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ADAPTING EXISTING MICROZONING TECHNIQUES IN INDUSTRIALIZED COUNTRIES TO REDUCE THE EARTHQUAKE RISK IN DEVELOPING COUNTRIES

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ABSTRACT

While most of the resources spent on natural hazard mitigation in the 20th century appear to have been directed at the needs of industrialized nations, the greatest urban earthquake risk, for example, in the 21st century will be faced by developing nations. This paper discusses a process to adapt existing techniques, most of them developed in industrialized countries, and implement them for risk reduction in developing countries. The adaptation process includes four stages: preparation of the basic information, adaptation of existing techniques to meet the local conditions, validation of the preliminary results, and preparation of the final results.

As an example of a pilot application of the proposed methodology, the Quito Earthquake Risk Management Project is presented. The objectives, results and achievements of this project are discussed. Finally, the effectiveness of this type of project in reducing the seismic risk is analyzed, and suggestions on future actions and strategies are proposed.

KEYWORDS

Risk management, seismic microzoning, seismic scenarios, developing countries, Quito, Ecuador.

INTRODUCTION

The world's population, which topped 5 billion in 1988, is expected by the United Nations' medium growth assumptions to reach 6.25 billion by the year 2,000 and 8.5 billion by 2025. The bulk of this growth will take place in the developing world, and in countries that have already suffered some of the world's worst natural disasters. Fifteen of the world's 20 most disaster-prone countries have population growth rates above the world's current average (1.7%) and 11 of them have even faster growth rates of over 2% annually (Coburn, 1993).

While most of the resources spent on natural hazard mitigation in the 20th century appear to have been directed at the needs of industrialized nations, the greatest urban earthquake risk, for example, in the 21st century will be faced by developing nations. Approaches to correct this imbalance are difficult to find, given the current slow world economy and rapidly shifting political alliances.

There is a common process of urbanization taking place in different regions of the world. Understanding the reasons for changes in patterns of urbanization–primarily the rural-urban shift–in the context of technological change and the corresponding economic structure help explain the increase in the vulnerability of cities to natural disasters. In two decades, most of the population of the world and most of its economic activities will be located in urban agglomerations for the first time in history. The urban population will be larger than the total population of the world in 1970 (Jones, 1993). The structure of the world economy will have changed from rural agrarian to urban fabrication, trade, and services. Vastly greater quantities of energy will be consumed. The implications are that the highest priority for all our efforts is to devote our attention, time, and resources to shaping the enormous urban environment that is emerging, especially in the developing world.

Populations at risk from future great earthquakes in the developing nations live near convergent and transform plate boundaries in the Middle and Far East, China, India, Indonesia, and Central and western South America. Three factors render this an observation of concern: a rapidly rising population in the developing nations, a rural-urban migration that places unprecedented demands on the construction of dwelling units and urban infrastructure, and an unhealthy world economy favoring the construction of low cost housing in the absence of earthquake resistant codes. The combination of these factors results in a higher proportion of the population living in more vulnerable conditions with respect to the occurrence of natural disasters in developing countries.

It is highly probable that the comparatively greater negative socioeconomic impact of natural disasters in developing countries will increase in the future. A comparison of losses related to the gross national product (GNP) shows that damage from Latin American earthquakes typically exceeded 5% of the total GNP in the year they occurred (Bitran, 1993). It was also observed that the weaker the economic position of the country, the greater the relative impact of the damages on the national economy. For instance, the losses caused by the earthquake that struck the capital of Mexico in 1985 represented only 2.8% of the GNP, whereas the one which occurred in El Salvador in 1986 produced losses that exceeded 31% of the country's GNP, and the earthquake in Managua, Nicaragua in 1972 caused losses that represented 40% of Nicaragua's GNP. In contrast, the 1989 Loma Prieta earthquake produced losses that represented just 0.2% of the country's GNP and 6% of the Gross Regional Product of the San Francisco Bay area (Tucker *et al.*, 1994).

In spite of all of these facts, the close linkage between natural disasters and social and economic development seems to have been ignored, and development programs have not been assessed with regard to these disasters. Neither the potential impact of disasters on development programs nor whether a given development strategy was likely to increase the severity of a given disaster's effects has always been considered. Earthquakes, for example, were seen in the context of emergency response, and not as part of long-term development planning. Only recently have earthquake managers begun to recognize the disaster-development relationship.

DISASTER MANAGEMENT PROGRAMS IN DEVELOPING COUNTRIES

The concentration of population and economic activity in major cities is more marked in developing countries than in developed countries. Moreover, densely concentrated buildings and facilities are often more vulnerable than those in developed nations. There is an urgent problem of mass supply of housing and, as a result, building code requirements are eased rather than intensified, housing built on inferior architectural principles is supplied, and it is not rare the emergence of not approved developments or illegal conversions or extensions. Therefore, the building, social, and economic conditions that are found in developing countries are often very different from those found in industrialized nations.

In many cases, however, disaster management projects implemented in developing countries consist only in importing technology and methods developed in industrialized nations. If there is not a proper adaptation of this technology to meet the local conditions and needs, the implementation of such a project will not produce the positive results that could be expected. It is seldom possible to apply sophisticated methods to disaster management in the developing world. For example, there is a remarkable difference in the availability of regional data between industrialized and developing countries, which makes the "import" of the method ineffective. It may be that what developing countries need is not new technology and methodologies, but to use properly and efficiently the existing ones. It is possible that old (in industrialized-countries' standards) but well-tested technology may bring important benefits to developing countries at very low costs.

It is also important that disaster mitigation projects contribute to indigenous capability rather than focussing only on supplying technology and expertise to developing nations. Unfortunately, according to the U.S. National Committee for the Decade for Natural Disaster Reduction (1994), the technical assistance provided by the U.S., for example, has not served to foster an independent science and technology capability for the most needed developing nations.

There are examples of disaster mitigation initiatives in which the prevalence of donor countries' objectives over the interests and needs of the recipient nations has hampered the effectiveness of the projects. A study undertaken in Bangladesh (Yunus, 1994) found that 75 percent of the total received in foreign aid since independence in 1971 went back to donor countries in payments for the services of consultants, advisers, commodities, equipment, etc. Of the remaining 25 percent, most went to local consultants, bureaucrats and engineers.

As a result of these problems, very little has been achieved so far in the reduction of the risk associated to natural disasters in developing countries. Records of earthquake-caused deaths during this century support the projection that, over time, earthquakes will increasingly affect populations of developing countries more than those of industrialized nations. In the period 1900-1949, earthquakes caused about 700,000 fatalities around the world. The ratio of number of earthquake-caused deaths in developing countries to the number in developed countries in that period was about three to one. Over the period 1950-1988 (about 500,000 fatalities), that ratio increased to more than nine to one (OFDA, 1990). This is in accord with the consequences of the 1988 Spitak earthquake in Armenia and the 1989 Loma Prieta earthquake in California: although the two earthquakes were of similar size and affected comparable-sized populations, the Armenian event killed 25,000 people, while the California earthquake killed 63.

The next section discusses a process to adapt existing techniques, most of them developed in industrialized countries, and implement them for risk reduction in developing countries. The process relays mainly on the work done by the local people, and includes the active participation of representatives of the academic, governmental, social and economic sectors of the community. These features are expected to make the process to result in an effective transfer of technology, the education and training of the local participants, and in the project addressing the actual needs and priorities of the local community.

ADAPTING TECHNIQUES DEVELOPED IN INDUSTRIALIZED COUNTRIES TO USE THEM FOR RISK REDUCTION IN DEVELOPING COUNTRIES

While a number of microzoning studies have been carried out in countries like Japan and the United States, very few have been performed in developing nations. However, most of the population at risk of an impending earthquake concentrates in developing countries. This situation has two main implications: 1) practically all the existing microzoning methods have been created in developed nations, and 2) most of the cities under seismic threat in the developing countries do not have the basic information that is usually needed for microzoning studies and for planning seismic risk reduction programs.

While there is an urgent need to provide the leaders and scientists of the developing countries with the tools, methods, and information necessary to implement disaster mitigation policies, the available microzoning techniques cannot be applied as they are to the local conditions. The existing procedures need to be adapted to meet the social, economic, and technical realities of the local people.

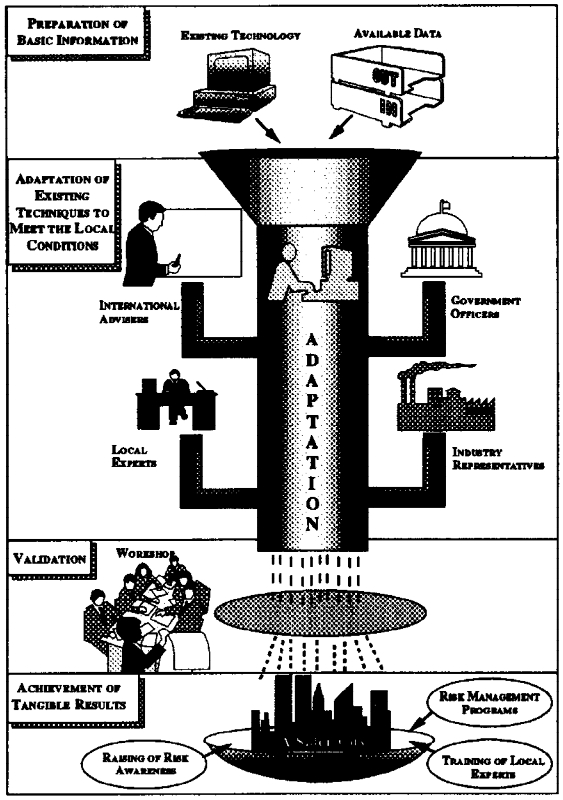

Fig. 1 Reducing risk in developing countries
by adapting existing technology

The adaptation process is presented schematically in Fig. 1. It includes four stages: preparation of the basic information, adaptation of existing techniques to meet the local conditions, validation of the preliminary results, and preparation of the final results. Figure 1 assimilates the proposed process to a production process in which the raw materials go through a process of transformation and quality control to result finally in a usable product.

Preparation of basic information: Often, enormous amounts of valuable data are scattered throughout storage rooms of different, unrelated institutions and organizations. A first step, rather than prepare or create new data, is to collect the existing information and organize and evaluate it systematically. A careful analysis then has to be performed to select those techniques that can most easily be adapted to meet the local conditions.

Adaptation of existing techniques to meet the local conditions: The adaptation must be carried out through the coordinated work of a multidisciplinary team of specialists that includes geologists, seismologists, structural engineers, soil engineers, urban planners, and data managers. Representatives of the local government and of the industrial and financial sectors must be included to incorporate all the elements that a risk management program requires to be realistic and applicable.

Although most of the work must be done by the local people, a group of international experts provides technical recommendation on how earthquake risk assessments have been made in other cities, as well as advice on what mitigation actions may be useful given the local conditions. Additionally, the international experts review the process for technical accuracy.

Validation:. Once the preliminary results have been obtained, they must be reviewed and validated by the local officials, the service systems' managers, and the people who will be in charge of implementing the recommendations and plans that the process will produce. A very efficient and effective way to carry out these tasks is to set up workshops in which the preliminary results are discussed and, based on those discussions, recommendations for risk reduction actions are prepared. The participation of international advisors contributes importantly to the success of the workshops.

Achievement of tangible results: The process is expected to result in the raising of the risk awareness, the training of the local experts, and the preparation of a realistic risk management program. Provided that the recommendations are implemented, that follow-up projects are carried out, and that there is continuity in the work, these products should result in a safer city, the final goal of these efforts.

As an example of a pilot application of the proposed methodology, the Quito Earthquake Risk Management Project is presented.

THE QUITO EARTHQUAKE RISK MANAGEMENT PROJECT

In a pilot attempt to adapt existing techniques for risk reduction in developing countries, an international project that included participants from Ecuador, France, United States, Canada, and Japan, was implemented to prepare seismic scenarios for Quito, Ecuador, and to provide recommendations for improving the preparedness of the city. The project took place between July 1992 and January 1994 (GeoHazards International, 1994.)

Objectives:

The earthquake risk reduction project for Quito had the following specific objectives:
- to improve the understanding of Quito's earthquake risk by assessing the seismic hazard distribution,
- to set up the basis for defining an earthquake preparedness plan for the city by recommending realistic countermeasures,
- to raise the awareness of seismic risk among public, government officials, and business leaders, both within Ecuador and internationally, by organizing interdisciplinary working sessions, and widely disseminating the results, and
- to demonstrate the efficacy of microzoning studies in reducing the earthquake risk in developing countries.

Interdisciplinary, multinational working teams combined the knowledge and the capability of the local specialists and the expertise of the international advisers to attain the following:

- an effective utilization of the capacity of all the people involved in the project,
- a proposal of specific and realistic recommendations for reducing Quito's seismic risk; and
- an active participation of the local people in making the recommendations. This implies that people who made the recommendations are also the people who are in charge of executing them and therefore, can be crucial in assuring the future implementation of the project results.

Results and achievements

The project demonstrated that Quito is unprepared for its next major earthquake and that it has become increasingly vulnerable with time. Additionally, it was strongly felt that immediate steps should be taken to reduce the vulnerability of the Quito City to earthquake damage. The Quito project produced several tangible results that can be put to use toward earthquake safety. Among the most important are:
- A comprehensive estimation of the consequences of potential earthquakes in Quito (Fig. 2),
- A survey of Quito's urban infrastructure with emphasis on its vulnerability to earthquakes,

-A framework, reviewed by specialists from the science and technology, industry, and government sectors from Ecuador and abroad, of a comprehensive program to manage Quito's seismic risk.

Besides this, the very nature of the project led to the following achievements which have, at least, the same value as the above mentioned results:

- The leaders of the local community, including Quito's Mayor and the leading businessmen, were involved and supportive from the very beginning.
- There were nine workshops in Quito in which for the first time more than 100 Ecuadorian and international specialists, including the Mayor and other officials, conferred about Quito's earthquake history and the present risks.
- Through the collaborative work carried out, the local experts and the Municipality of Quito acquired the capability to create new damage estimates for other potential earthquakes and the ability to gather new data of soils and structural responses. Additionally, the international advisers and experts could also get a first-hand image and understanding of the situation, and realize the needs of the developing nations.
- The project's activities included technical exchange, visits of Ecuadorian engineers to international universities, and visits of international experts to Quito. Also included was an international tour in which four Ecuadorian government officials and business leaders visited 12 Californian agencies and businesses that are specialists in earthquake preparedness.
- ALERTA, a private-sector disaster preparedness council to foster earthquake risk management, was created following the model of the Business and Industry Council for Emergency Planning and Preparedness of Los Angeles.

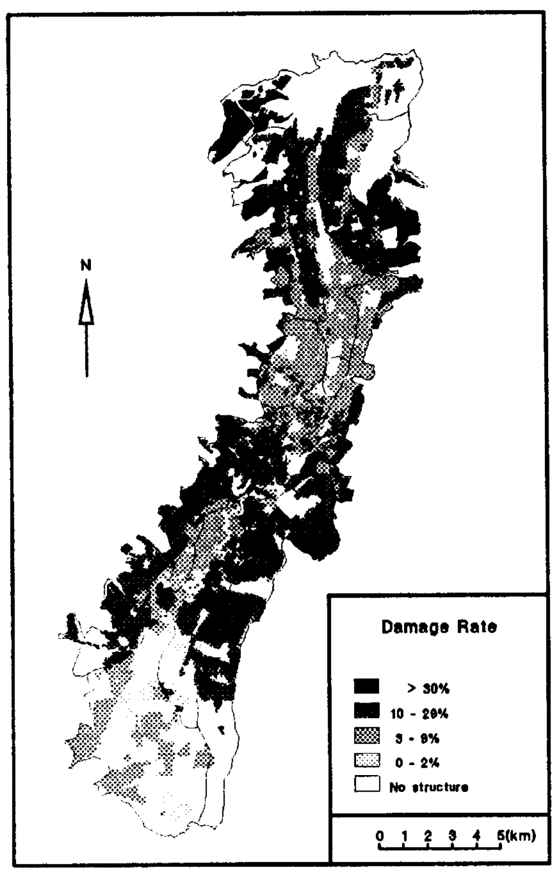

Fig. 2 Structural damage distribution resulting from a hypothetical earthquake

CONCLUDING REMARKS

Although the methodology presented here appeared to succeed in Quito, it will take some time to understand completely how effective the Risk Management Project will be in reducing the seismic risk in the Ecuadorian capital. To contribute to risk reduction, the project needs to be followed by a process of implementation of the recommendations and plans that it has produced. This may prove to be not an easy task. Even if the existing techniques were successfully adapted to the local conditions, putting such knowledge to work in reducing the effects of natural hazards would be a daunting challenge that requires considerable political will and stamina. Without political commitment, for example, it is unlikely that much can be accomplished either in developed or developing countries.

International cooperation programs should help disaster-prone countries develop alert systems, mitigation capabilities, and the capacity to assess their vulnerability to natural hazards. The Quito Project attained these objectives. More work, however, is needed to demonstrate the cost-effectiveness of investments in mitigation, and to make vulnerability reduction a routine, explicit objective for development projects.

From the technical point of view, advances in computer technology and applications (such as GIS and computer models) can facilitate the integration of hazard and vulnerability information, and thus improve the assessment of risk. It is necessary, however, to develop standard microzoning methodologies that regulate the quality and management of the data, the accuracy of the estimates, and the presentation, use, and dissemination of the results, regardless of the place where the studies are performed. Standard sources of information, such as remote sensing data, should be incorporated for this purpose.

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