of providing such staff would be to establish a "Training Centre for Natural Disasters" with inputs provided by UNDP, UNESCO, UNDRO and UNEP where short-term (1 month) or medium-term (3 months) courses and workshops could be organized periodically on all aspects of natural disasters and environmental considerations related to them. This activity would help ease the situation with respect to the deficit in trained personnel.

2. Experience and on-site observation plays a major part in the reduction of earthquake hazard in the stages of preparedness, response, recovery and reconstruction. We suggest that an advisory-capacity joint "Hazard Evaluation Team" should be formed by the executive power of the Training Centre. This way a more rapid diffusion of experience would be possible.

3. Following major earthquakes a workshop or seminar dedicated to this event only should be encouraged in the country of occurrence. Associated UN family organizations should contribute to these scientific meetings by providing travel and subsistence assistance to experts from the region or from outside it.

4. A centralized Data Bank should be established for continuous exchange of information, publications and relevant data among the regional countries. This Bank may be envisaged as part of the Training Centre.

5. Formation of Task Groups or Working Groups on a permanent basis would be helpful in identifying the common problems and requirements in relation to the reduction of earthquake hazards in the countries of the region.

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