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FOREWORD

Within present adult memory, severe earthquakes have caused widespread damage and loss of life in all three regional countries of CENTO. More specifically, two of these countries, Turkey and Iran, have experienced disastrous earthquakes within the past three years.

After the earthquake in Varto, eastern Turkey in 1966, considerable interest was generated in seeking a coordinated, interdisciplinary approach to action which could be taken to reduce and minimize this recurring threat to life and property. The earthquake in Adapazarı, Turkey in July 1967 reinforced this view and added a sense of urgency.

The result was the CENTO Conference on Earthquake Hazard Minimization held in Ankara in July 1968 and assisted organizationally and financially by the office of the U.S. Economic Coordinator for CENTO Affairs. The conference began, by coincidence, on the first anniversary of the Adapazarı earthquake. Experts from all five CENTO countries representing the fields of architecture, structural engineering, geology, seismology, housing administration and disaster relief, gathered in the modern conference hall of the Turkish Ministry of Reconstruction and Resettlement to attack the problem, primarily through a series of specialized panel discussions.

This book is a compilation of the proceedings of the conference, including the findings of the various panels and selected papers presented. Space limitations have unfortunately prohibited the printing of all of the papers presented, and some which do appear have been edited. This was necessary both to conserve space and to avoid repetition.

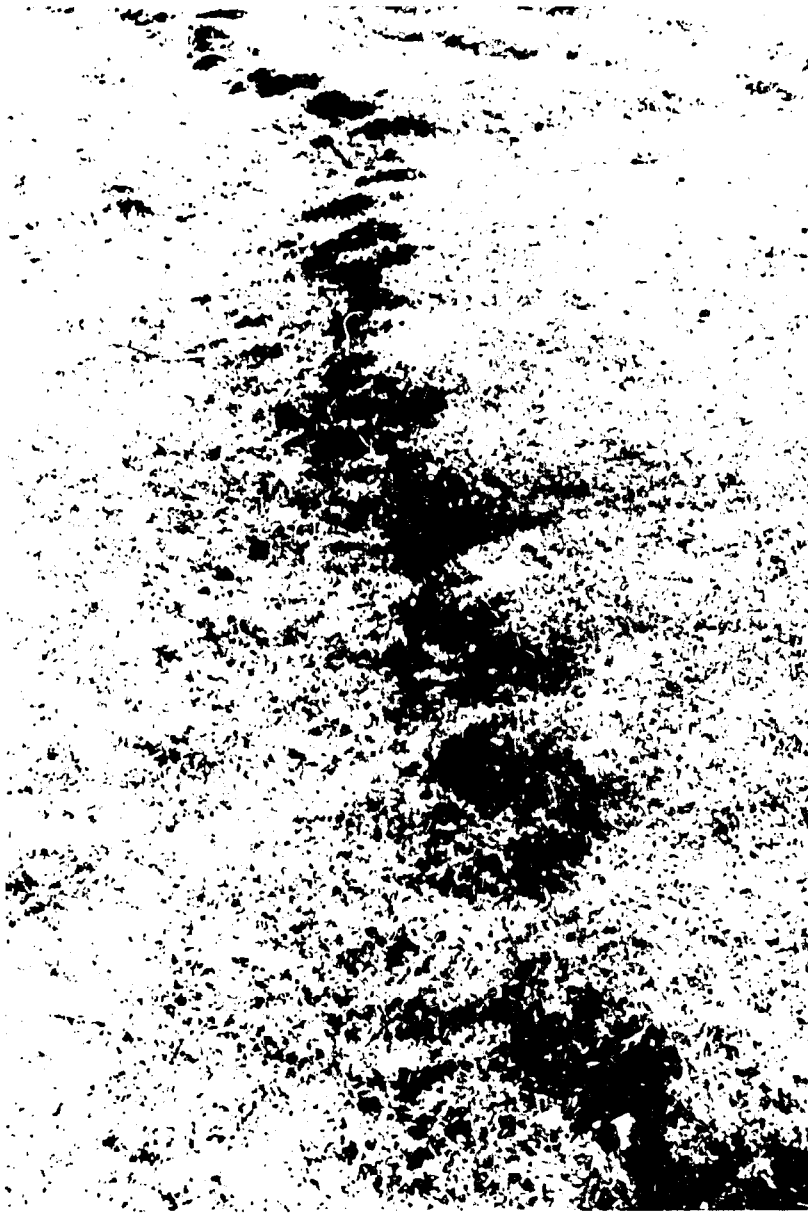
In an effort to follow up on the various recommendations made at the conference, a CENTO Association for Earthquake Studies was proposed for further coordination among the five CENTO countries. Within this framework, the designated country coordinators have already begun correspondence regarding further coordinated action.

A tragic postscript to the conference followed barely a month later in the form of a severe earthquake in Khorassan, Iran, which caused widespread distruction and loss of life. This latest holacaust further dramatized the urgent need for effective action to reduce earthquake hazards in the CENTO region.

Conference Participants visit Adapazarı earthquake site

At least three earthquakes have hit the CENTO region since the CENTO Conference on Earthquake Hazard Minimization was held in July. Two of the quakes caused heavy loss of life and widespread damage.

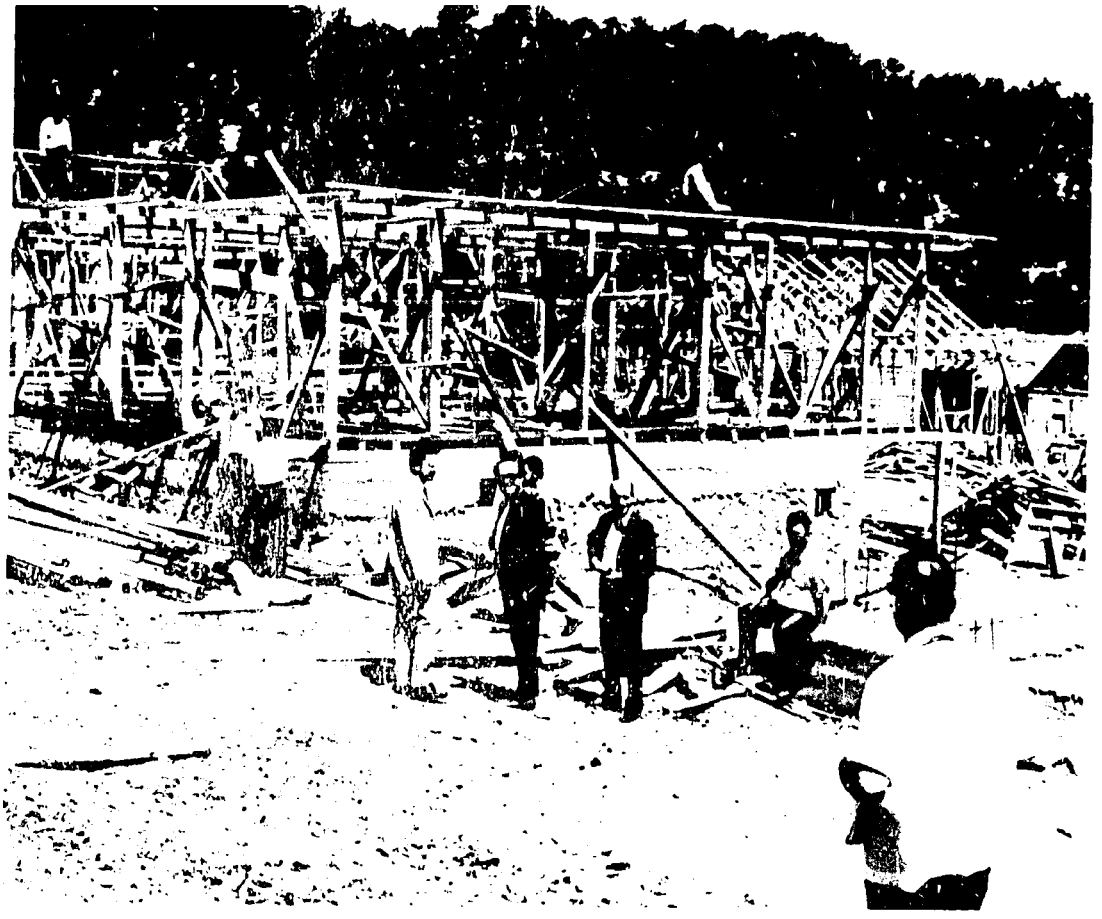
Following the technical work of the Conference in Ankara, the experts who participated were guests of the Turkish Government on a field trip to inspect the site of a 1967 earthquake near the town of Adapazarı in western Turkey.



This crack in the earth is still visible more than 15 months after the quake.

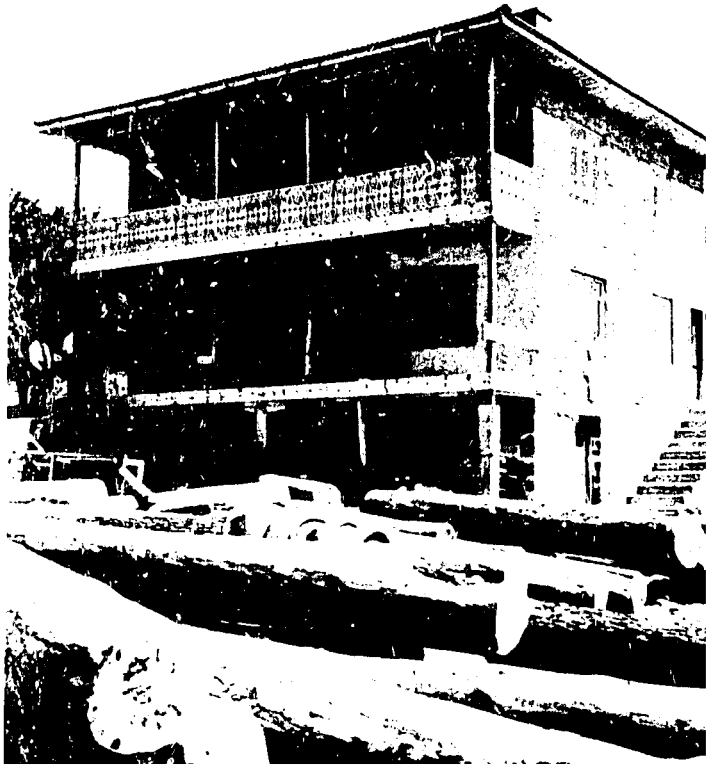
A villager points to the scene of major damage along the fault-line.

The party proceeds to a place where the fault-line crossed open fields.



The party watches construction of two new houses designed better to withstand earthquake shocks.

A newly completed house was inspected.



OPENING ADDRESS

By
HIS EXCELLENCY,
MR. TURGUT MENEMENCİOĞLU
Secretary General of CENTO

Gentlemen,

You have met today to deliberate on methods for minimizing, to the greatest possible extent, the effects of earthquakes on the lives and properties of the populations of our respective countries.

Since the turn of the century major earthquakes have occurred in four out of the five CENTO Countries, the United Kingdom being the exception in this respect. In 1906, San Francisco suffered the most severe earthquake in the history of the United States, with a casualty list of over 700 lives lost. In 1935, over 30,000 people were killed in Quetta, Pakistan. In 1939, more than 140,000 people were killed and injured within a few seconds around Erzincan in Turkey, and in 1962, Buyin-Zahra in Tehran had a death roll of about 9,500. Within the last two years, Turkey has experienced more earthquakes, notably that at Varto in 1966, when 2,500 died, and last July when 100 died at Adapazarı.

Unfortunately, earthquakes recur, but apparently not in any regular cycle, so one cannot predict the year much less the actual day or hour when another shock may be expected.

According to scientists, there is some evidence that full moon, high tides, heavy rainfall, sharp changes in barometric pressure and especially another earthquake elsewhere can act as "triggers" for earthquakes, but any useful predictions are

not possible. We can only be sure that earthquakes will recur again and again and that buildings should therefore be constructed to withstand the shocks.

In many earthquake regions, nearly every house in the shock-originating areas suffers damage, and many are destroyed. The destructive effects result from the falling of roofs and chimneys and from the breaking of foundations and walls. Therefore, so called earthquake-proof houses should be constructed.

In this conference you will examine the cause and effects of earthquakes and consider some measures that may be adopted to minimize their continuous danger to humanity.

It is hoped that from these deliberations some constructive proposals may emerge for the safety and security of the populace in general.

I hope that your meetings will be successful and that the results of your discussions will bring benefits to the CENTO peoples.

WELCOME ADDRESS

By
HIS EXCELLENCY,
MR. HALDUN MENTEŞEOĞLU
The Minister of Reconstruction and Resettlement of Turkey

Dear Delegates and Dear Visitors,

I wish to express my pleasure at welcoming you to my country. Your conference, with the purpose of working on an important problem of the CENTO region and to establish fruitful cooperation, is very valuable for us because many civilized settlements in the region, where our nations live, have been devastated by earthquakes throughout history.

Pakistan in 1953, Iran in 1962, Turkey in 1966 and 1967, experienced great earthquakes causing considerable loss of life and property. These phenomena which have occurred in ancient and recent times, guide us in cooperation, helping each other, and solidarity.

Each of us has worked on measures for earthquake hazard minimization and it is a fact that we struggle for establishment of a system for earthquake-resistant construction. We all know that earthquakes cannot be stopped, but we cannot refrain stressing pre-earthquake activities and being careful about the measures, obtained as a result of them. Although in our day, there are intensive studies for earthquake prediction, the results are not accurate enough for application in practice.

Even if earthquake prediction is realized, the importance of the earthquake-resistant construction problem will not be reduced.

Utilization of local building materials and labor are vital aspects for economy. CENTO countries have many common points in this respect. It is known that every CENTO country struggles to survive this great disaster source with a minimum hazard. But until now they had not been able to come together in a meeting for a give-and-take of knowledge and experience. Today's conference realized this purpose. This meeting indicates the necessity and use of the CENTO Pact and confirms our common benefit. I hope that it constitutes an example of inter-state cooperation.

On this occasion, once more, I greet friendly and allied CENTO States.

The subjects to be discussed at the conference are extremely important for us. Because our countries are in the struggle of planned development, earthquake disaster is an obstacle.

To consider our countries as a whole region will bring us nearer to the target than will individual geological and seismic studies.

Preparation and implementation of earthquake codes and establishing the principles of earthquake-resistant design are vital problems. Because, in this way only, earthquake-resistant construction can be realised. It will affect the rightness of decisions for investments, to know the increase of the construction cost to provide earthquake-resistance.

Development of earthquake sciences will evidently provide countless uses.

To attend and observe your conference is of great value. I express my sincerest thanks to the CENTO officials who cooperated with our government. I deem it a natural and useful consequence to our established cooperation for solution of our common problems, to deal with the disasters other than earthquakes.

Sincerely I believe that our friends are of the same opinion.

I convey my wishes that your conference will be successful.

KEYNOTE ADDRESS

By
DR. KARL V. STEINBRUGGE
Structural Engineer and Consultant to the Department of Housing and Urban Development, San Francisco, California, U.S.A.

Mr. Chairman, Your Excellencies, Ladies and Gentlemen:

I am indeed pleased and flattered to be able to speak before this eminent and respected audience of engineers, scientists and government officials representing the CENTO region. The fact that you represent many disciplines and several viewpoints is of great significance, as it is my conviction that many problems related to earthquake hazard minimization can best be solved by an interdisciplinary approach. The need for such an approach is now receiving greater recognition in many parts of the world, including the United States, and has been the basis for a number of successful earthquake conferences in the past two years.

Earthquakes are an exceedingly complex natural phenomena. The mathematical methods used in earthquake engineering are as sophisticated and as complex as will be found in any type of engineering. Electronic computers are required to solve many problems in building response to earthquake forces. Earthquake effects are much more complex than the simple shaking of the ground, and the effects include landslides, flooding, and seismic sea waves. Consequential effects may include epidemics and fires.

Interdisciplinary accomplishment takes more than just being together in a room such as this; it takes more than listening to

the viewpoints and findings of experts. It requires that persons from each discipline understand and make use of the work done by the other related disciplines. On the other hand, it is the responsibility of each person to produce results and conclusions in a form and type usable and understandable to the other disciplines. As a result, I cannot over-emphasize the need for each of us to be able to adequately communicate verbally and visually in a manner which will be of maximum value to all present.

We need only to look at the increasing proliferation of scientific, technical, sociological, and administrative journals to realize that the specialist is becoming even more specialized. I do not deplore this trend, although I do maintain that some problems can best be solved by a combination of specialized efforts.

I see this conference, then, as a means for promoting meaningful communication between and among those of us in the fields of seismology, geology, civil and structural engineering, economics, public administration, and other related fields. I also see this conference as a vehicle for bringing the theoretic results of the scientist and engineer into the hands of the people who must put this information into use, including construction workers, government administrators, planners, and other persons connected with direct action.

World conferences on earthquake engineering, such as that to be held in January of 1969, in Chile, in which many of us will participate, create problems of sheer size, in spite of an interdisciplinary approach. Here in Ankara we are fortunate in being able to largely avoid such problems and participate on a personal basis in discussing problems applying to this specific region.

It is obvious that you here represent a great deal of accomplished research and study. It is hoped that this conference will suggest ways so that at least a portion of the proposals advanced at this meeting will result in further locally-funded research within the several nations and agencies represented, and that at least a portion of this activity may be of a regional nature. However, research and study are not enough. They are limited unless they result in action programs such as improved codes and construction projects, made possible by continuing cooperation

and interchange of data and ideas between the various disciplines. An interdisciplinary approach and greater use of indigenous materials and human resources can greatly affect the future safety of village shelter and urban structure alike.

Earthquake hazard has two components which can be studied separately when thinking of the immediate effects. These components are life safety and control of property damage. If we consider life safety alone, we find that quite serious structural damage can be allowed, as long as the building remains standing and lives are safe within it. Codes incorporating this concept have been developed by the Structural Engineers Association of California, and have found acceptance in many parts of the world.

The consequences of this approach, however, can result in a heavy, if not excessive, economic burden on the property owner due to the necessity of extensive rehabilitation or even replacement of the entire structure. This approach may be acceptable in a setting where economic resources and alternative shelters may exist, or where the seismic risk is believed to be remote. However, this approach would be intolerable to the village or farmer who has no alternative, and the survival of whose family and stock may depend on the continued use of available shelter.

So we are faced with an economic cost-benefit problem of how much can be spent on damage control for the basic shelter, whether urban or rural. In other words, what is the degree of permissible damage. This problem has not really been solved anywhere in the world as far as I know, and its ultimate solution must involve the additional disciplines of economic and governmental policy.

While we are all aware of the modern steel and concrete structures which we see in the major cities of this region, a more pressing problem involves the traditional stone and massive earth structures used as dwellings by the major part of the populace in the CENTO region. These traditional structural types have been associated with the heavy loss of life throughout recorded earthquake history.

If costs and sociological considerations were completely disregarded then, of course, these collapse-hazard structures

could be replaced with highly reinforced concrete construction, light mass insulated steel construction,or light mass insulated wood frame construction, and so forth. These solutions are obviously impracticable. As a result, it is a heavy burden that the engineer, geologist and seismologist must share with the government administrator and policy maker. We must make the best use of available, and I stress available, resources of our individual countries, whether economic, material, or human, in doing what we can to eliminate the life hazard and to reduce property damage to tolerable limits. Each country and community must establish its own limits in this regard, keeping in mind that the human resources saved are the most valuable component in development.

In any event, imaginative answers must be found to better utilize indigenous materials,to better utilize self-help, and to better utilize available technical skills, in order to provide safer shelters in all areas subject to potentially significant earthquake damage.

This responsibility has become increasingly heavy during our lifetime due to accelerated scientific progress. We here now have enough available knowledge to partially or to fully solve many of our earthquake problems, and we must not fail to make the best possible use of this information within the limitations of our physical and human resources.

The discipline of seismology and its related fields forms one basis for a rational approach to earthquake risk in each locality. While earthquake prediction is a popular subject among seismologists and others, it would appear that reasonably determined estimates of earthquake frequency and earthquake magnitudes are of vital importance in any long-range program for life safety and property damage control. A different kind of risk exists, for example, for a region with a probable frequency of disastrous earthquakes once in every 50 years as compared with another community having a frequency of one in every 250 years. In response to this, scientists and engineers in many countries have zoned their countries on some sort of intuitive basis. We are all familiar with the resulting maps which usually must be revised with an increased seismic risk after each earthquake. Hopefully, these seismic risk maps can be drastically refined

to be able to give some indication of risk in terms of frequency and magnitude.

Vital, too, is information regarding focal depths common for destructive earthquakes. As you well know, the damage pattern for deep focal depths is vastly different than that for shallow shocks. This is not always well understood by engineers and those who write building codes. A clearer understanding of it can lead to better building codes and to safer and more economical structures.

In order to better determine earthquake risk, we must obtain from the geologists a clearer understanding of regional geology in the context of instrumentally located earthquake epicentres. Expanded and improved field mapping is necessary.

Unfortunately, recording of reliable seismic data began only about 1900. We know that some areas have been seismically quiescent for a hundred or more years, only to become active again. Thus, instrumentally determined seismic records may be very misleading unless modified by historic record and geological data. Certainly, the geologist can and must play a vital role in establishing earthquake risk by his evaluation of the geology. The understanding and evaluation of the potential activity of geologic faults, such as those which might be under dam sites or through cities, are very critical in risk evaluation.

The recent earthquakes in Turkey, as well as the 1964 Alaskan and 1967 Venezuelan shocks, have illustrated the need for increased knowledge regarding the dynamic properties of surficial geology. This is an interesting problem involving the disciplines of engineering geology, engineering seismology, and soil engineering. An interdisciplinary approach is needed to solve this problem which is of particular importance in the long-range planning of cities. For this reason, it is hoped that each country will allocate the resources necessary to expand this activity.

After the seismologist has given a meaningful evaluation of the probable frequency of destructive earthquakes, and the geologist has evaluated the earthquake geologic hazards, such as faulting and landslide, then the civil and structural engineer

must take these risk factors and translate them into suitable criteria for designing a building. Normally, this is not done on a building-by-building basis, but rather the rules under which structures are built follow accepted design standards as controlled by a building code. Therefore, building codes are vital and most useful, despite criticism that is sometimes levelled against them. In most parts of the world, the engineering provisions of the building code are written by the scientist and the engineer—that is, by many of us present today. If a code is obsolete, incomplete, or otherwise inadequate, then it is our problem to solve, since it is unreasonable to ask an engineer to adequately design a structure without standards to guide him. Also of importance is the principle that the best building code in the world is of reduced value unless it is properly administered and enforced. Thus, improved codes and the mechanisms that will make them work, are additional factors that should be explored by this group.

Like many other disciplines, civil and structural engineering can be divided into theoretical and applied segments. Mathematical progress has been excellent in earthquake engineering, but the transformation of the mathematical studies into the reality of well constructed earthquake resistive buildings has not always been successful. Mathematics must be adequately translated into detailed working drawings and specifications. These in turn must be translated into safe structures, buildable by the average workmen. As this problem is universal, I am sure it concerns the CENTO nations as well as the United Kingdom and the United States.

It is important that the designer, whoever and wherever he may be, field inspect and be responsible for his own designs during construction. As an example, a satisfactory solution has been found with a certain type of public structure in California, where the engineer not only prepares the construction drawings and design calculations, but also assumes a share of the legal responsibility for the actual construction to fully comply with the drawings and building codes. A related law requires that a competent geologist determine that the site be free of geologic hazards. While this is clearly not possible with every dwelling in every village of your region, every reasonable step and example should be taken to promote the best possible use of knowledge and technical skills.

It is clear from the foregoing that an interdisciplinary effort is necessary to produce and to exchange information which is not only understandable to those of us here, but to the builder and the villager who must often make the choice of site and structural system. This cooperation, coupled with simple but imaginative solutions, is the key to making the wealth of knowledge that you possess available to those whose lives and property may well depend upon your action.

Quite rightly, the topics for panel discussions are divided into reasonably self-contained subject areas. The resulting reports from each team will, therefore, tend to be self-contained, but possibly removed from other subject areas. As a result, may I ask a favor of each panel chairman: In your report, please discuss how your report will relate to, or be useful to, the work being done by other panels. In addition, each chairman might state the type of information that he would want from other panels. This type of interaction among panels will contribute substantially to the interdisciplinary approach which is my keynote for this conference.

If you are bold and as imaginative as I believe you to be, not only here but when you return to your offices and agencies, the result of this conference will set a high mark for such gatherings. Let us strive for the best.

REPORT OF THE CENTO CONFERENCE ON EARTHQUAKE HAZARD MINIMIZATION

INTRODUCTION

The Conference on Earthquake Hazard Minimization, which was organizationally and financially assisted by the Office of the United States Economic Coordinator for CENTO Affairs, was held in Ankara, Turkey from July 22 to July 27, 1968. All five Member Governments were represented.

The Conference was called to order by an officer of the Central Treaty Organization. An inaugural address was given by the Secretary General of the Central Treaty Organization, His Excellency Mr. Turgut Menemencioğlu. A welcome address was delivered by the Minister of Reconstruction and Resettlement of Turkey, His Excellency Mr. Haldun Merteseoğlu.

After brief opening statements from the heads of delegations of the five Member Countries, the leader of the Turkish Delegation, Mr. Turan Alpdemir was elected Chairman. The leaders of the Delegations of Iran and Pakistan were elected Vice-Chairmen.

A keynote address was delivered by Dr. Karl V. Steinbrugge, Structural Engineer and Consultant to Department of Housing and Urban Development, San Francisco, California, on the subject of "The Minimization of Earthquake Hazard; An Interdisciplinary Approach."

The United States Economic Coordinator for CENTO Affairs, Mr. Ragnar Arnesen made a few background remarks on the subject of the Conference.

ORGANIZATION

A Steering Committee composed of the Conference Chairman, leaders of the five delegations, the Assistant Economic Secretary of the CENTO Secretariat and a representative of the United States Economic Coordinator met several times to review the daily program and make minor changes in the schedule when necessary. The Steering Committee appointed the Chairman and Rapporteur for each panel who were responsible for preparing the reports of panels as well as the participants to each specific panel.

CONFERENCE OBJECTIVES

"Earthquake hazard minimization" in the CENTO Countries was the basic objective of the Conference. Iran, Pakistan and Turkey all have been struck by disastrous earthquakes in the past and because these countries are in an earthquake-prone region, future great earthquakes can be expected.

The basic objective of the Conference was pursued by bringing together specialists from each of five countries — Iran, Pakistan, Turkey, the United Kingdom and the United States of America — and from a wide range of disciplines including civil and structural engineering, architecture, construction, geology, geophysics, seismology, administration, planning and finance in an attempt to translate existing earthquake scientific and engineering knowledge into actions that will save lives and disastrous economic losses.

The Conference was an experiment in the interdisciplinary approach to a serious problem. The Conference attempted to reach conclusions by:

1. Examining design and construction practices which affect the earthquake resistance of structures and related facilities.

2. Examining existing programs for minimizing hazards of earthquakes such as building codes and standards, their implementation and enforcement.

3. Examining those aspects of earthquake science that can contribute most directly to earthquake hazard minimization, and in particular those geological hazards affecting the safe siting of structures and services.

4. Recommending administrative, organizational, financial, educational research, and other steps that can and should be taken.

5. Publicizing recommendations through publications and other techniques, and attempting to bring to the attention of responsible officials action steps needed.

PLENARY SESSIONS

The subjects discussed during the Plenary Sessions were the following:

1. Earthquake Problems and Programs in Iran, Pakistan, Turkey, United Kingdom and the United States.

2. Problems of Implementing Earthquake Code Requirements.

3. Additional Cost of Earthquake Resistant Construction, Financial Resources and Techniques Available for this Purpose.

CONFERENCE PANELS

In order to cope with the different aspects of the subject, the Conference was divided into six panels. The summaries of the findings and recommendations appropriate to each facet are attached. (The summaries of Panel 3 and Panel 5 are combined as the subjects of the two Panels were considered to be interrelated.)

PANEL No. 1

EARTHQUAKE PROBLEMS OF SMALL BUILDINGS AND DWELLINGS

The representatives of Iran, Pakistan and Turkey described failures of buildings in their countries in recent earthquakes, and illustrated them with slides. The methods and techniques were discussed.

In view of the shortage of technical staff in all three countries it was agreed that control of buildings through legislation could only be attempted in towns. The improvement of rural housing is a matter of education; it was considered that all available methods of education should be adopted to teach the villagers how, at minimum cost, to construct houses which would not collapse and kill the occupants in the next earthquake. Among the methods which could be adopted are posters in coffee houses, teaching in schools and mass education, teaching by the Army Education Corps or through Basic Democracy organizations or cooperatives.

Several basic systems for improving the earthquake resistance of traditional earth structures were discussed. These include the insertion of a wooden plate in the wall under transverse roof members. Another system involved the use of corner reinforcement of angle iron or wood, with the addition of horizontal bands of metal at door head height and roof levels. Suggestions were made that other material such as suitably prepared bamboo or cane might serve the same purpose.

Diagonal bracing, both horizontal (in roof) and diagonally and vertically (at corners and openings) was considered effective in reducing damage. Larger unit hollow concrete or ceramic blocks were indicated as lending themselves to vertical reinforcement.

Related to mortar in joints, it was noted that cement or cement/lime added appreciably to strength of walls, as opposed to earth alone. The strength of mortar in joints is important.

Cooperatives, aided self-help and other methods of involving the individual village were discussed. It was agreed that this involvement is essential. This might well include village level

savings programs to finance reconstruction or improved earthquake resistant shelter.

Means should also be explored to encourage participation by private industry and financial institutions through the use of government-sponsored programs of insurance and guarantees.

RECOMMENDATIONS

1. That studies should be extended in each of the three countries on subjects which will add to knowledge about building in seismic areas. These studies should include the stabilization of soils, techniques for reinforcing earth buildings (including the use of suitably treated bamboo and cane), protection against termites and fire, suitable roof systems and materials, and the standardization of the size and quality of components.

2. The development of local building materials should be studied, and action taken to increase production. In particular the planting of suitable quick-growing trees should be considered.

3. In view of the fact that existing codes and regulations are written for use by professional designers, and recognizing the necessity for simplified criteria for the guidance of small builders and villagers, it is recommended that committees should be set up in the three countries to prepare: a) national regulations covering small buildings in permanent materials; and b) codes of good construction for rural houses. Each should be fully intelligible to the user, and should be fully illustrated. All should be readily available.

The provision of standard plans is desirable. Handbooks, containing details and guidance for small builders and villagers, should be prepared in the national languages.

The regulations for small buildings in permanent materials cover the suitability of sites and structural points such as:

- Continuous or tied foundations;
- Details of openings, bonding and joints in walls and other members;

- Ring beams and vertical and diagonal reinforcement at corners and elsewhere and, in severely seismic areas, of additional horizontal reinforcement in walls;

- Tying all parts of the structure together;

- Where possible, making the roof of light-weight materials.

The code for rural houses should be short and contain only a few simple health and structural rules. This code might be in the form of the illustrated handbook mentioned above.

4. Early and continuing attention should be given to the education of people in rural areas in cheap methods of improving houses to resist earthquakes. All available means of education should be used.

PANEL No. 2

EARTHQUAKE PROBLEMS OF LARGE BUILDINGS AND STRUCTURES

Descriptions of different types of large structures and their design techniques against earthquakes, characteristics of materials of construction and problems encountered were presented by the delegates of the respective countries.

The Iranian delegate gave the requirements of the Iranian code for design of reinforced concrete and steel skeleton buildings against seismic forces. He also stated some of the general principles which contribute to resistance of buildings to earthquakes.

The Pakistani delegate discussed the methods adopted in the design of buildings and other structures against earthquakes and the provisions to be made against overturning and torsion of structures due to lateral forces.

The Turkish delegate mentioned the provisions of the new Turkish Code for design of high-rise buildings and suggested certain recommendations relating to their design and construction.

Some of the other delegates participated in the discussions. The Delegate of United States emphasized that nonstructural elements influence the fundamental period of a structure to a great extent. He also cited the examples of many buildings in Caracas, Venezuela which though adequately designed according to codes collapsed during an earthquake due in part to interaction of buildings with certain geological conditions not yet fully understood. He underlined the necessity of understanding the mechanism of a failure, i. e., why and where a failure occurs.

The Delegate of Iran, while discussing some of the causes of failure during the Varto earthquake commented that in many cases the buildings had been designed to take earthquake forces in the transverse direction, but not for resistance against lateral forces coming in the longitudinal direction. Frames should therefore be designed to resist the lateral forces in the longitudinal direction also.

RECOMMENDATIONS

1. Geological investigations over a large area around the sites should be undertaken to ascertain data for design of high-rise buildings and other large structures.

2. High-rise buildings especially in developing cities like Ankara, Tehran and Rawalpindi should be designed for long-period effects. The prevailing codes are good in many respects, but in case of high-rise buildings and other large structures, engineering judgment is also important and special studies are necessary.

3. In designing dams and hydro-electric plants, site investigation should be made ahead of design. Sites with faults should be avoided. When designing these structures adequate provisions should be made against seismic forces.

4. Teaching and research programs on earthquake resistant design and construction should be introduced in the technical universities of the participating countries.

5. Studies of actual behaviour of buildings during earthquakes should be made and recorded.

6. A network of strong-motion accelerographs should be established in the active seismic zones of the respective countries for having records of accelerations and the information obtained should be exchanged among the countries.

7. Pamphlets containing design procedures and computations for high-rise buildings should be compiled by the participating countries. These pamphlets may be exchanged among the participating countries.

8. Seismic codesshould be prepared if this has not already been prepared in the country concerned. Where it has already been prepared this should be revised in the light of latest studies.

9. A catalogue of basic structural data of each high-rise building and of the characteristics of its foundation soil should be compiled by each of the participating countries, so as to enable future investigators to study the performance of the structure during earthquakes if any occur and to correlate it to the design features and soil characteristics.

PANEL Nos. 3 and 5

EARTHQUAKE SCIENCE: GEOLOGICAL HAZARDS AFFECTING THE SITING OF STRUCTURES AND SERVICES

PRESENT SITUATION

Earthquake sciences and engineering including disciplines within the general fields of seismology, geophysics, geology, soils mechanics, and structural and civil engineering collectively have voluminous information which, if effectively communicated to governmental planners and administrators, to contractors and construction workers, and to others involved in direct action, can greatly minimize the hazards of earthquakes. Unfortunately, even within the sciences

and technologies themselves, greater interchange of ideas and communication is needed, both nationally and internationally.

Despite the existing voluminous scientific and engineering data available, there exist several areas of additional information that are critically needed for minimizing earthquake hazards.

In view of the above situation, the following Recommendations are being made and grouped in three categories:

A. Suggestions for improving the flow of existing technical information into action channels

B. Identification of new research and data needed that are of highest priority in minimizing earthquake hazards

C. Methods of improving education in earthquake engineering and science.

A. Improving Communication of Information

National committees, sub-committees, and local groups should be formed in each country to bring together the various earth scientists and engineers concerned with earthquake problems so that interdisciplinary exchange of ideas and information can be improved. Authorities governing construction and development should participate in such committees, and should receive active encouragement from the technical men to do so.

In addition to this interchange of ideas and data among various disciplines in each country, the CENTO countries should continue to exchange ideas and data about their common earthquake problem by means of periodic meetings which would convene successively in different CENTO countries.

The earth scientists and engineers in each country should develop ways of more effectively communicating their earthquake knowledge to administrators, contractors, construction workers and others. Some suggestions follow:

1. Earthquake scientists and engineers should develop simple, well illustrated pamphlets, leaflets, posters,

documentary films, television programs and other publications which can educate villagers, construction workers, contractors, city planners, administrators, primary and secondary level students and others in some of the basic aspects of earthquake-resistant construction and long-range planning to avoid hazardous areas.

2. Geologists of the appropriate agencies should develop special, easily interpreted "geologic hazards" maps which outline the most important earthquake hazards such as active and potentially active landslides, active and potentially active faults, and water-saturated and other "poor" ground which must be carefully analysed by engineering geologists and soil-mechanic experts before important structures are erected upon a site.

3. Seismologists should continue to produce and improve seismic zoning and seismic probability maps to provide needed background for improving building codes and standards and for guiding long-range planning and insurance programs. Correlation of earthquake catalogues, seismic zoning and regional seismicity among the three countries should be considered so that more meaningful comparisons and compilations can be made. Historic and pre-historic records as well as instrumental records should be included in catalogues to produce the best possible data on earthquake probability.

It is recommended that the CENTO microwave system be used as a means of rapidly communicating seismographic data to various seismological observatories within the CENTO countries and to international centers which correlate seismic data. Data such as determination of epicenters can be transmitted in this manner, so that field teams can be promptly despatched to the proper points to gather data such as after-shock records.

B. New Data and Research Needed

Seismological and tectonic observations in the active earthquake belts of the CENTO countries are grossly inadequate to provide the necessary background data for long-term regional planning and improvement of building codes and standards.

Following are the most important necessary additional programs.

Highest priority should be given to a program of strong-motion instrumentation keyed to analyzing the characteristics of vibration on different types of geologic formations, in different seismic regions, and in different types of structures. Such data are necessary if zoning techniques, and building codes and standards are to be effectively improved.

Each country should deploy at least five strong-motion instruments as soon as possible to the most critical areas, and preferably should have at least three additional portable instruments available to be implaced immediately after an earthquake to record the effects of large aftershocks. It is strongly recommended that these instruments be under the control of a central agency in each country to ensure effective maintainance.

This program can be effectively started if each country is granted funds to the extent possible ($10,000-$20,000) from the CENTO Multilateral Scientific Fund for the purchase of the strong-motion instruments, over a two to three year period starting in 1968.

Arrangements should also be established for teams from other countries to bring portable equipment to study aftershocks, inasmuch as seismologic data to be gathered in the CENTO region can assist not only the CENTO countries but all countries that have earthquake problems. The CENTO countries afford one of the best natural laboratories for the study of earthquakes.

The standard seismic nets of each country, needed for seismic zoning and for the basic understanding of seismologic principles, should be greatly enlarged and equipment brought to higher standards. Development of nets of approximately twenty fixed stations in each country, supported by portable seismographs, should be completed within the next five years. The panel recommends that discussions about such nets currently being carried out under UNESCO and other sponsorships be endorsed by this conference. A working group or sub-committee of the CENTO countries should be convened at least yearly to develop, coordinate and actively pursue this goal on behalf of the

CENTO countries. It is recommended that the CENTO Multilateral Technical Cooperation Fund support travel and meetings of such a working group.

Mapping of active faults and related tectonic features should be given high priority within the geologic mapping programs of each country.

Immediately after each significant earthquake detailed field investigations should be made, exact positions of surface faulting should be precisely located and mapped so that in future years these active fault strands can be avoided or taken into account in construction and planning. The lack of such data may preclude the future siting of important installations such as nuclear reactors or dams at desired places.

Field investigations should also be made by interdisciplinary teams including engineers, seismologists and geologists. Each CENTO country should provide support for its specialists to make on-the-spot studies of significant earthquakes in neighbouring CENTO countries.

Simple arrays of survey control points should be established as soon as possible across faults known or suspected to be active so that tectonic creep may be detected and strain rates determined. As time and funds permit, these nets may become more extensive and sophisticated, but, most importantly, a start should be made now.

Earthquake engineering research should be improved within each CENTO country in order to consider the special construction materials, practices and other factors unique to each country. Although much data developed in other countries such as Japan, the United States and Europe are valuable, they must be interpreted in light of local problems.

C. Education

The long-term improvement in earthquake sciences and engineering, and the effective use of the output from these disciplines depends upon education. Earthquake sciences and engineering requires the focussing of many types of studies upon the earth-

quake problem. In order to bring about this focus the following actions are recommended:

1. Courses and lectures specifically directed toward earthquake science and engineering should be developed in universities in each of the CENTO countries. To begin with, an exchange of professors among the educational institutions of the CENTO countries should be arranged on short-term bases. For example, a professor, particularly versed in some aspect of earthquake engineering, should give a series of about ten lectures at a university in another CENTO country. Similarly, specialists from countries other than CENTO countries, may be sponsored to lecture for short terms.

The panel recommends that funds for such a "visiting professor" or "exchange professor" program or lectures by highly qualified engineers be supported by the Multilateral Technical Cooperation Fund of CENTO.

2. In time available the panel could not reach a consensus on whether or not a centralized institution of earthquake engineering is desirable, and the panel, therefore, recommends that a working group be established to seek out various practical ways to improve earthquake engineering, seismologic, and tectonic education and research within the CENTO countries.

PANEL No. 4

METHODS OF ACHIEVING EARTHQUAKE RESISTANT STRUCTURES

Presentations and general remarks were made by representatives of each of the five countries.

The point was made that codes should be simple and preferably illustrated, and that these must allow for experimental adoption of systems not specifically covered in the document. It was noted that there is need for flexibility in basic laws and codes to meet new conditions and technologies.

Note was made of the complex nature and behavior of seismic forces and their effect on structures. Of particular note are the various soil conditions including liquefaction, where much can be learned from similarity to conditions in areas of recent major earthquakes.

Numerous valid points were raised relative to code supervision and enforcement. It was noted that it is necessary to ensure quality control during both the design and construction phases. It was noted that the organization for inspection systems should be unified at the highest possible level to insure uniformity and consistent quality. Means must be found to reduce local pressures on inspectors who may be induced to accept poor quality work. One suggestion was that outside inspectors be secured for limited tours of duty, who would be responsible to some central authority. Certification of design and works by qualified professionals also encourage acceptable practices.

Where insufficient professional staff exists, master artisans, familiar with local practices can be utilized to advantage by local authorities in enforcement and inspection.

General discussion indicated that code enforcement in the region is substandard, and that this area must be improved to allow the application of such new concepts as earthquake insurance. This latter might well involve government backing for participation by private industry, with at least token contribution from the individual house owners in earthquake prone areas.

RECOMMENDATIONS

1. It is recommended that all possible means be explored and implemented to insure improved systems of inspections and enforcement of codes and standards throughout the region. To this end, each Member Country should review and evolve improved systems and methods suitable for its own needs at the earliest possible date.

2. As education at all levels is a key to improved earthquake resistant construction, it is recommended that refresher courses be organized at the several universities in the region

to renew the interest of practicing professionals in the subject of improved design, and to provide them with the most recent technologies in their fields.

Exchange of data and teaching staff might well be arranged on a regional basis.

3. It is recommended that all possible means be explored to encourage participation by private industry in earthquake insurance programs. This will involve an interdisciplinary exchange of data between professions not presently involved in planning earthquake resistant structures and programs.

To this end, all concerned government agencies should participate by providing data, guidance and encouragement between and among themselves and private industry.

PANEL No. 6

ORGANIZATION FOR EARTHQUAKE DISASTER RESPONSE RELATED TO THE PERMANENT REBUILDING OF THE COMMUNITY

Representatives of the five countries informally presented papers relative to the subject of pre-planning and response to earthquake disaster, which was followed by a general presentation of thoughts and recommendations by other delegates and observers.

The point was made that efforts for planning and disaster response must be coordinated among the various agencies and disciplines involved. In addition, it was noted that a central authority, either in committee or authoritarian form, is necessary to direct and assume coordination of all projects and programs.

The point was made repeatedly that prevention is a most urgent factor, and that education at all levels is necessary to allow significant results, whether at administrative, technical or village level.

It was noted that it is necessary to establish criteria for pre-planning, programming and disaster response. These would be based on necessary legislation and quidelines established by the various agencies concerned, and would cover construction, re-settlement and emergency relief activities.

Several delegates noted self-help and aided self-help as necessary for involvement of the people, and for maximum accomplishment relative to government assistance efforts in cash, materials and technical guidance. Related to this matter is the involvement of the villager in improved development of his community, and an awareness of what he is capable of doing for himself.

An important activity at the community level is the evolution of a plan, which if properly enforced, or voluntarily followed, will reduce loss of life and property damage, and will greatly assist in the reconstruction process, land use, the zoning of structures on the safest available sites, and the provision of open spaces and adequate streets to isolate damage due to fire.

For urban areas, legislation and enforcement of plans and codes are essential to reduce damage and allow coordinated controlled reconstruction.

The interdisciplinary approach was stressed, and a need was voiced for regional efforts which would also involve the U.S. and the U.K. The gathering of data, and making it available to all pertinent agencies for both planning and disaster response purposes was stressed as the lack of statistical data has sometimes been a retarding factor in previous reconstruction.

An appeal was made for both political and social awareness on the part of all concerned. All disciplines should devote some time to acquiring an understanding of what might happen in the event of a disaster, what they could contribute, and how this could be coordinated with the efforts of others. Factors involved include temporary and permanent housing, transportation and communication, water supply and other public facilities.

1. It is recommended that necessary revision and improvement be made to assure adequate pre-planning and disaster response agencies, facilities and staff. This would include a coordinating function by some appropriate central authority which would be responsible for establishing responsibility on an interdisciplinary basis.

2. It is recommended that all possible means be used to assure educational programs and social awareness at all levels to promote local programs as well as central government research and development related to reduction in the loss of life and property damage due to earthquake disaster. This would include the evolution of town and village plans, an assessment of local resources, and the establishment of regional education and technical centers.

It is recommended that all pertinent statistical and technical data be made available to all government agencies and private organizations and institutions interested in and responsible for planning, programs, and disaster response. Past experience, present and evolving technologies and statistical records should be drawn upon, and should be readily procurable.

It is further recommended that such data be made available on a regional basis where appropriate, and should be a part of the resources drawn upon by regional and local working parties and committees.

Finally, as an important socio-economic consideration, it is recommended that government-supported insurance be made available to the public, covering earthquakes and other natural disasters with encouragement to the private sector for underwriting participation.

SUMMARY OF FINDINGS

The objective of this Conference was to bring together representatives of the various professions concerned with the problem of providing earthquake resistant structures within the CENTO region, with the view in mind of exchanging and improving necessary data and techniques through the establishment of an inter-

disciplinary approach. Seismologists, geophysicists, geologists, engineers, architects and related disciplines can and have made significant contributions to research and applied technology necessary for a systematic reduction in loss of life and property due to earthquake activity. If this conference has accomplished anything of lasting significance it is hopefully due to an improved understanding of the problems, needs and potential of each of the disciplines, between and among the various professions and nations involved. The important language barrier which must be overcome in this regard is, therefore, the communication of data, ideas and functional concepts which will allow each discipline to understand what the other has to provide; how meaningful requests and exchanges can be made; and how each can direct its research and development to best benefit of all concerned.

In the various presentations and discussions, it was evident that basic problems within the various parts of the regions are very similar, and that the scientists and engineers of each nation and agency represented are not only concerned, but have something of significance to contribute— ranging from geological data to improved uses of indigenous materials. Papers and discussions explained the question of collection of seismological data, the significance of geological phenomena, the place of codes and standards, the development of materials and techniques, questions of finance and insurance, education of the rural population and the responsibilities of the designer.

MAJOR CONCLUSIONS

As a result of the above, some significant conclusions were reached, and important areas of concern were defined for further research and action. It is apparent that all involved, whether delegation or individuals, are anxious that the interdisciplinary exchange begun at this conference be continued both on a national and regional basis, and that significant action programs should result. Although it was not always evident how this end could be achieved, specific recommendations were agreed upon as the basis for the all important "follow-up" phase of the conference.

1. It is recommended that individuals, agencies, institutions, governments and professional bodies use every means

possible to promote further inter-disciplinary exchange both within the individual nations and between the various parts of the region through further conferences and exchanges at some regular interval, as well as informally between the delegates of this seminar.

This activity should result in the foundation of permanent working groups both at national and regional level. Each country should appoint a representative to attend to liaison and other interim affairs which arise between the present and any future conferences.

2. It is recommended that within the various communities, agencies and countries, means be actively promoted to assure an adequate exchange of data between the various disciplines, including scientists, engineers, architects and administrators. The gap between resource and program personnel must be bridged.

3. As education is the key to any significant long-term progress in this field, that all means, both national and regional, be used to provide basic professional and sub-professional technical training for additional staff and refresher courses for those now in practice. This should involve an exchange of professional and teaching staff within the region, for which funds should be made available by CENTO and/or Member Governments.

   Educational efforts should extend to the villages, and should promote the necessary awareness of the problem, and the provision of technologies and techniques better utilizing indigenous materials.

4. To provide essential equipment and further an exchange of personnel within the region, modest sums should be requested from existing regional funds. These should be supplemented by funds of the various national agencies.

5. It is essential that codes and regulations should be provided for small buildings as well as for professional designers, and all should be reviewed at intervals. These should include regulations for permanent structures in

urban areas, and simplified guides for village construction, utilizing indigenous materials for basic components and reinforcement. It is also essential that improved methods of enforcement be evolved and implemented at the earliest possible date for all urban structures, and that example and educational efforts be utilized in the villages for the same purpose.

6. An essential immediate and long-term program is expanded pre-planning for earthquake resistant structures and earthquake disaster response. All development activities in shock prone areas whether urban or rural, should involve consideration of site and structural conditions that will prevent damage in the event of an earthquake.

7. The Delegate of the United Kingdom proposed to adopt a resolution on the creation of a CENTO Association for Earthquake Studies with the establishment of an Ad Hoc Committee to be convened by Dr. Hossain Kashi Afshar and Mr. Kafiluddin Ahmed with Professor Dr. Murat Dikmen as Executive Secretary. As contacts between delegations have proved so useful that the delegates liked to ensure that it continued uninterrupted. The Resolution was adopted as seconded by the Delegate of the United States.

8. Improved means must also be found to respond to need following disaster - in particular a better utilization of available resources and self-help involvement of the earthquake victims in the controlled reconstruction of his community. This should include coordinated efforts through centralized control.

NOTE: Due to the fact that it is impossible to incorporate all the substantive comments and recommendations of the various panels in this summary report, reference should be made to the detailed recommendations following each panel presentation.

ACKNOWLEDGEMENTS

The Conference expressed its appreciation and gratitude to the Government of Turkey for acting as host to the Conference, and for the generous hospitality extended to the delegates.

The Conference also expressed its thanks to the United States Government for the role it played in organizing and financing the Conference and its appreciation for the excellent facilities and organization provided.

The Conference adjourned with an expression of appreciation to the Chairman and Vice-Chairmen for their leadership and able help towards the smooth working of the Conference and to the Secretariat for its efficient servicing of the meeting.

EARTHQUAKE PROBLEMS AND PROGRAMS IN TURKEY

(With Reference to Activities at Recent Earthquake Sites: Varto and Adapazari)

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INTRODUCTION

Anatolia has been an earthquake country throughout its history. Many settlements in various parts of Anatolia have been devastated by earthquakes, some several times.

Geological investigation shows that the land is cut through by fault zones, and the blocks on each side of the fault move both laterally and vertically. The North Anatolian Fault Zone especially exhibits an interesting feature which provides a field laboratory where tectonic movements can be clearly observed under quite suitable conditions.

Considerable movements along the fractures can be observed where the chain of mountains join the valleys accommodating major rivers flowing almost in east-west direction. The epicentres of the earthquakes in the northern part of Anatolia generally fall in this strip. As the rivers provide the required irrigation to the surrounding land, these valleys are mostly fertile with a population density higher than in other parts. Lower parts of the slopes of the chain of mountains offer a good route for highways, railways,

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energy, and communication lines; however, the land is exposed to periodical violent ground motions resulting in great damage.

The situation is not much different in the earthquake regions other than that of the North Anatolian Fault Zone. A high underground water table and thick alluvium layers increase the rate of damage. The tectonic movements often cause or at least accelerate such phenomena as landslides and rockfalls. The General Directorate of Highways spends a great amount of money for repairs and preventive measures to keep the routes free from slides.

A considerable percentage of the settlements in earthquake zones are apt to be exposed to flood disaster too, which brings about more problems.

GENERAL SEISMIC PATTERN

The existing seismic network does not cover all parts of Turkey. The stations were established recently and most of the data have to be macroseismic. Following is a list of the great earthquakes which have occurred in Turkey.

HISTORICAL BACKGROUND OF EARTHQUAKE PROBLEMS IN TURKEY

There is plenty of evidence in Turkey that many settlements have been exposed to earthquake disasters. Izmit, Izmir and Erzincan are examples. Earthquakes always attract a great public interest just after they occur. Costly activities are performed in emergency aid but soon public interest decreases and when it is time to rebuild not much consideration is given to earthquakes. In the past earthquake-resistant construction problems were considered only by clever and prudent individual builders who were few in number.

The first official seismic observations were performed in 1935 by the Kandilli Observatory (established in Istanbul in 1910). But there is evidence that actual observations were made before that by some religious men in the churches.

LIST OF EARTHQUAKES IN TURKEY

No.	Location of Earthquake	Date	Latitude (In degrees)	Longitude (In degrees)	h	M	I_o (MM)	Damage: Number of buildings collapsed	Damage: Loss of life	Ground Formation
1	Şebinkarahisar	2/9/09	40.0 N	38.0 E	60	6.75	7			Earth layer, gypsum and marl.
2	Denizli	4/4/11	37.86 N	29.1 E	140	7				Alluvial cones, gravel, sand, clay, conglomerate.
3	Mürefte-Şarköy	8/9/12	40.5 2N	27.0 E	0-60	7.75	10	5,540	216	River deposits, marine deposits, miocene.
4	Isparta-Dinar	10/8/14	38.0 N	30.0 E	0-60	7.1	9			Recent river, old river deposits, various formations.
5	Tokat	4/29/23	40 N	37 E		6.75				Alluvial, limestone, schist.
6	Van-Özalp	9/13/24	38.7 N	44.0 E	0-60	6.5	6			Earth layer, sand, clay, gravel, neogene.
7	Erzurum-Pasinler	9/13/24	40.0 N	41.7 E		6.5	8			Earth layer, volcanic tuff, agglomerate, andesite.
8	Torbalı	3/31/28	38.0 N	27.0 E	0-60	6.25	8			Earth layer, compact sand, gravel, gneiss.
9	Muş Ovası	11/12/34	39.0 N	41 E	0-60	6				River deposits, debris, schist.
10	Marmara Adaları	1/4/35	40.5 N	27.5 E	0-60	6.25	9		5	Alluvial, crystalline, granite.
11	Kiği-Karlıova	5/1/35	39.5 N	40.6 E	0-60	6				Earth layer, debris, old river gravels, andesite.
12	Kırşehir	4/19/38	39.5 N	33.7 E	0-60	6.25	10	4,066	155	River deposite, marl, crystalline
13	Dikili ve Kabakum	9/22/39	39.0 N	26.9 E	0-60	6.50	9	698	41	Recent marine deposits, agglomerate, compact lava.
14	Erzincan	12/27/39	38.7 N	39.7 E	0-60	8	11	29,000	40,000	Compact river deposits, various formations.
15	Afyonkarahisar	2/29/40	38.8 N	30.5 E	0-60	6				Sand, clay, tuff, agglomerate, gravel, volcanic.
16	Akdağmadeni	7/3/40	39.5 N	35.2 E	0-60	6.25	6			Marble, crystalline schist.
17	Manisa, Izmir	5/23/41	37.2 N	28.3 E	100	6	8			Debris, alluvial, andesite, serpentine, schist.

No.	Location of Earthquake	Date	Latitude Longitude (In degrees)	h	M	I_o (MM)	Damage: Number of buildings collapsed	Damage: Loss of life	Ground Formation
18	Van-Başkale	9/10/41	39.1 N - 43.0 E	0-60	6.25	8			Earth layer, sand, clay, gravel, neogene.
19	Erbaa	12/20/42	40.7 N - 36.6 E		7.3	10			Earth layer, gravel, sand, clay, neogene.
20	Adapazarı-Hendik	6/20/43	40.8 N - 30.4 E	0-60	6.25	9			All river deposits, marl.
21	Aydin	11/16/43	37.4 N - 27.9 E	100	6.5				Alluvial deposit, conglomerate
22	Samsun-Lâdik	11/26/43	40.7 N - 36.0 E	0-60	7.6	10	40,000	4,000	Marine depostis, under clay layer, volcanic rocks.
23	Çerkeş-Gerede	2/1/44	40.8 N - 32.4 E	0-60	7.4	10	50,000	4,000	Earth layer, alluvial, marl, sandstone.
24	Karaburun-Çeşme	7/23/49	38.6 N - 26.3 E		7	10	2,200	7	Marine deposits, volcanic tuff and limestone, marl.
25	Kiği-Karlova	8/17/49	39.5 N - 40.6 E		6.75	8			Earth layer, debris, old river gravels, andesite.
26	Çankırı	8/13/51	40.8 N - 33.4 E		7	9	3,354	50	Marl, sandstone, gypsum, serpentine.
27	Yenice-gönen	3/18/53	40.0 N - 27.3 E	50-60	8	10	500	250	Recent river deposits, old river deposits.
28	Kurşunlu	9/7/35	41.2 N - 32.8 E		7				Alluvial, clay, agglomerate andesite.
29	Çankırı	9/7/53	41.2 N - 32.8 E		6.25				Marl, sandstone, gypsum, serpentine.
30	Hınıs	3/28/54	39.2 N - 41.4 E		6.25				Earth layer, neogene marls, basalt.
31	Söke-Balat	8/16/55	37.9 N - 27.1 E		7.1	8			Alluvial, neogene formations.
32	Fethiye	4/24/57	36.3 N - 28.5 E	48	7.4	6			Alluvial cones, river deposits, marine deposits, various formations.

No.	Location of Earthquake	Date	Latitude Longitude (In degrees)	h	M	I_o (MM)	Damage: Number of buildings collapsed	Damage: Loss of life	Ground Formation
33	Fethiye	4/25/57	36.4 N - 28.56 E	53	7.8	8	3,000	18	Alluvial cones, river deposits, marine deposits.
34	Abant	5/26/57	40.67 N - 30.86 E		7	9		66	Various formations.
35	Bingöl	7/7/57	39 N - 40.5 E		6.5				Recent river deposits, old river deposits, volcanic.
36	Köyceğiz	4/25/59	37 N - 28.5 E		6.3	6	58		Alluvial, gravel, sand, silt, clay, lenses, serpentine.
37	Varto-Hınıs	10/25/59	39.4 N - 41.6 E		6.2	7		18	Earth layer, basalt, neogene marl, clay.
38	Yalova-Çınarcik	9/19/63	40.5 N - 29.1 E		6.5	8	43		Earth layer, neogene marl, sandstone.
39	Manyas	10/5/64	40.3 N - 28.2 E	10	6.5		4,000	19	Thick earth layer, neogene marl.
40	Varto	8/19/66	39.2 N - 41.6 E	6.8	9		20,007	2,279	Alluvial cones, alluvial and neogene marl, clay.
41	Mudurnusuyu Vadisi	7/22/67	40.6 N - 31.0 E	7.1	10		7,116	86	Various formations, crystalline.
42	Pülümür	7/26/67					1,280	97	Alluvial, clay, sandstone, marl, andesite, andesite tuff.

Until 1939 earthquake-resistant design was not studied seriously. That year the great Erzincan earthquake occurred: 40,000 lives were lost and 29,000 houses were destroyed or heavily damaged. The resulting disaster produced a great public interest and response of governmental and engineering authorities. Before this experience there were no earthquake-resistant codes. Soon after, an Earthquake Commission was formed, attached to the Directorate of Building and Reconstruction, of the Ministry of Public Works. This Commission initiated its studies by making a map of earthquake-danger regions and a temporary regulation for construction in these regions. At this time some other countries'regulations (including Italian, Russian and Greek) were translated.

The first code was promulgated in 1940. It was the "Temporary Regulation for Buildings in Earthquake Regions." In 1944 the "Regulation for Major Repairs in Earthquake Regions" was published. The first earthquake map appeared in 1945, although the existing regulation referred to only one region, with a horizontal coefficient of c = 0.10, which was considerably higher than today's regulation.

The First National Congress for Construction was held in May, 1948. Among various commissions, there were the Earthquake Commission and the Commission of Regulations for Construction in Earthquake Regions. The reports of these commissions led to the preparation for publication of another regulation in the next year (1949). In this regulation, the horizontal force had to be calculated according to the formula:

$$H = c\,(g+np) + \frac{W}{2}$$

i.e if the earthquake and wind forces are assumed to act simultaneously, the maximum wind force will be halved.

In March 1951 there was an agreement between the Technical University and UNESCO to establish a Seismological Institute. The next year it was realized. The same year, the Geophysical Institute was established within the University of Istanbul. In 1953, The Ministry of Public Works revised and improved the 1949 regulation. This time soil and building importance factors were considered.

Within the frame of Seismological Institute's program, a seismic station at Çine (1954), and another in Kastamonu (1957) were established (later, stations at Batman, Ankara and Erzurum followed).

In 1958 the Ministry of Reconstruction and Resettlement was established with Act No. 7116. The duty of dealing with all kinds of natural disaster affairs (including earthquakes) was given to this Ministry. The General Directorate of Housing was formerly responsible for this kind of work.

In 1959 Act No. 7269 for "The Measures and Aids in Relation to Natural Disasters, Affecting the Life of General Public" came into effect. This act is a major step in earthquake disaster response. It provides the government with proper resources and authority to act.

In 1961 the revised "Regulation for Buildings in Natural Disaster Areas" was promulgated. The difference were as follows: a) there were different coefficients for r. c. and steel frames, in respect to soil conditions, and b) there was an increase of coefficients.

In 1965 the organization for disasters assumed the form of the "General Directorate of Natural Disaster Affairs."

On August 19, 1966 the Varto earthquake occurred. Immediately after the disaster an Executive Committee was established. This Committee was given extensive resources for emergency and permanent housing.

Until the Varto earthquake the activities of the governmental authorities were in the form of aiding the survivors of the disasters. After the Varto earthquake it was accepted that research activities must be stressed. The Research and Investigations Board was formed in 1967. A few trained technical personnel formed the core of this board. It is hoped that the Board will develop and assume the character of a governmental research Center, cooperating with related universities and other institutions (in and out of Turkey).

In July 1967 the Adapazari earthquake occurred. In January 1968, a new Regulation for Buildings in Natural Disaster Areas came into effect. The most outstanding aspects of this regulation were consideration of dynamic properties of the structure and the adoption of triangular distribution of base shear. This time, three kinds of regional coefficients were taken according to the division of the existing earthquake regions map. In July 1968 an explanatory note was published, as an appendix to this. In July 1968 "The Criteria for Determination of the Causes Affecting the Life of the General Public" went into effect.

On July 17, 1968 new amendments were made to Act No. 7269 for "The Measures and Aids in Relation to Natural Disasters, Affecting the Life of the General Public." These amendments came into effect just a few days before this conference.

For an overall survey it would be very helpful to mention the educational activities in Technical University of Istanbul, Middle East Technical University, Institute of Earth Physics, Institute of Geology and Geophysics, Kandilli Observatory, etc.

Also we want to stress the help given by the United Nations, UNESCO and countries with experience in earthquake problems in the form of experts, fellowships and conferences.

GENERAL DIRECTORATE OF NATURAL DISASTER AFFAIRS

The responsibilities of the General Directorate of Natural Disaster Affairs are determined by Act No. 7269. The criteria for consideration is defined by the regulation (in compliance with the amended paragraph No. 1). Aid is based on the damage assessment conducted by the General Directorate. Twenty-year no interest loans are provided for rebuilding on the condition that plans and projects prepared by the Ministry are implemented. During construction the government supervises and applies the "aided self-help" method.

Among the duties of the General Directorate of Natural Disaster Affairs, are: provision of food, clothing, accomodation and medical treatment, geological and flood condition studies, determination of new settlements, mapping, planning, cadastre and application, etc.

Activities - Every year for the past six years, 84 disasters of various kinds have hit Turkey and 4,000 dwellings have been destroyed or heavily damaged. For the purpose of comparison, these disasters and short explanations are given below.

Organization - At present the following departments are connected to the General Directorate: 1) Department of Studies and Planning, 2) Department of Projects and Resettlement, 3) Department of Implementation.

The following three departments are connected to the General Directorate, through an Administrative Assistant General Director: 1) Department of Financial Affairs, 2) Department of Material Affairs, 3) Department of Procedures.

The General Director is also the Head of the Executive Committee, being assisted by two Assistant Heads (one central and one executive) and by a Technical Advisor for executive affairs.

The following are directly connected to the General Director: 1) Technical and Legislative Advisors, 2) Department of Methods and Coordination, 3) Research and Investigations Board.

1960-1965

Kind of Disaster	Number of Disasters	Number of Buildings Destroyed or Heavily Damaged
Flood	213	10,360
Earthquake	195	9,556
Fire	62	1,745
Landslide	23	839
Rock-fall	10	323
Snow	1	42
TOTAL	504	22,865

The procedure is such that the places that were subjected to a past disaster or are subject to a probable disaster are included in the studies program. The required studies are accomplished, and according to priority, included in that year's implementation program.

The implementation of the "aided self-help method" was initiated in 1959. Public facilities (roads, water, electricity and sewer installations) are also aided by the fund. But it is considered as a grant and not subject to repayment.

VARTO EARTHQUAKE

The Varto earthquake occurred on August 19, 1966 and caused great harm. The distribution of the losses according to provinces was as follows:

Province	Town	Loss of Life	Wounded	Houses Destroyed
Erzurum	Merkez	-	-	213
	Hınıs	124	183	7,056
	Tekman	-	-	590
	Çat	-	-	453
Muş	Merkez	32	40	3,116
	Varto	2,331	1,148	5,036
	Bulanık	-	-	775
Bingöl	Karlıova	30	40	1,839
	Solhan	-	-	295
	Kiği	-	-	60
Bitlis	Merkez	-	-	289
	Hizan	-	-	16
TOTAL		2,517	1,420	20,007

25,818 families needed aid.

Materials for temporary housing used

41,489 m.^{3} timber,
1,762 t. corrugated iron plate,
249 t. nails,

2,790 t. cement, used and transported to 307 villages
500 km. road was constructed for transportation.

As a result, (for temporary housing) 10,098 timber barracks, and 1,893 prefabricated houses were built. A total of TL. 35,446,575 in aid was given to 12,335 families; 10,560 tons of food was given; and 943 families were relocated.

For permanent housing - 9,815 dwellings were built.

ADAPAZARI EARTHQUAKE

The Adapazarı earthquake occurred on July 22, 1967. Although the magnitude is not less than that of the Varto earthquake, the rate of damage was less, due to the type of construction (timber frame and light roofs).

Province	Loss of Life	Wounded	Houses Destroyed or Heavily Damaged*
Sakarya	79	224	4,365
Kocaeli	1	-	110
Bolu	6	11	760
Bursa	-	97	-
TOTAL	86	332	5,235

(* These numbers do not contain the effects of aftershocks.)

Following several aftershocks, the number destroyed or heavily damaged was determined as 7,116.

After the Adapazarı earthquake, the "aided self-help method" was extensively implemented: TL. 48,500,000 was given to 5,569 families; 17,000 tons of cement; 26,000 m.^{3} of timber; 650 m.^{3} of lumber was used; TL. 4,500,000 spent for primary schools in 364 villages.

THE IMPORTANCE OF PREVENTION AND MINIMIZING EARTHQUAKE HAZARDS IN CENTO COUNTRIES

By
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On behalf of my Government I wish to express my sincere appreciation and thanks to the CENTO authorities for being conscious of the most vital problems and exigencies of the region in really assessing and evaluating the requirements connected with the safety and protection of the CENTO countries concerning the earthquake damage to life and property.

Out of some 300.000 shocks per year, either felt or not, occurring throughout our planet, some 3.000 are registered in Iran and more or less the same figure could be fixed for Turkey and Pakistan. This is due to the fact one of the strongest and the most severe seismic belts, the Alpide, crosses the three countries and from time to time casualties and heavy losses to life and property are imposed on the region.

The long tectonic line called "The North Anatolian Scar" continues through Iran and Pakistan. In the last 20 years alone the Farsinaj earthquake, the Lar earthquake, the Buyin Zahra earthquake and lately the Maku earthquake on the Iran-Turkish frontier have caused casualties of some 20,000 to 25,000 lives with earthquake magnitudes from 5 to 7.3. As assessed in Iran, the extent of damage during such catastrophes amounts to an average of 10,000,000 rials per year. The losses in other countries are more or less on the same order, if not heavier.

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The CENTO countries have launched development projects such as housing schemes, dam construction, communication systems, multistoried buildings, bridges, cross-country pipe lines, tunnel work etc. or similar projects involving capital investments of millions of dollars, the failure to undermine the devastating earthquake effects will continue to impose tragic consequences as long as the orogenic struggle in the active zones continue at one point and at one time or another somewhere else. The engineers and architects should through their cooperative plans design structures providing greater safety.

There is little likelihood that man will be able to predict in this century the occurrence of earthquakes accurately and the probability of being able to predict and control them is even more remote, but it is possible by a series of measurements and observations to locate areas where they will most probably strike. In such areas special building codes and regulations based on the study of the waves recorded by strong motion seismographs can reduce greatly the damage.

Since poor construction design and material is the major cause of destruction, the proper use of seismic codes of construction and their legal enforcement with proper construction materials seems to be the only scientific defense measure. The building regulations in the various active zones should be set by the responsible authorities and duly respected. To ensure proper application of these regulations, strict inspection and enforcement policies have to be established. The professionals in construction industries should be advised to contribute to the improvement of design and construction practices used in earthquake resistant structures. The tragedy lies in the fact that earthquake catastrophe is not only due to the poor quality and improper use of construction materials, but also to lack of proper antiseismic design and calculations incapable of resisting such earthquake movements.

When assessing the earthquake hazards in our countries, the damage caused to water mains, electric cables, gas pipe lines, lack of water to fight the fire, etc. cannot be ignored. In such cases exact and reliable figures for the loss of life and property damage, though difficult to evaluate, results in paralyzing the current activities of daily life and existence. Despite

these facts, the experience gained in the last half of the present century has demonstrated that we can learn to combat and resist these destructive forces of nature.

It has been only in the last three decades that by careful observation and study of the earth and the damage resulting from earthquakes during recent times that man has come to recognize earthquakes for what they are and their consequences can be. Briefly expressed, earthquakes as a phenomena are a dynamic rebalancing of the internal forces in parts of the earth's crust which have been subjected to stress through differential uplift, subsidence or lateral forces and shifting.

Each bit of information which has been gathered and accumulated through a systematic study and analyses of earthquakes has assisted today's engineers in assessing the ability of the present constructions and use of former centuries to provide reasonable safety from collapse or serious damage. Without such accumulated knowledge it would not have been possible in many parts of the world to design structures of modern civilization, skyscrapers, dams, tunnels, etc. with a reasonable degree of safety.

When earthquakes strike a major city, nature conducts an experiment for the structural engineer. It is an experiment, but uncontrolled and catastrophic. The information thus provided through such catastrophies is of great help to the structural engineer. Therefore, it is absolutely necessary to inspect the effects of major earthquakes in large cities and rural districts prior to their demolition or repair.

It is the knowledge that we gained from the failure of structures and the damage caused to construction in the historic earthquakes of Agader, Lar, Buyin Zahra, Varto, Skopje, and Anchorage that has given us valuable background information. The geological and seismological data thus gathered have helped us in setting forth the disciplines of earthquake engineering. Proper application of these diciplines present varied and unusual difficulties, especially in verifying the theories of strucutural response to earthquake forces by experiments. These precise experiments involve simulating the earthquake motions which ultimately can test the structural components both statistically and dynamically.

In order to cope with the objectives of this conference, a set of recommendations were put forward and it is hoped that during the meetings we will be able to discuss the possibility of carrying out these suggestions in the overall interest of the CENTO countries and the other countries of the Middle East and the Mediterranean Basin.

EARTHQUAKE PROGRAMS IN IRAN

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1. A National Committee has been organized with the title of "The Iranian National Committee for Earthquake Engineering" to encourage, guide and assist those interested in the field to promote the proper application and official recognition and use of antiseismic construction codes and earthquake-resistant materials.

2. Plans have been made for the establishment of a Department of Earthquake Engineering at Tehran University which will centralize all the problems connected with earthquake engineering such as research, training, antiseismic design calculations on construction and material.

3. The existing code which is really a working formula will be duly scrutinized and after modifications will be the official and legal operating code of the country.

4. In order to enforce the code, steps have been taken through the legislative channels to legalize the antiseismic construction code and the necessary regulations.

5. Cooperative programs are being planned with the Iranian Relief Organizations such as The Red Lion and Sun which is equivalent to the Red Cross and the Iranian Civil Defense Organization to meet the local requirements in cases of disaster.

6. The installment of some strong motion seismographs are in the process of study and budgetary arrangements.

7. The planned construction material and testing laboratory in Tehran will cooperate with the Earthquake Engineering Unit to effect the proper use of construction materials and ensure the necessary safety of the buildings in towns and in the rural development projects.

8. Cooperative plans have been drafted between the Institute of Geophysics, the Iranian Geographic Center, the Army Map Service and the Geological Service to study the regional topographical, geological and tectonic movements and changes.

9. Cooperative programs between the various responsible scientists such as geologists, geomorphologists, seismologists, geophysicists and geodesists are in the process of formulation whereby the detailed geological structures, the tectonics, seismotectonic and the geophysical characteristics of the crust and its behaviour could be investigated.

10. Since sufficient seismic data in the country are rather insufficient, plans have been made for the establishment of some new seismic stations in the cities of Kerman, Isfahan, Maku, Ghouchan and Zahedan.

11. The preparation of Earthquake Catalogues and a Systematic Seismic Zoning and the Regional Seismicity are in progress.

12. Sub-Committees of the corresponding National Committee for Earthquake Engineering are planned with a view to devise structural designs and coordinate the corresponding resolutions on all antiseismic problems.

MINIMIZATION OF DISASTERS: BRITISH EXPERTISE

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BRITISH INTEREST IN EARTHQUAKES

There have been many earthquakes in Britain, but they have not been serious enough to warrant including a seismic coefficient in our design codes. At the same time one must remember that building control is exercised throughout Britain and the general standard of construction is high. This means that the factor of safety inherent in our buildings is sufficient to take minor shocks. Hence designers working in Britain have no reason to take a deep interest in earthquake research.

However British engineers have a tradition of working overseas; hence a number of us have acquired some knowledge of the subject. The best evidence of this is that the International Association for Earthquake Engineering (IAEE) has a British National Section of about 120 members. The section holds four meetings a year in the Institution of Civil Engineers at which papers on earthquake subjects are presented and discussed. Other evidence of British interest includes the two seismological observatories at Kew (London) and Edinburgh and the research being undertaken at Imperial College, London.

REPAIRING BUILDINGS AFTER DISASTERS

Though we have never had to restore a shattered city after an earthquake we have experience of man-made disasters: the bombing of London during the last war gave us plenty of reconstruction and repair work. In those days the Building Research Station brought out a series of pamphlets on repairing buildings, the effect of fire on concrete, and similar subjects. Some of this work is directly pertinent to repairing buildings after earthquakes. Not all the work is applicable because repairs after bomb damage are intended to make the building strong enough to last the rest of its natural life: an assumption is that there will not be a second bomb in the same place. On the other hand a building damaged by an earthquake needs to be both repaired and strengthened so that it will resist the next earthquake.

One technique developed in Britain during the war was adapted for use in Skopje. Damaged buildings were strenthened by using a technique called "splints and bandages." It is used to repair brick or masonry walls. The old plaster is cut from some horizontal bands and vertical strips of damaged walls and reinforced plaster is fixed to them with gunite. Thus the walls are strengthened ready for the next earthquake.

BRITISH TECHNICAL ASSISTANCE

There are several ways in which help is offered through bilateral British Technical Assistance. After the 1965 earthquake in El Salvador three scholarships were given to engineers from that country to come to England and study the "splints and bandages" method of repairing buildings. Other scholarships have been given to nationals of various countries to attend the postgraduate course on engineering seismology at Imperial College, London. Another example is help with finance and staff to the Seismic Research Unit of the University of the West Indies in Trinidad. Other assistance includes providing model building legislation for tropical and other developing countries. This aspect will be discussed in more detail.

BUILDING LEGISLATION IN GENERAL

Building control is properly concerned only with the health and safety of people, particularly of the occupants of buildings: separate legislation should deal with planning control, and this includes all questions of amenity. Building control is exercised by determining, enacting, and then enforcing certain minimum standards: it is assumed that anyone building below them would endanger the health or safety of the future occupants of the building. These minimum standards include regulations covering structural safety.

Modern thinking is that many countries need several sets of regulations. The first set is intended for use by professional designers, and applied to all buildings. The regulations lay down what results are to be achieved and are followed by "deemed-to-satisfy" clauses which indicate techniques which will be accepted. To quote an example from the new English regulations, D. 8. "The structure of a building above the foundations shall safely sustain and transmit to the foundations the combined dead load and imposed load without such deflection or deformation as will impair the stability of, or cause damage to, the whole or any part of the building."

This regulation is followed by deemed-to-satisfy clauses including - "deemed-to-satisfy provision for structural work of reinforced concrete. The requirements of regulation D. 8. shall be deemed to be satisfied as to any structural work of reinforced concrete if the work complies with CP. 114:1957."

In addition there are schedules to the regulations which lay down the loading to be assumed on certain floors and the assumed periods of fire resistance of certain types of construction. In this way the professional designer has the maximum possible freedom: he must comply with the regulation, and the Code of Practice shows some ways in which he can do so. If he wishes to use a new material or technique he has to prove to the authority that it will meet the requirements of the regulation.

In some countries a second set of regulations is required for the small builder, to whom the words "Code of Practice" and "Period of Fire Resistance" mean little or nothing. The small

builder is a very important person because he constructs the houses in which 85 percent of the population live. For his work he needs both control and guidance. In this second set of regulations the actual regulations are similar to those in the first set, but say the same thing in more simple language. For example the regulation about walls might read:

1. "All walls shall be sufficiently strong to carry the expected loads on them without collapse or undue deformation and all external walls shall be waterproof:

2. Smooth interior surfaces shall be provided to all rooms, corridors and passages;

3. All walls shall be adequately connected to the parts of the building on which they abut."

Then the deemed-to-satisfy clauses are phrased as brief specifications, e.g. A masonry wall shall be deemed to satisfy regulation . . . If; being a wall of concrete or cement/fine aggregate blocks, 1) it is not less than 6 inches (150 mm) thick; 2) the blocks are mixed not weaker than 1:8 cement/aggregate; 3) the mortar is not weaker than 1:1:8 cement/lime/sand. Subsequent clauses deal with bonding, the maximum length between cross walls etc. Other clauses again deal with walls of stone, bricks, framed timber and concrete. In this way the small builder can select any one of several types of walling and use it.

A "small building" is defined as having not more than two storeys, with a total floor area of, say 1200 square feet (110 meters). It is worth mentioning here the legal point that the simplest way to introduce building regulations is to have an Act or Ordinance passed by the Central Legislature which empowers a Minister to make regulations and to apply any or all of them where he thinks fit. Subsequently the regulations are administered by the local authorities, each in its own area. It is a principle of law that one should never attempt to apply regulations where they cannot be enforced.

To draft building regulations is a slow and painstaking task, and in many of the smaller developing countries the pressure of work on the professionally qualified staff is so great that they

have no time to undertake it: and if they could spare some time they would not have the library and other facilities to collate what has been written elsewhere. In an attempt to help these countries the Overseas Division of the Building Research Station in England has produced some model regulations: it is the intention that these models should be carefully considered by committees of qualified persons in any interested country, and altered as necessary to suit that country. Much time is saved by the committees amending drafts which have already been prepared rather than starting from the beginning. These models include a Main Ordinance (or Act), Regulations for temporary housing areas, Regulations for small buildings, Regulations for the control of building operations for small buildings and Regulations for small buildings in hurricane and earthquake areas. No models have been offered for large buildings.

BUILDING LEGISLATION IN EARTHQUAKE AREAS

Turning to earthquake engineering, all engineers are mainly interested in large buildings and engineering structures. The design of major construction work is controlled by regulations which are - and should be - written for use by professional designers. It is a very interesting exercise to compare the regulations of the different countries which are seriously affected by earthquakes. Some few sets of regulations, for example New Zealand and Turkey, include rules written for the small builder, but in general he and his work are ignored.

At the Building Research Station in England we have not done any work on drafting earthquake regulations for use by professional designers: many experts in other countries are working on the subject. What we have done is to produce some model Regulations for Small Buildings in Earthquake and Hurricane Areas, and it is to this model that I would draw your attention today. The drafting has been done in this way. There was circulated in 1963 a set of model Regulations for Small Buidlings (in ordinary areas). This model included one chapter headed "Materials and Construction." What has been done since then is to re-write this chapter for seismic areas and for hurricane areas.

When drafting the deemed-to-satisfy clauses for seismic areas the object was to permit the construction of building which would be as cheap as possible consistent with a reasonable degree of safety. By this is meant that should a major earthquake occur during the life a small building it might crack but should not collapse and so kill the occupants. To achieve this object it seemed best to write three sets of deemed-to-satisfy clauses to each regulation which affects structural safety. The first set is intended for use in minor seismic areas with average to good ground. The second set is for use in both, a) minor seismic areas with weak ground, and b) moderate seismic areas with average to good ground. The third set is intended for use in both, a) moderate seismic areas with weak ground, and b) major seismic areas with average to good ground. It was felt that no general recommendations could be made for major seismic areas with weak ground.

Reference has been made earlier to the suggestion that any country which is interested in these model Regulations for Small Buildings should set up a committee to amend them to suit that country: it would be for this committee to decide which deemed-to-satisfy clauses should be used in each particular area.

Copies of any of the models mentioned in this paper can be obtained by any interested authority as part of British Technical Assistance. The work of preparing them forms part of the research programme of the Building Research Station.

CODE ENFORCEMENT

By
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The writing of an adequate, workable building code is a demanding technical task at best. Enforcement and administration of that same code may appear doubly difficult, and call for superhuman vision and courage. In a sense this is true, because workable codes call for two characteristics uncommon to the professional and to mankind at large - Simplicity and Consistency.

Simplicity

As it is not realistic to separate the consideration of a code and its enforcement, the two must be considered together. First, the code must be written in such a way that it can be enforced. It must cover all areas and items that might effect structural safety, habitability and health under all foreseeable circumstances. On the other hand, it must allow maximum flexibility to the designer and allow for changes in materials and technology without the need for frequent redrafting of the basic document. For this purpose, a performance, rather than specification code is desirable. Specifications for commonly used systems could then be in an appendix which would be added to as desired, but would not restrict innovation and development in the meantime.

In addition, the code must be written in the clearest, most concise and consistent manner possible to make accurate interpretation a simple matter for its users. While there is a certain

professional pride in using complicated technical terminology, which sets one apart from the layman, the first duty of the codes writer is to provide the basis for the design and construction of adequate shelter. Standards must be high enough to provide this "soundness and adequacy" while being low enough to allow them to be achieved by the lowest possible income groups.

Once we have achieved this first apparent miracle, we must next create a mechanism through which our code may be translated into drawings and specifications, and then into a useful shelter. Here again, our key concepts of simplicity and consistency must apply at each stage of administration and enforcement - design adherence to code, granting of building permits, supervision, inspection, recording and where necessary, legal action.

Design Adherence to Codes

Adherence to codes during the design phase is primarily the responsibility of the architect and engineer, which calls for a thorough grasp of available technologies and resistance to pressures of time, economics and whims of the client - among other things. Assuming the perfect code and the perfect professional, who would oversee the laying of every brick and the driving of every nail, we could theoretically adopt an "honour system" and cease to worry about code enforcement. We must face the reality, however, that even the best of codes and professionals are not perfect and that a high percentage of single family housing, which is a major concern in earthquake resistant construction, is designed and constructed by the builder or householder without benefit of architect or engineer, and often without a real understanding of systems and techniques.

Here the consistent, easily understood code comes into its own, easing the task of the professional designer, and making possible some reasonable control of all permanent housing. To this end, codes must be readily available to all interested persons, either free of charge or at some minimal cost. No one can be expected to adhere to something to which he does not have access. This is another argument for a concise document, on purely economic grounds.

Granting of Building Permits

There are two basic dangers in any system requiring building permits. First, this may be thought of as merely a means of collecting revenue, with little or no concern for the quality of plans or the resulting structure. At the other extreme is the system which becomes so lengthy, complex, and demanding of professional staff that construction is effectively and consistently discouraged. It is somewhere between these extremes then, that we must find our solution.

Part of the answer lies in placing legal responsibility on the designer for seeing that the code is adhered to in the drawings and specifications, and that adequate supervision is provided during construction. This does not rule out the necessity of some technical review, and for the retention of drawings and basic calculations as part of the record in case of need. It does mean that structural failure from any cause, including earthquakes, places the designer in a position of accountability.

For those who do not or cannot use the services of a professional designer, part of the answer lies in making available a variety of suitable "stock" plans which would carry automatic approval if built without change, and to which modification could be made with prior approval.

The cost of securing building permits should vary according to need, with a very nominal charge to low income builders. Places for submitting application should be decentralized and readily accessible to the average person. This could be handled through some established office such as the postal service. Reviewing and recording staff should be salaried rather than depending upon fees for a livelihood, in order to encourage consistently acceptable practices.

Supervision

For all structures designed by a professional, supervision, either direct or through a clerk of works, should be handled by the designer. Here the legal responsibility should be shared by the contractor, with some system for establishing his capability to carry out the project in question. This should be determined by the designer before the project goes out for bids.

While it is not always technically possible to provide professional supervision for rural and small urban construction, all means possible should be employed to encourage acceptable practices. This might well include courses for small contractors in interpretation of design data, improved technology and business practices, such as keeping a simple but adequate records system.

Inspections

While in practice it would apply mainly to larger urban projects, an adequate inspection system is an important part of code enforcement. Inspection at foundation and completion stages is not enough. The placing of steel and mixing and concrete placing practices are important to the earthquake resistant characteristics of the finished structure, and should be reviewed on some regular basis, as should the quality of masonry or other structural components.

The cost of such additional inspections could be handled through the fee system or be a part of the construction or long-term funding, as it is in the interest of the investor or guarantor to assure a sound, permanent structure.

In rural areas inspections could be a function of some locally competent artisan, or in the case of structures such as schools and other public buildings, of the public works or other central government services.

Records

Records need not be extensive nor burdensome. On the other hand, they should contain any available design data (this could be simply a numerical reference to type in the case of a "standard" plan), and names of designer, contractor, materials suppliers, etc. who have any significant responsibility for the structure or its components. This would also include the results of any required tests, such as concrete and block compression strengths.

In all but the more complex structures, a carefully designed single sheet form plus any drawings and specifications would be sufficient. Numerous duplicates are burdensome and wasteful.

Following completion of the structure in question, a single copy in the central office of the responsible institution should be sufficient for bureaucratic purposes. In addition, the designer should be required to retain complete design data in his own files, as is normally done.

Legal Action

The use of legal action is based upon, 1) legislative or other established procedure, and 2) a willingness to use this power in all necessary cases in an impartial manner. The latter is by far the most important, although a recognized but simple legal procedure is a necessity.

Legislation and procedure should be a function of the central government to assure uniformity and prevent conflict where designer, contractor, owner, and actual structure may be from or in two or more municipalities, regions or states.

Investigations should be the responsibility of a single institution, as overlapping or inter-related agencies tend to cause unnecessary delays and a proliferation of unnecessary paper.

A branch or department of the same institution should constitute a "court" to carry out hearing and impose any necessary penalties. The use of the general courts is often the accepted procedure, but this tends to impose delays. Again, to prevent unnecessary delay, definite time limitations should be placed on appeal proceedings.

Needless to say, penalties, where indicated, should be consistent and in keeping with the extent of damage, loss of life or injury,etc. To this end, bonding and insurance companies should be consulted during the formulation of the system and should be included in any legal proceedings. Where bonding and/or insurance processes are not generally used, these should be encouraged, with the necessary safeguards to assure reasonable fees and services.

While sometimes an unpleasant or unpopular move, the use of available legal processes, where called for, is a necessary step if the enforcement and administration of codes is to be

meaningful. To be believed, a concept must be practiced. A wall which must be torn down and replaced during the construction process, or compensation which must be paid for damage due to negligence in design or fabrication is soon heard of and heeded by others in the construction industry. While basically conscientious, the pressures of time and economics sometimes tempt the technician to become careless. A forceful but just system of code enforcement is, therefore, the best insurance against structural failure due to earthquake or other forces. In addition it assures a quality product, in keeping with the necessary investment in time, manpower, and money.

Cooperation

In addition to the characteristics of simplicity and consistency, a major key to code enforcement is cooperation by all concerned. Architect, engineer, client, builder, materials supplier, financier, codes official, municipal official, legislator, lawyer, and insuring agent are among the many persons directly interested in the question of codes and code enforcement. Each must understand his role in the process and be willing to negotiate, and where necessary, compromise on less important points in order to achieve and maintain a system of codes enforcement that is respected by all, and will result in better structures and less loss of life and property due to earthquake and other damage.

Cooperation also means an adequate use of available resources. In many areas adequate codes exist, and are often supplemented by the necessary legislative authority. In some cases various factors, including misguided vested interests and political considerations make these resources ineffective or cause them to be ignored. In others the fear of high costs and an additional bureaucracy delay implementation of this important function. If simplicity, consistency, and cooperation are properly adhered to, the legitimate interests of all will be served at a reasonable cost and with a minimum of bureaucratic "red tape."

PROBLEMS OF IMPLEMENTING EARTHQUAKE CODE REQUIREMENTS IN IRAN

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Regulations designed to protect buildings against earthquakes are a new provision in Iran. The first tentative regulation was prepared by a special committee in 1964. This regulation came into effect in 1967, as the Iranian Antiseismic Code, after minor revisions by another committee. The Code is divided into 2 chapters and 63 clauses.

The first chapter of the Code sets forth the regulations for ordinary masonry buildings, defined as buildings of less than three stories, or less than eleven meters high, and the second chapter contains regulations for those buildings which are more than three stories high, or which are otherwise outside the provisions of the first chapter.

Most buildings in the cities of Iran are of brick masonry, and are two to three stories in height; however, recently buildings of five and six stories can be observed which have been constructed of ordinary masonry without any structural frame. Thus, in framing the Code, we have limited the number or stories and the height of all masonry buildings.

Although brick is not itself an aseismic material, for reasons of economy it is necessary to use this material in Iran for ordinary buildings; so in addition to limiting the height of

this type of construction, we have also had to provide certain aseismic reinforcements.

The floors which are used typically in ordinary buildings in Iran are constructed with steel I-beams filled out with brick jack arches. We can never assume this type of floor as rigid, because it can be deformed, and is not capable of transferring lateral forces to different elements. Again, however, for several reasons, such as simplicity of erection, resistance to change and lack of training of the masons and laborers, and because of economic considerations, we do permit the use of this type of floor when it has been properly reinforced. These reinforcements will be explained in Panel I of this conference, where "Earthquake Problems of Small Buildings and Dwellings" will be discussed.

Further provisions of chapter one of the Iranian Antiseismic Code concern limitation of the size of openings, minimum wall ratios, and similar requirements, which will also be discussed in Panel I.

Buildings higher than three stories, or eleven meters, should be constructed of reinforced concrete or steel frames under the provisions of this Code. Buildings higher than forty meters must have complete moment resisting frames capable of resisting at least 30 percent of the total earthquake force on the building. For buildings less than five stories or less than eighteen meters high we have endeavored to provide coefficients for simplified seismic calculations of the frame. Structures of this height are frequently built in Iran. It is possible to establish exact seismic coefficients for these buildings, regardless of their fundamental periods; the coefficients range between 0.08 and 0.125 depending on soil conditions and whether the building is intended for public or private use.

Under the Code, for buildings higher than five stories or eighteen meters, the seismic coefficient should be determined with consideration of the fundamental period of the building. In these buildings, we use the formula $c = \frac{0.025}{T}$ in which T is the fundamental period of the building. It may be assumed that $T = 0.09 \frac{H}{\sqrt{D}}$ in which H is the height of the building above the

ground in meters and D is the width of the building in the direction under consideration in meters. The value of C should not be less than 0.03 and not more than 0.10.

As to the distribution of the earthquake force, we decided for the Code that the forces in buildings of three stories or less should be considered uniform over the height of the buildings, and for buildings of more than three stories should be considered a triangular shape.

In the Iranian Antiseismic Code, special attention has been paid to the seismic coefficients for particular parts and elements. For example, the seismic coefficient in any direction for cantilevered parapets and exterior and interior decorative elements is taken as one, and for chimneys, towers, tanks, etc., when connected to the building, as 0.020.

It should be pointed out that all the requirements of the Code mentioned, including the provisions of the Code's chapter one for low buildings are not applicable to rural buildings, and special additional regulations are required for the methods of construction prevalent in the countryside.

Because of economic problems, the shortage of skilled labor, and various local conditions, housing in the rural areas of Iran is constructed by the people themselves, and the materials they employ for this purpose are commonly clay, rubble stone, and sun dried bricks. There is therefore, a special need for antiseismic protection in these buildings, and for a set of regulations for this type of construction.

I am looking forward to the success of this conference in finding solutions to the problems presented by these rural buildings, and in planning a long term program to improve the rural buildings of the region.

PROBLEMS OF IMPLEMENTING EARTHQUAKE CODE REQUIREMENTS IN PAKISTAN

By
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There was no regular building code in the Indo-Pakistan continent before 1935 to guide engineers and architects in the proper design and construction of buildings, which could afford a reasonable degree of safety both to the occupants and to the passers-by in the event of an earthquake.

The attention of engineers and administrators was drawn to this subject after the historic earthquake which devastated Quetta and the surrounding country in May 1935. It was one of the most disastrous earthquakes that has visited our country within historic times. The tragic irony of the disaster lay in the fact that although it occurred in the least populated district of Pakistan, it happened to strike that area at its most populated point causing great damage to life and property.

This area experienced a similar kind of earthquake in 1931 and though it was slightly less in intensity than the one at Quetta, it provided an opportunity for people to think about earthquake-proof houses. It became obvious during the earthquake of 1935 that buildings must be designed and built which could resist the destruction caused by earthquakes. The structures which were built after 1931 to resist earthquakes remained intact to a large extent, saving much life and property. Most of the buildings which were built with ordinary specifications completely crumbled, killing 30,000 people.

It was realized that the major part of the destruction in the city was due to two causes; inferior construction and the height of the buildings. Either alone was bad enough, but the combination of the two was disastrous. An example of this combination was a town hall which was built of burnt bricks with mud mortar and was composed of two high stories completely crumbled, while small electricity sub-stations which were built of lime mortar and were smaller were only slightly cracked.

It was the view of the Commander-in-Chief after this earthquake that the Army in Quetta should not again be exposed to the risk of another calamity such as befell the city in 1935. It was thought that this end could be most easily attained by having no city at all. It seemed, however, that it was impossible to avoid having another city of some kind associated with the future Quetta Cantonment and it therefore became necessary to ensure that the new city did not present the same risks to future earthquakes that the last one did.

It was apparent that the destruction in the city was due largely to the inferior construction of the buildings. Since the temperament of the average local builder is to take risks by economising at the expense of safety, it seemed probable that another similarly built city would eventually spring up and again become a source of danger unless steps were taken to control the building construction. It was thought a definite Building Code should be drawn up which could be strictly enforced. The enforcement of such a code would ensure that new buildings would be reasonably earthquake-proof.

The buildings which were then in existence were broadly classified into the following categories:

1. Reinforced cement concrete buildings with RCC structural frame work, both vertical and horizontal members tied together with no weight bearing walls.

2. Reinforced burnt brick buildings with RCC bands and ties at foundation, plinth, lintel and roof level.

3. Combination of 1 and 2.

4. Hutted buildings (temporary balli framed construction).

5. Pre-1935 buildings (very few in existence).

The earthquake gave the engineers an opportunity to examine the stability and resistibility of the above mentioned structures against the seismic forces for which they were designed before the earthquake. These buildings were monolithic i. e. all the parts were tied together in such a manner that the structure acted as a single unit.

A close inspection of the two storied buildings such as Orchard House, Residency, Chiltan Hotel, Secretariat and Circuit House, revealed that with the exception of one or two hair cracks in two beams, there were no other faults in the structural frame work. These hair cracks were carefully examined and found not to extend deeper than the concrete covering of the beams.

In Orchard House the hair cracks in a beam occurred at a distance of two feet from the supporting columns on either side. The top wooden floor was opened up and it was noticed that there were no cracks on the top surface of the beam or floor slab. These hair cracks had occurred owing to the shear forces produced by the hammering of the building. Necessary grouting was carried out and since then no further development has been noticed, although there have been further minor shakes.

Hutted buildings - These were constructed with ballis frames and stood up very well.

Pre-1935 buildings - These buildings were badly affected at the joints between cross walls and long walls and were declared unsafe for residential purposes.

It was further noticed that the buildings were built too close to each other and the streets and highways were very narrow, with the result that it made rescue operations extremely difficult. The streets were blocked with debris and one house fell over another. Many people were killed who could have been saved had these buildings been built at a reasonable distance from each other and if the roads and streets had been wide enough to facilitate the movement of rescue workers.

Rabbit netting was used in plaster which fell on people during the earthquake either from the roof or from the walls, thus completely restricting movement, and lime dust choked and suffocated people. This small thing turned out to be a very big hazard during the earthquake.

BUILDING CODE

The Municipality of Quetta laid down a Building Code which was brought into force February 31, 1937. The Army authorities also issued a similar kind of Code in May 1938,for earthquake resisting structures.

The Building Code of Quetta Municipality lays down the following types of earthquake proof buildings:

TYPE 1 - Steel frame, one or two storey.

TYPE 2 - Pucka brick or concrete block masonry reinforced vertically and horizontally - single storey.

TYPE 3 - Reinforced brick work,cheap design - single storey.

TYPE 4 - Timber-framed with panels of brick-nogging or other material.

TYPE 5 - All timber superstructure.

TYPE 6 - Framed with lath and plaster.

TYPE 7 - Timber or steel frames with corrugated iron sheets.

TYPE 8 - Rough ballie framework with pise work.

In Type 1, 2 and 3 it is desired that the foundation should consist of a continuous frame of reinforced cement concrete which gives a very rigid base and in Type 4 to 8 the foundation may consist of ordinary cement concrete.

In Type 1, steel-frames should be designed to carry all superincumbent loads and to resist a lateral force on any member equal to one-eighth of the load both live and dead. The columns must have properly designed feet of ample proportions and must be securely bolted to the foundations. All joints should be properly bolted or riveted in position and should have corner gusset plates large enough to resist distortion due to the lateral forces mentioned above.

Plinth masonry should be of pucka brick work or cement concrete blocks not weaker than 1:3:6 set in cement mortar 1:3. It should be finished off with a cement concrete band (1:2:4) containing two 5/8 inch rods for preventing disruption. This band should be of the full width of the masonry and not less than 6 inches in thickness. The top of the plinth should not be more than two feet above ground level.

Superstructure - The walls should preferably be made either of cement concrete blocks (of a mixture not weaker than 1:3:6) or of first class pucka bricks, set in cement mortar (1:3) and reinforced with a suitable reinforcing fabric in every fourth course or with two rows of hoop iron not less than 1/2 inch x 1/8 inch spaced 1 inch from each face at intervals of not more than every eighth course or at such lesser numbers of courses as may be required to resist the seismic effect on the wall. The reinforcement in every case must be securely fastened to the steel frame. The thickness of the walls should not be less than 9 inches for single storey buildings, and for the upper storey of two-storey buildings, the lower storey in the latter case must not be less than 13 1/2 inches but the controlling factor is the necessity for safety against an acceleration of 4 feet/sec.^{2}.

The roof should be of reinforced concrete of approved design or it may be pent roof, provided always that the main building is designed to be stiff enough without any help from the roof.

In Type 2 and 3, the walls should be similar and either a reinforced concrete roof can be laid or it can consist of: a) corrugated iron sheets, b) corrugated cement asbestos sheets on boarding, c) flat iron sheets made up to the Naini Tal pattern, d) timber boarding with roofing felt.

In Type 4 to 8, the walls can be of masonry up to about 3 feet height and the balance portion up to the roof can be of ballies, corrugated iron sheets, etc. The roofs can be similarly of corrugated iron sheets or any other cheaper material.

The height of buildings except in the case of Type 1 should be restricted to 8 feet to 13 feet and in Type 1 it can be 27 feet.

The size of the rooms is also restricted to a maximum width (or least dimension) of rooms without internal columns to 19 feet for Type 1 and for Type 2 the rooms should not have dimension larger than 13 feet and longer than 16 feet. It should have central pillars if larger dimensions are used. In the other types there is no restriction on the size of the rooms. Probably it is envisaged that people would not ordinarily build large rooms to these specifications.

PROBLEMS OF IMPLEMENTING EARTHQUAKE CODE REQUIREMENTS

The areas which have been visited by severe earthquakes during the last century are:

1. A belt of about 150 miles long between Srinagar and Peshawar, lying slightly to the north of Peshawar. Srinagar was visited by a severe earthquake during 1885 and a place about 80 miles northeast of Peshawar was also affected. This belt passes through the Murree Hills.

2. Mach

3. Chaman-Quetta-Kalat and the adjoining area towards the southeast of Kalat

4. Cutch.

There is no Code for the construction of earthquake resistant buildings in the Murree Hills. This area has not been affected by a severe earthquake but does experience small tremors and land slides. Most of the buildings show signs of failure. Walls are usually cracked. Roofs are usually made of corrugated sheets, therefore, much damage to human life and property cannot be expected but still it is very necessary that some sort of uniform building code be laid down for the construction of houses in this area.

There are not very many people living in Cutch and as most of the area has gone to India, probably it would not be economical for Pakistan to enforce any code in this area. People living here are usually extremely poor and cannot afford more than low mud huts with thatched roofs. If a earthquake strikes much damage is not expected as the area is extremely thinly populated.

Most of the attention is being paid to the buildings which are being built at Quetta and Kalat proper. These places are the Divisional Headquarters in ex-Baluchistan. In Quetta the Code is being enforced by the municipal engineer who is assisted by a building inspector. The municipal engineer is supposed to inspect the buildings at various stages of construction as laid down in the Code. It is not possible for the municipal engineer to visit every building himself and, therefore, the work is entrusted to building inspectors who are not qualified engineers. It is feared that proper technical guidance is not readily made available to the ordinary builders. It was probably due to this reason that some of the buildings showed signs of failure during the earthquake of 1955. It is, of course, rewarding that due to the formulation of the Code and its enforcement by the municipal engineer there was very little damage to life and property during the later earthquakes.

Even though it is laid down that for Type 1 structure, steel frame structures would be used, rarely is this specification enforced for multi-storied buildings. The cost of steel is exorbitant in our country and, therefore, steel frames are being replaced by reinforced cement concrete structures. The columns and the roofs require careful consideration since the weight of such structure would considerably increase and in the event of an earthquake a greater factor of safety would be required against the horizontal forces. It is necessary that some sort of detailed specifications be laid down if R. C. C. structures are adopted, as is being done now.

Little attention is being paid to Type 4, 5, 6, 7 and 8 houses. Most of our population lives in these houses and it is necessary that the codal formalities be rigidly applied to these houses.

People are not properly educated to observe the code formalities. There is no Master Plan for Quetta indicating the land use. Thought should be given to this aspect so that development of the cities could be properly regulated and building lines be demarcated.

The Code is not being enforced in the rural areas at all. It is frequently stated that the construction of earthquake proof houses in the ordinary villages is difficult on account of cost. People of Mach and Kalat suffered quite heavily during the last earthquakes and it is necessary that the villagers be properly educated about the construction of earthquake proof houses and technical know-how should be imparted to them through the village elders. Material should be made available to them at cheaper ates until they are convinced that such structures are essential for their safety.

In Quetta a new township is developing on the other side of railway line. Some of the houses are pucka, but most of the structures consist of mud walls and thatched roofs. These buildings have not been built to resist the destruction caused by earthquakes and it is feared that in case these structures fail, there would be much loss of human life and property. The Municipality is probably unable to enforce the Code in this area, as there is no strict force of law behind this Code. The people are poor and it is not possible for them to afford to build earthquake proof structures. The government might consider giving some sort of subsidy to these people so that they could build safe houses.

The new areas are not being developed properly; the streets are narrow and it is imperative that proper land use plans be prepared by competent town planners. The houses should be built strictly in accordance with these plans. There are no proper water supply arrangements and in the case of fire there would be great difficulty in controlling it.

The structures which are being built by the government need very careful consideration. These are usually multi-storied structures and are exempt from the enforcement of the Building Code. Some sort of authority should be created which would check all the structures and this authority should not be directly under the influence of the municipality and the government. The design of the buildings should be checked by independent agencies and there

should be periodical checks by this authority during the construction of the structures, as is being done by the municipality for private structures. It would probably be worthwhile to consider that the government buildings be built of steel, which can resist better the seismic effect of the earthquakes.

Little attention has been paid to structures which are being built in Kalat and surrounding areas. A uniform building code for all of this area, i. e., comprising the Quetta Division and Kalat Division should be formulated and enforced by an Act.

In the end I would say, the big problem in the implementation of this Code is the meagre resources of the people, inadequate supply of cement and steel, and lack of appreciation of the situation by the ordinary builders.

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PROBLEMS EXPERIENCED IN IMPLEMENTING EARTHQUAKE CODE REQUIREMENTS IN TURKEY

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INTRODUCTION

It is not an easy problem to analyse in detail the maximum effects caused by vibrations during earthquake movements at a certain part of the construction. It is a dynamic problem and many factors need consideration. When we have to construct buildings of different types, in large numbers and in a wide area, we cannot expect all the engineers to devote their time to such calculations. We have to establish some practical rules that can be understood and implemented by the designers. The rules must be simple yet adequate to provide strength and economy. Earthquake codes and earthquake-resistant regulations are the practical tools which can help assure the existence or at least the construction of sound buildings at reasonable cost.

Some approximations are unavoidable in this kind of work since all the buildings (or constructions) similar to the considered model would not have similar properties. A reasonable rate of damage to buildings resulting from earthquakes must be expected. But the regulations must assure that in no case will there be loss of life. If some unimportant parts of the building were damaged, but the load bearing system strong, the regulation should not be blamed.

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Here I would like to refer to Professor Sakai's simulation in expressing this concept: the buildings must be like "tokage." "Tokage" means lizard in Japanese; if it were caught by its tail, the tail breaks but the body escapes safely.

If all the buildings in a certain area were built according to the regulations, when a severe earthquake strikes, the differences in damage rates would be due to other factors (such as workmanship, material and cases not covered in the regulations).

BACKGROUND OF EARTHQUAKE CODES IN TURKEY

Initial studies on earthquake codes in Turkey started after the Erzincan earthquake in 1939. In 1940, the first code appeared. The first earthquake regions map was printed in 1945. The regulations sequence is shown in the following list:

Year	Title
1940	Temporary Regulation for Buildings in Earthquake Regions
1944	Regulation for Major Repairs in Earthquake Regions
1949	Building Regulation for Earthquake Regions in Turkey
1953	Regulation for Buildings in Earthquake Regions
1961	Regulations for Buildings in Natural Disaster Areas
1968	Regulations for Buildings in Natural Disaster Areas

The above list shows the regulations were revised about every five years. The existing earthquake regions map came into effect in 1963. Turkey is divided into four zones on this map: 1) first degree earthquake zone; 2) second degree earthquake zone; 3) third degree earthquake zone; 4) earthquake danger-free zone.

It is notable that, in the regulations of 1961 and 1968, provisions relating to fire and flood disasters are also included. But at the present time no map or other means of illustration is used except the cards prepared after each disaster based on the report of the expert group that studied the case.

The landslide disasters exhibit an interesting feature. We do not have a map showing the regions most liable to this type of disaster. A preliminary survey of the existing cases showed that there is a close similarity between landslide distribution and that of earthquakes. We can claim that the locations subjected to flood disaster coincide fairly well with the earthquake regions, especially first degree quakes, because these regions are generally depression valleys, accommodating major rivers. We can say also that the earthquake regionalization map represents the distribution of disasters in general. We can even extend this generalization to fire disasters as the forest map of Turkey somewhat resembles this map except for the eastern part of Turkey.

As the implementation of codes closely depends on this map, we think it is better to discuss the map problems first. This map was prepared by a group of experts considering both the macroseismic data and geological aspects. For ease of implementation the borders of districts (bucak) and towns were followed as the border line between earthquake regions. Therefore, towns and in a few cases districts, were considered as entities that cannot be divided. This principle apparently created some problems of illustration where there is a steep change in conditions with respect to earthquakes. In such cases the border lines cannot come close enough together. In some parts of the map it is possible to see that first degree regions neighbor danger-free regions. This does not seem logical and is criticized by a number of experts.

Where the towns are extraordinarily large, they were necessarily cut by the contours; but in a number of cases this segment of the contour is not defined except in the illustration on the map. It creates some problems in determining the earthquake region to which the location belongs. Of course this is a formal problem; the decision could be made depending on local soil conditions which are actually more important.

ENFORCEMENT OF THE CODE

Act No. 7269 "Measures and Aids in Relation to Natural Disasters Affecting the Life of General Public" came into effect in 1959 and was amended in 1968.

Paragraphs 1, 2 and 3 provide:

Paragraph 1 - The provisions of this Act are applied when it is determined that due to such disasters as earthquakes, fires, flood, landslides, rock-falls, avalanches, etc., structures and public facilities are damaged or probably will be damaged and "affects the life of the general public."

The Council of Ministers, on the proposal of Ministry of Reconstruction and Resettlement, determines whether the disaster "affects the life of the general public." The Governor of the province where the disaster occurred is fully authorized to take immediate measures in compliance with the provisions of this Act.

Paragraph 2 - The regions that are subject to disasters such as earthquakes, landslides, floods, rock-falls, avalanches, etc., are determined by the Ministries of Reconstruction and Resettlement, Public Works, National Education, and Agriculture, jointly approved and promulgated by the Council of Ministers.

The areas subjected to fire disaster are determined by municipal assemblies in cities and towns, by village assemblies in villages confirmed by town governors and province governors and promulgated.

Paragraph 3 - The technical conditions for all public and private structures to be constructed or repaired in the disaster regions are announced in compliance with the provisions of Paragraph 2 of this Act and are determined by a regulation prepared by the Ministry of Public Works, jointly.

In settlements where a municipal organization exists, the provisions of this regulation shall be considered in issuing construction permissions. Where there is no municipal organization the village assembly is responsible for the implementation of this regulation. The constructions not being built under the provisions of this regulation shall be destroyed in accordance with the provisions of Paragraph 13 of this Act.

As seen in Paragraph 3, municipalities are responsible for the implementation of the code, through approval of the designs on the basis of its conformity to the provisions. This means that

municipalities must have enough qualified technical personnel specialized in the field of earthquake-resistant construction. But a survey of the distribution of municipalities (based on 685 of them), shows that they are not capable of carrying out this responsibility properly. Of the 685 municipalities 56% had no technical personnel concerned with earthquake construction, 38% had one, 3% had 2, 1.5% had 3, and 1.5% had more than 3. Of the technical personnel involved in building codes 6.3% had no technical education, 20% had primary or middle school education, 4% had high school, 32% graduated from building or construction schools, 31% from other types of technical schools, and only 7% from universities.

Where there is no municipal organization, village assemblies are responsible for the implementation of the code. Not much competence can be expected because of the lack of technical personnel in the municipalities.

Simple codes, depending mostly on illustrations, may prove a good approach. Education through local construction courses, demonstrations, distribution of posters illustrating how to construct one or two storey earthquake-resistant, announcements on the radio, movies, and newsletters would be helpful. When the people are aware and interested in the effects of earthquake disasters, the need for safety will stimulate them to seek ways to avoid such great loss of life and property. Every effort must be made to make them aware.

A NOTE ON THE SEISMICITY OF WEST PAKISTAN

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The three main subregions of West Pakistan, the mountain arcs of Baluchistan and Himalaya, the Indus alluvium and the Peninsula, are very different in structure and geological history. About 30 million years ago, the mountains began to rise and at the same time they began to push the foredeep against the stable Peninsula, folding it and causing downwarping. The foredeep became filled with the products of erosion. From Figure 1 it can be seen that the Himalayan arc appears to be pressing southward toward the Peninsula while the arcuate structures of Baluchistan are pressing toward the Peninsula from the west. It seems as if the mountain structures, convex toward the Peninsula, press on it, compressing the Indus alluvium against the stable Peninsula.

As a result of this compression of the Indo-Gangetic alluvium, and most probably because of the gradual subsidence of the foredeep at the foot of the mountain arcs, the Siwaliks and the older rocks beneath them have been folded against the mountain masses and have been strongly downwarped into the trough close to the foredeep. This thrusting from the northeast and west can be seen in places where older beds have been thrust over younger rocks or where their bedding is now found to be almost vertical.

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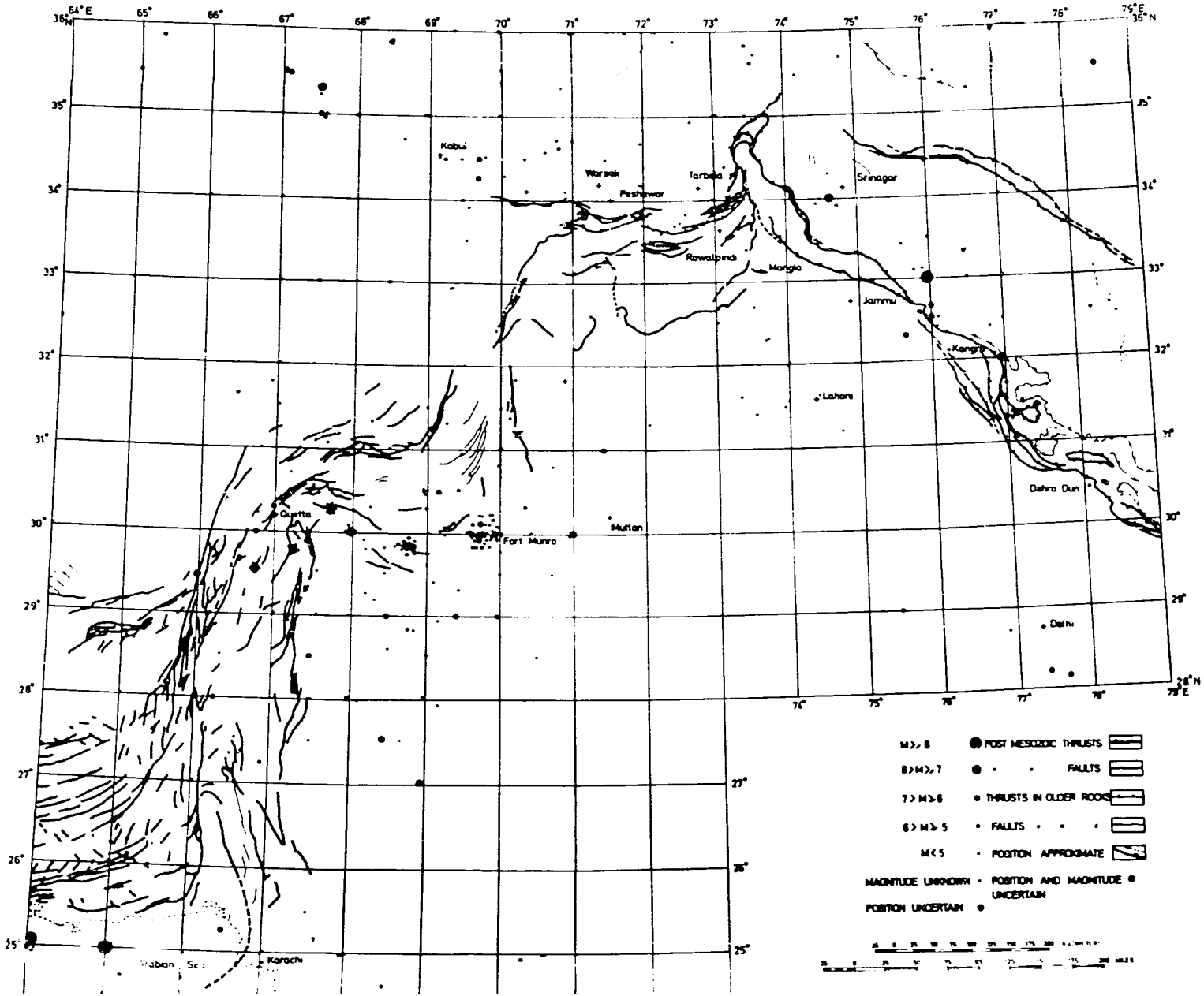
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Dehra Dun
Quetta
Fort Munro
Multan
Delhi
Karachi
Arabian Sea
M≥8
POST MESOZOIC THRUSTS
8>M≥7
FAULTS
7>M≥6
THRUSTS IN OLDER ROCKS
6>M≥5
FAULTS
M<5
POSITION APPROXIMATE
MAGNITUDE UNKNOWN
POSITION AND MAGNITUDE UNCERTAIN
POSITION UNCERTAIN

Figure 1

The most intense overthrusting and folding occurs within the Boundary Fault zone, a comparatively wide belt bordering the Himalayas. Earthquakes in this belt are caused either due to some shallow movement of the folded and faulted foredeep at its junction with older rocks, or due to movements connected with faults in the sagged floor of the foredeep itself. Here we have the earthquakes of 1905 at Kangra and Dera-Dun in which local re-entrants are also involved, and also the earthquake of 1934 in Bihar where the shock occurred over the downwarped alluvium. The Baluchistan earthquakes are also connected with re-entrants, at the northern end of which is situated Quetta.

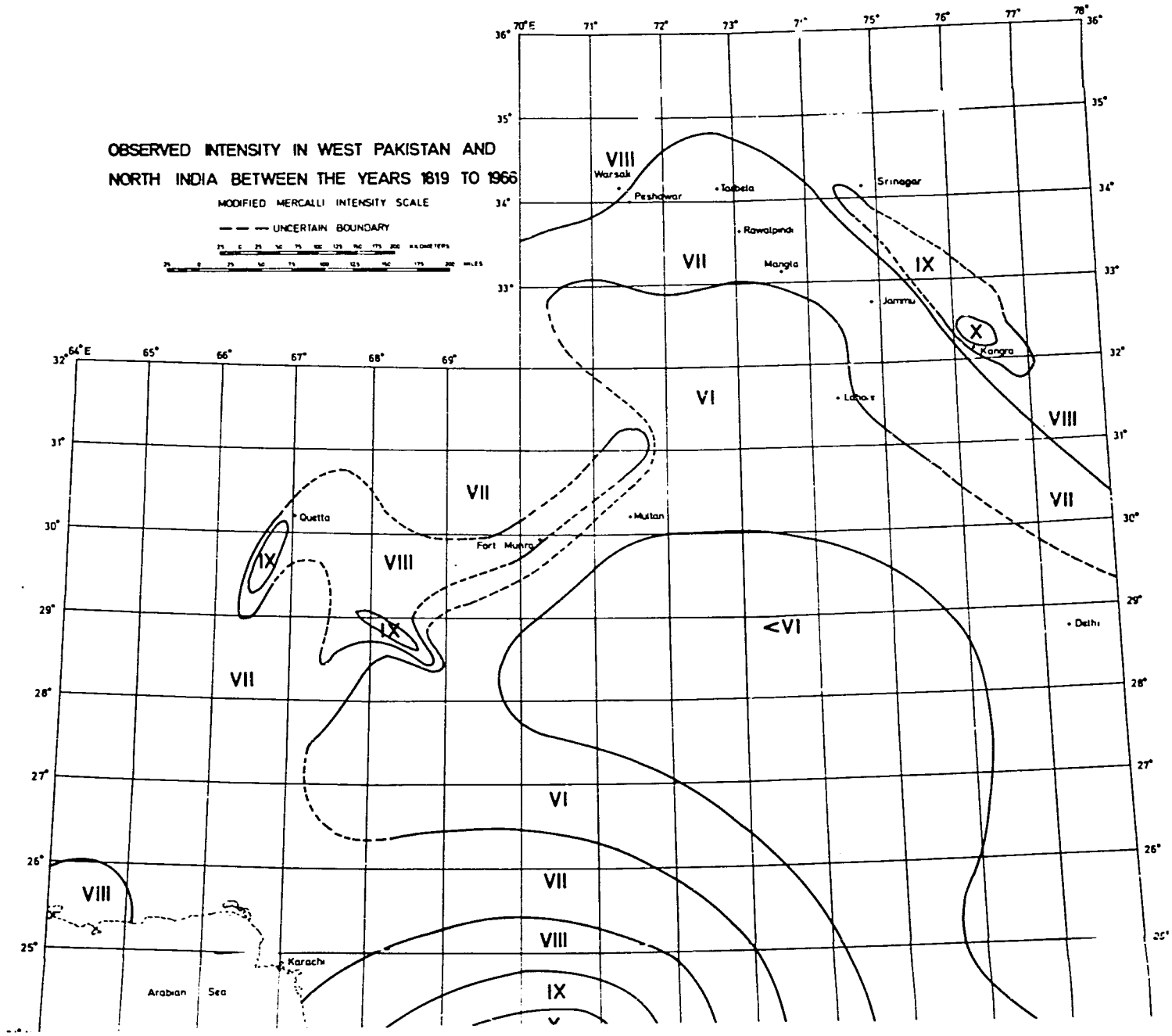
In general, it appears that earthquakes in West Pakistan are connected with the foredeep of the mountain arcs, and as it can be seen from Figure 1 their epicentres follow closely the inner perimeter of these arcs. Re-entrants seem to form the weak points of the downwarped foredeeps, notably the Quetta-Sibi re-entrant which may be connected with the recent seismic activity around Fort Munro, Barkhm and Dukki.

A study of the largest earthquakes in the region shown in Figure 1 indicates that shocks connected with re-entrants and with foredeeps are much shallower than those associated with the more central parts of the Indus Valley. Most of the larger shocks along the periphery of the Valley show depths of 5 to 15 kilometers, and in some instances these events are associated with surface faulting.

In spite of their large magnitude, earthquakes along the foredeep have shown comparatively small epicentral areas, mostly elongated, the intensity of shaking falling off rapidly with distance.

A study of the seismicity of West Pakistan showed that the largest known earthquakes are connected with the:

Western Himalayas:	1885 Kashmir, 1905 Kanga, 1906 Kangra, 1945 Chamba, 1947 Badarwah, 1963 Badgam.
Baluchistan:	1892 Chaman, 1909 Kachhi, 1931 Sharigh, 1931 Mach, 1935 Quetta, 1955 Chasma.
Mekran:	1851, 1864, 1945, 1947, 1953 (off shore).


OBSERVED INTENSITY IN WEST PAKISTAN AND NORTH INDIA BETWEEN THE YEARS 1819 TO 1966
MODIFIED MERCALLI INTENSITY SCALE
UNCERTAIN BOUNDARY
Warsak
Peshawar
Taxila
Rawalpindi
Srinagar
Mangla
Jammu
Kangra
Lahore
Multan
Quetta
Fort Munro
Delhi
Karachi
Arabian Sea
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VII
IX
X
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Figure 2

For proper guidance in the design of structures in West Pakistan it is necessary to have the fullest possible understanding of the seismicity of the country. At the present time, although we cannot predict the magnitude and the time of occurrence of future earthquakes, it is possible to indicate to some extent the zones where earthquakes may occur. For instance, if earthquakes of a certain character are associated with a certain tectonic zone, then it may be assumed that earthquakes of the same character may occur along the whole length of this zone at any time; in particular, if new data indicates the predicted trend, the reliability of such an assumption may be increased.

Figure 2 shows the distribution of intensity in West Pakistan based on data collected for the period 1819 to 1966. It must be recognised, however, that the earthquakes of 150 years ago do not provide an adequate basis for estimating the seismicity of the country. There is little to justify the common assumption that the strongest earthquake known to have occurred in a given area in the past will never be exceeded there.

INCREASE IN BUILDING COST DUE TO SEISMIC COEFFICIENT

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INTRODUCTION

Turkey is situated on an active seismic belt which is called the Alpide Belt. In recent years rather strong earthquakes attacked the Varto and Adapazari areas. These disasters caused casualties as well as damages to cities and towns. In developing countries like Iran, Pakistan and Turkey destruction of engineering structures through natural disasters is a serious threat to investment plans and this may reduce the speed of economic progress. On the other hand, developing countries have limited economic resources, which have to be used efficiently, through inexpensive projects. All structures in seismic areas should have enough strength against future earthquakes and the increase in structural cost should not be excessive.

It is not difficult to predict that the measures that render a structure earthquake-resistant depend on the type of structure. In other words, the price of earthquake-resistance is not a fixed amount independent of structural type. However, in this paper, for the sake of simplicity, among the various structural systems the one span multi-storied reinforced concrete structure is taken as a model and the increase of cost versus seismic coefficient was studied. The results will show the effect of seismic coefficient on building cost for this specific type of structure. The writer

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strongly hopes that after similar studies are repeated on other kinds of structures the value of seismic coefficient will be related more quantitatively to the cost of earthquake-resistance.

SELECTION OF MATHEMATICAL MODEL

Reinforced concrete structures are most common in cities and towns in Turkey. Building sites in crowded quarters of the cities are usually narrow. Many buildings are necessarily designed as single span parallel frames. The model frame on which the computations were carried out is shown in Figure 1. The number of stories, story heights, span length, distance to neighbouring frame, dead and live load of the slab, specific weight of filler walls, allowable stresses of materials and bearing capacity of soil, minimum dimensions of beams and columns, live load factor, etc., were taken as parameters and the analysis of frame under vertical and horizontal loads were formulated. Because dead load due to members varies with the member dimensions, final sections were obtained through iteration. Columns were designed to have minimum reinforcement and beams to have minimum height. All the dimensions were rounded to integers. To provide resistance to lateral forces in a perpendicular direction, the columns were designed to have square sections. First, the seismic coefficient was taken as zero and sectional dimensions were computed until their final values were reached. Then the footings and tie beams were designed and the cost of structure was estimated using unit prices of the Turkish Ministry of Public Works. The computations were repeated with increased seismic coefficients and the variations in cost were studied. All phases of computations were carried out on an IBM 1620 computer of the Computation Center, Technical University of Istanbul, through one main program and thirteen local sub-routines.

ANALYSIS OF COST INCREASE WITH VARYING MODEL PARAMETERS

In the computations, the parameters shown in the first column of Table I were kept constant. To know the effect of variation of these parameters on results, some of the parameters were changed on six five-storied sample frames and increase of cost

(ΔC) was studied with different values of seismic coefficient (SC). In cost estimation, unit prices of 1967 shown in Table 2 were used. The results are shown graphically in Figure 2 and numerically in Table 3. The results obtained in this section show that the effect of seismic coefficient on cost is not the same for frames with different parameters. Cost increase seems to be inversely proportional to span length. Namely, cost increase is highest in frame No. 1 which has the smallest span length, 4.5 m., and lowest in frame No. 6 which has the longest span length, 6 m. Difference of cost increase among frames is at most 4 percent of the cost of the one with zero seismic coefficient. Deviation of the values from those of frame No. 3 is smaller.

ANALYSIS OF COST INCREASE ON MODEL FRAME

The above mentioned study shows that parameters of the model affect the cost increase. However, the graphs for different frames are almost parallel and values obtained are not too far from each other. Consequently, to proceed with the analysis of a definite frame, e.g. frame No. 3, will be significant. One can easily guess that the same computations for frames No. 1 and 2 would give somewhat higher values and for frames No. 4 and 5 somewhat lower values compared to frame No. 3.

Numerical computations for frame No. 3 were repeated for the following cases:

a. Number of stories N: changing from 2 to 10.
b. Lateral load distribution: uniform or triangular*
c. Structural frame: with or without filler walls.

In actual buildings some frames have masonry filler walls and some do not. Since from the standpoint of cost increase, it is difficult to decide which frame behaves more favourably the same computations were repeated for both cases. In computations, seismic coefficient SC was changed from zero to 0.15 with 0.01 intervals.

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* Turkish seismic code of 1953[1] specified uniform distribution of seismic coefficient along the height of structure. In the seismic code of 1961[2] seismic coefficient is increased trapezoidally after 16 m above the foundation. In the recent seismic code of 1968[3] triangular distribution was adopted.

For uniform distribution of seismic coefficient along the height of structure the results are graphically shown in Figure 3 and Figure 4. For triangular distribution the results are shown in Figure 5 and Figure 6. Numerical values are given in Tables 4-7.

At first sight it is observed that, generally for small values of N, graphs of computed values of cost increase versus seismic coefficient are composed of broken lines. This is quite natural, because, to have an executable design, all column dimensions were rounded to integers and all beam dimensions were rounded to even integers. These modifications increased building cost further, but not always in equal percentages.

CONCLUSION

After careful examination of the results, it is easy to arrive at the following conclusions:

a. When the seismic coefficient is smaller than a definite value, it does not effect the cost. The reason is the specified increase of allowable stresses in seismic design.

b. The higher the structure, the greater is the effect of seismic coefficient on the cost.

c. Generally for low seismic coefficient the increase in cost is not high.

d. The effect of seismic coefficient in walled frames is higher than open frames.

e. Triangular distribution of seismic coefficient affects the structural cost unfavourably.

"Estimated cost of building," used in this research includes only the cost of the reinforced concrete frame. It by no means gives the total cost of the building. For this reason, the percentage of cost increase in respect to total cost of the building is about half of the presented values.

NOMENCLATURE

H	=	story height
G	=	dead load of slab
P	=	live load
EL	=	span length
BE	=	distance between frames
PD	=	specific weight of wall
SBC	=	allowable stress of concrete (compression)
SBE	=	allowable stress of concrete (bending)
SBN	=	allowable stress of concrete (negative moments)
SBME	=	allowable stress of concrete (combined axial force)
SBSO	=	allowable stress of concrete (footing)
SE	=	allowable stress of steel
SZ	=	bearing capacity of soil
XZ	=	ratio of allowable stresses of seismic analysis and permanent loading
BKI	=	minimum width of beam
BKO	=	minimum width of column
HD	=	wall height under the window
HYK	=	live load factor
U	=	earth cover above footing.

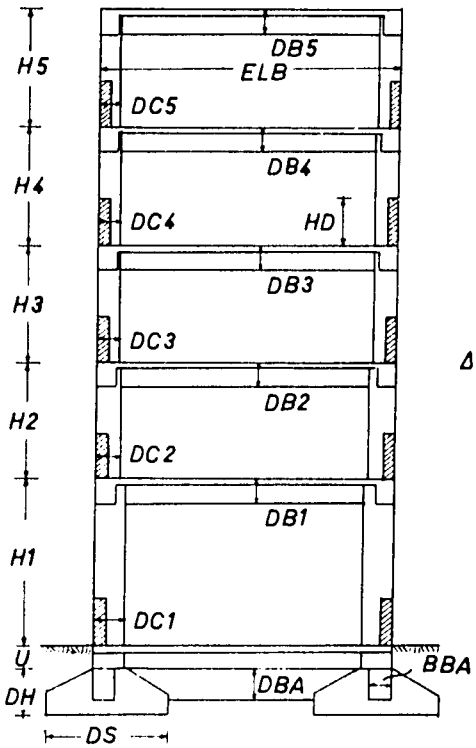

Fig. 1

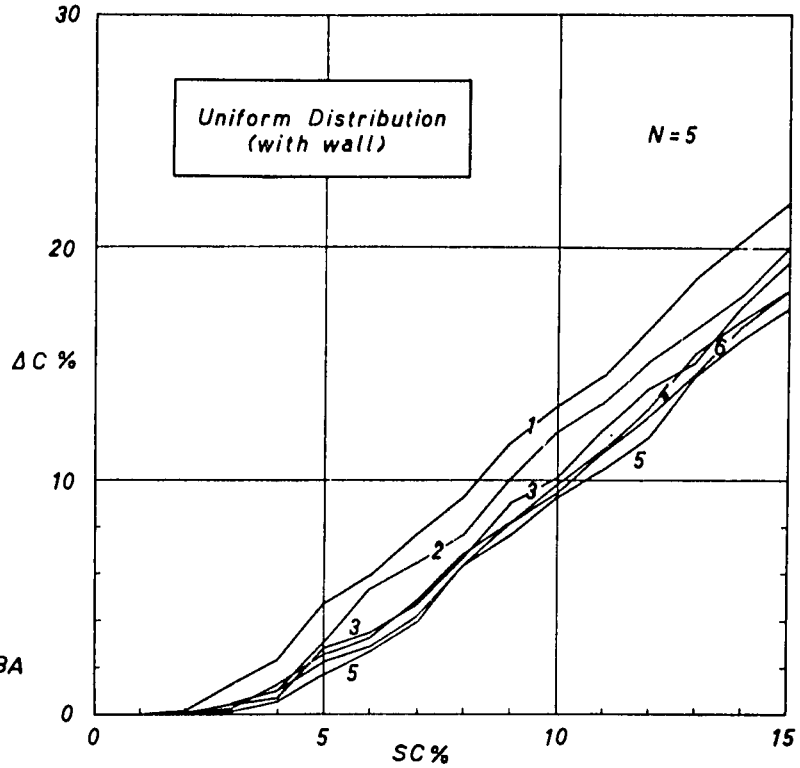

Fig. 2

TABLE 1

	Parameter	Sample frame No. 1	2	3	4	5	6
	H1	4	4	4	4	4	4
	H2 - 5	3	3	3	3	3	3
	G	.380	.380	.380	.380	.380	.380
	P	.200	.200	.200	.200	.200	200
∘	EL	4.5	5	5	5	6	5.5
∘	BE	5	3.5	4	5	4.2	3.5
∘	PD	.6	.6	.6	.5	.7	.6
	SBC	65	65	65	65	65	65
	SBE	70	70	70	70	70	70
	SBN	90	90	90	90	90	90
	SBME	90	90	90	90	90	90
	SBSO	40	40	40	40	40	40
	SE	1400	1400	1400	1400	1400	1400
∘	SZ	3	4	2	1.5	2.5	2.5
	XZ	1.5	1.5	1.5	1.5	1.5	1.5
	BKI	20	20	20	20	20	20
	BKO	24	24	24	24	24	24
∘	HD	1.2	1.2	1.2	1.2	1.	.8
	HYK	.5	.5	.5	.5	.5	.5
∘	U	20	25	10	10	10	10

TABLE 2

1967 UNIT PRICES IN T.L. USED FOR COST ESTIMATION		
1	Concrete B225	134.86
2	Concrete B160	124.86
3	Brick wall	179.85
4	Steel	2790.00
5	Wooden form	18.91
6	Excavation	16.20
7	Tile blocks for slab	24.91

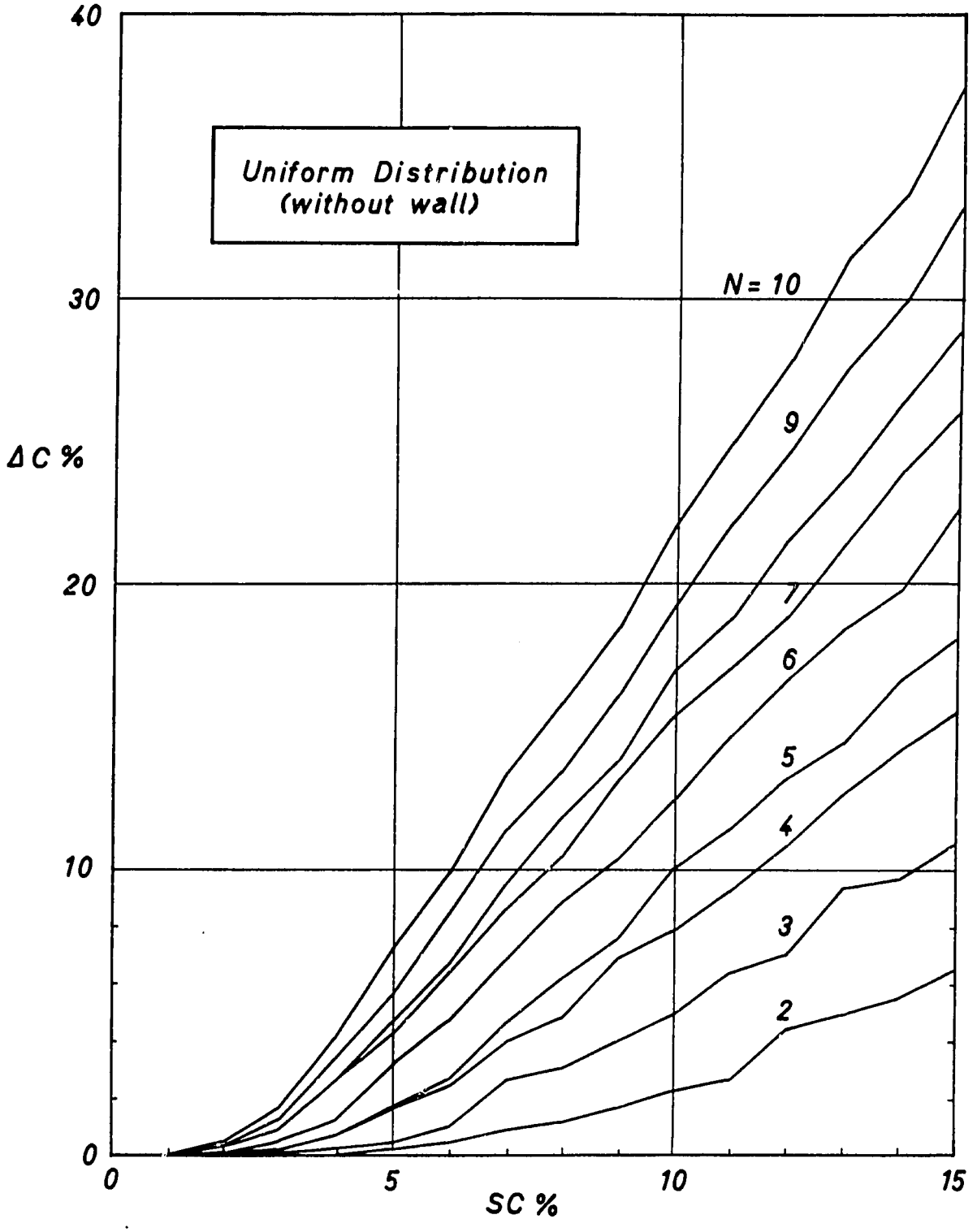
Uniform Distribution
(without wall)
N= 10
9
7
6
5
4
3
2
ΔC %
SC %
0
10
20
30
40
0
5
10
15

Fig. 3

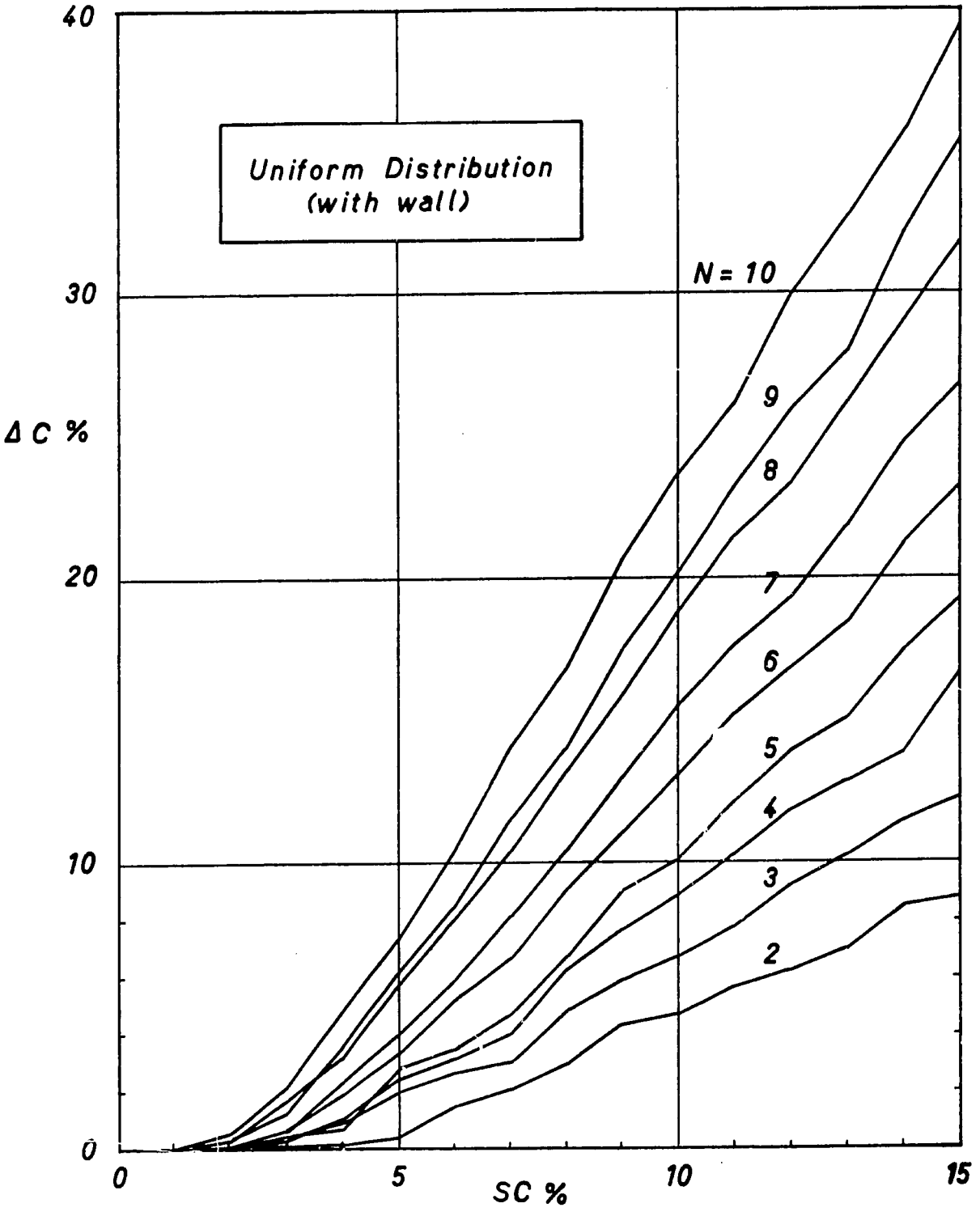
Uniform Distribution
(with wall)
N = 10
9
8
7
6
5
4
3
2
40
30
20
10
0
Δ C %
0
5
10
15
SC %

Fig. 4

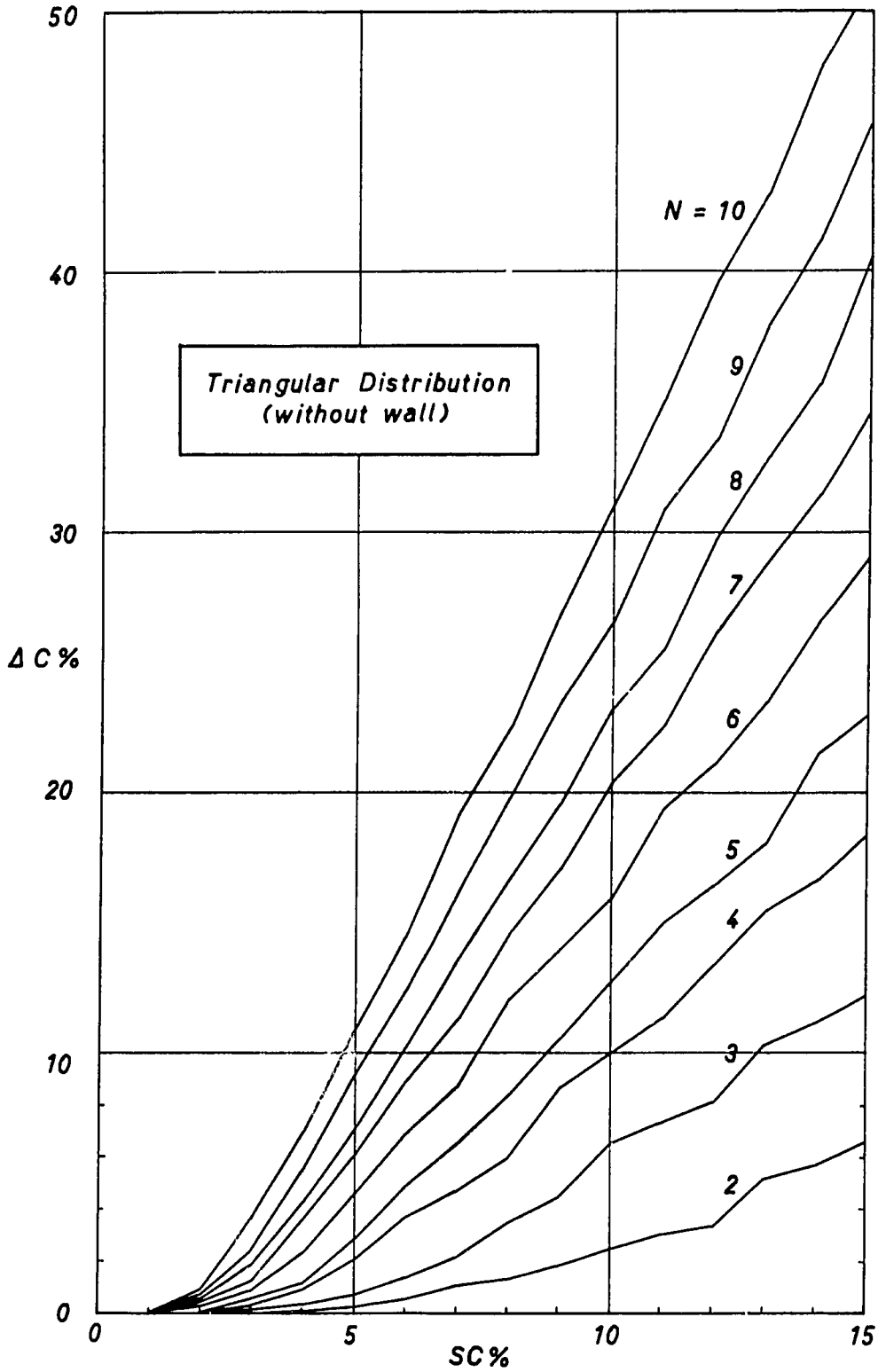
50
40
30
20
10
0
ΔC%
0
5
10
15
SC%
N = 10
9
8
7
6
5
4
3
2
Triangular Distribution
(without wall)

Fig. 5

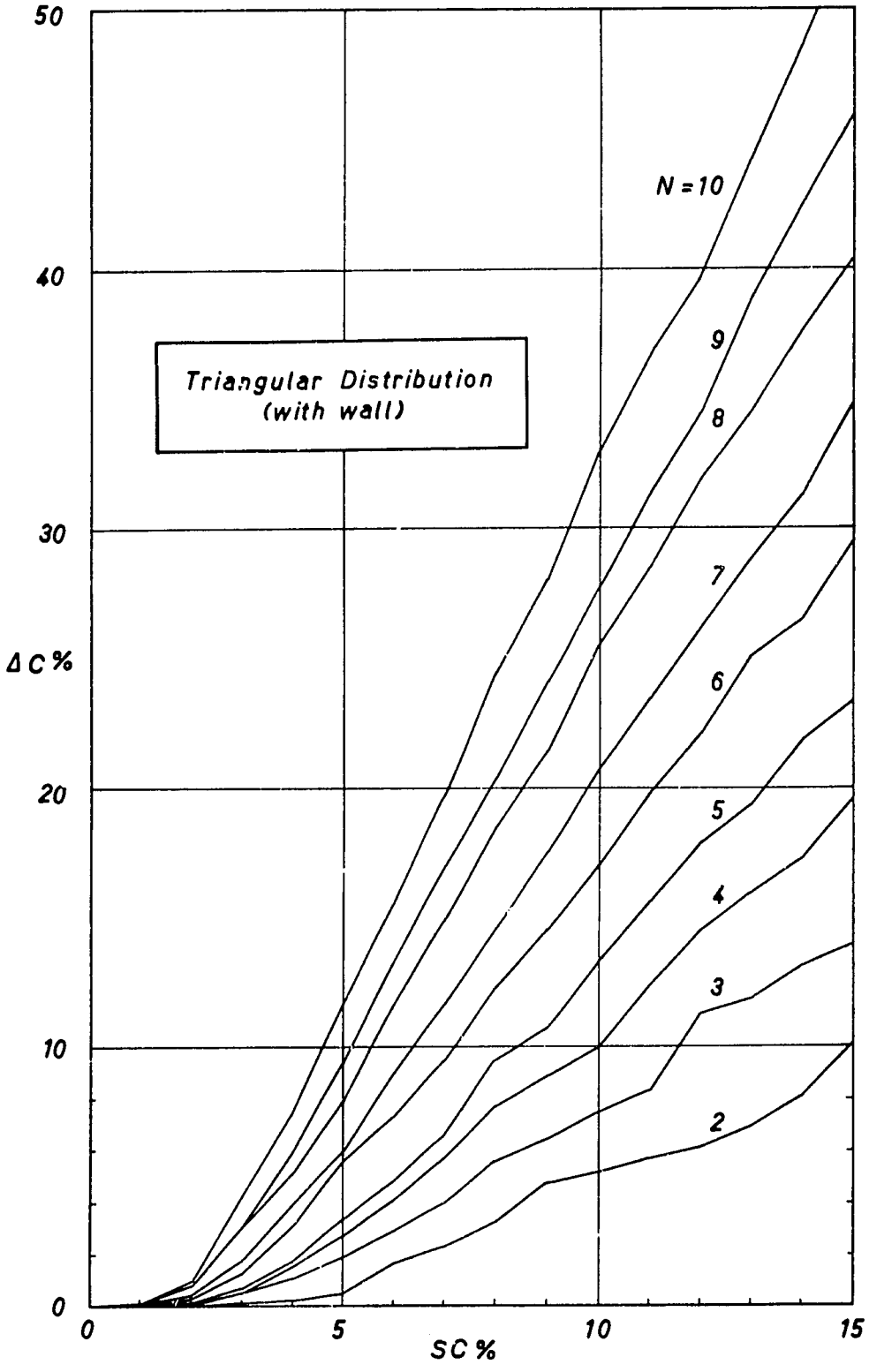
50
40
30
20
10
0
ΔC %
0
5
10
15
SC %
N = 10
9
8
7
6
5
4
3
2
Triangular Distribution
(with wall)

Fig. 6

TABLE 3

PERCENTAGE OF COST INCREASE (UNIFORM DISTRIBUTION, WITH WALL) (N=5)						
SC	DATA NO.					
	1	2	3	4	5	6
1	.0	.0	.0	.0	.0	.0
2	.1	.1	.1	.1	.0	.0
3	1.3	.5	.5	.4	.2	.3
4	2.2	2.0	.7	1.4	.6	1.0
5	4.7	3.0	2.8	2.6	1.7	2.2
6	5.8	5.4	3.5	3.2	2.8	2.9
7	7.6	6.6	4.7	4.8	4.0	4.2
8	9.2	7.7	6.8	6.8	6.4	6.4
9	11.7	10.1	9.0	8.2	7.8	8.2
10	13.3	12.2	10.2	9.9	9.4	9.5
11	14.5	13.4	12.2	11.3	10.5	11.2
12	16.5	15.1	14.0	13.1	11.9	12.8
13	18.7	16.6	15.1	15.4	14.5	14.6
14	20.3	17.9	17.6	17.0	16.1	16.9
15	21.8	19.9	19.3	18.1	17.3	18.1

TABLE 4

PERCENTAGE OF COST INCREASE (UNIFORM DISTRIBUTION, WITHOUT WALL)									
SC	NUMBER OF STORIES								
	2	3	4	5	6	7	8	9	10
1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0	.0	.1	.1	.1	.1	.3	.4	.5
3	.0	.1	.2	.3	.5	.7	.9	1.4	1.7
4	.0	.3	.8	.7	1.3	2.6	2.6	3.6	4.2
5	.2	.6	1.8	1.8	3.3	4.3	4.8	5.7	7.3
6	.5	1.1	2.5	2.8	4.7	6.5	6.8	8.6	9.9
7	.9	2.7	4.0	4.8	6.9	8.7	9.5	11.5	13.4
8	1.2	3.1	4.9	6.3	8.8	10.5	12.0	13.6	15.9
9	1.7	4.0	6.9	7.6	10.4	13.2	13.8	16.2	18.6
10	2.3	5.0	7.9	10.2	12.5	15.2	17.1	19.4	22.3
11	2.7	6.5	9.4	11.5	14.8	17.0	18.9	22.4	25.2
12	4.4	7.1	10.9	13.3	16.8	19.0	21.7	24.8	27.9
13	5.0	9.4	12.7	14.5	18.5	21.6	23.9	27.7	31.6
14	5.5	9.8	14.2	16.7	19.9	24.1	26.5	30.0	33.8
15	6.5	11.0	15.5	18.2	22.7	26.1	28.9	33.3	37.5

TABLE 5

PERCENTAGE OF COST INCREASE (UNIFORM DISTRIBUTION, WITH WALL)									
SC	NUMBER OF STORIES								
	2	3	4	5	6	7	8	9	10
1	.0	.0	.0	.0	.0	.0	.1	.0	.0
2	.0	.0	.1	.1	.1	.2	.3	.4	.6
3	.1	.3	.3	.5	.7	.5	1.7	1.4	2.2
4	.2	1.0	1.0	.7	2.0	2.4	3.2	3.6	4.9
5	.5	2.0	2.4	2.8	3.4	4.0	5.8	6.2	7.4
6	1.5	2.7	3.2	3.5	5.3	6.0	8.0	8.5	10.5
7	2.1	3.1	4.0	4.7	6.8	8.2	10.5	11.6	14.1
8	3.0	4.8	6.3	6.8	9.1	10.5	13.3	14.1	16.8
9	4.4	5.9	7.6	9.0	11.1	13.1	16.0	17.6	20.6
10	4.7	6.7	8.8	10.2	13.2	15.6	18.9	20.3	23.8
11	5.7	7.8	10.4	12.2	15.3	17.7	21.6	23.3	26.2
12	6.3	9.3	11.9	14.0	16.9	19.3	23.4	26.0	30.1
13	7.0	10.2	12.9	15.1	18.4	21.9	26.3	28.0	32.7
14	8.6	11.5	13.9	17.6	21.4	24.8	29.1	32.2	35.8
15	8.8	12.3	16.7	19.3	23.4	26.9	31.9	35.5	39.5

TABLE 6

PERCENTAGE OF COST INCREASE (TRIANGULAR DISTRIBUTION, WITHOUT WALL)									
SC	NUMBER OF STORIES								
	2	3	4	5	6	7	8	9	10
1	.0	.0	.0	.0	.0	.0	.0	.0	.0
2	.0	.0	.1	.1	.2	.3	.5	.8	1.0
3	.0	.2	.3	.6	.9	1.2	1.8	2.4	3.7
4	.1	.4	.9	1.1	2.3	3.6	4.3	5.6	7.0
5	.3	.7	2.1	2.2	4.6	6.0	7.2	9.2	10.9
6	.6	1.4	3.7	4.9	7.0	8.9	10.3	12.5	14.5
7	1.0	2.2	4.8	6.6	8.8	11.4	13.7	16.4	19.2
8	1.4	3.5	6.0	8.4	12.1	14.7	16.6	19.8	22.5
9	1.9	4.5	8.8	10.6	14.0	17.2	19.6	23.6	27.0
10	2.5	6.5	10.0	12.8	16.0	20.4	23.2	26.5	31.0
11	3.0	7.4	11.3	15.0	19.4	22.6	25.6	30.9	35.1
12	3.4	8.1	13.4	16.5	21.2	26.2	29.8	33.6	39.7
13	5.2	10.3	15.5	18.1	23.5	29.9	32.9	38.1	43.0
14	5.8	11.2	16.6	21.6	26.6	31.6	35.8	41.3	48.0
15	6.6	12.3	8.6	23.1	29.1	34.8	40.5	45.9	51.4

TABLE 7

PERCENTAGE OF COST INCREASE (TRIANGULAR DISTRIBUTION, WITH WALL)									
SC	NUMBER OF STORIES								
	2	3	4	5	6	7	8	9	10
1	.0	.0	.0	.0	.0	.0	.0	.0	.1
2	.0	.0	.1	.2	.3	.4	.8	.8	1.0
3	.1	.4	.5	.6	1.3	1.8	3.0	2.9	4.4
4	.2	1.1	1.6	1.8	3.1	3.8	5.1	5.8	7.6
5	.5	1.9	2.8	3.4	5.5	5.9	7.9	9.4	11.7
6	1.6	2.9	4.1	4.8	7.2	9.0	11.6	13.4	15.6
7	2.3	4.0	5.7	6.5	9.4	11.6	14.9	16.8	19.7
8	3.2	5.6	7.7	9.5	12.4	14.5	18.5	20.3	24.4
9	4.8	6.4	8.9	10.8	14.5	17.5	21.5	24.1	28.0
10	5.2	7.5	10.0	13.4	17.0	20.7	25.5	27.8	33.1
11	5.7	8.3	12.4	15.7	19.8	23.4	28.4	31.3	36.7
12	6.2	11.3	14.5	17.9	22.2	26.1	31.9	34.4	39.6
13	6.9	11.9	15.9	19.4	25.1	28.8	34.5	40.0	44.3
14	8.1	13.2	17.2	21.8	26.5	31.3	37.7	42.5	48.7
15	10.1	14.0	19.5	23.4	29.5	34.8	40.5	46.0	53.2

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SEISMIC ACTIVITIES AND THE CONDITION OF RURAL HOUSES IN THE COUNTRIES OF THE REGION

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Pakistan, Iran and Turkey are situated in a highly active seismic zone and we have experienced many destructive earthquakes. The magnitude of many of these earthquakes was greater than 7 (earthquakes of class "b") and even earthquakes of class "a" (magnitude greater than 7.75) have occurred in this region.

In 1935, in Quetta, Pakistan an earthquake with magnitude 7.6 occurred which caused extensive damage over a wide area and killed over 30,000 people. The earthquake of Erzincan, Turkey in 1939 had a magnitude of 8 and caused more than 140,000 casualties and can never be forgotten.

In 1930 the northwestern part of Iran was shaken by an earthquake of magnitude 7.2 which caused extensive damage in the Iranian cities near the Turkish border. Rezaiyeh and Salmas (Shahpur) were almost destroyed by this earthquake.

On July 2, 1957, an earthquake of class "b" with a magnitude of 7.4 originated in the Alborz Mountains and struck the Mazandaran District. This earthquake killed 45 people and destroyed 200 villages.

On December 13, 1957, a class "b" earthquake occurred in the western part of the Zagros Mountains, destroying about 200

villages in Farsinaj near Hamedan. The magnitude of this earthquake was about 7.3 and 1,130 people perished in it. A second earthquake in 1958, epicentered at Nahavand, near Farsinaj, was of class "b" magnitude and killed 128 people. On April 24, 1960, an earthquake of magnitude 5.4 (class "d") struck Lar, a large town, and destroyed 75 percent killing 400 people.

The most tragic earthquake of recent years in this region is the famous Buin-Zahra earthquake of September 1, 1962. Striking the heavily populated Ghazvin plain, this earthquake demolished more than 300 villages with some 12,000 fatalities. Damage extended over area of 13,000 square kilometers.

Since the Buin-Zahra earthquake there have been several earthquakes, more or less destructive, to remind us that future major earthquakes are always a possibility in this region. The most recent semi-destructive earthquake in Iran occurred in April of this year. It was of magnitude 5.7 and caused damage to about 40 villages in the vicinity of Maku near the Turkish border.

The most disastrous results of earthquakes in our countries can be seen in the villages where the condition of the buildings is terrible and the materials and workmanship used in home construction are of very poor quality.

Almost 95 percent of rural houses are adobe. The commonest materials are clay, rubble stone with clay mortar, sundried bricks, etc. One can hardly find properly designed buildings executed with suitable materials and good workmanship in the countryside, and it is possible to state that the fundamental reason for the great loss of life experienced in earthquakes is the poor condition of our buildings and not the force of the earthquake itself.

The foundations of the bearing walls in these rural buildings are very poor, the common practice being to build the wall directly on the earth and the walls themselves, as was mentioned before, are of very low quality materials.

The roofs of rural houses are generally of timber pole joists with straw mat and clay cover. The thickness of these roofs often exceeds 50 centimeters. A new layer of clay-straw

plaster is added to this type of roof every two or three years for waterproofing, and the roof becomes progressively heavier as it grows older. Other typical roof types are domes and vaults also built of clay. The vault type of roof especially has been responsible for a large part of the damage and loss of life in many earthquakes in Iran. The Buin-Zahra catastrophe was largely due to the inadequacy of this type of roof.

Special investigations are required to improve the condition of rural houses in our countries and broad cooperation between the countries of the region is called for. It would not be easy to introduce new materials in the countryside, partly because of the economic position of the people, and partly because of the shortage of skilled workers.

I believe that each country in the region should form a special committee to solve these problems. These committees, taking into consideration the local materials and the earthquake dangers known to exist,should investigate ways of improving rural housing in the region.

Perhaps one possible solution to propose to the committees would be for the governments to construct a structural frame for each new building, leaving the farmers themselves to build the walls, the doors and windows, and accomplish the finishing. Such a building even with clay walls, could be resistant to earthquake damage.

At the same time that the local committees are carrying out their special investigations, a joint committee formed of members from all the countries should discuss the problem and provide regulations for minimizing earthquake hazards for rural buildings. Special consideration should be given to the local conditions described.

Our current Antiseismic Code in Iran cannot be adopted to the countryside because of economic and labor problems. The need for special regulations for rural houses is urgent. I hope this conference will be a successful step towards filling this need.

SEISMIC DESIGN FOR HOUSING

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INTRODUCTION

Considerable seismological data has been gathered in the past 30 years with the result that seismic design criteria has been developed which, if applied properly, will reduce loss of life and property to a minimum. Unfortunately, the availability of this important tool has not prevented, in the past decade, catastrophic losses of life and property from earthquake activity. In many cases, these losses were attributed directly to the lack of a design incorporating internationally recognized seismic design criteria.

It follows, therefore, that in order to materially reduce this terrible loss of life, all countries, and in particular those located in the principal earthquake belts, should require enforcement of recognized seismic provisions. These provisions should incorporate both performance and specification type requirements in order that all types of structures will be adequately protected. The performance type provisions or detailed design criteria are necessary in order to cover all types of structures where the services of a professional is obtained and would be particularly applicable to multi-story buildings or any building incorporating untried methods of construction. Specification type requirements are a practical necessity since it would not be plausible to require

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every home owner to obtain the services of a professional to design his one story dwelling. Therefore, these specifications must include construction details which will insure that even strong seismic forces will be transmitted to the ground without loss of life and without major damage to the building.

The purpose of this paper is to briefly discuss the U. S. A. development of model codes which incorporate specification type seismic requirements for housing and thereby hopefully demonstrate to the representatives of other nations the need to develop similar provisions, using materials and methods of construction applicable to their construction practices.

HISTORY OF DEVELOPMENT

Building code enforcement in the United States is accomplished through the activities of three model code groups representing the western, eastern, and southern areas of the country. They are non-profit and are controlled by the local communities which have the final enforcement authority. The primary purpose of the organizations is to provide uniformity through the distribution and servicing of a model building code. These codes include the Uniform Building Code, published by the Building Officials Conference of America; and the Southern Standards Building Code, published by the Southern Building Code Congress. Other services are provided by the Model Code Groups to their member cities covering recognition of new products and type of contruction, education, plan checking, field consultation, uniform interpretations of building codes, and the distribution of publications covering the entire field of building department operation.

Most of the seismic activity in the world is located along either Circum-Pacific or Alpide Earthquake Belts. The Alpide belt runs through the East Indies, the Himalayas, and the Caucasus to the Mediterranean whereas the Circum-Pacific Belt extends around the entire rim of the Pacific Ocean from New Zealand, through Japan, the Aleutian Island Chain, down the Pacific Coast of North America, and then continuing down the West Coast of South America. Since the western part of the United States is located along the Circum-Pacific Belt, most of our seismic code

provisions have originated in that region because of necessity. Although consideration is given in this paper to seismic development only in the United States, it must be acknowledged that our code provisions were based in no small part on the earthquake engineering data and seismic codes found in other parts of the world.

The year 1925, because of the impetus given by the Santa Barbara earthquake, may be considered as marking the real beginning of earthquake studies and research in the United States. It was in this year that, by direction of the United States Congress, the United States Coast and Geodetic Survey was given the responsibility to make investigations and reports on seismology. The work of the U.S. Coast and Geodetic Survey, in particular the publishing of strong motion earthquake records, was to have a significant influence on the development of codes.

The first edition of the Uniform Building Code of the International Conference of Building Officials was published in 1927 and contained in the appendix a chapter on earthquake provisions, planned for optional use.

In 1928, the California State Chamber of Commerce recognized the need for a building code which would afford protection against earthquake damage through the inclusion of a section on seismic design. This project evoked widespread and active interest and stimulated studies and research by engineers on the subject of earthquake-resistant design. The resulting requirements for the design of structures in seismic areas provided for greater security and sounder investment to the public than had been previously offered.

The first mandatory seismic codes used to any extent in the United States were published following the March 10, 1933, Long Beach (Southern California) earthquake as the 1934 edition of the Uniform Building Code.

The Field Act, which placed complete control over structural design of public school construction in the Division of Architecture, California State Department of Public Works, authorized the Division of Architecture to approve or review all public school plans and specifications and to furnish general supervision of the work

of construction. This law became effective as an emergency measure on April 10, 1933. The Division of Architecture at the same time adopted Rules and Regulations, including requirements for seismic analysis. The excellent leadership of the Division of Architecture was an influential factor in stimulating a genuine interest in seismic and in a better understanding of design for seismic loading.

The second law, the Riley Act, which became effective May 26, 1933, made provision for design and construction to resist seismic or wind forces and was formulated for more general application than the Field Act which applied to schools only. Exempted from the Riley Act were; 1) buildings located outside the limits of an incorporated area and not intended for occupancy by human beings, and 2) dwellings outside the limits of an incorporated area and planned for not more than two families. The Riley Act specified a seismic design coefficient of two percent of the design load, which for most situations would mean approximately 2.5 percent of the design dead load. (Minor modifications of this legislation have been made from time to time).

GENERAL SEISMIC CONSIDERATION

Any structure which is designed to withstand vertical loads of its dead weight and its contents has some resistance to horizontal or lateral forces. If this were not true, collapse would occur under the force of a gentle breeze or a very mild earth shock from any cause. That this incidental rigidity cannot be relied upon to furnish adequate resistance to a violent wind or earthquake has been proven many times by the collapse of buildings having no designed resistance under the action of such forces. Any but minor structures in all geographical locations should be designed with definite resistance to lateral forces. Almost every quarter of the globe is subject to wind storms. In some regions violent winds need not be expected, in others they occur with such frequency as to make their consideration in building design imperative.

Earthquake-resistant design has not had the history of wind design nor as wide application geographically. An earthquake in itself is not force but motion and energy which induce force in anything that tends to resist that motion. Generally speaking, the

more resistance in mass and rigidity, the more force induced; if the force cannot be sustained, damage results. The hypothetical code forces for either wind or earthquake may produce the same effect on a particular building or part thereof, but this would be pure coincidence since the two are not related. Wind force is determined by exposed area, whereas seismic design forces are determined by weight or mass, not only on an exterior exposed area, but for the whole mass under consideration. The building codes usually provide that the structure, or its parts, be designed to resist the greater of the two (wind or earthquake) since the probability of wind and earthquake occurring simultaneously in maximum degree and in identical direction is almost negligible and is certainly a calculated risk which can be safely ignored.

Generally speaking, the lateral design of light-weight buildings is controlled by wind, and of heavy buildings by earthquakes. The plan layout, however, may cause exceptions as, for example, with a light-weight building of narrow, rectangular shape. In the direction of force parallel to the long side, the narrow shape and exposure may lead to wind shears which are less than seismic shears induced by the mass of the entire plan of the building.

Obviously, the design for wind alone, which was a former practice almost everywhere, does create some resistance to earthquake for all structures. Since the relationship is indirect and uncertain, such haphazard practice of providing a seismic resistance design is not technically logical nor in favor today in regions having a history of earthquake damage. Simple structures, such as residences that have considerable permanent interior walls and partitions, not only offer more paths of resistance for lateral forces but induce relatively light seismic forces because of their light construction and floor loading. It has been found, however, that a complete lack of design for lateral forces or the mere application of some diagonal sheathing as a panacea has led to failures. Although it is economically difficult and technically unnecessary to make a comprehensive lateral force analysis of very simple and traditional forms of construction, certain basic requirements must be fulfilled to insure safety. Heavy, multi-story buildings, or buildings of only one or a few stories having a large plan area and few walls and permanent partitions, must be carefully and individually analyzed and designed structurally for lateral forces.

A great deal of progress has been made in research, field investigations, design practice, and in building code requirements on the problem of earthquake-resistant design and construction in the last quarter century. Scientists, engineers, building officials, and others have worked diligently to acquire more knowledge and experience on a very complex problem, which is rendered even more difficult by the fact that major destructive earthquakes do not occur very often and thus offer few practical tests of new methods and few examples for study and analysis. It would be impossible to mention here the many individuals, institutions, organizations, and agencies which have and which are rendering valuable service in this field, often without remuneration. Although this comparatively new design practice has been developed considerably, particularly in California and in Japan, most "experts" acknowledge that there is still room for further knowledge and advancement, particularly in the realm of economy in earthquake design. Many of those who work in the structural design of buildings to resist forces induced by earthquakes are in some disagreement as to the amount of code requirements for seismic forces, especially for slender or flexible framed structures, and in other detailed requirements. Only time and effort can provide the final answers. In the meantime, in those areas with seismic activity, adequate building code requirements, good structural design, and good construction can and do provide security. Too much complacency over structures that have "gone through" an earthquake is dangerous since earthquakes may vary in intensity, direction, duration, and frequency; a soldier who has come through a battle unwounded is not necessarily bullet-proof.

SPECIFICATION TYPE SEISMIC CONSIDERATIONS

As indicated previously, it is necessary that detailed construction practices be established for all minor structures and, in particular, those structures which house the greater part of the population. Since most housing does not have the advantage of individual consideration by a professional, these details of construction must represent the average condition and be applicable only to those materials and methods of construction which are readily available and are most frequently used. However, it should be noted that in a small percentage of the cases that

even one-story, single family dwellings may incorporate untried materials or systems and, therefore, necessitate the design services of a professional.

In the United States all of the seismic activity has occurred in the western part where the natural resources dictate the use of light wood framing to house the population. In general, this type of construction is of light weight material and has frequent interior partitions with the result that it has a nominal seismic risk. Typical construction details include continuous masonry or concrete footings for exterior walls; isolated interior flooring; solid sheathed floors; walls of 2" by 4" wood studs spaced 16" O. C. and sheathed on each side with plywood, gypsum board or plaster; and gabled or hip type roof systems, using wood rafters or trusses and solid or sheathing covered with composition or wood shingles.

Experience gathered from actual earthquakes has revealed that these light wood frame structures have a low seismic risk if certain details of construction are incorporated in accordance with the Uniform Building Code and if common sense is used in providing and properly arranging adequate vertical shear resisting elements, such as interior and exterior walls faced with wood or fibre panels, gypsum board, or plaster. The low seismic risk enjoyed by this type of construction is the result of code requirements which are specification type provisions and which were developed prior to 1933 and the detailed seismic design criteria adopted in the western part of the United States. It is the author's opinion that these minimum requirements were the result of bitter field experience from earthquakes over the years and represent the most practical approach to insure earthquake resistance in wood frame housing even though the reasons for these provisions may have long been forgotten.

Details incorporated in the Uniform Building Codes and which provide for earthquake-resistant housing cover all aspects of wood frame dwelling construction covering the footings, floors, walls, roof, and their interconnection.

Exterior wall footings are required to be continuous and must be constructed of concrete or solid grouted masonry. The reason for this type of construction is to provide a means whereby the horizontal force caused by the acceleration of the mass of the

dwelling can be transmitted into the ground. Earthquake experience reveals that dwellings constructed on isolated concrete piers or stacked unbonded masonry units shift and fall off the foundation resulting in considerable damage to the buildings. In order to transmit the horizontal force into the footings from the walls or floor, the code requires that a wood plate be anchored to the foundation wall by means of 1/2" diameter bolts spaced not more than 6' O. C. and located not more than 12" from each corner of the building. A structural analysis will show that the bolt size and spacing will adequately transmit the seismic forces involved in the great majority of one and two story dwellings.

The code requires all exterior walls to be braced with 45° 1" x 4" cut-in braces, nailed to the top and bottom plates, located at each corner of the building and spaced not more than 25' O. C. The necessity of these requirements is often questioned, particularly where adequate sheathing is provided in the form of plywood, fiber board, gypsum board, or plaster. As previously stated, these requirements must insure minimum safety without the services of a professional conversant with detailed seismic design procedure and with the growing trend to extensive exterior wall openings the braces serve as an added factor of safety. In most cases exterior and interior walls are sheathed with one of the materials previously mentioned. Their required method of connection to the wood studs and plates also insures that the walls will act as vertical diaphragms to transfer tributary seismic loads from the walls, roof, and floor to the foundations.

The code also requires double top plates on all exterior walls with adequtely spaced and lapped splices. These plates serve as horizontal beams to transmit tributary seismic forces from the roof structure and walls acting perpendicular to the wall. These plates and their method of splice also insures flange type action where the roof or floor serves as a horizontal deep beam or diaphragm to transmit seismic forces to the vertical wall elements located parallel to the direction of the applied loads.

The code requires rafter to be tied near the plate line and braced to interior bearing partitions. Although these provisions are important for the support of vertical live and dead loads, they also serve the important function of transmitting seismic forces from the roof system to the top plate and the interior partitions.

The foregoing examples of specification type seismic requirements could be expanded considerably to demonstrate the built-in earthquake-resistant features found in housing construction in the United States, including parallel provisions for reinforced masonry construction. The importance of these requirements are emphasized not only by the fact that professional design services are not usually available to private housing but also by the fact that, since the greater part of the population is usually housed in this manner, it represents a major part of the earthquake life hazard involved.

In conclusion, it should be noted that the type of materials and method of construction used in housing is dependent upon both natural resources and the available labor market. In recent years, thousands of lives have been lost and extensive property damage has occurred throughout the world as a result of the improper use of natural resources and the lack of enforcement of sound principles of seismic design. Even where only rudimentary materials are available, such as mud and sticks, it is felt that the application of sound principles would reduce materially the loss of life and property. Therefore, it is urged that we marshall our forces and, using the basic principles of internationally recognized seismic design criteria, develop specification type code requirements for housing covering all types of materials and methods of construction.

GEOLOGIC FACTORS IN EARTHQUAKE DAMAGE*

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INTRODUCTION

Geologic factors play a key role in earthquake damage, but as yet only rarely have these factors been considered in attempts to reduce the potential hazard of earthquakes to a community. Most efforts toward minimizing the hazard of earthquakes have depended upon design and engineering techniques, largely disregarding hazardous or special earthquake-sensitive conditions of the ground.

A dramatic example of geologically controlled earthquake damage is to be seen in Figure 1, which shows the Turnagain Heights landslide, one of several landslides that developed at Anchorage, Alaska, during the earthquake of March 27, 1964. There, under a residential part of Anchorage built on a bluff overlooking Turnagain Arm, sand lenses in a layer of clay failed through the process of liquefaction, permitting overlying blocks of ground to slither in disorder toward the bay. This slide and others like it produced chaos in an area of several square miles and ruined many homes situated upon them. Far more damage in Anchorage resulted from landsliding than from shaking alone, and Anchorage was more than 100 kilometers from the epicenter of the main earthquake.

* Publication authorized by the Director, U.S. Geological Survey

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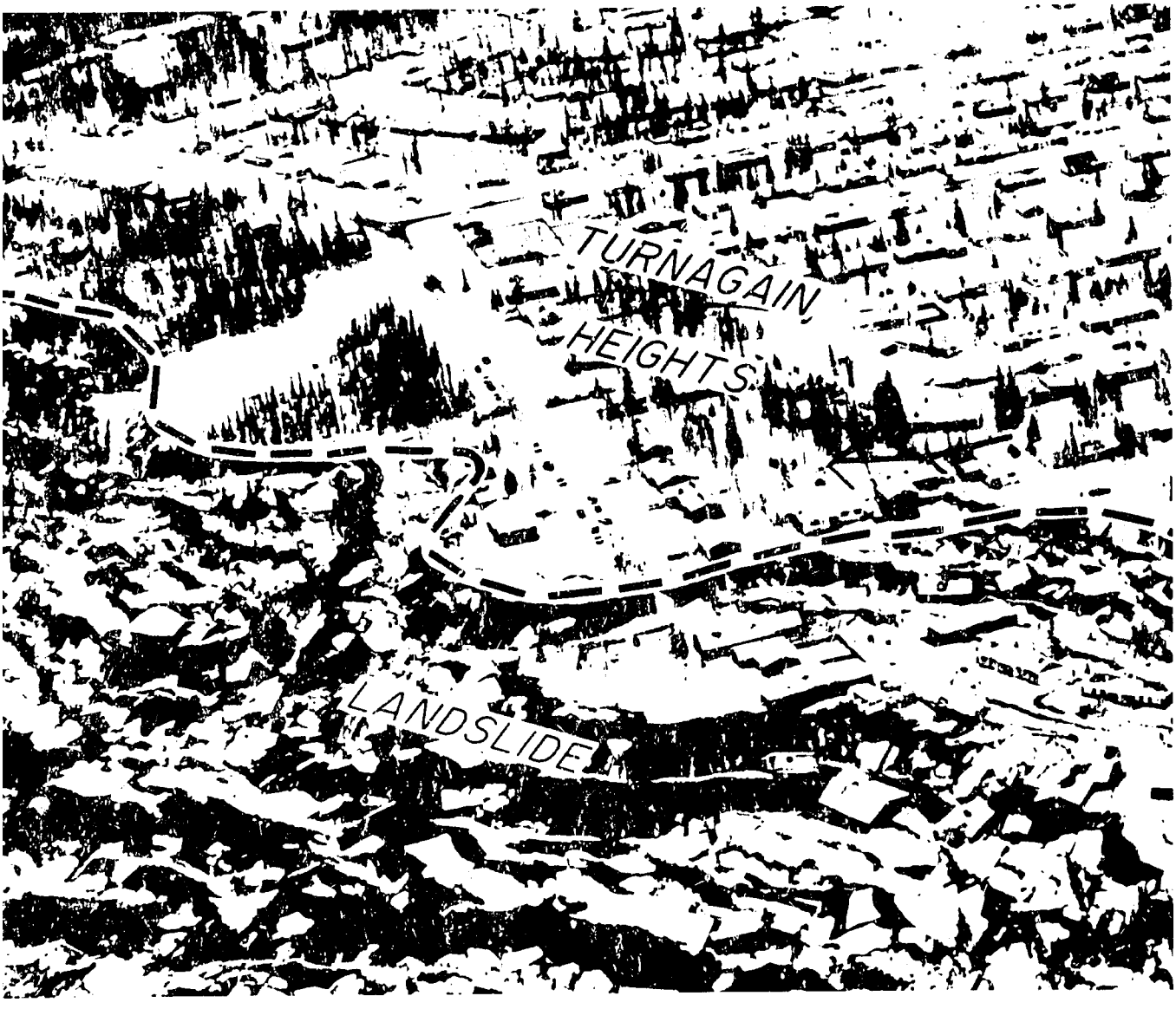

Figure 1 Great landsides triggered by the Alaskan earthquake of 1964 did far more damage than shaking. The Turnagain Heights area in Anchorage, furthermore, was over 1000kilometers from the center of the earthquake. Photo by R. Kachadoorian, U.S. Geological Survey.

Four types of geologic factors should be considered: 1) failure of unstable ground under earthquake excitation, 2) faulting, 3) tectonic warping, and 4) influence of ground on shaking.

FAILURE OF UNSTABLE GROUND

Landslides very commonly are triggered by earthquakes and constitute one of the most serious hazards of many earthquakes. In addition to the Turnagain Heights landslide referred to above, many others developed during the great Alaskan earthquake of 1964. Some were largely submarine. The coastal towns of Valdez and Seward lost most of their dock facilities catastrophically when the steep seaward side of deltas on which they are situated collapsed and slid into the deeper water of the harbors. Such submarine landslide movement can produce the additional hazard of devastating waves, as at Prince William Sound, Alaska (see Hansen and others 1966, p. 94-99).

As another example, Ambraseys (1967) reports that "Landslides and slumping of the ground accounted for the majority of the damage . . ." produced by the series of moderate-sized earthquakes of 1965-66 in the Peloponnesus, Greece.

In addition to landslides, ground settling, particularly differential settling, can place severe strains on structures. During the Niigata earthquake of June 1964, in Japan, liquefaction of the ground so decreased the bearing strength of the foundation material that the buildings tilted as much as 80 degrees (i. e., to within 10 degrees of horizontal). Interestingly, this amount of tilting did not produce failure of some of the structures. Some tilted buildings were later righted by jacking. The structures had been well designed and built to withstand shaking, but apparently the potential failure of the ground had not been taken into account.

McCulloch and Bonilla (1967) described still another form of ground failure, produced by the 1964 Alaskan earthquake. This was "the mobilization of wet unconsolidated water-laid sediments . . . The mobilized sediments moved nearly horizontally toward topographic depressions in gently sloping and nearly flat areas." Ground displacements produced compression and skewing of bridges at streams, and an intricate widespread network of cracks.

Similar ground failure occurs in many earthquakes, particularly in water-saturated sediments adjacent to a stream, lake, or other body of water. At the hotel site in Sapanca, during the 1967 earthquake in western Turkey, this type of ground failure is believed to have been the main cause of damage. There, ground within 100 meters of Lake Sapanca moved laterally several meters northward toward the lake, carrying the hotel with it. The lateral movement was accompanied by a meter or more of downward movement so that the foundations on one side of the hotel came to rest under water.

FAULTING

A generally held concept is that earthquakes are generated when elastic strains accumulated within the earth are released by sudden movement along major faults (large fractures in the earth's crust). This undoubtedly is the principal source of earthquakes, at least of the shallow type, in Turkey, Iran, and Pakistan, and western United States. In many large earthquakes (Richter magnitude 6.5 or greater) fault displacement occurs at the ground surface. During the great earthquake of 1939 at Erzincan, Turkey (Pamir and Ketin, 1941), for example, the North Anatolia fault broke along a line about 340 kilometers long. The blocks on opposite sides of the fault moved 1 to 2 meters relative to one another, and both vertical and lateral displacements developed. Many succeeding earthquakes along the North Anatolia fault have also been accompanied by fault breaks at the ground surface. In 1906 the San Andreas fault similarly broke along a line over 400 kilometers long and relative lateral movement of the two sides was as much as 6 meters.

The principal hazard from faults that break the surface is from the shearing action along the break itself which can tear apart foundations, structures, or utility lines. Damaging shaking is not necessarily greater adjacent to the fault than several kilometers away, and under certain conditions may be less.

These surface fractures, which develop during an earthquake along a fault such as the North Anatolia or San Andreas, commonly disturb the ground surface in a zone 3 to 10 meters wide (see Figure 2), although branching and subsidiary fractures may lace.

Figure 2 Trace of surface break on fault in Mudurnu Valley, western Turkey, earthquake of July 22, 1967. At this locality land on right (north) side of fault shifted two meters toward the viewer respect to land on left side.

through a zone a hundred meters or more wide. The fault trace has the appearance of a line along which the ground has been churned; elongate mounds are formed, as well as hummocks, and a network of cracks a few tens of feet long and a few centimeters wide. On faults characterized by displacement that is predominantly vertical, escarpments from a few centimeters to several meters high may develop as a result of crustal dislocation and landsliding along the surface fractures. A complex network of fractures hundreds of meters wide may form, and acute surface tilts may occur at or in the immediate vicinity of the fault trace.

Recently, evidence has been found (Wallace, 1968b) that individual strands within a complex fault zone tend to be reactivated again and again. Thus, a fault strand that has been identified as recently active must be considered hazardous during future earthquakes. During a particular earthquake, however, other branches, or subsidiary, may also have considerable movement.

TECTONIC WARPING

Warping or tilting of the land surface on a large scale has accompanied many major earthquakes, for example, the Chilean earthquake of May 1960 (see Weischet, 1963), and the Alaskan earthquake of 1964 (see U.S. Geological Survey, 1966, p. 14-17). During the Alaskan earthquake an area of possibly 280,000 square kilometers was either elevated or depressed. A meter or more change in elevation was common, and locally land was elevated 11 meters.

Such changes are particularly disastrous along coastal areas. Low-lying areas can be inundated when the land drops, and shipping lanes and harbor facilities can be adversely affected by their elevation or depresion. In Alaska, the elevation changes also caused extensive damage to coastal forests, salmon spawning waters, and shellfish habitats.

INFLUENCE OF GROUND ON SHAKING

Shaking does not die away uniformly from the epicenter of an earthquake or from the fault that generates the earthquake.

In almost every large earthquake it has been recognized that the type of geologic materials under a given site significantly affects the damage by shaking. In 1906 during the great earthquake in California, for example, in the city of Santa Rosa, about 32 kilometers fron the nearest point on the San Andreas fault, damage was severe, far greater than in many areas a few kilometers from the fault. Even very locally, foundation conditions can strongly influence the damage from shaking, as shown in the photograph of the school site at Varto, Turkey (Figure 3), which illustrates this point. On the old river channel, in which the water table stood at, or very near, the surface, 12 of 14 buildings collapsed, whereas on the adjacent bench, about 5 meters higher, none of the buildings of similar construction collapsed (Wallace, 1968a).

Simultaneous seismic recording of ground motion on bedrock and water-saturated muds in the San Francisco Bay area, California, by Roger D. Borcherdt of the National Center for Earhquake Research, U.S. Geological Survey (oral communication), indicates that amplitudes of waves can be from five to ten times greater on water-saturated muds than on bedrock, and that the amplification factor is relatively greater in the horizontal than in the vertical component. The ground waves recorded in these recent experiments were generated by underground nuclear blasts in Nevada. The water-saturated muds in the San Francisco Bay test area are from a few meters to a few hundred meters thick.

COPING WITH GEOLOGIC HAZARDS

In general, the geologic factors considered here cannot yet be controlled by engineering techniques; instead, regions characterized by such geologically sensitive conditions must either be avoided or used in special low-hazard ways. If structures are to be built, they must be designed to minimize the hazard.

Major faults responsible for destructive earthquakes are such large features that there is no conceivable way to stop them from moving, nor can tectonic warping be prevented. Similarly, although small masses of unstable ground are amenable to control by engineering techniques, such control becomes less and less feasible as the size of the mass and the degree of instability

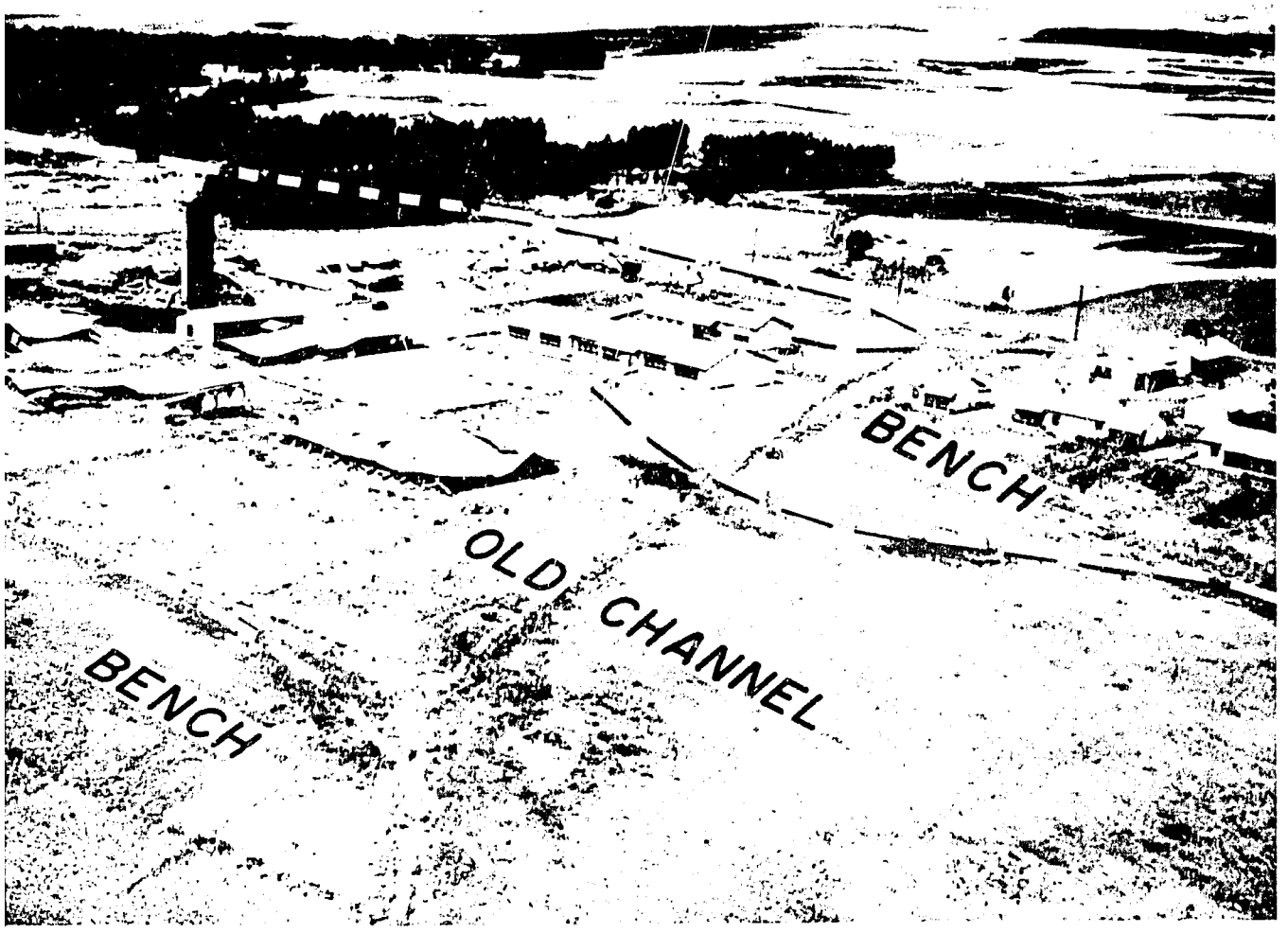

Figure 3 Damage commonly is much more severe in buildings situated on water-saturated alluvium. Here 12 of 14 buildings situated on an old river channel collapsed, whereas buildings on an adjacent dry bench did not. Earthquake of 1966, Varto, Turkey.

increases. Nor do the shaking characteristics of major geologic units, in which many cubic kilometers of materials may be involved, lend themselves to ready modification. In general, therefore, rather than changing the geologic situation, human activities must be accommodated to it.

Landslides or fault strands that have been recently active should be avoided as sites for any structures that might be hazardous to life. Of highest concern should be sites for schools, public meeting places, buildings having high-density occupancy such as high-rise apartments or office buildings, or structures of special hazard such as nuclear reactors. In urban areas the most hazardous geologic areas are best reserved for parks or other relatively open spaces.

Areas in major fault zones, which may be kilometers wide, but not directly on the most recently active strand, may be suitable for low-density housing. One or two-story houses engineered to withstand shaking can be built here, even though there is some danger from movement on branching and parallel fault strands. Similarly, older relatively stable landslides can be put to uses that do not entail undue risk.

The principal means of minimizing the hazard of tectonic warping is in site selection; generally it is feasible to consider tectonic warping only for certain critical installations. For example, it would be wise to place major fuel storage tanks above a level likely to be inundated, but it might be extremely difficult and uneconomical to preclude all damage to dock facilities.

The relative amplification of ground shaking on unconsolidated materials requires some adjustment in the design and construction of buildings. Thus far, however, the variations have not been defined precisely enough for engineering techniques to accommodate the differences, or building codes to satisfactorily take the differences into account. But the unconsolidated water-saturated ground must be considered more hazardous and at least minimum earthquake code standards should be adhered to.

Two steps are necessary to minimize the geologic hazards: 1) recognition and evaluation of the hazardous geologic situation,

and 2) use of the hazardous ground in the least hazardous way.

The first step involves skillful geologic mapping and interpretation by geologists and soils engineers. "Geologic hazard maps," as distinct from more general geologic maps, are only now being developed in a few places; such maps should be used more and more regularly as tools for long-range regional planning and site selection.

The second step aimed at achieving the most appropriate use of land is a complex one involving both the public and private sectors. In the public sector the problems can be dealt with by long-range regional planning, by zoning ordinances, and grading and building codes. As an example, the California Education Code (Calif. Dept. Education, 1967), which involves the construction and siting of schools, included the following statement regarding school sites: "The investigation shall include such geological and engineering studies as will preclude siting of a school over or within a fault, on or below a slide area, or in any other location where the geological characteristics are such that the construction effort required to make the site safe for occupancy is economically unfeasible."

The private sector may take, and more and more has been taking, an enlightened approach and has obtained geologic and engineering advice on how to minimize the hazards. Generally speaking, however, only in the larger engineering projects, for which engineering firms are employed that have diverse talents at their disposal, are geological hazards adequately considered.

In either the public or private sector, inclusion of expert geologic advice in the planning, execution, and monitoring phases constitutes a cost to a project, the benefit of which is rarely appreciated by management. Thus, geologic factors all too commonly are ignored. Repeatedly, however, the costs of ignoring geologic factors are shown to far exceed the cost of early considering such factors.

The goal of using land in earthquake-prone areas in the least hazardous way is not easy to achieve. Improvement of existing techniques for delineating such areas is needed almost everywhere in the world. Geologists and soils engineers must define geologic

hazards in more precise and useable forms. Builders, engineers, and land-use planners, together with the earth scientists, should translate geologic information into suitable action. The politicians and administrators need to write codes and ordinances and to design administrative techniques that will assure the land user of an acceptable level of risk at an acceptable cost.

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THE ROLE OF THE IMPERIAL IRANIAN CIVIL DEFENSE ORGANIZATION IN EARTHQUAKE HAZARD MINIMIZATION

By
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The aim of our Civil Defense Organization, as all over the world, is to protect lives, property and national wealth against any kind of disasters. Earthquake hazard is considered to be the most important and most common of all the natural disasters. According to scientific estimates, there are approximately five thousand shakes per year on the earth. Fortunately all these shakes do not present damage indications and we do not feel most of them. Around one hundred of these shakes are acute and some cause severe damage. There is about one severe or relatively severe earthquake monthly, in some region, resulting in destruction and loss of lives and property. During the last decade some 261,000 lives were lost as result of earthquake hazards.

We hope that the experienced scientists and well informed experts attending this Conference establish a detailed program which could provide solutions for existing problems concerning earthquake hazard minimization.

At this point I would like to bring your attention to the role of the Civil Defense Organization in earthquake hazard minimization. As already indicated the basic aim of the Civil Defense Organization is the physical protection and safeguarding of the lives and property against any disaster including earthquake hazard. As the realization of civil defense aims is based

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on technical competency in all fields, so our organization is always looking for any possibility to profit from the guidance, recommendations, experiences and information concerned with civil defense matters. In fact this is the essential reason of our participation at this conference.

I think that all of you are well informed on civil defense activities. However, in order to refresh your minds I would like to bring the following points to your notice. To face any emergency and disaster civil defense activities are in three distinct stages: a) prevention and foresight, before disaster, b) life saving operations, immediately after disaster, c) completion of life saving operations, survival and recovery.

Prevention and foresight stage - At this stage the essential activity of the Civil Defense Organization consists in informing the people even a few minutes before the outbreak of disaster by an appropriate warning system. For earthquake disaster, establishing a warning system does not seem to be of use in earthquake-threatened areas. Perhaps one day with the development of science and industry it will be possible to overcome this deficiency. At present we can only profit from scientific studies and investigations.

The Imperial Iranian Civil Defense Organization at the prevention stage is trying to encourage appropriate technical methods in constructional plans and designs regarding strength and resistance against earthquake hazards.

Our organization is in direct contact with the authorities responsible for housing and urban development all over the country and is bringing to their attention the proper planning and use of resistant materials for construction in localities exposed to earthquake hazards. We are sure that the conclusions obtained at this Conference will help to set up definite technical principles on this matter so that earthquake hazards which cause great losses can be prevented or at least reduced.

Our organization at the prevention stage is also in charge of another important task which is the training and instruction in self-help and self-protection on a nationwide scale. We also try to teach the factory and other establishment managements

how to protect and safeguard the lives of their personnel and how to reduce the losses which could be incurred from earthquake. It is evident that instruction in self-help and care for others and self-protection systems in the earthquake-threatened regions has priority.

Life saving operations immediately after a disaster - At this stage the Iranian Civil Defense Organization has prepared a project outlining the required measures to create an efficient system of control and survey together with organized rescue, fire fighting, first aid and ambulance, welfare, transportation, debris removal units and other services of civil defense which are designed to be equipped with the most modern equipment and to be capable of fast movement during emergencies. By close cooperation of the municipalities and other competent authorities the Civil Defense Organization shall soon be in position to implement this project.

Completion of life saving operations, survival and recovery stage - The civil defense organization acts mostly as a coordinator because the problem of management and coordination of various activities submitted from governmental departments, public utilities, municipal and private concerns, benevolent societies, as well as national and international organizations is considered to be of great importance and necessity.

The Civil Defense Organization will complete the life saving operations, take survival measures and accomplish recovery and rehabilitation of the damaged area by despatch of mobile operational units and technical experts. With the cooperation of the concerned municipalities and governmental and national authorities, through the Civil Defense Offices in earthquake struck areas, the civil defense organization will take the necessary measures to complete life saving operations, to provide for survival of the inhabitants, reparation of damages, and any other measures necessary for recovery and rehabilitation. Morever it should be also noted that the phsychological factors resulting from disasters are important and will greatly affect the life saving operations. This factor should be taken into consideration particularly in case of earthquake disaster which most often happens as a surprise. The casualties may be faced with great mental shock. Based on these facts the Civil Defense Organization

should make arrangements as soon as possible to train inhabitants of the earthquake-threatened areas in techniques of self-help and care of others so as to reduce the number of casualties and loss of lives.

The organization is always trying to extend and develop its activities. We do hope that, by implementation of the projects outlined, the Civil Defense Organization would be able to fulfil its tasks and missions satisfactorily in any emergency period especially that of earthquake disaster.

SHALLOW EARTHQUAKES AND SURFACE FAULTING IN NORTHERN CALIFORNIA AND IRAN

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INTRODUCTION

The question of earthquake genesis still remains one of the fundamental problems of Seismology and Tectonophysics. Although surface faulting has been observed to be associated with numerous large earthquakes, some seismologists express doubt as to the generality of such an association. Still others may consider faulting as the "effect" and not the "cause" of earthquakes (see, for example, Evison, 1963). The cause, according to this group, may be related to the phase changes of the minerals which constitute the crust and upper mantle, due to the prevailing high pressure and temperature, or owe itself to the motion of magma at depth. A detailed review of the subject of earthquake genesis has been published recently by Bolt (1968).

Leaving the intermediate and deep earthquakes with less likely surface manifestation aside, more pronounced surface faulting is expected to be observed in the regions experiencing either large earthquakes or very frequent smaller ones. This statement would be acceptable regardless of whether faulting causes earthquakes or vice versa. Relative importance of frequency versus size regarding this correspondence is very difficult to estimate at this time simply because the period of

observation is so short. Field studies after several of the recent earthquakes, however, have led to empirical linear relations between the length of breakage and the energy released by an earthquake (Tocher, 1958). Relationships of this nature have also emerged from theoretical considerations (Knopoff, 1958; Niazi, 1964).

In practice, the size of an earthquake is expressed in terms of its instrumentally determined magnitude, which is considered to be proportional to the logarithm of energy (Richter, 1958). With magnitude, therefore, being linearly proportional to the logarithm of the breakage length, more continuous, well-defined surface breaks would be expected to be associated with earthquakes of higher magnitude. Stating it in a different way, one would expect the energy to be released in larger amounts along the fault systems of larger linear extent and in smaller doses along the en echelon type auxiliary fracture systems.

If such a correlation can be shown to exist, then the areas of highest earthquake risk can be delineated around the zones of extensive faulting. Several comments are in order here. First, although earthquake risk is a problem concerning the immediate future, some of the mapped surface faults may be relics of the distant past. Geologically they are there, but tectonically they may be inactive or dead, so to speak. Seismological investigation over periods of tens of years should clarify this distinction. Secondly, it is not necessary that all fault surfaces in the crust extend to the surface. Also, detailed studies in recent years have revealed in some sections along the major faults, substantial displacements may be accommodated by numerous small earthquakes and intermittent slippage. The question arising from simultaneous consideration of these points is still the fundamental one advanced by Louderback (1942) that "given a probable active fault, is it a possible source of a destructive shock?"

PRESENTATION OF DATA

Figures 1 and 2 have been prepared with the view of examining the spatial distribution of the largest earthquakes of a region, within a period, in relation to the existing fault systems. Figure 1 covers northern and central California and western Nevada. The earth-

quake data presented in this figure belong to the five-year period of 1956-1960 and have been taken directly from the Bulletin of the Seismographic Stations, University of California, Berkeley. The known blasts have been eliminated from the list. Nevertheless, a few may not have been identified and consequently may have been treated as earthquakes. Inclusion of such events, whenever located in seismic regions, will be nullified due to their smallness and to the fact that the method selects the largest event within any unit area.

The circles in Figure 1 represent the magnitude ranges of the largest earthquakes occurring in quadrangles of one-fourth degree dimension. They are plotted at the centers of their corresponding quadrangles. The locations of the points on the map, therefore, do not exactly coincide with the epi-central locations of the largest shocks, but are close to them. Furthermore, each point may represent from a single earthquake to as many as several tens of earthquakes having magnitudes between 2 and the indicated maximum range. The fault traces of the Figure are redrawn from the most recent tectonic map of the United States prepared by the United States Geological Survey and the American Association of Petroleum Geologists in 1962.

In Figure 2, the same procedure has been followed for the earthquakes which occurred in Iran during a ten-year period from mid-1957 to mid-1967. The selected quadrangles in this figure extend over one-half degree of latitude and longitude. A more detailed analysis of the seismicity of the region during this period is given by Niazi and Basford (1968). The epicentral locations of the earthquakes in Iran during the early parts of the period are based on the records made at distant stations. In recent years, four stations with three-component recordings have been established in that country. Still, the average distance between adjacent stations is over 500 kilometers. A detailed complete geologic map of Iran is also to be desired. The fault traces in Figure 2 are mainly taken from the most recent map published by the National Iranian Oil Company in which a wide area along the northern frontiers is quite sketchy.

Discussion

Since tectonic processes operate on a large time scale, short-term studies are not expected to provide us with a complete

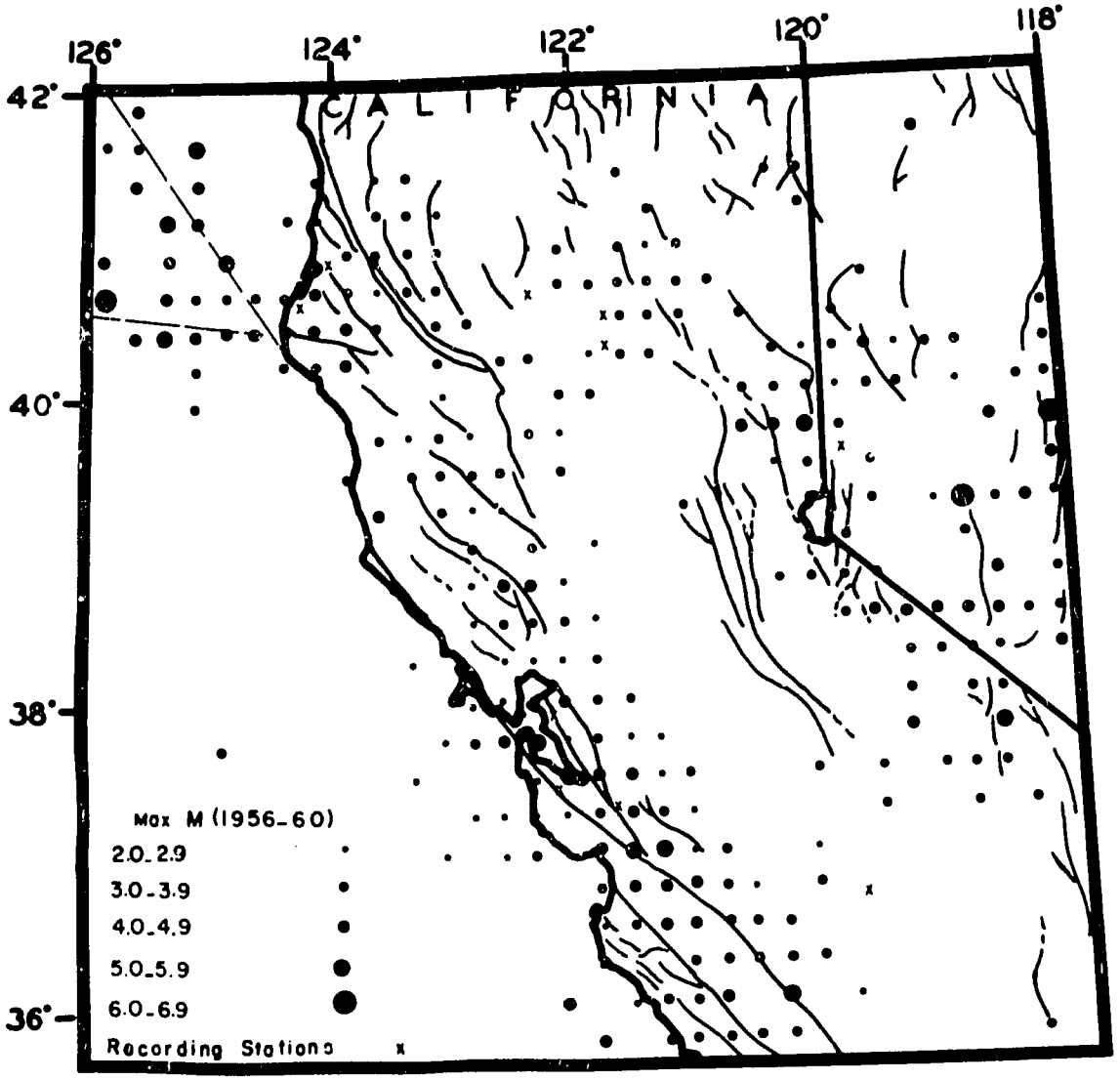

Figure 1

Magnitude range of the largest earthquakes occurring quadrangle one-fourth dimension during five-year period of 1956-1960.

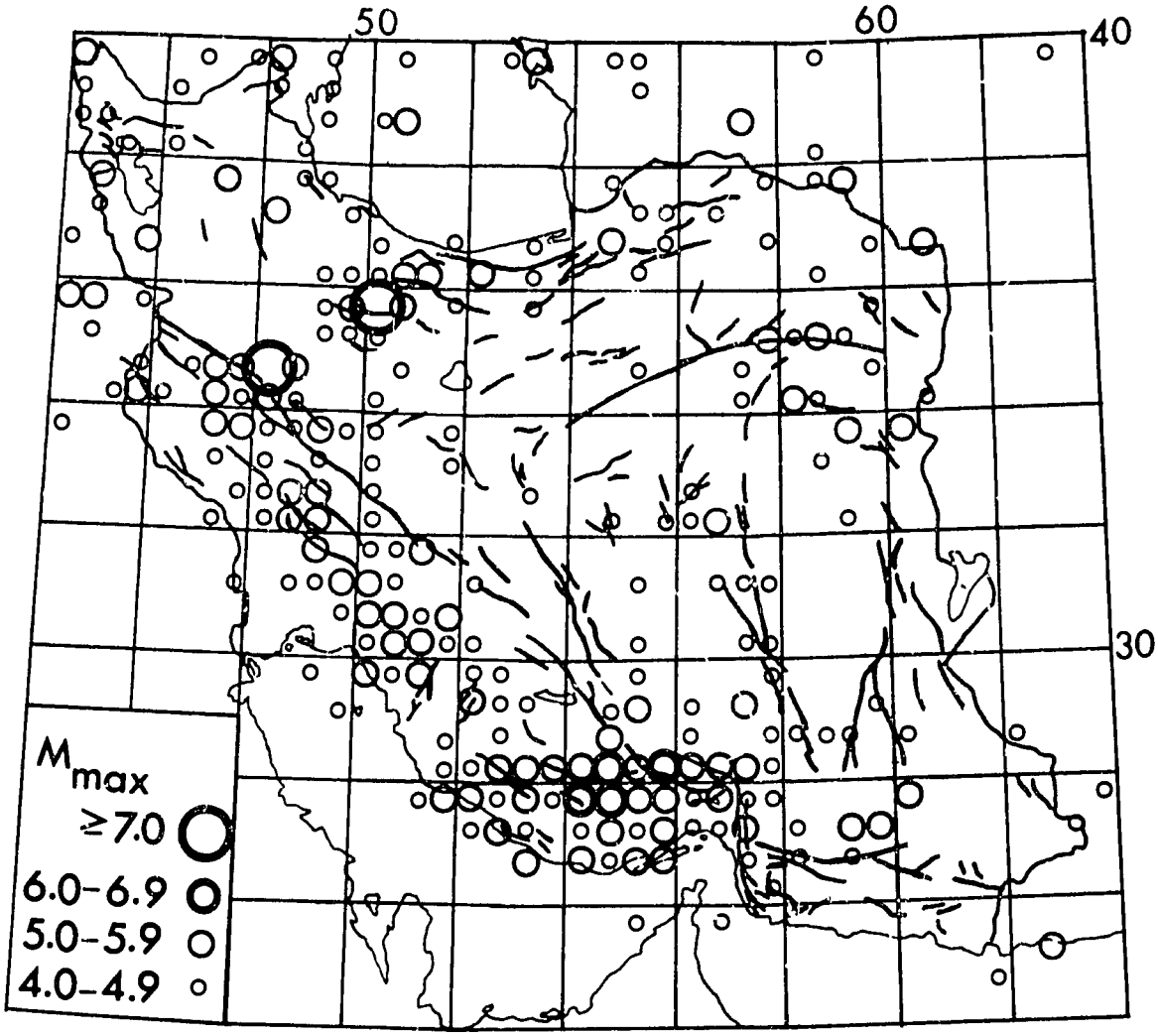

Figure 2 Magnitude range of the largest earthquakes occurring in quadrangle of one-half dimension during the ten-year period of July 1,1957 to June 30, 1967.

picture. This point becomes particularly important when classification of the existing fault systems to active versus inactive faults is in mind. Analysis of the seismic activity in southern California during recent years led Allen et al (1965) to conclude that "Virtually all areas of high seismicity in this region fall within areas having numerous Quaternary fault scarps, but not all intensely faulted areas have been active during this particular 29-year period." The section of the San Andreas fault between latitudes of 38° and 39° very clearly exemplifies this point. This is the section in which the displacement, due to the 1906 San Francisco earthquake, attained its maximum value of 21 feet (Byerly, 1942). Since then, no important seismic activity has been observed along that portion of the fault, which otherwise is considered to be one of the most active fault systems of the world.

A careful examination of Figure 1 indicates that the statement made by Allen et al (1965) can equally be applied to northern California and western Nevada. In general, the seismic activity is concentrated in regions of extensive faulting. An exception is the almost north-south-trending Melones Fault System along the eastern margins of the Great Valley. The time of formation of the Melones Fault System may be as early as Jurassic (Bateman and Wahrhaftig, 1966). The two dashed lines off the coast of northern California are alternative suggestions for the trend of the continuation of the San Andreas fault off Cape Mendocino. Although not inversely true, practically all the earthquakes of magnitude 5 and above in Figure 1 are located close to the most conspicuous fault traces of their immediate neighborhood.

The correspondence of the large earthquakes of the last ten years and the mapped surface faults, as shown in Figure 2, does not appear as good as the data of Figure 1. Most of the seismic activity has taken place along the Zagros Mountains in western and southern Iran. There have been some shocks of magnitude 5 and above, including the destructive Buin-Zahra earthquake of September 1, 1962, which had a magnitude of 7.2, in the northern and northeastern provinces. The two important requirements for the present study, i.e. a detailed geologic map and a dense network of recording stations, were not in existence to the desired extent for the period of interest. Therefore, the coverage of the two factors discussed here, active faults and earthquake population, may well be incomplete. Undoubtedly, many of the earth-

quakes of magnitude 5 and smaller in the unpopulated central deserts have gone unnoticed. Also, as work continues, more detailed geological features as well as their relations with respect to each other in the field are expected to emerge.

While, as has already been emphasized, gross tectonic features do not always coincide with their short-term representations, still the distribution of the larger earthquakes in Figure 2, within the limits of accuracy of the data, is not inconsistent with the conclusions made in the discussions of the data of Figure 1. The long chain of the quadrangles which were struck by earthquakes of magnitude 5 and above during the last decade runs nearly parallel with, but for most parts about 200 kilometers to the southwest of, the major fault trace drawn as an almost continuous straight line from the vicinity of the Hormoz Strait to about 35° latitude on the border of Iraq. If large earthquakes are to be associated with major fault systems, two possible explanations for the apparent shift may be suggested. The combined geological conditions along the Zagros Mountains and the distribution of the recording stations around it may have introduced a systematic error in the epicentral locations of the earthquakes of this region. Or, the most active fault zone of southwestern Iran may not have been encountered by field geologists yet.

The most extended region of seismic activity in Figure 2 is along the 28° latitude. Some of the circles in this region represent as many as 70 earthquakes of magnitude 4 and above. The epicenters of the two largest and most destructive earthquakes of the last decade, while not more than 250 kilometers apart, are situated in two different physiographic units. The Hamadan earthquake of December 13, 1957 was centered near the eastern margins of the Zagros Mountains, while the Buin-Zahra earthquake of September 1, 1962 caused considerable damage along the southern slopes of the Elborz Mountains which run in an east-west direction parallel to the Caspian Sea shores. The proximity of the two centers of high tectonic flux in recent years poses the following important question. Are the tectonic forces which are presently in operation within these two units coupled? If so, what is the state of stresses in the region connecting the two centers?

Questions of this nature are quite fundamental to any effort directed toward the earthquake hazard minimization. Tentative answers to these questions and others which require detailed studies of the distribution of tectonic elements in the region are of primary importance. An intensified effort is called for to provide the regions of high seismic activity with accurate geologic maps and adequate instrumentation. In such an effort, priority should be given to the Lar region, centered at 28° N, 55° E and the Hamadan-Qazvin complex which includes the epicentral regions of the two largest earthquakes on the map. Instrumentation should be oriented toward supplying near-source strong motion and microearthquake data and should make provisions for several strainmeter sites and geodemeter benches.

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PRECAUTIONS BY GOVERNMENT IN EARTHQUAKE AREAS*

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INTRODUCTION

No man can predict accurately when, where, or how destructive the next earthquake will be: we know the regions in which large earthquakes are likely to occur, and there is some statistical evidence of their frequency and magnitude. Our knowledge is continually being increased by research, but there is in existence enough expertise to enable governments to introduce legislation which will protect the lives and property of the inhabitants of any country. This legislation comprises Town and Country Planning Control, Building Control, and the preparation in advance of Emergency Legislation which can be put into force immediately after a disaster.

After agreement on the principle of introducing legislation each government can consider the extent of precautions which can reasonably be taken and arrangements for enforcement. These questions are discussed later in this paper.

Town Planning Control

Town and Country Planning legislation works through the control of land use. The wider aspect of physical (land-use) planning is often known as "country" or "regional" planning and is an important part of the overall development planning of

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a country. A "town plan" (which should be considered as part of a regional plan) sets out in some detail the proposals for the future use of land in and adjoining a particular town. In all countries the orderly development of towns is possible only by having town plans; these should be reviewed every five years or so to keep them up to date.

In seismic areas a town plan is needed even more than elsewhere, and certain additional factors must be taken into consideration: they are discussed below. However before any town plan can exist there must be legislation for its preparation and implementation. Rapid advances have been made in improving planning legislation during the last few decades with the result that existing legislation in some countries is out-dated and not of a type which can guide development in the best way: all countries, particularly those in seismic areas, would be wise to review and, if necessary, revise their planning legislation. Assistance in doing this has been given by the Overseas Division of the Building Research Station to several countries whose legal systems resemble that of Britain.

Town Plans for Towns at Risk

A sound town plan cannot be prepared in a few days: many factors have to be taken into consideration such as the probable population increase of the town, the location of industry, future transport requirements, the best siting of the civic centre, shops, schools and residential areas. If a disaster strikes a town for which there is no town plan it means that hurried decisions will have to be taken on questions such as where emergency housing should be sited and where reconstruction should be started. Experience has shown that wrong decisions have been made in the heat of the moment and much money and effort have been wasted. This could have been avoided by having a town plan prepared before the disaster.

The preparation of town plans can be done by either a professional planner in the public service, or by consultants, or as part of international or bilateral technical assistance.

Special Factors Affecting Town Plans in Seismic Areas

Major earthquakes are often followed by wide outbreaks of fire. It is possible, by connecting open spaces with wide avenues, to form firebreaks and so prevent fires from spreading from one part of the town to another. When considering the normal redevelopment of parts of a town it is wise to give priority to areas containing a large percentage of structurally weak buildings. By replacing them with sound buildings it is possible to save many lives in the next earthquake. A study should be made of any areas where there is weak ground for foundations: these areas should preferably become open spaces.

Another point is to consider what decisions will have to be made immediately after a disaster. The purely temporary accommodation for homeless can be erected on open spaces where the foundation soil is weak - provided that the site is not subject to flooding. New permanent buildings such as factories can be sited at once in the correct zones, and adequate provision left for transport.

Some regulations (Russian for example) insist on a 20 per cent increase in the distance between buildings in seismic areas. This is useful in case of collapse or fire.

Staff to Enforce Town Plans

It is no use having a town plan prepared unless it is enforced. This entails setting out new roads and plots in the right places and controlling the type and siting of new buildings as well as extensions to existing ones and changes in their use.

There is a shortage of qualified town planners, so it is quite likely that many towns will have to rely on the town architect or engineer to supervise the day to day administration. He will need survey staff to assist him.

Building Control

Building control applies to new buildings and to alterations and additions to existing buildings; its object is to ensure that buildings are safe and healthy to live in. Certain minimum

standards are set out, and any person building below them is considered to endanger the health or safety of the future occupants of the building. During the last twenty years much thought has been given to framing building legislation; this is discussed in another paper (Minimization of Disasters - British Expertise) presented at this Conference. All that need be said here is that unless there is building control many lives will be lost in the next earthquake through the ignorance or occasionally the cupidity of builders. The question of how resistant different types of buildings should be and where control can be enforced should be considered in each country. As a general indication it can be said that the difference in cost between a good building in an ordinary area and a similar but earthquake-resistant one, is of the order of five per cent. The difference between a bad building and an earthquake-resistant one is much greater. Taking into account the infrequency of earthquakes and the scarcity of money some governments may decide on trying to make small buildings survive the expected size of earthquake without collapse, though with cracks. Assembly buildings and other major buildings should probably be made stronger.

Regulations should be applied only where they can be enforced. In many countries this means only in the larger towns. Enforcement is in two stages: in the office, the drawings and calculations are scrutinized by a suitably qualified engineer; on the site, a building inspector checks that the building is erected in accordance with the drawings. There are ways of making the burden of inspection easier for local authorities, but they cannot be discussed here.

Survey of Existing Buildings

It is useful to arrange for a structural survey of existing buildings, in particular the large ones which might kill many people if they collapsed. Any building which is found to be potentially dangerous in an earthquake of the expected size can be given a high priority in the redevelopment programme. Any attempt to strengthen such a building might well create a feeling of panic among the public.

Disaster Legislation

In the event of a major disaster which destroys a large part

of a city the government of the country is faced with a situation which cannot be dealt with satisfactorily by normal methods. A large number of matters all need immediate attention and control: these include organising food, medical care and shelter for homeless; clearing and treating the injured; controlling food, medical supplies and building materials to prevent profiteering; organising transport of goods to the disaster area; assessing the damage and demolishing dangerous buildings; clearing blocked streets; setting out areas for temporary accommodation and permanent reconstruction; restoring public utility services; taking precautions for public health; and many other matters.

Experience has shown that the best results are achieved by setting up at once a small committee, or nominating a person, with almost dictatorial powers within the affected area. The exact arrangement depends on the traditions and method of government of the country concerned. Much work has been done by the United Nations Housing, Building and Planning Centre, New York, on collecting information and experience from different countries on the best way to organise affairs after a disaster. All that is done in this paper is to draw attention to the need for preparing in advance emergency regulations which can be introduced in the event of either a major national disaster or a minor local misfortune.

Education

Schools - In some regions, particularly among rural communities, the majority of the inhabitants think of an earthquake not as a natural phenomenon but as an act of Providence against which no precautions can be taken. Many lives will be saved in the future if normal education includes simple explanations of the phenomenon and lessons on cheap ways in which homes and other small buildings can be made more earthquake resistant. The impact of this teaching will take time, but that is no reason for not starting it.

Colleges - Technical colleges should include elementary theory of earthquake-resistant construction in the curriculum: particular attention should be paid to practical construction methods, including those applicable to small buildings. In this way the builders and building inspectors of the future will be able to construct well and spread their knowledge.

Universities - In earthquake prone countries the first degree courses of all civil and structural engineers should include engineering seismology. The courses for a degree in architecture should enable the architect to appreciate the need for structural precautions and to have a general knowledge of them, even if he leaves the actual calculations to the specialist engineer concerned. In addition to the undergraduate training there is a need for postgraduate research into problems which are specific to the country concerned. This work can be undertaken either in the country - which is of course preferable if adequate facilities exist - or abroad. The essential point is to increase knowledge of the conditions in the country and so to enable the designers of the future to meet earthquake problems more efficiently, thus saving lives and money.

SCOPE OF EARTHQUAKE RESEARCH OF AGENCIES WITHIN THE GOVERNMENT OF THE UNITED STATES*

DEPARTMENT OF COMMERCE

The Environmental Science Services Administration earthquake-research program is shared by the Earth Sciences Laboratories, the Coast and Geodetic Survey, and the Atlantic and Pacific Oceanographic Laboratories. In addition, the Bureau of Standards does earthquake-related research in design techniques, building codes, and engineering.

Geophysical and Geological Surveys of Earthquake Fault Zones

Geodetic surveys to measure crustal movement are the main geophysical field study within ESSA related directly to this program. The geodetic monitoring includes measuring and analyzing horizontal and vertical changes in the earth's surface along known fault lines and in adjacent regions using standard geodetic techniques. By periodically resurveying affected areas, the rate of change in crustal deformation is determined. This geodetic technique will provide for resurveying areas previously neglected and for incorporating new areas, particularly in the densely populated areas.

An intensified geodetic research effort is underway to develop a mathematical technique for simulating deformation of the crust

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* Excerpt from: Proposal for a ten-year national earthquake hazards program; A Partnership of Science and the Community: Report of Ad Hoc Interagency Working Group for Earthquake Research of the Federal Council for Science and Technology, W. T. Pecora, Chairman, 1967.)

in three dimensions. Any rebound or other type of displacement noted at the time of an earthquake will permit the calculation of shear components, rates of accumulation of strain, and other related data on a regional basis.

The above work on geodetic measurements will be supplemented by the expansion of an existing strain meter network now centered in Denver and San Francisco in an attempt to delineate the area over which coherent strain fields exist.

Instrumenting Earthquake Fault Zones

The Earthquake Mechanisms Laboratory of the Environmental Science Services Administration, San Francisco, California, has established an experimental cluster of instruments in the San Andreas fault zone 20 miles south of Hollister. The instrumentation includes strainmeters, tiltmeters, seismometers, fault creep meters, telluric current meters, and magnetometers, whose signals are telemetered to San Francisco. Successful monitoring of ultra-microearthquakes has been achieved by a tripartite array of borehole seismometers straddling the San Andreas fault zone. Four other microearthquake monitoring stations have been established elsewhere along the San Andreas fault. This system is currently being expanded into a closely spaced series of borehole microearthquake stations along the San Andreas and related faults, with all data transmitted by hard wire or radio telemetry to the Earthquake Mechanisms Laboratory.

Other fault-zone instrumentation programs of ESSA include use of portable short-period and strong-motion seismographs to study after-shocks, tiltmeter studies in Alaska, experiments in quartz-tube and vacuum-laser strainmeters, and studies of fault creep on the San Andreas, Hayward, and Calaveras faults. In Alaska a permanent network of seismograph stations at College, Anchorage, Palmer, Kodiak Island, Middleton Island, and Sitka, together with a network of University of Alaska stations in southern Alaska is continuously monitoring the fault zone of the 1964 Prince William Sound earthquake area. A network of strong-motion seismographs, including 15 accelerographs and 100 seismoscopes in the Alaska-Aleutian earthquake area, has been monitoring all moderately strong to destructive earthquakes for the past year. Similar studies were conducted for the 1965 Rat

Islands earthquakes delineating a large fault block and an extension of the North Rat Island Ridge and for the 1965 Mexican earthquake related to the extensive continental volcanic belt. Similar studies of earthquake fault zones will be conducted after the occurrence of large earthquakes in domestic and foreign areas. Geomagnetic measurements are being conducted or planned by the Coast and Geodetic Survey and the Earthquake Mechanisms Laboratory.

Physical Basis of Earthquakes

Earthquake-physics research includes: 1) research on the mechanism of tsunamis; 2) studies of the propagation of seismic waves and earth strucuture; and 3) research on earthquake mechanisms including the radiation of seismic waves, changes in the mechanisms of earthquakes with depth, energy release of earthquakes; and the relations between earthquakes, tectonism, and earth structure. Research in rock mechanics is planned.

Earthquake-Engineering Research

The Coast and Geodetic Survey conducts an extensive program of earthquake-engineering research that includes: 1) operating and maintaining several hundred strong-motion instruments in North and South America which are located in areas where earthquake recurrences are great and in structures of special interest where there is need for earthquake-resistant information: 2) studies of soil mechanics and ground amplification, the latter by operating calibrated seismographs simultaneously on firm and soft rock and analyzing the results for relative amplification. Studies with HUD and CDWR have been concentrated in California south of San Francisco; however, the complete program envisages work in Montana, Colorado, Missouri, South Carolina, and New England; 3) studies of seismicity and seismic zoning include a review of the seismic history of the United States, the construction of a revised seismic map and a strain-release map of the United States, and the construction of a special seismic probability or risk map of the United States after a comprehensive review of the surface geology and the development of appropriate ground amplification factors; 4) studies of seismic hazards associated with nuclear reactor siting in the United States and foreign areas and other seismic studies required for missile and rocket launches with

special reference to the protection of the necessary monitoring instrumentation.

The Coast and Geodetic Survey, since late 1930, has actively conducted studies with the Bureau of Reclamation for the effects of water load behind dams on local seismicity and of earthquake motions on the dams; with the Atomic Energy Commission for the effects of nuclear explosions on numerous types of structures, the prediction of the expected ground motions caused by explosions of different yields in various geological formations; with the Department of Defense for the detection capability of global seismograph stations and the computation of magnitude and energy release of foreign and domestic explosions.

The National Bureau of Standards conducts research in design techniques and, in cooperation with the Coast and Geodetic Survey, studies of the economic aspects of earthquakes.

In addition to earthquake research within the program elements outlined above, the Coast and Geodetic Survey maintains a Worldwide Net of Standard Seismographs, an earthquake-reporting program at the National Earthquake Information Center in Rockville, Maryland, and a Tsunami-warning service centered in Honolulu, Hawaii.

The Worldwide Net of Standard Seismographs operated in 61 countries provides quantitative data with accurate time control for national and international earthquake reporting organizations, for compilation of earthquake statistics for use in earthquake and engineering seismology. The National Center for Earthquake Information provides prompt information on moderately strong to great earthquakes to the public.

DEPARTMENT OF THE INTERIOR

Most of the Interior Department's earthquake-research program is conducted by the various organizational units of the Geologic Division of the U.S. Geological Survey. The program as a whole is coordinated by the National Center for Earthquake Research in Menlo Park, California. In addition, the Bureau of Reclamation conducts research in earthquake engineering and

the Bureau of Mines conducts research programs that are relevant to earthquake problems.

Geological and Geophysical Investigations of Earthquake-Fault Zones

The Geological Survey is conducting a broad, inter-disciplinary program of geological and geophysical research on the earthquake faults of California, Nevada, Alaska, and parts of the Rocky Mountains. The temporal and spatial patterns of movement along these faults are being investigated as a basis for estimating the probabilities of how frequently and where fault displacements and destructive earthquakes may occur. Geomorphic and photogeologic studies, aided by remote sensor data obtained from a NASA aircraft, are determining the precise location and the characteristic long-term rate of movement of these active faults.

Regional geologic syntheses and tectonic analyses are aimed at discovering and evaluating the relations of earthquake generation to geologic processes. These studies, with the addition of sub-bottom acoustic profiling and other methods of marine geological research, are also being conducted offshore in order to extend our knowledge to the earthquake faults of the continental shelf and to relate them to the fundamental geological structures and tectonic processes at the western margin of the North American Continent.

The deep geologic structure and lithologic contrasts of the San Andreas and related fault zones are being investigated by seismic-refraction, gravity, and aeromagnetic surveys. Seismic velocities in fault zones measured by seismic profiling are being used to improve the accuracy with which earthquake hypocenters can be located and to relate earthquakes to specific geologic structures. In addition, fault movements and crustal strain are being measured, and related to earthquakes and other geologic processes, by geodimeter nets and by other means.

Instrumenting Earthquake-Fault Zones

The National Center for Earthquake Research has established a network of 32 short-period seismographs along the San Andreas fault zone from San Francisco to Cholame, California. The purpose of the network is to study the relations among earthquakes,

fault-zone geology, and fault movements, and to provide a basis for estimating earthquake probabilities. Signals from all stations are telemetered via telephone lines to NCER headquarters in Menlo Park. The networks are now being extended by additional telemetering stations, and supplemented by portable seismograph stations. Initial experiments are being conducted to add strainmeters, tiltmeters, gravity meters, and magnetometers to the nets.

A local network of 17 short-period seismograph stations has been established in the immediate vicinity of the Rocky Mountain Arsenal waste-disposal well near Denver, Colorado, to study the relations between fluid injection and earthquakes. This study is a continuation of an earlier study based on portable seismograph stations. Another local network is being maintained in the vicinity of Yellowstone National Park to study the relations between faulting and seismicity in the vicinity of the Hebgen Lake earthquake of 1959.

Local earthquake and aftershock studies, based on a net of 20 portable short-period seismograph systems, are being conducted in the earthquake-fault zones of California, Nevada, and other areas.

Physical Basis of Earthquakes

A new high-pressure rock-deformation laboratory research program, aimed at discovering the manner in which rocks actually deform and fail when an earthquake occurs, has been established at NCER headquarters in Menlo Park. Laboratory studies of the mechanics of rock deformation and the fundamental physical properties of rocks have been carried out by the Geological Survey in the Washington, D. C., area for more than ten years. A program of measuring rock stresses in drill holes along the San Andreas fault zone will be started in the near future. These studies are being related to research on earthquake mechanisms based on seismological, geodetic, strain, and geologic observations.

Earthquake-Engineering Geology Research

Earthquake-engineering geology investigations in progress designed to increase man's ability to live safely in earthquake zones include: 1) soil mechanics and ground motion studies to define and clarify the critical parameters that govern the seismic response of soft sediments (ground amplification, subsidence,

strength loss of sensitive clays, and liquefaction of sands); 2) investigation of the nature, distribution, and behavior potential (particularly response to seismic shock) of the sediments of San Francisco Bay and bordering marshlands; 3) studies of the damaging submarine slides associated with the Alaskan earthquake of 1964; 4) determination of the geologic and related onshore and offshore earthquake hazards in the San Francisco Bay area, Juneau and vicinity, Greater Anchorage area, and Alaskan Coastal communities; 5) studies of the physical characteristics of historic faults (surface displacements, distribution of main, branch, and secondary faults, and width of fault zones) in the U.S.; 6) studies of potential geologic and seismic hazards associated with nuclear-reactor siting problems in California and other earthquake-prone areas of the United States.

In addition, the Bureau of Reclamation conducts an active program in earthquake-engineering studies using available research and project funds. The principal areas of work are: 1) analysis of the response of engineering structures such as concrete arch and gravity dams, powerhouses, and a variety of miscellaneous major structures, earth and rock slopes, and foundations to earthquake phenomena; 2) laboratory dynamic studies, materials, models, structures, and structural components, and soil and rock properties; 3) measurement on dams and other strucutures and foundations, and surveillance of reservoir rim stability.

Earthquake-Related Research

Research on volcanic eruption at Kilauea Volcano is being conducted by the U.S. Geological Survey's Hawaiian Volcano Observatory. A network of seven telemetering seismometers near the summit of Kilauea is augmented by six locally recording seismographs at more distant locations. The relations among volcanic eruptions, seismic activity, harmonic tremor, earth tilt, and crustal strain have been successfully used to predict specific episodes of volcanic activity.

Research by the Geological Survey's Water Resources Division on the frequency response of water wells to seismic waves has confirmed the fact that a water well is very sensitive to aquifer dilatations. Because a well is so sensitive to dilatations, it can be used as a seismograph for low-frequency waves. Research

in progress indicates that an open well should record all the long-period waves that produce dilatations with periods in excess of a few seconds. Some water wells exhibit a marked response to earth tides, and water wells should also respond to the so-called "permanent" displacements associated with major earthquakes.

Other earthquake-related research in the Geological Survey's Geologic Division includes extensive seismic, gravity, and aeromagnetic studies of continental structure; studies of heat flow in tectonically active regions; and field and laboratory studies of mineral phase changes that are related to conditions in the earth's interior and possibly to the earthquake mechanism.

In addition, some of the research programs of the Bureau of Mines are related to earthquakes, though primarily directed toward other problems, particularly at the development of the technology of rapid excavation. These programs include: 1) studies aimed toward predicting failure in open pit slopes; 2) near surface measurements of stress in rocks; and 3) studies of rock fracture and of the physical properties of rocks.

ATOMIC ENERGY COMMISSION

The Atomic Energy Commission supports an extensive research program in earthquake-related investigations such as seismology, geology, and geophysics as an integral part of major Commission programs in weapons testing, the peaceful use of nuclear explosives, and the safe siting of nuclear facilities.

The interests of the weapons-testing program in earthquake-related studies, including tsunamis, are oriented toward applied research or engineering-type studies that are required to assure an effective and safe underground testing program. The measurement of yield by seismic measurement of surface motion around nuclear events and the measurements of motion near buildings subject to damage, and the development of the ability to predict the effects of nuclear explosions are examples of the use of seismic technology being developed in this program.

A major problem in connection with the siting of large nuclear power reactors in seismic areas is the sparsity of geologic data

that are related directly to seismic responses of different kinds of earth materials in a complex structural environment. These data are required to provide a technical basis for developing satisfactory seismic designs for reactor containment and associated component systems. The absence of detailed geoseismic data in coastal California and of proven engineering seismic design for reactor facilities have been significant factors affecting the growth and development of nuclear power in this section of the country. Cooperative programs have been arranged with the Geological Survey and the Coast and Geodetic Survey to evaluate the geologic hazards of reactor sites, to collect seismic data, and to substantiate predictions of ground motion and building response from natural and underground nuclear events.

DEPARTMENT OF DEFENSE

Both the Advanced Research Projects Agency and the Corps of Engineers have investigations that support an earthquake research program. The major justification for Department of Defense activities in earthquake investigations is for underground nuclear detection and identification. In carrying out this research and development activity through the VELA UNIFORM Program, theoretical seismology in wave propagation and source mechanisms have been advanced significantly. Other contributions have been in increased knowledge of the structure of the crust, in systems development, and in the form of data obtainable from seismic instrumentation built and operated for research in the nuclear test detection program. The background accomplishments in instrumentation make feasible the concept of instrumental clusters for specific earthquake problems, which is the heart of earthquake prediction research.

The Corps of Engineers has a modest program in earthquake engineering in support of its construction program. It has published the first volume in a series of manuals on the seismic design of buildings and other structures. They carry out some model studies aimed at developing means of estimating earthquake motion and energy in geologic formations at specific building sites.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Although NASA supports no research on earthquakes per se, space technology can contribute tremendously to a National Earthquake Research program through: 1) rapid reporting of seismic activity, utilizing remotely located surface instruments and a satellite data relay system; 2) accurate, repetitive altimetry and ranging measurements for the monitoring of crustal movements on a global scale; 3) timely surveying of damage by satellite-borne cameras and other imaging systems; and 4) accelerate rate of topographic mapping in seismically active areas where maps are not available.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

HUD has an obligation to Congress to report on the feasibility of earthquake insurance in accordance with Section 5 of the Southeast Hurricane Disaster Relief Act of 1965. To make this judgment, much more information is needed to evaluate the probability that earthquakes of a given magnitude will occur in a specified area during a given period of time and the effects of different geological formations on earthquake shock waves so that expectable damage can be related to different types of exposed formations and to different types of buildings or structures. The capability to provide the required evaluation lies within the combined capabilities of the Coast and Geodetic Survey and the U.S. Geological Survey.

NATIONAL SCIENCE FOUNDATION

The mission of the National Science Foundation is the support of basic research and education in the sciences. The immediate purpose is to acquire basic scientific knowledge and assure the United States of an adequate supply of competent scientists. The ultimate purpose is to provide the reservoir of basic scientific knowledge necessary for the applied research and development that are focused on our economic and social well-being. To accomplish its purpose the Foundation considers proposals for the support of research and education in all fields of science and

disburses funds through grants and contracts, largely to academic and non-profit institutions.

Although the research support by the Foundations is basic rather than applied, many of its grants in geophysics support work in seismology, gravity, heat flow, rock mechanics, and the behavior of rocks under high pressures and temperatures — all of which contribute fundamental knowledge in the study of earthquakes, their causes, and their characteristics. A portion of the effort in advanced experimental and theoretical research on earthquakes and earthquake engineering called for in this report is conducted in universities.

The present NSF program in directly applicable earthquake research is exemplified by the following selected list of grants and contracts awarded in FY 67:

Earth Sciences

Bombolakis	-	"Process of Br ,tle Shear Fracture"; Boston College; $21,600.
Chinnery	-	"Theoretical and Field Investigations of the Mechanism of Faulting"; Brown University; $14,900.
Allen	-	"The Mechanism and Tectonic Environment of Earthquakes"; Caltech; $150,000.
Anderson and Archambeau	-	"A Study of the Elastic and Anelastic Properties of Rocks and Rock-Forming Minerals at High Temperature and High Pressure"; Caltech; $75,000.
Brune and Roy	-	"Studies of the Crust and Upper Mantle Under the Western United States"; Caltech; $346,200.
Bolt and McEvilly	-	"Analysis of Central California Large-Scale Array Data"; U. of Calif.; $48,700.

Gilbert	-	"A Study of the Earth's Strain Field"; U. of Calif.; $24,300.
Kennedy	-	"The Effect of Pressure on Melting"; U. of Calif.; $72,200.
Newton	-	"High Temperature and High Pressure in Solid State Geophysics - Extension"; U. of Chicago; $40,000.
Drake and Oliver	-	"Relationship of Microearthquakes to the Geology and Tectonics of Kenya and Iceland"; Columbia U.; $54,800.
Oliver and Isacks	-	Deep Earthquakes and Island-Arc Tectonics and Structure"; Columbia U.; $146,200.
Decker	-	"Measurement of Horizontal Ground Surface Deformation in Iceland"; Dartmouth College; $13,000.
Seifert and Sendlein	-	"National and Experimental Deformation of Anorthosite and Rock Gypsum"; Iowa State U.; $45,000.
Brace	-	"Experimental Studies of Fracture of Rock Under Crustal Conditions"; M.I.T.; $84,200.
Simmons	-	"Temperature Dependence of the Elastic Constants of Rock-Forming Minerals"; M.I.T.; $18,900.
Walsh	-	"Theoretical Studies of Fault Mechanics"; M.I.T.; $41,100.
Sanford	-	"Properties of Microearthquakes in Central New Mexico"; New Mexico Inst. of Mining and Technology; $58,400.
Tryggvason	-	"Measurements of Crustal Movement in Iceland"; U. of Tulsa; $22,200.

Mateker, Sharon and Hinchey	-	"Regional Tectonic Study of the New Madrid Earthquake Zone"; Washington U.; $68,900.
Cooms	-	"Beam Extension of the Boeing Laser Seismograph to 1000 Meters"; U. of Washington; $30,200.
Carter	-	"Pressure Dependence of Ductile Flow of Silicates"; Yale U.; $60,000.
Oliver	-	"Study of Microearthquakes"; Columbia U.; $40,500.

Earthquake Engineering

Housner and Hudson	-	"A Comprehensive Program in Earthquake Engineering"; Caltech; $407,400.
Penzien, Boukamp and Clough	-	"Energy Absorption Characteristics of Structural Systems Subjected to Earhquake Excitation"; U. of Calif.; $401,100.
Adams and Jordaan	-	"Tsunami Runup Experiments on a Scale Model of Oahu"; U. of Hawaii; $35,000.
Matthiesen	-	"Forced Vibration Studies of Buildings"; U. of Calif.; $52,500.
Kemp	-	"Earthquake Forces in Shear Building with Artificial Foundations"; West Va. U.; $8,000.
Kozin and Bogdanoff	-	"Engineering Applications of Stochastics"; Purdue U.; $187,800.
Nielsen	-	"Earthquake Engineering Research Summary"; U. of Illinois; $11,000.

Hutcheson	-	"A Study and Report on Earthquake Engineering Research"; National Academy of Engineering; $76,000.
Hutcheson	-	"Site Investigations after Destructive Earthquakes"; National Academy of Engineering; $15,000.
Hudson and Housner	-	"Conference on Earthquake Engineering Research at Universities"; Caltech; $9,700.
Schiff	-	"Strong-Motion Seismograph Design"; Purdue U.; $20,000.

ORGANIZATION FOR EARTHQUAKE DISASTER RESPONSE

By
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When an earthquake strikes it is probably the greatest killer of life besides being highly destructive of property. It does not follow any boundaries, like war, nor does it follow any special climatic regions like the epidemic outbreak of cholera, malaria, etc. The devastating powers of an earthquake can be imagined when we realise that the energy released during the largest shocks is roughly equivalent to 10,000 of the original atom bombs of Hiroshima dropped upon an area all at once. Billions are spent on nuclear and space research yet the subject of earthquakes does not seem to receive the recognition it deserves, especially on an international basis.

Against the Aristotelian theory of entrapped air escaping from the earth's interior and the views of some theologians who thought that earthquakes were the manifestation of God's wrath, or shifting of the weight of the earth from one horn to the other by the sacred bull, the modern earthquake theory is based on factual data. Earthquakes are produced by slippage of rock masses along a fault. The "elastic rebound theory" is the most popular concept on which the seismologists can explain the mechanism of earthquakes on a rational scientific basis. With the advancement in scientific instrumentation it is now possible to calculate quite accurately the focii and epicentres of seismic disturbances, and determine the intensity of seismic activity on

the globe. The most active area is that known as the "Circum Pacific Belt" which includes the Aleutian Islands, Japan, the Philippines, New Guinea, New Zealand and the West Coast of North and South America. Another belt extends from the Mediterranean eastward through Asia and eventually joins the Pacific belt in the East Indies.

Pakistan is situated on the latter belt. Many regions in the sub-continent are subjected to frequent earthquakes, though only a few of them have been disastrous in their consequences. The Bihar earthquake in 1934, the Quetta earthquake in 1935 and the Assam earthquake in 1950 are examples of the few most calamitous earthquakes that struck the subcontinent during the century. Out of these Quetta falls in Pakistan which is perhaps the only station that was severely devastated by an earthquake of comparatively recent origin. It may be relevant to state a few salient facts here. The earthquake occurred on the night of May 30-31, 1935 at about 3:03 A.M. The entire damage caused to life and property was within 45 seconds of the first shock, there being left very little for the subsequent shocks to damage. The epicentre of this earthquake extended over a tract about 68 miles long by 16 miles wide, passing from Balali, just northeast of Quetta, through the Sariab Valley, at one end of which Quetta is situated, through Dingar and Mastung up to Mandi Haji to West of Mastung-Kalat Road. The shock was felt over a much greater area which included Kalat, the Pishin sub-division, Nushki and the Bolan Pass, but no great damage was done in any of these places.

The city of Quetta was completely destroyed while Quetta Cantonmentt fared better. Main reasons of damage were: 1) the inferior construction and tall buildings as most of the houses were of sun-dried mud bricks; 2) narrowness of streets, as the people who rushed safely out of their houses were soon buried under falling houses from both sides of the streets; 3) wire-netting used in partitions proved a veritable trap for the injured as people even not seriously injured could not escape from these snares.

After the March 1931, earthquake the railways constructed their buildings for an acceleration of two to three feet per second square, the design essentially consisting of the use of old rails

placed horizontally and vertically. These buildings stayed safe. Loss of life alone amounted to 25,000 to 30,000. There exists an excellent Report on the Quetta Earthquake by Capt. L. A. G. Pinhey, I. A., Additional Political Agent,Quetta (Government of India Publication-1938) which comprehensively deals with every aspect connected with the disaster, its aftermath, and rehabilitation of victims. During the period 1954 to 1960 in Pakistan and the surrounding area, more than 869 earthquakes were recorded on the network of seismological stations of the Pakistan Metorological Department.

From the foregoing it would appear that once an area is struck by an earthquake immense force is released and complete destruction is wrought in a few seconds. It may thus appear that the need for organizations or institutions dealing with the aftermath of a quake is important yet such institutions are significant by their absence in most of the countries of the world. The main reason for this is perhaps the fact that as far as probable forecast of an earthquake is concerned, science is still in its infancy. It is also extremely doubtful whether geophysicists will ever be able to predict the time of an earthquake to the nearest day or week although it is not beyond the realm of possibility that eventually they may be able to predict the time of occurrence to the nearest year or so.

Since all the countries have other compelling demands on their budget few can afford to have organisations and institutions, elaborate in men and material, but which have no work to do over the years except serving as stand-byes. In Pakistan also there is no single institution which can probably deal with some success in such an emergency. The most significant of such organisations is the Civil Defence Department.

The subject of minimising earthquake damages should be introduced in the academies and training institutions of the Civil Defence Department. New academies and training institutions may be set up if found necessary. The Civil Defence Department is being reorganised. It is suggested that a post of Controller, Seismic Rescue and Reconstruction be introduced in the revised set up. This could be a subsidiary department of the Civil Defence. The Department may be headed by a director who should have additional and deputy directors incharge of staff and training, rescue and codes, publication and coordination. A skeleton of the proposed Seismic wing appears in Appendix I.

A director general with the rank of a Joint Secretary in the Ministry of the Interior may look after the work of this department along with that of Civil Defence. This is likely to increase the budget of the Civil Defence Department by about 15 percent.

PRESENT PROGRAMME

Unfortunately no place is safe from earthquakes and in Pakistan seismic activity of detrimental nature can be expected in both the wings. In the event of an earthquake the situation will be dealt with like any other emergency. The only safeguard that exists is perhaps that all the buildings of public importance constructed under government agencies should be designed, among other things, for seismic considerations. It is hoped that buildings emanating in the private sector will also cater to this, once the codes are strictly enforced. Only in Quetta do the urban authorities insist on seismic-proof construction under an urban construction code. The comprehensive formulation of the code will depend on the intensity of the earthquake that is anticipated to occur in the region.

Providing Immediate Temporary Houses

Because of special political circumstances the country has been dealing successfully with a gigantic refugee rehabilitation problem— an act of our neighbours, and rehabilitation of flood victims— an act of God.

These very organisations can be made to work with earthquake problems if the need arises. Immediate temporary houses for earthquake victims are provided by buying camping equipment generally in stock in the market. This problem can further be solved by erecting temporary tin sheds. The tin sheets and wood for this purpose are stockpiled. District authorities have powers to ask for evacuation of educational and public buildings and use them as temporary shelters. Schools and Colleges, etc. are thus made use of in an emergency. This is obviously not a very good arrangement as it disrupts normal functions of community life with far-reaching consequences. Public buildings in seismic regions have been constructed earthquake-proof, especially after the Quetta earthquake.

Providing for the Reconstruction or Re-location of Houses

After the Quetta earthquake a phase of reconstruction followed. Before the earthquake, Quetta did not have any R. C. construction. The ordinary burnt bricks in mud or burnt bricks in cement lime mortar construction, along with the kutcha mud houses, collapsed like a pack of cards. In the post-quake reconstruction period it was not found necessary to relocate the housing estates, though for reconstruction it was made compulsory that all construction be made on R. C. or B. B., with adequate built-in resistance for a lateral thrust of the sort experienced in an earthquake.

Generally speaking, it is not thought possible to abandon earthquake-prone sites and relocate the construction in a safe zone as the factors which cause development of a town are many and probably seismic considerations will not weigh much amongst other factors.

Financial Assistance (Loan and/or Grants)

With the experience of Quetta it can be concluded that financial assistance does fall under "relief funds," loans, pay advances to public servants, revenue remissions, taqavi suspensions, etc. Organisations like the House Building Corporation also advance loans and help people rebuild their houses. These loans are recoverable on easy payment of instalments.

RECOMMENDATIONS AND CONCLUSION

It emerges then that an earthquake is a great calamity from which no zone in the country can be considered safe. Once the calamity strikes, mammoth loss of property and life can be expected. If possible, all efforts should be made to take preventive and curative measures that may minimise the loss to life and property. Some such measures are listed below:

1. The network of seismological installations should be extensively strengthened so that their observations are of a high accuracy and therefore dependable. They should be equipped with the most modern instruments. Optimum

of observation stations should be provided. The most modern laboratories have been set up at Quetta and other principal locations in West Pakistan. At least three such laboratories must be established in East Pakistan in order to make epicentral calculation by triangulation for that region independently. Seismographs having a magnification of 50,000 are urgently needed. This can be done if international agencies extend their assistance.

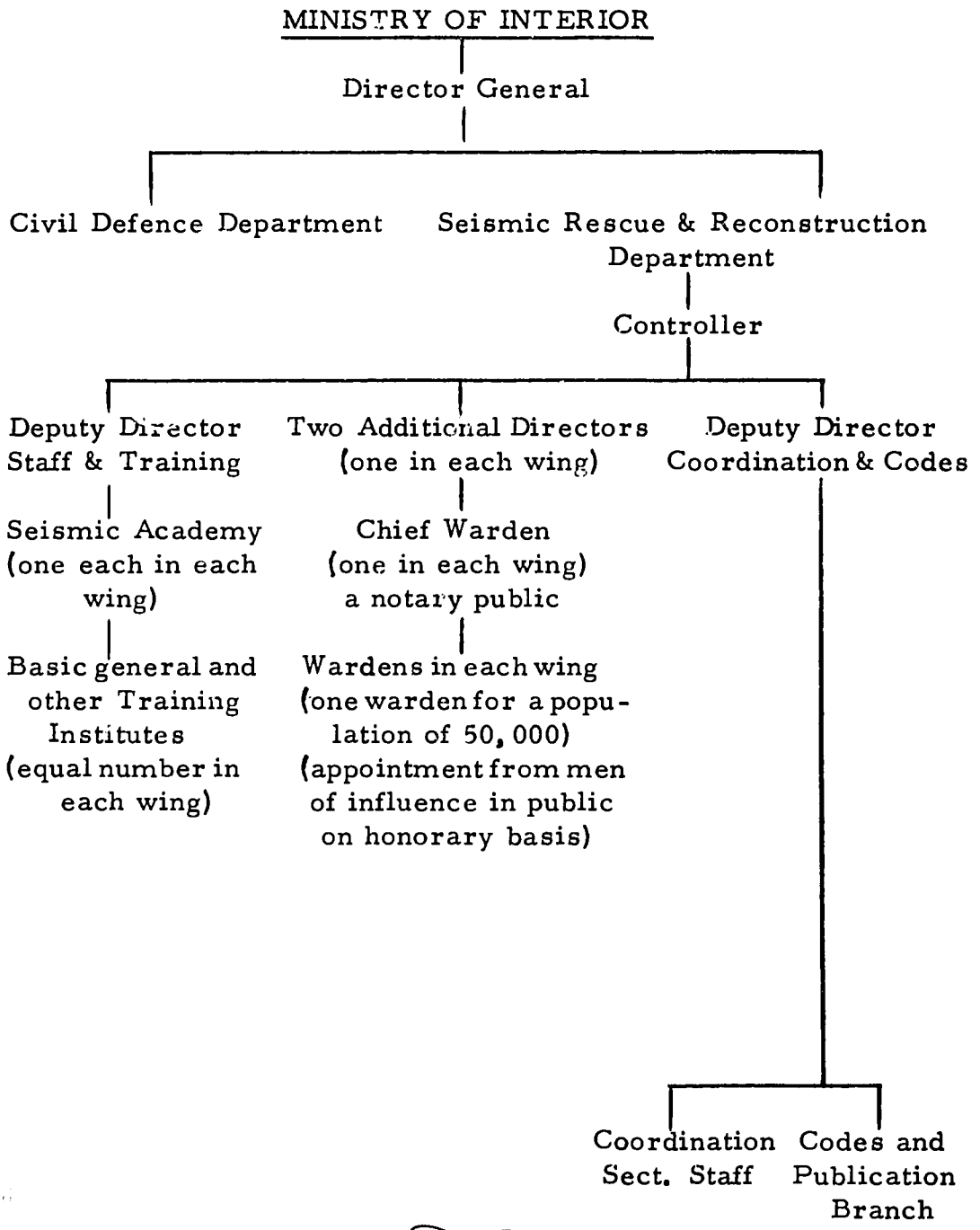
2. It is recommended that a separate organisation to deal with the earthquakes at the international level be created under the auspices of the United Nations. This organisation should come to the immediate help of the country affected by an earthquake.

3. All permanent structures being built in the country should conform to a seismic code, which may be made for the whole country by the central government. Local authorities may not pass on plans for buildings unless the seismic codal requirements are fully met. Strict adherence to this may be desirable and some random central checking may also be necessary.

4. A department for earthquake rescue and reconstruction may be created so that it could effectively deal with the aftermath of an earthquake. The department should have academies and institutions attached to it to train instructors and keep the knowledge of relief workers up-to-date through refresher courses.

APPENDIX I

PROPOSED SET-UP OF A SEISMIC RESCUE AND RECONSTRUCTION DEPARTMENT



SOME THOUGHTS ON ORGANIZATION FOR VILLAGE DEVELOPMENT AND RECONSTRUCTION FOLLOWING EARTHQUAKE DAMAGE

By
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In areas subject to recurring earthquake damage, long-range planning is necessary at local, as well as national level. While it is recognized that technical staff and funds for research and planning are not available in the average village, a good deal can be done to assure organized, rational reconstruction, with the best possible use of available resources and the least possible dislocation of community life.

The average village has grown over generations or centuries with little thought for form other than that of convenience of the moment; and with location determined by availability of land and water and accessibility to existing roads and markets, etc. While these are certainly valid criteria, as far as they go, the resulting community often evolves into a less than desirable living environment. In an earthquake zone, village placement and the design of its individual dwellings may well represent a hazard to life more potent than crowded compounds and poorly placed wells. Except for communities experiencing frequent quakes, where attention is drawn to mistakes through bitter and repeated experience, most villages are poorly prepared to cope with the aftermath of a major earth tremor. While no simple or all inclusive answer exists, the following recommendations are intended as the basis for one course of action which would involve the man with the most to lose.

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DEVELOPMENT AND REDEVELOPMENT DATA

While it is economically impossible to provide a "disaster plan" for every community in the nation, it is possible to provide broad guidelines for use wherever needed. Such basic data might well include the following:

a. A series of "sketch plans" for villages of various sizes. These should not be intended to rigidly control or "standardize" the various communities, but would simply provide guidelines for extension or redevelopment of communities based on the best possible compromise between tradition and efficient and economic land use and activity patterns.

b. A set of criteria for land use and zoning which can be used to interpret and modify the sketch plans in "a" to meet individual community requirements. These should be directed to the layman and should be well and simply illustrated to show the effects of various communication patterns, noise, objectionable activities and odors, etc. Again a reasonable compromise may have to be reached between social, commercial, and religious custom and what might be considered good practice under other circumstances.

c. A set of criteria outlining simple means and methods of constructing earthquake resistant housing and community structures using available materials and the least possible imported materials and skills. The question of a light roof, corner bracing, panelized walls, etc., should be covered in what amounts to a performance code geared to the economic means of the average village family.

   The areas of living spaces, ventilation, potable water, and sanitary facilities should be covered in clear detail with ample illustrations to allow and encourage improved structures where dwellings must be repaired, extended or replaced. These criteria should apply before a disaster where possible as a preventative measure, and would be used as a guide for reconstruction following earthquake damage.

In all the above, it must be remembered that whatever guidelines are proposed must be acceptable to those who must use them. As urban oriented professionals, we often lose sight of the fact that village patterns and methods are based on tradition that in the main has evolved through necessity and reasoning as valid in its own way as much of what is learned in the university classroom. As a result, we are often guilty of attempting locally unrealistic or objectionable standards because they represent "the modern way." Often the wisest course is to treat the village as a client, whose needs and desires must be considered and balanced against available technology, resource, and a thorough knowledge and understanding of local conditions.

EDUCATIONAL MEANS AND PROCESS

Although the use of design teams to evolve individual village emergency plans is normally out of the question, adequate means do exist to accomplish what is necessary. Teachers, agricultural agents, postal agents, regional medical personnel, police and the military are among those available to carry out the necessary spread of information and initiate local action. The schools, meetings of village elders or elected officials, gatherings for fairs, markets or holidays, offer opportunity for discussion. Posters in schools and other public buildings offer excellent opportunities for sparking interest in and spreading information on construction methods and village organization. Coffee houses and places of worship offer similar opportunities, and may well provide the necessary public discussion and leadership.

The transistor radio has proven to be an almost universal medium for reaching the village. Here one professional, through carefully prepared messages can span the nation with vital information on simple technology and indicate how further material can be secured.

Each community should be provided with "kits" of appropriate data. While essentially self-explanatory, local persons or groups must be designed to organize and discuss the material, how it should be used, and how local plans can be implemented.

In order to produce the necessary data and coordinate its distribution and use, a single government agency or office should be designated as responsible. In most cases, this will simply mean an extension of or addition to present responsibilities of an existing agency.

NATURE OF LOCAL ACTION - PLANNING PHASE

Once a community has been convinced that preventative action and/or reconstruction planning should take place, the nature of that action and the designation of locally responsible persons should take place as quickly as possible. Some of the action which should take place include:

a. The choice of an alternate site or sites for use in reconstruction in the event the present community proves or has proven to be particularly vulnerable to earthquake damage.

b. An allocation of "zones" within the alternate area(s) for residential, public, storage and other purposes to be generally known in the event of the need for evacuation of the present community.

c. An assessment of human resources, including medical personnel, building trades, community and religious leaders, etc., who could assist with organization, salvage and reconstruction. Each of the persons with a special skill should be assigned a specific task in the event of need.

d. An assessment of material resources such as vehicles, building supplies, alternate water sources, etc. Individuals under "c" would be assigned responsibility for utilization of these resources in the event of need.

CENTRAL GOVERNMENT FUNCTION - PLANNING PHASE

Central Government action relative to the foregoing might well take three forms. First, the preparation of sketch plans, land use, and construction criteria must be carried out by an

agency with knowledge of all areas of the nation, with adequate technical competence to provide original, imaginative solutions, and with access to the necessary means for distributing redevelopment data to all communities in the areas likely to be effected by earthquake.

Secondly, the agency in question must be able to provide program explanation and training to regional personnel in those functional fields operating in smaller communities (health, security, education, etc.). Such personnel would in turn coordinate the efforts of staff at the local level, and would act as liaison with the central agency.

Thirdly, the agency in question must be able to provide incentives for pre-disaster activities and technical and material assistance following any earthquake damage. For example, regional competition between villages is often high. This can be used to advantage by providing the community producing the best redevelopment plans within a specified period with some material reward and/or national recognition through the press, radio, etc. All communities completing a plan might be recognized in published lists, with some appropriate symbol, such as a special flag being provided for display in the community. Pumps, small generators, or similar items of equipment are excellent rewards to encourage development planning, and can be useful in the event of disaster.

Redevelopment plans might well be prerequisites for government assistance in various community programs, such as existing or proposed assistance for housing, roads and bridges, water supply and waste disposal systems, etc., which might be adversely effected by earthquake activity.

Once adopted, there must be reasonable assurance that redevelopment plans will be implemented in case of disaster and in any interim development which may effect the community. To this end, copies of all development plans should be on file in the central agency, so that immediately following notification of the location, and approximate extent of damage, all authorities concerned will have access to information necessary to implement meaningful action. (This would include availability of local skills, materials, vehicles, potential water sources, alternate roads, evacuation areas for refugees, etc.).

For normal development, administration and enforcement of the simplified building codes or standards suggested would probably have to be undertaken by regional staff, which might be from Public Works, the Housing Ministry, or, where acceptable or desirable, Military Engineers.

While resident staff in every community is often out of the question, a simplified reporting and recording system is necessary to provide adequate knowledge of construction and other development data. This can be done by one of the existing agencies, such as postal service, village government, etc., or might become a function of an organized "self help" group within the community. Maximum local participation and responsibility is, naturally, desirable.

Self Help Construction

It is normally true that where reconstruction is most urgent, not only funds but professional assistance, skilled labor, and material resources are insufficient. As, traditionally, much rural and village housing is accomplished through the self help efforts of a family or "neighborhood" group, this concept can be utilized to great advantage for reconstruction.

While most countries, including those of the CENTO region have attempted Aided Self Help Programs, few have utilized the full potential of this concept. The key is in the word "aided," which implies organization, education, and on site training which is normally not available to the family or village. The provision of a technical and social self help organizer from a central agency or ministry is a small investment indeed when compared to alternatives which constitute a significant drain on available resources.

Through self help, not only labor but significant amounts of indigenous materials can be provided. It is also a rare village indeed that cannot provide some skill in masonry, carpentry, plastering, brick and block making, etc., to convert those materials, whether salvaged or new, into improved dwellings where the necessary guidance is provided.

Self help housing is only a beginning once a group has been organized and realizes its own potential. Schools, markets, places of worship, roads, drainage, bridges, etc., all lend themselves to self help efforts. In addition, these same groups should be encouraged to improve their economic means, whether through agriculture or the processing of agricultural or mineral products. This latter type activity can provide alternate means of employment for those no longer needed on the farms, or for the youth who does not wish to become a farmer. Self help and aided self help thus provides a "countermagnet" for some who would otherwise migrate to the city, unknowingly providing problems for the villages they leave and the communities they enter.

Local aided self help groups are ideally formed to take part in the normal development of community, and are thus immediately available and skilled should earthquake or other disaster strike their community.

Financing Reconstruction

The use of government financing for reconstruction is often limited to grants and direct loans. Because many of those displaced by earthquakes damage have little in the way of savings or earning power, grants are necessary if these families are to receive significant assistance. On the other hand, many families can afford to repay at least modest loans for reconstruction of dwellings and commercial structures, etc. Government funds, however, are normally limited, and direct servicing of such loans places a further burden on tax revenues.

A useful mechanism, well worth consideration if not already in use, is the guarantee. Under this system private lending institutions are encouraged to make medium and long-term loans to those families whose income is sufficient to cover the necessary payments. The central government guarantees the repayment of these loans with the "full faith and credit" of the nation and the agency concerned.

It is normal for a small fee to be charged by the government agency for this service to cover administrative costs and to build a fund to be used in the event the guarantee must be used. Fortu-

nately, due to the fact that most communities and nations have a housing deficit, it is seldom necessary to "trigger" the government guarantee if arrangements are made to allow the lending institutions to foreclose and resell the property when necessary. Such action is often more acceptable when carried out by private enterprise than by government. In any case, such government guarantee can provide the necessary incentive to private industry to undertake multiple unit programs which would otherwise be considered "high risk," or too insignificant on an individual basis.

In addition to the above, long-term planning should involve the encouragement of private savings institutions, which can handle small deposits and small loans for housing and rehousing on an economic basis. While Savings and Loans and Savings Banks can fill a need for middle and upper income groups, credit unions, cooperatives and similar institutions should be encouraged to allow participation by lower income families. Limited seed capital and technical assistance might well be provided by central government to assure proper management. In all cases, low down payment and relatively long terms will be necessary to assure participation by lower income families in both savings programs and economic repayment of loans.

Other funds which might well be tapped under proper controls for village reconstructing are postal savings, production and sales cooperative reserves, insurance and retirement funds, etc. In each case, safeguards should include some form of government guaranty to reduce risk at a level where it can be least afforded.

The Key

While technical assistance in the form of the criteria suggested and field activity, plus some form of financial aid, is necessary for reconstruction following a major disaster, the key to village reconstruction is "self help." Self help in planning for possible post disaster action, controlled development within the existing community, cooperation with officials designated for informational and educational activities, organized construction teams, designation of local responsibility in the event of need, designating alternate construction sites, formation of local savings institutions, and similar activities all improve present village life, and increase chances for survival

and make possible rapid reconstruction should an earthquake strike.

In the CENTO region the vitality and resources of the several nations are in the people and the land or perhaps more aptly in the people of the land. While the ability of the people of the villages to survive hardship is legend, a vital part of the development of this human resource is the organized ability to utilize the technology of the geologist, engineer, architect, banker, builder, and industrialist in a manner which will make life safer, more comfortable, and more productive. To this end, the villager must feel that the resources of his nation are backing his efforts to help himself. As a result, he will contribute more to these same resources through the utilization of his own skills and the material available to him.

EARTHQUAKE HAZARDS AND EMERGENCY PLANNING

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During the last three centuries earthquakes caused a total death-roll throughout the world of over 2.5 million. Statistics relating to fatalities caused by earthquakes show that during the period 1900-1968, more than 800,000 people have been killed and that the number of people killed every year has reached 14,000, Figure 1b. The damage to houses and public works has amounted to more than £4 billion. With the spread of urban civilization throughout the world the toll taken by earthquakes and particularly the damage caused has been steadily increasing.

Earthquakes are one of the most destructive natural hazards, if not of human life itself, most certainly of the works of man. The total number of people killed annually is certainly less than the number of persons killed by motorcars every year in the United States alone. Yet, the economic effects that an earthquake may have on the development of a country can lead to serious disaster. The damage and sudden crippling of the economy of a developing country may lead to population movements, emigration, increase in taxation and to undesirable though necessary loans from foreign countries. Such hazards have long been associated with crises in human affairs, the extent of the crisis being inversely proportional to the financial resources of the country.

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Earthquake hazards are not always perceived to their full extent. They are seen as having certain effects or consequences which are rarely specified in advance or fully understood. In a developing country of limited resources and with investments concentrated in single large projects, it is the consequences that should be feared rather than the earthquake phenomenon itself. An earthquake, for instance, may cause heavy loss of life, which if of course lamentable, but it may also cause the collapse of, say, a large dam, which will have perhaps far more disastrous consequences than the earthquake itself. Apart from the total loss of the structure, the flooding will add to the death-toll taken by the earthquake. The silting up of the downstream valleys will destroy cultivation for many years to come. Communications will be disrupted and the industry will suffer from lack of electricity. In an unstable economy these effects may lead to famine and to a belated loss of life, perhaps greater than that caused by the earthquake proper.

At the present levels of technology, earthquakes cannot be prevented. However, subject only to economic and budgetary restraints their disastrous effects can be prevented. Earthquakes are destructive because man has made them so by investing his wealth with a disregard for the hazards that nature may have in store for him. This disregard stems from a variety of causes. The most important being the mere lack of awareness and lack of technical knowledge for the alleviation of such hazards. Another cause is the apathy of the populace which is due to ignorance. It is not uncommon for people to accept earthquakes and their effects as acts of God about which very little can be done.

Differences in attitude to earthquake hazards in various countries cannot be explained in terms of the magnitude or frequency of the disaster alone. It is the perception of the disaster that controls the attitude and stimulates awareness. For instance, very little improvement in building materials and in methods of construction will result from an earthquake that destroys hundreds of remote villages in a developing country. After a very short period of enthusiasm for restoring plans, the interest of the few concerned with the alleviation of future hazards will die out. Apart from those inflicted, few in the country will be affected and soon the whole problem will be forgotten. In contrast, the damage or destruction of a capital city

or of a major engineering construction on which depends the economy of the country will stimulate a completely different degree of awareness. Here, the disaster will affect the economy of the country and the strain will be felt by all.

People view differently the challenges and hazards of their natural environment. Figure 1a shows the loss of life caused by earthquakes in Italy, Japan and Turkey. It is seen that in spite of the high population density (280 per square kilometer) and high seismicity the loss of life in Japan is less than that in Italy which has a density of population of about 170 per square kilometers. Without going into details, this difference reflects among other things the attitude of the technical and administrative societies of the two countries in dealing with earthquake hazards.

TABLE 1
(1900 - 1968)

Country	Pop. per sq. km.	Average annual income per head (Ł)	Loss of life	Property loss Mill. Ł	Loss per life in (Ł)
West Pakistan	45	25	46,000	12	260
Iran	13	30	34,000	30	880
Turkey	35	50	40,000	80	1,340
United States	21	530	1,000	400	400,000

NOTE: Average annual income and property and loss deducted from data of varying reliability.

* Average for California (43), Washington (18), Nevada (1.0) and Alaska (0.15).

Table I gives the losses from earthquakes in Pakistan, Iran and Turkey during the period 1900-1968; these figures are not precise but are at least adequate for comparative purposes. We notice that during the last 68 years about 140,000 people lost their lives in these three countries, and that the average annual loss of life is about 2,000 or one-seventh of the total world loss due to earthquakes. The loss of property per fatality increases with increasing income and the annual property loss in West Pakistan, Iran and Turkey amounts to 5, 25 and 50 mills £ per head respectively. Thus other things being equal, earthquakes in Turkey are more "expensive" than Iran or in West Pakistan.

Earlier we pointed out that it is the consequences that should be feared rather than the earthquake itself. It is true that the earthquake itself will cause damage that will be proportional to the invested wealth in the affected area. This does not necessarily imply that the country as a whole will be wealthy or that its economy is stable. The consequences of the earthquake will depend on whether the country will be in a position to face losses without undue economic strain. Take for instance the earthquake of July 1963 in Skopje. It caused damage to property of about £500 million, killing over 1,000 people. The earthquake itself was small, about 3,000 times smaller than the Alaska earthquake of 1965. It struck a small, densely populated area, which incidentally was quiescent for 13 centuries. In contrast, the Alaska earthquake caused over £120 million damage and a loss of 125 lives in a region with a population density 20,000 smaller than that of Skopje. Here, the property loss incurred by the Alaska earthquake is a small fraction of the annual budget of the United States while the property loss caused by the earthquake in Skopje is comparable to the annual budget of Jugoslavia. The strain imposed by these events on the economy of the two countries is vastly different. It is obvious that developing countries are more sensitive to earthquake disasters and more in need of planning against earthquake hazards.

The following notes concern the measures that a country should take in order to restore housing and community facilities in an earthquake disaster area.

The problem of reducing earthquake damage and of restoring housing after an earthquake can be divided into two stages: 1) planning before an earthquake, and 2) emergency action after the event. Both stages should be studied in advance by a special National Agency, whose task would be to investigate methods and study techniques for the prevention of disasters caused by earthquakes.

After an earthquake it is found very difficult to establish an effective central agency for the direction and control of the rehabilitation and reconstruction of the affected area, and much effort and funds are usually diffused in disparate activities. In economically developing countries, after a disaster, there is always the difficulty of deciding on the spur of the moment, how local and foreign aid should be best used and what priority should be given to the innumerable needs of the area. Invariably, this problem is left to the local authorities to resolve or to an ad hoc committee without much deliberation. Often a large proportion of the aid is misused. The lack of regional development plans and the absence of any planning policy may result either in regrettable reconstruction errors, or in long delays which might have detrimental repercussions on the efforts for restoring housing.

To facilitate the establishment of such an Agency, a country should have an Act or Ordinance passed by the central legislature. This act would empower the Agency to carry out research, make building regulations pertinent to earthquake problems, and to apply any or all of them in any desired area. Also, the Agency should be kept informed and up to date on rural, urban, town and country planning developments, should participate in the country's economic policy in the event of a disaster, and should direct emergency and permanent housing.

Planning before an earthquake, is extremely important in reducing earthquake damage and in minimising earthquake after-effects. It must be understood that such planning, no matter how well it may apply in one part of the world, may prove completely insufficient or even detrimental in another. Such planning should be intended as a starting point, it should be studied, and amended as need be by the Agency's professional men who are familiar with the problems involved. There is no way of producing rules-of-thumb which will be generally applicable, or effective, without

adapting them to local conditions, which may vary even within the same country from district to district, and from year to year.

The most important item in the planning stage is education. The relief of a country crippled by a natural disaster is largely based on the efforts of its inhabitants. In most of the economically developing countries the majority of the population is ignorant about the dangers that natural forces have in store for them, and those who do know, have no idea of their causes or their effects. Superstitions, misinterpretations of well known natural phenomena, and ignorance, often lead to additional disasters.

In a seismic country, the population must be educated about natural phenomena and their effects, at an early stage of their lives. Secondary school education must include such a study so that the absurdity of superstition may be brought out. Instructions in earthquakes should be given in the form of public lectures and of pamphlets. The destruction caused by earthquakes, should be explained, pointing out that improperly built houses are death-traps, making their owners responsible and aware of what might happen during an earthquake. Above all they must realise that acts of God of today are often tomorrow's acts of criminal negligence.

It is not so much what one can prescribe for those inflicted by an earthquake, but one's understanding of particular needs and one's success in gaining the co-operation of the inhabitants that is important.

Building control is properly concerned only with the health and safety of people, particularly the occupants of buildings. This control is exercised by determining, enacting, and enforcing, certain minimum standards below which no person is permitted to build. It is assumed that anyone adopting lower standards would endanger the health or safety of others.

Experience has shown that nearly all countries need several sets of building regulations. The first set should apply to all buildings and is intended for use by professional designers. In most developing countries professional designers deal with only a few percent of the total housing capacity of the country.

The second set, which concerns the majority of the housing capacity of the country, would be intended for use by small builders. These small builders cannot be overlooked; they build the houses in which more than 90 percent of the population live. Regulations for the use of builders to satisfy certain economically minimal rules for earthquake resistance must be simple and the deemed-to-satisfy clauses must be brief specifications. This set of regulations would cover buildings of one or two storeys in villages, towns and in the countryside.

A third set of regulations may be needed to control houses built of temporary materials, or of prefabricated elements; these are often necessary to replace, after an earthquake at minimum cost, uncontrolled shanty towns or emergency camps.

In the planning stage, regulations for the earthquake resistant design of all types of structures should be studied. These regulations should be the task of a special committee, which will study and elaborate new methods and materials of construction, and which will keep these regulations up to date, taking into consideration local conditions, the economy of the country, and the seismicity of various populous areas.

For the stage of relief, the Agency should have plans made well in advance for assessing the damage and the needs of the damaged area. On the basis of these assessments the Central Agency should mobilise its reserves of first aid supplies (food, medicaments, tents, etc.) and dispatch them within a very short period of time. The Armed Forces of the country should be prepared to cooperate with the Agency, particularly in transporting first aid material, in the rescue work, and in the clearance of rubble. However, the Agency should guide the demolition units in their work in order to avoid additional destruction caused by uncontrolled actions.

The Agency, at this stage, should be in a position to assess its needs and make proper use of the foreign aid. A lot of valuable time and badly needed money is usually wasted in erratic actions of a multitude of charitable bodies which act without any centralised control. Tens of nations and of welfare bodies contribute independently with absolutely no control organisation, and without any knowledge of what is really needed. Even from

the same country, aid is fragmented and relief actions are taken independently, wasting part of their efforts and confusing their recipient. The Central Agency should be in a position to know shortly after the earthquake what is needed and where. Such co-ordinated action would avoid the useless repetition and waste of funds involved.

Temporary housing after disastrous earthquakes in economically developing countries often follows a pattern detrimental to long-term planning, particularly, where there is no regional planning available. After a short period of enthusiasm for ambitious restoring plans, the interest in the application of various schemes begins to die out, as the available funds are found to be insufficient; some of them having been already squandered, and as the problems which rehabilitation poses becomes more involved and less exciting.

The usual pattern is that as with time the interest of the authorities begins to decrease, many rehabilitation sites are left unfinished and poorly equipped,and more villages and camps turn into slum areas. Villages and small towns turn into ghost settlements and their inhabitants begin to migrate to the nearest city, leaving the less active members of their community behind.

In most cases the authorities decide at this stage to relieve the stricken area by issuing free building materials for repairs, or, more often, by granting loosely termed loans. Since this method of relief is not always the best the results are often unsatisfactory. What happens is that the materials are either misused, since villagers and townsfolk are far from able to do a proper job of repair, or they are sold for cash. The loans often are used partly for the purpose intended and partly to finance a small business or to help members of the family to emigrate and settle in another part of the country.

Although in some cases the issuance of loosely termed loans to destitute villagers is the only alternative, the authorities should not forget that as supervision for the proper use of the loans becomes more slack, abnormally high profits are made at the expense of funds raised for relief and rehabilitation. Moreover, when there are no more funds to be spent, the half finished houses are patched up, to be damaged or destroyed by the next earthquake or by heavy rain.

It has been said that the solution by granting loans will stimulate the "self-help" of the population. This does not seem to be always the best solution. Ready cash is always spent more easily, even by persons who have no means of paying the loan back. High profits are made by the local builders and by those who sell local building materials. Also, loans will cause locally an increase in prices, which though temporary will affect the living standards irreversibly.

Proper Emergency Planning should consider raising the local living standards through the increase of the productivity of the region, (by stimulating with large funds the main income indices), rather than by giving cash.

Figure 2 shows a more detailed distribution of loss of life and damage in Turkey for the period 1900-1966. During this period about 300,000 housing units were destroyed and at least twice as many were damaged. About two-thirds of this damage occurred along the Anatolian fault zone. The distribution of damage and loss of life along this zone is not uniform. In spite of the density decrease in population the loss of life and damage to property increases from west to east. There are many factors that explain this, among which the most important is that of the gradual decrease of woods and the scarcity of timber in the east. Woods abound in the western part of the zone and village houses are of timber frame construction. In the east-central part of the zone, from about Amasya to Susehri, timber begins to be scarce and it is replaced gradually by adobe and rubble masonry. East of Susehri to Lake Van and on the Zagros in Iran, timber becomes a rarity and adobe becomes the main building material. The Agency should study the possibility of producing in mass a variety of prefabricated houses. With the financial support of the State and of private sources, a number of small factories for the production of suitable prefabricated units should be established, particularly in areas of seasonal unemployment, since this will boost the local economy. Surplus of prefabricated units could be exported to neighbouring countries or sold to welfare bodies who would like to donate them to earthquake-striken areas abroad.

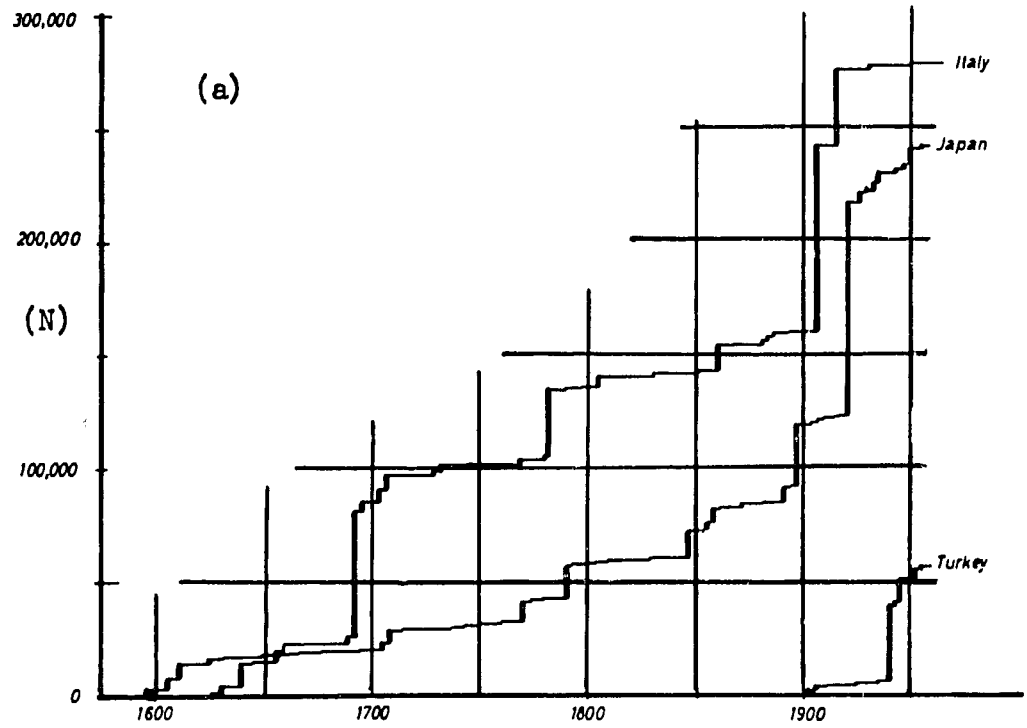

Figure 1a Number of persons killed (N) by earthquakes in Italy, Japan, and Turkey.

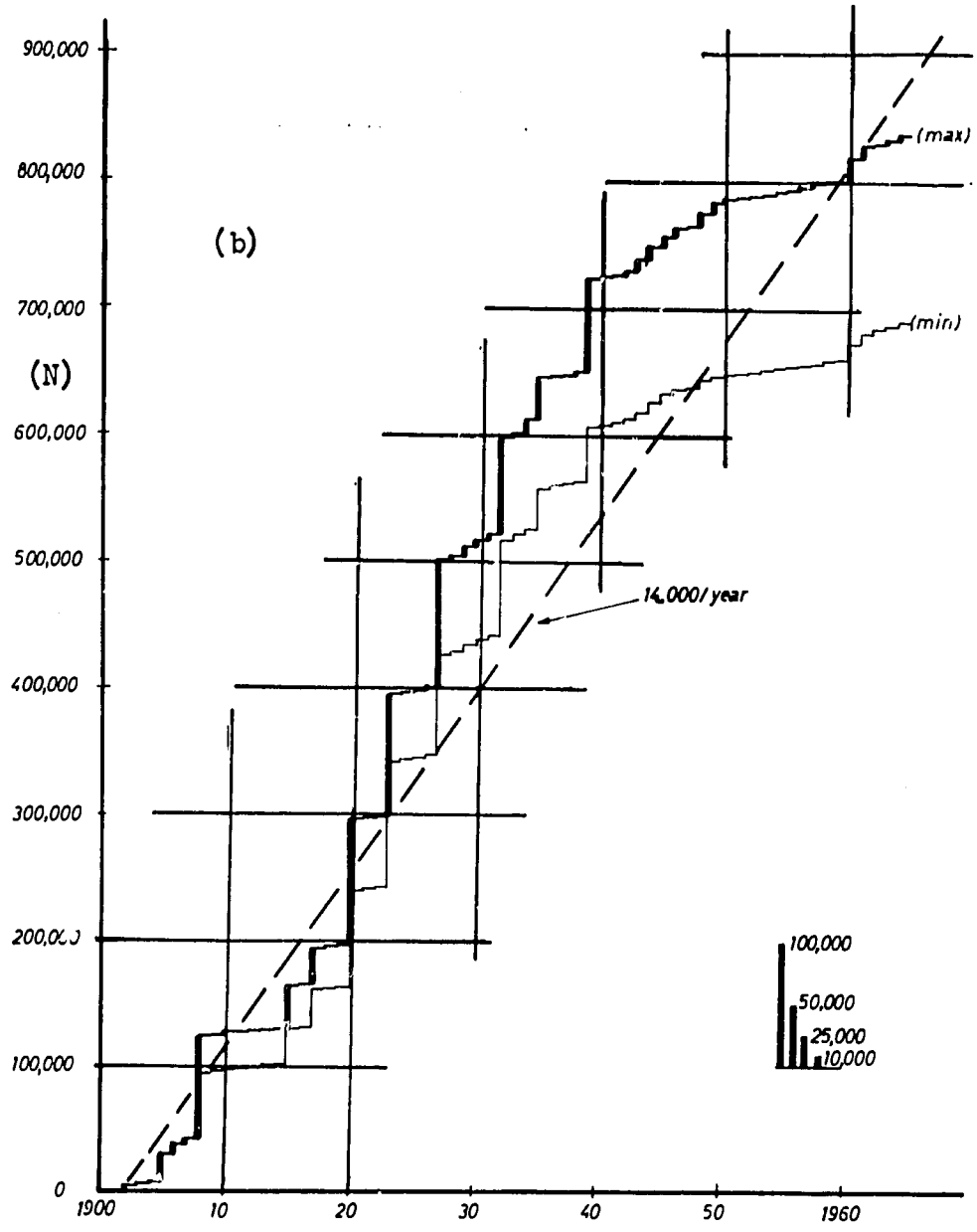

Figure 1b Total number of deaths caused by earthquakes for the whole world during the period 1900-1963.

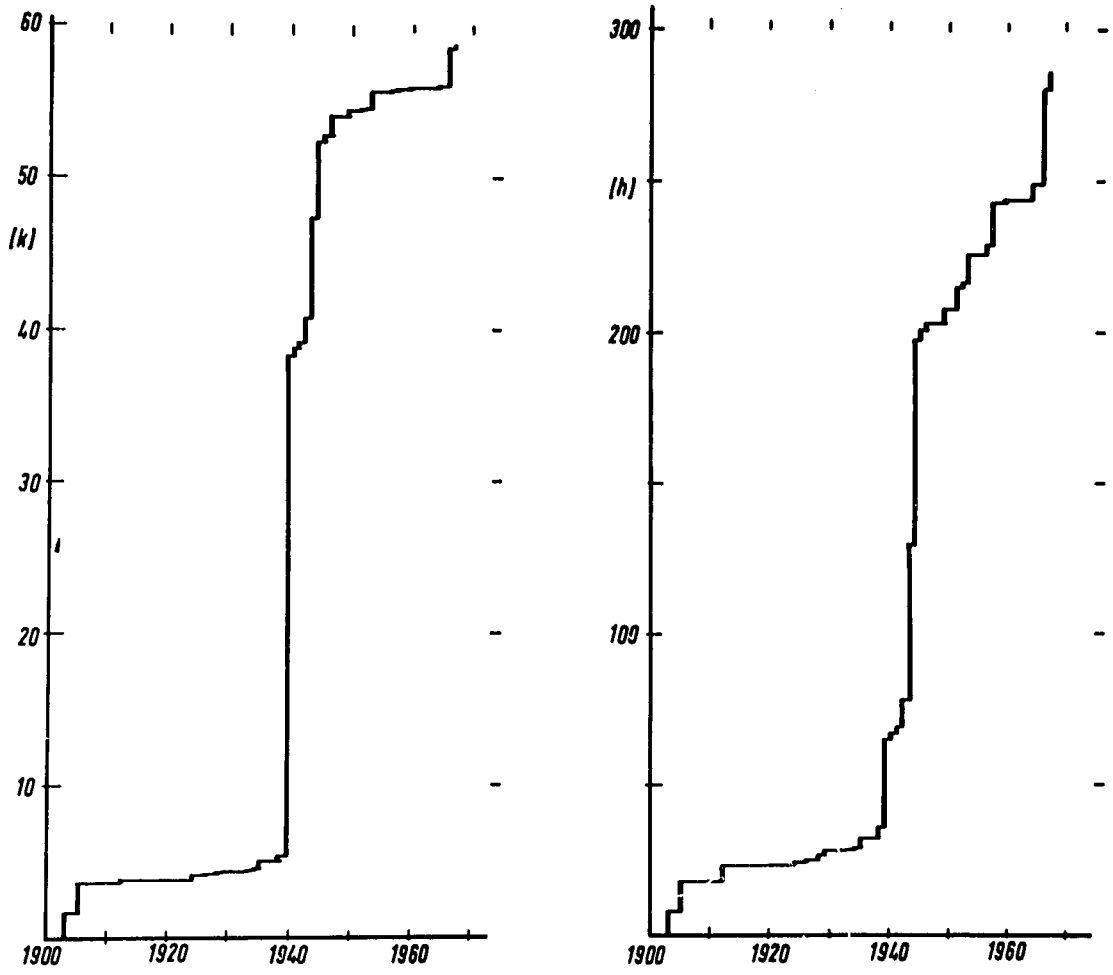

Figure 2

Loss of life in Turkey due to earthquakes 1900-1966.
(k= number of people killed in 1000's)

Loss of property in Turkey during the period 1900-1966.
(h= number of houses destroyed in 1000's)

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APPENDIX I

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