RADIUS

Risk Assessment Tools for Diagnosis of Urban Areas against Seismic Disasters

United Nations Initiative towards Earthquake Safe Cities

Containing CD-ROM with the RADIUS tools and final reports

International Decade for Natural Disaster Reduction
IDNDR
1990-2000
Building a Culture of Prevention

International Strategy
ISDR
for Disaster Reduction

UNITED NATIONS

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Preface

Urban seismic risk is rapidly increasing, particularly in developing countries, where a number of mega-cities are growing. Almost half of the world population lives in cities, where all kinds of human activities are concentrated. Thus, cities are more and more vulnerable to disasters, particularly to earthquakes, which can strike any city suddenly without warning. Once an earthquake takes place in a large city, the damage can be tremendous both in human and economic terms. Even an intermediate earthquake can cause destructive damage to a city as in the cases of the 1995 earthquake in Kobe, Japan and the 1999 earthquake in Kocaeli, Turkey.

There is a tendency to think that disaster prevention would cost much more than relief activities. However, the reality is the reverse. Our society has been spending a lot of resources for response activities after disasters; these resources could have been drastically reduced if some had been spent for disaster prevention. There is also a tendency to look at disasters mainly from a humanitarian angle, bringing us into the position of giving priority to the response to disasters. However, relief activities can never save human lives that have already been lost. Response activities can never help immediately resume functions of an urban infrastructure that have already been destroyed. The bottom line is that buildings should not kill people by collapsing and infrastructure should not halt social and economic activities of the city for a long time.

It is essential particularly for seismic risk reduction to concentrate our efforts on prevention and preparedness. The secretariat of the International Decade for Natural Disaster Reduction (IDNDR 1990-2000), United Nations, Geneva, therefore, launched the **RADIUS** (**R**isk **A**ssessment Tools for **Di**agnosis of **U**rban Areas against **S**eismic Disasters) initiative in 1996, with financial assistance from the Government of Japan. It aimed to promote worldwide activities for reduction of seismic disasters in urban areas, particularly in developing countries.

Nine case-study cities were selected, namely, Addis Ababa (Ethiopia), Antofagasta (Chile), Bandung (Indonesia), Guayaquil (Ecuador), Izmir (Turkey), Skopje (The former Yugoslav Republic of Macedonia), Tashkent (Uzbekistan), Tijuana (Mexico), and Zigong (China) from 58 applicant cities. The case studies were carried out for 18-months to develop earthquake damage scenarios and action plans to reduce seismic risk, and involved decision makers, local scientists, local government officers, representatives of the communities, and mass media. Three assigned international institutes, namely, GeoHazards International (GHI, USA), International Center for Disaster-Mitigation Engineering (INCEDE)/OYO Group (Japan), and Bureau de Recherches Géologiques et Minières (BRGM, France), provided the case-study cities with technical guidance through intensive communication. Regional advisers also provided them with technical advice.

Based on the experiences of the nine case studies, practical tools for earthquake damage estimation and implementation of similar projects were developed so that any earthquake-prone cities might start similar efforts as the first step of seismic risk management. A comparative study to understand urban seismic risk in the world was also conducted. More than 70 cities participated in the study to exchange information. As associate cities, more than 30 cities participated in RADIUS to provide other cities with their valuable experience. The RADIUS home page was created to present all the information developed through the project. Indeed, exchange and dissemination of information was one of the most important aspects of RADIUS, as its major objective is to raise public awareness.

I, as the RADIUS manager, thank all the experts involved in RADIUS. I highly appreciate the enormous efforts made in the 9 case-study cities, where local scientists and government officers collaborated very closely. I thank the regional advisers who actively and kindly participated in various meetings and workshops on a voluntary basis. I also thank the three international institutes for their dedication in directing the case-study cities. GHI and OYO Corporation dedicated themselves to conduct the comparative study and develop the practical tools, respectively. GHI kindly offered their precious experience that was fully applied to RADIUS, playing the leading role in the initiative. My special thanks go to Dr. Carlos Villacis, GHI, without whom RADIUS would not have been completed successfully. Last but not least, many thanks also go to Ms. Etsuko Tsunozaki, IDNDR secretariat, who assisted us in solving many administrative problems through the course of the initiative. Without her patient work, RADIUS would have staggered on many occasions.

It is my sincere hope that as many cities as possible will apply the developed practical tools for the initiation of their seismic risk management so that action towards earthquake-safe cities will be taken.

Kenji Okazaki
RADIUS Manager, IDNDR secretariat
OCHA, United Nations, Geneva

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Chapter I

Outline of the RADIUS Initiative

Kenji Okazaki, RADIUS Manager, IDNDR secretariat, OCHA, United Nations, Geneva

I. Objective and Scheme

The United Nations General Assembly designated the 1990s as the "International Decade for Natural Disaster Reduction (IDNDR)" to reduce loss of life, property damage, and social and economic disruption caused by natural disasters. The IDNDR secretariat launched the **RADIUS** (**R**isk **A**ssessment Tools for **Di**agnosis of **U**rban Areas against **S**eismic Disasters) initiative in 1996, with financial and technical assistance from the Government of Japan. It aimed to promote worldwide activities for the reduction of urban seismic risk, which is growing rapidly, particularly in developing countries. The primary goal of the initiative is to help people understand their seismic risk and raise public awareness as the first step towards seismic risk reduction.

The direct objectives of RADIUS were:

A) To develop earthquake damage scenarios and action plans in nine case-study cities selected worldwide;

B) To develop practical tools for seismic risk management, which could be applied to any earthquake-prone city in the world;

C) To conduct a comparative study to understand urban seismic risk around the world; and

D) To promote information exchange for seismic risk mitigation at city level.

The results of applying the tools will be useful to decision makers and government officials who are responsible for disaster prevention and disaster:

- To decide priorities for urban planning, land-use planning, and building regulations;
- To prepare an improvement plan for existing urban structures such as reinforcement (retrofitting) of vulnerable buildings and infrastructure, securing of open spaces and emergency roads; and
- To prepare for emergency activities such as life saving, fire fighting, and emergency transportation.

The results will also be useful to communities, NGOs, and citizens:

- To understand the vulnerability of the area where they live;
- To understand how to behave in case of an earthquake; and
- To participate in preparing plans for disaster prevention.

The results will be useful to semi-public companies that maintain urban infrastructure to understand the necessity of prevention and preparedness. The results will also be useful to business leaders, building owners, developers, real estate agents, and insurance/reinsurance companies so that they may minimize the damage on their human resources as well as properties for their business.

Time table

Year 1996

- Planning of the initiative

Year 1997

- Invitation for the case-study cities
- Pre-selection of the 20 cities
- Establishment of the STC subcommittee for RADIUS
- Selection of the three international institutes

Year 1998

- Selection of the nine case-study cities (January)
- Implementation of the case studies (1.5 years from February)
- Kick-off meetings and earthquake damage scenario workshops
- Training seminars in Japan (May/June)
- Comparative study on "understanding urban seismic risk in the world" (1 year from April)
- RADIUS Workshop at the International Conference in Yerevan, Armenia (September)

Finally, an "Action Plan" was proposed. It prioritized the necessary actions so that they could be implemented soon after the project. Therefore, the action plan had to be practical. It may be a first small step for each community in the city. The scenario and action plan were disseminated to relevant organizations and the public.

2. Assistance to the case-study cities

- The IDNDR secretariat provided the grant (US$ 50,000 to a full case study city and US$ 20,000 to an auxiliary case study city);
- An internationally experienced institute supervised and coordinated the case studies and offered technical assistance. An expert(s) from the institute visited the case-study city several times. The expert(s) also offered technical assistance through electronic communications;
- Regional Advisers visited a city once or twice to participate in the local RADIUS workshops, to provide technical advice, and to raise public awareness;
- Experts of the case-study cities were invited to two kinds of training seminars, which were held in 1998 in Japan, to learn basic knowledge for the project; and
- The cities were invited to an international symposium, which was held in 1999 in Tijuana, Mexico, to exchange information. Some of the cities were also invited to certain regional meetings to present their progress of the project.

3. Selection of the case-study cities

In early 1997, the IDNDR secretariat sent invitation letters for participation in the RADIUS initiative as case-study cities, to major cities prone to earthquakes all over the world. By the end of July 1997, it accepted applications for the case studies from 58 cities worldwide, mainly from developing countries.

In September 1997, the IDNDR secretariat pre-selected 20 cities from the 58 cities, based on the objective criteria and on the information in the application forms, taking into consideration the regional distribution. Experts of the assigned international institutes, namely, the International Center for Disaster-Mitigation Engineering (INCEDE, Japan), the Bureau de Recherches Géologiques et Minières (BRGM, France), and GeoHazards International (GHI, United States), visited the 20 candidate cities from October to December 1997, to collect more information and assess the feasibility of the case studies. The IDNDR secretariat selected 9 cities in January 1998, under consultation with the STC (Scientific and Technical Committee for IDNDR) subcommittee for RADIUS.

List of the cities that applied for RADIUS case studies (58 cities)

- **Asia** (27 cities)
  Almaty (Kazakhstan), Amman (Jordan), Ashgabat (Turkmenistan), Bandung (Indonesia), Baoji (China), Bishkek (Kyrgyztan), Calcutta (India), Damascus (Syria), Daqing (China), Dushanbe (Tajikistan), Hefei (China), Istanbul (Turkey), Izmir (Turkey), Kathmandu (Nepal), Mandalay (Myanmar), Metropolitan Manila (Philippines), Mumbai (India), Shiraz (Iran), Tabriz (Iran), Tangshan (China), Tashkent (Uzbekistan), Tbilisi (Georgia), Tehran (Iran), Urumqi (China), Yangon (Myanmar), Yerevan (Armenia), Zigong (China)
- **Europe and Africa** (12 cities)
  Accra (Ghana), Addis Ababa (Ethiopia), Algiers (Algeria), Belgrade (Yugoslavia), Bucharest (Romania), Conakry (Guinea), Dodoma (Tanzania), Giza (Egypt), Petropavlovsk-Kamchatsky (Russian Federation), Skopje (The former Yugoslav Republic of Macedonia), Sofia (Bulgaria), Tirana (Albania)
- **Latin America** (19 cities)
  Ambato (Ecuador), Antofagasta (Chile), Cali (Colombia), Cumana (Venezuela), Guayaquil (Ecuador), Kingston (Jamaica), La Paz (Bolivia), Lima (Peru), Manizales (Colombia), Medellin (Colombia), Pasto (Colombia), Pereira (Colombia), Popayan (Colombia), Quito (Ecuador), San Juan (Argentina), Santiago (Chile), Santo Domingo (Dominican Rep.), Tijuana (Mexico), Toluca (Mexico)

Most of the case-study cities established a local steering committee, which took the responsibility for the implementation of the case study. The committee basically had two co-chairpersons, one from the city and the other from the responsible international institute. Each city also established a local advisory committee, whose role was to provide the steering committee with comments in defining needs and priorities, and to help in raising public awareness. The committee consisted of representatives from various sectors such as relevant organizations, semi-public and private sectors, mass media, politicians, and communities.

In order to substantially launch the case studies, a RADIUS kick-off meeting was held from April to July 1998 in most case-study cities. Its purpose was to explain the objectives and methodologies of the project to relevant experts and organizations as well as government officers, raising public awareness.

Some case studies were incorporated in a comprehensive project or closely collaborated with another similar project with independent resources. For example, Zigong City was selected at the same time for a national project called "Demonstration Study on Prevention and Reduction of Earthquake Disaster in Large and Medium Size Cities" by the Chinese Seismological Bureau. In Bandung, the case study was carried out in close cooperation with AUDMP (Asian Urban Disaster Mitigation Program) of the ADPC (Asian Disaster Preparedness Center), funded by USAID.

7. Regional advisers

Three international advisory committees were established in May 1998 regionally so that they might advise the case-study cities in each region. The role of the committees was to visit the cities, provide them with technical advice and to raise the public awareness there. The regional advisers, together with the assigned international institute, visited the cities once or twice. During their visits, they actively participated in the meetings and workshops to discuss the city's seismic risk with decision makers and local experts. The three international institutes coordinated the activities of the regional advisers.

Regional advisers (in alphabetical order)

Asia

- Dr. Anand S. Arya, Former STC member, Former Professor Emeritus, University of Roorkee, India
- Dr. Jack Rynn, Director, Centre for Earthquake Research Australia (CERA), Australia
- Dr. Tsunehisa Tsugawa, Senior Chief Research Engineer, Kajima Technical Research Institute, Japan

Europe, the Middle East and Africa

- Dr. Mohamed Belazougui, Director of CGS, member of the STC, Algeria
- Dr. Victor Davidovici, French Bureau de Contrôle SOCOTEC, France

Latin America

- Ms. Shirley Mattingly, Former Chair of the Emergency Management Committee, City of Los Angeles, United States
- Prof. Carlos E. Ventura, Dept. of Civil Engineering, University of British Columbia, Canada

8. Training seminars

A seminar on "Seismology and Earthquake Engineering" was held in support of the RADIUS initiative by the International Institute for Seismology and Earthquake Engineering (IISEE), Building Research Institute (BRI), Japanese Ministry of Construction, in Tsukuba, Japan from 11 May to 19 June 1998. It was financed by the Japan International Cooperation Agency (JICA). A RADIUS training seminar for city government officials was held from 22 to 30 June 1998 in Tokyo and Fukui, Japan. It was co-organized by the United Nations University (UNU), the United Nations Centre for Regional Development (UNCRD), and the IDNDR secretariat. They participated in the World Urban Earthquake Conference in Fukui City from 26 to 28 June as part of this seminar.

III. Development of Practical Tools

One of the major objectives of the RADIUS initiative was to develop two kinds of practical tools for urban seismic risk management, based on the experience of the nine case studies implemented worldwide. One of the tools is a set of Guidelines for Implementation of Risk Management Projects. It is expected that the guidelines will be used:

- To explain the philosophy and methodologies adopted by RADIUS;
- To assist in reading, understanding, and interpreting the RADIUS case study reports; and
- To provide general guidelines on how RADIUS-type Risk Management Projects can be implemented in other cities.

GHI developed the guidelines, based on the experiences in Quito (Ecuador), Kathmandu (Nepal), and the nine RADIUS case studies. The emphasis was put on:

A) How to involve decision makers, relevant organizations/institutions, communities, private sectors and scientists in a multidisciplinary way;

B) How to practically transfer scientific data into decision making information;

C) How to disseminate information and educate people, particularly through the mass media;

D) How to prepare a risk management plan as well as an action plan; and

E) What to do as the next step.

A computer programme for simplified Earthquake Damage Estimation was developed by the OYO Group (OYO Corporation and OYO International). It is intended that this programme will be used as a practical tool to aid users in understanding the seismic vulnerability of their own cities and encourage the start of disaster prevention programmes. The results of the application of the programme should be regarded as a preliminary estimation. The programme requires input of a simple data set and provides visual results with user-friendly prompts and help functions. Input data are population, building types, ground types, and lifeline facilities. Outputs are seismic intensity (MMI), building damage, lifeline damage and casualties, which are shown with tables and maps. Users can apply a historical earthquake such as Tangshan (1976, China), Kobe (1995, Japan), Kocaeli (1999, Turkey) and Chichi (1999, Taiwan) as a hypothetical scenario earthquake. The programme is available on CD-ROM and can be downloaded from the RADIUS home page, along with other outcomes, including guidelines and reports of the RADIUS project.

IV. Comparative Study on Urban Seismic Risk

In April 1998, the IDNDR secretariat and GeoHazards International (GHI) launched the Understanding Urban Seismic Risk Around the World (UUSRAW) project, with the participation of more than 70 member cities worldwide, that are seismically active. The study aimed:

A) To provide a systematic comparative assessment of the magnitude, causes, and ways to manage earthquake risk in cities worldwide;

B) To identify cities that are facing similar earthquake risk challenges and foster partnerships among them; and

C) To provide a forum in which cities could share their earthquake risk management experiences using a consistent, systematic framework for discussion.

The Earthquake Disaster Risk Index (EDRI) provided a framework for the UUSRAW project. The EDRI compared metropolitan areas according to the magnitude and nature of their earthquake disaster risk, which is analysed using five main factors, namely, "hazard", "vulnerability", "exposure", "external context" and "emergency response and recovery". The study

An International IDNDR Symposium on "The RADIUS Initiative - Towards Earthquake Safe Cities" was held from 11 to 14 October 1999 in Tijuana, Mexico. It was the closing event for RADIUS to present and discuss the results of the case studies, developed tools, the comparative study on urban seismic risk, and reports of similar efforts. It was co-sponsored by the City of Tijuana, the United Nations Centre for Regional Development (UNCRD), the United Nations University (UNU), and the IDNDR secretariat, and endorsed by the International Association for Earthquake Engineering (IAEE), the International Association of Seismology and Physics of the Earth's Interior (IASPEI), and the World Seismic Safety Initiative (WSSI). The objectives of the symposium were:

- To present achievements of RADIUS, including, among others, results of the nine case studies, developed tools, and the results of a comparative study on urban seismic risk worldwide;
- To discuss and identify the lessons learned throughout the initiative and other similar efforts; and
- To propose future activities for earthquake safe cities in the 21st century.

About 300 people participated in the symposium and discussed how to make cities safer against earthquake disasters. They enthusiastically participated in discussions throughout the four days, and learned lessons from the nine case studies and other similar efforts in the world. The developed tools for RADIUS-type projects and the result of the comparative study on urban seismic risk were introduced and assessed.

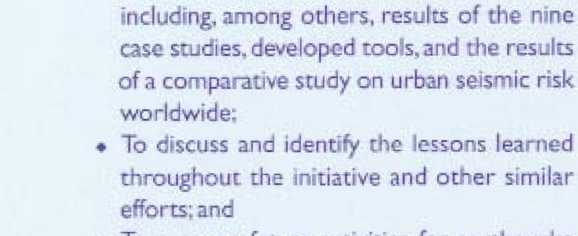

Figure 4: Opening ceremony of the International IDNDR Symposium on "The RADIUS Initiative - Towards Earthquake Safe Cities"

VII. Cost

The total cost of the RADIUS initiative was approximately US$ 2.5 million, mostly spent from the IDNDR trust fund, which was mainly covered by a contribution from the Government of Japan. Several international organizations such as UNU and UNCRD collaborated in funding and organizing the seminars and the symposium. One of the training seminars was financed by JICA. From February 1996 to January 1998, Kenji Okazaki, the RADIUS manager, was seconded by the Japanese Government through JICA. In addition, almost all of the nine cities allocated some additional local funding, including in-kind contributions to carry out the case studies. The training seminar for technical experts was sponsored by JICA. Participation of some experts in the RADIUS related meetings was covered by a United Nations fellowship. Tijuana City allocated local funds to hold the Symposium there in October 1999. It was very generous of the regional advisers to have participated in many workshops and meetings on a voluntary basis. Many experts of both member and associate cities also worked on a voluntary basis to collect data on their city and to prepare their city report. A lot of people participated in the RADIUS symposium at their own expense.

VIII. Evaluation

Evaluation of the nine case studies was made in a simplified way at the final stage of RADIUS. This evaluation was subcontracted to Tobin & Associates, California, United States, which had not previously been involved in RADIUS so that it might fulfill the assignment objectively. A questionnaire was prepared just before the RADIUS symposium, and distributed to the representatives of the case-study cities during the symposium.

The nine case-study cities greatly raised public awareness as their activities were broadly covered by the mass media and information was disseminated to communities. They built up close partnerships between scientists and local governments. The outcome of

Chapter 2

Case Studies in Latin America
(Antofagasta, Guayaquil, Tijuana)

Carlos Villacis and Cynthia Cardona, GeoHazards International (GHI), United States

Introduction

In 1996, the United Nations secretariat of the International Decade for Natural Disaster Reduction (IDNDR) launched the RADIUS initiative to assist in reducing the effects of seismic disasters in urban areas, particularly in developing countries. Working in close collaboration with local people in nine cities around the world, the project evaluated the seismic risk of those cities, prepared risk management plans based on those evaluations, and most importantly, raised awareness of the local community on seismic risk. Significant progress was made towards incorporation of the entire community in risk management activities. Citizens and institutions participated actively throughout the project, and committed efforts were made to set up conditions that will allow the establishment of long-term initiatives to reduce seismic risk. The project made good use of existing information and counted on the knowledge, insight and expertise of local people to ensure that the results reflect local conditions.

This report describes the implementation and achievements of the RADIUS initiative in the Latin American cities of Antofagasta (Chile), Guayaquil (Ecuador) and Tijuana (Mexico). GeoHazards International, a non-profit organization working to reduce earthquake risk in the world's most vulnerable communities, was in charge of the implementation of RADIUS in Latin America.

The RADIUS initiative

The RADIUS case studies were designed with the specific objective of initiating long-term risk management processes in the cities where the project was implemented. The case studies had three main tasks:

- Assessment of the city's seismic risk and development of an earthquake scenario describing the effects of a probable earthquake on the city;
- Preparation of an action plan based on the results of the risk assessment, describing activities to reduce the city's seismic risk; and
- Creation of conditions that will facilitate the institutionalization of risk management activities in the city.

In order to produce realistic results and raise the awareness of the communities on the seismic risk, the project ensured that representatives of all sectors of the society were actively involved throughout the project. Furthermore, the project ensured that the general public was well informed about the project's achievements and activities through coordination with the local media.

The project's main activities were collection of existing data, estimation of potential damage, and preparation of an action plan. Because the active participation of the community was crucial to the project's success, the programme of activities included repeated meetings in which key representatives of the community were first informed about the project's progress and then were asked to comment.

RADIUS in Latin America

Three cities were selected in Latin America for the RADIUS initiative: Antofagasta (Chile), Guayaquil (Ecuador) and Tijuana (Mexico). These three cities make up an interesting and diverse group. Antofagasta is a relatively small city of 220,000 inhabitants, whose existence is dependent on mining. Antofagasta last experienced a destructive earthquake (Ms 7.3) in 1995.

Figure 3. Road damage estimated for Antofagasta, Chile.

people would die and almost 7,000 would be injured, requiring hospitalization. An estimated 43,000 people would be left homeless by the disaster. The estimations also show that it would take at least 6 months to clear the debris.

In Guayaquil, it was estimated that more than 26,000 people would die and almost 53,000 would be injured, requiring hospitalization. It would take about 1 week to start providing emergency housing after the disaster, 1 month to start providing temporary housing and up to 2 years to reconstruct or repair the damaged houses. The estimations also show that the city would be without power for up to 1 week and without potable water for almost 2 weeks.

The estimation prepared for Tijuana indicated that 1 percent of the residential buildings, where 25,000 people live, would be destroyed and 35 percent of the residential buildings, providing dwellings to 325,000 people, would suffer severe damage. As a result, more than 18,000 people would die and almost 37,000 would be injured, requiring hospitalization. An estimated 130,000 people would be left homeless by the disaster. The estimations also showed that it would take about 1 month for the water supply system to recover 30 percent of its pre-earthquake capacity and more than 2 months to recover completely.

The results of the damage estimation were used to prepare a preliminary earthquake scenario. The scenario was presented and discussed by representatives of the various sectors of the community during the scenario workshops that were held in each city with the following objectives:

- Presentation of the results of the seismic damage estimations to the community, with the request for comments;
- Estimation of the impact of the estimated damage on the city activities;
- Development of ideas for actions to reduce the impact of an earthquake on the city's life; and
- Discussion of the institutionalization of risk-management activities in the city.

The information produced in the workshop was used to prepare the final version of the earthquake scenario that was published and distributed to the community. Figure 4 shows some of the participants of the scenario workshop in Guayaquil.

Planning

The results of the damage estimation and the ideas for risk management activities produced during the scenario workshops were used to prepare action plans to reduce each city's seismic risk. Frequent working meetings were carried out with city officials in charge of implementing risk management activities in order to define objectives, tasks, schedules, and budgets of the activities provided for the action plan.

The proposed activities addressed the three stages of disasters: (a) pre-disaster, when preparedness and mitigation are important; (b) during and immediately after the disaster, when the emergency response capability is depended on; and (c) post-disaster, when the city's capability to recover in the shortest possible

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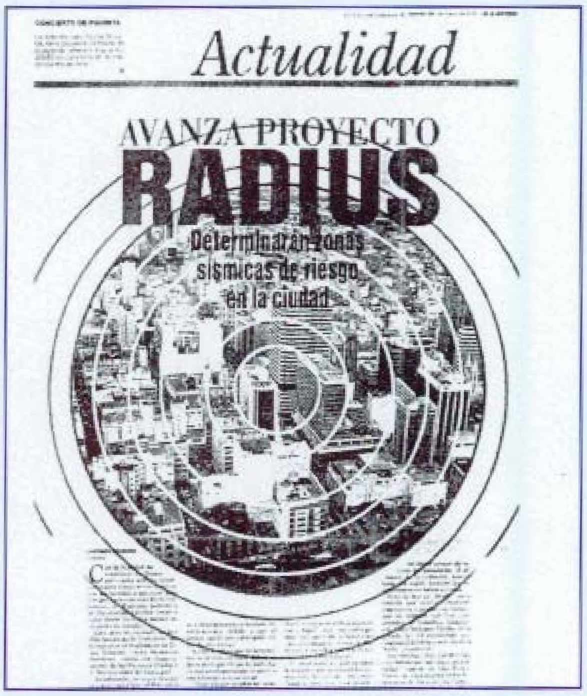
EL MERCURIO DESARROLLO REGIONAL A-2

POSIBLES DAÑOS EN CONSTRUCCIONES

¿Qué pasará con otro terremoto?



Actualidad

AVANZA PROYECTO RADIUS

Determinarán zonas sísmicas de riesgo en la ciudad

Figure 5: Newspaper articles about RADIUS in Antofagasta and Guayaquil.

Chapter 3

Case Studies in Asia
(Bandung, Tashkent, Zigong)

Fumio Kaneko, Rajib Shaw and Jichun Sun, OYO Corporation/INCEDE, Japan

Introduction

Three cities were chosen from Asia out of 27 pre-selected cities for RADIUS case studies. These are Bandung (Indonesia), Tashkent (Uzbekistan), and Zigong (China). All three cities are very important in their respective countries and regions, although the infrastructures and local conditions are quite different from one city to another.

Bandung is a tropical resort with a cluster of universities and research institutes. It is a rapidly growing city, the largest in the Western Java Province, it has a very high population growth rate and is one of the most important business and trading center in this region. In contrast, Tashkent is the capital of Uzbekistan, and one of the most strategic cities in Central Asia for education, culture, trading and business. Tashkent itself contributes more than one-fifth of Uzbekistan's total GDP. Zigong is a city in southern China, located in the Szechwan Province within mountain ranges. The city is a major industrial center for mechanical and chemical engineering, and salt production. Dinosaur fossils and an ancient salt producing well (more than 1,000 metres deep) are major attractions. Figure 1 summarizes the demographic features of these three cities.

Urban policy and disaster management

Although all the case-study cities are well equipped with modern infrastructures, they differ in the level of understanding of disaster issues, which is reflected in their future growth plan. A brief description of each city is given below.

In Bandung, there is a single coordinating office for emergency response, which becomes active during disasters, receiving reports and transmitting them to other agencies for emergency response. Disaster management is marginal in the urban growth plan. Because annual flooding is the most frequent disaster in the city, the focus is on flood disasters and seismic considerations are almost neglected. Bandung, a relatively new city, has no record of damaging earthquakes since its establishment almost 100 years ago. Therefore, the general awareness of citizens and decision makers of seismic risk is very low.

In contrast, Tashkent has experienced damaging earthquakes, and seismic risk issues are taken into consideration in urban planning. After the 1966 Tashkent earthquake, a special governmental commission was created comprised of ministries, scientists and engineers. There is also the Department for Extraordinary Situations in the Tashkent city government. Disaster management is carried out in accordance with a civil defence action plan, including emergency preparedness. The Uzbekistan Academy of Sciences coordinates earthquake research through the

City	Area (km²)	Status	Population (in millions)	Annual growth (pop.)	GDP contribution
BANDUNG	168	Provincial capital	2.06	3.48%	9.13% (regional GDP)
TASHKENT	326	National capital	2.08	2.00%	21.00% (national GDP)
ZIGONG	817	Industrial city	3.13	0.74%	7.60% (regional GDP)

Figure 1. Basic demographic data of the case-study cities in Asia.

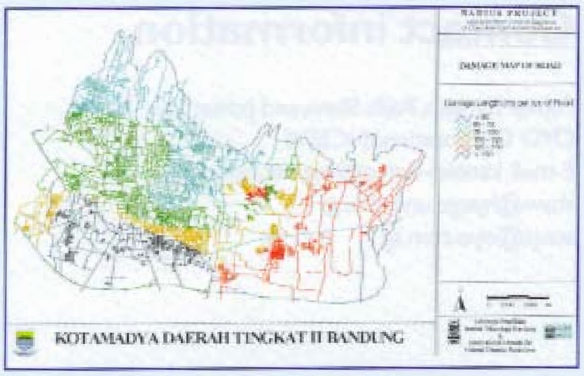


Figure 2. Damage to the road network in Bandung.

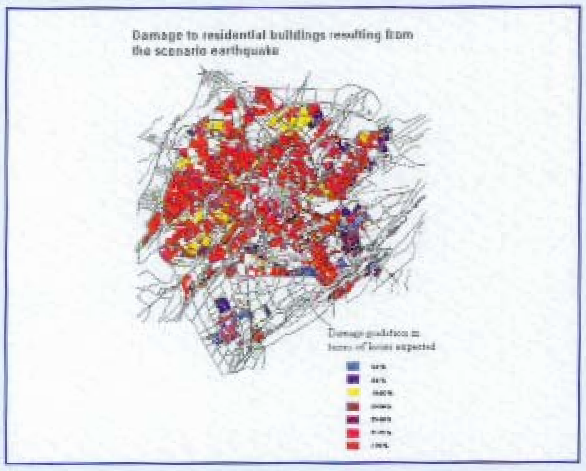


Figure 3. Damage to residential buildings in Tashkent from the scenario earthquake.

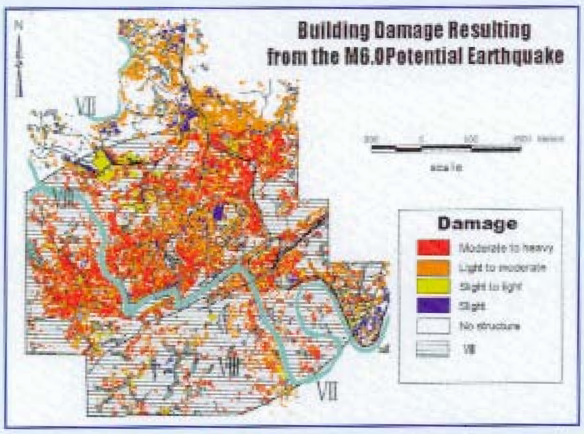


Figure 4. Damage to buildings in Zigong from the scenario earthquake.

The interview results and damage estimation output were compiled to prepare the final scenario in simple terms and written by professionals. The scenario was described in a time frame of post-earthquake and recovery over time. This scenario was presented in a workshop held between October and November 1998 in each of the case-study cities.

Earthquake risk management

The process of action planning began with identification of problems during preparation of the earthquake scenario and identification of the vulnerable elements in the city. Analyses at different stages are necessary in order to take into account available resources and the city's priorities. The overall aim of the risk management plan is to assist city decision makers on decisions about present infrastructure, existing elements, and future development. It aims to help mitigate earthquake risk through community participation and disaster education. For this, different priority areas were chosen for each city.

Emphasis has been given to improvement of emergency response planning and capability, public awareness of earthquake risk issues, seismic performance of buildings and infrastructure (including lifelines, critical buildings, and school buildings), and safety measures for school children. To achieve these objectives, several actions have been proposed. These actions include long-term actions before an earthquake (prevention and preparedness), immediate actions after an earthquake (emergency response and relief), and long-term actions after an earthquake (rehabilitation and restoration).

The current status of the actions and responsibilities related to the seismic disaster were first listed and reviewed. Intensive interviews were carried out with concerned organizations, and the results were used to prepare the draft action plan. This integrated plan was then presented in the workshop in April-June 1999, and the interdependence of different agencies were studied. Group discussions were held to reach consensus on the

Chapter 4

Case Studies in Africa, the Middle East, and Eastern Europe
(Addis Ababa, Izmir, Skopje)

Philippe Masure, Pierre Mouroux, Christophe Martin, Bureau de Recherches Géologiques et Minières (BRGM), France

Introduction

The three selected cities for Africa, the Middle East, and Eastern Europe are important and fast growing cities with very different development and characteristics.

Addis Ababa

Addis Ababa is the capital of Ethiopia. It was founded 110 years ago in central Ethiopia. The area of the greater metropolitan city is about 54,000 hectares, with a population of 2.9 million and an annual growth rate of 3.8 percent. More than 95 percent of the population live in single-story residential units with an average of two rooms. The city's development depends largely on manufacturing industries, followed by trade and services. The city is located on the western edge of the Ethiopian rift system. Several earthquakes have occurred along the rift and its vicinity and were felt in the city. Notable cases are:

- 1906 earthquake in Langano (epicenter 110 km from Addis Ababa) with an intensity of Mercalli scale 8 in the city, at a time when fewer than 50,000 people were living in Addis Ababa; and
- 1961 Kara Kore earthquake (epicenter 150 km from Addis Ababa), with an intensity of Mercalli scale 7 felt in Addis Ababa, which caused some damage in the city.

There is a high vulnerability of buildings since more than 80 percent are made with wood, mud, thatch, and reeds (Chika houses), and do not respect the building codes. Numerous, masonry, schools, hospitals, and bridges would not withstand even a medium-level earthquake. National earthquake resistant regulations exist since 1992, but these regulations are not enforced. Using the national disaster prevention and preparedness management plan, the Addis Ababa Foreign Relation and Development Cooperation Bureau serves as the focal institution. For coordination and establishment of contact points in each participating organization, nodal officers from all relevant government agencies of the city administration are assigned as contact persons to the focal institution (FRDCB).

Izmir

Izmir is a wealthy Turkish city (third in population and second in economic activities) on the west coast with important activities in industry, trade, tourism, health, education, and culture. Its population is about 3 million and has an annual growth rate of 3 percent, with considerable migration from eastern Turkey. It spreads over 90,000 hectares. The metropolitan municipality assembly of Izmir includes nine municipalities and deals with policies of transportation, city planning, land-use and metropolitan planning, road construction, water distribution, and waste water collection.

Throughout its history, the city has experienced several strong earthquakes, the latest in 1994. The ancient city, Smyrna was destroyed several times. On 10 July 1688, an earthquake killed 16,000 to 19,000 people. The earthquakes on 26 June 1880 and 31 March 1928 caused heavy damage in the city. As a result of the 1 February 1974 earthquake, 47 apartment buildings were damaged, two people died and seven were seriously wounded. The magnitude of the 1992 earthquake was Richter scale 6.0 with an epicenter of 50 km; there were about 100 buildings reportedly damaged.

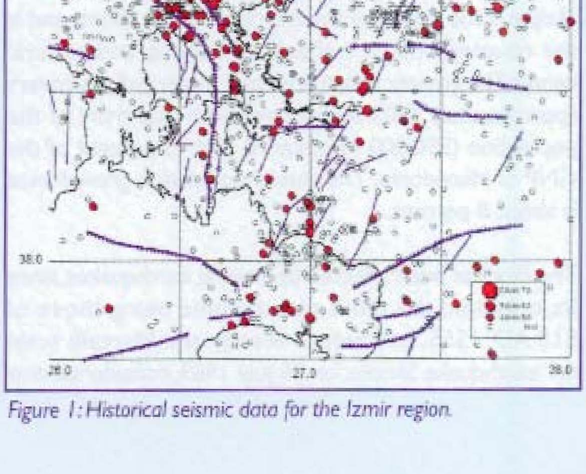


Figure 1: Historical seismic data for the Izmir region.

Implementation of RADIUS

The local conditions for the implementation of the RADIUS initiative were very different for the three cities. In Addis Ababa there are few specialists and limited practice in seismology and earthquake engineering, low awareness of earthquake disaster risk at the political level, and limited financial resources. There is a higher level of development, risk awareness, risk mitigation in urban activities, and level of scientists in charge of project implementation in the other two cities. As a result, Addis Ababa was selected for a full case study, while Izmir and Skopje were chosen for auxiliary case studies.

Taking into account the absence of previous seismic risk assessment in Addis Ababa, a full case study was made using basic RADIUS methodology. It was necessary to be more precise in the scenarios for the two other cities selected for auxiliary case studies and to adapt the action plans to local initiatives in prevention and urban planning. The Bureau de Recherches Géologiques et Minières (BRGM) judged that the previous environmental programmes in Izmir (UNEP project) and the revision of the master plan in Skopje were potential and important opportunities for the integration of a seismic risk reduction programme into the sustainable development of these cities. For that reason, it was decided to apply the French GEMITIS methodology for characterization of the urban areas, classification of its main components, and an assessment of their vulnerability. The basis of this methodology is to consider not only lives and physical elements at risk but also non-material and social aspects (economic and functional activities, city government, identity, local culture, town planning, and development) that can be important issues in the event of a seismic disaster. In this case, risk reduction is integrated into development planning.

Finally, during implementation of the RADIUS project local steering committees suffered the indirect effects of war in Ethiopia and Macedonia, and political changes in Turkey and Macedonia. Because of these special circumstances, there were delays in implementation of the case studies. In spite of these difficult conditions, the results have been very positive.

Results

Addis Ababa

Under the direction of the municipal Department for Urban Planning and the Geophysical Institute, five working groups were formed:

- Regional seismic hazard assessment and definition of reference earthquake and groundmotion
- Local seismic hazard assessment: influence of soils on ground motion, slope instability
- Building damage assessment
- Water system damage assessment
- Roads and bridges damage assessment

The risk management plan focused on the following eight objectives of short- and long-term goals to integrate earthquake disaster in Addis Ababa:

- Improvement of emergency response
- Improvement of awareness of issues related to earthquake risk
- Improvement of the seismic performance of existing buildings
- Improvement of the seismic performance of lifelines infrastructure and services
- Integration of seismic resistance into land-use
- Organization of a system of regulation of construction
- Increase in knowledge of earthquake phenomena, consequences and mitigation techniques
- Assessment of local and international financial resources to continue the programme

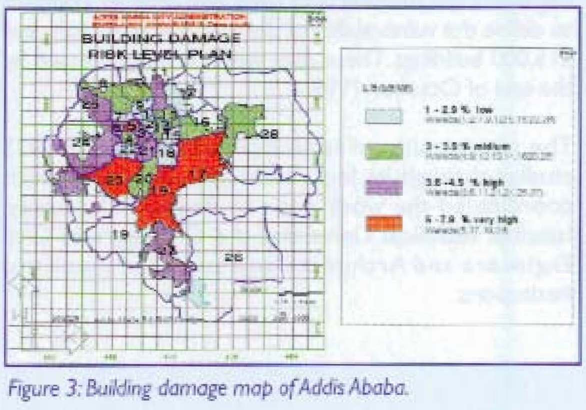


Figure 3: Building damage map of Addis Ababa.

municipality the department for urbanism is in charge of preparedness, emergency management, and contingency planning. Good communication between these services has insured close collaboration between the project and political officials.

It was decided to concentrate the activities of the RADIUS project on:

- Urban development plan for lifeline components, health care systems, and schools;
- Emergency activities of transportation, search and rescue;
- Collective measures to improve the functioning of the aforementioned systems;
- Individual counter measures for vulnerable important facilities;
- Improvement of regulation and insurance systems: building code, monitoring of construction and insurance; and
- Dissemination of the scenario and action plan.

The RADIUS study was an opportunity to enforce the building code, to strengthen the mechanism for technical supervision of design and construction, through the physical plan and the master plan for the city of Skopje. Links between the government and municipal departments involved in the planning were considerably strengthened during the project.

In order to improve the present situation, it was decided:

- To increase national coordination between sectors;
- To include the results of the Radius project in the preparation of the master plan and of the physical plan; and
- To institutionalize efforts by improving the laws and by creating a committee for the development of a multidisciplinary and multi-risk management plan.

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Chapter 5

Guidelines for RADIUS-Type Risk Management Projects

Carlos Villacis and Cynthia Cardona, GeoHazards International (GHI), United States

Background

The RADIUS initiative was launched by the IDNDR secretariat to promote worldwide activities for reduction of seismic disasters in urban areas, particularly in developing countries. One of the main objectives of the project was to develop practical tools for urban risk management. One of these tools is a set of guidelines for the implementation of risk management projects that describe the methodology employed by the RADIUS initiative. The guidelines include lessons learned during the implementation of case studies in nine cities.

The 18-month case studies were implemented using methodology developed by GeoHazards International (GHI) for risk management projects in developing countries. This methodology has been developed by GHI through projects in Quito (Ecuador) and Kathmandu (Nepal).

Purpose of the guidelines

The guidelines for the implementation of RADIUS-type risk management projects should be used to:

- Explain the philosophy and methodology adopted by the RADIUS risk management projects;
- Assist in interpretation of the reports prepared for the case studies; and
- Provide guidelines on how to implement RADIUS-type risk management projects in other cities.

RADIUS methodology

Urban seismic risk is steadily increasing worldwide, especially in developing countries. Among the reasons for this increase are worldwide urbanization, lack of planning and resources to accommodate rapid urban growth, lack of appropriate building and land-use codes or lack of mechanisms to enforce them, and most importantly, lack of awareness by the community and its leaders. This lack of awareness has kept communities, institutions and citizens from supporting risk management initiatives. In most cases, the community instead contributes to an increase of risk by making uninformed decisions due to the lack of awareness and information.

Most of the existing risk management techniques and methodologies have been developed in industrialized countries and cannot be directly transferred to developing countries. There must be an adaptation of these existing methodologies to the conditions found in countries and cities of the world. For this adaptation to be successful, the active participation of those most aware of the local social, economic, political, and cultural conditions - the local community - needs to be ensured.

Another characteristic of risk management efforts in developed and developing countries is the emphasis on the preparation of very accurate estimates of the losses and the effects that a natural disaster could cause in a city. There have been few examples of the actual use of the results of these preparations by leaders and members of the community to reduce risk. Most of these studies are not even known by the community that could benefit from them. There are many instances in which efforts have been duplicated and resources have been spent without producing tangible improvement.

With all of these considerations in mind, GeoHazards International has developed a methodology for the implementation of risk management projects in developing countries. This methodology has the following characteristics:

- Optimization of the time and resources needed to prepare damage estimates and realistic risk management plans;
- Preparation of sound damage estimates that identify the main factors contributing to a city's earthquake risk;
- The best possible use of existing information and of local expertise;

Assessment of a city's urban risk

Estimation of the potential damage that would be caused by a hypothetical earthquake was carried out in a theoretical step and a non-theoretical step. The theoretical estimation was performed by combining the seismic intensity distribution, estimated for the hypothetical earthquake, with the inventory of the city's structures and infrastructure. This combination was performed using vulnerability functions (see figure 2) developed to reflect the seismic behavior of the city's structures and infrastructure.

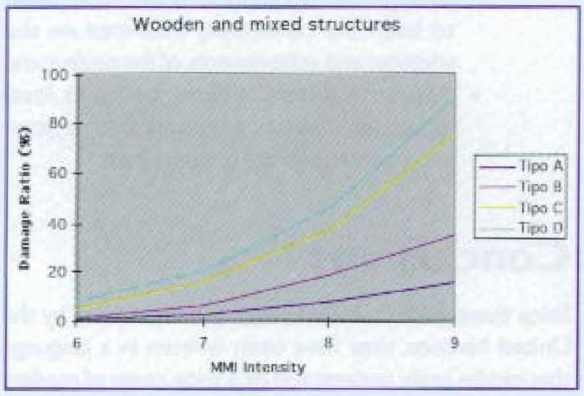

Figure 2. Example of vulnerability functions for the estimation of building damage. ("Tipo" = "Type")

Figure 3. Example of an interview with officials in charge of the city services.

Figure 4. Some of the participants of the scenario workshop in Zigong.

The non-theoretical estimation was performed through a series of interviews (see figure 3) with those responsible for the city's systems and services. The information collected in these interviews allow for the characteristics of the city systems to be included in the damage estimation.

The results of the damage estimation were used to prepare a preliminary earthquake scenario that was presented and discussed by representatives of the various sectors of the community during the scenario workshop (see figure 4). The information produced in the workshop was then used to prepare the final version of the earthquake scenario that was distributed to the community.

The guidelines describe in detail the following steps of the risk assessment process:

- Preparation and data collection
- Kick-off meeting to introduce the project to the community
- Hazard assessment
- Vulnerability assessment
- Damage estimation (theoretical)
- Damage estimation (non-theoretical)
- Preparation of the earthquake scenario
- Implementation of the scenario workshop
- Dissemination of the earthquake scenario

Chapter 6

A Tool for Earthquake Damage Estimation

Fumio Kaneko and Jichun Sun, OYO Group, Japan

Based on the activities of nine case studies of the two year RADIUS project, it has been observed that there is a wide variation in earthquake understanding, technical competency, earthquake risk preparedness, and emergency response and recovery countermeasures. In developing countries, awareness of earthquake risk must be promoted in addition to provision of advice.

The main purposes of the RADIUS project were to raise awareness and provide practical tools for earthquake risk reduction. This tool has been developed from the experiences of RADIUS case studies. The tool has been simplified in order to promote understanding, of the process and earthquake damage estimation, by decision makers and the public. Because earthquakes and natural disasters differ widely, the tool should be used for only preliminary estimation, requiring further validation and more detailed studies. It is hoped that this tool will assist many users to understand the seismic vulnerability of their cities and to assist starting preparedness programmes for future earthquake disasters.

The tool is a computer programme running on the widely available Excel 97. It is not a Geographic Information System (GIS) type of programme. The user needs to input the following information:

- Shape of target region by meshes
- Total population and distribution
- Total buildings, building types and their distribution
- Ground condition (soil type)
- Total numbers of lifeline facilities
- Choice of scenario earthquake and its parameters

The programme then validates the input data and performs analysis. Output from the analysis includes:

- Seismic (ground shaking) intensity, such as PGA and MMI Intensity
- Building damage
- Lifeline damage
- Casualties, such as number of deaths and injuries
- Summary tables and thematic maps showing the result

The tool requires only simple input data and will provide visual results with user-friendly process with help and instruction documents. For more active users, a GIS View Sample of Bandung has been prepared since the GIS tool is useful for more detailed studies.

All the activities of the RADIUS project have been summarized on a CD-ROM together with this tool, which can be used as a tutorial for users. The CD-ROM includes the RADIUS project description, reports from the case-study cities, report on the comparative study, the guidelines for RADIUS-type projects, proceedings of the RADIUS symposium, and other reports.

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Chapter 7

Understanding Urban Seismic Risk around the World:

A comparative study of the RADIUS initiative

Carlos Villacis, Rachel Davidson and Cynthia Cardona, GeoHazards International (GHI), United States

Introduction

Earthquakes are infrequent, so no single city has suffered many earthquake disasters. Every city has much to gain through the sharing of their resources and experiences with earthquakes and earthquake risk management. To use the untapped potential of inter-city collaboration, the secretariat of the International Decade for Natural Disaster Reduction (IDNDR) and GeoHazards International launched in April 1998 the Understanding Urban Seismic Risk Around the World (UUSRAW) project. The UUSRAW project was implemented as part of the RADIUS initiative. The 18-month project was designed to help cities around the world compare their earthquake hazard and to share their experiences and resources in working to reduce the impact of future earthquakes.

Project objectives

The objectives of the UUSRAW project were to:

- Provide a systematic comparison of the magnitude, causes, and ways to manage earthquake risk worldwide;
- Identify cities facing similar earthquake risk challenges and foster partnerships among them; and
- Provide a forum in which cities can share their earthquake and earthquake risk management experiences using a systematic framework for discussion.

Project participants

The IDNDR Secretariat invited seismically active cities around the world to participate in the UUSRAW project. The city governments of 74 cities from 50 countries expressed interest in participating (see figure 1).

Figure 1: Map of the 74 cities that applied to the UUSRAW project

City representatives

For each of the 74 cities that applied to participate in the study, a scientist served as city representative. The city representatives were the key to the project's success. Using their personal knowledge, connections and resources, they gathered the information required to develop an earthquake risk profile of their respective cities. They formed partnerships and shared comments about the process of gathering information, the proposed methodology, and the project.

Project coordinators

The project coordinators developed worksheets to gather information from the city representatives, compiled and analyzed information for each city, moderated an internet forum for city representatives and international advisors, kept participants informed of the project's status, and wrote the final report and city profiles.

International advisors

Several international advisers participated in the internet forum with the city representatives and the project coordinators. They answered questions and shared their experience and knowledge of earthquake risk.

For various reasons, only 20 of the 74 cities participated actively in all phases of the project, collecting the requested information and participating in discussions. These 20 cities represent a diverse group with respect to their size, seismicity, collateral hazard potential, structural types, economic and political situations, and social and cultural characteristics.

Earthquake risk and risk management assessment

The report provides comparative assessments of earthquake risk, each cities contributing factors, and the state of risk management in each participating city. Because the information for each city was gathered using the same worksheets, systematic descriptions of the key elements of a city's risk and risk management efforts are also included.

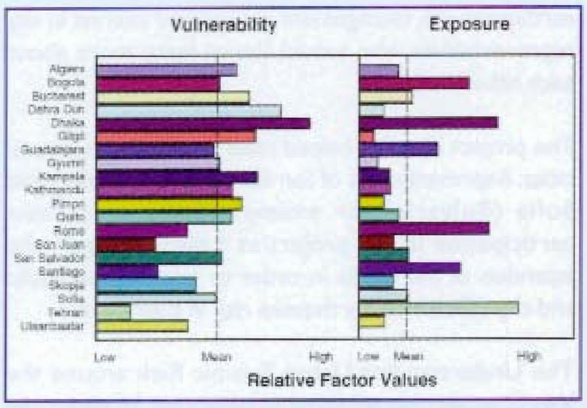

Figure 2: Sample results of exposure and vulnerability factor values for the twenty cities actively involved in all phases of the project. While Dhaka (Bangladesh) shows the highest vulnerability factor value of the sample, Tehran (Iran) has the highest exposure factor value. Results are relative to the sample.

City profiles

For each of the participating cities, the project coordinators developed a two-page profile of the city's earthquake risk, its causes, and efforts undertaken to reduce it. Each city profile includes a map of the greater metropolitan area, basic information about the city, significant historical developments in the seismic building codes, a graph of the city's population growth, a list of significant earthquakes, a comparative analysis describing the city's earthquake risk in relation to other cities, a list of agencies involved in earthquake risk management, and examples of efforts undertaken to reduce the city's earthquake risk. Figure 3 presents an example of a city profile for Algiers, Algeria.

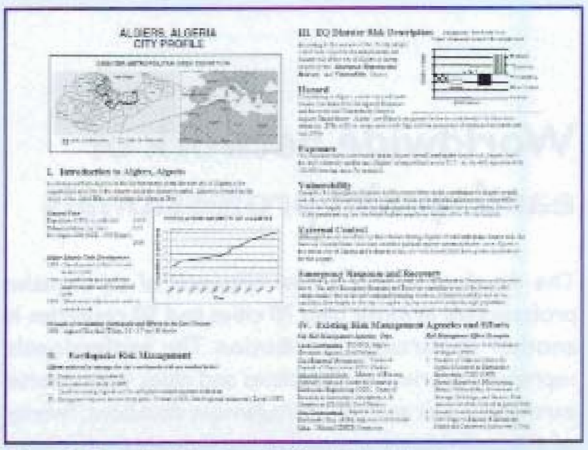
ALGIERS, ALGERIA
CITY PROFILE

Figure 3. Example of a city profile for Algiers, Algeria.

Risk management effort case studies

The final report also includes more than 65 risk-management effort case studies from 26 cities. Together they cover a variety of types of efforts. These efforts implemented by different groups (local government agencies or the private sector), target a variety of groups (schools, transportation network, small businesses) and needs (emergency response planning, infrastructure strengthening, public education), use different forms of implementation (establishing an organization, developing a new technology, passing legislation), and they cover different areas (local, state, national). The compilation can be expanded and updated over time and provided city representatives with specific risk management ideas and contact information should they wish to obtain more information.

Feedback

The report also summarizes the comments provided by city representatives during the project. This input was compiled from responses to a worksheet designed to solicit feedback, discussion in the internet forum, and meetings during the RADIUS symposium that complemented the project's internet discussion. Comments were requested on the EDRI methodology, project design, potential uses and users of the study's results, global earthquake risk assessment in general, and the potential for conducting related work in the future.

Chapter 8

Evaluation of the RADIUS Case-Studies Project

L.Thomas Tobin, Tobin & Associates, United States

Introduction

This report evaluates the achievements of the RADIUS case studies, city-level projects, and the methodology used for the case studies. The findings are based on confidential opinions of project participants in response to a 52-question questionnaire. The case-studies project is an earthquake risk mitigation planning project, and as is true for all planning efforts, the planning process is as important as the resulting plan. The methodology and process influence the long-term achievements of the project. It is too early to expect that implementation efforts would have achieved significant successes, but successes were described. These initial successes and the positive tone of the responses are encouraging, but success depends on the inspiring long-term commitments to mitigating earthquake risk.

Objectives

The ultimate objective of the RADIUS case studies project is to reduce the physical, economic and social damage in the case-study cities. However, each case study was expected to meet the following city-specific objectives:

- To raise the awareness of seismic risk among decision makers and the public;
- To transfer appropriate technologies to the cities;
- To create local institutional support needed to sustain the earthquake risk mitigation plan;
- To promote multidisciplinary collaboration among the local government and between government officers and scientists; and
- To promote worldwide interaction with other earthquake-prone cities to share their valuable experiences.

The case studies were expected to meet the following specific goals:

- Develop a seismic damage scenario which describes the consequences of a possible earthquake; and
- Prepare a risk management plan and propose an action plan for earthquake disaster mitigation.

Evaluation of achievements

The case study goals, *to develop a seismic damage scenario which describes the consequences of a possible earthquake* and *prepare a risk management plan and propose an action plan for earthquake disaster mitigation*, were achieved. The local and RADIUS team respondents described the use of scenarios and referred to the action plans. These products, scenarios, and plans, served as a means to address the city-specific objectives.

The first objective, *to raise the awareness of seismic risk among decision makers and the public*, was achieved. Responses described increases in awareness and support for reducing earthquake risk and for emergency management among government officials and the general public. Increases in awareness and support for reducing earthquake risk and for emergency management were noted among business leaders, but nearly half of the responses indicated no change. Media awareness was improved. Maintaining awareness is critical to carrying out the action plans.

The second objective, *to transfer appropriate technologies to the cities*, was met. Responses endorsed the RADIUS methodology. The scenarios produced useful results that were appropriately accurate. The RADIUS "tools" include the planning process. The use of international institutes to transfer technology was successful. A few respondents suggested that more contact time was needed. The initiative empowered local professionals to use their knowledge.

RADIUS CD-ROM

Includes RADIUS tools, demonstrations, and final reports

UNITED NATIONS

International Decade for Natural Disaster Reduction
IDNDR
1990-2000
Building a Culture of Prevention

International Strategy
ISDR
for Disaster Reduction

United Nations Initiative towards Earthquake Safe Cities

RADIUS

Risk **A**ssessment Tools for **D**iagnosis of
Urban Areas against **S**eismic Disasters

Prepared by OYO Group

How to start

1. Load RADIUS CD-ROM in CD-ROM drive
2. In Window's Explorer, go to CD-ROM drive
3. Double-click "RADIUS.htm".