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TOWARDS COMPREHENSIVE RESOURCE MANAGEMENT AND PLANNING FOR NATURAL DISASTER PREVENTION

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Centre Prof. M. Watabe
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FOREWORD

The International Seminar on Regional Development Planning for Disaster Prevention was held in September 1986 by UNCRD to commemorate the International Year of Peace and the Fifteenth Anniversary of the United Nations Centre for Regional Development in collaboration with other related UN organizations such as UNDTCD, WMO, FAO, UNESCO, UNDRO and UNCHS and the Government of Japan. The number of participants attending the seven day Seminar averaged around 250 persons per day. Professionals and specialists in the field of regional development Planning for disaster prevention assembled from all over the world and actively discussed globally pertinent issues of prevention and mitigation of the effects of natural disaster in the world, particularly focusing on those of relevance to developing countries.

The papers presented at the Seminar numbered more than one hundred, covering a diverse range of relevant subjects. UNCRD publishes the papers presented at the Nagoya, shizuoka and Tokyo sessions as a series of grouped volumes, since they represent a firsthand source of information pertaining ta the policies of disaster prevention and mitigation in the participating countries. This publication is a third volume of the series, which consists of twelve papers concerned on planning and management for the prevention and mitigation from natural disasters in metropolis presented at the Tokyo sessions.

UNCRD publishes another three volumes. First volume of the series has eighteen papers concerned on planning and management for the prevention and mitigation from flood and highwind disasters at the Nagoya sessions, and sixteen papers in second volume concerned on planning and management for the prevention and mitigation from earthquake disasters at the Shizuoka sessions. Forth volume of the series consists of twenty-four papers concerned on planning and management for the prevention and mitigation from natural disasters in Japan at each session presented by national and local governments of Japan.

This volume is divided into three groups. First group, consisting of first five papers, document concept report in a metropolitan context. Second group, consisting of following six papers, document case study of each country/region, two of them presenting the studies/countermeasures for Tokyo which has been repeatedly damaged in the past by big earthquakes and has the possibilities of occurrence of big earthquakes in near future. And third group has last one paper concerning the simulation of effects caused by the forthcoming big earthquake.

It is hoped that this publication will serve as a point of departure for considering the manner in which experience of each country in the field of planning and management for the prevention and mitigation from natural disasters in metropolis can be made relevant for, and accessible to, development planners and managers in charge of natural disasters of the developing countries. Additionally, it is also hoped it will help in building effective linkage among database, research, education and training, which is one of the most urgent needs in implementing effective regional development planning for natural disaster prevention and mitigation at the global level towards International Decade for Natural Disaster Reduction(IDNDR) in 1990s.

Credit for making the volume possible rests with the contributors, who deserve our fullest gratitude and sincere thanks for their unstinting cooperation.

December l 988

Hidehiko Sazanami
Director, UNCRD

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CONCEPT REPORTS

POLICY REPORTS

TECHNICAL REPORT

ABBREVIATIONS OF UNIT

l . DISTANCE	mm	millimetres
	cm	centimetres
	m	metres
	km	kilometres
	ft	feet
2. AREA	cm2	square centi~1etres
	m2	square metres
	km2	square kilometers
	ha	hectares
3. VOLUVIE	cm3	cubic centimetres
	m3	cubic metres
	l	litres
	kl	kilolitres
4. WEIGHT	g	grammes
	kg	kilogramrnes
5. TIME	sec	seconds
	min	minutes
	h, hr	hours
	yr	years
6. LATITUDE & LONGITUDE	d	degrees
	m	minutes
	s	seconds
7. TEMPERATURE	C	centigrades
8. OTHERS	mb	millibars
	cal	calories
	kcal	kilocalories
	G	gravity
	KW	kilowatts
	MW	megawatts
	Hz	Hertz
	KHZ	kilo-Hertz
	MHZ	mega-Hertz
	KB	kilobytes
	MB	megabytes

PLANNINC AND MANAGEMENT FOR THE PREVENTION AND MITICATION OF NATURAL DISASTERS, ESPECIALLY IN A METROPOLITAN CONTEXT: INITIAL QUESTIONS AND ISSUES WHICH NEED TO BE ADDRESSED

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INTRODUCTION

Almost all the discussions and recommendations on the subject matter of the topic of our paper are plagued by ambiguities, inconsistencies and uncertainties in the central concepts involved. Good policies and implementation measures for planning and managing the prevention and mitigation of natural disasters cannot follow from such a confused, unclear and problematical starting point. We need to be clear first about what we are talking of before anyone can seriously advance conclusions and suggest means and ends which ought to be pursued.

As we see it, there are at least seven major questions and issues which initially need to be addressed. Thus, the rest of this paper is organized around what we shall call seven basic themes. Obviously we shall present aLlr own paint of view. But whether it is our ideas or those of others that are used, these are the central matters on which some degree of cansensus will be necessary if intelligent recommendations are to be made.

We draw our observations primarily from the extensive work of the Disaster Research Center (DRC) which, since 1963, has conducted field studies of social aspects of over 475 different mass emergencies. Since its inception, DRC has sent teams to earthquakes in Mexico, Japan, Yugoslavia, Iran, Italy. E1 Salvador, Greece, Chile, California and Alaska; hurricanes in the southern and eastern United States, as well as in Japan; floods in Italy, Canada and more than a dozen states in America; massive brush fires in Australia and the western United States; and tornadoes and hazardous chemical incidents in Mexico, Canada and the United States. 1/ In addition, we also draw on the empirical and theoretical research undertaken by other social scientists not only in the United States, but also in such countries as India, Canada, Belgium, Australia, Sweden, Japan, Italy Mexico Great Britain Yugoslavia and West Germany. 2/

THE CONCEPT OF “NATURAL" DISASTER

The first of the seven major themes we want to develop is the need for clarifying the concept of “natural disaster." The way in which the term is most frequently, but imprecisely, used, suggests that there is no such phenomena as a natural disaster. The term is also very misleading in its surface implication as to where solutions for the source of the problems of natural disasters ought to be sought. In short, we need to rethink what we mean by natural disaster. Our position is that if we rethink and clarify what we mean by natural disaster, we will also be forced to rethink how we can go about preventing and mitigating such kinds of disasters.

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We should note how the attributed source of disasters has changed over time. For mast of history it has been traditional, at least in the West. to call certain sudden an~ extraordinary physical disturbances “Acts of God." Whether volcanic eruptions, earthquakes, floods, or tsunamis, the source of the disaster agent was seen as in the supernatural domain. In more recent times, and with the spread of more secular and non-religious ideologies, we have shifted to the term "natural” disaster, substituting nature for the supernatural. So earthquakes are the result of plate dynamics or floods are the consequences of rainfall and drainage capabilities. But in either case, the imagery is that something external and beyond the realm of the human victims was responsible for whatever happened. In more recent decades, it has become progressively impossible to attribute all responsibility to God or nature, so the notion of human created disasters has increasingly been applied, especially in the area of technological accidents. So, to Acts of Cod (or Nature) have been added Acts of Men and Women.

We would not deny that it is possible to draw valid distinctions for certain limited scientific research goals between disasters involving different disaster agents. The physical factors which generate earthquakes are different from those involved in creating hurricanes. But we would say that for most purposes, including that of prevention and mitigation, the distinction often drawn between so-called Acts of God (or Nature) and Acts of Men and Women is both a useless and false one. It implies not only dubious notions of causality, but more important, the equally questionable idea that as a whole, certain kinds of disasters are fundamentally different in origin and consequences from other kinds of disasters. Thus, in one case, nature or God is blamed. In the other case, the responsibility for the happening is assigned to human beings as say in the case of a nuclear plant accident such as Chernobyl or releasing a poison gas cloud as in Bhopal. There also lurks in the distinction a supposition that one kind of disaster is more directly controllable than other ones.

In fact, all disasters are always primarily the results of human actions. A disaster is not a physical happening, it is a social event. Thus, it is a misnomer to talk about natural disasters as if they could exist outside of the actions and decisions of human beings and societies. For instance, floods, earthquakes, volcanic eruptions, tsunamis and other so-called natural disaster agents have social consequences only as a result of the pre-, trans-, and past-impact activities of individuals and communities. Allowing high density population concentrations in flood plains, having poor or unreinforced earthquake building codes for structures, delaying evacuation from volcanic slopes, providing inadequate information or warnings ~about tsunamis, for example, are far more important than the disaster agent itself in creating the casualties, property and economic losses, psychological stresses, and disruptions of everyday routines that are the essence of disasters. In one sense, there never is natural disaster; at most, there is a conjuncture of certain physical happenings and certain social happenings. Without the latter, the former has no social significance (in fact, the former can be totally absent and there can still be a disaster in the social sense, as; can be seen in the behavioural responses to threats or false alarms of tsunamis or floods). We should think of all disasters, natural agent-based or otherwise, as social events.

Now there are at least four major implications of rethinking of "natural" disasters as social and or natural phenomena. For one, there is an implication that prevention and mitigation must stress social rather than physical solutions for the problem. If disasters are in one sense the manifestations of the social vulnerabilities of a social system, then prime attention should be given to doing something about such vulnerabilities. Thus, if a population lives in a flood plain or in unreinforced building structures, and these ~re always the consequences of human actions and social decisions, prevention and mitigation activities such as community relocation and enhanced building practices and codes become the measures which should be primarily considered. In other words, essentially it is attitudes and behaviours which have to be changed.

Furthermore, emphasis on the social rather than the physical nature of "natural" disasters implies a proactive rather than just a reactive stance. That is, instead of waiting for the disaster to occur, encouragement is given ta the idea of taking relevant actions before occurrence. If the phenomena is thought of as natural and physical, it is sometimes very difficult to see what could be done to mitigate the consequences of the disaster agent such as an earthquake or a flood before impact. On the other hand, if the point of view is that the phenomena is primarily a social happening, encouragement is given to taking pre-impact measures. It may not be possible to prevent the land from shaking, but it is possible, through laws, not to allow chemical or nuclear plants to be built on, or very near to, earthquake faults or soil that will easily liquefy.

Another value of thinking of disasters as social rather than physical happenings, is that emphasis comes to be focused on internal rather than external factors. A disaster in this view is not an outside force that impacts upon a social system, but a manifestation of internal flaws and problems in the society. Thus, the threat is not vaguely "out there," but concretely within the social system and as such, easier to address.

Finally, the view of disasters as social phenomena should allow them to be more readily seen as something which can be reacted to as part of ongoing policies and programmes of national or social development, which could reduce societal vulnerabilities. Activities of a developmental nature thus can be seen as an integral part of disaster prevention and mitigation. There is a tendency for the latter to be treated as a separate sphere of action and responsibility. But by stressing the social nature of disasters, it becomes much easier to plan simultaneously both for societal development and disasters. This link between the two activities is explicitly argued by those who say that disasters are indicators of the failure of development, and that development must be part of the process of reducing vulnerabilities to disasters. 3/

DIFFERENCES BEIWEEN PLANNING AND MANAGING, AND PREVENTION AND MITIGATION

Our second theme is that a variety of different disaster relevant activities need to be clearly distinguished. We draw a major distinction between planning and management processes, essentially seeing the former as the strategic and the latter as the tactical approach to the problem. We also need to distinguish between the goals of disaster prevention and of disaster mitigation. Here the difference is that the first is usually only ideally attainable, whereas the second is, at least in part, always practically possible. Combining the processes and goals leads us to see, by way of the following graphic design, that there are four major parts that we should pursue in thinking about the problem of dealing with disasters.

	PREVENTION	**MITIGATION**
PLANNING	**STRATEGY**	**STRATEGY**
MANAGING	**TACTICS**	**TACTICS**

Let us look at these distinctions in more detail. Our overall intent is to suggest that, unless we drat~ the finer distinctions indicated, we will, at best, frequently talk past one another and, at worst, simply misunderstand what each other is saying. Although we will not be able in this paper to document in detail what we have just said, it would be easy enough to show that when some use the term prevention, others use mitigation; that what some mean by using the word planning, others call managing, etc. As the Tower of Babel story illustrates, this is not the proper way to build any structure, whether of a material or a non-material kind. We first have to communicate before we can see if there is or is not agreement on the substance of what is said.

There are four possible courses of action available to us with respect to coping with disasters. We can try to prevent them in the first place. If they occur anyway, we can attempt to mitigate their effects, respond to their impacts, or recover from their consequences. Prevention, mitigation, response and recovery -- these are the four major possibilities.4/

It is generally assumed that prevention is the best course of action to pursue. There are several comments which can be made about such a view. In the first place, real prevention would mean the blacking of the potential disaster agent from appearing in the first place. Thus, cloud seeding, in principle, could prevent hurricanes or cyclones from initially forming, or at least developing fully from an embryonic state. But as we know from the area of nuclear or chemical hazards, it is impossible even in the more technologically advanced areas to completely eliminate risks. Although apparently some medical hazards such as smallpox have seemingly been eliminated as potential threats to the human race, there is almost no reason to think we are going to eliminate or prevent the appearance of standard disaster agents such as hurricanes, earthquakes, tornadoes, floods, volcanic eruptions and so on. (We may one day prevent famine and perhaps even droughts, but these are disastrous conditions for which there is not a concrete agent, as in the case of those disasters just enumerated. Furthermore, even in the case of famine there may be prevention in fact, but in principle the possibility will always exist.) Thus, contrary to what is sometimes occasionally voiced, it is our view that prevention for the disasters we are discussing is at best an ideal, but unattainable goal in the foreseeable future.

Furthermore, even if we think of disasters in the social sense as discussed earlier, we can confidently assert that we have not been and will never be able to prevent all disasters. This is insured in the short run by the greater vulnerabilities of ever larger populations in high risk areas, and more risks to communities from technologically related developments (e.g. we have now toxic chemical disasters which can be generated by earthquakes even if we ignore the area of technological accidents per se). In the long run, disasters are assured by human errors and group misjudgments.

Perhaps we should stop the misleading talk of preventing disasters. Certainly if by prevention is meant elimination of disaster agents, we would not appear to be on a particularly fruitful path. If on the other hand, by prevention we mean reducing the social impact of disasters, it would appear we are then talking of mitigation measures. Also, as we have noted, there is a difference in eliminating or preventing disasters in fact and in principle. We really should clarify what we mean by prevention of disasters.

As to mitigation there are all sorts of measures both of a structural and non-structural nature, which could be used to reduce the direct impact of a disaster. This is not the place to discuss the pluses and minuses of each separate mitigation measure possible. However, we would raise the question if mitigation as a whole or in terms of separate kinds of activities should always be viewed positively. For example, relocation of endangered communities to new, safer localities is a potential mitigation course of action. However, as we have suggested elsewhere, relocation is often not feasible, frequently is impractical, and usually the disadvantages of moving specific communities outweigh the advantages. 5/

We need to think through what we mean by mitigation. Having established that, we then need to put mitigation measures into an appropriate context of feasibility, practicality, and relative cost benefits among other things. If we do, our suspicion is that we shall become less sanguine than we presently are about disaster mitigation. We do not argue against mitigation measures as such, but do suggest they need ta be assessed realistically and not advocated without qualification.

There is also a need to draw a distinction between planning and managing disaster related activities. Perhaps the best way of doing this is by drawing a parallel to thinking in the area of the military. ~to s t military organizations anywhere draw a distinction between a strategic and a tactical approach to military problems. Strategy involves applying' overall principles to the general situation such as winning the war ar conducting a particular military campaign. In contrast, there is the matter of tactical principles -- what a unit has to do to deal with the specific problems associated with capturing a particular hill, the details of which could not be encompassed in a strategic approach. Thus, to draw the parallel, disaster planning should be thought of as the overall strategic approach to the general problems associated with disasters. Disaster managing involves the specific tactics which have to be used with the particular contingencies associated with a very concrete and actual case of disaster prevention, mitigation, response or recovery.

Planning is not managing and vice versa. Planning may be a factor in managing, but is not the only one or even necessarily the most important one. Studies in the disaster area, for example, of emergency responses at the community level, tend to show that even where there has been good planning, it does not follow that there will be good managing of the disaster. Good strategy does not automatically translate into effective tactics.

It follows from what we have just said, that there are four different paths, two of a strategic and two of a tactical nature, which need to be distinguished in thinking about the problems of dealing with the prevention and mitigation of disasters. We will only confuse ourselves and others if we do not see and maintain the distinctions. The tactics to capture a specific hill in a particular combat situation may have little to do with the general strategy to be pursued in winning the overall war. Similarly, what might be effective tactics to manage the prevention of specific disasters, may have little in common with the best strategy to use in planning the mitigation of disasters generally.

PROBLEMS AND PRINCIPLES OF PLANNING

We now move on to our third theme, namely, that in disasters and development planning, emphasis must be an the planning process. The importance of planning is not in the production of a written document or plans per se. Rather what is crucial is the carrying out of a process. To illustrate this, we discuss some major general principles of planning. In some respects we are addressing some of the strategies which should be used in planning for disaster prevention and mitigation.

Improvement in the prevention and mitigation of disasters will not be brought about by the production of written plans. This may appear to be a strange statement to make. However, we state it deliberately in this way to emphasize that what is crucial is the planning process, not the production of documents. Too often, particularly in governmental bureaucracies, what are intended to be means to laudable ends -- such as plans to improve disaster prevention and mitigation -- become ends in themselves. Thus, the counting of plans or the meeting of deadlines in producing documents comes sometimes to be taken as the achievement of the goal.

To avoid this, therefore, what should be emphasized in the disaster area is the planning process. If we are to make progress in this area we should not set goals to produce plans, but instead we should develop mechanisms or means which will encourage or facilitate planning activities of various kinds. True planning involves, besides the writing of plans, developing techniques for training and information transfer, undertaking public educational activities, establishing informal links and ties between relevant groups, conducting disaster simulations and exercises, convening meetings for the purpose of sharing knowledge, thinking and communicating about future dangers and hazards, undertaking risk assessments, drawing up model laws and legislation, to mention but some of the more important activities.

Approaching disaster planning in this way also suggests that it is a never ending process. Disaster planning for prevention and mitigation is not a problem that should be approached as having a definite conclusion.

Rather, the planning instituted should assume a continual process of revision and updating.

In addition, there are some general principles of planning which should be kept in mind. Some are applicable to any kind of planning, others are more relevant to the disaster area. Among the strategic approaches that can be taken are:

a) Good planning must be based on systematic research knowledge.

Too much planning in the disaster area is based on common sense notions, popular suppositions, or anecdotal examples. Several decades ago perhaps that is all planners had available. But at the present time, there is a body of social science knowledge about various social aspects of disaster phenomena, including prevention and mitigation questions and problems. Disaster planning should be rooted in that research base.

b) Good planning is based on "more likely" rather that "worst case" scenarios.

Some planners like to start with the worst possible case. While catastrophic possibilities cannot be ignored, extreme or unlikely scenarios will have little credibility or credence among citizens at large or important officials and decision makers. A believable case has to be made and that is not usually accomplished by stressing extreme possibilities. Furthermore, too much emphasis on the worst is at variance with many social and psychological studies which show human beings are far more motivated by hope than by fear.

c) Good planning is predicated on sharing information widely rather than restricting it.

There is an unfortunate tendency at times to organize planning around controlling information about a threat or a risk. The supposition is that certain kinds of information cannot be shared with the public at large, in part because it is thought citizens cannot comprehend the situation or that they will react negatively. People understand far more than many public or private bureaucrats give them credit for, so that instead of restricting information, disaster planning should aim at informing and involving the public as much as possible.

d) Good planning attempts to reduce the unknowns and increase the options in a problematical situation.

While in some instances planning can be oriented to prevention, most planning has to be directed towards altering or modifying what may or will happen. Therefore, planners should not only indicate the range of problems which may or 1!ill occur, but also the range of possible solutions to them. It is very rare for only one option to be available for dealing with a problem.

e) Good planning involves educating others as well as oneself.

If planning is to work, those persons and groups that are covered by the planning must know their designated roles. Put another way, disaster planning cannot only be from the perspective of the planner. I~ communities, organizations and people are an integral part of the planning, their perspectives have to be taken into account. At the very least, what and why is being asked of those affected by the planning must be explained.

PROBLEMS OF MANAGEMENT

Our fourth theme is that, apart from planning questions, there are management issues which have to be considered in both preventing and mitigating disasters. These matters usually involve choices of what tactics might be used to deal with the social organizational problems involved. However, since the means used would vary with each situation, we give examples of four problem areas rather than the tactical management measures which might be employed.

Managing a disaster-related matter almost always involves a question of the mobilization of the proper personnel and resources needed for the problem. This can become particularly complicated if, as indicated earlier, disaster prevention and mitigation measures are treated as part of ongoing development programmes and policies. This would bring together planners and officials with rather different backgrounds, interests and goals. The particular combination of personnel and who among them would occupy the more important decision-making positions would create a different situational contingency in every case, and would require a keen sense of appropriate tactics to avoid exacerbating the existing group differences.

Frequently, disaster relevant programmes and policies require communicating to and within groups with rather different bureaucratic jargons. The processing of information through and across different vocabularies is not easy. To use the jargon of one group makes the information inaccessible to others. To reduce the language to popular discourse requires a sense of what can and cannot be used in a particular organizational context.

Managing disaster prevention and mitigation programmes and policies is also usually handicapped by the fact that real acceptance often cannot be imposed by authority. Seldom are disaster measures advanced by very prestigious organizations or powerful agencies. Other government groups and officials generally have to be persuaded that the disaster measures are worthwhile supporting, or at least not to be opposed. Skill is required in deciding what tactics will work best in any given social situation.

Finally, the managing of disaster relevant programmes and policies generally requires obtaining some interorganizational coordination. In societies where there is both a public and private sector, such coordination on disaster measures is typically very difficult to obtain. But even in societies that are totally state controlled, getting governmental bureaucracies to coordinate their disaster relevant activities is far from easy. All kinds of social factors may be at play in the situation and influencing the degree of cooperation which can be achieved. Picking the right tactics to obtain, cooperation often necessitates the reading of very subtle cases.

Our discussion of problems of managing certain problems likely to arise in efforts to prevent or mitigate disasters has been necessarily somewhat abstract. This is because each specific situation in reality can manifest so many different behavioural possibilities. But as already indicated, it is the very purpose of tactics whether in this area or in the military, to deal with such situational contingencies.

CROSS-SOCIETAL DIFFERENCES

Our fifth theme is that societies are organized in different ways and this has to be taken into account in considering both the processes and goals of disaster prevention and mitigation. Thus, there are differences in the social structures of societies what countries include under disaster planning and development, whether an agent specific or a generic approach is taken to disaster planning, and differences in the social science capabilities and disaster knowledge base in different societies. 6/ These and other differences such as the degree of urbanization which exists, can affect all aspects of disaster policies and programme implementation.

Let us consider how social structural aspects can affect both disaster studies and applications of research findings. As an example, the United States and Japan are socially similar in many respects. They are both subject to many common natural and technological disaster agents. They are both highly industrialized and urbanized countries. They both have a strong scientific base and a tradition of using research to solve practical problems. However, the united States and Japan are drastically different in their governmental-political structure -- .Japan is a very centralized society; the United States is a very decentralized society. This affects fundamentally the meaningful social science disaster research questions Which can be asked in the two countries, what kind of disaster planning and managing can best be implemented, and what features of disaster planning and managing can be usefully borrowed from one society for use in another.

In terms of the illustration just given: Italy and Japan, as another example, are quite similar in that both are highly vulnerable to many similar disaster agents (e.g. major earthquakes), both are urbanized and industrialized societies, and both have centralized governmental systems. It follows that along some lines disaster research and disaster planning and managing could be quite similar in both countries, and that both could borrow and learn from one another. Of course, there are also socio-cultural differences and for certain purposes these would be important in planning for, managing, and researching disasters.

To have effective and efficient disaster planning requires drawing from an adequate research base. We have tried to suggest that this link between planning and managing, and research might vary somewhat because of the social structural differences between societies. As we will discuss later, this becomes even more complicated when we compare developed and developing countries.

There can also be societal differences in conceptions of disaster planning and development. For example, in the United States, a variety of activities are researched under the label of disaster mitigation. In general, reference is to measures that will lessen the occurrence and/or impact of the disaster agent.

Almost all such measures can be classified as structural or non-structural. The former for floods, for example, includes such activities as dam construction, stream channel and floodwall construction, and reforestation. With regard to earthquakes, improvement in building construction would be an example. These elements involve research in engineering, geology, hydrology, physics and the natural sciences. In addition, there are non-structural measures which can be taken which involve legislation, management and enforcement issues. For example, laws which prohibit building and development in flood prone areas represent this type of activity. The production of building codes and the enforcement of such regulations could mitigate the impact of earthquakes. In general, social science research is more likely and useful with respect to the effectiveness of non-structural activities.

However, while such activities are frequently a part 0~ disaster , planning and managing for disaster mitigation in the united St8tes, this is not necessarily true in other countries. For instance, such activities appear to be far more a function of regular community planning agencies in Japan than in the United States where to an extent some of them are also the partial concern of emergency operational groups, if anyone at all. Our point is that there is considerable variation in what disaster relevant , activities are considered the province of emergency groups-, planning agencies or developmental organizations in different societies.

A third way in which the disaster research, planning and management; might be influenced has to do with the position which is taken on whether -- both for research and planning and management purposes -- disasters are approached in generic or agent specific terms. That is, one position is that both research and planning and management are best when it is assumed that there are common elements which cut across most, if not all, disaster agents. Thus, there is the view, for example, that there is little difference in how effective warnings should be issued -- it does not matter if the agent is a flood, a toxic chemical cloud, a volcanic eruption, or a massive fire. Research indicated that warnings to be effective must indicate personal danger, relative certainty of impact of danger, and probable occurrence in a short time. This approach contrasts with one which assumes that planning, management and research will have to vary depending on the specific disaster agent involved. Thus, an agent specific approach assumes that studies and planning for chemical disasters, for instance, will differ markedly from those for flood disasters.

In the United States, there has been an interesting historical development on this matter. Social science researchers, almost from the start of studies on disasters, took the generic approach to disaster. Physical science researchers, disaster planners and management and operational personnel from emergency organizations tended to take a relatively agent-specific approach. This made sense in terms of the physical sciences and engineering -- a researcher interested in physical aspects of earthquakes will obviously be interested in ar7d study rather different phenomena than a researcher interested in the physical aspects of floods. But disaster planners and managers, and operational personnel in the United States, slowly and eventually swung around to a generic rather than agent specific approach especially with respect to emergency preparedness and emergency response management measures. Researchers point out that a generic approach is cost-effective (that is, it saves money), that it avoids duplication of personnel and resources, and that it simplifies disaster-oriented training and educational efforts.

A partial consequence of the position taken by American disaster researchers was that about five to six years ago, the federal government established at the national level an organization called the Federal Emergency Management Agency (FEMA). This organization with overall responsibility for the federal or national involvement in disaster planning and management in American society, advocated and established as national policy a generic, or what is called the Integrated Emergency Management System, approach to disasters. Thus, what had been resisted ten years earlier has now become institutionalized as national policy (an integrated or generic approach has also been instituted in Great Britain and some other countries).

Of course, even in the United States, the general or generic approach has been more strictly applied to preparedness and response activities than to prevention or mitigation measures. There certainly is a question of how well a generic disaster approach is applicable to all phases of disasters, namely prevention, mitigation, response and recovery. Nonetheless, at least in some societies, the generic approach has more or less superseded an agent-specific approach.

This brings us to the way the planning and management of disasters has been influenced, and that is the social science capability and disaster knowledge that exists in a given country. There are huge differences around the world with respect ta this matter.

Twenty-five years ago, there was only the start of social science research in the disaster area. Thus, in only a few countries was it possible for researchers to contribute much to disaster planning and management. However, there has been a tremendous increase in the last decade in the number of disaster studies, of disaster researchers, of countries where disaster research is undertaken, and of societies where disaster research and planning has been linked. This increase is uneven around the world, but there are now about two dozen countries where social science disaster research is being systematically undertaken.

In some countries, such as Japan and the United States, there is both quantity and quality in disaster research studies. In others, such as Italy and Australia, while the research production so far has been relatively moderate, the quality of the work has been particularly high. A start has been made in developing societies such as India and Mexico, but as a whole there is not even much quantity of research in those countries where natural disasters are frequent and often of major magnitude.

It is true that all researchers are slowly linking with one another. There is now a network of social science disaster researchers from an international disaster community. 7/ One positive outcome of this is that new researchers in the area can have the guidance and advice of other groups elsewhere. In fact, the computerization of library and data resources in the more advanced disaster research groups will make it increasingly easier for researchers, planners and managers to quickly learn about what is being done elsewhere. However, for the time being, research users in different countries have radically varying social science research bases from which they can directly draw.

DEVELOPING AND DEVELOPED SOCIETIES

Our sixth theme is that there are differences between developed and developing societies. These can, and do, affect the possibility of both organizational planning and managing for the prevention and mitigation of disasters. We will suggest some of t*'hat is involved after first noting there are some general conceptual problems with the notion of developed and developing societies.

The question of the applicability of the findings from social science disaster research, mostly carried out in developed countries, to developing countries is a very complicated matter. Even the way the issue is posed is a somewhat debatable one. As we have discussed elsewhere, there is tremendous variation in the societies generally called "developing." 8/ They exhibit considerable social and cultural heterogeneity. The cultural values, beliefs and norms, not to mention their political, economic and social organizational structures, class and intra-group relationships, and the bases of social integration involved, comprise most of the variation known to exist in the world. Equally as important as the heterogeneity itself, is that, along certain dimensions, some of the developing countries are almost certainly closer to developed societies than they are to other developing nations. For example, there is wide variation in the attitudes towards and the legitimacy accorded, by elites and the public at large to their political institutions. This would not be an unimportant factor in the possibility of policy implementations regarding disaster prevention and mitigation measures.

Our general point is that anything learned from developed societies can probably be applied only selectively to developing countries. The general principle almost certainly is that the greater the social and cultural similarity of the developing country to developed countries, the easier it will be for the former to borrow elements of planning and managing of disaster prevention and mitigation from the latter. Actually we should know this from the developmental area, where we have many unfortunate examples of unsuccessful efforts to impose Western style structures and functions on non-Western societies.

Leaving that general point aside, what are some of the general organizational differences between developed and developing societies which could affect the transfer of disaster technology from one type of society to another. We would mention these five:

l) Developing societies do not have as complex organizational structures as do developed societies. There is simply less of an infrastructure in such countries.

2) Most of the very top organizational personnel have obtained their training and education outside of their own societies. Officials have been primarily socialized to Western professional ideals and contexts rather than local situations.

3) Such complex organizational structures as do exist tend to function from the top down. While almost all organizations anywhere are reactive rather than proactive, this is especially true in developing countries with a strong tendency for initiatives only at the very top.

4) In many organizations, emphasis is on structures or forms rather than functions or tasks. The means often become ends as seen in the proliferation of paperwork and plans.

5) Few distinctively separate disaster preparedness or responding organizations exist. The further away from the national level, the rarer the existence of disaster specific groups.

In the main, these observations suggest that, in most developing countries, the existing social organizational structure is not conducive to taking steps to prevent and mitigate disasters. Put another way, many of these societies do not have the kinds of groups and/or personnel which would be needed to initiate, institute and carry out relevant programmes and policies regarding disaster prevention and mitigation. One implication is that perhaps priority ought to be given to building a social organizational structure before concerning one self too much with the desired functions. It is unlikely, given the financial resources most. developing countries have, that new structures could be created. This suggests, and is in line with what was said earlier, that disaster prevention and mitigation measures might best be added to existing programmes and activities for societal development.

THE PAST AND THE FUTURE

Our seventh theme basically is the idea that the future will not be the same as the past. For example, for a variety of reasons, more and worse so-called "natural" disasters can be expected as we move into the twenty-first century. In addition, probable forthcoming changes, both in technology and social organization, are likely to compound the problem of dealing with disaster in the future. However, there ace also some countervailing trends. Disaster research, especially of a social and behavioural science nature has, and will, increasingly provide planners, managers and policy makers in the disaster area with the knowledge and understanding they will need to do a better job in the coming decades of this and the next century.

Too often officials involved with various aspects of disasters tend to look to the past, to disasters that have already happened. Clearly past experiences should be drawn on, although this is easier said than done. "War stories” do not contribute very much to military strategy and tactics; similarly "war stories" of prior disaster-related experiences are equally useless unless systematically analysed and examined.

More important, looking at past disaster experiences may lead to the planning for and management of a disaster in the future which will be similar to what has been experienced in the past. This can be a major mistake. The future is what we will live in or die. The future will not necessarily be a repetition of the past.

Both from a quantitative and qualitative point of view there is reason to think that, as a whole, future disasters, even so called “natural" ones will be worse than those we have had in the past. Because of population increases, the land-use patterns of contemporary societies, the greater interrelationship of social units in the modern world, etc., disasters of similar magnitude, as might have occurred in the past, will have far greater impact. In one sense, there are simply more people and property vulnerable to damage or disruption. For example, an earthquake in the area now occupied by Mexico City would have affected only a relatively small population, even just twenty-five years ago. Today it will effect the largest city in the world, with a population of perhaps 18 million and growing every day. Flood waters of tidal surges from cyclones which would have engulfed a few villages several decades ago, now would sweep over a large number of residents in many cities in a number of developing Asian countries.

The greater dependence of the population on one another and on certain facilities also means that many future disasters will have qualitatively worse impacts than similar magnitude disasters of the past. To some extent, modern technologies are also more vulnerable to the disasters of the future. To the extent that computerization takes hold in different sphere of life, for instance, the more there can be kinds of social disruptions unthought of in the past. Even disaster responding organizations are mare likely to be vulnerable than they were in the past. Modern bureaucracies can accomplish much more than could once be done, but they also are more susceptible due to their increasingly complex nature to disruptions occasioned by disasters.

Thus, to the extent that the past is taken as a guide to the future, we could be very badly misled. That which might well have served to adjust to or to cope with a disaster in a community a decade ago might well be rather inadequate a decade from now. Mitigation measures which were once adequate may now fall rather short in the light of the changing circumstances at the end of this century and the beginning of the next one.

We think that upcoming disasters in metropolitan areas are especially likely to be negatively affected by looking primarily at the past. At least as far as peacetime disasters are concerned, we have been fortunate in recent years that very few large metropolitan areas in modern societies anywhere have been hit by a natural disaster of major magnitude. But metropolitan areas have the potential for the greater quantitative and qualitative disaster consequences we have just noted. Most past disasters even in relatively recent times, have not had consequences of that degree. Thus, we need to realistically project into the future what potentially could be, rather than merely trying to extrapolate from past historical incidents of considerably lower quantitative and qualitative consequences.

However, while we need to be concerned about the worst future which will befall us, there is at least one positive compensating factor. In the past, we had little systematic social science knowledge to guide us on what to anticipate or expect. Today, that is no longer the case. Our knowledge base is far fro~1 complete or comprehensive, but we do know much more now about planning and managing for disaster prevention and ~itigation. The social and behavioural science research that is currently available can be very useful ' . Much of the research, unfortunately, Is either unknown or not used by disaster planners, managers and policy makers. But the knowledge exists, and there is every reason to think that the research knowledge base will continue to increase in the future.

We simply will have to work out better social mechanisms for transforming the research findings into practical applications. This very conference is perhaps the kind of general research technology transfer mechanism that we need. We hope that this paper might also be seen as an example af how research findings and conclusions can be used to give some guidance to potential research users.

NOTES

1/ Among the major publication of the Center which are directly available from DRC are:

- Russell R. Dynes, Organized Behavior in Disaster (Newark, Delaware: Disaster Research Center, University of Delaware, 1964);
- E.L. Quarantelli, Evaluation Behavior and Problems, Finding and Implications from the Research Literature (Newark, Delaware: Disaster Research Center, University of Delaware, 1984);
- E.L. Quarantelli, ed..Disaster: Theory and Research (Beverly Hills, California: Sage publications, 1978);
- Russell R. Dynes, E.L. Quarantelli and Gray Kreps, A Perspective on Disaster Planning (Newark, Delaware: Disaster Research Center, University of Delaware, 1981);
- Benjamin McLuckie, Italy, Japan, and the United States: Effects of Centralization on Disaster Response (Newark, Delaware: Disaster Research Center, University of Delaware, 1977):
- E.L. Quarantelli, Inventory of Disaster Field Studies in the Social and Behavioral Science 1919-1979 (Newark, Delaware: Disaster Research Center, University of Delaware, 1984);
- E.L. Quarantelli, Organizational Behavior in Disasters and Implications for Disaster Planning (Newark, Delaware: Disaster Research Center, University of Delaware, 1985).

A free copy of the DRC Publication List which contains several hundred Items produced by the Center can be obtained by writing the Publications Clerk, Disaster Research Center, University of Delaware, Newark, Delaware 19716, USA.

2/ Among disaster researchers in the United States, especially worthwhile are the publications as follows:

- Allan Barton, Communities in Disaster (New York: Anchor Doubleday, 1970;
- Thomas Drabek and J.E. Haas, Complex Organizations: A Sociological Perspective (New York, Macmillan, 1973);

- Dennis Mileti, T. Drabek and J. Haas, Human S Systes in Extreme Environments (Boulder, Colorad0: Institute for Behavioral Science, 1975);
- James Wright et al., After the Cleanup : Long Range Effects of Natural Disasters (Beverly Hills: Sage, 1979);
- J. E. Haas et al., Reconstruction Following Disasters (Cambridge , Massachusetts: MIT Press, 1977);
- Thomas Drabek, Human System Response to Disaster: An Inventory of Sociological Findings (New York: Springer-Verlag, 1986);
- Ronald W. Perry, Comprehensive Emergency Management (Greenwich, Connecticut: JAI Press,1985) ;
- Peter Rossi et al., Natural Hazards and Public Choice (New York: Academic Press, 1982);
- Ronald Perry and Alvin Mushkatel, Disaster Mana ement (Westport, Connecticut: Quoriem Books, 19S4);
- William Petak and Arthur Atkisson, Natural Hazard Risk Assessment and Public Polic (New York: Springer-Verlag, 1982)

Outside of the United States some worthwhile publications are as follows :

- lan Davis, Shelter After Disaster (Oxford: Oxford Polytechnic Press, 1978);
- Russell Dynes and Carlo Pelanda, eds., Sociology of Disasters (Milan, Italy: Franco Angeli, 1986);
- Sandro Fabbro, 1976-1986 La Ricostruzione del Friuli (Udine,Italy: lres, 1986);
- Bernardo Cattarinussi. Carlo Pelanda, and A. Moretti, Il Disastro: Effetti Di Lungo Termine (Udine, Italy: Grillo, 1981);
- Robert Gieipel, Disaster and Reconstruction (London: Allen and Unwin, 1982) ;
- Bernardo Cattarinussi and Carlo Pelanda, eds., Disastro E Azione Umana (Milan: Franco Angeli, 1981);
- B. C. Jones and M. Tomazuic, eds., Social and Economic Effects of Earthquakes (Ithaca,New York: Programme in Urban and Regional Studies, Cornell University, 1982);
- Lars Clausen and Wolf Dombrowsky, eds., Einfuhrung in Die Soziologie Der Katastrophen (Bonn, West Germany: Osang Verlag, 1983);
- Proceedings of the International Conference on Disaster Mitigation Programme Implementation. Ocho Rios Jamaica November 12-16 1984 (Alexandria, Virginia: Center for International Development, Virginia Polytechnic Institute and State University, 1986);
- "Education for Development in the Context of Disasters: Special Supplement," Disasters 9 (1985): 1-53:
- Frederick Cuny, Disasters and Development (New York: Oxford, 1983);
- Michael Glantz, ed., The Politics of Natural Disaster (New York: Praeger, 1976);
- Keizo Okabe and Hirotada Hirose, eds., “Disaster Research in Japan” International journal of Mass Emergencies and Disasters 3 (19S5):1-160.

3/ See, for example, Mary B. Anderson, "A Reconceptualization of the Linkage between Disasters and Development," Disasters 9 (1985): 46-51. See also Frederick Krimgold, Overview of the Priorit Area Natural Disasters (New York: United Nations, 1976).

4/ Some of the definitional problems involved are indicated by the fact that there is not complete consensus on how different disaster phases should be distinguished. Many formulations put prevention and mitigation together and have a separate category of preparedness before the response phase. For a description of some of the problems involved and a classification of mitigation, preparedness, response and recovery see Hilary Whittaker, 1978 Emergency Preparedness Project Final Report (Washington, D. C. : National Governor s Association 1978).

5/ See E. L. Quarantelli, "Social Problems of Adjustment and Relocation: Some Questions and Conlments," in Proceedings of the International Conference on Disaster Mitigation Programme Implementation. Ocho Rios Jamaica November 12-16 1984 (Alexandria, Virginia: Center for International Development, Virginia Polytechnic Institute and State University, 1986): 84-90.

6/ See E. L. Quarantelli and Dennis Wenger, "Factors affecting the relationship between the research users: An American view for an Italian audience," Preliminary Paper #103 (Newark, Delaware: Disaster Research Center, University of Delaware, 1985).

7/ This is considerably facilitated by the International Research Committee on Disasters whose secretariat is housed at Arizona State University, and which publishes the journal International Journal of Mass Emergencies and Disasters, and the Newsletter , Unscheduled Events. Further information can be obtained from the Committee's secretariat located at the Office of Hazardous Studies, Arizona State University, Tempe, Arizona 85287, USA.

8/ See E. L. Quarantelli, “Research findings on organizational behaviour in disasters and their applicability in developing countries, Preliminary Paper #107 (Newark, Delaware: Disaster Research Center, University of Delaware, 1986). See also E. L. Quarantelli, “Problems in disaster preparedness and response: A commentary for a conference in a developing country," Preliminary Paper #106 (Newark, Delaware: Disaster Research Center, University of Delaware, 1986).

PLANNING AND MANACEMENT FOR DISASTER MITIGATION IN URBAN METROPOLITAN REGIONS: EARTHQUAKE RISK REDUCTION

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ACKNOWLEDGEMENTS

The present paper is essentially a review and synthesis of the collective experience and knowledge of many distinguished professionals who have been closely associated with UNDRO in earthquake risk mitigation activities over the past decade. These include: Dr. S.T. Algermissen, Prof. N.N. Ambraseys, Dr. I. Davis, Dr. V. Karnik, Prof. J. Petrovski, Dr. P. Radogna, Dr. H. Sandi, Prof. H. Shah, Dr. J. Tomblin and others. Agencies of the UN family who have co-operated with UNDRO are UNCHS, UNDP, UNEP and UNESCO. Governments of the Balkan and Mediterranean Regions exposed to high levels of earthquake risk are also to be recognized for their contribution to the body of knowledge currently under review. Particular mention must be made of two projects which were closely linked in concept and execution: Seismic Risk Reduction in the Balkan Region (RER/79/014), and Physical Planning in S.R. Montenegro. Yugoslavia (YUG/79/104).

INTRODUCTION

Recent large earthquakes have once more demonstrated how unprepared most nations are to face such apparently random events. In the last ten years earthquakes of magnitudes ranging from 6 to more than 8 on the Richter scale have severely damaged major towns and cities in Albania, Algeria. Argentina, Chile. China, Ecuador, Greece, Italy, Indonesia, Japan, Mexico, the Philippines, Romania, Yugoslavia, the USA and the USSR to name those which spring most immediately to mind. In each successive case we have had to count our losses in the knowledge that these could have been significantly lower had we addressed a number of basic problems at the outset. While it is evident that beyond a certain threshold, the forces of nature are such that little can be done short of moving out of the way altogether, for the majority of natural hazards, however, much can be done to manage the risks involved, not only through emergency plans and related public education programmes, but equally through the building and physical planning processes. Much has been achieved in the theory and practice of emergency preparedness, as has also been the case for earthquake engineering.

The use of physical planning as a tool for earthquake risk management has received relatively little attention, and indeed its overall impact on risk management is still somewhat uncertain. There is no well-established state-of-the-art in this domain. The present paper argues that physical planning is fundamental. It also attempts to demonstrate that earthquake risk assessment methodology is accessible to planners, and does not remain the exclusive domain of specialized scientists or engineers. The only precondition for the success of the methodology is that it be carried out on an interdisciplinary basis.

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CONCEPTUAL FRAMEWORK

To avoid conflicts of nomenclature and to establish a set of standard terms for practical use which will be widely understood and accepted (especially across professions), definitions of the concept of risk and its constituent parts have been proposed by UNDRO:

- Natural Hazard:

Natural hazard means the probability of occurrence, within a specific period of time in a given area, of a potentially damaging natural phenomenon.

- Vulnerability:

Vulnerability means the degree of loss to a given element at risk, or set of such elements, resulting from the occurrence of a natural phenomenon of a given magnitude, expressed on a scale of 0 (no damage) to 1 (total loss).

- Elements at Risk:

Elements at risk are the population, buildings and public works, economic activities, public services, utilities, infrastructure, etc. at risk in a given area.

- Specific Risk:

Specific risk means the expected degree of loss due to a particular natural phenomenon, as a function of both hazard and vulnerability.

- Risk:

Risk is the probability of expected losses, i.e. the expected number of lives lost, persons injured, and material damage. Indirect damage due to the disruption of industry, commerce and services can also be estimated, but such an exercise is necessarily open co a greater degree of interpretation and speculation.

RISK ASSESSMENT

From the foregoing, it is evident that one may express the concept of risk management in its simplest form by postulating that risk is the convolution of hazard, vulnerability, and elements at risk. Changes to one or more of these parameters automatically modifies risk itself, that is to say the total expected losses resulting from a particular event in a given area . Such a technique has three fundamental advantages: first, it provides an integrated model for risk management; secondly, it allows one to identify precisely what aspects of the problem are being dealt with and in which sequence; thirdly, the task of allocating roles and responsibilities is considerably facilitated, as is that of policy-making.

Hazard Assessment

The principal question the authorities and the public invariably want a quick answer to is “when and where will the next damaging earthquake occur, and what will its size be?". They often feel a strong attraction for prediction but we must, at the outset, discard any form of deterministic form of earthquake hazard assessment as a viable tool for disaster mitigation. Scientifically, prediction is insufficiently developed. Most prediction techniques rely on too few parameters and are particularly open to error (for example, a group of physicists made firm claims of being able to predict significant earthquakes in Greece within hours by monitoring changes in teluric fields, but to the author's knowledge, this group did not predict the recent Kalamata earthquake (M6.2), which claimed twenty lives and left several tens of thousands homeless).

The next alternative is to assess earthquake occurrence in probabilistic terms. This method has the merit of being more realistic from every point of view. It does away with the potentially dire consequences of firm "predictions" liable to cause social and economic insecurity. For the planner, it is important to understand the nature of earthquake hazard in broad outline. His task is to be able to ask the specialists relevant questions so as to obtain a fair picture of the probability of occurrence of potentially damaging earthquakes likely to occur in a given area or region over a certain time span. He should also be aware of the extent to which local ground conditions may amplify earthquake effects. In general terms, we can anticipate where earthquakes are likely to occur, but not when to any significant degree of accuracy. It is furthermore possible to evaluate hazard locally.

Non-specialists in general, and planners in particular, frequently confuse earthquake intensity and earthquake magnitude. Magnitude is a measure of the size of an earthquake at its source, whereas intensity is a description of observed earthquake effects (ground shaking) on settlements in particular locations. Magnitude is derived from instrumental records of ground motion amplitude, corrected for distance and seismic wave attenuation. Each gradation on the well-known Richter magnitude scale represents a tenfold increase in amplitude, and about a thirtyfold increase in the amount of seismic energy released. The only direct correlation between the nlagnitude of an earthquake and intensity occurs in the epicentral area where maximum intensity will be observed for that earthquake. Otherwise, intensity attenuates with distance from the epicentre.

One reason for confusing magnitude and intensity is that “large magnitude earthquakes” are constantly referred to as “damaging". The fact is that many earthquakes occur at depths of 15 to 30 km beneath the earth’s surface . At these depths, earthquakes of more than Richter M6 are, more often than not, damaging. However deeper earthquakes must of necessity be of larger Magnitude to have equivalent effects in terms of epicentral Intensity, as is evident from the Romanian earthquake of 1977. The Vrancea earthquake, of M7.2, had a focal depth of about 150 km. It is worth noting that the deeper the earthquake, the wider the area affected. Very deep, large magnitude earthquakes may produce relatively modest intensities, but because these intensities are distributed over wider areas than shallow earthquakes of higher intensity, the total amount of damage may be considerable. Not only are epicentres of interest to planners, but also focal depths where there is a pattern such as in Romania where the Vrancea earthquake is a recurring phenomenon (average return period: fifty years).

Earthquakes are recorded from two sources: historical records and instrumental records, the latter dating back no more than a century. Whereas historical records describe intensity, instrumental records, of course, have recorded earthquake magnitudes. From the study of both types of records it has been possible to estimate the seismicity of regions and local seismic hazard.

It is clear therefore that we are bound to know more about seismic activity in well populated regions with long histories, than about areas under new or recent development. This poses problems for planning. In extreme cases, planners and engineers are inclined to assume a general and somewhat arbitrary level of seismicity and examine local geology and ground conditions as closely as possible in order to arrive at reasonable estimates of hazard.

It is worth drawing a distinction between seismicity and seismic hazard. The former denotes the seismic activity in a given area and is usually expressed as a magnitude/frequency function. Hazard is directly related to strong ground motion in a given area, i.e. intensity. In general terms, the regional planner is likely to be as concerned with seismicity as with local hazard. The architect and community planners are essentially hazard-oriented. Earthquakes are, of course, associated with such phenomena as surface faulting, ground deformation and subsidence, and ground failures, especially liquefaction and landslides. A11 these factors put together are fundamental to land-use planning and should be mapped.

The conclusion one may draw from the foregoing is that earthquake hazard is, as with all natural phenomena, extremely difficult for the layman to grasp. Much reliance is therefore placed on the seismologist, the geologist and the engineering seismologist. However, the architect and planner cannot escape the responsibility of grasping the concept of hazard, both in theory and practice. They must understand magnitude/frequency relationships, intensity, and the behaviour of seismic waves and ground shaking in relation to building development; of regional and local seismicity; and indeed of seismic micro-zoning. They must also be capable of mapping hazards in a form relevant to their needs, which implies a transposition of hazard data into planning constraints or limitations to reduce earthquake losses. As yet, there are no standard planning-related hazard mapping techniques, and the author believes this is an area requiring urgent research and development. Intensity maps fall short of guiding the planning process. A standard method needs to be developed, in which land-use can be altered as a function of hazard, recognizing that zoning in seismic areas is, to a large degree, structure-type dependant.

Vulnerability Analysis

Vulnerability analysis has generated a considerable amount of discussion in past years. The UNDRO definition is restrictive in that it excludes imponderables such as social vulnerability. Be that as it may, the definition of vulnerability given above brings a measure of order into the assessment process.

Assuming a vulnerability scale of O (no damage) to I (total collapse), damage can be expressed fairly simply in proportional loss of function (for example, as a percentage of floor area) or in economic terms as a fraction of the value of the building (or its replacement cost) at the time of the earthquake. The vulnerability of buildings is determined by two factors: (1) the intensity of ground motion at the site, and; (2) the vulnerability of the building to that intensity. These two factors are independent, the vulnerability of the building being an intrinsic characteristic of its category .

In order to better understand this concept, it may be useful to revert to the problem of ground shaking and the response of buildings. The mechanism of seismic wave propagation is complex, and functions as follows. As a general rule, the intensity of ground shaking increases with magnitude and decreases with distance from the epicentre. Ground shaking may further be amplified by the effects of resonance between seismic waves and ground, and then between ground and buildings. Lastly, the duration of shaking is also critical.

Seismic waves cause the ground and buildings to vibrate. Compressional P waves and shear S waves mainly cause high frequency vibrations (greater than I Hz) which in turn induce vibrations in low, short period buildings. The S waves are the most damaging because buildings are more vulnerable to horizontal than vertical motion. The surface waves which arrive last cause low frequency, long period vibrations which affect tall structure$ (which themselves have long natural periods). Under certain condition~, vibrations are amplified by resonance between ground and building. Because the amplitudes of low frequency waves decay less rapidly over distance than those of high frequency waves, it is common to observe serious damage to tall buildings at considerable distances from the earthquake epicentre. Such was the case in Mexico in September 1985. Here, the predominance of long period (about two seconds), low frequency waves was amplified by loose, alluvial soil in Mexico City. These soils then entered into resonance with certain categories of buildings whose natural periods were also in the order of two seconds, and which consequently collapsed. In addition to shaking, resonance, therefore, is one of the keys to the problem of vulnerability. It causes one to establish a fairly clear relationship between soil and structural types; buildings must be tuned to their sites.

Some experts (Edmund Booth/EEFIT, UK) have suggested, as a result of the 1985 Mexican earthquake, it is time to re-think the entire concept of engineered earthquake resistant design. Losses from this earthquake were unexpectedly high and cannot solely be attributed to the non-observance of codes or poor building practices.

The nature of the underlying soil and clay, and resonance in tall buildings played an important part in producing damage and severe loss of life. In the design and construction of multistoried buildings, more emphasis should may be put on the building's capacity to absorb vibrations rather than oo its strength to resist them. There is an argument for a high ductility/10w force, rather than low ductility/high force approach to vulnerability reduction. Many of the buildings which collapsed in Mexico seemed to have been built with low to medium ductility, the emphasis being on strength and solidity. Seismic building codes should provide clearer guidance in this respect.

Vulnerability assessment, in the main, comes from the analysis of previous earthquake damage, the inspection of existing buildings currently in use, or from the laboratory. As there tends to be a very wide scatter of damage degrees within any single structural category for a given intensity of ground shaking (which may be due to sharp changes in ground conditions over short distances), it would be unwise to cumulate several structural types into a generalized expression of vulnerability. Furthermore, vulnerability assessments of engineered and non-engineered structures are likely to require different methods of analysis. Risk, or the total losses to be expected from a particular event, is obtained by convoluting hazard, vulnerability, specific risk and elements at risk.

RISK REDUCTION

Unfortunately, planned risk reduction is a long-range activity highly vulnerable to conflicting priorities and demands, especially if decided on economic criteria. Buildings have economic lives ranging from fifty to one hundred years; historical monuments and settlements, and other cultural property are immutable. To move existing settlements of any significant size is, without exception, prohibitively expensive and unrealistic both in social and economic terms. In the end, one is left with fairly limited possibilities of modifying what exists, while calling the attention of decision-makers to the potential consequences of prevailing hazards when new development is planned.

Physical planning is not only a problem of designing the layout and distribution of human activities, but also a problem of resolving the sectoral conflicts of development planning at the national and local levels. The purpose of disaster prevention, therefore, is not merely to identify the physical parameters of risk reduction. Perhaps a more meaningful substitute for the term “Disaster Prevention" might indeed be “'Risk Management" Preventing disasters from occurring altogether is, in many instances, neither technically nor economically feasible. Ultimately, society accepts a compromise between exposure to hazard and economic or social necessity. Such compromise may be expressed as the society’s "acceptable level of risk”. While setting an acceptable level of risk is essentially a political division, it is nonetheless essential to understand its parameters, both in physical and socio-economic terms. Its physical parameters have been described.

All the artifacts of man can be classified as elements at risk. They can be divided into different functional categories, and can further be categorized into structural systems which, for the purpose of vulnerability assessment, is essential.

In assessing the interaction between disasters and development, however, direct loss of function or investment is not the onlv disaster-related criterion to worry about. There are chains of secondary effects which in the long-run can lead to irreparable national economic damage: 10ss of production and income, loss of serviced larnd, deterioration of certain natural resources, pollution, etc.

The rapid growth and spread of population in hazardous areas is rapidly contributing to the mounting costs of disaster in terms of lives lost and damage to property and investment. While the frequency and magnitude of natural hazards do not significantly chance over time, population growth, density and concentration have produced disasters of increasing magnitudes in recent decades. Most developing countries double their populations every twenty to twenty-five years (assuming national population growth rates of 2 per cent to 3 per cent), while the urban population in these countries doubles every twelve to fifteen years (assuming urban growth rates of 4 to 7 per cent). The rate of expansion of slums and squatter settlements around major urban agglomerations is even larger, growing at about twice the average urban rate. In settlements such as these there is a doubling of population every five to seven years. Densities are usually very high: up to 100,000 persons /km2. Even the average densities for urban areas as a whole are high enough to cause concern. The problem of exposure of low-income settlements to hazards is aggravated by the fact that they develop on land which is itself often located in hazardous zones.

The problem of exposure to disaster risk among rural populations should not be underestimated as experiences in developing countries have demonstrated. Although the population growth rate in rural areas is usually lower than the national average, due to rural/urban migration, the scarcity of arable, quality land, combined with the fact that, on the average, more than 70 per cent of total national populations are still rural, can create significant risks. Rural population densities can exceed 1,000 persons/km2 in areas where rainfall, topographical and soil conditions limit the amount of arable land. Wherever rural populations are sedentary and engaged in agricultural or animal husbandry on hazardous land, the risk of substantial disaster cannot be ignored.

Thus, the list of potentially negative interactions between the built and the natural environments appears to grow longer with the passage of time . However, there is little evidence to suggest that a sufficiently large number of countries are able to take firm action to reduce disaster risks substantially at all levels of development planning and programme implementation. The mere existence of technology, building codes, land-use regulations and other provisions for risk reduction do not in themselves suffice. Risk management is of very much wider concern, and implies a systematic approach both to the analysis and the control of all the factors liable to cause disasters.

While progress has been made in the earth sciences to define the physical characteristics of earthquakes, storms, floods, etc., less has been done to carry the analysis one step further, i.e. to increase the basic understanding of how these natural phenomena, by their severity, can affect lives and property in social and economic terms. It is necessary to estimate the casualty and damage potential of geophysical events in existing or future populations and properties at risk, using whatever pertinent information is currently available, since operational decisions must be made on a day-to-day basis.

As has been described in some detail, the basic requirement is to understand and collect data on the interaction of four factors determining the magnitude of natural hazard impact:

- The first factor is the geographical distribution and severity of the phenomenon or phenomena;
- The second factor is the number, spatial distribution and density of population and property exposed to the effects of the various natural hazards:
- The third factor is the vulnerability of the elements at risk when they are subjected to different frequency/magnitude relationships of hazards, and;
- The final factor is the effect of local conditions in modifying the severity of the event at a given location. For example, as regards earthquakes, local ground conditions can markedly affect the severity of ground motion in terms of simplification and resonance.

The interest of the third factor, vulnerability, lies in the fact that it is the determinant of risk. It is therefore an important tool for economic planning, investment programming, physical planning, design and building. Vulnerability, as we have seen, refers to classes or categories of structures and not to individual structures. It measures the degree of damage due to past events. It estimates degrees of future loss to the existing building stock on probabilistic terms. It can even be used to estimate the loss potential of future development, given sound information on building practices and local ground conditions. It is a commentary on the prevailing quality of design, materials and workmanship. It measures, or at least evaluates, the extent to which building, land-use and other codes are applied or require modification. It permits economists and engineers to carry out cost-benefit analyses of repair, reconstruction and new development. In sum, it is essentially a tool for the economic analysis of risk reduction policies and programmes.

It should be emphasized that vulnerability assessments can prove to be unreliable and even severely misleading if they are based on observations following a single event. It is most important that data on damage be collected for as many past disasters as possible for a given type of hazard, and that the general condition of construction be monitored on a continuing basis.

In the absence of clear information on vulnerability, existing building codes should be applied to design and the supervision of construction. It has been observed that even in the absence of hazard-specific codes, the mere observance of good building practice can reduce vulnerability by as much as 50 per cent. In the absence of severe environmental or ecological consequences, siting need not systematically be a determining factor, provided that the additional costs for risk reduction in the face of extreme hazards such as landslides, rockfalls, direct faulting, frequent flooding, ground instability, etc., are taken into account.

Land-use planning in seismic areas requires that all parameters associated with ground shaking be taken into account, especially with reference to soil amplification and ground failure (landslides, liquefaction, subsidence). These characteristics need to be composed into a single map for cumulative classification into broad categories of relative hazard. Ranges of land-use then need to be identified and related to the various hazards identified. Thus we have geotechnical maps and land-use capability. The planner then needs to identify land-use capability or, conversely, land-use limitations and constraints associated with these maps.

For example, one may consider four types of land-use:

1) Land suitable for urbanization without limitation;
2) Land suitable for urbanization with moderate constraints;
3) Land with severe limitations for urbanization, and;
4) Land suitable for urbanization.

These four levels of land-use are determined by hazard input factors Such as:

1) Topography (slope);
2) Depth of water table;
3) Composition and depth of bedrock;
4) Soil stability;
5) Soil nearing capacity, and;
6) Earthquake intensity rating for the area under consideration (seismic Hazard, including local soil amplification).

These parameters are fundamental in assisting planners in development of the decision-making process and implementation. Once established, a correlation must be established between land-use categories and the six hazard factors listed above. To do this, a procedure is needed whereby each of these six input factors are evaluated on a multi-disciplinary basis bringing together geophysicists, geologists, civil engineers, economists, architects and physical planners, leading to land-uses based on land capability. In principle, the most sensitive land-uses must be directly correlated with the most stable ground conditions.

Where there is doubt, a further system of evaluation is required using “capability rating and weighting”1/. This is a refinement of the basic approach. It uses numerical ratings and allows the user to weight factors according to their relative importance. The two components of the system are the land-use/environmental matrix and the land-use capability map. The environmental factor is, in fact, the hazard present in a particular location (for example faulting, and potentials for liquefaction, landslide and ground failure). These are given a rating in accordance with their severity. Against these hazards, various land-uses (such as load-bearing residential, high-rise residential, commercial facilities, key-facilities - hospitals, utilities, etc.) are also given a rating in terms of their significance, and the two parameters are correlated and mapped.

The long-term prevention of disasters in human settlements further depends on urban design parameters. With respect to earthquake disasters, four basic objectives are sought: to prevent the collapse of structures one on top of the other: to provide readily accessible escape routes: to provide sufficient open space for mass emergency use, and; to allow access for relief and rescue. Density of plot use, distances between buildings, road widths and distances to emergency assembly spaces are the subject of deliberate design procedures. Much the same approach may be used for protecting life-1ines. For maximum safety and minimal interruption of operation, life-lines in hazardous areas should be designed with a high degree of redundancy. As far as architectural design is concerned, all structures should be symmetrical and regular in layout (on plan, section and elevation). The architect should work especially closely with engineers where significant soil amplification and resonance can be expected. Siting is often the key to successful resistance to hazard at reasonable economic cost.

Fire is a significant hazard in earthquake-prone settlements. Not only is city layout important in this respect, but also the choice of building materials. Most of the damage and loss of life resulting from the 1923 Tokyo earthquake was due to fire. The same hazard persists today, so that fire preparedness is an important element of earthquake disaster-prevention in present-day Tokyo.

Urban disaster preparedness is, indeed, an integral element of prevention. As far as urban planning is concerned, it is difficult to separate the two. Within the framework 0~ physical planning, one may identify the following preparedness measures:

Regional level (within a country):

l) Draw-up an inventory of the physical infrastructure, identifying by-pass loops, duplication and other forms of redundancy;
2) Map hazards likely to cut life-lines, and;
3) Draw-up an inventory of rescue and relief resources and locate (map) them .

Urban level:

l) Draw-up an inventory of critical facilities and map these;
2) Analyze and code traffic systems, especially with reference to level and width of road, junctions and other characteristics for evacuating people out, and routing rescue/relief into the disaster area;
J) Map other infrastructural networks at the regional level;
4) Map open areas suitable for emergency assembly (especially for shelter and related services), and;
5) Prepare an inventory of available building materials, depots, tools and equipment for emergency use, including shelter.

An important aspect of preparedness closely related to vulnerability assessment and prevention is the systematic survey and recording of the condition of buildings, especially critical facilities. It is important to know which segments of a city are more at risk than others. A detailed vulnerability assessment of critical facilities and typical building types should be undertaken. As this procedure is inherent to the periodic revision and up-dating of building codes, it ought to be feasible in most large cities with public works departments.

RELIEF

In the emergency phase, the role of the physical planner/architect is limited to assisting relief personnel in assessing the spatial and geographic aspects of emergency operations, and in providing advice on emergency shelter. Engineers have a significant role in assessing structural damage and collapse in order to facilitate rescue of those trapped beneath debris, and also to assess which buildings can be re-occupied without major risk of collapse from after-shocks. Engineers also have a key role in assessing the condition and restoration of the physical infrastructure.

RECOVERY

Architects/planners have an important role to play in guiding shelter programmers, particularly with a view to limiting the costs or duration of “temporary" shelter programmes, and speeding-up housing and urban reconstruction programmes.

RECONSTRUCTION

Reconstruction policies following major disasters invariably include preventive measures for the future. Advantage should be taken of such policies while allowing for balanced economic and social development. Reconstruction strategies and programmes should be based on the risk assessment and reduction methods discussed above.

Where traditional building and planning practices prevail, especially in rural areas, it is not always possible, nor even relevant, to impose official codes and regulations. Poverty, climate and scarcity of suitable materials for earthquake-resistant construction may also combine to perpetuate or aggravate risks, for example, in areas where, traditional building consists of dry-stone or adobe walls, and heavy tiled or flat mud-filled roofs. These buildings have the thermal capacity required to protect both man and beast form extreme diurnal and seasonal fluctuations of temperature. They often have great architectural merit, expressing the culture and traditions of a people. Unfortunately, their low resistance to shaking makes them extremely vulnerable to earthquakes. In cases such as these, the communities concerned can nevertheless benefit from technical assistance and training in "hazard resistant" methods of construction in conjunction with traditional patterns of building. Professional groups of architects and engineers have emerged in a number of industrialized and developing countries, out of concern for the conservation of cultural heritage and the protection of deeply rooted¥ traditions and ways of life. Instruction booklets have been compiled describing simple measures for strengthening traditional buildings. In any event, hazardous siting ought to be avoided to the extent that it is economically and socially possible.

CONCLUSION

We may now ask "where does risk management fit in?" Risk is the convolution of hazard, vulnerability, specific risk and elements at risk. It is an expression of total expected loss due to a particular natural phenomenon. Risk thus is the output value of the estimation and interaction of several variables. It is, therefore, a tool for modeling disaster scenarios, from which risk management policies can be formulated. By creating varying scenarios of total expected losses, it becomes possible to evaluate different levels of risk Vis-a-vis social, economic and other criteria and from such and evaluation, to estimate locally acceptable levels of risk.

Acceptable risk is, of course, never explicitly stated. It exists implicitly in building codes and regulations. The richer the society, the lower the acceptable risk and the lower the threshold of probability of exceedance admitted in the code. Knowing the life expectancy of buildings and the relative economic prosperity of a nation or community is therefore important in formulating a risk policy.

This consideration in turn affects the manner in which settlements are likely to evolve: there are intricate relationships between hazard, vulnerability, replacement costs, society and risk policies. These relationships must be examined regionally as well as locally. In so doing one enters the domain of pure planning - probably one of the more intuitive professions . It is extremely difficult to manipulate quantitative and qualitative parameters simultaneously, or to express one in terms of the other. For this reason, clear, explicit and quantifiable risk management policies will continue to elude us for some time to come. It is probably important to remember that science, technology and objective knowledge can only carry us to a certain point in the decision-making process. Ultimately policy and planning decisions depend as much on human factors as they do on objective scientific criteria and technology. This is perhaps an important observation to make to scientists and engineers. Indeed, experience shows us that it is most important and urgent that "hard" scientific data on earthquake risk be adapted to the needs and language of planners, architects and those responsible for the protection of the population in times of earthquake emergencies. In effect, the problem is that of the transfer of technology.

NOTE

1/. Cf: George Mader, UNDRO, 1985

PLANNIN AND MANAGEMENT FOR THE, PREVENTION AND MITIGATION OF NATURAL DISASTERS IN A METROPOLITAN CONTEXT

Barclay G. Jones (*)

DISASTERS AND DEVELOPMENT

The whole world has been distressed and dismayed at the catastrophic natural disasters that have struck nations in the developing world since World War II. The loss of life has been enormous and grievous to all who value human life. The social disruption has caused heartrending setbacks for societies in the process of often painful periods of transformation. The destruction of property has been immensely discouraging in economic systems in which capital goods are scarce and precious, and the potential for saving and investment is limited. The loss of production during the period of the emergency and the reduced levels of production during the recovery period impose additional hardships on economies in which per capita income is already depressingly low.

Certainly, anything that can be done to reduce the impacts of inevitable natural disasters on developing nations is of utmost importance in improving the level of well being in the world, alleviating human suffering, and advancing the cause of development.

All of this is true of the past. It is even more true of the present, and in the course of the next generation it will become of even greater urgency. In 1900 the thirty-five largest agglomerations in the world held a total of 46.2 million people. 1/ Nine of the ten largest and twenty-three of the thirty-five were in Europe (including Russia) or North America. By the year 2000 it is estimated the thirty-five largest agglomerations will hold 422.8 million people, and only one of the ten largest and eight of the thirty-five will be in Europe and North America. The situation is changing rapidly; as short a time ago as 1950 five of the ten largest agglomerations in the world were in Europe and North America. and those areas contained twenty-one of the thirty-five largest. The population of the thirty-five largest centres grew from 144.2 millions in 195a to 281.3 millions by 1980, but at that time only four of the ten and eleven of the thirty-five largest were in those regions. (See Table 1) By the beginning of the twenty-first century some of the largest urban centres will be in newly industrialized nations, but many of them will be in what we currently regard as developing nations. Of course, if one extends the list to include all agglomerations over one million or even further to half a million, the number and percentage in the developing world become even more pronounced.

Reducing the vulnerability of metropolitan areas to natural disasters becomes by definition a problem of the developing world. Not only are the majority of metropolitan areas and most of the metropolitan population in developing countries, the evidence indicates that they are more vulnerable than those in the developed world for a number of reasons. Scarce capital resources have not permitted building to the same degree of engineering

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Table 1. Thirty-five Largest Urban Agglomerations Ranked by Size 1900, 1950, 2000.

safety. Funds available to invest in urban infrastructure systems such as utilities and transportation networks have been scarcer. Capital fundshave been too scarce to allocate to protective measures, which are often quite expensive, such as levees, flood channelization projects, water impoundment systems, etc. Warning systems are often not as developed, and communication systems to convey messages of impending danger may not exist.

Measuring Impact

While it is generally believed that the relative impact of disasters on metropolitan areas is greater in developing than in developed countries, it is difficult to establish this fact unequivocally. Measuring the impact of a catastrophe is difficult. Various indices measure the force or the physical characteristics of the event. For earthquakes, the Richter scale is universally used to measure magnitude or the amount of energy released, and the Mercalli scale is used to measure the intensity of vibration at the surface at a given point. The combined Fujita and Pearson scales which measure both wind velocity and width and length of path classify tornados. Hurricanes are classified by the Saffir-Simpson scale. Volcanos are often described in terms of the cubic amount of ash and pumice ejected. Sea surges are measured in height above mean sea level, and similar measures are used for floods. Tsunami are measured by the distance between crests and the speed with which the wave travels, and, of course, by the height and speed of the wave when it hits land. The strongest earthquake in the United States was at New Madrid, Mississippi on 16 December 1811, but the strongest one recorded in the United States was the one that measured 8.3 on the Richter scale that hit Anchorage, Alaska, on 27 March 1964. The greatest volcanic eruption was that of Mount Tambora on 10 and 11 April 1815. The largest Tsunami was that following the volcanic eruption of Krakatoa Island on 27 August 1883, which created a wave reported to have been over 100 feet high.

The effect on social systems is frequently expressed in human deaths and injuries, buildings destroyed or damaged, and physical objects lost expressed in monetary terms. The disaster which caused the most deaths is generally believed to have been the cyclone of 13 November 1970, which struck East Pakistan and may have cost as many as a million lives. The most destructive disaster was Hurricane Agnes which struck the eastern United States 22-23 June 1972, causing $4.5 billions in im~1ediate damages. The death toll from earthquakes can be high. The one that struck Tang'shan, P.R.C., 28 July 1976, resulted in perhaps as many as 655,000 deaths. An earthquake in Shensi Province. P.R.C. in the mid-1950ts has never been confirmed, but reportedly claimed over a million lives. The same Province was struck 23 January 1556, with a loss of an estimated 830,000 lives.

But such enumerations tell us very little about the relative magnitude of the impact an the social system. Bath has proposed a measure called specific destruction, which is defined as a measure of the number of victims due to an earthquake per unit of seismic energy. 2/ Ribaric has extended this concept to a measure which sums human losses over three decades versus sums of released seismic energy of the events and compares them with gross national product per capita normalized in relation to per capita gross national product in the U.S. 3/ By taking the economic capacity of the country into effect. Ribaric is attempting to include the relative capability to rebuild. The index he derives, FCE, has the highest values for India, Pakistan, Morocco, and Turkey, of the selected set of countries he measures. The results are strikingly different from those derived using Bath's method. Hewitt takes a different approach. He suggests that development may change the natural ecology of a region and increase the vulnerability of the social system there in complex ways. 4/ 5/

Whatever the merit of these systems, relative impacts are different. The death of an adult with an elementary school education is a loss of capital investment in human resources, less of a loss than of a college educated adult of the same age. However, the relative magnitude of the investment is quite different in countries with different per capita gross national products and different mean number of years of school completed.

Perhaps the relative costs are unmeasurable and indeterminate. Nevertheless, one thing is quite clear. Natural disasters impede development. Nations pursuing development objectives should provide themselves with protection against the setbacks disasters can cause. Metropolitan areas are critical concentrations in these countries. And the metropolitan areas of developing countries will shortly be so vast and numerous that this is a matter of the welfare of the human race.

PLANNING AND MANAGEMENT ro MITIGATE DISASTERS

Planning and management can mitigate the effects of natural disasters on metropolitan areas. The significant advances that have been made in the reduction of losses of life and damage to property in a number of countries clearly demonstrates that is the case.

General kinds of steps can be taken that can mitigate the impact of many kinds of emergencies. However, natural hazards have different effects, and many preventive measures will have to be disaster specific. In assessing dangers, three distinct concepts are involved: hazard, vulnerability and risk. 6/ Hazard refers to the probability that an event of a given magnitude of severity will occur at a particular place. Vulnerability means the degree of loss that will be suffered by a given element from an event of a given magnitude. Risk is the probable loss from natural disasters of various kinds combining the hazards of a location and the vulnerability of the objects there.

The first responsibility is that of determining the hazards to a metropolitan area. To what extent is it subject to hazards of different kinds: earthquakes. land or mud slides, sea surges, riverine or flash floods, cyclones and tornados, etc. The second problem is that of assessing the vulnerability of the elements contained in the area to the different kinds of hazards to which they may be subjected. Risk assessment then can establish priorities for taking protective measures.

Different activities and facilities have different degrees of vulnerability to different hazards. These activities and facilities also vary in their importance to the function of the social and economic system. Specific locations and sites within the metropolitan area will have various levels of vulnerability to different hazards. The hill top region of the city of Ulcinj most severely damaged in the Montenegro earthquake of 15 April 15 1979, is the area least susceptible to damage by floods or sea surges. A Hazard Cross-Reference System would rate the susceptibility of particular sites, the vulnerability to those hazards of specific activities carried on or proposed at those locations, and the protective measures that should be taken if such activities are to be located in such places. 7/

Planning for Disasters

The governments of metropolitan areas play two major roles in prevention and mitigation of disasters. First, they are producers of goods and services and providers of facilities. Second, they are regulators of the activities that are carried on within them and the facilities that house them. It is useful to treat each of these roles separately.

(1) Public Facilities

Metropolitan governments produce vitally important goods and services that are essential to the operation of the social and economic system within their areas. It is of utmost importance that the facilities associated with these activities have the lowest feasible levels of vulnerability to the hazards to which the area is subject. Sanitary services such as water supply, waste water collection and disposal, solid waste collection and disposal, and related systems for water for fighting fires and storm drainage and flood control must not fail in emergencies, and if they do, must be restorable to operation as soon as possible. Reservoirs are by nature sensitive to landslides, earthquakes and floods. The famous Johnstown. Pennsylvania flood of 31 May 1889, was the result of the collapse of an undermaintained dam after heavy rains. Sewage treatment plants are frequently in floodplains. Other utility systems such as electricity, gas, and telephone are extremely also important. The simultaneous rupture of gas lines and water mains produced the uncontrollable fires that were the cause of so much of the destruction that accompanied the San Francisco earthquake of 18 April 1906. Loss of refrigeration in summer may spoil badly needed foodstocks. Loss of space heating in winter may endanger populations.

Transportation facilities are vital to rescue and recovery efforts as well as the operation of the system. Airports must remain functional to maintain contact with the rest of the world. Railroads are particularly vulnerable to many kinds of hazards, and alternative facilities must exist. Port facilities are especially vulnerable to sea surges and floods. Bridges frequently fail. Five major freeway overpasses failed in the San Fernando, California earthquake of 9 February 1971. Highways roads and streets may be severely damaged or made impassable by debris. Redundancy in transport network design trolleys, subways, etc. need to be restorable rapidly.

Emergency services are critically needed during disasters, and they should be given the highest levels of protection. Much of the destruction of downtown Managua. Nicaragua, after the earthquake of 23 December 1972, resulted from fires that raged for three days. The newly constructed central fire station collapsed, burying the fire-fighting equipment. In the San Fernando earthquake mentioned earlier, the reinforced concrete canopy that sheltered the ambulances of Olive View Hospital collapsed, pinning them underneath. Security forces have communication systems that can substitute for standard ones that may be inoperative.

Hospitals and other health and medical facilities are particularly vulnerable and are often made inoperative in emergencies, so they not only cannot render badly needed services, but place an additional burden on the system since their patients must be evacuated and cared for.

Governments are often responsible for the care and protection of the cultural heritage of regions through the maintenance and operation of monuments, museums, and libraries. Care should be taken that these elements important to the identity of the area and often to its economy also are well protected. 8/

One of the main functions of governments is maintaining public records. Unfortunately, there are innumerable instances of losses of vital records in both major and minor catastrophes. A fire on 12 July 1973 in the National Personnel Records Centre in Overland, Missouri, destroyed four hundred thousand cubic feet of records covering two million personnel. With computerizatian, a new element of vulnerability has been introduced.

It is critically important that governments give careful attention to ordering the city in such an way as to reduce vulnerability and provide places of safety. After the great urban fires of the late eighteenth and early nineteenth centuries, cities began to require firewalls between buildings and built firebreaks in the urban fabric. The London fire of 1-5 September 1666, led to banning wooden construction and creating wider thoroughfares. Wooden structures were forbidden in Philadelphia in 1724. The earthquake that struck Lisbon 1 November 1755 and subsequent events in Sicily and Calabria led to town plans with more open spaces for refuge and wider and straighter streets less likely to be impassable with rubble. 9/

Places of refuge should be planned, and they will vary by types of hazard and situation. Parks and open squares at frequent intervals are useful in earthquake zones. People can take refuge there and remain near their homes and families. However, in extreme climates and unfavourable weather, shelters must be available. Well constructed, well situated, and accessible public buildings that can be converted to shelters are sensible precautions for many types of hazards. High locations out of flood plains are essential when those hazards are present. Soil condition should be carefully reviewed for earthquake hazards and earth movements like land and mud slides. For such refuges to be useful, they must be accessible, and wide thoroughfares should connect them to the parts of the metropolitan area they serve. Stadiums and playfields can provide sites for temporary shelters and refuge. Schools and public buildings can serve as refuges and locations for emergency services such as kitchens to supply cooked food. Refuges are necessary not only for the population to flee to, but also as the storage and distribution points for emergency supplies and the headquarters of relief services. Metropolitan areas should be surveyed to assure there is a network of such sites and structures.

(2) Regulation

The second major role of governments is that of regulation of activities within their jurisdiction. In this regard codes and ordinances of various kinds -- zoning, building, seismic, fire, occupancy, wiring, plumbing, etc. -- are used to regulate enterprises, whether public or private, and individuals in the ways in which they construct and use buildings. The writing and adoption of such codes requires careful survey and scrutiny of the environment -- the identification of floodplains, microzonation with respect to soil conditions, recognition of unstable slopes, etc. -- and expert assessment of the hazards to which the area is prone. Technical cooperation of professional and scientific societies can assist in these tasks. This vital role has done much to reduce the impact of disasters in recent decades. Since much attention has been given to this role it will not be covered at length in this paper.

Management of Disasters

In his keynote address to the Eighth World Conference on Earthquake Engineering in San Francisco, California, on 23 July 1984. Dr. Frank Press, the President of the National Academy of Sciences and Chairman of the National Research Council of the United States, said, “History will judge governments not only by their attention to health, education, and economic growth, but also by how well they prepare their countries for natural disasters.” 10/ Most political leaders are well aware that disasters threaten the stability of political systems. The way in which an emergency is handled may determine whether or not a political regime survives. The delays in and the inadequacy of the rescue and relief measures by the central government of Pakistan after the cyclone that struck East Pakistan in 1970, mentioned earlier, caused such resentment that a civil war broke out which led to the establishment of the new state of Bangladesh. 11/ Political leaders usually know quite well that the way in which they respond to emergencies is a critical matter. However, what is often not fully recognized is that the ability to respond appropriately depends to a large extent how well one has prepared for an emergency in advance. Stukelj has given an excellent description of the planning of one such response system and its operation in an emergency. 12/

The government of a major metropolitan centre should have a permanent official charged with the responsibility for coordinating the management of emergencies. This official should be cognizant of the hazards to which the area is subject. In addition the official should have response plans in place, and should have a complete inventory of the necessary resources available.

(1) Personnel

The most important single element in determining the capacity to respond to a disaster is having a trained and expert group of people on hand who understand what has happened and know what to do. Training people takes time, and it is necessary to anticipate needs well in advance of the event. In one country with which I am familiar, which has a long and violent seismic history, there was not a single seismologist until five years ago, and there are still no earthquake engineers although the major agglomeration over a million people and the present government has been in power for about sixty-five years. The official charged with emergency management should have a complete list of technicians and scientists in the region who have various kinds of expertise that would be needed in different kinds of disaster situations. If the necessary skills do not exist, the official should urge the metropolitan and central governments to promote education and training in these specialties. It may be that people will have to be trained in disciplines that do not presently exist. On the other hand, sending people trained in related fields to international conferences and similar kinds of less formal and elaborate educational programmes, may be sufficient. Working through local or national organizations, and establishing committees which meet regularly may also help to meet these needs.

(2) Sensing Systems

Frequently, the magnitude of the impact of a disaster is directly relater to the extent it was unanticipated. It is vital that metropolitan areas maintain continual monitoring of systems of instruments that sense and record changes in various aspects of the environment. These may be as simple as rainfall gauges which can assist in anticipating flash floods, to flood level gauges in rivers and streams, meteorological sensors of various kinds from barometers to wind gauges and more elaborate instruments. Such systems should be in effect for all the kinds of hazards to which an area is subject.

Constant monitoring is essential because environmental change can occur rapidly. Hurricane Diana started as a tropical storm off the coast of Florida on 8 September 1984. It moved north along the east coast of the United States, and by 11 September it had become a dangerous hurricane off the coast of Georgia. By 12 September it had moved farther north off the coast of North Carolina where it remained in the same location for twenty-four hours. Then it abruptly turned west and moved inland striking the coast on 13 September. By the end of the day on 14 September it had abated to a tropical storm again. It moved north parallel to the coast and was out at sea again on 15 September. 13/

International warning systems exist for many types of hazards such as Tsunamis, but, unless they are monitored locally and the information is communicated to responsible officials, they will be of little help. Our capacity to anticipate catastrophes has increased enormously in recent years. Taking full advantage of this capability should do much to reduce the toll from such events in future years.

(3) Response

Rapid response to emergencies is extremely effective in reducing their impact. The ability to respond is directly related to preparedness and anticipation. After the earthquake that struck Skopje, Yugoslavia, 23 June 1963, Marshall Tito, the chief of state, was not informed of the event for almost eight hours. There was no seismic monitoring system in the country at that time, and communications facilities were damaged. After the earthquake that struck Montenegro 15 April 1979, Marshall Tito appeared on national television within four hours, inspecting the damage at the site.

Several things need to be known very rapidly: precisely what was the magnitude and nature of the event and what was the area affected; what was the loss of life and the extent of injuries; how much damage was done and to what kinds of facilities. Capability must be in place before the event to assess the impact. This requires a network of individuals of various kinds and effective communications systems that continue to operate. Various kinds of expert technical assistance will be needed to survey damage, and lists of such individuals must be available in advance. For example, after a seismic event earthquake engineers must be sent rapidly into the field to identify buildings that require demolition, those must be strengthened and braced, those are stable but not occupiable, and those which can be inhabited although damaged.

Needs must be assessed rapidly. How severe and extensive is the damage, and how much assistance is needed? After the Campania-Basilicata earthquake of 23 November 1980 it took several days to determine the extent of the damage. The most badly shaken areas were in hilly, inaccessible areas; the road system went directly through towns that were clogged with debris: communications lines were damaged; heavy fog and low clouds prevented aerial reconnaissance for several days. 14/ It is difficult to mount a response effort without knowing the magnitude of the situation.

The task of mobilizing resources in a short period of time is very complex. The resources are personnel, equipment and materiel. Trained experts in a wide variety of fields must be identified and assembled. It is necessary to have types of people and updated lists of them available in advance of the emergency. This will require establishing networks, creating official organizations, and working in cooperation with professional and scientific associations. The types of specialists needed may be of a wide range and include: emergency management specialists; telecommunications experts; utility engineers; transportation facility engineers: public health and medical personnel; demolition experts: architectural and art conservators, etc. In addition, there may be extensive needs for personnel without particular skills to assist in rescue operations, transport, clearing debris, cleaning up, stabilizing and boarding up buildings, repairing damage, administering first aid, cooking meals, erecting tents or temporary shelters.

Specialized equipment of various kinds may be needed. Heavy construction equipment is frequently necessary such as earth moving equipment, digging equipment, cranes, etc. Fire fighting equipment may be needed, as well as ambulances and other emergency vehicles. Helicopters and light aircraft, boats, all-terrain vehicles and other specialized transport may be required. Additional standard vehicles, such as busses and light and heavy trucks may be necessary to supplement local supplies. Pumps, generators, radios, heaters, stoves, fans, refrigerators and similar machinery may need to be assembled. Sophisticated medical facilities may have to be established on a temporary basis. Cutting and welding equipment and power and hand tools are essential for clearing and repairing.

Materiel is certain to be required. Sand bags, plywood, lumber, cement, masonry blocks and bricks and other constriction materials, and plastic sheeting, tarpaulins, and canvass are required to protect, stabilize and repair. Fuels for transport, cooking, heating, and running equipment have to be available. Potable water, food and medical supplies are often essential. Clothing, bedding, towels and other household textiles must be available.

The resources of personnel, equipment and materiel must then be organized first to stabilize the situation and keep it from getting worse, further endangering survivors and those who have come to assist. Then victims and survivors must be sought and their needs met. The dead must be identified and buried, the injured treated, other survivors must be provided with heat in winter, clothing, food, water, sanitary services, shelter and lighting, In some instances it will be desirable to evacuate part or all of the population. A destination must be arranged and the logistics of moving people and their belongings solved. The earthquake that struck the Friuli region in northeastern Italy on 6 May 1976, was followed by a severe aftershock on 15 September 1976, which caused structures weakened in the first shock to collapse and destroyed stabilization and repairs that had been carried out. With the advent of winter it seemed desirable to evacuate as many as possible and more than 30,000 were relocated to summer resort hotels on the Adriatic coast.

(4) Recovery

Recovery should be accomplished in as short a time as possible. Debris must be removed, destruction cleaned up, and damage repaired so that the social and economic systems can return to some approximation of normal operation. After the earthquake that struck Bucharest 5 March 1977, high priority was given to removing as rapidly as possible all traces of the event, in part to help the population to forget the tragedy. The sites of collapsed buildings were cleared and leveled and planted with grass as quickly as possible. 15/ If the disaster is extensive, the recovery period may take some time. However, advance planning can reduce the duration of the time required to return to normal. Utilities including water, waste water collection, electricity, and gas should be restored as soon as it is safe to do so. Telecommunications should receive the highest priority. Transportation facilities should be repaired rapidly and systems put back into operation as soon as possible. After the Bucharest earthquake in 1977, the airport functioned with almost no interruption. In contrast, after the Montenegro earthquake of 15 April 1979, air service to the region was unavailable for well over a month. While the airport in the stricken area operated within a few hours of the event, it was deliberate policy to discourage people and reporters from flocking to the stricken region.

(5) Reconstruction

Reconstruction periods should be as short as possible. Much human deprivation can be avoided by restoring the system to full operation quickly. After the earthquake mentioned earlier that struck Managua on 23 December 1972, the government delayed the reconstruction of the centre city interminably while they produced plans and attempted to assemble land. As a consequence, activities relocated outside the centre in a desperate effort to restore operations. Plans that are instituted can promote or impede development, and the effect they have can be a complex function of the rapidity with which reconstruction proceeds. 16/

Planning and management for the prevention and mitigation of natural disasters in metropolitan contexts are extremely complex subjects. However, the tremendous toll of human lives and deprivation that we have observed in just the last generation, justify any effort we can make. The enormous expansion of metropolitan areas, particularly in developing countries, over the next generation indicates that unless great efforts are made now, the level of human suffering will be vastly greater than anything that has ever been known.

NOTES

1/ Jones, Barclay G. and William F. Shepherd. “Cities of the Future: Implications of the Rise and Relative Decline of the Cities of the West," paper presented at Wingspread Foundation Seminar, April 13, 1986.

2/ Bath, M. "Earthquake. Large, Destructive,” International Dictionary of Geophysics, Vol. l, S. K. Runcorn, et al., eds.. New York: Pergamon Press, 1967, pp. 417-424.

3/ Ribaric, Vladimir. "An Extension of the Concept of Specific Destruction of Earthquake on the Basis of Gross National Product of Affected Countries,” Social and Economic Aspects of Earthquakes, Barclay G. Jones and Miha Tomazevic, eds., Ithaca, N.Y.: Programme in Urban and Regional Studies, Cornell University, 1982, pp. 439-452.

4/ Hewitt, Kenneth. “Settlement and Change in 'Basal Zone Ecotones': An Interpretation of the Geography of Earthquake Risk," Social and Economic Aspects of Earthquakes. Barclay G. Jones and Miha Tomazevic, eds.. Ithaca, N.Y.: Programme in Urban and Regional Studies. Cornell University, 1982, pp. 15-41.

5/ Hewitt, Kenneth. Interpretations of Calamity. Boston: A1len and Unwin, Inc., 1983.

6/ United Nations. Office of the United Nations Disaster Relief Coordinator. Natural Disasters and Vulnerability Analysis, Report of the Expert Group Meeting 9-12, July 1979. Geneva: Office of United Nations Disaster Relief Coordinator, 1980.

7/ Jones, Barclay G. “Disasters and Urban Systems,” Journal of Architectural Education, Vol. XXXIII, No.4 (Summer 1980), pp.16-18.

8/ Jones, Barclay G., ed., Protecting Historic Architecture and Museum Collections from Natural Disasters. Boston: Butterworths, 1986.

9/ Tobriner, Stephen. “Earthquake and Planning in the 17th and 18th Centuries,” Journal of Architectural Education. Vol.XXXIII, No.4 (Summer, 1980) pp.11-15.

10/ Press, Frank. “Keynote Address: The Role of Science and Engineering in Mitigating Natural Hazards,” Proceedings of the Eighth World Conferences on Earthquake Engineering: Post-Conference Volume, Englewood Cliffs, N.J.: Prentice Hall, 1986, pp. 13-23.

11/ Cornell, James. The Great International Disaster Book. New York: Charles Scribner’s Sons, 1982.

12/ Stukelj, Polde. "Rescue Operations After an Earthquake," Social and Economic Aspects of Earthquakes, Barclay G. Jones and Miha Tomazevic, eds., Ithaca, N.Y.: Programme in Urban and Regional Studies, Cornell University, 1982, pp. 405-412.

13/ Committee on Natural Disasters, National Research Council, Hurricane Diana: North Carolina, September 10-14, 1984. Washington, D.C.: National Academy Press, 1986

14/ Logorio, Henry J. and George G. Mader. Earthquake in Campania-Basilicata, Italy, November 23, 1980: Architectural and Planning Aspects. Berkeley, Ca.: Earthquake Engineering Research Institute, July, 1981

15/ Jones, Barclay G. and Amos Avgar. "A Protocol of the Effects of Urban Systems of the Earthquake in Romania of March 4, 1977," unpublished paper, June 23, 1977.

16/ Jones, Barclay G. "Planning for the Reconstruction of Earthquake Stricken Communities," Proceedings of the P.R.C.- U.S.A. Joint Workshop on Earthquake Disaster Mitigation Through Architecture, Urban Planning, and Engineering. Beijing: Office of Earthquake Resistance, State Capital Construction Commission, 1981, pp.240-255.

AN INTERNATIONAL DECADE OF HAZARD REDUCTION:A STRATEEGY FOR INTERNATIONAL COLLABORATION TO REDUCE NATURAL HAZARDS

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The idea of an International Decade of Hazard Reduction was first proposed by Frank Press, President of the National Academy of Sciences, in a keynote address to the Eighth World Conference in Earthquake Engineering in San Francisco on 23 July 1984. He suggested that governments should attach high priority to mitigating natural hazards that are characterized by low probability and high societal consequences (e.g., earthquakes and hurricanes). In view of the fact that the technical means to minimize destructiveness are becoming available for at least some of these hazards, he considered that engineers, natural scientists, and social scientists might now facilitate hazard mitigation by organizing a decade of international collaborative activities.

Several versions of this speech were published in more than twenty-five countries in a variety of languages and were widely circulated among a global audience of scientists and engineers. The response made it clear that the idea of international scientific and engineering collaboration to reduce natural hazards has wide appeal. Evidence of support is strangest in the engineering community. National delegates of the International Association of Earthquake Engineering moved quickly to approve a Board of Directors decision to pursue the idea of an International Decade of Hazard Reduction. Other engineering and architectural organizations that have subsequently endorsed the concept include the American Society of Civil Engineers, the Council on Tall Buildings and Urban Habitat, the Wind Engineering Research Council, the Trilateral Symposium on Engineering for Multiple Natural Hazard Mitigation (including Japan, the Peoples Republic of China, and the United States), the Association de Ingenieros Estructurales in Argentina, the Institute of Engineers in Singapore, and the Architectural Association of Kenya.

The proposed International Decade of Hazard Reduction received less publicity among natural scientists, social scientists, and hazard mitigation organizations, but available evidence suggests that high degree of interest also exists among these groups. The Disaster Research (part of the Science Council of Japan) have both endorsed the concept. Various units of the U.S. National Research Council in the United States have also expressed support or interest (e.g., the Committee on Natural Disasters, the U.S. Geodynamics Committee, and the Committee on Earthquake Engineering). Prospects for broader international collaboration are viewed enthusiastically by landslide researchers in the U.S. Geological Survey who are already undertaking cooperative hazards studies with scientists in Japan, China, Korea and other nations. Other organizations that have indicated support or interest include the Committee on Disasters of the International Sociological Association, the Organization of American States, the UN Center for Regional Development, the Development Workshop on Building and Planning in the Third World, and the Building Research Establishment in the United Kingdom. Finally, as evidenced in letters and

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comments from hundreds of individual researchers and mitigation specialists, the prospect of and international collaborative activity that focuses on natural hazard reduction has caught the attention of a large number of scientists and engineers in developed and developing nations.

A meeting of experts was held in Washington, D.C. on 18 and 19 February 1986, to discuss the feasibility of a collaborative, international programme to reduce adverse impacts of natural hazards. The forty-nine attendees at that meeting came from academic institutions, federal government agencies, professional societies, organizations engaged in regional economic development and natural resource utilization, and other private sector institutions. The vast majority of the attendees were from the United States, with Canada, France, and Japan each represented by one participant.

Five of the individuals present at that meeting were asked to constitute a working group whose task was to prepare a document reflecting the views expressed at the meeting. The first draft of that document was completed in April. It was based on the record of discussions at the meeting, on ideas developed during a subsequent one-day meeting of the working group, on written submissions from thirty-eight of the participants in the February meeting, and on a substantial body of correspondence from scientists and engineers throughout the world.

A revised and edited version of that draft was completed in mid-July and was distributed to the participants in the February meeting for their suggestions and comments. A final version is now being prepared. That version will be reviewed by the National Research Council and will by published before the end of this year.

This paper describes some of the main points set forth in the draft report.

There is an acute and growing need to reduce natural hazards throughout the world. This problem requires an international response because many hazards cross national boundaries and some are virtually global in scope. The technical capabilities for addressing natural hazards vary widely among nations. While considerable national and international cooperation does take place, especially with regard to post-disaster relief, major natural hazards can easily overtax international arrangements for relieving human hardship and can severely disrupt national and global economies.

The draft report describes the framework for a collaborative, global programme to reduce natural hazards. The primary goal of this programme is to reduce future losses of lives and property by encouraging use of the best available hazard reduction information in decisions that affect areas at risk. The programme’s initial focus would be on the development and use of procedures for incorporating information about natural hazards into decisions about major investments in hazard-prone areas that have rapidly growing populations. Such areas contribute disproportionately to the increasing potential for losses. There is likely to be less opposition to, and greater opportunity for, increasing the use of information about natural hazards prior to major development or redevelopment activities than at any other time.

In order to provide the most favourable conditions for adoption of hazard reduction measures, it will be essential to foster close cooperation and mutually supportive working relationships between the producers and users of scientific and technical expertise. The producers are typified by physical and social scientists and engineers. The users are typified by governments, investors, developers, international and intergovernmental organizations concerned with economic development and hazard mitigation, and governmental and non-governmental organizations concerned with emergency management and disaster relief. It is important to remember that these institutions act not for themselves, but on behalf of the populations of areas where natural hazards pose a threat to life, property, and community well-being, and that the context within which they operate is often not that of science and engineering, but rather that dictated by the local sociocultural and political setting.

It will be the job of scientists and engineers to provide the best available information about natural hazards and natural hazard reduction and to encourage the use of that information in public and private decision making. They will take the initiative in increasing awareness, expanding knowledge, and improving the transfer of information about hazard reduction to public and private user groups. However, the programme's success will depend on the extent to which the public and private organizations that are responsible for developing, managing, and protecting hazard-prone parts of the world are willing and able to make use of that information. This in turn will require a flow of information from users to scientists and engineers -- a flow of information about local needs, criteria for decision making, constraints imposed by available resources, and other considerations that will affect the kinds of technical information that can be effectively used, especially on a local level where most planning, development, hazard mitigation, and emergency management activities are conducted.

Many different activities can contribute to natural hazard reduction an a global scale. These include: (1) worldwide assessment of natural hazard risk and vulnerability at the regional, national, and local scale; (2) shared access to existing information about the performance of structures, organizations, and people in disasters; (3) cooperative programmes of natural hazard research and engineering; (4) cooperative development of hazard research and engineering facilities; (5) collaborative research on the development of incentives for the adoption of hazard reduction measures; (6) evaluations of alternative institutional mechanisms for promoting hazard reduction; (7) development and use of procedures for matching scientific and engineering capabilities with the needs of specific public and private user groups; (8) development and use of procedures for incorporating information about natural hazards into public and private decision making, and; (9) creation of information clearing houses, experiment stations, extension services, training programmes, personnel exchanges, and other education and outreach programmes to strengthen the scientific and engineering components of public and private hazard mitigation activities. Although these tasks might be undertaken separately -- and indeed, many of them are being undertaken now within individual nations and by some international organizations -- their incorporation into and organized international effort makes it more likely that their benefits will be shared with, and specifically tailored to, the many nations that are not heavily involved in present hazard reduction activities.

The international programme envisaged in the draft report would have four interrelated goals:

1) To increase awareness of natural hazards and of available means for hazard reduction among the populations of hazard-prone areas;

2) To increase knowledge about natural hazards and natural hazard reduction within the global scientific and engineering community;

3) To improve the exchange of information about natural hazard reduction among scientists , engineers , governmental bodies , developers , investors, public and private organizations responsible for hazard management, and the populations of hazard-prone areas, and ;

4) To promote the use of hazard reduction measures and the evaluation of their effectiveness.

A number of factors favour the creation of such a programme at this time. These include the existence of a large number of scientists and engineers with expertise in natural hazards and in hazard reduction techniques; the existence of an ample body of knowledge concerning natural hazards and the human response to them; the existence of technology, especially in the areas of remote sensing, automated data processing, and information retrieval, that can be applied to natural hazards and natural hazard reduction; and the emergence of new intellectual paradigms and new institutional arrangements for bringing together the producers of hazard reduction information (i.e., scientists and engineers) and such users as governmental agencies and national and international non-governmental organizations. There is also widespread support for a global programme of natural hazard reduction among the world's scientific and engineering community.

It will be important to seek broad international involvement and cooperation in the development of this programme. In the draft report some suggestions are offered concerning ways to get started. Foremost among these are the suggestion that the programme initially focus on the vulnerability of such vital facilities as schools and hospitals to catastrophic, rapid-onset events such as earthquakes, floods, landslides, and severe windstorms and the suggestion that the programme begin with a pilot group of eight to ten countries representing a broad range of natural hazard reduction problems and opportunities. Implicit in these suggestions is the idea that as the programme gains momentum and experience it will be desirable to expand its international participation and its geographic coverage and to address additional types of natural hazards, additional target institutions and populations, and additional contexts for the application of scientific and engineering expertise. The suggestions presented in the draft report will be offered to the international community as possible ways to make a start; the authors of that document have neither the wisdom nor the authority to pre-empt the decisions that will have to be made jointly by professional and governmental organizations around the world concerning the best way to embark on this major undertaking .

The draft report, when finalized and published, will be given wide distribution among physical and social scientists, engineers, hazard reduction experts, professional societies, and governmental and non-governmental bodies, both national and international, throughout the world. It will be offered to this broad audience in the hope that it will stimulate a response in the farm of expressions of interest, suggestions concerning possible approaches that might be adopted, and offers to participate in the planning activities to follow.

In the meantime, there are several tasks that should be undertaken to provide a base on which the programme can be developed. These tasks focus on extending and refining available information about natural hazards and natural hazard reduction. The most important of these involve: (1) documenting and assessing existing collections of data that describe the global distribution of natural hazard exposure, vulnerability, and losses, and; (2) collecting and assessing existing information about past experience with loss reduction measures. Other tasks that might be undertaken include: (3) developing a general conceptual model of natural hazards and loss reduction measures to provide a framework for undertaking and evaluating loss reduction measures in the future; (4) identifying and evaluating past experience with, and potential opportunities for, incorporation of information about natural hazards and hazard reduction into different kinds of pre-investment decisions, and: (5) evaluating, on the basis of past experience, alternative institutional arrangements for fostering collaboration among scientists, engineers, and hazard mitigation practitioners .

These tasks can be accomplished through a combination of activities such as research, preparation of background papers and issue papers, and the convening of workshops, conferences, and symposia. If these activities were to be undertaken by individuals, professional societies, and governmental and non-governmental organizations in different parts of the world, a substantive international base could be established for a truly global hazard reduction programme.

TRENDS IN DISASTER MANAGEMENT IN ASIA

Brian A. O. Ward (*)

INTRODUCTION

The recent very severe disasters in Africa - drought and famine leading to countless deaths and terrible suffering - have demonstrated once again, with painful clarity, the vulnerability of the world to the effects of disasters. While it is understandable that in recent years attention has been focused on the problems of Africa we, here in Asia, must never lose sight of the fact that one day our turn will surely came.

The Asian region is exposed to almost every type of disaster - those caused by natural phenomena and so called “man-made” disasters. This paper explores briefly the prospects for disasters in Asia, examines progress that has been made in disaster management in recent years and discusses ways of improving responses to the threats of future disasters.

THE RISKS

There is no evidence to suggest that the pattern of disaster-causing natural phenomena is going to change. Earthquakes, cyclones, typhoons, volcanic eruptions, etc. will continue to occur and it is at present beyond man’s capacity to prevent them. The number of people affected by them is, however, rising steadily. Between the 1960s and the 1970s the number of people killed by natural disasters increased fivefold and the number of people who were affected doubled. This trend has continued throughout the 1980s.

One reason has been the continuing increase in population. According to projections prepared by the United Nations, the population of Asia will have increased above its 1984 level by 27.6 per cent by the year 2000 and 60 per cent by the year 2025. Yet the total area of land available for people to live on will, at best, remain virtually unchanged. The world is becoming ever more crowded.

Rising population creates increasing pressure on natural resources; over-exploitation of land and environmental degradation ensue. Tropical forests are cut down; fertile topsoil is washed away; people searching for land to till are compelled to move into marginal areas which they over-graze and over-cultivate. Arable land is turned into desert. According to the united Nations Environment Programme (UNEP), nine million hectares of land are decertified every year. The people move on and, in a chilling phrase coined by UNEP, become "environmental refugees”. By contrast the ambitious plan of the Indian Government to reclaim five million hectares per year is most laudable. Competition for cultivable land in border areas can induce international tensions and the people affected may then become “political refugees”. The United Nations High Commission for Refugees (UNHCR) is probably the biggest relief agency in the world.

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Rapidly expanding industrialization inevitably increases the threat of industrial accidents.

Finally, there are other emerging disasters which are less easily qualifiable and therefore more speculative in their possible impact - ozone layer depletion and acid precipitation.

There is, thus, a sombre catalogue of potential disasters confronting us, encompassing at one end of the scale disasters caused by natural phenomena, and at the other, purely man-made ones, with a middle-ground af disasters attributable to man's impact on the environment. Sadly, it is usually the people least able to protect themselves, the poor, who suffer most from their effects.

RECENT PROGRESS IN DISASTER MANAGEMENT

In 1971 the General Assembly of the United Nations adopted a resolution which led to the establishment of the Office of the United Nations Disaster Relief Coordinator (UNDRO). Its very name is indicative of thinking at that time; disasters were equated with relief. Before 1971 the only international organization to address seriously the subject of international cooperation in disasters was the Red Cross, a voluntary organization . It is astonishing to reflect that it was barely fifteen years ago that Governments made a concerted effort to address the problem of disasters, and then only in the context of relief. Within a very short space of time, two or three years, UNDRO was stressing the importance of prevention and preparedness; indeed in some quarters it was criticized for placing too much emphasis on these aspects.

In recent years there has been an increasing awareness that disaster affairs cannot be conveniently dissected into separate components - prevention, preparedness, relief, rehabilitation and reconstruction - but that there is a close inter-relationship between the parts. Disaster management, in the sense that it embraces an organized body of accumulated knowledge, has emerged as a science to take its place alongside other inter-disciplinary applied sciences such as Human and Natural Resources Development. Disaster management is increasingly recognized as an integral part of development planning. Programmes for disaster management, training and research are being established. The disaster research institutes here in Japan are among the foremost in the world. Elsewhere in the region attention should be drawn to the remarkably successful cyclone preparedness programme in Bangladesh (which has played a significant part in reducing the horrendous death tolls in that tragically disaster-prone country); the newly established Project for Strengthening Disaster Preparedness and Disaster Management in Indonesia, the embryonic Natural Disaster Research and Training Center in the Philippines and the proposed Disaster Management Centre in India. Other countries in the region have all established disaster management structure backed by legislation. Food production has increased significantly and many countries are now self-sufficient. These are significant and most praiseworthy steps in the right direction. The realization of their own capabilities has led to an increasing reluctance on the part of disaster-prone developing countries to have external solutions imposed upon them. This trend is likely to continue. Yet Asian countries readily admit that there is room for improvement in their national disaster management structures and they have not been ashamed to ask for advice.

It was in response to such requests that the Asian Disaster Preparedness Center was established earlier this year at the Asian Institute of Technology in Bangkok, Thailand. Its role is to provide a regional service to Asian countries. Its primary functions are to offer a regional training facility and the focus of a regional disaster information network. Concomitant activities include research, planning services, technical programmes and consultancies appropriate technology and awareness presentations.

What further steps can be taken to strengthen the capacities of Asian countries to meet emergencies in the coming years? Since it is not only a matter of "what" but also of "by whom" this question will be addressed in two parts: firstly, what can Asian countries do to help themselves and. secondly, what can the international community do to help? Although the points covered are addressed as logically as possible, the sequence should not be regarded as a priority list. The activities proposed are complementary to one another.

WHAT CAN ASIAN COUNTRIES DO TO HELP THEXSELVES?

It is generally agreed that the prime responsibility for meeting with emergencies rests with individual countries. Seven ways in which Asian countries might strengthen their capacities in that respect are suggested.

Increased Research

Research is fundamental to the science of disaster management; without it we cannot improve our knowledge. We must study not only disaster-causing phenomena themselves, but also their social and economic impact, means of mitigation, human responses, the effectiveness of organizational responses and so on. Disaster "Myths" must be debunked. Evaluations can contribute greatly to meaningful research provided they are conducted honestly and are not, as they all too often are, simply white-washing exercises designed to show how well everybody performed. At present, most disaster-related research takes place in developed countries. Is it relevant to developing nations? Are conclusions drawn from an external perspective appropriate to developing Asian countries? Answers to these questions and others will only be found if research is conducted in the region.

Improved Information Systems

Good information is an essential pre-requisite to meaningful study, sound planning and effective response; it is the raw material of research. There is at present a paucity of good disaster-related information in Asia and such information as there is, is hard to find. Asian countries should now embark on an aggressive campaign to acquire disaster-related information which must then be assessed and collated. Inaccurate information must be rejected; irrelevant information put to one side lest it clog the system (but never discarded since what may seem irrelevant today may one day be of great significance) and then, since information is only useful if it is available to the people who need it, actively disseminated. In this process Asian countries may well find it convenient to utilize the latest tools of information technology - data base systems and networking (though there should be more to networking than the exchange of bibliographies). The media in general have an important part to play; their libraries can be valuable sources of written and audio-visual material and they have an obvious role in disseminating information to the public.

Improve Management of Natural Resources

We must take positive steps to preserve our resources. We must conserve our natural forests, arable areas and water sources. We must try to turn back the onslaught of desertification, giving first priority to those critical areas which would otherwise soon be lost.

Strengthening Disaster Response Systems

Effective disaster responses depend upon effective pre-disaster planning. What is sometimes overlooked is that effective pre-disaster planning and coordination can only take place if the disaster management organization also exists in the pre-disaster period. Too often disaster structures only come into effect after the event. Legislation is needed to establish permanent national disaster management structures, their terms of reference, powers and rules o~ procedure so that appropriate pre-disaster activities can take place. Needless to say the powers given to disaster organizations in the pre-disaster period will be concerned mostly with coordination and contingency planning. Warning systems must be established, tested and the public informed of them. Contingency plans must be prepared to meet anticipated threats, but kept sufficiently flexible to cope with the unexpected. People must be trained. Plans, and the people who will be responsible for implementing them, must be practiced. The following principles for disaster planning are suggested:

1) CLARITY: Aims must be positive, clear and precise. Plans should be so arranged that people can quickly comprehend them and understand what has to be done. If they have not been practiced regularly, response plans may have to be implemented by people, other than the authors, who are unfamiliar with them and under stress. Response plans should facilitate decision making in the event; this can sometimes be achieved by writing them in the form of Check Lists and Standard Operating Procedures.

2) FLEXIBILITY: Events will seldom go exactly as anticipated; planning data and assumptions will never be absolutely correct. Plans must allow for the unexpected.

3) I NFORMATION : Good information is fundamental to sound planning and effective response. Facts must be marshalled as comprehensively as possible prior to planning, and constantly reviewed. Response plans must include arrangements for continuous reporting, assessing and disseminating of information.

4) CONTINUITY: Wherever possible adhere to the existing infrastructure. It will be necessary to streamline procedures, but a time of crisis is the worst possible moment to rearrange the whole organization.

5) MAKE MAXIMUM USE OF ALL RESOURCES (PEOPLE AND MATERIEL): Spread the workload as widely as possible by allocating additional responsibilities for relief which are similar to routine ones. Effective crisis management calls for a collective effort. Avoid allocating unfamiliar responsibilities.

6) PLAN IN PACKETS: In assessing the anticipated impact of a disaster think in round numbers. Likewise try to organize relief in teams. This process of approximation will make the organization of responses much easier in the event.

7) CREATE RESERVES: Always have reserves far the unexpected

8) ESTABLISH A CLEAR CHAIN OF COMMAND: The system for making decisions and reporting information and actions taken must be clear and known to all.

9) PRACTICE: Practice plans to identify and correct weaknesses in them. Practice the people who will have to implement them.

10) EVALUATE: A procedure for evaluating operations should be part of any contingency plan.

<u>Exploit the Potential of Non-Governmental Organizations</u>

In the recent drought-induced disasters in Africa more than half of the relief provided to the victims was distributed by Non-Governmental Organizations (NGOS). Particular attention should be paid to the potential of indigenous NGOs, with, or without, international connections; the remarkable effectiveness of the major international NGOS is already well recognized . It is suggested that as national disaster management structures become stronger, international NGOS will find it increasingly appropriate to operate through their national counterparts after the manner of, for example, the League of Red Cross Societies which operates through National Societies.

Indigenous NGOS usually have close contacts at the community level about which they can be an invaluable source of information. They can often master considerable resources of people and materiel for relief: indeed in some Asian countries they are the biggest relief resource. Their response systems are usually simpler than those of Governments and sometimes they can act more quickly. They can be useful implementing agencies for field trials.

<u>Increase Regional Cooperation</u>

The recent Disaster Management Training Course at the Asian Disaster Preparedness Center afforded a very special opportunity to disaster managers from different countries in the region to share experiences and to converse with the technologists who constitute the routine staff of the Asian Institute of Technology. The opportunity, which is all too rare, was seized upon by the participants. They found that they had much useful information to exchange and when they departed they regarded themselves as the nucleus of a regional disaster management network. There is scope for much more regional cooperation. A precedent was set several years ago by the Association of South East Asian Nations (ASEAN) with its Panel of Experts on Natural Disasters. Let us build upon this precedent.

Increase Disaster Awareness

In the development of this paper this activity comes last; in implementation it is likely to be a precursor to most of the other activities. Awareness must be developed from two approaches. Firstly, there is public awareness - impressing upon the general public the threat posed by disasters and the steps which they themselves can take to mitigate the effects. Secondly, there is institutional awareness - impressing upon policy decision makers the close inter-relationship between disasters and development and the need to consider the disaster factor in development plans. Too often officials have said "Don't postulate hypothetical disasters; don't you realize that I already have enough real ones on my hands?" It is an attitude with which one can sympathize, but not condone. Effective disaster management is an inter-disciplinary responsibility; disasters are everybody's business. We must avoid falling into the trap of supposing that having appointed a Minister for the Environment with a small budget or as Disaster Coordinator we have solved the problem and can go to bed with a sense of fulfillment and safety. These are only the first steps in a long and laborious process.

WHAT CAN THE INTERNATIONAL COMMIJNITY ro ro HELP ?

Help National and Regional Initiatives

It may seem obvious, but the first way in which the international community can help is by supporting national and regional initiatives.

Match National and Regional Initiatives with International Ones

Research, information systems, natural resource management systems, warning systems, responses by international organizations (governmental and non-governmental), cooperation and awareness can all be improved at the international level. FAO’s Global Information and Early Warning System on Food and Agriculture (GIEWS) monitors food and crop development worldwide and can give early warnings of incipient food emergencies. WMO’s early warning systems are designed to identify areas where meteorological conditions may produce deficit harvests; it is now turning its attention to improving the process of disseminating tropical storm warnings. WHO has cooperated in studies on drought in Africa and is helping to develop the programme of the Asian Disaster Preparedness Center. UNDRO plays a nodal role in the information sector, relief coordination and in sponsoring international, regional and national programmes.

Food Management

It must surely be unacceptable that people are dying of starvation in some parts of the world while elsewhere there are surplus stocks of food.

There is enough food in the world to feed everybody, but the system for distributing it is defective. Whilst some countries face famine others have been encouraged to produce surpluses which they cannot now sell or store, and yet others spend huge sums of money amassing subsidized stockpiles only to recycle them at great financial loss as animal fodder or, worse still, release them on the world markets with devastating effects on the unsubsidised farmers in developing countries. We must develop a better world system for food management.

CONCLUSIONS

The prospect for the occurrence of disasters is sombre. Taken together, natural disasters, man-made ones and those caused by man's impact on the environment are likely to increase as will the numbers of victims. There is, therefore, a compelling need to improve our capabilities to deal with them. Already some steps in the right direction have been taken. Primary responsibility for disaster management rests at the national level, The role of the international community is a supportive one.

Disasters should be seen as opportunities to support integrated development programmes. Relief materiel should be used, if appropriate, to replenish national stocks exhausted at times of emergencies or left in place to strengthen indigenous support systems so that they are better able to cope with subsequent events. Every effort should be made to improve standards of living so that individual self-sufficiency and reserves rise above basic subsistence levels. Above all, governments must give greater recognition to the benefits of investing in disaster prevention and preparedness and resist the temptation to cut budgets for these activities in times of economic difficulty. Where would we all be if Noah had suspended work on the Ark because of short-term cash flaw problems?

REFERENCES

l. Cuny, Frederick C. Disasters and Development. New York Oxford University Press. (1983).

2. Htun, Nay. "Environmental Degradation and Disaster", (Paper presented at the Asian Disaster Preparedness Centre in First Course on Disaster Management, July 28 - September 5, 1986. Bangkok, Thailand: Asian Institute of Technology.).

3. Quarantelli, E. L. and Russel R. Dynes. Images of Disaster Behaviour: Myths and Consequences. Columbus, OH.: Disaster Research Center, Ohio State University. (1972) .

4. Ressler, E. M. "The Changing Role of the International Community in Refugees Situations" Paper presented at Annual Conference of the Committee for the Coordination of Services to Displaced Persons in Thailand (CCSDPT), Bangkok, Thailand, 11 July. (1986).

5. U. N. Secretary General. "Review of the United Nations System-Wide Emergency Situations Preparedness and Its Co-ordination Aspects and Links to Longer-term Development, in the Light of the Experience

Gained from the Emergence Operations in Africa,tf 2lst Series of Joint Meetings of the Committee for PrograTnme and Co-ordination and the Administrative Conunittee on Co-ordination, Geneva, 1-2 July. (1986).

6. "United Nations World Population Chart.”

NATURAL DISASTER MITIGATION IN VRBAN AREAS

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INTRODUCTION

During the period following the end of the Second World War, there were tremendous economic and cultural changes throughout many regions of the world which in turn led to the building at unprecedented rates of structures and systems in areas of the world in which large scale destructive natural events occur. At the same time, many of those locales which are most attractive or contain great natural resources (river floodplains. coastal sections, mountainous areas) are also the most frequent sites for natural disasters of one kind or another. Therefore hurricanes. landslides, storm surges, floods, earthquakes, etc. of only moderate extent and intensity have begun to produce economic and human losses of unprecedented magnitudes. It is in response to this situation that the U.S. National Research Council (NRC) established and maintains a Committee on Natural Disasters (CND) to study natural disasters as "full scale prototypes" far future disasters. Study teams are mobilized and sent to sites of disasters as soon after their occurrence as possible, to collect, collate, evaluate and interpret data on the events, the performance of the engineered systems, and preparedness and response of appropriate government agencies. Our hope is that the experience gained from these disasters and the published reports an their effects and available perishable data will assist in formulating building codes; formulating strategies in responses ~or government agencies which carry responsibility for assisting the public during and after emergencies; developing improved warning systems; and implementing insurance and other mitigation measures to lessen the loss of life, damage and hardships resulting from future disasters.

THE COMMITTEE ON NATURAJL DISASTERS: HISTORY AND OBJECTIVES

The activities of CND began in June, 1966 when the U.S. National Academy of Engineering (NAE) received a grant from the U.S. National Science Foundation to finance on-site investigations of damage to buildings and other structures. This committee, which was originally known as the Committee on Earthquake Inspection, was part of the NAE's Committee on Earthquake Engineering Research, which had beeD organized in September 1965. A grant was received from NAE which specified that earthquakes to be Studied would be selected by the Committee on Earthquake Engineering Research. The committee was to decide quickly after an earthquake if the event was to be studied by one of its study teams, and immediately dispatch a group of experts to the site to conduct the study before reconstruction efforts were underway and "perishable data" were lost. Each team was directed: "to report on damage caused by vibration, ground movements, and in coastal regions, earthquake-generated waves." The committee was to establish the size and composition of each team, depending on the magnitude of the shock and of the initially reported damage. Experts were drawn as needed from the fields of engineering, structural engineering, soil

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mechanics, engineering geology, and coastal engineering. For example, an earthquake such as the one which struck Niigata, Japan (1964), which caused approximately $1 billion of damage, mainly from soil failures, would have required a team especially strong in soil mechanics. Far the Skopje, Yugoslavia earthquake (1963), which caused tremendous damage to buildings without soil failure, a team with expertise in structural engineering would have been more appropriate. Moreover, a great earthquake such as that of Chile (1960) which caused extensive vibratory damage to buildings, many soil failures, gross tectonic movements, and severe tsunami damage, would have called for a balanced team with representation in several disciplines.

Quick field studies following earthquakes

The first opportunity to send experts for a study of earthquake effects was presented by the 29 July 1967 earthquake at Caracas, Venezuela. During the period 3-21 August 1957 a four-member team studied the earthquake event and damage to structures in Venezuela. This study produced important observations on the performance of well-constructed high-rise buildings subjected to earthquake forces far greater than those assumed in design.

The earthquake of January-February, 1968 in western Sicily were relatively modest in strength with magnitudes ranging from 4.1 to 5.4. However the sequence of seventeen separate occurrences in twenty-three days resulted in a great toll of hurnan suffering. A two-member team, a sociologist and a structural engineer, made a study and reported their findings to the committee.

ENLARGEMENT OF CND SCOPE TO WIND STORMS AND FLOODS

In May 1970 the scope of the committee's activity was expanded, at the request of the NSF to Include "winds and other natural disasters" as well as earthquakes. At that time, a six-member team of specialists from three Texas Universities made an engineering and meteorological study of the Lubbock, Texas, tornadic storm of 11 May 1970. This tornado moved through the centre of metropolitan Lubbock, killing twenty-six people, injuring 2,000, and producing an estimated $135 million in property loss. Most important, this tornado was the first documented case of a multiple-vortex tornado, i.e., one with section vortices or section swaths (after Fujita, 1970). Nearly l0,000 single and multiple residence units and 600 commercial structures were damaged. This was, therefore, a remarkable opportunity to study the response of buildings to extreme wind conditions.

In 1971, the committee’s name was changed to the “Committee on Natural Disasters” -- the name under which postdisaster studies have been conducted and recorded since. The first study of a dam failure was made early in 1972, following the failure of Dam Number 3 on the Middle Fork of Buffalo Creek near Saunders, West Virginia. In 1976 the first study of a flash flood -- the 31 July 1976 flash flood in Big Thompson Canyon, Colorado -- was completed for the committee by a team of four specialists from Colorado State University.

Since its inception in 1966, CND has conducted post-event studies on fifteen earthquakes, six tornadoes or tornado outbreaks, four hurricanes, five floods, two volcanos, four landslides, and two dam failures. Five of the earthquake studies were made jointly with the Earthquake Engineering Research Institute (EERI). In recent years, the committee has also undertaken the sponsorship or co-sponsorship of post-event symposia on major disasters. This was done for the storms, flash floods, and debris flaws in southern California and Arizona during the 1978 and 1980 rain storms, in a symposium held at the California Institute of Technology in September 1980. The debris flaws, landslides, and floods in the San Francisco Bay region during January, 1982 were the subject of a conference held at Stanford University during August of that year. The committee also served as co-sponsor and co-organizer of a symposium on the 1983 Utah landslides, which was held at Utah State University in June, 1984. The objectives of the symposia are to bring together specialists who have studied one or another aspect of the disasters for their own employers (state or U.S. federal agencies, universities, private companies) to present, compare, and correlate their findings: and to produce a coordinated, permanent record of the experience gained from the disaster. Appendix 1 lists the completed reports prepared on committee studies to this date. So far thirty-one reports have been published by the committee of which about one half are earthquake related events.

ORGANIZATION, CURRENT MEMBERSHIP AND POTENTIAL TEAM MEMBERS

The committee functions, as did its forerunners, under the umbrella of the NRC which is responsible for administrative, editorial, funding, and other non-technical aspects of the committee’s activities. Appendix 2 is a listing of the current members and officers of the committee. In addition to the committee members, about 200 other specialists in the relevant disciplines, from all regions of the United States, have been identified as "potential team members." These experts have indicated their willingness to serve voluntarily on post-event study teams, and have provided information which is needed by the committee officers and director when a study team is being organized, on their language capabilities, passport availability, telephone numbers, expertise, etc. The committee also maintains a mailing list of about 4,500 experts with skills covering aspects of earthquakes, flooding, landslides, windstorms, and subsidence.

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Two main criteria are considered when deciding whether or not the committee should organize a disaster response team: (1) the likely availability of important information that will probably not otherwise be recovered and recorded (i.e., perishable data), and; (2) teams are sent to foreign country disasters only when data and experience are believed relevant to U.S. hazards management and mitigation. Study teams that are thereby dispatched work under the general direction of the principal operating arm of the U.S. National Academy of Sciences (NAS) and NAE. The NAS was established more than a century ago, during the administration of President Lincoln, as both an honourific organization and to serve in a scientific advisory capacity to all three branches of the U.S. government. The NAE was organized in 1964 under the charter of the NAS. The NAS and the NAE are self-governing bodies of outstanding scientists and engineers who elect their own members. They share the responsibility to examine questions of science and technology at the request of the U.S. government. This role is carried primarily through science-and engineering-related studies conducted by committees organized by the NRC. Presently, the CND consists of thirteen members, each appointed by the chairman of the NRC to serve for a period of three years. Two of the current members are specialists in earthquake engineering, three in wind engineering, one in meteorology, one in coastal engineering, two each in geotechnical engineering and social sciences, one in geography, and one in hydraulics. Three of the members serve one year terms as officers -- Chairman, Vice Chairman, and Immediate Past Chairman. The committee works closely with its Committee Director (newly named to that position in the fall of 1985 was Dr. Riley M. Chung), a full-time employee of the NRC, who is responsible for the committee officers and members, and the Committee Director . After a field study is completed, the team prepares a report manuscript. This manuscript is then reviewed by selected members of the committee and by the NRC. After each report is approved for publication, it is printed by the National Academy Press and distributed through the committee's mailing list to interested specialists and federal and local government agencies in the United States and other countries. It is also sent to the U.S. National Technical Information Service, from which it is available on request by anyone.

The committee has been operating under two premises: (1) valuable scientific information can be gathered immediately after disasters occur, and; (2) disaster protection and mitigation measures can be improved by applying this information. The CNDIS past activities have emphasized the first premise. However, recent Academy external reviewers have suggested that the CND broaden its scope to include: (1) provision of guidance to hazard research, policy, and management agencies; (2) analysis of cumulative experiences that grow out of individual disaster surveys, and; (3) close attention to the concerns of mitigation professionals such as building code officials, emergency operations planners, architects, and engineers. The committee at present has a subpanel set up to specifically look into the feasibility and the extent to which the charges to the committee can be revised to incorporate these recommendations.

BRIEF OVERVIEW OF RECENT, REPRESENTATIVE DISASTERS STUDIED BY THE COMMITTEE

The disasters that the committee has studied in the past two years which are most relevant to this international seminar and workshop on natural disaster mitigation in urban areas include reports on: the August 1983 Hurricane Alicia and September, 1984 Hurricane Diana; August,1985 Cheyenne, Wyoming flood and tornado (in draft); September 1985 Hurricane Elena (in draft); September 1985 Mexico earthquake (preliminary report released February 1986): October 1985 Puerto Rico landslide (report being printed); and November 1985 Colombia volcanic eruption (advance report released July 1986); and finally, May 1985 Pennsylvania and Ohio tornadoes (in draft). We now proceed to summarize some of the most important findings from some of these recent reports and studies. (Latest findings and recommendations from those studies noted above as "in draft" will be presented at the Tokyo workshop.)

OVERVIEWS OF RECENT, REPRESENTATIVE DISASTERS STUDIED BY THE CND

The following abridged summaries present brief descriptions of disasters studied over the past three years by the committee, and outline the principal conclusions and recommendations arrived at the committee and the study team or symposium participants. Special emphases is given to the findings which apply to urban areas and how the effects of disasters in those areas, and in similar areas, might be mitigated in the future.

ADVANCE REPORT ON WARNING SYSTEM IN COLOMBIA FOR RENEWED ERUPTIONS OF THE NEVADO DEL RUIZ VOLCANO

Shortly after the 13 November 1985 eruption of the Nevado del Ruiz volcano in Colombia, South America, the CND organized and dispatched a four-person study team to gather data about the eruption, its consequences, and especially the warning and recovery capabilities available to deal with future eruptions. This team is currently in the process of preparing a full report of its findings; however, the NRC has also recently prepared and forwarded to Colombian officials an advance report to bring to wide attention the few critical issues with respect to the existing warning systems that need to be improved immediately in order to minimize a major disaster that could result from an impending eruption of the volcano. using population data and the information from township maps and risk maps an estimated 50.000 to 80,000 additional people are at risk of losing their lives when the volcano again erupts. As of late July 1986 geological and seismological data on the activities of this volcano gathered at the Manizales Observatory indicate that the volcano has an extremely high probability of another major eruption soon. (One did, indeed, occur on 30 July 1986)

At about 9:OO p.m. on 13 November 1985 two sudden blasts followed by a twenty-five minute eruption of red hot pumice blocks from the crater of the Nevado del Ruiz volcano melted part of the ice cap that crowns the volcano. The resulting mud flow sped rapidly down the sides with such force that it caused the collapse of a natural dam on the Lagunilla River and buried the town of Armero, located about 45 km. east of the volcano. Between 22,000 and 24,000 people at Armero perished.

The record of the events of 13 November 1985 confirms that the disaster at Armero resulted not from a failure of scientists to warn of the impending eruption, but from breakdowns in the dissemination of information to those who could have been evacuated. Repeated orders for the evacuation of Armero were constrained from being fully received in the town, were not fully implemented, and never reached many members of the public.

Despite the sincere and elaborate efforts of many dedicated Colombians, the warning-evacuation system designed to save lives of the thousands of people currently at risk from the volcano's next eruption is flawed. Therefore, key improvements to alleviate these flaws in the warning system recommended by the study tea~1 in its advance report are as follows:

- Additional instruments should be installed for monitoring potential mud flows;

- The time it takes to inform the public at risk should be reduced to much less than three hours;
- Preparations should be made to give on the spot public information based on what is known about verbal evacuation warnings, and;
- Existing electrical supplies should not be relied upon, and a reliable backup power source should be provided to run communication systems for whatever warning period is considered appropriate, plus a four- to six-times reserve.

Finally, the team urged that three major groups of technical issues must be addressed in order to implement these recommendations: (1) technical hardware for mud flow monitoring, communications from scientists to officials to the public, and backup electrical supplies: (2) emergency preparedness and exercises to provide for timely public alert, the delivery of sound verbal warning messages to the public, and local official monitoring of public actions in response to warning messages, and ; (3) the financial and personnel resources needed to achieve these first two objectives.

THE 19 SSPTEMBER 1985 MEXICO CITY EARTHQUAICE

In varying degrees, all earthquake events provide an opportunity to acquire important information applicable to earthquake hazard mitigation in any country. This was certainly the case in the magnitude 8.1 earthquake that struck Mexico City shortly after 7:00 a.m. on the morning of 19 September 1985. Numerous buildings deigned under building code standards comparable to those used in parts of the United States were severely shaken -- both in the epicentral region along the Pacific coast and inland, in Mexico City itself. In both areas strong-motion instruments provided some coverage of the ground motions and of the effects of local soil and geological conditions upon these motions. There were many instances of collapse お r severe damage of structures, as well as many examples of excellent structural performance. Lifeline systems were put to the ultimate test. Emergency response procedures were severely strained. In short, this earthquake significantly tested earthquake hazard mitigation practices in a densely populated urban area. As part of the programme of scientific and technical cooperation established between the governments of the twO countries, a Research Agenda report on the Mexico City earthquake has been prepared jointly by two panels -- one from the United Stated (Committee on Earthquake Engineering) and the other from Mexico. The report sets forth an agenda for learning from the Mexican earthquake to guide those planning to participate in post-earthquake investigations and analysis. The bulk of the report discusses recommended research subjects under each of the seven identified areas of common interest to both nations, and these are: (1) ground motion; (2) geotechnical and foundation problems; (3) response and performance of engineered structures; (4) lifeline engineering; (5) repair and retrofit; (6) disaster response and mitigation, and; (7) architectural issues such as building configuration, nonstructural components, and building contents. In the area of disaster response and mitigation, the panel identified three general research areas for future follow-up research in both countries: (1) emergency response issues; (2) early recovery phase, and; (3) long-term recovery issues. These research topics are of both theoretical and empirical interest to the research communities in all countries that are concerned with the societal effects of disasters. It is anticipated, however, that recommendations from these research efforts will be different for Mexico and the United States because of the different contexts within which national planning takes place and national priorities are established. The panel recommended that collaborative projects of a parallel, as well as a joint nature, be established so that different extrapolations to a country's specific policies and practices can be derived from these research efforts on the Mexican earthquake.

THE OCTOBER, 1985 FLOODS AND LANDSLIDE AT BARRIO MAFIEYES. PONCE, PUERTO RICO

Following nearly two days of very heavy tropical rains over Puerto Rico, a landslide destroyed a large section of the Mameyes neighborhood in Ponce, Puerto Rico during the early morning hours of 7 October 1985. Shortly after the landslide the CND selected a geotechnical engineer to visit the site and assess the need for an in-depth technical study of the landslide. The report summarizes observations made at Mameyes, outlines tasks for an engineering study of the landslide, and recommends urgent actions to assess the safety of other heavily populated slopes in the area.

The landslide occurred during a tropical disturbance which later developed into Hurricane Isabel, after moving away from the Puerto Rico area. The storm produced the heaviest precipitation in Puerto Rico since 1899, and storm totals over the two-day period leading up to the landslide exceeded 18 in. over the south central portions of the island. The slope apparently failed around 4:30 a.m. and moved in sections. The Mameyes landslide destroyed or damaged over 200 houses, and estimates of fatalities range from 130 up to 500 people.

Local and national press coverage referred to the Mameyes disaster as a mud flow or an avalanche. However, field inspection indicated that Mameyes experienced a wedge-type landslide explainable by soil and rock mechanic fundamentals. Determination of the slide geometry, pore pressures, and strengths acting at the time of failure require additional investigations. Almost certainly, high positive pore pressures existed along the failure surface at the time of failure. Sources of these positive pore pressures include: (1) heavy rainfall of over 18 in ' . In twenty-four hours; (2) seepage from domestic sewage, and; (3) leaks from 8 in. cast iron and other smaller diameter pipes. The report strongly recommends that a detailed investigation of the Mameyes landslide be made, and also recommends that a geotechnical safety programme be undertaken for other densely populated slopes in the area of Ponce, Puerto Rico.

RECENT HIJRRICANE STUDIES: HIJRRICA,TES ALICIA, 1983 AND DIANA. 1984

Hurricane Alicia, which came ashore near Galveston, Texas during the night of 17-18 August 1983, was the first tropical cyclone of full hurricane intensity to strike the U.S. mainland in over three years. It was recorded as the second most costly storm to strike the United States (only surpassed by Hurricane Agnes in 1972 which caused inland flooding over a large part of the U.S. east coast and northeast. Alicia's coastal property damage was exceeded only by that of Hurricane Frederick which came ashore near Mobile, Alabama in 1979.

Though Alicia was not a particularly intense hurricane, the area of maximum winds in the storm crossed a large metropolitan area -- the Galveston-Houston area of Texas -- placing that area's network of expensive structures, high-rise buildings and lifeline facilities at risk. Wind damage was extensive throughout the area, and rain and storm surges caused flooding damage in some areas bordering the Gulf of Mexico and Galveston Bay. A unique effect of the storm was concentrated damage to the glass windows and panels of a cluster of high-rise buildings in downtown Houston. A report prepared by a five-person team of scientists, based on a four-day survey by that team on 23-26 August of the conditions after the storm and on oral and written follow-up has been published by the CND.

In general, Hurricane Alicia's winds did not exceed design values included in building codes in the Galveston-Houston area. In addition, damage from flooding and storm surge was limited to one or two localized areas. Therefore, little building and structural damage should have occurred from Alicia yet this was not the case, and preliminary estimates of Alicia's damage ranged from $750 million to as much as $1.65 billion. Reasons for damage and suggestions for studies or changes that would improve the performance of buildings and structures during future hurricanes are given in the survey team's report for two areas, the Houston central business district and the city of Galveston. Some of the key recommendations are as follows:

1) A wind tunnel study should be required for all high-rise buildings in central and suburban business districts. The favourable or adverse influences of proposed buildings on adjoining buildings should then be conveyed to their owners for possible action prior to the construction of the new building. Any changes in laws or codes needed to implement this recommendation will require careful phasing and interpretation to avoid unnecessary delays in the construction of new buildings .

2) For small buildings, a stringent design review by a professional experienced in wind engineering should be required in lieu of wind tunnel testing. (It is certain that windborne debris -- that is, 100se sheet metal, roof gravel, construction debris, broken glass, and parts of appurtenances from roofs -- ricocheting in street canyons was a major source of glass damage in the central business district of Houston.)

3) Local government officials in hurricane-prone areas should consider the following actions: (a) prohibiting the use of roof gravel in future construction in central business districts and other urbanized areas;, (b) requiring either vacuuming, bonding gravel, paving, or construction of adequate parapets for existing gravel roofs; (c) ensuring structural integrity of roof top appurtenances -- such as sheet metal components -- from good structural design requirements; (d) instituting measures to control debris at construction sites, especially during the hurricane season, and; (e) requiring periodic inspections to ensure that appurtenances on roofs -- such as aerials,

antennaes, skylights, vents, and other attachments -- are securely fastened .

4) Local government officials in hurricane-prone areas should consider design reviews and testing of products, followed by on-site testing and inspection, to minimize faulty glass installation in commercial buildings.

5) Penthouses proposed for construction on existing buildings should be given proper engineering attention, including wind tunnel testing.

6) A glass survey should be required of all buildings with a large expanse of glass, after passage of a hurricane to detect any damage to large glass windows. Damaged windows should be replaced as soon as possible .

7) (a) The architectural, engineering, construction, and meteorological communities, cities and coastal regions, the NSF, and NOAA should consider a joint effort to make windspeed measurements in and around selected coastal cities to define windspeeds during extratropical and tropical storms. (b) Designers should investigate the consequences of a storm passing through the Houston area with windspeeds exceeding the recommendations of the Houston code, especially on the cladding features of high-rise buildings.

For the city of Galveston, recommendation for consideration by beach community officials include the following: (a) providing code requirements for appropriate anchorage, bracing, and connection, especially in wood structures; (b) establishing code requirements for adequately fastening elevated air conditioning units; (c) including code requirements for effective storm shutters; (d) inspecting on-going construction to ensure compliance with code requirements, and; (e) consulting with structural engineers to develop code requirements for lateral bracing of piling supports for beach area buildings. In summary, the team found that most of the damage from Hurricane Alicia in the Houston-Galveston area was caused by a lack of hurricane resistant construction rather than by the storm. This is so because most of the damage was caused by winds, and measured winds (100 to maximum 125 mph. well to the east of the eye) rarely exceeded building code design speeds.

Other important recommendations regarding the warnings, responses, storm effects, and recovery from Alicia included: (a) local officials should identify and make arrangements for the use of local structures to be used as refuges of last resort in case of evacuation failure; (b) Local officials should seek understandings and agreements with nearby inland communities for the use of suitable public buildings as evacuation centres, and make the designated centres well known to their coastal populations ahead of time, and; (c) Local officials should plan for debris cleanup and removal after hurricanes.

<u>Hurricane Diana</u>, September 1984, highlighted some well known hurricane protection issues and some newly emerging problems. Similar to Hurricane Alicia, this was a weak storm that nevertheless inflicted significant economic losses along the southeastern coast of the United States. Unlike

Alicia, it struck an area that is thought to be relatively well prepared to withstand such storms.

Study team members surveyed damage and responses in North Carolina between 16 and 21 September 1984. Diana was the first full-fledged hurricane to strike the east coast of the United States in five years. Although initially a category 3 hurricane on the Saffir-Simpson scale, it stalled offshore losing strength for more than twenty-three hours. By the time it made final landfall early on 13 September 19S4 Diana had become a relatively weak borderline category 1/category 2 storm. It caused limited damage to coastal districts of New Hanover county and Brunswick county, North Carolina, an area that had been heavily damaged by Hurricane Hazel in 1954. In the disaster survey team report sponsored by the CND, three aspects of Hurricane Diana are pointed to for particular emphasis: (1) its complex meteorological and hydrological characteristics; (2) the fact that it struck in an area where there have been significant efforts to mitigate the effects of hurricanes, and; and (3) the long-drawn-out warning, evacuation, and sheltering process.

In spite of the generally good performance of North Carolina residences that were built in conformance with current codes, it must be recalled that windspeeds did not reach the design level there, nor were buildings subjected to storm surge or wave action that typically accounts for significant hurricane damage. Moreover, in light of the extensive damage caused by Hurricane Alicia under similar conditions in an area with poor building controls, it is clear that there are advantages to be gained from the use of a specific and easily understood code for non-engineered structures. North Carolina's experience with Hurricane Diana should encourage the use of similar codes in other hurricane-prone areas.

In damage surveys, very little attention is generally paid to superficially minor problems, such as loss of roof shingles. Unfortunately, hurricane winds are usually associated with torrential rain -- up to 14 in. in twenty-four hours during Hurricane Diana. Loss of shingles and even poorly designed roof vents and windows will permit water penetration and subsequent interior damage. Because of the large number of buildings affected by this type of damage, a substantial proportion of the total loss from storms may be due to these types of failures, particularly where strong building codes and good building practices have significantly reduced the risk of serious structural damage. This was true in Hurricane Diana, where many buildings lost roof shingles or waterproof membranes, and there were many reports of water penetrating through the roof vent. The study team therefore made the following recommendations:

1) Building inspectors should pay careful attention to cladding systems used in engineered buildings.

2) Every effort should be made to discourage large roof overhangs in hurricane-prone areas. Failing this, more specific recommendations for anchoring overhangs should be contained in building codes.
3) Serious consideration should be given to ensuring that complete roofing systems -- not just roof structures -- are capable of resisting design windspeeds, and that vents and windows do not leak under driving rain.

4) Screen nets or grids should be placed around inlets and outlets of drainage pipes associated with dams and embankments.

5) Elevated water tanks should be anchored by cables or stays.

As evidenced by the limited damage from Hurricane Diana, relatively few changes were needed in the design, installation, or operation of lifeline systems in the North Carolina coastal areas.

The performance of emergency preparedness and response systems during Hurricane Diana varied from adequate to excellent. Nonetheless, weaknesses that may foreshadow future difficulties were evident. In particular these include: (1) unsatisfactory provisions for preventing premature preoccupation of evacuated areas; (2) failure to plan for circumstances that may prevent full evacuation of barrier islands; (3) inadequate measures for ensuring the safety of emergency shelters, and; (4) confused lines of authority in some local municipalities.

In the area of hazard mitigation, no more than a handful of buildings suffered large scale damage. Most of these either: (1) predated the introduction of strong building regulations; (2) were poorly constructed; (3) were in the process of being erected, or; (4) occupied sites that had already suffered serious undermining and erosion. With the possible exception of agriculture, the bulk of the $80 million in estimated losses appeared to have been made up of small-scale losses. Few people suffered catastrophic losses in the conventional sense. Typically there was damage to trees and shrubbery, exterior lighting, signs, shingles, glazing, and overhead electric poser lines. As coastal populations continue to grow, and as development fills in areas of intermediate hazard, landward of the outer bands of coastal structures, even small and moderate hurricanes threaten to inflict substantial losses of these types. At present, mitigation measures for hurricanes emphasize the reduction of major losses to homes and businesses. Attention also needs to be paid to the problem of reducing small individual losses that produce large aggregate, community-wide totals. The survey team report made three recommendations in this area: (1) Communities at risk should plan to reduce routine, but costly storm damage to trees, beaches, boardwalks, overhead power lines, and outdoor architectural features that existing mitigation programmes overlook; (2) In concert with state floodplain management programmes, state coastal management programmes should undertake and publish detailed postdisaster analyses of sample public and private property to determine the effectiveness of existing mitigation measures and to identify needed improvements, and; (3) Federal and state agencies with responsibilities for funding, insuring, constructing, operating, or otherwise managing facilities or activities on developed barrier islands should explore the potential for mitigating chronic and acute storm damage by selectively reducing or eliminating these responsibilities.

We note in closing that the 1985 hurricane season was one of the most active of this century for the United States and a record number of six hurricanes made landfall. Table I and figure I which summarize the meteorological characteristics, damages, and deaths from these tropical cyclones.

Appendix l. NATIONAL RESEARCH COUNCIL REPORT OF POST-DISASTER STUDIES l964 – July 1986

EARTHQUAKES

The Great Alaska Earthquake of 1964: a/

Biology, 0-309-01604-5/1971, 287 pp.
Engineering, 0-309-01606-1/1973, I198 pp.
Geology, 0-309-01601-0/1971, 834 pp.
Human Ecology, 0-309-01607-X/1970, 510 pp.
Hydrology, 0-3a9-01603-7/1968, 446 pp.
Oceanography and Coastal Engineering, 0-309-01605-3/1972, 556 pp.
Seismology and Geodesy. 0-309-01602-9/1972, 598 pp., PB 212 981. a/, c/
Summary and Recommendations. 0-309-01608-8/1973, 291 pp.

Engineering Report on the Caracas Earthquake of 29 July 1967 (1968) by M. A. Sozen, P. C. Jennings, R. B. Matthiesen, G. W. Housner, and N. M. Newmark, 233 pp., PB 180 548. c/

The Western Sicily Earthquake of 1968 (1969) by J. Eugene Haas and Robert S. Ayre, 70 pp., PB 188 475. c/

The Gediz, Turkey, Earthquake of 1970 (1970) by Joseph Penzien and Robert D. Hanson, 88 pp., P B 193 919. b/, c/

Destructive Earthquakes in Burdur and Bingol, Turkey, May 1971 (1975) by W. O. Keightley, 89 pp., P B 82 224 007 (A05). b/, c/

The San Fernando Earthquake of February 9, 1971 (1971) by a Joint Panel on the San Fernando Earthquake, Clarence Allen, Chairman, 31 pp., PB 82 224 262 (A03). b/, c/

The Engineering Aspects of the QIR Earthquake of April 10, 1972, in Southern lran (1973) by R. Razani and K. L. Lee, 160 pp., P B 223 599. c/

Engineering Report on the Managua Earthquake of 23 December 1972 (1975) by M. A. Sozen and R. B. Matthiesen, 122 pp., P B 293 557 (A06). b/, c/

The Honomu, Hawaii, Earthquake (1977) by N. Nielson, A. Furumoto, W. Lum, and B. Morrill, 95 pp., P B 293 025 (A05). c/

Engineering Report on the Muradiye-Caldiran, Turkey, Earthquake of 24 November 1976 (1978) by P. Gulkan, A. Gurpinar, M. Celebi, E. Arpat, and S. Gencoglu, 67 pp., P B 82 225 020 (A04). b/, c/

Earthquake in Romania, March 4, 1977, An Engineering Report, National Research Council and Earthquake Engineering Research Institute (1980) by Glen V. Berg, Bruce A. Bolt, Mete A. Sozen, and Christopher Rojahn, 39 pp., PB 82 163 114 (A04). b/. c/

E1-Asnam, Algeria, Earthquake of October 10, 1980, A Reconnaissance and Engineering Report, National research Council and Earthquake Engineering

Research Institute (1983) by Vitelmo Bertero, Haresh Shah, et al., 195 pp., P B 85 110 740 (A11). b/, c/

Earthquake in Campania-Basilicata, Italy, November 23, 1980, A Reconnaissance Report, National Research Council and Earthquake Engineering Research Institute (1981) by James L. Stratta, Luis E. Escalante. Ellis L. Krinitzsky, and Ugo Morelli, 100 pp., P B 82 162 967 (A06). b/, c/

The Central Greece Earthquakes of February-March 1981, A Reconnaissance and Engineering Report, National Research Council and Earthquake Engineering Research Institute (1982) by Panayotis G. Carydis, Norman R. Tilford, James O. Jirsa, and Gregg E. Brandow, 160 pp., P B 83 171 199 (A08). b/, c/

The Japan Sea Central Region Tsunami of May 26, 1983, A Reconnaissance Report (1984) by Li-San Hwang and Joseph Hammack, 19 pp., P B 84 194 703 (A03). b/, c/

FLOODS

Flood of July 1976 in Big Thompson Canyon, Colorado (1978) by D. Simons, J. Nelson, E. Reiter, and R. Barkau, 96 pp., P B 82 223 959 (A05). b/, c/

Storms, Floods, and Debris Flows in Southern California and Arizona --1978 and 1980, Proceedings of a Symposium, September 17-18, 1980, National Research Council and California Institute of Technology (1982) by Norman H. Brooks, et al., 487 pp., P B 82 224 239 (A21). c/

Storms, Floods, and Debris Flows in Southern California and Arizona --1978 and 1980, Overview and Summary of a Symposium, September 17-18, 1980, National Research Council and California Institute of Technology (1982) by Norman H. Brooks, 47 pp., P B 82 224 221 (A04). b/, c

The Austin, Texas, Flood of May 24-25, 1981 (1982) by Walter L. Moore, Earl Cook, Robert S. Gooch, and Carl F. Nordin, Jr., 54 pp., P B 83 139 352 (A04). b/, c/

Debris Flows, Landslides, and Floods in the San Francisco Bay Region, January 1982, Overview and Summary of a Conference Held at Stanford University, August 23-26, 1982, National Research Council and U. S. Geological Survey (1984) by William M. Brown III, Nicholas Sitar, Thomas F. Saarinen, and Martha Blair, 83 pp., P B 84 194 737 (A05). c/

California Coastal Erosion and Storm Damage During the Winter of 1982-83 (1984) by Robert G. Dean, George A. Armstrong, and Nicholas Sitar, 74 pp., P B 85 121 705 (a05). b/, c/

The Tucson, Arizona, Flood of October 1983 (1984) by Thomas F. Saarinen, Victor R. Baker, Robert Durrenberger, and Thomas Maddock, Jr., I12 pp., P B 85 150 597. b/, c/

DAM FAILURES

Failure of Dam No. 3 on the Middle Fork of Buffalo Creek Near Saunders, West Virginia, on February 26, 1972 (1972) by R. Seals, W. Marr, Jr., and T. W. Lambe, 33 pp., P B 82 223 918 (A03). b/, c/

Reconnaissance Report on the Failure of Kelly Barnes Lake Dam, Toccoa Falls, Georgia (1978) by G. Sowers, 22 pp., P B 82 223 975 (A02). b/, c/

LANDSLIDES

Landslide of April 25, 1974, on the Mantaro River. Peru (1975) by Kenneth L. Lee and J. M. Duncan, 79 pp., P B 279 287

The landslide at Tuve, Near Goteborg, Sweden on November 30, 1977 (1980) by J. D. Duncan, G. Lefebvre, and P. Lade, 25 pp., P B 82 233 693 (A03). c/

The Utah Landslides, Debris Flows, and Floods of May and June 1983 (1984) by Loren R. Anderson, Jeffrey R. Keaton, Thomas Saarinen, and Wade G. Wells II, 96 pp., P B 85 111 938 (A06). b/, c/

TORNADOES

Lubbock Storm of May ll, 1970 (1970) by J. Neils Thompson, Ernest W. Kiesling, Joseph L. Goldman, Kishor C. Mehta, John Wittman. Jr., and Franklin B. Johnson, 81 pp., P B 198 377. c/

Engineering Aspects of the Tornadoes of April 3-4, 1974 (197S) by K. Mehta, J. Minor, J. McDonald. B. Manning, J. Abernathy, and U. Koehler, 124 pp., P B 252 419. c

The Kalamazoo Tornado of May 13, 1980 (1981) by Kishor C. Mehta, James R. McDonald, Richard D. Marshall, James J. Abernathy, and Daryl Boggs, 54 pp., P B 82 162 454 (A04). b/, c/

Building Damage in South Carolina Caused by the Tornadoes of March 28, 1984 (1985) by Peter R. Sparks, 46 pp., P B 85 204 469/AS (A04). b/, c/

The Los Angeles, California Tornado of March 1, 1983 (1985) by Gary C. Hart, Luis E. Escalante, William J. Petak, Clarkson W. Pinkham, Earl Schewartz, and Morton C. Wurtele, 44 pp., P B 814 1991/AS (A03). b/, c

HURRICANES

Hurricane lwa, Hawaii, November 23, 1982 (1983) By Arthur N. L. Chiu, Luis E. Escalante, J. Kenneth Mitchell, Dale C. Perry, Thomas Schroeder, and Todd Walton, 129 pp., P B 84 I19 254 (A07). c/

Hurricane Alicia, Galveston and Houston, Texas, August 17-18, 1983 (1984) by Rudolph P. Savage, Jay Baker, Joseph H. Golden, Ahsan Kareem, and Billy R. Manning, 158 pp., P B 84 237 056 (A08). c/

Hurricanes lwa, Alicia, and Diana -- Common Themes (1985) Committee on Natural Disasters, National Research Council, 30 pp., P B 85 218 220/AS. b/, c/

Hurricane Diana, North Carolina, September l0-14, 1984 (1986) by James K. Mitchell, Ahmed M. Abdel-Ghaffar, Peter R. Sparks, 108 pp. b/, c/

NOTE

a/ National Academy Press, 2101 Constitution Avenue, N. W., Washington, D.C. 20418.

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Appendix 2. COMMITTEE ON NATURAL DISASTERS

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PLANNING AND MANAGEMENT FOR THE PREVENTION AND MITIGATION OF NATURAL DISASTERS IN METROPOLISES OF INDIA

G. C. Mathur (*)

DISASTER VULNERABILITY IN INDIA

Human settlements in India have been subject to the vagaries of natural disasters caused by floods that perennially occur; cyclones and duststorms which are a seasonal feature; and earthquakes which occur frequently. Being a vast country, India has been prone to recurrent natural calamities from time to time which have had a debilitating effect on the agricultural and industrial economy and posed grave problems of relief and rehabilitation.

Floods pose a serious problem in thickly populated States like Uttar Pradesh, Bihar, West Bengal and Assam. On average, 8.2 million hectares of land are annually affected by floods in the country. The number of houses damaged is colossal.

Cyclonic storms from the Bay of Bengal severely affect the coastal districts of Tamil Nadu, Andhra Pradesh and Orissa. The worst cyclone, in which approximately l0.000 people perished, hit the Andhra Pradesh Coast on 19 November 1977.

Earthquakes have been occurring frequently as more than 55 per cent of the land area in India, particularly in the northern belt, lies in a seismic zone of moderate to severe intensity. The Himalayan range from Kashmir to Assam, Indo-gangetic plains and the Kutch and Kathiawar region of Western India are geologically the most destructive earthquakes have occurred in towns along the Himalayan Belt like Shillong (1897), Kangra (1905), Bihar (1934) and Assam (1959).

Other forms of natural disaster which occur in India include avalanche in the snow-bound northern region, tornadoes in different parts of the country and landslides in the north eastern region.

In the planning and development of human settlements, particularly the metropolitan centres, therefore, high priority is being given to disaster prevention and mitigation.

GROWTH OF POPIILATION AND METROPOLITAN CENTRES

Urban Population

India is the most populous country in the world, second only to China. With a population of 770 million in 1986, the country has experienced and unprecedented rate of urbanization, resulting in massive increases in urban population. The proportion of urban to total population has increased from 11 per cent in 1901 to approximately 23 per cent in 1981. There were only

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25.6 million people living in urban areas in 1901, increasing to 156 million by 1981. By the turn of the century, the urban population is expected to be more than double accounting for approximately one third of the total population of the country.

Growth Metropolitan Centres

There was an increase of 49 million in urban population during the last census decade between 1971-1981 and a few large cities have become still larger. The growth of population in twelve metropolitan centres in India, having a population of I million plus, since 1951 and projected to the year 2001 is given in Table I.

Disaster Risk

The process of rapid urbanization has significantly contributed to risk exposure to larger sections of population in the event of the occurrence of natural disaster. Almost a quarter of the urban population, which is about one third of the country's total population, is living in tweleve metropolitan centres whose population is one million plus. Due to heavy concentration of population in large cities like Calcutta, Bombay and Delhi, the density of population in some parts of metropolises is amongst the highest in the world on the order of 1000 persons per hectare. Sometimes the Indian metropolises are exposed to large scale damage and destruction from more than one type of natural disaster.

Rapid economic and social development have been taking place in metropolises involving, on a large scale, the construction of different types of buildings and other structures and the provision of infrastructural services. It is, therefore, a pressing need to insure the safety of these in the event of natural disasters to minimize loss of life and property.

Poverty Syndrome

Generally, it is found that in developing countries there is a steep rise in mortality with decreasing income. There are more deaths per disaster in low income countries and less per event in high income countries. The poor countries which suffer natural disasters are the same countries in which environmental degradation is proceeding most rapidly. Countries with severe deforestation, erosion, over cultivation and overgrazing tend to be hardest hit by disasters. In many cities, the poor live on land prone to natural disasters. They live in self-built shelters unable to stand up to strong winds, rain or tremors and do not know how to protect themselves from natural disasters.

The size of the urban population in India and its unabated growth pose a major challenge to Indian policy makers and planners in the task of natural disaster prevention and mitigation. The urgency of formulating comprehensive national policies for disaster mitigation is being increasingly emphasized by the national government to minimize the heavy 10ss of life and property which has been taking place from time to time, and also to avoid abrupt disruption of industrial and agricultural development activities and sufferings of the millions who are victims of natural disasters.

DISASTER PREPAREDNESS AND MANAGEMENT

Recognizing the increase in population and the expansion of human settlement, the Seventh National Five Year Plan (1985-1990) aims at building up an effective system of disaster preparedness and management taking advantage of the technologies available for weather forecasting. For this purpose, the approach will be mainly based on the following Measures:

- Zoning and mapping of vulnerable areas;
- Land-use regulations;
- Early warning and communication;
- Community preparedness, and;
- Contingency planning.

More purposive public policies for natural disaster mitigation are being formulated and steps are being taken to strengthen the existing legislative frame work at the national and state level for effective implementation of the policy measures. These include a policy shift from disaster relief to management; financial grants by the Union Government to State Government for relief and rehabilitation; formulation of national policy for environmental protection and ecological balance; support to science and technology for disaster mitigation; assessment of new development projects from the point of view of natural disaster mitigation; strengthening of the legislative framework for effective implementation of policies; stress on regional and spatial planning of human settlements; organizing people's participation and preparedness, etc.

PREVENTION AND MITIGATION OF DISASTERS

With the fast increase in population and the expansion of human settlements, the threat to life and property has increased on account of natural disasters. To appreciate the gravity of the problem the extent of occurrence of major natural disasters and damage and destruction caused in recent decades in India are briefly indicated in the following paragraphs along with the measures being taken for planning and management for the prevention and mitigation of natural disasters with special reference to metropolitan centres.

Floods

The seriousness of the flood problem in India can be judged from the extent of damage it causes. Available data for a period of twenty-five years from 1954-1976 reveal that the average annual direct damage is on the

- Total area affected	8.2 million hectares;
- Cropped area affected	3.5 million hectares;
- Number of houses damaged	9.25 lakh.;
- Population affected	24.6 million;
- Number of human lives lost	1,240, and;
- Number of cattle lives lost	77,000.

In addition to the direct damage, there are indirect losses resulting from disruption of railways, road traffic, and the dislocation of normal life.

(1) Flood Forecasting and Warning

Flood forecasting and timely warning are the essential pre-requisites for preparedness to meet the disaster when it strikes. The Central Flood Forecasting Organization of the Central Water Commission is responsible for flood forecasting. It has set up forecast sites at 120 locations and observations are recorded from 320 gauge/discharge sites. The meteorological department has opened flood Meteorological Offices at important cities like Patna, Bhubneshwar, Gauhati, Jalpaiguri, Lucknow, Delhi and Surat. They provide information to the forecasting centres regarding weather, rainfall and quantitative forecasts of preparation for the next twenty-four hours for the river basins.

The multi-purpose Indian National Satellite (INSAT) launched recently is being utilized for warning purposes and it is possible to have a reliable and complimentary warning system via satellite. Through this system, it is possible to reach officials lower than the district level authorities directly when all other land link systems of communications are affected by the disaster.

(2) Flood Preparedness and Preventive Operations

During the flood season every year, control rooms are opened in all the vulnerable districts and also in the State headquarters, which operate round the clock for receipt and dissemination of messages relating to floods, etc., to all concerned. District level flood relief coordination committees are set up in each district with officers of various departments as well as non-officials, for the purpose of undertaking necessary precautionary measures well in advance. The people in the disaster-prone areas are being made aware of disaster management and educated on what they should do in the event of a disaster.

All flood-prone villages, blocks, etc., are properly identified and steps are taken to see that all such areas can be reached over telephones/Walkie-Talkie sets in the event of disaster. Food grains, clothing, tents, tarpaulins, medicines, dry food, etc., are kept ready in all vulnerable areas well in advance to avoid dislocation of relief operations after the occurrence of calamities. Suitable lands are also selected in advance for air dropping of food grains and relief materials.

The Government of India has formulated a Model Action Plan for disaster preparedness for floods and circulated it to all State Governments and the Union Territories.

(3) Rescue and Relief Operations

Rescue operations are undertaken by the local authorities, police force, air force, local volunteers, etc. During the floods in West Bengal and Delhi in 1987, local volunteers, philanthropists and other agencies played a very useful role. Most of them were either students or young men. Educational institutions and charitable organizations also came forward with food supplies, clothing and other necessities. The Panchayats and 10cal leaders were also involved in this work. They helped select proper sites, brought more volunteers, helped with publicity and offered local hospitality .

(4) Flood Control

It is estimated that the area liable to be affected by floods is about 40 million hectares. According to the National Flood Commission, 32 million hectares of such land could be protected. Accordingly, reasonable protection has been provided to about IC million hectares. Hence the residual area still requiring protection is approximately 22 million hectares.

At the time of attaining independence in 1974, India had 5,280 km of embankments along different rivers, giving protection against floods to about 3 million hectares. During the first Plan, the technique of flood protection through multi-purpose reservoirs was adopted for the first time, in addition to the traditional method of embankrnent. Inadequacy of flood protection measures taken in the past were evident during the severe floods of 1954.

A national policy regarding the problems of floods and remedies in a comprehensive manner was enunciated in 1954. In brief, this policy envisages that floods in the country can be contained and managed. It also called upon the administration and the people to bear the responsibility and undertake this task of huge magnitude in order that the country may be rid of the menace of floods. Since then, considerable work has been done for providing flood protection in the most vulnerable areas.

(5) National Commission on Floods

To develop a long-term strategy for control and management of floods, the Government of India set up the National Commission on Floods in 1976. The Flood Commission has submitted its report containing important recommendations covering methodology, flood damage assessment, areas needing urgent attention, land-use and regulations, cost and benefits criteria for future approaches, planning and administration, financing research, education and training, etc.

Special river commissions have been set up in some of the States where flood problems are serious. The Brahmaputra Flood Control Commission for the planning and implementation of works in the Brahmaputra Valley, and the Flood Control Commission at Patna (Bihar) for the Ganga basin have been established. These Commissions will prepare comprehensive plans and also ensure their implementation in a phased manner.

Cyclones

Every year some part or other of India's vast sea coast is affected by violent storms. The east coast of India stretches over a length of 3,000 km from Rameshwaram to Calcutta and is prone to severe cyclones with winds of nearly 200 km per hour. (figure l)

The fury of the cyclone that struck Andhra Pradesh and Tamil Nadu on the night of 19 November 1977 was the worst unprecedented in over a century. Approximately 7.1 million people in 2,302 villages were affected by loss of life, property, crops and other damages. In Krishna district alone, the death toll was estimated over 10,000 besides the loss of 231,000 cattle and 45,00a other live stock. About 36,000 huts were completely washed away. In all, property worth Rs. 450 crores was lost, while communication, railways, roadways, telephones, electrical installations, canals and storage buildings suffered substantial damage.

(1) Disaster Preparedness

Contingency planning has been developed by the State Government to deal with any situation on the basis of advance preparedness and planning. In Andhra Pradesh there is a Standing Committee under the Chief Secretary of the State Government for overall responsibility for disaster preparedness. Operational responsibility is given to the relief section in the Revenue Department. The government plan generally involves identification of villages within a specified distance from the coast or within the specified distance along the disaster prone belt; location of suitable pucca buildings likely to be outside the reach of major disasters; establishing contact with the local people by the various levels of Government administration; location of free kitchen facilities, Government vehicles available, possible evacuation routes, location of suitable markets for various needs of the refugees, etc.

As a permanent rehabilitation measure, construction of more than 100,000 pucca cyclone-proof houses has been taken up by the State Government on a priority basis in a 2a km belt along the coast. A special Housing Corporation has been set-up for the construction of houses along the coast line in the State.

The government of Tamil Nadu has adopted a state level Anti-Disaster Plan to meet the challenge of disasters like cyclones, floods, etc. in the state. This plan, together 1lith the pre-disaster preparatory meetings convened by the Member for Natural Calamities, Board of Revenue, at various District Headquarters have considerable increased the preparedness level in the field and have not only reduced loss of life, but have led to faster postdisaster response and to increased confidence in Governmental response among the people.

(2) Special Building Rules

In order to ensure that structures in vulnerable areas are specially de8igned to resist disasters, the Directorate of Town and Country Planning has formulated special building rules for cyclone prone areas. The Directorate has set up an Anti-Disaster Planning Cell to study the vulnerability of areas to disaster and suggest long-term plans for reducing the hazards.

A chain of cyclone and flood shelters have been constructed at strategic spots along the coastal areas under a phased programme. These buildings will, during natural calamities, provide shelter to the local people and at other times, the buildings can be used for community purposes such as schools, adult education centres, library-cum-reading rooms, meeting halls, etc. Similar efforts have been made in the state of Orissa to strengthen and equip the Government machinery to meet all possible disaster situations. The Board of Revenue is responsible for all kinds of relief operations and from the Board of Revenue a special Relief Commissioner is appointed. Special Committees called Natural Calamity Committees have been constituted both at the state and district levels to consider situations arising out of natural disasters and take all necessary decisions and relief measures with promptitude.

Earthquakes

About two-thirds of India lies in seismic zones of moderate to severe intensity. The loss of life in the case of earthquakes has been on the order of about l,oa0,000 people in the last two centuries. An earthquake occurring near Calcutta in 1737 claimed 300,000 lives.

Earthquakes are the most disastrous of all national calamities which catch people mostly unaware and unprepared. While it is possible to predict the occurrence of an earthquake in a region, precision in terms of place and time is still a difficult task despite modern technology. Areas around the globe which are earthquake-prone have been identified and demarcated. India too has been divided into various seismic zones as per IS Code 1893-1975, which are shown in figure 2 considering the varying nature of intensity of earthquakes occurring in different parts of the country.

As precise timing of an earthquake is generally not known, people must be educated to take steps to meet the situation. The key to minimizing the impact of such incidents is earthquake preparedness. The problems that are generally faced after disastrous effects of earthquakes include: damages to buildings and other structures; occurrence of fire, blocking of roads; land slides or rock fall causing damages of blockage, devastating floods, tidal waves; damage of communication facilities; failure of drinking water pipe lines; maintenance of law and order; protection of public and private properties; provision of emergency shelters for refugees; first aid treatment to the injured; and prevention of spread of disease and epidemics.

(1) Relief and Rehabilitation

During the Bihar earthquake of 1934, an international team of Services Civil International (SCI) came to India at the invitation of the Bihar Central Relief Committee for carrying out relief operations. Until the late 1960's, most operations in natural disaster situations focused on relief operations. There was hardly any consciousness about disaster management . The United Nations has of late been increasingly concerned about Disaster Mitigation and prevention. A world body named United Nations Disaster Relief Organization (UNDRO) was set up in March 1972 at Geneva. It helps mobilize and coordinate relief, develop contingency plans at the national level and promotes disaster preparedness.

Some voluntary agencies have contributed significantly to the work of disaster relief and rehabilitation. These include the Red Cross Society of India, the Village Re-construction Organization, India (VRO), CARTITAS-India; the Appropriate Reconstruction Training and Information Centre (ARTIC); the Church's Auxiliary for Social Action (CASA), the Evangelical Fellowship of India Commission on Relief (EFICOR); the Ramakrishna Mission (RKM), the Service Civil International India (SCI) and the National Services Scheme (NSS).

(2) Preventive Measures

Based on the research work done in the country and elsewhere, the Indian Standards Institution has formulated standards for design and construction of seismic resistant buildings and other types of structures to be built in different parts of India. These are being followed by major construction Departments and other agencies, particularly in metropolitan centres which lie in seismic zones of moderate to severe intensity as in Delhi and Calcutta. Special considerations are given in the planning, design and construction of important structures like high-rise buildings, large dams, transmission towers, atomic energy power stations, etc. to ensure their safety in the event of earthquakes.

Research in seismic design of buildings and other types of structures is being given due importance. A chain of seismological stations has been set up in the country to record the occurrence of earthquakes and to develop a proper data base. The University of Raorkee, Department of Earthquake En8ineering is the premier institution which has done notable research work in the design of earthquake resistant structures. The National Buildings Organization is promoting the design and construction of earthquake resistant buildings and houses, including low cost mud houses and load bearing masonry buildings which are the principal modes of construction. (photos I and 2)

Other Types of Natural Disasters

Other types of natural disasters which occur in India include landslides and avalanches in the northern high mountain region of the Himalayas, and fires which occur accidentally, particularly in and around villages and in large human settlements, particularly in high-rise buildings. Depending on the local situation, several measures are being taken for the prevention and mitigation of such disasters.

Fire Research is being undertaken by the Central Building Research Institute, Roorkee which has suggested several measures in planning, design and construction of buildings and houses to minimize fire hazards and to mitigate the disaster. These have been incorporated in building standards and codes of construction practices brought out by the Indian Standards Institution. More stringent building by-laws for fire safety have been formulated in metropolitan centres.

The Snow and Avalanche Research Institute, Manali is studying the various aspects of the problem far prevention and mitigation of disasters therefrom. Research and investigations to prevent land slides have also been undertaken by some research institutions in the country.

DISASTER RELIEF ANO REHABILITATION

Responsibility of States

The primary responsibility for relief measures for people affected by natural calamities is that of the State Governments concerned. If the seriousness of a calamity calls for relief measures and consequent expenditure is of an order beyond the means of a State in a particular year, the State Government calls upon the Central Governn7ent for financial assistance.

Central Assistance

The policy and arrangements of financing relief expenditure in the States affected by natural calamities like cyclones, floods, hail storms, landslides and drought are covered by the recommendations of the seventh Finance Commission, constituted by the Government of India. The State Governments needing assistance from the Central Government approaches the Union Ministry of Agriculture and Co-operative Department of Agriculture which constitutes a Central team consisting of the representatives of the Ministry of Finance (Plan Finance Division) and the Planning Commission who visit the State to make an on the spot assessment of the damage caused and their requirements of additional expenditure. Under the present policy of financing relief expenditure in the State, financial ceilings are determined every five years by the Finance Commission. The expenditure on relief for the period 1974-1980 was Rs. 8,878.8 million. Emergency relief is provided for people accommodated in temporary shelters and also for people whose life has been dislocated in the disaster affected areas as per the guidelines an4 norms stipulated by the Central Government.

Rehabilitation and Reconstruction

Rehabilitation refers to the process of restoring the public and community assets as well as private assets to the pre-flood conditions. Reconstruction goes beyond rehabilitation and aims at improving upon the conditions prevailing before the occurrence of the disaster.

Immediate repair and restoration of public assets is undertaken by the respective Government departments. Restoration of communication, water supply and electricity is done with maximum speed and expertise. The persons rescued are provided with temporary shelters like tents or structure put up with bamboo or bamboo mats, etc. The houses are constructed in case they are washed away and repairs made to the damaged houses .

If the lands are damaged, steps are taken for reclaiming them. The damaged roads, culverts, bridges, etc. are repaired immediately. Financial help to recover the loss is given to the affected people either in the farm of a subsidy or loan. Health and education measures are taken in addition to cultural programmes to boost the morale of depressed victims and help them to recover from the shock.

In India most of the low income families do not have proper housing facilities which can withstand natural disaster. Therefore, measures are being taken to improve the housing conditions by way of better planning and safe house designs. For low-cost and durable houses/buildings, improved use of local materials and innovative techniques suggested by the institutions like the National Buildings Organization are being increasingly adopted in areas prone to natural disasters.

International Cooperation

Besides the central and state government agencies, the role played by voluntary organizations in a disaster situation have now been acknowledged as very important and significant. A number of international organizations like OXFAM, UNICEF, CARE, RED CROSS. CASA undertake relief operations in case of large-scale disaster.

DISASTER PREPAREDNESS IN URBAN CENTRES

The most important aspects of the strategy of disaster preparedness comprise:

a) Firstly, the development of contingency plans in disaster prone areas to meet different probabilities;

b) Secondly, establishment of a Centre for training in Disaster Preparedness, and:

c) Thirdly, the creation of adequate linkages between the relief and other schemes for providing work and employment.

The important measure for disaster preparedness which have been taken in India for planning and management of prevention and mitigation of natural disasters which have special significance for metropolitan centres are briefly mentioned below:

l) Mapping of Areas Prone to Natural Disasters: The specific areas prone to natural disasters like floods, cyclones, earthquakes, etc. should be identified. In India such mapping has been done especially with respect to cyclones and earthquakes, and such maps have been published in the National Building Code of India. The Central Water Commission has also prepared a map zoning out areas prone to floods.

City Planning : While drawing up development plans, especially for the development of metropolitan centres and large cities, these maps should be taken into consideration. Although the master plans for development of metropolitan centres and many large cities in the country have been prepared, the zoning regulations, which form an integral part of the ~aster plan, do not include provision for treatment of areas vulnerable to natural disasters.

Model Laws: A model Regional and Town Planning and Development Law has been formulated by the central Town and Country Planning Organization which is to be adopted by all States and Union Territories. Suitable provisions in the Model Law should also be incorporated to cater to the areas prone to natural disasters. The city planning and development authorities should, at the plan preparation stage, identify such areas by carrying out surveys and studies. Expert advice of concerned institutions and experts should be consulted to formulate suitable provisions in the zoning regulations which form part of the master plan, in order to cater to the specific types of natural disaster in vulnerable areas. The detailed development plans for different metropolitan areas should then be prepared.

2) National Building Code: The National Buildings Code of India, formulated in 1969 by the Indian Standards Institution, provides suitable guidance for design and construction of buildings and other structures to resist different types of natural disasters to which a specific area may be prone. The revised 1983 edition of the National Code contains more detailed provisions regarding structural safety, construction safety, fire safety and health safety for prevention and mitigation of natural disasters.

The existing local building by-1aws in many metropolitan centres and large cities, which are outmoded, are being revised in conformity with the National Building Code. As a result, mare stringent building by-laws for fire safety, especially in high rise buildings, have been adopted in metropolitan centres like Bombay, Delhi and Madras.

Greater attention is also being given to modifications of the existing building by-laws in respect of safety of buildings and other types of structures from earthquakes in metropolitan centres like Delhi, which lies in a seismic zone of severe to medium intensity.

In metropolitan centres which are in coastal regions as in the case of Madras, appropriate measures for protection of buildings and other structures from cyclonic effects are being increasingly adopted. To ensure the safety of buildings and other types of structures as well as the people, the provisions in the National Building Code of India need to be reviewed further from time to time particularly in densely populated metropolitan centres and large cities which lie in areas prone to natural disasters, on the basis of latest advances in science and technology.

3) Mandatory Provisions: The psychological impact on the population of the area where a major structure is to be built in an area prone to disaster is a matter of common concern. The fear that a structure will collapse in the event of natural disaster needs to be dispelled, as in India major river-valley projects lie in severe seismic zones along the Himalayas and large atomic power plants, satellite launching stations, major ports and harbours are located in coastal areas prone to tropical cyclones. To alleviate fears, all possible measures for disaster prevention and mitigation have to be taken.

In metropolitan centres it should be mandatory to design and construct all important buildings which include multi-occupancy buildings, hospitals, cinema halls, offices and also important structures like water tanks, power stations etc., so as to make these disaster resistant as much as possible. In the case of Government funded constructions, a minimum set of provisions for improving these structures against natural disasters should be formulated and made known to all concerned.

In the case of law cost houses and other types of buildings, disaster resistant features should be incorporated in stages on an incremental basis, so that when the buildings and houses are finally completed over a period of time, they have the necessary disaster resistant features incorporated in them. Such low cost techniques for imparting disaster resistant features to houses and buildings should be formulated and widely publici2;ed particularly through audio visual media for the benefit of the common people.

4) Meteorological Forecasting: For efficient management of floods and cyclones due attention should be given to strengthening of arrangements for forecasting, warning and communication systems, purchase of equipment for rescue and relief operations, construction of cyclone shelters and training of personnel in disaster management measures.

The Government of India has approved a national technological mission for improving the Weather Forecasting and Meteorological Services in the country during the seventh Five-year Plan (1985-1990) which will greatly help in issuing warnings well in advance of impending cyclones, floods, heavy rainfall, hailstorms, snowfall, avalanches, etc .

Taking advantage of recent advances in science and technology, the following are meteorological forecasting services which are being provided.

Rainfall Forecast: Meteorological Services have been organized in India on a countrywide basis. Short range weather forecasts district wide for thirty-six hours, medium range forecasts that are weekly and long range forecasts which include monthly and seasonal forecasts regarding rain and monsoons, are regularly issued by the Indian Meteorological Department (IMD). Government of India. Radio is effectively utilized for dissemination of forecast data.

Flood Forecast: The Central Water Commission (CWC), Government of India has Water Resources and Flood Forecasting Division Stations at twenty-two places in the country and eight more such stations are being set up for issue of timely flood warnings to protect life and property from devastating floods. IMD has established ten Flood Meteorological Offices (FMD) at Delhi, Hyderabad, Ahmedabad and at other large cities to provide active support to CWC in flood forecasting and regulation of medium/large dams and reservoirs.

Cyclone Forecast: A cyclone warning system is one of the most important factors in cyclone preparedness. The four essentials of an effective warning system are accurate detecting facilities, reliable forecasting techniques, fast communication channels for disseminating information and clearly worded warnings and advice on precautions. The IMD is using latest technology for its cyclone warning system. INSAT-IB is used for continuous monitoring and tracking of cyclones which provides cloud pictures every hour to half-an-hour all day and night during cyclones.

Cyclone Detection Radar (CDR) have been installed at Calcutta, Madras, Bombay and five other stations with 400 km range each to track the cyclones continuously. Area Cyclone Warning Centre have also been established at Calcutta, Madras and Bombay. Modern telecommunication facilities like telephones, teleprinters, telex and Walkie-Talkie facilities exist at these centres. Computers are being used for data processing, preparation of forecasts and exchange of meteorological data.

Earthquake Forecast: So far, no reliable technique has been developed for forecasting earthquakes. Some warning signs have nevertheless been identified which show promise in yielding accurate forecasts. Such signals include a decrease of seismic wave velocity before earthquakes, a decrease of seismic activity before major events, change in random content in well-water, changes in the electric and magnetic properties and deformation in the earth's rod. For detecting these, specialized instruments have been developed. Under the programme of the Department of Science and Technology in the north eastern region, which is prone to severe earthquakes, instrumentation for recording strong ground motions are being installed for recording different types of measurements. The data so obtained will promote understanding of the behaviour of severe tectonic forces prevailing in the region.

Ecological Balance: Although natural calamities cannot be averted, their destructive impact in terms of loss of human and animal life and upsetting the ecological balance can, no doubt, be considerably mitigated. India's sixth National Five-Year Plan (1980-1985), therefore, listed protection and improvement of ecological and environmental assets as one of its basic objectives. Further, the national policy for science and technology states that development should not upset the ecological balance for either short or long-term consideration. Poorly planned efforts to achieve apparently rapid development, ignoring the long-term effect on the environment, have resulted in serious ecological damage. It is, therefore, essential to analyse the environmental impact of the application of development policies and technology and emphasize the preservation and enhancement of the environment in the choice of technologies.

Emergency Shelters: Instant shelters must be set up in disaster areas for the protection and well being of the people. Generally, emergency shelters, particularly in areas where the weather is inclement, have to be put up in less than twenty-four hours using materials that are readily available at hand. In metropolitan centres and large cities, in order to put up temporary shelters in large numbers as quickly as possible, a variety of new materials and construction techniques are being employed which include: asphaltic sheets, ferrocement sheets, precast reinforced concrete products for roofing and masonry walls made of stabilized soil blocks, burnt clay bricks, concrete blocks, steel structures such as tubular sections, cold formed light gauge sections, timber frame structures, etc.

Use of prefabricated building components and housing elements such as prefabricated timber huts, portable cabins, fibre glass, shelters and prefab houses have also been developed which can be adopted in large cities and metropolitan centres with economy and speed. For construction of emergency shelters and temporary houses at as low cost and in as short time as possible, research and development work should be undertaken to evolve appropriate techniques and packages of building materials and component kits.

SUGGESTED ACTION PROGRAMME

Planning and Management for prevention and mitigation of natural disasters is a matter of vital significance for the safety and well-being of the millions of people who inhabit the globe in disasterprone areas. In addition to national action, international and regional cooperation should be promoted for prevention and mitigation of natural disasters. It is suggested that the following proposals be considered in this regard with particular reference to metropolitan centres.

l) Forum for Exchange of Information: A regular forum should be established to exchange information on the decisions and decision making process for design of major projects in various zones vulnerable to natural disasters in different countries. Appropriate planning regulations and building by-laws can greatly help in prevention and mitigation of disasters in metropolitan centres.

2) Case Studies: On account of the vast similarity of situations arising out of geographical factors, and social and economic conditions, it will be advantageous to undertake specific case studies of work done for natural disaster prevention and mitigation in metropolitan centres in different countries of the Asian and Pacific region which are most prone to frequent disasters. This will bring out typical features common to many countries, which can be considered by the countries concerned in natural disaster mitigation and prevention work.

3) Network of R&D Institutions: A network of R&D institutions should be developed, particularly in the Asian and Pacific region, to undertake joint surveys, studies, investigation and research to understand the various phenomena associated with natural disasters and to make collaborative efforts for devising ways and means for prevention and mitigation of natural calamities. Some internationally reputed R&D organizations in the Asian region have done pioneering work in disaster prevention and mitigation. The two UN Regional Housing Centers of ESCAP - one located in the National Buildings Organization, New Delhi and the other in the Building Research Centre at Bandung, can help in coordinating the activities of the network and disseminating the findings.

4) Regional Action Programme: The phenomena of natural disasters often transcend national boundaries and international and regional cooperation is called for in natural disaster mitigation and prevention work. The suggested Regional action programme for disaster mitigation in housing and human settlement is briefly outlined in figure 3. International and regional agencies like UNCRD should consider taking up follow up action which will be of great consequence in mitigation of natural disasters, particularly in the large urban centres in many Asian countries which are densely populated.

SELECTED REFERENCES

1. Human Settlement Atlas for Asia and the Pacific Part-1. Bangkok, Thailand: United Nations Economic and Social Commission for Asia and the Pacific, 1984.

2. India Meteorological Department, Government of India, New Delhi, India.

3. Seventh Five-Year Plan (1985-1990) . New Delhi: Planning Commission, Government of India, 1985.

4. Inter Link. Volume 4, N0.3 September 1984; Newsletter of ASEAN Association for Planning and Housing , Manila, The Philippines.

3. Planning for Human Settlements in Disaster-Prone Areas. Nairobi: UNCHS (Habitat), 1983.

6. G.C. Mathur, Housing in Disaster-Prone Areas. New Delhi, India: National Buildings Organization & U. N. Regional Housing Centre, ESCAP, 1986.

7. International Conference on Natural Hazards Mitigation Research and Practice : Small Buildings and Community Development : October 8-l1, 1984, New Delhi, India Organized by International Council for Building Research Documentation and Studies, Rotterdam and National Buildings Organization, New Delhi.

8. 8th World Conference on Earthquake Engineering. San Francisco, 1984.

9. G.C. Mathur, State-of-the-art Report on Design and Construction of Earthquake Resistant Buildings and Structures. New Delhi: Department of Science and Technology, Government of India, 1986.

10. "Design and Construction of Single Brick Thick Load Bearing Walls for 4 and 5 Storeyed Residential Buildings in Earthquake Zones." Journal of the National Buildings Organization. October, 1983.

11. Indo-U. S. Workshop on Earthquake Engineering. New Delhi, 1978.

12. Monograph on Earthquake Resistant Non-Engineered Construction. UNESCO.

13. G.C. Mathur, "Cyclone Damage and Rehabilitation" Paper presented at the Asia Pacific Symposium on Wind Engineering December 5-7, 1985, University of Roorkee, Roorkee.

14. S.P. Mukherji, Preparedness Including Flood Control Measures - A Guide for Relief Works. Department of Agriculture, Government of India.

15. K.S. Chandrasekaran, "Floods - Problems and Solutions" Paper presented at the International Conference on Flood Disaster, December 3-5 1981, New Delhi.

16. Symposium on Earthquake Disaster Mitigation. Roorkee: University of Roorkee, March 1981, Volume I.

17. Dr. Jai Krishna, 'Earthquake Disaster". Paper presented at Annual General Meeting of the Indian Society of Earthquake Technology, March, 1982.

18. Position Paper on Anti-Disaster Planning in Tarnil Nadu. Directorate of Town and Country Planning, Government of Tamil Nadu, India.

19. Technical Report on the Cyclone Shelters. Tamll Nadu, India: Public Works Department.

20. Cyclones and Building Behaviour, School of Planning and Architecture, New Delhi.

21. National Building Code of India. New Delhi: Indian Standards Institution, Revised edition 1983.

STRUCTURAL CHARACTERISTICS OF TOKYO METROPOLITAN AREA AND ITS PROBLEMS OF EARTHQIJAKE COUNTERMEASURES

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DISASTER IN METROPOLITAN AREAS

There are three major metropolitan areas, Tokyo, Osaka and Nagoya, in Japan. In these areas the population, management functions and industries are excessively concentrated. Large scale disasters have occurred repeatedly in these areas because not only of the natural environment, but also due to social conditions. When such metropolitan areas were filled with wooden houses and modern fire services were still insufficient, large urban fires often occurred because of strong winds or earthquakes. In addition, as such areas are located in low lying coastal areas, large scale water hazards due to flooding and high tides have frequently occurred.

The metropolitan areas of Tokyo and Nagoya have suffered earthquake disasters as they are located along the Pacific coast, which is vulnerable to large scale earthquakes. For big fires or floods, countermeasures such as construction of fire-proof houses, enforcement of fire services and reinforcement of river banks are effective. But in case of large scale earthquakes, it is likely that wide areas would suffer damages not only due to direct damages by earthquake vibration, but also of secondary disasters such as numerous simultaneous fires or floods which would lead to the destruction of houses and river banks, etc.

In 1923, the Kanto Earthquake occurred in the Tokyo metropolitan area and killed 120,000 people. It is now believed that a large scale earthquake may occur in the Tokai region in the near future.

The Tokyo metropolitan area has developed around the city centre of Tokyo. This area comprises the cities of Yokohama. Kawasaki and Chiba which are industrial satellite cities facing the Tokyo harbor. The area has now become the real centre of Japan in administrative, economical and cultural fields. The population of the area is more than 25 million and the radius of the built up area is 20-40 km. The area's huge population is served by many kinds of facilities, which are highly systematized. However this metropolitan area consists of quite frangible components, when we consider the countermeasures for earthquakes in metropolitan area such as Tokyo it is necessary to understand that the disaster phases which are attributable to characteristics of spatial, functional and social structure of metropolitan area are inter-related.

SPATIAL STRUCTURE AND DISASTER PREVENTION

Problems

The built up area are consecutively spread. There are few open-spaces, roads and parks, and wooden houses are built up densely. The population density is high in this area. Therefore , once simultaneous

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fires occur, fire service capabilities may not be sufficient to prevent them from sweeping wide areas. Furthermore, the lack of evacuation roads and evacuation spaces would made the evacuation of the residents difficult.

The coastal low land and reclaimed land are generally in bad condition, occupied by many industrial factories such as oil and chemical complexes. Oil tanks or other hazardous storage facilities would be damaged by an earthquake, and explosion of high pressured gas tanks or poisonous gas diffusion would spread to the urban areas adjacent to such industrial areas.

The delay of network construction of main roads and the narrowness of the roads causes chronic traffic congestions even in normal times. If an earthquake occurs, emergency activities such as ambulance or fire service would be dangerously impeded.

The central zone of the metropolis is an assemblage of fire-proof buildings, but there also are many high rise buildings and underground markets, where many people work and stay. Panic may ensure when these spaces become dark and isolated if electricity is shut off, further complicating relief measures.

Countermeasures

As it is difficult to reconstruct the whole town with fire-proof structures, the countermeasures for containing fires would be to construct belt-shape fire-proof zones. Based on urban planning, the road network and parks should first be arranged, then fire-proof buildings should be constructed along the roads and parks. By connecting such zones, so called anti-fire zones would be constructed, and these zones would divide the densely built up areas into daily life spheres. This method would make it possible to prevent the fire from spreading, and facilitate emergency activities while obviating the need for long distance emergency evacuation.

The oil and chemical complexes in coastal zones can not easily be removed. Therefore, it is preferable to construct wide green belts which would separate these zones from urban areas. The belts would also contribute to preventing environmental pollution.

FUNCTIONAL STRUCTURE AND DISASTER PREVENTION

Problems

The central management functions of politics, administration and culture, which are not only domestic, but also those related to foreign countries, are concentrated in Tokyo. If such centralized functions are severely damaged by an earthquake, social and economical damages would be extremely large. The buildings in which these functions are located would probably suffer less damage. However, the problem is that it would be difficult to secure the people who operate these organizations and the lifeline facilities such as electric power, communication cables, water supply, etc.

The residential areas where those who operate central management functions live are far from the central zone of the Tokyo metropolis. Therefore, people would not be able to come to the central zone if their own homes are damaged or the transportation system is interrupted.

It is possible that even partial damage could interfere with linear lifeline facilities. Under this scenario, comprehensive management functions supported by the lifeline facilities could also affected. Not only these functions, but also public utilities such as drinking water, light and fuel may suffer from large damages.

<u>Countermeasures</u>

As the fundamental countermeasure for earthquakes in metropolitan planning, it is important to move some governmental organizations and some of the private companies which do not have to be located in Tokyo to external areas.

It is desirable to effectively use the land of the inner city area of Tokyo and to construct seismic resistant apartments so that the distance between residence and office would be closer.

For the security of the lifeline facilities, division of the system into several blocks and construction of a double network system in each block would mitigate damages.

SOCIAL STRUCTURE AND DISASTER PREVENTION

<u>Problems</u>

As the population of the metropolis is large, the number of potential victims would be large, and the security of the necessities of life, medical facilities and housing would be become difficult. The housing problem would be especially severe because the majority of the houses in Tokyo are rented and to repair the damage would be difficult. Furthermore, as the majority of those who live in Tokyo do not maintain close links with their family's home towns, they would not have access to temporary shelter outside Tokyo. Therefore, the shortage of housing would probably continue for a long time after the earthquake.

As the distance between residential and business areas is long, people would not be able to come to the city if transportation is interrupted. This means that many functions may suffer from the shortage of labour power. Especially, as few adult males remain in residential areas during the day, disaster prevention activities in these areas may lag if they have to be performed by women, and children and the aged. In case of disaster, the lack of consciousness as a member of the community especially for the people, living in the metropolitan areas may lead to insufficient cooperation .

The majority of the people may not have experienced disaster at all. Also, the shape of built up area is too complicated and usually too difficult to understand. Thus it is hard to imagine or estimate what would happen in a case of disaster or where it would be dangerous.

Countermeasures

It is quite important to estimate the damage from an earthquake to the emergency activities such as storage of foods, drinking water and other materials, and mobilization of the people.

It is necessary for the residents to check and be acquainted with their environment and to be aware of dangerous areas in their town, and to engage in voluntary cooperation emergency activities such as fire drills, first aid drills and evacuation exercises.

The countermeasures for the safety of the aged, the physically handicapped, travelers and foreigners are also be important.

BASIC STUDIES ON EARTHQUAKE DISASTER PREVENTION FOR TOKYO DISTRICT

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INTRODUCTION

Basic surveys on earthquake disaster prevention by the authors and their colleagues including over fifty persons have been carried out for over twenty administrative organizations and the basic studies at the Centre for Urban Studies can be grouped as follows:

- Type A: General view of the problems on disaster prevention of the areas concerned-
- Type B: Damage estimation due to future earthquakes;
- Type C: Danger degree of the areas concerned, and;
- Type D: Basic studies on the earthquake disasters of Japan and overseas .

Basic surveys of Type A, B and C have been carried out based on the Basic Law on Disaster Prevention and By-1aws, ordinances and regulations (see table 1).

The results of these surveys have been used as basic data for the planning of regional disaster prevention, of evacuation, of urban renewal, etc. Unfortunately, however, froul a scientific point of view, these basic surveys have certain limits such as shortage of basic data, budgets, time, etc., and basic and constant continuation of studies are necessary. Basic studies at the Centre for Urban Studies, Tokyo Metropolitan University, aim at fundamental research, and the results will be applied to basic surveys for the administrative organization.

Major subjects surveyed and studied are shown in figure l. The basic thought is to make clear the regionality and recurrency and/or time-space sequential change of disasters based on regularity and relationships among the factors concerned with earthquake disasters. Attention should also be paid to the ideas shown in figure 2.

ESTABLISHMENT OF MODEL EARTHQUAKES FOR STUDIES

Usami (1976) has analysed the earthquakes which have shaken the city of Tokyo at an intensity of 5 or more on the Japan Meteorological Agency (JMA) Scale (nearly equal to that of 8 on the Modified Mercalli Scale) since 1600 and has shown that there were a total of thirty-seven such earthquakes.

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Because of the fires that followed them, damage was especially extensive in the Ansei Earthquake of 1855 and the Great Kanto Earthquake of 1923. A distinction is made, however, between the two earthquakes; in the case of the 1855 earthquake, the destruction of houses was due more to the direct impact of ground motion than to the fires while the fires were the chief cause of the destruction in 1923.

Major earthquakes in the Tokyo area usually originated in and around the transform fault along the eastern edge of the Sagami Trough which stretches from Sagami Bay to the waters south of the Boso Peninsula. The magnitude of the Genroku earthquake of 1703 was 8.2 on the Richter Scale and that of the Great Kanto Earthquake was 7.9. The Ansei Earthquake and the earthquake of 1894 were less intensive than the Great Kanto and the Genroku Earthquakes. Nonetheless, they inflicted devastating damage on Tokyo because their foci were directly under the metropolis (table 2, figure 3).

The Great Kanto Earthquake of 1923 is used as a model earthquake to examine future earthquakes in the Tokyo district, because it affected the whole Kanto area, and a big earthquake with an epicentre near the Sagami Trough is more likely to occur.

SOME CHARACTERISTICS OF LANDFORMS AND SUBSURFACE GEOLOCY OF TOKYO

Landforms and Subsurface Geology of Tokyo

Landforms of Tokyo are composed of the Musashino upland, the Tokyo Lowland and valley flats dissecting the upland. The Musashino Upland with a height of 20 to 50 m consists of the terraces originating in the coastal plains and in the alluvial fans formed during the end of the Pleistocene era. The upland is composed of the marine sandy deposits and the fluvial gravels covered with 3 to 9 m thick tephra named Kanto Loam. The Tokyo Lowland was one of the inlets opening to Tokyo Bay at ca. 5,000 years B.C, or at the highest stage of sea level of the post-glacial transgression. The inlet was buried with deltaic deposits in pace with the gradual falling of the sea level during these several thousands of years. In addition, the southern part of the Tokyo Lowland was reclaimed and filled-up since the sixteenth century. The original altitude is less than 2 m in the Tokyo Lowlands.

The recent deposits in this area are formed through the transgression occurring after ca. 20.000 to 15,000 years B.C. They are divided into two members, upper and lower, by the middle sand bed, in addition to the lowest buried valley floor gravel. The lithofacies of the lower member is characterized by abundant organic matter and remarkable facies changes of sandy and claylike materials. Tn contrast, the upper member is characterized everywhere by widespread homogeneous marine clay and deltaic sand. The thickness and lithofacies of the recent deposits are determined by the buried topography beneath them. The buried topography has been classified into three types: (1) buried abrasion platforms at two levels, -10m and -20 to -30m; (2) buried river terraces at two levels, -30m and -40 to -50m, and; (3)buried valley floor cut down to -60 to -70m between ca. 20,000 to 15,000 years B.C. (figure 4).

Subdivision of Tokyo on the Basis of Frequency Response Analysis

Subsurface geological conditions are determined by the characteristics and thickness of the late Pleistocene and Holocene deposits. These deposits are classified into some units which have nearly uniform lithofacies and soil engineering properties, that is, they have specific density and secondary wave velocity. Ground type is determined by the configuration of these units. Although about 100 ground types are found in Tokyo, they are arranged in eighteen types. Frequency response analysis was done for these eighteen types by using the multi-reflection method. As a result, predominant frequency and response amplitude were calculated. It is often seen that the Japanese wooden houses which have been built on the ground showing small predominant frequency and high response amplitude are easily collapsed by an earthquake. Eighteen ground types were classified into five grades on the basis of predominant frequency and response amplitude (figure 5).

Land Subsidence in the Tokyo Lowland

Land subsidence due to withdrawal of ground water is apt to enlarge damage caused by an earthquake-induced flood in the Tokyo Lowland. Land subsidence in this area began in the end of the 1920's and accelerated in the end of the 1930's. Tokyo suffered bombing during the end of the World War 11 and her industrial regions were destroyed. As a result, withdrawal of ground water decreased in amount and land subsidence came to a sudden stop. However, as the industrial regions were reconstructed after World War II, land subsidence resumed and accelerated since 1950. Control of ground water use was taken into account as a countermeasure for land subsidence and regulation of withdrawal of ground water started in 1961. Land subsidence has been on the decrease since around 1965 (figure 6).

Figure 7 shows the general outlook of the total amount of land subsidence in the Tokyo Lowland since 1929. Many bench marks were newly set in this year. Though the largest amount of land subsidence is supposed to be about 4 m in figure 7, the 3,377 and 9,832 bench marks subsided more than one meter until 1929 (figure 5). Accordingly, the largest amount of land subsidence in the Tokyo Lowland has reached about 5 m.

Using the mean sea level of Tokyo Bay as the datum plane, contours in the Tokyo Lowland are illustrated in figure 8. The zero meter contour shows the mean sea level. The contours of plus I m and minus I m represent the high tide level and the low tide level, respectively. The land lower than the high tide level invades about 3 km inland from the coast. The land below the mean sea level came into existence around 1930 and continued to expand gradually. Its area is now about 68 km2. The land below the high tide level covers an area of about 125 km2, of which about 32 km2 is located below the low tide level.

The people in the Tokyo Lowland are apt to suffer three types of flood disaster. The first is a flood caused by a storm surge, an influx of high water driven by a typhoon. Destructive storm surges rushed over the Tokyo Lowland eight times since 1900. A heavy rainfall is apt to cause inundation in a lowland. Because the water levels of the rivers and canals are higher than the land surface, rain water can not drain away. Such flood disaster is the second type. The Tokyo Metropolitan Government constructed continuous high embankments along the coasts of Tokyo Bay, Sumidagawa River and Arakawa River and built up pumping stations and water gates. Countermeasures for these two types of flood have been almost accomplished in the Tokyo Lowland where there has been little damage since 1966. The last type of flooding, which may be severest, is induced by an earthquake. If the embankments of the riverwalls are destroyed by an earthquake, sea water or river water will rush into the land below sea level. A part of Niigata City was under water for about two weeks when the embankments along the Shinanogawa River were broken by liquefaction of sandy deposits caused by the Niigata Earthquake of 1964.

DAMAGE ANALYSIS FOR APPLICATION TO DAMAGE ESTIMATION

Seismogeomorphological Analysis of Seismic Intensity Distribution of the Great Kanto Earthquake

Seismic intensity distribution of the Great Kanto earthquake was analysed in order to obtain basic data for seismic risk zoning. For explaining seismic intensity distribution, the minimum distance from the fault plane which generated the Great Kanto Earthquake was inferred and seven types of land form areas representing particular ground conditions were used.

The total collapse ratio of wooden houses is defined by dividing the number of totally collapsed wooden houses by the number of households for each district, because the number of wooden houses existing before the Great Kanto Earthquake is unknown. Distribution of the total collapse ratio of wooden house$ is shown in figure 9. The fault model of the Great Kanto earthquake deduced from geodetic data by Kanamori and Ando shows the earthquake fault being 85 km long, 55 km wide and dipping toward the northeast with a dip angle of 30 degrees. The horizontal projection of the fault plane is also shown in figure 8.

The authors would like to present the procedure for estimating the maximum horizontal acceleration from the size of tombstones, because the method is peculiar to Japanese seismology and it is important for the problem being discussed here. A Japanese tombstone usually has the form of a parallelepiped. Therefore the maximum horizontal acceleration A necessary to topple it can be obtained by the following equation;

$$A = g * W / H \qquad (1)$$

where H and W are the height and the shorter width of base of a tombstone, respectively and g is the acceleration of gravity.

Some thirty records of seismic intensity were derived from the width-height ratios of tombstones by Mononobe and Nakamura. The relationship between seismic intensity and total collapse ratios of wooden houses was analysed in order to convert the total collapse ratios into seismic intensity and to grasp the distribution of seismic intensity for the whole Kanto region. This idea is based upon the studies done by Mononobe. He defined a seismic intensity K as the value obtained from dividing A by g, namely ,

$$K = A / g = W / H \qquad (2)$$

Also, he gave the relationship between the total collapse ratio of wooden houses P and the seismic intensity K in the form of equation (3):

$$P = \frac{100}{\sqrt{\pi}} \int_{-\infty}^{hy} \exp(-h^2y^2)\, d(hy) \qquad (3)$$

in which, $y = k - k_0$, k_0 is the reference earthquake resistance (seismic coefficient) of a wooden house, and h is an index on the uniformity of such house's earthquake resistance. Mononobe estimated ka as 0.45-C.50 and h as 7-10 in the Great Kanto Earthquake. The authors, however, have reexamined the values of k_0 and h by using the thirty records, and have determined those parameters under the condition that the sum of the errors is minimum in equation (3). As a result, k_0 and h were found to be 0.49 and 7.55, respectively (figure 10).

The authors tried to explain the distribution of seismic intensity by using the minimum distance to the fault plane and landforms which represent subsurface geological conditions. The landforms of the Kanto region can be classified into eight categories of landforn2 area: (a) deltaic lowland; (b) valley flat; (c) coastal plain; (d) alluvial fan: (e) terrace; (f) hill; (g) mountain, and; (h) volcanic landform. Geologically, (a), (b), (c) and (d) roughly correspond to Holocene, (e) to Pleistocene, (f) to Tertiary and (g) to Mesozoic or Palaeozoic. Volcanic landforms, however, were classified as belonging to other landform areas corresponding to the peculiar geological conditions. For example, depositional landforms composed of pyroclastic flow were put together with terraces.

Figure 11 shows the relationship between the minimum distance from the fault plane X and the seismic intensity K into which the total collapse ratios of wooden houses were converted by using equation (3). The deltaic lowland shows the highest value of K followed by the valley flat, coastal plain and alluvial fan in descending order. This order is very reasonable from the geomorphological and the seismic engineering points of view, because deltaic lowlands are composed of thick sandy-muddy deposits, coastal plains consist of sandy deposits and alluvial fans are composed of gravely deposits. Materials composing valley flats are usually muddy, but their thickness is less than those of deltaic lowlands. Seismic intensity is reasonably related to the minimum distance from the fault plane for each landform area.

<u>Analysis of Damage Affected by Liquefaction</u>

In lowland areas, attention should be drawn to the effects of liquefaction in damage analyses. The areas of liquefaction, intensity of liquefaction and damages due to liquefaction based on data on engineering soil should be clearly identified. Three figures, 12, 13 and 14, prevent basic data to examine liquefaction based on soil data. They were done as a case study in Niigata City after the Niigata Earthquake of 1964.

Figure 12 shows the relationship between N-value of standard penetration test and effective depth or safety factor of pile foundation. $S' = 40NA / R_a$, in which N is mean N-value near the pile pointed end 1.0 m (before earthquake), A is the sectional area of pile(m2), and R= is the design load(ton/one pile). The horizontal axis shows the ratio L/LI , in which L in pile length (m), and L1 is the thickness of N<NL layer. The degree of damages is classified by symbols in the figure.

The straight line of figure 13 is given by the method of least squares from the point of each critical value at every 1.0 m depth. This line is called the "N_L-line" , and the "N_L-value" at each depth is given by the following equation.

$$N_L = 1.35Z + 0.4 \qquad (4)$$

in which Z is depth in meters.

For trial, above mentioned values “depth 8 m : N-value 10” are compared with “depth 8 m : N_L 11.2" from equation (4), and the trial shows a little difference between them. N_L-1ine does not show a value at the point deeper than about 16 m, because it may be considered that those layers are constituted of old heaped sands and fairly compact (N>30), besides the change of N-value is not remarkable at greater depths.

The distance parallel to the vertical axis from 4S degree line to each point shows the thickness of loose sand ($N<N_L$) in figure 14. In the case of 6 m (upper limit) to 10 m (lower limit), even though the thickness was 4 m ($\sim<N_L$), heavy damage occurred. From this figure, it may be considered that the liquefaction of loose saturated sand at the depth of 4 m to 9 m seriously influenced those heavy damages. Meanwhile this figure shows that the existence of loose sand ($W<N_L$) near the ground surface, such as G.L. 0 m to S m, is not greatly concerned with them, and according to the bore hole record of them, the thickness of the saturated sand accounts for 3 to 4 m of above 5 m, and generally, the thickness of sand is 2m, the rest being silt or clay by the usual classification.

Analysis of the Injured

Distribution of the injuries caused by the Miyagiken-oki earthquake of 1978 in Sendai City was analysed. The numbers of slightly injured and seriously injured persons in Sendai City were about 9,000 and about 300, respectively. Distribution of the injured is usually explained as a function of the damage ratio or the collapse ratio of wooden houses, for damage to wooden houses was related to intensity of ground motion and most of the injured were caused by damaged wooden houses in past earthquakes. In the 1978 Earthquake, however, many persons were injured in areas where no wooden houses were totally or half collapsed, that is, where the damage ratio of wooden houses was zero.

The injuries resulted from many causes and it was remarkable that casualties caused by collapsed houses did not cause a high proportion of the injuries (see table 3). Many persons were injured directly by intensive ground motion, but wooden houses were not seriously damaged. Accordingly, partial damage to wooden houses was seen as the main cause of injuries. The modified number of the damaged wooden houses Z is defined by the following equation:

$$Z = T + H * 0.5 + P * a \quad (5)$$

Where T and H mean the number of totally collapsed wooden houses and that of half collapsed wooden houses, respectively. P is the number of partially damaged wooden houses and "a" is a constant which maximizes a correlation coefficient between the number of the slightly or seriously injured persons and the modified number of damaged wooden houses Z. Results are shown in figure 15. The numbers of Z, Y, and Y' are calculated for each topographic unit, because it well explains the distribution of the maximum horizontal acceleration and the extent of the damage to wooden houses .

DAMAGE ESTIMATION AND SOCIO-ECONOMIC ASPECTS OF EARTHQUAKE DISASTER

If Tokyo is hit by a great earthquake, what would happen? The aspects of damage such as collapse of wooden houses, the numbers of the dead and injured, the number of houses burnt down by the spread of fires and so on can be estimated. But the entire spectrum of the damage caused by an earthquake in Tokyo cannot be estimated, because the methods of damage estimation, especially the ones concerning the socioeconomic aspects of disaster, have not been established, and the interrelation among the various aspects of disaster are imperfectly understood.

Table 4 shows the anticipated effects of an earthquake disaster in Tokyo, which is expected to occur in an evening of a weekday in winter. The estimated values, which are presented by the figures in the table, refer to the reports on damage estimation of an earthquake in the ku-area of Tokyo published in 1978. Some characteristic aspects of earthquake disaster in a metropolis which can be derived from this table are as follows :

l) The shake of an earthquake will cause direct damage such as collapse of wooden houses, destruction of water supply networks and so on. The extent of these direct damages is apt to increase relative to the city size . It is estimated in the ku-area of Tokyo that 62,200 wooden houses will collapse, landslides will occur in 1,300 places, the water supply network will be destroyed in 216 places and the gas supply network will be destroyed in 669 places.

2) Direct damage will induce secondary damage such as the spread of fires, flooding of lowlands and so on. Fires following an earthquake will dominate the total amount of damage in case of an earthquake disaster in Japanese cities. It is estimated in the ku-area of Tokyo that 300 fires will burn dawn 473,300 wooden houses and the collapse of banks will flood l0.78 km2 of lowland. One of the serious problems is that it will take time to relieve the flooded areas.

3) Figure 16 shows the influencing structure of damage and restoration process concerning people's behaviour and livelihoods in the residential areas of a metropolis. This chart explains the flow of damage and human behaviour from the occurrence of an earthquake, and the effect of disaster to the restoration of livelihood in each family. The restoration bf people's livelihoods will take a

relatively long time due to the lag in restoration of such lifeline network facilities as water, gas and electric supplies.

4) The activities of people in Tokyo are very complex in space and time, because the built up areas of Tokyo are spread over a 50 km sphere. In addition, so many people will suffer from the damages. The number of those victims who lose their dwellings or work places by collapses, fires and flooding, are estimated at 1,240,500 households, or 3,499,200 residents, Also, the numbers of dead and injured are estimated at 35,700 and 63,000, respectively. The victimized areas will spread so wide that the people will not be able to commute without traffic services. The difficulty in the people's mobility will retard the restoration of Tokyo.

5) Tokyo is not only the centre of national, but also the centre of international governmental and economic activities. The damage of this central function, especially its support systems such as new-information systems, will cause the confusion of administration and economy. The restoration of these central functions will be determined by the rapidity of restoration of people's livelihoods.

As mentioned above, some socioeconomic aspects of earthquake disaster can be analysed and estimated qualitatively. However, the quantitative analyses of them are one of the future problems. In addition, though they are very important problems, analyses of the restoration process of people's livelihoods and of interrelations among the various urban functions are still poorly understood.

FUTURE PROBLEMS FOR BASIC STUDIES AND PROPOSALS FOR ADMINISTRATIVE ORGANIZATION

1) Studies on socioeconomic aspects of disasters should be encouraged, because disaster is a socioeconomic matter.

2) The mechanism of growth and accumulation of damage potential in urban areas should be made clear. Even under various legal controls for disaster prevention, damage potential in and around urban areas is not always decreasing. The legal structure of disaster mitigation and its application should also be reexamined in order to improve the ability of disaster prevention.

3) It is not so easy to mitigate damages due to disasters only by structural adjustment. Although the necessity of non-structural adjustment should be understood the adjustment of the people should not be over-estimated, as it has a certain limit.

4) Integration of research findings should be enforced. Individual, particularly scientific and technological, research has been developed, but still the integration of the research findings into policy formulation remains limited.

5) Studies on the damages from a social science viewpoint should be encouraged. Table 5 is an example of economic and monetary loss from different types of disasters. But the estimates are still very

preliminary .

6) Urban policies should be enforced from the viewpoint of disaster prevention. The road systems of urban areas in Japan are very poor. Without improvement of the road systems, the danger of earthquake fires can not be mitigated.

7) Recognizing the importance of basic data such as statistics, reports on disasters* etc., we should encourage documentation of disasters covering not only physical, but also socioeconomic aspects in cooperation with national and local governments.

REFERENCES (Papers in English only)

1. Enomoto, T. and T. Mochizuki, (1985): "Investigation on the Charac- teristics of Incident Seismic Wave Considering the Seisn7ic Source Model and the Underground Conditions. Proceedings of the Second Conference on Computing in Civil Engineering, pp. 778-789.

2. Kaizuka, H.. Y. Naruse, and I. Matsuda, (1977): "Recent Formations and their Basal Topography in and around Tokyo Bay, Central Japan." Quaternary Research. Vol. 8, No. l, pp. 32-50

3. Matsuda, I. (1974): "Distribution of the Recent Deposits and Buried Landforms in the Kanto Lowland, Central Japan." Geographical Reports, Tokyo Metropolitan University, No. 9, pp. 1-36.

4. Matsuda, I. (1980): "Land Subsidence as Dynamic Environment in the Tokyo Lowland." Records of Symposia on the Cartography of Environment and of Its Dynamics, pp, 11-16.

5. Matsuda, I. (1984): "An Introductory Note on Earthquake Damage and Measures." Geographical Reports, Tokyo Metropolitan University, No. 19, pp. 209-216.

6. Matsuda, T., T. Mochizuki, and M. Miyano, (1982): "Consideration of Seismic Intensity Distribution of the Great Kanto Earthquake of 1923." Geographical Reports, Tokyo Metropolitan University, No. 17, pp. 77-85.

7. Matsuda, I., T. Mochizuki, Miyano, M. and T. Koizumi, (1981): "Damage to Wooden Houses and Human Beings by the 1987 Miyagiken-oki Earthquake in Sendai City." Geographical Reports, Tokyo Metropolitan University, No.16, pp.103-112.

8. Mochizuki,T., T. Enomoto, Y. Numajiri, H. Matsumura, and T. Tajime, (1984): "Investigation on the Earthquake Damage of RC Buildings by Considering the Soil-Structure Interaction." Proceedings of the 8th World Conference of Earthquake Engineering, pp. 809-816.

9. Mochizuki, T. and N. Goto, (1983): "Structural System of Buildings in Turkey and Empirical Evaluation of their Aseismic Strength." A Comprehensive Study on Earthquake Disasters in Turkey in view of Seismic Risk Reduction, Hokkaido University, pp. 87-129.

10. Mochizuki. T., M. Miyano, and T. Tajime, (1982): "Relationships among Hypocentral Distances Radiation Patterns, Landforms and Seismic Intensities Estimated from Toppled Tombstones and Damage to Wooden Buildings in the Great Kanto Earthquake 1923." Journal of Natural Disaster Science, Vol. 4, No. l, pp. 31-49.

ll. Nakabayashi, I. (1984): "Case Study on Intensity of Damage caused by Recent Disasters in Japan." Geographical Reports, Tokyo Metropolitan University, No. 19, pp. 195-208.

12. Nakabayashi, I. (1984): "Assessing Intensity of Damage by Disasters in Japan." EKISTICS, Vol. 51, No. 308, pp. 432-438.

13. Nakabayashi, I. (1986): "Spatial Structure of Damage Intensity by Disasters in Japan of the 1970's. Geographical Reports, Tokyo Metropolitan University, No. 21, pp. 275-292.

14. Nakano, T. and I. Matsuda, (1976): "A Note on Land Subsidence in Japan." Geographical Reports, Tokyo Metropolitan University, No. 11, pp. 147-161.

15. Nakano, T. and l. Matsuda, (1980): " Earthquake Damage, Damage Prediction and Countermeasures in Tokyo." Geographical Reports, Tokyo Metropolitan University, nos.14/1 5, p. 141-153; Revised in EKISTTCS, Vol. 51, No. 308, 1984, pp. 415-420.

16. Tajime, T. and T. Mochizuki, (1965): "On the Liquefaction of Saturated Sands in the Niigata Earthquake." Memoir of Faculty of Technology, Tokyo Metropolitan University, No. 15, pp. 91-l04.

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MEXICO: THE SEPTEMBER EARTHQUAKE, ITS CONSEQUENCES, REHABILITATION AND RECONSTRUCTION

Hugo Garcia Perez (*)

INTRODUCTION

On the morning of 19 September 19 1985, at 7:19, a strong 7.8 degree Richter scale earthquake hit Mexico City for a period of approximately three minutes, It was followed by a second large earthquake on 20 September at 19:30, causing serious human and material damage. As the earthquake moved away from the epicentre, it lasted longer, thus producing more devastating effects in the Federal District than in the rest of the provinces.

In spite of the fact that the Mexican Republic is located in one of the most seismically active regions of the world, and despite the fact that its population is accustomed to earthquakes, this time the people were not prepared for such destruction. During this century we have had some very strong earthquakes before such as the 7.7 degree quake on 30 July 1909, an 8 degree one on 7 July 1911, which was similar to the 1985 one, a 7.5 degree one on 28 July 1957, and some others ranging from 6.5 to 6.8 degree during the 1960s, all measured by the Richter scale.

From the seismological standpoint, the highest risk area is located on the borders of the Pacific shelf between the North American and Cocos shelves. These borders break at the speed of 6 cm per year, while the 19 September 1985 earthquake corresponds to a 2 m shelf movement.

Experts believe that the quake broke a 200 km length along the Pacific coast, which extends approximately from the Colima and Michoacan borders up to Petatlan, Guerrero. To give you an idea of its size, the 1957 earthquake broke an 80 km coastal length. Comparatively speaking, the 1985 earthquake was far more violent than the one that shook San Francisco, California in 19a6. According to UNAM'S specialists, the September 20th earthquake was only the continuation of the first one, and not a response, as was previously believed. Shelves started breaking on 19 and completed breaking on 20 September.

The epicentre was located 400 km from the Federal District, in the state of Michoacan, at 17.6 degree North latitude, 102.5 degree West longitude, and 50 km offshore. It affected some 800 km2, covering the states of Jalisco, Michoacan, Guerrero, Colima, Oaxaca. Chiapas. Veracruz, Puebla, Estado de Mexico and the Federal District.

Due to the lack of electrical power and the fact that TV stations were off the air, the first news of the damage was broadcast through the radio one hour later. Thus, information stated that in a 30 km radius area, buildings had collapsed, there were gas leaks, fires and explosions. Communication and transport systems were temporarily down, and all the

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activities in the downtown area of the Federal District were disturbed, as this was the most damaged area.

The most serious damages were concentrated in a limited area due to a combination of factors, as: the degree of resonance that hit, especially eight to fifteen story buildings, in view of the long duration of the quake; the Earth's resonance in the central region of the Valley of Mexico located on lake beds, where the frequency of shock waves coincided with it, and finally: buildings had seen designed to take weaker shock waves, based on the features of the 1,957 quake, which was three or four times weaker than this one.

RESCUE ORGANIZATIONS

Volunteers

Since the quake hit the city very early in the morning, most people were still at home, although a considerable number already were at their workplaces. Rescue corps and brigades formed by neighbours, sports associations, artists, alpine rescue teams, diggers, oil workers, members of the Army and Navy, firemen, Federal District preventive police, Red Cross volunteers and students, started rescue activities. A rescue corps made up of over a million volunteers, was scattered throughout the city and worked endlessly day and night.

City Authorities

Army officers and city authorities coordinated the application of an Emergency Plan to undertake rescue tasks and the evacuation of affected buildings. With this purpose in mind, 200 police officers in motorcycles, seven battalions, fourty ambulances and thirty helicopters from the Ministry of Defense started operation. In addition, the Navy sent some 2,000 marines to several sites. The Ministry of Urban Development and Ecology formed fifty-three brigades. Petroleos Mexicanos brought over 5,800 workers and 630 heavy machines into the Federal District, 10 per cent of these machines belonged to contractors. The Institute of Social and Services for Public Workers (ISSSTE) established rescue centres with 459 workers . In summary, 280 centres were established which rescued 4,096 people . 14,268 wounded were transferred to 131 first aid stations and hospitals, while 4,900 patients were transferred to other hospitals. In addition, 401 fires and 828 gas leaks were controlled.

Mass Media and Transport System Support

Citizens were given full support in all kinds of communications, with provision of services free of charge, so as to facilitate transmission of messages in and outside the country and to describe rescue teams' equipment needs. In particular, the national television network, IMEVISION, used the national channels 7, 11, 13 and 22 to serve community needs. And some radio ham operators immediately offered their help to the interior. In the metropolitan area, 13,000 phone booths operated constantly, 600,309 telegrams were sent, as well as 85,000 telex messages. A public service, Locatel, established to find people who were lost or had an accident, received over 144,000 calls of different types and formulated lists that were distributed to fourty-two information and inquiry centres.

Passenger and mass transit systems also provided services free of charge to move people, rescue equipment, machinery, food and clothes, thus expediting emergency actions. One hundred and twelve information booths were installed in different parts of the city, where 642 representatives of twelve institutions and agencies took care of aver 168,535 people, orienting citizens on health and hygiene standards, emergency procedures, degree of damage in largely populated buildings, relocation of public offices, housing problems and health and communications services among others. Services included the transmission of 38,380 radio messages, 1,246 television messages, 263 bulletins were published in major newspapers and one million brochures were distributed.

MEDICAL CARE

The health sector installed 281 first aid stations in the affected areas, where 5,784 individuals received medical care for major wounds, 10,188 for minor injuries and 22,699 people with other than physical problems. As part of inter-institutional actions, the IMSS provided over 12 tons of drugs and treatment materials to the Mexican Red Cross and the Health Ministry's General Hospital. A total of 4,900 patients were transferred to safer places, since some hospitals were in dangerous conditions or did not have water or electrical power supplies, while others had the risk of stationary gas tank explosions.

Water chlorine content was increased in the city networks, as part of a health prevention programme, since 50 per cent of the samples showed contamination.

The health sector organized mental health brigades, using over 1,000 people as health promoters and 150 supervisors. These groups provided mental health care for the general population. These actions were carried out at social security centres and were later extended to different corporations by fourty health and occupational safety brigades formed by the Department of the Federal District (DDF: the city government), the Ministry of Labor and Social Welfare, the Ministry of Urban Development and Ecology, the Energy, Mines and Parastatal Industries Ministry, the Mexican Social Security Institute, the National Autonomous University and Labor Congress .

Popular orientation campaigns, including the publication of newspapers, information, press conferences, civil health workers and health expert's interviews on television, all contributed to prevent epidemic outbreaks, a shortage of drugs, or overcrowding of hospitals.

NATIONAL AND INTERNATIONAL COOPERATION

The international community gave generously to Mexico. In order to effectively receive outside help, a system was established at the Benito Juárez airport, headed by the Airport and Services Organization (ASA), supported by the staffs of the Ministry of the Interior, the Army, the

Ministry of Agriculture and Water Resources, and the Health Ministry, in order to receive aid coming from other countries, to clear customs and to deliver shipments, to the consignees.

Two hundred and thirty-seven flights were received as of 13 October coming from fourty countries. This aid included economic donations, food, clothes , skilled personnel , technical equipment , and dogs specifically trained to rescue people. The weight of goods received was 1,462 tons. International aid arrived in Mexico City the day after the earthquake coming from different countries sympathetic to the tragedy that had hit us.

Countries outstanding in view of the assistance they provided to help the victims of the September 19 quake are:

Saudi Arabia	Guatemala
Algiers	Holland
Argentina	Israel
Australia	Italy
Belgium	Japan
Belize	Nicaragua
Brazil	Norway
Canada	Panama
Colombia	Paraguay
Cuba	Peru
Czechoslovakia	Poland
Denmark	Puerto Rico
Dominican Republic	Soviet Union
Democratic German Republic	Spain
Ecuador	Switzerland
Federal Republic of Germany	Turkey
Finland	United States of America
France	Venezuela
Greece	Yugoslavia

In addition, the International Red Cross, the United Nations, the International Monetary Fund, the World Bank, the Inter American Development Bank, were all willing to consider extraordinary support for the reconstruction of Mexico City.

ORGANIZATION OF TEMPORARY HOUSING

Basically, there were two types of temporary housing provided: (1) the so-called provisional shelters, adapted in buildings such as schools, churches, and auditoriums, and; (2) tent camps that were set up around neighbourhoods and houses damaged by the earthquake, in streets, parks, gardens and parking lots. Some only had makeshift huts, whereas others had tents. The national volunteers, associations, urban districts (wards) and embassies collected water, groceries, clothes and home appliances and distributed them throughout the shelters and camps.

A few days after the quake, however, some people still refused to leave their homes, so during the day they came to carry out some activities and at night they returned to spend the night there.

Universities and urban districts were in charge of providing medical services, the Metropolitan Autonomous university offered help to build latrines, light water tanks, organic material and refuse treatment plants, making water drinkable, and detecting water and gas leaks. In turn, the urban districts took over security procedures and in son]e cases even organized groups of civilians to carry out necessary tasks.

Altogether seventy-five camps were set up to shelter ll,364 people, including 58 camps at the Cuauhtemoc Urban District, fifteen camps at the Venustiano Carranza District, and two more in the Gustavo A. Madero district . One hundred thirty-five shelters were established in all the urban districts lodging a total of 18,614 inhabitants basically concentrated in the Cuauhtemoc, G.A. Madero (15), Miguel Hidalgo (12), V. Carranza (14) and B. Juarez (8) districts. Homeless people received instructions to go to the closest urban district offices to be referred to the nearest shelter.

The rest of the people in the community offered shelter to victims in their own homes, supplementing that provided by shelters and camps, thus exhibiting their community spirit.

DAMAGE ASSESSMENT

Damage Assessment

The earthquake that hit the capital's population produced a total of 6,000 casualties, 4,096 victims rescued alive, 30,000 homeless, 20,000 missing, 40,000 injured, fifteen severely injured, twenty-five minor lesions and sixty with slight physical damage. In addition, 50,000 people suffered serious material losses as well as mental disturbances.

Building

5,728 buildings where damaged, of which 47 per cent had minor damages, 38 per cent cracks, 15 per cent total or partial collapses. 56 per cent of the damaged structures were located in the Cuauhtemoc Urban District, 18 per cent in V. Carranza, 17 per cent in the B. Juarez and the remaining 9 per cent was distributed among the other thirteen urban districts. The most damaged buildings were twenty-seven used for housing purposes which represent 65.4 per cent of the total, commercial buildings accounted for 14.7 per cent of seriously damaged buildings, educational building 12.3 per cent, office buildings 6 per cent and industrial buildings 0.3 per cent.

(I) Housing

Among those buildings used for housing that were seriously damaged, there was the Nuevo Leon apartment buildings in Tlatelolco, the tenements in the downtown area and the Juarez apartment buildings. Total losses, approximately 76,000 units, increased an existing housing deficit of 30 per cent .

(2) Lodgings

In the tourist sector, five hotels were totally destroyed, four more partially damaged, thirty-six required minor repairs and thirty-five more only had damages in their furnishings. Among the first category were E1 Regis, Versailles, Principado, Romano and Finisterre. Altogether 1,704 hotel rooms were totally destroyed - less than 8 per cent of total capacity .

(3) Schools

Earthquakes affected 704 school buildings. As a result, approximately 14,000 students and 700 teachers had to be permanently relocated, and another 1,000 teachers and 50,000 students temporarily relocated. It was estimated that the temporary interruption of classes affected some 150,000 students, due to lack of services and rescue works in progress.

(4) Industry

Small apparel industries located in the downtown area were severely damaged: 1,326 workshops experienced losses in their infrastructure, machinery equipment and stocks.

(5) Public Office Buildings

Several government office buildings were seriously damaged, covering a surface of 1.7 km2 of office space where 145,560 civil servants worked. Of these buildings, 343, or 30 per cent were government property, while the remainder were leased from private individuals. The main Ministries affected were: the Navy; Communications and Transport; Trade and Industrial Development; Labor and Social Welfare; Agrarian Reform; District Attorney's Office; Treasury and Public Credit; Programming and Budget; Health; Ministry of the Interior, and; the Department of the Federal District.

(6) Health

Regarding medical facilities, five hospitals collapsed and twenty-two were seriously damaged. The Institute of Social Security and Services for Public Workers lost 28 per cent of its hospital capacity, 17 per cent of its clinic capacity, 27 per cent of their medical offices, and the October 1st Hospital was severely damaged. The Mexican Social Security Institute experienced substantial losses in its hospital capacity, since the National Medical Centre was almost entirely destroyed. Hospitals that suffered the greatest damage were the Children's Hospital, the Gynecology and Obstetrics Hospital and the Traumatology and Oncology Hospital. The Health Ministry also lost the Juarez Hospital, and some private hospitals and clinics were also damaged.

<u>Water Infrastructure</u>

Due to damages in the Chalco. Xochimilco, Canal Nacional, Tlahuac, la Caldera and Texcoco waterways (service connectors), 7.6 m3/sec did not flow into the network, affecting the Cuauhtemoc, Juarez, Madero. Carranza, Iztacalco, Coyoacan, Iztapalapa, Xochimilco and Tlahuac districts. 15,000 leaks were found, eighty in the primary water networks and 1,420 in the secondary networks. As regards the surface drainage systems, Rio de la Piedad suffered serious problems that were solved immediately through emergency repairs.

Transport and Traffic

Some streets and main avenues were damaged including: Lazaro Cardenas, Avenida Juarez. Chapultepec, Rio de la Loza, as well as some pedestrian bridges and freeway entrances. All are being repaired through repaving, filling holes, and making new sidewalks.

Urban transportation was intermittently out of service on 19 and 20 for sevem hours fourty minutes the first day and five hours the second; 40 per cent of the service was affected. The STC Metro System had to shut down thirteen of its 101 stations. The electric transport system had problems in three of its lines. As a result of collapsing buildings, 1,200 private cars, plus 7,300 mass transit units were damaged.

Communications

The total number of telephones out of order was 14,500, all of the national and international long distance service, which stopped completely, since the Victoria and Pugibet Central Offices collapsed. In addition, fifty branch networks were seriously damaged, 750 Multiplex machines, six automatic long distance centrals, two tandem centrals, three local centrals were completely destroyed and six buildings and all manual communications centres were left unusable.

Electric Power

After the first quake, approximately 40 per cent of Mexico City's inhabitants suffered a blackout. Eight of the centre's light and power substations suffered temporary damages that prevented their use. There was also failures in 4 ,230 km transmission lines, two high energy cables. As regards distribution and generation systems, 270 feeders had problems and two hydroelectrical dams had fissures.

Impact on Employment

It has been estimated that damages produced by the earthquake affected a total of 150,000 workers. This can be translated into a loss of approximately $8.43 billion in personal income, over a three month period of total lost income, 50 per cent was in the industrial sector, where 33 per cent affected workers were employed.

Assessment of the Cost of Damages

A preliminary estimate of damages from the earthquake suggests a figure of $4,100 million. Repairs totaled $527 million. Equipment expenditures reached $288.7 billion while indirect expenses were $515,000 million.

An estimate of direct damages per sector shows that public buildings were the most damaged, representing 34 per cent of the total. The health sector incurred 15.4 per cent, housing 15.7 per cent and education ll.4 per cent. Now, in the area of indirect damages or losses, we find that, according to ECLACTS estimates, the highest expenditures were for demolition and rubble removal, or 28.4 per cent of the total, followed by the losses in trade and industries, 23.4 per cent losses of small industries, 20.9 per cent and, finally, communications, with 20.0 per cent. ECLAC'S experts believe that losses were so bad because only a relatively small percentage of these damages were covered by insurance against this type of risk.

IMMEDIATE ACTIONS FOR BUILDINGS

Preliminary damage diagnostics were carried out to investigate the safety of the inhabitants, with the participation of technicians from our Department of Public Works, the Ministry of Controllership, Urban Districts, the Ministry of Defense, PEMEX (National Oil Corporation), the Ministry of Urban Development and Ecology, professional and technical associations, the National University, the Polytechnical Institute and other higher education institutions, as well as professionals who offered their work as volunteers. This adds up a total of 7,924 expert studies made, concentrating on schools.

In order to preserve the safety of people and their properties, 613 evacuations were ordered due to fourty direct damages. Ninety-nine more evacuations were also ordered as a result of problems in neighbouring buildings, while 1,500 permits to retrieve property were issued. In order to avoid risks from loosening facades, 1,063 requests to rehabilitate buildings were answered, in some cases to remove glass, in other cases plaster walls or ceilings, marble plates, tiles and other types of facade materials .

So as to prevent epidemics due to contaminated wastes, the city government, health sector institutions, as well as the Navy and PEMEX, carried out pest control programmes and sprayed the disaster areas, covering 683 work sites.

The city government together with the Ministry of the Controllership, the City Public Works Department and the city's legal coordinating body, formulating standards and guidelines to be applied by administrative units and deconcentrated offices for the demolition of buildings. In addition, they immediately determined the need to demolish 1,195 buildings. For this purpose, a programme defining risks, needs and cost criteria was established, with a timetable to carry out the demolitions, cleaning of the plot and removal of rubble, according to a programme specifying routes and schedules .

RECONSTRUCTION STRATEGY

Reconstruction Services

(1) Education

In order to avoid further delays in school programmes, lessons were taught through television while some private and public schools lent their facilities on afternoon shifts to accommodate students from damaged schools . Prefabricated classrooms were built to supplement these facilities and by the end of November schools were operating regularly.

(2) Health

Regarding the re-establishment of health services, patient admittances were reopened at national health institutes, Health Ministry’s hospitals in the Federal District, and DDF medical services in order to serve the extraordinary demand. By the end of February 1986, the General, Juarez and other hospitals had been rehabilitated.

(3) Waterworks

Since one of the main problems was provision of drinking water, which affected one fourth of the population, emergency repairs permitted restoration of 95 per cent of the service, one month after the earthquake; 5.3 of the 7.6 m3lsec that were lost in the beginning were recovered. The general waterworks operation and construction office of the Department of the Federal District, as well as the Mexican Valley Water Commission, repaired 4.2 km of pipelines, six supply sources and sealed off 2,035 leaks .

In spite of the fact that the drainage system was not seriously damaged, it will be necessary to line it and perform certain repairs in the following dry season at the Rio Piedad.

(4) Transport and Traffic

One month after the quake, Lazaro Cardenas, Juarez and Dr. Rio de la Loza avenues were fully operational once again. Seven SCT Metro System lines have been working with their normal schedules in spite of having shut down the Isabel la Catolica and Pino Suarez stations on line I and the Chabacano station on line 2, due to demolition works that had to be performed on the surface. The route 100 urban transit buses are working normally on 20a routes, and the electric transport system is also operational .

(5) Utilities

Most failures in electrical power were temporary, and repaired in less than seventy-two hours except for the cable line connecting Jamaica and Indianilla substations, which was repaired in November 1985. These rehabilitation actions were carried out by approximately 6,000 workers working around the clock. This work was completed by I October 1985 and includes the repair of eight power substations, 849 transformers, 26 km of high tension lines, 32 km of low tension lines, 5km of pipelines and 1,520 poles .

In the area of communications, local service was restored by 20 October 1985 except for lines in the series 58S and 747, which were totally destroyed. Telephones in that area are being connected to other series at the Victoria Central. National long distance service started operating once again on 20 September 1985 and one month later it had recovered 73 per cent of its coverage, despite the fact that recovered circuits represented only 32 per cent of the units' capacity prior to the earthquake. International long distance service was recovered at a faster pace, since 7S per cent of the circuits have been reconnected to the U.S and Canada, and 55 per cent to the rest of the world. The telex and the

Telegraph services were re-established during the first ten days of the emergency stage.

Institutions Responsible for Reconstruction

On 20 September 1985 the President ordered the creation of the Metropolitan Area Aid Commission, in charge of solving the problems produced by the earthquake. On that same day, the House of Representatives formed a Multiple Party Commission to participate in the rescue, emergency and rehabilitation tasks in the areas affected by the quake.
commission in turn was divided into six committees and four coordinating bodies in the areas 0~ reconstruction, decentralization, social assistance, health, education, employment, housing, international aid and preservation of civilian safety.

On 30 September 1985, an Earthquake Evaluation Commission was established to support aDd advise the Chief executive and the City government in assessing and quantifying the proble~s created by the earthquake. On 3 October, the committee to supervise danations for the victims and the reconstruction of areas damaged was established, headed by the Minister of the Controllership, to ensure that the donations received reached their proper destinations. The National Reconstruction Commissiorl was established on 4 October, headed by the president, as aD advising body, to participate in all actions undertaken by public, social and private sectors to solve the problems. The Commission was formed by the following assistance committees:

l) Mexico City's Metropolitan Area Reconstruction Committee, chaired by the head of the Department of the Federal District, with the tasks of shortening the time to put public utilities back in service, taking care of the victims and establishing priorities for the reconstruction programmes. This committee was assisted by the board of directors in charge of analyzing and presenting proposals, and by the Victims' Assistance Committee. The Urban Redevelopment and Projects Committee, Construction Standards and Procedures Committee, Modification and Adaptation of Urban Lifestyles Committee, Funding Alternatives and Resource Allocation Committee, and finally, the Social Movement for Civilian Defense Committee.

2) The Decentralization Committee, coordinated by the Minister of Programming and Budget, is in charge of orienting public, social and private sectors' action towards the decentralization of national life and activities within the framework of reconstruction programmes. It has the participation of Health and Education, higher education decentralization, public industries privatization, service decentralization and regional development coordinating bodies.

3) The Financial Affairs Committee, in charge of the Minister of the Treasury and Public Credit, was responsible for orienting the actions of all sectors towards the promotion, tapping and mobilization of financial resources, needed by the reconstruction endeavour.

4) Social Assistance Committee, coordinated by the Ministers of Health and Education, to re-establish the hospital system and teaching activities, and to achieve decentralization at all levels, by the

Labor and Social Welfare Ministry to recreate jobs, and by the Urban Development and Ecology Ministry to address housing needs and the set forth programmes to support decentralization actions. This committee is formed by the Health, Education, Employment and Housing coordinating bodies.

5) The International Aid Coordinating Committee, headed by the Minister of Foreign Affairs, to properly distribute donations from friendly countries and individuals.

6) Civilian Safety Committee, coordinated by the Minister of the Interior, in order to diagnose foreseeable risks, prepare specific civilian safety plans and programmes, and to organize and set forth a national civilian protection system.

7) The technical hospital infrastructure reconstruction coordination for the metropolitan area of Mexico City was established on 18 October as a provisional administrative unit of the Health Ministry, constituted by an internal reconstruction committee headed by the Minister of Health and divided into the following Subcommittees: Fund Control and Allocation; Infrastructure Construction, and: Hospital Equipment and Human Resource Training for Health.

These committees and commissions periodically submit reports to the President to show progress made and results obtained.

Housing Strategy Expropriation Decree

Considering that main damages recorded were in housing facilities, the President of the Republic issued, through city government, an expropriation decree encompassing 4,291 plots located in the Cuauhtemoc. Madero. Carranza districts, in order to undertake the main reconstruction efforts.

There were three types of victims:

l) Homeless people who were living in government housing units, such as Nonoalco Tlatelolco and the Juarez housing units managed by public agencies:
2) Homeless victims coming from low income neighbourhoods and old tenements in the downtown area, and ;

3) Middle class victims who owned or leased their lost homes.

For the first kind of victim, the President instructed the Minister of Urban Development and Ecology, together with the city government, to study alternatives, to communicate them to the victims involved and to them implement the appropriate actions.

Information modules permitted the creation of files which were used in the allocation of dwellings and the granting of credits to earthquake victims. This procedure was a major step to address the needs of victims.

At the Benito Juarez housing project, 70 per cent of the victims had been taken care of by 20 October 1985, involving allocation of 450 dwellings and 100 credits. These actions were supplemented by the support granted to the victims by ISSSTE stores in the purchase of goods, clothes and appliances.

Popular Renewal Programmes were implemented for the second kind of victim in order to repair, improve and build dwellings with the help of neighbours. For the victims in the middle class neighbourhoods, the government established linkages to enable them to have better access to housing supplies and credits from private, public and social sector promoting institutions.

The 14 October 1985 presidential decree established the Popular Housing Renewal programme designed to supply housing units to affected people whose housing was expropriated. Approximately ten months after the quake, the first 1,284 housing units and 110 trade locals were supplied. The average prototype of a housing unit is about 40 m2 of construction at a cost of approximately $10,000. The housing actions of this programme include new housing units, rehabilitation and minor repairs.

Building Regulations Emergency Modifications

The first building regulation in the Federal District directly related to earthquake design, dates back to 1942. Later, and as a result of the 28 July 1957 earthquake, emergency standards were issued. In 1966, new building regulations were issued for construction in the Federal District, including more sophisticated techniques and the possibility of dynamic analysis, subsequently reformed and expanded by the 1976 regulations which was still enforced when the last earthquake hit.

The accelerations produced by the 19 September 1985 earthquake, greatly exceeded the standards contained in the 1942, 1957, 1966 and 1976 regulations. The types of damages observed are classified as: total or partial collapse of the building; extreme structural damage; severe structural damage, and; minor structural damages. The area included in the high collapse and extremely severe damages zone is approximately 23 km2 and the minor damage zone, is estimated at 65 km2.

It is obvious that there is a close linkage between the geographic distribution of damages and the type of subsoil. This means that the effects produced by the quake's movement were greater in those areas with a soft soil layer. The area most damaged is located west of the lakebed where the first hard layer’s depth fluctuates between 26 and 32 m, and the second between 30 and 41 m.

It is interesting to compare those zones that were damaged by the 28 July 1957 and 14 March 1979 earthquakes and those damaged by this more recent earthquake. In all cases there was a geographic coincidence of damages. Only, in the recent earthquake the damage zone was remarkably larger, extending into the southeast, while on the west side it was still limited by the transition border. The greatest number of faults and damages occurred in six to fifteen story buildings. The number of five stories buildings that collapsed was relatively low. Also buildings over fifteen stories that suffered serious damages or collapsed was not too high. It is necessary to clarify that considerable damages were caused by neighbouring buildings that hit, leaned or actually collapsed over the others. In sum, damage was concentrated in medium height buildings (constructions from six to twelve stories, 45 per cent of damages), followed by low old constructions, with faults in their steel structures, as well as others built of ribbed slabs.

The main reason why many buildings failed was the exceptional intensity of the quake, especially in the city where soft land movements in the subsoil made it particularly sensitive to the dominating movements transmitted by the underlying hard layer. Ground movement in that zone was characterized by the repetition of large amplitude cycles with high vibrations that introduced considerable inertia, that in reducing the

structure's rigidity, increased their natural period and subjected them to ever higher vibrations that finally made them fail.

In view of of this experience, the Federal Executive ordered the establishment of a construction standards and procedures commission, a few days after the earthquake, whose task was to update the regulations enforced so far, and headed by CFE's Chief Executive Officer and the city government's secretary of Public Works. On 17 October 1985 emergency standards for construction regulations for the Federal District were decreed. Visual and apparent construction damage was considered in them. since all the severely damaged buildings were in such a conditions that careful inspection from within was impossible.

These standards consider the types of damages that prevailed during this earthquake and affected mostly structures such as columns, flat slabs, opened floor buildings and many interior walls, corner buildings, friction piles foundations and structur8s damaged by prior differential sinking. Emergency standards include construction design improvements, and reinforcement or repair of facilities damaged by the 1955 earthquake. These measures were adopted, the same way complementary standards for the use of different construction materials are accepted, according to the difference in zones. In addition, authorities are considering larger spaces between neighbouring structures to avoid the damages described above. In this manner, the reconstruction programme in the Federal District is being expedited to warrant greater safety for the capital's inhabitants.

Before proposing a new construction set of regulations for the Federal District, the Standards Subcommittee is sponsoring different studies and research projects on geophysics, seismologic reflection and refraction aspects, vibroquake, field research of rock and soil formations, and study of building structures and foundations when hit by an earthquake that will permit a better interpretation of quake movements. These study findings will lead to improved design and construction which will make buildings stronger and better able to withstand the effects of earthquakes. The subcommittee is advised by the National Autonomous University's technical staff from the geophysics and geology departments as well as staff from PEMEX, in the development of new regulations for the Federal District scheduled far submission at the end of 1986.

The city government moved to include the preparation and education of the population for cases of the Federal District. In order to make the strategy preventive, and not solely alleviating, it is necessary to consider earthquake risks and the regionalization of damages produced, identifying them by districts and neighbourhoods, bearing in mind not just the number of buildings damaged, but also the built surface, its use, population density, water infrastructure, urban utilities and transports.

Decentralization-Deconcentration

In view of the costly damages produced by the earthquake, it is necessary to reconsider the many aspects related to the processes of deconcentration and decentralization, so as to consolidate the city's development and to strengthen ties with regions of the country through the establishment of a new order.

The government is in the process of analyzing different cities according to their features, to find out whether they can accommodate public administrative offices and new economic activities.

The Ministry of Programming and Budget took the first step when they transferred the National Geography and Statistics Institute (INEGI) to Aguascalientes. Then the Ministry of Communications and Transport transferred the Airports and Auxiliary Offices to Cuernavaca, and the Ministry of Energy, Mines and Parastate Industries relocated the Mining Development Commission to Pachuca.

The Federal Public Administration is promoting the decentralization of public administration offices to some seventy-five cities. The decrees of 22 January 1985 and 22 January 1986 have strengthened supports to promote the deconcentration of industrial activities and industrial subgroups that produce commodities. Incentives for micro-industries are allocated and a higher ratio of them are granted in regions specifically chosen for this purpose in the central region of the country, Hidalgo, Tlaxcala, Puebla and Morelos.

In order to supplement these actions in the Federal District, the overall urban development programme is trying to even out the distribution of services and federal headquarters through an urban centres scheme that will shelter new activities and populations. It is also the government's intention to allocate a larger amount of the budget for expenditures related to essential utilities and drinking water, sewage, garbage collection, housing programmes, etc. These efforts are designated to improve the city's administration and rendering of services in each urban district.

Mexico City’s Reconstruction Programme

Throughout its history, Mexico City has had problems to address the needs of the growing population that has come to settle in it, and to provide basic utilities such as drinking water, health, sewage and education. The housing problem is by far the most important, since in view of population growth dynamics it experiences a yearly requirement of 110,000 additional dwellings. To this it is necessary to point out that the Federal District now has a deficit of 76,000 dwellings as a result of the quake's destruction. While the need for large investments is recognized, the federal government finds it difficult to undertake such staggering outlays given the present economic crisis.

The City Government reviewed programming and budgeting geared towards changing 1986's investment priorities, as an answer to the commitment made to provide greater support and service the needs of citizens, while re-establishing order in the city. The Federal District established Mexico City's Reconstruction Programme within its planning system. The Planning Committee for the Federal District Development (COPLADE) supports the implementation of the programme, which became part of the overall development programme in urban activities for the Federal District. This committee has set procedures for the participation of private, public and social sectors. Thus the government will be able to provide more services at a lower cost.

Reconstruction committees and commissions established by presidential mandate contributed elements that have become standard in this programme. The reconstruction programme includes the revision of the situation directly affecting planning in urban districts and the city, where the earthquake produced large damages. These districts are V. Carranza Cuauhtemoc, G. A. Madero and Benito Juarez. In view of the substantial damages sustained in Mexico's historical centre, efforts will be concentrated there to preserve the nation's rich cultural heritage. Io addition, the bases for internal reorganization and operation of the city should be set forth and deconcentration and decentralization policies should by promoted. Main efforts envisioned by this reconstruction programme are:

l) Provision of timely assistance to victims of problems related ta infrastructure equipment, utilities and housing;
2) Ensure the re-establishment of utilities to promote a better territorial use and distribution in the Federal District, and;
3) Provision of utilities, services and housing for victims.

The main tasks to be undertaken in reconstruction plans have been determined and ranked through a comprehensive study, assessing damages in buildings, population, etc., as well as optimal use of land to build dwellings, increase green areas and spaces, to remodel patrimonial estates and address the needs of a larger number of victims. Thus, actions have been identified including the following:

Reconstruction Housing	Expropriated	- To build 44,000 dwellings on expropriated plots:
	Non-expropriated	- To remodel l0,000 tenements damaged by the earthquake; the rescue and reconstruction of the Roma North and South neighbourhoods;
	Community Facilities	- Using expropriated empty plots to build urban facilities to support the communities ;
	Health	- The reconstruction of the twenty-first century National Medical Centre with 50 per cent of the capacity of the previous medical centre;
	Service	- The reconstruction of the Pino Suarez administrative centre project to serve the population; To rebuild and remodel the twentieth of November Avenue as the site of the City Hall and shelter for victims,

	and ;
Infrastructure	- Emergency rescue actions, demolition and repair of infrastructure.

Urban development planners foresee the identification of alternate sites to reorganize Federal Public Administration Offices at Mexico City's historical centre, thus supporting the most suitable departure or relocation of other federal bureaus, as well as other basic necessities like hospitals, schools, etc., so as to identify these in relation to population. In order to achieve this, we have envisaged functions provided by urban centres that according to their vocations, will provide the basis to promote the present scheme in the Federal District. Main actions defined for this first stage are:

- URBAN DEVELOPMENT AND REVITALIZATION OF THE HISTORICAL CENTRE	- To restructure the seventy-eight most damaged neighbourhoods. - To consolidate street and typical markets . - To reconstruct and remodel buildings around the Alameda Park. - To relocate federal government offices in the inner city. - To remodel public squares with patrimonial value at the historic centre of the city. - To create pedestrian streets.
- DECONCENTRATION OF ADMINISTRATIVE SERVICES	- To deconcentrate the city government's treasury to other urban centres. - To deconcentrate 50 per cent of the beds in the National Medical Centre towards urban centres and other cities of the Region.

Regarding the support required by job generating sources that could absorb some of the victims and support urban centres, it is our intention to undertake actions to stimulate productive and service activities in those places that, according to their vocation and better zoning, will help improve territorial organization. Main actions are oriented towards:

- EMPLOYMENT

Supporting employment by creating small handicrafts and service industries.	- The establishment of industrial parks for small handicrafts and service industries. - The reconstruction and establishment of parks and automotive workshops at Buenos Aires Neighbourhood.

Land-use studies have been undertaken, as part of the strategy, as well as the establishment of an emergency standards systems, in order to prevent and alleviate damages, in case of disasters and to make the population aware of them.

- DISASTER PREVENTION	- To formulate a master damage preventions and disaster mitigation plan. - To develop emergency standards and,

- To revise land-use regulations and con struction codes.

In order to warrant the attainment of objectives, actions and goals, the programme is undertaking a permanent evaluation system with participation of city authorities, reconstruction commissions and committees, House of Representatives, Universities and Professional Associations, so as to correct deviations and ensure their correct application.

URBAN DEVELOPMENT STRATECY

In order to promote realization of the objectives previously discussed, the city authorities are developing a series of programmes and specific projects, including:

l) The Barrios Restructuring Programme for seventy-eight densely populated neighbourhoods affected, and master plan that will coordinate proposed actions. Exhaustive analysis was conducted to ascertain damages to infrastructure, urban facilities and housing. The authorities have used this opportunity to establish a urban strategy not limited to reconstruction. Priority programmes were identified with full estimation of costs and designation of public offices responsibles for executing them. This review covered an area of 3,124 ha which represents approximately 8 per cent of the Federal District’s total area. It is estimated that to carry out the reconstruction of these zones requires an investment of approximately $245 million, of 1lhich 43 per cent is for housing construction on expropriated land, 16 per cent on non-expropriated land and 39 per cent for urban facilities and open spaces.

As a second stage of this Programme, in order to strengthen local economic and social activities, there is a programme to create Barrio Centres, which consists of a series of projects for developing services and urban facilities using Historical Centre buildings with patrimonial value which are rescued from abandonment and deterioration. Initially, the City Government will finance these projects, but eventually it is expected that they will become financially self-sustaining. The most important projects involve buildings and public squares with patrimonial value, located in the first neighbourhoods that were formed in the Federal District. By reviving the role of these facilities the government hopes to revive the local neighbourhoods and sense of community. This programme envisions :

- Strengthening community life in the barrios;
- Establishing groups of urban facilities to address demands for local services ;
- Rescuing the use of public areas for recreation activities that will increase the supply of open spaces in the barrios, and;
- Improving the urban image of the barrios.

2) On the other hand, because large portions of Federal Public Administrative offices were affected, some projects are being made for

rehabilitating and relocating these, including:

- Review of the adequacy of some buildings along the 20th of November Avenue, Iocated in the heart of the city, to lodge Federal District Government Offices and to commission their entire remodelling accarding to the cityls functions.
- The rebuilding of an Ad~inistrative Complex, the Pino Suarez, in order to restore the anterior building which incorporates parking areas. The estimated cost for this project is $1.03 million.
- The Relocation of Federal sees in an area of 4,400 ha, principally the Federal Public Administration, the Federal District Government and the Judicial Administration. This project includes a renewal of affected zones rescuing the history, functions and features of the Metropolitan Area Centre and the national life, to promote and revive commercial, touristic, cultural and recreation activities, to rearrange industrial activities and to renovate the symbolic identity of national institutions; as well as making them functional and giving them an identify in the community.

The project includes a zoning proposal from the area according to the fundamental activity of each zone and complementary functions. The study foresees a vertebral column constituted by a group of urban ways that lodge avenues, squares, buildings and infrastructure, with symbolic meaning that will give an image according to the predominant local activity.

3) Because one of the stronger impacts was on employment, a number of studies explored the creation of new jobs, suggesting:

- The use of 0.93 ha of expropriated idle hands for industrial handicraft workshops. This fulfills another objective of eliminating under utilized areas which are zones of deterioration and abandonment in the barrios.
- The creation of a shopping centre for automotive parts that will contribute to reduce unemployment and will solve very particular social problems in some neighbourhoods such as vandalism and robbery.
- Programme of Industrial Restructuring and Work Development which includes 28 ha for building 3 nodules to lodge small and medium size industry; and 7.5 ha for 20 modules to lodge small scale industry. This project will promote: deconcentration of activities and relocation out of the Federal District; restructuring of industry in areas which will not affect domestic services nor cause traffic problems, and reduction of internal migration by relocating industry in areas of labour surplus. For these projects the possibilities of 170 expropriated idle lands with an area of 8.21 ha were studied.

4) Regarding roads, there were some projects designed to improve the urban image and relieve traffic congestion. Efforts involve renewing the Izazaga-San Pablo, Rio de la Loza-Fray Servando Teresa de Mier roads, and transforming 1.7 ha of traffic roads into pedestrian streets and public spaces. The Functional Traffic System for the Central Zone is designed to improve operational conditions and modify the use of traffic-roads in order to attain the objective of having 42 per cent as main avenues, 24 per cent as local streets, 32 per cent as pedestrian walkways and 2 per cent mixed. There are also plans to

rearrange the surface transport system in the city centre, increase capacity of parking areas and revitalize commercial, industrial and administrative activities.

5) As a testimony to the citizenship unit and the support of friendly countries there are plans to build a "Solidarity Garden” in the place that previously was the site of the famous Regis Hotel and Salinas y Rocha Building. This will provide open spaces for recreation, integration with the Alameda Park of Mexico City and the restoration of the "Pinacoteca Virreynal" Museum.

6) Related to disaster prevention, a "Guide of Geometrical Analysis for Anti-Seismic Security in Buildings”, will disseminate findings of the Proceedings and Rules Subcommission, which elaborates the new Construction Regulation~, for the design and security of typical buildings, failure mechanisms and the behaviour of construction facing seismic disturbances. The Guide provides structural, architectonic and urban advice means of reinforcement and basic requirements for necessary calculations. The Guide also analyses the level of risk in construction, the subsoil of the Federal District and the buildings.

BIBLIOGRAPHY

1. Revista Proceso No. 465 Sep. 30, 1985. Mexico, D.F.
2. Revista Proceso No. 464. Sep. 23, 1985, Mexico. D.F.
3. Revista Comunidad Conacyt, Marzo 1980, Ano VI Num. III Mexico, D.F.
4. Periodico Uno Mas Uno, Suplemento Especial, Sep. 1985, Mexico, D.F.
5. Revista Imagen, Num. Especial Banamex, Sep. 1985, Mexico, D.F.
6. Revista Informacion Cientifica y Tecnologica, Num. Especial Volumen 7, No. 10, Noviembre 1985, Mexico, D.F.
7. Boletin Dialogo-Camara de Diputados, Contaduria Mayor de Hacienda, 2a. Epoca Alo 1 No. 10 Sep-Oct 1985, Mexico. D.F.
8. Periodico el Dia, 4 de Nov. 1985, Suplemento Especial. Informe de la Comision Metropolitana de Emergencia. Mexico D.F.
9. Boletin Mexico Esta en Pie. Comision N~cional de Reconstruccion Secretaria de Programacion y Presupuesto. Oct. 1985, Mexico D.F.
10. Terremoto, Septiembre Rojo. Elene Colmenares. Editorial Libra. Dic. 1985, Mexico D.F.
11. E1 Problema de la Vivienda in Mexico, Ponencia “Respuesta del Gobierno de la Ciudad". Dr. Hugo Garcia Perez. Director del programa de desarrollo Urbano. D.G.R.U.P.E.
12. Informacion Basica Sobre los Sismos Ocurridos en la Ciudad de Mexico el 19 y 20 de Septiembre de 1985. Volumen 1 y 2. D.D.F. Secretaria General de Obras*
13. Estadistica e Informacion Basica Sobre las Consecuencias de los Sismos, Ocurridos en la Ciudad de Mexico D.D.F., D.G.R.U.P.E., 26 de Septiembre de 1985.
14. Reporte Sobre Albergues y Campamentos, Unidad Departamental de Coordinacion de Proyectos Ejecutivos. D.G.R.U.P.E.
15. Uno, Economic Commission for Latin America and the Caribbean, October 23, 1985, Damage Cause by the Mexican Earthquake and Its Repercussions upon the Country’s Economy.
16. Revista IMCYC. No Especial 176, Volumen 23, Dic-Ene 1986, Mexico D.F.

17. Esto Paso en Mexico. No, 7 Editorial Extemporaneos. Varios Autores Diciembre 1985. Mexico D.F.
18. Revista IMCYC, No. 174, Volumen 23, Oct. 1985, Mexico D. F.

PLANNING AND MANAGEMENT IN REGIONAL DEVELOPMENT FOR THE PREVENTION AND MITIGATION FROM FIRE DISASTERS IN RANGOON

Thaung Lwin (*)

INTRODUCTION

Population

The population of the Socialist Republic of the Union of BURMA is approximately 37.7 million, of which 2.5 million are in the capital city, Rangoon. The degree of urbanization is reflected in the fact that in 1941, the population of Rangoon was just 0.5 million.

After World War II, like most of the Southeast Asian countries, significant rural-to-urban migration, due to various causes, was observed within the Union. Large population growth in the capital city Rangoon was observed between the year 1953 and 1965, with a yearly growth rate of 5.73 per cent. During the following years, the growth rate eased down gradually to reach the yearly growth rate of 2.02 per cent between 1973 and 1983. The population of Rangoon compared with Burma's Urban Population and mean annual population growth rate of Rangoon City within the decades since 1891 to 1983 are presented in table l.

Physical Growth

BURMA was one of the war-torn countries in Asia, and started to develop, after 1945. Due to rural-to-urban migration, there were squatter resettlements scattered all over the capital city. These settlements gradually changed into urban slums, subject to epidemic diseases and to out-breaks of fire.

Clearance of slums and squatter settlements was carried out from 1958 to 1960 when the rate of migration was high. A site and services scheme was adopted in Rangoon since then. Three satellite towns namely, Thaketa, Okkala South, Okkala North, were established in the east and north-east fringe of the city. Each town contained 10,000 residential plots, with an area of 401 x 60'. Households from the squatter settlements and slums were relocated into the newly established towns. One household per plot of 40’ x 60’, or two-households per plot in some cases were alloted. However, relocation of some squatter settlements in the city limits has not yet been accomplished .

Urban Squatter Settlements

Rural-to-urban migration is observed as one of the causes for urban squatter settlements. Such settlements are almost unplanned; inadequate water supply, narrow lanes, poor drainage, crowded houses very closely built, sub-standard houses of cheap local materials, timber and bamboo walling with thatch roofing, all of which are generally prone to fire and create a big fire hazard.

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Burmese kitchens have no gas-fuel; however, kerosene-oil was previously commonly used, and fire-wood and charcoal are now very widely used. Burmese families are fond of drinking hot plain tea all day and late at night. Consequently, the kitchen fire is kept going and until late at night. This characteristic of Burmese households makes them prone to fires .

FIRE OUTBREAK

Fire Outbreaks throughout the Country

From 1976 to 1985, for a decade, outbreaks of fire were observed a thousand times all aver the country, and the main cause of fire was left-over kitchen fire. The loss by fire was estimated to be very close to two thousand million Kyats, claiming the lives of 291 persons. The data so recorded is shown in table 2.

Fire Outbreaks in Urban Areas in the Country by States and Divisions for the Year 1985

The Union is composed of seven states and seven divisions. As noted by the Department of fire services, there were 900 fire outbreaks in overall urban areas in the country, of which 715 cases were started from left-over kitchen fire, and the loss was estimated very close to 80 million Kyats and claimed the lives of twenty-five persons. Detailed data is shown in table 3.

Fire Outbreaks in Rangoon

During April 1985 - April 1986, major fires occurred in the capital city in five places namely Sein-pan-myaing, Kamayut, Thingangyun, Okkla-South and Dawbon. Almost all of the places affected by fire happened to be squatter settlements and the cause of fire was from kitchen-fires in all cases. No report exists the loss of human lives; over 2.000 houses were burnt down. Total losses were estimated close to 50 million Kyats. The data chart is attached in table 4.

Widespread Fires in the City

Congestion of houses caused large scale fires which swept entire neighbourhoods. Blown off burning thatch roof would fall on neighbouring roofs, and the spread of fire would then be inevitable. Narrow lanes that could not permit access for firefighting-engines to the required spot was another cause for the rapid spread of fires. Moreover, inadequate quantity of water available in the nearby sources and insufficient amount of chemical extinguishers hampered fire fighting efforts.

Emergency Relief

After the fire, the fire victim families were given temporary shelter in school buildings and emergency relief camps. They were in the good hands of the People's Councils concerned. Personnel from various government agencies and public organizations joined in the relief activities. Donations in kind and in money raised were under the management of the People's Councils concerned. United Nations' Relief Funds were also made available.

CITY DEVELOPMENT AND RELOCATION OF FIRE-VICTIM HOUSEHOLDS

Rangoon City happens to be a mono-centre city. Activities of the city are concentrated in down-town land-use. Due to underdevelopment of the city's infrastructure, high-rise physical development for higher density is not possible, and thus sprawl development towards the fringe of the city has ensued. The consequences of such development create a need for a secondary centre for the city. Insein township, which is located on the northern fringe of the city, surrounded by a growing cluster of towns, namely Hlaing, Mayangone, Okkala-North. Mingaladon and Ok-Po, has become a focal point as the secondary centre.

With Insein township as a focal point, Tha-ya-gon Area stands on the other bank of the Hlaing River, west of Insein. The main road connecting Insein from various parts of the lrrawaddy Division passes through the Tha-ya-gon Area. Based on this trunk road, development plans for a new settlement were prepared and the implementation was started in 1985.

The new settlement is composed of six Blocks (neighbourhood), accommodating a total of 3,598 plots with an area of 40' x 60'. Public facilities will be adequately provided and public utilities also will be installed along with it.

THA-YA-GON AS A PLACE FOR RELOCATION

It was normal practice for squatter families on the government land, with who were victims of fire, to be relocated to OKKALA-NORTH or THA-KE-TA township. However, in recent years there were not enough places left in these townships for the relocation of all the fire-victims in recent years. At this time, THA-YA-GON, a site and services project, was under construction. The authorities decided to make THA-YA-GON into a place for relocation of the displaced families by fire. The resettlement programme was administered by the Township People's Council concerned, under the guidance and supervision of the Rangoon Division People's Council. As a standard, a plot of 40t x 60t per burnt housing unit was allocated. Almost 1,800 plots were alloted to the victims of the fires in 1985 and 1986. The Ministry of Construction and Township Councils concerned rendered necessary help throughout the process. As for housing, victims are expected to participate in self-help programmes. However, the provision of low-cost housing in some parts of the area in also under way.

POSITION OF A SQUATTER FAMILY BEFORE AND AFTER THE FIRE

A squatter family on government land is just an illegal occupant; occupancy is very temporary, and liable to eviction by law at anytime.

After a fire, each family is given a permanent place to live on, without paying for the land, in a site and services neighbourhood, which would place them in a better position than before.

REDEVELOPMENT OF THE BURNED OUT AREA

Most of the squatter settlements are on government land. There were development plans already prepared and adapted for most of the squatter settlements. When it was time for development, the removal of squatter settlements was carried out. However, squatter families were allowed to settle in the established towns. OKKALA-North and THA-KE-TA. At the time of big fires in such squatter settlements, families victimized by fire were relocated to OKKA-LA-NORTH and THA-KE-TA. The affected area was developed according to the development plan as adopted. The recently burned-out area KA-MA-YUT, covering 46.2 acres, may be cited. The victimized families were relocated to the established town THA-YA-GON. The burned-out area is to be developed according to the adopted redevelopment plan, and the area is to become a government housing estate. It will be a typical housing estate with high density. It comprises sixty-seven four-story, twenty-four unit type residential buildings, with public facilities such as schools and markets. Proper access to neighbouring settlements is provided. The planned estate will accommodate 1,608 families. Allotment may be made to government services personnel.

APPROACHES AND METHODS TO PREVENT FIRE DISASTERS

<u>Area from Where the Fire Disaster Starts</u>

It is found that most fires start from the family kitchen. However, kitchens are not in the permanent building structure, but usually in hits of bamboo, or wooden structures. Burmese households are vulnerable to fires because:

l) Burmese families are fond of drinking hot plain tea, all day long, and consequently it is necessary to boil the water all day long. Thus fires are kept going all day. Once the fire is left-over or left unattended, it is apt to fire outbreak.

2) Once there is fire outbreak, the congested bamboo-wooden houses are engulfed in flames one after another in no time.

3) Small narrow lanes do not permit access to fire-engines at the time of emergency .

4) Lack of enough supply of water, or water source near enough to where the fire is.

5) The thatch roofs easily catch fire from sparks of neighbouring thatch roofs in the neighbourhood and thud large scale fires rapidly develop.

To prevent fire, we should keep an eye on the density of squatter Settlements.

Fire Services Department

The Fire Services Department renders the following services:

a) Fire precaution;
b) Fire prevention, and;
c) Fire fighting.

Regular fire service personnel are reinforced with trained auxiliary forces from the community. These auxiliary forces advise precautions, and facilitate prevention of fire, in the local communities. Keeping watch posts and going watch around the settlement, the community is kept alert far fire outbreaks.

There are fourteen major fire stations in Rangoon which are able to render fire-services, each owning three to six engines. In 1965, the Fire Services Department acquired 197 fire engines - 163 Toyotas, and 34 Isuzus. At present, there are altogether 1,188 fire-engines for the entire country.

Water supply for fire fighting is from artisan, fells and ponds, but ponds cannot be used in the dry season. In many cases water-bowsers are also used. Fire information is received from fire-towers, by telephones, by special messengers and by the local fire alarm system.

Disaster Preventive Measures in the Process of Local and Regional Development Planning

As observed, the major source of fire disasters is the squatter settlements. By up-grading, or by removing such settlements, these areas would beome better neighbourhoods and public uses safer from fire disaster. To develop now settlements with probable job opportunities and to remove the squatter-dwelling families without undermining their livelihood as performed are under consideration.

A regional concept of planning has been adopted and the Insein Area is designated as a secondary centre. All townships that surround it would adopt comprehensive local plans with a focus on proper planning. Open spaces wide enough to prevent fire spreading from one neighbourhood to the other shall be provided.

A Structure Plan for Rangoon is under preparation by the Urban and Regional Department, Ministry of Construction, with the collaboration of UNDP personnel. Looking ahead, effective measures for fire disaster may be administered within the framewall of regional development planning.

A CONCEPTUAL MODEL FOR PREDICTING LONG-RANGE EFFECTS OF THE FORTHCOMING KANTO EARTHQUAKE

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I INTRODUCTION

Since Prince (1920) published his Ph.D. thesis on Catastrophe and Social Change which dealt with the influence of explosion accidents of warships on the regional community, many surveys and studies on the social consequences of natural disasters have been made in the U.S.A., particularly in the field of sociology 1/. In the initial stage, in the early 1960ts, most surveys focused on people’s behavior in an emergency as well as institutional relief activities after disasters.

As the technology of disaster prediction gradually improved, the topics of sociological research on disasters also shifted to the warning system and its social and psychological effects. Recently, more emphasis has been placed on international comparative studies and theoretical approaches to emergency behavior. From the planning point of view, however, more attention should be given to the long-range socioeconomic effects of disaster, which may substantially affect the successful restoration and reconstruction programmes of the community.

There are some useful contributions in this respect. Anderson (1966) surveys the long-term consequences of the Alaska Earthquake in terms of organizational change 2/. Hass and Kates (1977) make a comparative study of the reconstruction process in San Francisco, Anchorage and Managua 3/. Trainer and Bolin (1976) discuss the persisting effects on people's daily activities following the Managua earthquake and the flood disaster in Rapid City 4/. Rubin (1985) analyses how institutional relationships among different agencies influence effective community recovery from a natural disaster 5/.

In Japan, people's responses to emergency cases have frequently been investigated after disasters happened. However, a very limited amount of research has been made in terms of the long-range effects of disasters. Some economists discuss the effects of the Kanto Earthquake (1923) in terms of its impact on the economic history of Japan 6/. Hirose (1982) tries to describe haw society would change by the force of a disaster 7/.

All of these analyses, however, deal with the consequences of disasters that occurred in the past, and few of them forecast the social impact of a forthconiing disaster on which the reconstruction planning following disaster should be based, although the estimation of physical damage has been intensively made in the field of seismic engineering. Yoneda (1975) gives a rough estimate of economic damage which would be caused by the forthcoming Kanto Earthquake 8/. Watanabe (1978) tries to describe how the money market would be disrupted and how productivity would decrease in Tokyo, resulting in a significant reduction in gross national product (GNP) in Japan 9/. The Research Institute of the Future also

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provides some socioeconomic data for predicting the effects of the forthcoming Kanto Earthquake 10/-

This paper aims to propose a more systematic and general framework for a model to predict the long-range socioeconomic effects of the forthcoming large-scale earthquake in the Tokyo metropolitan area as a case study.

SCOPE OF THE MODEL

To begin with, the area where the influences of a disaster are described should be clearly determined, because the socioeconomic effects of an earthquake differ from one place to another. Supposing that the metropolitan area of Tokyo were hit by a large-scale earthquake, all urban activities in Tokyo would stop or be paralyzed, causing the same influence in the areas where most social activities depend on Tokyo, while some other areas where no damage was caused would be able to do brisk business, due to the great demand for restoration work in Tokyo. Sometimes, impacts may be observed just in a small area, but with no signs of damage in a wider region. Thus, specification of the area is essential to describe earthquake impacts.

The prediction time reference is also important because some effects are absorbed into dynamic change of the society as time elapses while others have persistent repercussions on the entire scope of social activities which can not always be directly attributed to a disaster. In this paper, following an emergency recovery period of one month after the earthquake, the influence of the earthquake in the area directly affected over the next five to ten years is described.

OUTLINE OF THE OONCEPTUAL MODEL

Figure I shows a causal diagram of the conceptual model. The effects are described in three sectors which are strongly interrelated: the household sector; the governmental sector, and; the business sector.

First, in the household sector, the process of severe dislocation of the household economy is modeled. According to the Report of the Expert Committee on Seismic Hazard and Damage Estimation, Tokyo Metropolitan Government ll/, it is estimated that the number of houses which may be destroyed by the quake is about 62,000 units, while 473,000 houses would be burned down by the ensuing large-scale city fire.

It is also estimated that the casualties would be around 63,000 wounded and 36,000 killed, and that 1.2 million families would suffer at least some losses. Thus, it is inevitable that people who lost their houses would be saddled with long-term housing loans, even though a certain subsidy would be given by the government. Generation of a great number of deaths and injuries means, in itself, the loss of earnings which support a family, and the level of household income declines. As a result, the household economy of enormous numbers of families would be tightened.

Secondly, in the governmental sector, scarce resources for restoration activities such as available budget and manpower would pose problems. The

Report 11/ says that 1,300 precipices and revetments would be destroyed and at least three bridges would be in danger of collapsing. Water lines and gas pipes would be cut in about 220 and 670 places respectively.

The local government would have to start repairs or reconstruction work on these facilities immediately after the earthquake, requiring tremendous manpower and expense. Compensation for injured people, provision of temporary housing and subsidies for a housing construction fund for families which lost their houses would involve additional extraordinary expenditure by the government, while tax revenues would decrease because the level of household income and areal production would decline. Thus, the government would be put in financial difficulties, and community recovery efforts would be delayed, although emergency relief funds would be provided by the central government.

Security and the living environment of the community would markedly deteriorate, accelerating evacuation of people from their destroyed community. After the Kanto Earthquake in 1923, about 700,000 people were evacuated from Tokyo, or 32 per cent of the total population of 2.2 million. If a similar proportion of Tokyo residents were now affected, about 2 million people would be evacuated from Tokyo to the rural areas.

Thirdly, the business sector would also be severely affected. All commodities for daily life or materials for repairs and reconstruction would become scarce, because of the decrease in productivity of the industrial sector the facilities and equipments of which would also sustain extensive damages. Imports would, therefore, increase while exports would decrease, and naturally the value of the Yen currency would become lower on the international foreign exchange market. Accordingly, the prices of all commodities would become higher due to rampant inflation and people would have to manage to withstand the high cost of living.

It is also possible that the temporary interruption of bill accounts, which may or may nor occur, or diminution of effective demand due to lowered economic activities in the disaster area would result in a large number of bankruptcies, creating substantial unemployment. Needless to say, the situation strongly depends on the financial policies of the central government, and some events can be avoided by appropriate policies while some would be accelerated by failure to take proper actions.

Several estimates of the financial impact of earthquakes have been made. The decrease in GNP just after the earthquake would be 3 to 5 per cent 9/, 10/. Katoh reports a devaluation of the Yen by 30 per cent after the Kanto Earthquake in 1923 6/. The author observed that the Peso value also dropped 30 per cent after the Mexico Earthquake in 1985, although some other factors aside from earthquake contributed to this devaluation. Watanabe found that commodity's prices rose by 10 to 15 per cent on average after the 1923 Kanto Earthquake _9/, but without an inflationary impact because most enterprises had over-invested in their capital stock, causing supply to exceed demand, and thus overissue of currency was avoided.

With regard to bankruptcy and unemployment, no exact information is available. However, relying on rough estimates based on forecasts of direct damage to buildings and constructions mentioned earlier, approximately 600,000 people would be fired or temporarily lose their jobs.

As a point of reference, the Mexico Earthquake created unemployment of 150,000 workers equal to 2 per cent of all employees.

SUMMARY

The conceptual model proposed in this paper is not complete. Some causal events may or may nor occur. The knowledge of what happened following past earthquakes should be collected and analysed in more detail. This kind of conceptual framework for a model to predict the long-term consequences, however, provides proper guidelines for future analysis and suggests the need for appropriate political actions to be taken beforehand.

NOTES

1/. S. H. Prince, (1920), Catastrophe and Social Change, Columbia University Press.

2/. W. A. Anderson, (1966), “Disaster and Organizational Change: A Study of Some of the Long-term Consequences of the ~larch 27, 1964, Alaska Earthquake," Ph.D. thesis, Ohio State University, Columbus.

3/. J. E. Hass. R. W. Kates & M. J. Bowden, (1977), Reconstruction Following Disaster, Boston: The MIT Press.

4/ P. Tarainer, & R. Bolin, (1976), "Persistent Effects of Disasters on Daily Activities: A Cross-cultural Comparison," Mass Emergency, Vol.1

5/ C. B. Rubin, et al., (1985), "Community Recovery form a Major Natural Disaster,” program on Environmental and Behavior Monograph #41, Institute of Behavioral Science, University of Colorado.

6/. T. Katoh, (1976) "Earthquake and Economy: Japanese Economy after the Kanto Earthquake, 1923,” (in Japanese), Earthquake, University of Tokyo Press.

7/. H. Hirose, (1982), "Social Influences of a Disaster” (in Japanese), Disaster and Human Behavior, University of Tokyo Press.

8/. S. Yoneda, (1975), “Catastrophe after a Large-scale Earthquake”(in Japanese), Economist, Toyo-keizai.

9/. I. Watanabe, (1978), "The Influence of a Disaster in Tokyo on the National Economy in Japan,” The Research Report of the National Centre of Disaster Protection Science and Technology, Vol. 20.

10/. The Research Institute of the Future, (1979), “A Study on Reliability and Effectiveness of Urban Disaster Prevention System” (in Japanese), NIRA.

11/. Tokyo Metropolitan Government, (1978), "A Report of Forecasting Damage of an Earthquake in 23 Wards Area in Tokyo.”