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

NOTE

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
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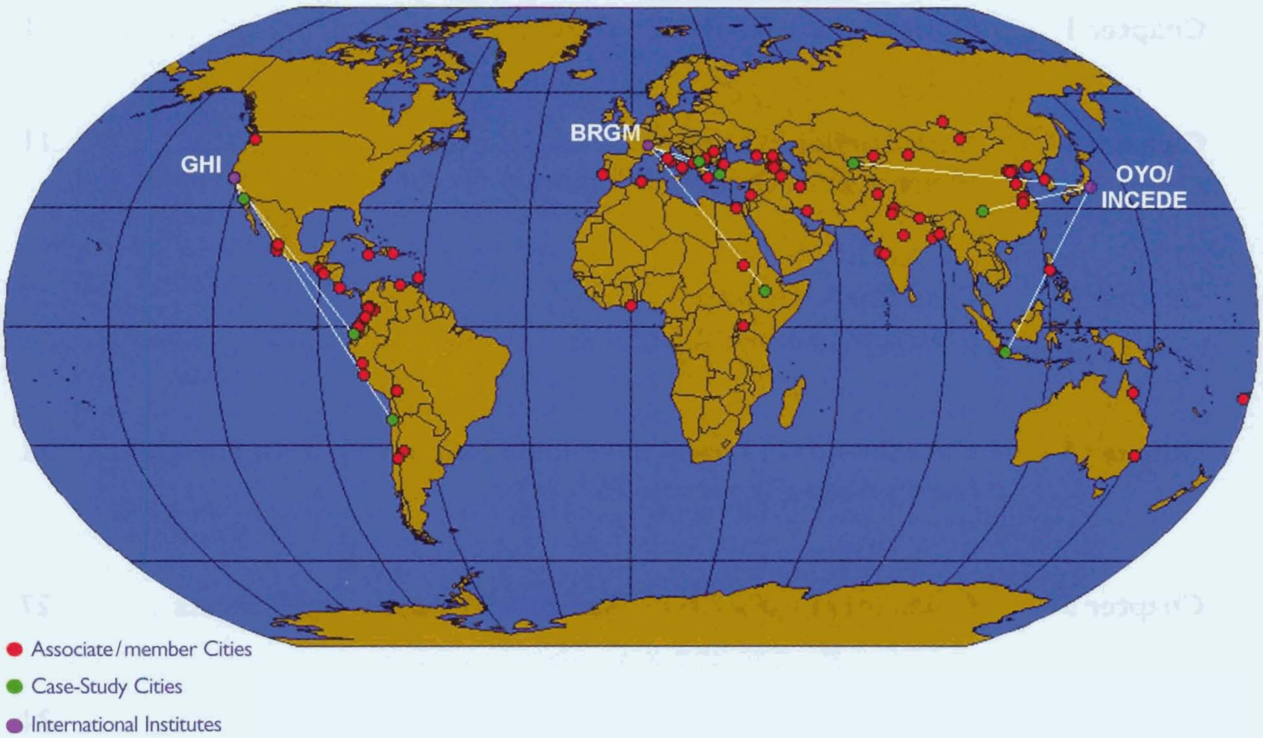
United Nations Initiative towards Earthquake Safe Cities



Risk **A**ssessment Tools for **Di**agnosis of **U**rban Areas against **S**eismic Disasters

Chapter 1

Outline of the RADIUS Initiative

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

1. 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)

Year 1999

- Implementation of the case studies (continued)
- Action plan workshops
- Comparative study on "understanding urban seismic risk in the world" (continued)
- Development of practical tools
- RADIUS Workshop in the IDNDR Programme Forum in Geneva (July)
- International RADIUS Symposium in Tijuana, Mexico (October)

Year 2000

- Publications (see below)
- Evaluation of the case studies

Publications

A) Two brochures - outline and outcome of the RADIUS initiative

B) Summary of RADIUS with CD-ROM

C) Full reports:
Volume I - Project document and the developed tools
Volume II - Nine case studies

II. Case Studies

1. Objectives

The direct objectives of the case studies were:

A) To develop **an earthquake damage scenario** which describes the consequence of a possible earthquakes; and

B) To prepare **a risk management plan** and propose an **action plan** for earthquake disaster mitigation.

The case studies aimed:

A) To raise the awareness of decision makers and the public to seismic risk;

B) To transfer appropriate technologies to the cities;

C) To set up a local infrastructure for a sustainable plan for earthquake disaster mitigation;

D) To promote multidisciplinary collaboration within the local governments as well as between government officers and scientists;

E) To promote worldwide interaction with other earthquake-prone cities.

In order to develop earthquake damage scenarios, the physical damage to buildings and infrastructure, human losses in the city, as well as the effects on urban functions and activities were first estimated. The earthquake damage scenario describes the various stages of the city's damage during and after a probable earthquake. Human loss was estimated, based on the damage of buildings and infrastructure, the efficiency of relief activities, and outbreaks of fires.

A risk management plan was prepared, based on the scenario. It contained the following aspects:

- Urban development plan to mitigate seismic disasters;
- Improvement plan for the existing urban structures such as reinforcement (retrofitting) of vulnerable buildings and infrastructures, securing of open spaces and emergency roads, and designation of areas for evacuation;
- Emergency activities such as life saving, fire fighting, emergency transportation, and assistance to suffering people;
- Individual countermeasures for important facilities; and
- Dissemination of information to, and training of, the public and private sectors.

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)

City	Addis Ababa	Anto fagasta	Bandung	Guayaquil	Izmir	Skopje	Tashkent	Tijuana	Zigong
Area	54 km^2	90 km^2	168 km^2	340 km^2	90 km^2	1,860 km^2	326 km^2	250 km^2	4,373 km^2
Population (in millions)	2.90	0.22	2.06	2.10	3.00	0.55	2.08	1.25	3.13
Population growth	3.80%	3.00%	3.48%	3.20%	3.00%	8.00%	2.00%	6.02%	0.74%

Figure 1. Basic information on the nine RADIUS cas-study cities.

Case-study cities

Full case study (5 cities)
Addis Ababa (Ethiopia), Guayaquil (Ecuador), Tashkent (Uzbekistan), Tijuana (Mexico), Zigong (China)

Auxiliary case study (4 cities)
Antofagasta (Chile), Bandung (Indonesia), Izmir (Turkey), Skopje (TFYR Macedonia)

4. STC subcommittee for RADIUS

At the ninth Session of the Scientific and Technical Committee for IDNDR (STC), which was held in Geneva in October 1997, the "Subcommittee for RADIUS" was newly established. Its role was to review the RADIUS activities and to provide the IDNDR secretariat with advice and comments. The members were as follows:

- Dr. Tsuneo Katayama (Chair), Director-General, National Research Institute for Earth Science and Disaster Prevention, Japan
- Mr. Robert Hamilton, Chairman of the STC, U.S. Geological Survey, United States
- Prof. Mustafa Erdik, Kandilli Observatory, Bogazici University, Turkey

5. Selection of the three international institutes

The IDNDR secretariat identified three international institutes in three regions, namely, Asia, Europe/the Middle East/Africa, and America. The role of the international institutes was to supervise and coordinate the case studies. In order to guide the case studies technically, they were requested to visit a case-study city several times and to communicate frequently through electronic means.

For Asia (Bandung, Tashkent, Zigong)
OYO Corporation and International Center for Disaster-Mitigation Engineering (INCEDE), Japan
Fumio Kaneko, Rajib Shaw, Shukyo Segawa, Jichun Sun, Ken Sudo

For Europe, the Middle East and Africa (Addis Ababa, Izmir, Skopje)
Bureau de Recherches Géologiques et Minières (BRGM), France
Philippe Masure, Pierre Mouroux, Christophe Martin

For Latin America (Antofagasta, Guayaquil, Tijuana)
GeoHazards International (GHI), United States
Carlos Villacis, Cynthia Cardona

6. Launch of the case studies

The local authorities of the case-study cities prepared a cost plan to launch the RADIUS case studies. In most cities, the local governments allocated complementary local funds for the project. The IDNDR secretariat concluded the Grant Agreement with the nine cities respectively. It also concluded the Grant Agreement with the three international institutes. It was stipulated in the agreements that the cities and institutes should complete the project in 18 months, hold RADIUS workshops, and submit periodical progress reports to the IDNDR secretariat.

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.

All of the participants concluded that the lectures, information and materials that they received in Japan were going to help them very much in their work for the reduction of seismic risk in their cities. What they found most valuable was the opportunity to establish relationships with people from other cities in similar conditions. During the RADIUS seminars most of the discussions were centered on what the RADIUS cities were doing, what their problems were, and what they could and needed to do in the future to reduce the risk.

Figure 2: Some of the participants of the Workshop on the Action Plan for reducing the seismic risk of Guayaquil

9. "Earthquake Damage Scenario" workshops

All the case-study cities held Earthquake Damage Scenario workshops from October 1998 to March 1999, the end of the first phase of the case study. The workshops greatly raised public awareness through various coverage by mass media, such as newspapers, radio and TV. The common objectives of the workshops were to:

- Present the damage estimates to the city and ask for feedback from the participants;
- Estimate the impact of the estimated damage on the city activities;
- Produce ideas of actions that could reduce the impact of an earthquake on the city; and
- Discuss the conditions needed to institutionalize the risk management activities.

- **Zigong** 14 and 15 October 1998
- **Bandung** 20 and 21 October 1998
- **Tashkent** 11 to 13 November 1998
- **Antofagasta** 17 and 18 December 1998
- **Tijuana** 13 to 15 January 1999
- **Guayaquil** 20 to 22 January 1999
- **Izmir** 18 and 19 February 1999
- **Addis Ababa** 24 to 26 February 1999
- **Skopje** 1 to 3 March 1999 (in conjunction with the Action Plan Workshop)

10. "Action Plan" workshops

In most of the nine case-study cities, the second workshop, the "Action Plan" workshop, was held from April to July 1999. The objectives of the workshops, were to develop a Risk Management Plan, based on the evaluation of the earthquake damage scenarios and propose an Action Plan for immediate actions. Active discussions widely covered by mass media, such as TV and newspapers, greatly raised public awareness of disaster preparedness.

- **Bandung** 14 April 1999
- **Zigong** 21 May 1999
- **Tashkent** 26 May 1999
- **Tijuana** 27 and 28 May 1999
- **Antofagasta** 9 and 10 June 1999
- **Guayaquil** 30 June to 3 July 1999
- **Addis Ababa** 20 to 22 July 1999

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 report includes (a) a summary of the assessments of earthquake risk and risk management in the participating cities; (b) a compilation of the city profiles; (c) a compilation of specific risk management efforts undertaken in the participating cities; and (d) a summary of the feedback received from the project participants throughout the course of the project. The project established a worldwide network of earthquake professionals that can support continued work in comparative urban earthquake risk assessment.

V. Information Exchange

More than 30 cities, all of which had carried out a seismic risk assessment or were in the process of doing so with independent resources, joined RADIUS as "Associate Cities" for information exchange and international cooperation. Most of the associate cities kindly wrote a "city report" and sent it to the IDNDR secretariat. The reports are presented on the RADIUS home page.

35 Associate Cities

Algiers (Algeria), Baoji (China), Beijing (China), Bogota (Colombia), Cairns (Australia), Calcutta (India), Dalian (China), Damascus (Syria), Gyumri (Armenia), Hefei (China), Istanbul (Turkey), Jabalpur (India), Kathmandu (Nepal), Khartoum (Sudan), Lima (Peru), Manizales (Colombia), Mumbai (India), Newcastle (Australia), Pereira (Colombia), Pimpri (India), Quito (Ecuador), St. George's (Grenada), San Juan (Argentina), Shiraz (Iran), Sochi (Russia), Spitak (Armenia), Suva (Fiji), Tai'an (China), Tangshan (China), Tehran (Iran), Tianjin (China), Tuscan Region (Italy), Ulaanbaatar (Mongolia), Urumqi (China), Yerevan (Armenia)

"IDNDR highlights" was published monthly by the IDNDR secretariat and sent to a number of governments and experts by e-mail. The progress of RADIUS was reported in the publication each month. The RADIUS Web site was created in early 1998, and the information on the initiative was fully revised and updated in 1999. This was carried out with the technical assistance of GHI. Available on the site are full reports of the nine case studies, reports from the three international institutes, city reports from the associate cities, the developed practical tools, the result of the comparative study, and the proceedings of the RADIUS symposium in Tijuana. The address of the RADIUS home page is: **http://www.geohaz.org/radius**
The IDNDR home page, which was created later, also started presenting the result of RADIUS. It now contains major information on RADIUS.
The adddress is: **http://www.idndr.org**

VI. RADIUS Symposium

Prior to the International RADIUS Symposium, there were two RADIUS workshops and more than ten conferences where the RADIUS initiative was presented. A RADIUS workshop was held from 18 to 19 September 1998 during the Second International Conference on Earthquake, Hazard, and Seismic Risk Reduction in Yerevan, Armenia, held from 15 to 21 September 1998, to review the progress of the RADIUS case studies and to discuss urban seismic risk reduction practices.

The IDNDR Programme Forum was held from 5 to 9 July 1999 in Geneva, as an essential event of the concluding phase of IDNDR. In the Forum, a thematic session on *"Towards Earthquake Safe Cities: How to Reduce Earthquake Damages"* was held, focusing on RADIUS and similar activities in the world. It was pointed out that RADIUS was one of the most significant and successful projects for IDNDR, establishing excellent integrated international cooperation. In the poster session on the same theme, exhibited were many reports, pamphlets, and posters from the RADIUS case-study cities as well as the associate cities for the entire week.

Figure 3: Session on "Towards Earthquake Safe Cities: How to Reduce Earthquake Damages" at the Programme Forum

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

RADIUS was presented publicly at a press conference in November 1999 and is being published in early 2000. It is our hope that the developed tools and experiences of RADIUS will be utilized in as many cities as possible to initiate similar efforts towards earthquake safe cities.

Yet, the RADIUS initiative is just the first step on a long journey. Seismic risk reduction is a long-term undertaking. It will take decades to make cities safe against earthquakes. It is difficult to strengthen existing vulnerable buildings, or change their location in the short-term. Even in the nine case-study cities, unless they take immediate actions, the earthquake risk of the cities will continue to grow. However, the RADIUS approach should help raise public awareness among the communities. It will eventually help fix land-use planning priorities, conform building regulations, retrofit existing structures, and, most importantly, promote preventive management of earthquake damage.

RADIUS does not draw a closed circle but an open circle. I sincerely hope that the circle continues to grow and helps more cities and people in the world to be safe from earthquake disasters.

Figure 5: Press conference on 26 November 1999 at the United Nations in Geneva

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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.

Guayaquil is a large city of 2.1 million inhabitants that contributes 2 percent of Ecuador's total GNP. It last experienced a destructive earthquake (Ms 7.9) in 1942.

Tijuana is a relatively young city, intermediate in size (1.25 million inhabitants), that has not experienced a destructive earthquake since its founding approximately a century ago.

While there are several differences among these three cities, they experience similar problems, such as significant amounts of traditional construction, modern construction built without the use or enforcement of building codes, vulnerable critical facilities (schools, hospitals, etc.), lack of earthquake awareness within the community, and little support from local government for risk management activities. Figure 1 shows some basic information for the three cities.

Figure 2. Working session with representatives of the Federal and Municipal Education Systems of Tijuana.

Risk evaluation

Damage that could be caused by a probable earthquake was estimated for each of the three cities. The hypothetical earthquakes, based on studies of the local and regional seismology, adopted for the analysis were the following:

- Antofagasta (Ms 8.0, epicentral distance 60 kilometres)
- Guayaquil (Ms 8.0, epicentral distance 200 kilometres)
- Tijuana (Ms 6.5, epicentral distance 10 kilometres)

Estimation of potential damage was first carried out as a theoretical estimation and then as a non-theoretical estimation. The theoretical estimation was made by combining the seismic intensity distribution, estimated for the adopted earthquake, with the inventory of the city's structures and infrastructure. This was performed using vulnerability functions developed to reflect the seismic behavior of each city's structures. The non-theoretical estimation was performed through a series of interviews with the officials in charge of the city's systems and services (figure 2). The information collected in these interviews allowed for the characteristics of the city's systems to be included in the damage estimation. Figure 3 shows the estimated damage to the roads for Antofagasta.

The estimation results for Antofagasta indicate that 6 percent of the residential buildings, where 15,000 people live, would be destroyed and 37 percent of the buildings, providing housing to 85,000 people, would suffer severe damage. As a result, more than 3,000

City	Population (in millions)	Annual growth	Area (km²)	Contribution to the country's economy
Antofagasta	0.22	3.0%	90	6.5% of the country's GNP and 31% of its exports
Guayaquil	2.10	3.2%	340	20% of the country's GNP and 60% of its exports
Tijuana	1.25	6.02%	250	3.8% of the country's GNP

Figure 1. Basic information on the three RADIUS cities in Latin America.

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 time from the disaster is extremely important. A preliminary action plan was prepared for presentation to the community during the action plan workshop. The objectives of this workshop were:

- To present to the community the preliminary action plan and receive their comments;
- To reach a consensus on the activities that should be incorporated into the plan and set up priorities; and
- To prepare recommendations on the institution to be in charge of implementing the plan and a strategy to ensure its implementation.

The results of the workshop were used to prepare the final version of the action plan that was submitted to city authorities. Summaries of the plan were also prepared for distribution to the community.

Institutionalization

Besides the main activities of risk assessment (earthquake scenario) and planning (action plan), the RADIUS initiative worked actively to set up conditions for a process of implementation. The project:

- Involved all sectors of the community through the selection of a representative local advisory committee and the holding of well-attended workshops;
- Informed the community about the project through the local media on the advances and achievements of the project. (Figure 5 shows examples of full-page articles on the project published in Antofagasta and Guayaquil); and
- Sought potential funding from potential donors such as local industries, the financial and insurance sectors, and international aid organizations.

Conclusions

The RADIUS initiative has been successfully implemented in the three Latin American cities of Antofagasta, Guayaquil, and Tijuana. It may be the first important step towards the establishment by the cities of long-term initiatives to prepare for seismic disasters. Significant progress has been made to increase awareness in the three cities, and actions are already being taken to implement the plans prepared by the project. Follow-up projects have been generated and there is consensus on the need to continue the efforts initiated by the project.

The RADIUS initiative proved to be important and effective for several reasons. The initiative (a) produced tangible results such as the earthquake scenarios and action plans for the cities and practical tools based on the experiences of the case studies (b) the project also promoted the collaboration of cities worldwide through interaction and sharing of experiences, identifying common problems and solutions, and forming international partnerships; and (c) most importantly the RADIUS initiative proved to be very effective in incorporating the community in the management of seismic risk. It is expected that the work initiated by the RADIUS initiative will be continued by the three cities and that other cities will benefit from the experiences gained during the project.

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

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EL MERCURIO DESARROLLO REGIONAL A-2 DOMINGO 24 DE ENERO DE 1999

4 EL TIEMPO Lo positivo y negativo de "La Niña"

6 CAPITALES Millonario flujo de inversión extranjera

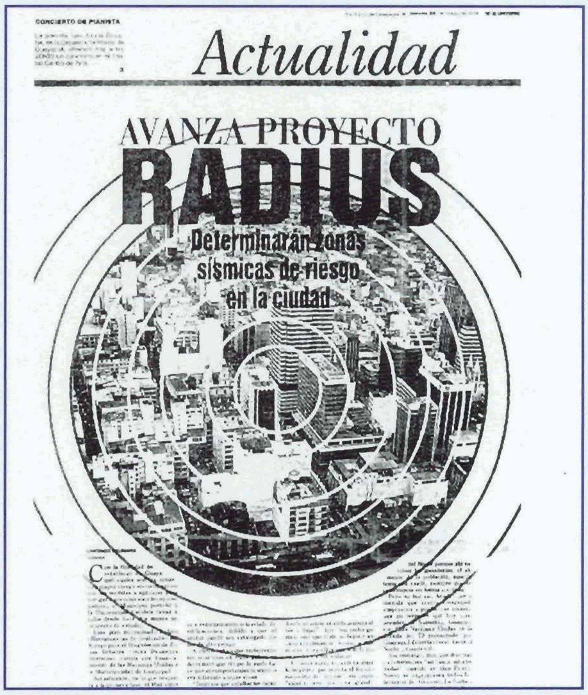
Esta pregunta tratan de contestarse los investigadores del proyecto Radius de Naciones Unidas en base a la simulación de un violento sismo en nuestra ciudad, que sirve de laboratorio virtual frente a daños y reacción de la comunidad

¿Qué pasará con otro terremoto?

POSIBLES DAÑOS EN CONSTRUCCIONES

ANTOFAGASTA - CHILE

Rango de daños



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.

Council of Safety and Seismic Resistant Construction. Tashkent has good planning for the seismic risk assessment and management. The level of public awareness is also quite high.

In Zigong, the administrative department for earthquake disaster prevention and mitigation is the Zigong Seismological Bureau, established in 1971. The Zigong Seismological Bureau coordinates with the provincial seismological bureau (in Szechwan Province) for seismological work. Seismic countermeasures have been included in the Ninth Five-Year Plan for the Economy and Social Development of Zigong City and the Year 2010 Development Plan. Programmes about seismic safety and countermeasures are presented on television, quake awareness pictures are shown on street billboards, and information is disseminated through radio and local newspapers. Consequently, the people of Zigong have a relatively high level of awareness regarding the possibility of earthquake damage.

Case studies

The case studies were jointly coordinated by OYO Corporation and the International Center for Disaster Mitigation Engineering (INCEDE). At the city level, a steering committee responsible for administrative and monetary matters was formed of representatives from the city government, local educational institutions, and international advisers. Several working groups were designated for specific tasks with the participation of community members. These activities were monitored by two advisory committees, one at the regional level consisting of international experts and the other at the local level with the participation of decision makers, government officials, and academicians.

Risk evaluation and earthquake scenario

To evaluate the seismic risk of each city a target area and organizations to be studied were designated. Data on past seismicity were collected to understand the magnitude and recurrence of earthquakes. Based on these data the scenario earthquake was chosen. To choose the scenario earthquake, special caution was taken, depending on the future urban planning and management. The return period of the scenario earthquake was also a strategic decision, which would ultimately lead to modification of existing building laws and seismic codes. In all three cases, the scenario earthquake was decided by the steering committee with the agreement of community representatives. In the case of Bandung, a probabilistic approach was taken with a 200-year return period with a probability of 60 percent. In Tashkent, the scenario earthquake was considered to be of Richter Scale 6.1 magnitude at a depth of 10 km beneath the city. In the case of Zigong, two different scenario earthquakes were postulated, one of 5.5 and the other of 6.0 magnitude.

Ground classification is the second step in earthquake hazard analysis. Deep geological structures were carefully studied in and around the city, and geological profiles were made. An inventory of the buildings, lifelines and infrastructures was prepared, and vulnerability curves were decided, modified from ATC and examples of similar earthquake damage. Damages to lifelines were calculated based on these vulnerability curves. Several damage maps are shown in figures 2 to 4.

A parallel process included interviews of several stakeholder organizations by the working group representative, with active participation of the media. At first, a detailed questionnaire was prepared and sent to the organizations for a reply. Based on this, a detailed interview was held with major decision makers and technical officers. The interviews covered earthquake preparedness, emergency drills, earthquake risk assessment, earthquake recovery, major earthquake impact, vulnerable points, responsible organizations, and damage estimation from the scenario earthquake.

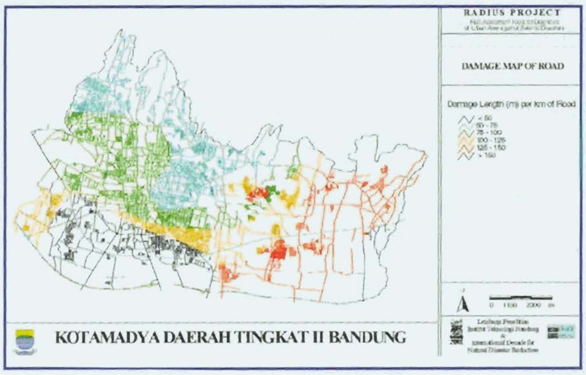


Figure 2. Damage to the road network in Bandung.

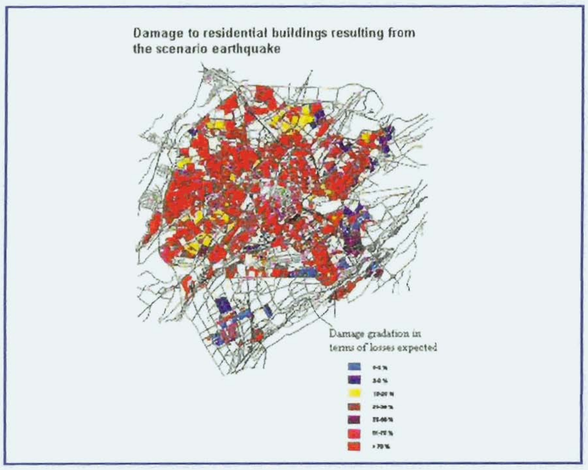


Figure 3. Damage to residential buildings in Tashkent from the scenario earthquake.

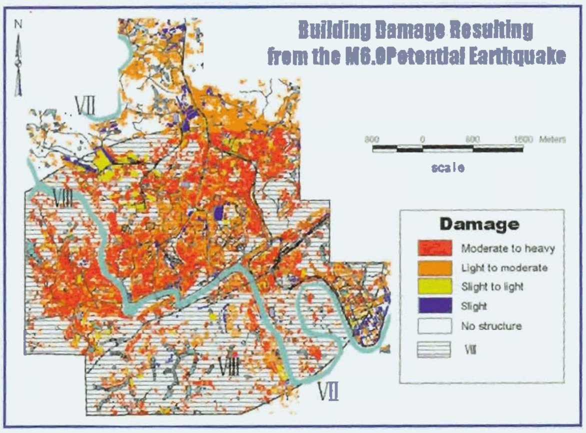


Figure 4. Damage to buildings in Zigong from the scenario earthquake.

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 proposed plan. Suggestions from these discussions were incorporated into the final version of the plan. Some of the recommendations of the action plans have already been taken into consideration in the form of new projects. In Bandung, for example, school buildings are being reinforced and public awareness is being promoted.

Evaluation and conclusion

The current project incorporates a unique methodology for mitigating seismic risk in a city. The most important part of this project is the involvement of diverse organizations and communities in mitigation efforts. It has been found that several invisible aspects, especially social and cultural features, are deeply related to the risk of the city and therefore should be taken into consideration in future disaster management plans. In each city and country there are several sensitive issues related to daily activities that are difficult for foreigners to understand or take into consideration. Involvement of the communities is a very important point.

The present project has made recommendations and has prepared ground for future studies. However, sincere and continued efforts are needed to turn those recommendations into real actions and to implement the action plan. Sustainability is an important issue in disaster management. More effort should be made to ensure that the process is continuous and meaningful. National and international development agencies should have a strong commitment to these issues and incorporate disaster issues in development planning to make it more sustainable. More activities of this type are needed and should focus on local participation to build capacity among the local community while respecting traditions.

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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.

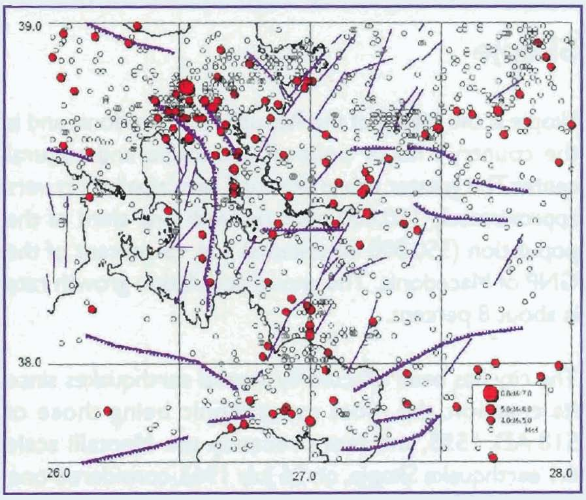

Figure 1: Historical seismic data for the Izmir region.

Turkey is a very centralized country. The governor's office is responsible for disaster management. The regional directorates of the Ministry of Public Works and Settlement and the Civil Defense Board work under the authority of the governor. They are also the members of the Natural Disaster Coordination Committee for each city. The mayor of Izmir and the engineering department, fire department, potable water, sewage systems, and food stocks of the Metropolitan municipality are the participants of this committee. Until the RADIUS project, the seismic risk management programmes carried out by the governor's office and the civil defense directorate were mainly bureaucratic activities. Implementation of the RADIUS project has facilitated cooperation among these central institutions and the municipal government. As was obvious during the recent management of the Izmir earthquake, coordination must be better organized for an efficient crisis management in the metropolitan area.

Another important factor in earthquake disaster mitigation and preparedness is enforcement of building codes that regulate the earthquake resistant design of buildings. A new code entered into force at the beginning of 1998 (the old code was from 1975). Construction permits are issued by the municipalities. The municipality of Izmir has signed a protocol with the Chamber of Civil Engineers and the Chamber of Architects to monitor engineering and architectural design, before the issuing building permits.

Skopje

Skopje is the capital of the Republic of Macedonia and is the country's major political, economic, and cultural center. The greater urban area of 7 municipalities covers approximately 180,000 hectares with one third of the population (550,000 inhabitants) and 45 percent of the GNP of Macedonia. The annual population growth rate is about 8 percent.

The city has been affected by several earthquakes since its creation, the most catastrophic being those of 518 AD, 1555, and more recently the Mercalli scale 6.1 earthquake Skopje, on 26 July 1963, considered one

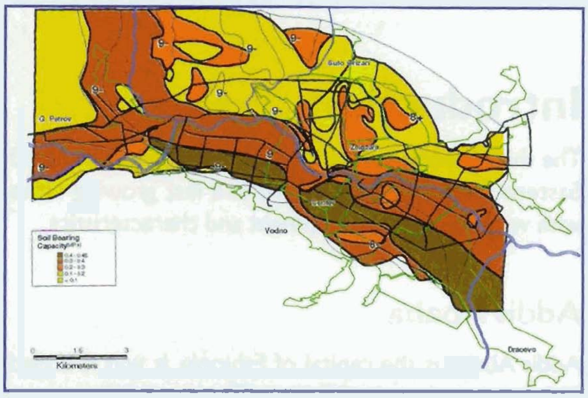

Figure 2: Seismic exposure of the transportation routes of Skopje.

of the most destructive earthquakes in modern Europe. The earthquake killed 1,070 people, seriously injured 3,300, destroyed 10 percent of the buildings, and 60 percent of the buildings suffered enough damage to justify reinforcement and repair. Of the total population 75 percent were left homeless. Information on that earthquake can be found in an appendix to the RADIUS project report for Skopje.

The first building code, Technical Regulations for Design and Construction of Buildings in Seismic Regions, was prepared in 1964 and was revised in 1981. It has been expanded with other codes and technical regulations for repair, reinforcement, and reconstruction.

After the 1963 earthquake, a seismic microzonation map of Skopje was prepared as the basis for the post-earthquake master plan enforced in 1969. Because of the former political system, all relevant activities are planned and centralized. Preparedness, emergency management and contingency planning are a legal obligation required by the law on protection against natural disasters.

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

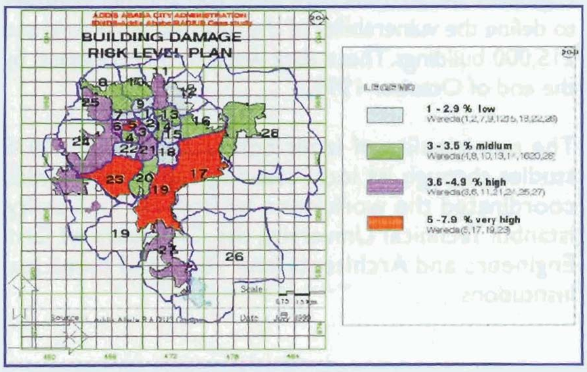

Figure 3: Building damage map of Addis Ababa.

The RADIUS project has already improved awareness on earthquake risk and increased expert's knowledge of earthquake engineering. It is planned to simplify the existing Ethiopian seismic code for use by civil engineers, architects and other potential users. The goals of making this code mandatory are to:

- Seek more efficient control of design and construction;
- Prepare guidelines for design and construction of new houses and the strengthening of existing dwellings;
- Prioritize buildings for intervention and rescue;
- Improve the seismic performance of lifeline infrastructure and services; and
- Adapt emergency response to earthquakes.

Recognizing the importance of the continuation of the project for Addis Ababa and Ethiopia and the need for implementation of the action plan, BRGM decided to request the cooperation of the French minister, to provide funds for training of local specialists in earthquake engineering.

Izmir

In the case of Izmir, the municipality had developed contacts before the RADIUS project started with a group of national scientists from Bogazici University and from Istanbul Technical University. Their objective was to prepare an earthquake master plan for Izmir, collect appropriate data, and for Izmir University to conduct an initial seismic hazard analysis using basic RADIUS methodology. Once the contract was signed the national group began hazard and vulnerability assessment studies in more detail. At the same time, the Chambers of Civil Engineers and Architects of Izmir had another contract to define the vulnerability of the main infrastructure and 215,000 buildings. These data were to be processed by the end of October 1999.

The municipality of Izmir conducted the RADIUS studies through its local steering committee, which coordinated the work done by Bogazici University, Istanbul Technical University, the Chambers of Civil Engineers and Architects, and state and municipal institutions.

Two approaches were used for the project implementation:

- Incorporation of the RADIUS initiative into the city's global seismic disaster reduction policy; and
- Analysis of the long-term city urban and environmental planning and the integration of seismic risk reduction.

Emphasis was placed on cooperation by all institutions involved to closely link preventive and environmental planning (Local Agenda 21). New links between the national institutions (governor's office and civil defence directorate) and the municipal government were created. In addition, it was possible to incorporate several international cooperation programmes in the global perspective of seismic risk reduction in Izmir. These included German cooperation for relief organization and equipment, preparedness, and training for crisis management and UK cooperation for hospital and school vulnerability assessment and retrofitting. After the Izmir disaster, the new mayor emphasized that:

- Soil questions and seismic microzoning will be a priority for land-use planning;
- Illegal buildings will not be permitted and construction will be regulated;
- Public awareness campaigns will be carried out; and
- A risk management department will be established.

A communication plan is being developed to raise public awareness through coverage by the media and to integrate the media into policy.

Skopje

Based on decisions of the International Consultative Board and the governments of the Republic of Macedonia and the City of Skopje, the Institute for Earthquake Engineering and Engineering Seismology at the St. Cyril and Methodius University (IZIIS) was created in 1965. Its mission is to provide data and design and planning elements for long-term reconstruction and development of the city and to incorporate new techniques in the field of planning and design. In the 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;

- Incorporation of representatives of the community throughout the project; and
- Setting up of conditions that will allow the immediate implementation of the risk management.

GeoHazards International has applied this methodology to risk management projects in Quito (Ecuador) and Kathmandu (Nepal). The RADIUS initiative adopted this methodology for implementation of case studies in nine cities around the world. The guidelines reported in this paper describe the methodology and how to use it to implement risk management projects in cities in developing countries.

Methodology

The case studies were carried out over 18 months in two phases. The first phase, the evaluation phase, covered the seismic risk assessment for the city in which an earthquake scenario was constructed. This was done through the collection of existing data and an estimation of the potential damage caused by a hypothetical earthquake. The second phase was that of planning. In this phase, an action plan was developed that would reduce the earthquake risk of the city. This action plan was prepared using the results of the risk assessment phase.

A detailed programme of activities for the RADIUS initiative case studies is presented in figure 1. The main project activities consisted of the collection of existing data, estimation of potential damage, and preparation of an action plan. Since the active participation of the community was crucial for the project's success, the programme of activities included a series of meetings (represented by the large dots in figure 1) in which key representatives of the community were informed about the project and then asked to comment.

The guidelines explain in detail activities included in the methodology described above. For each activity the following information was presented:

- Objectives
- Required information
- Process, methodology
- Intermediate products
- Participants
- Products
- Examples
- Observations

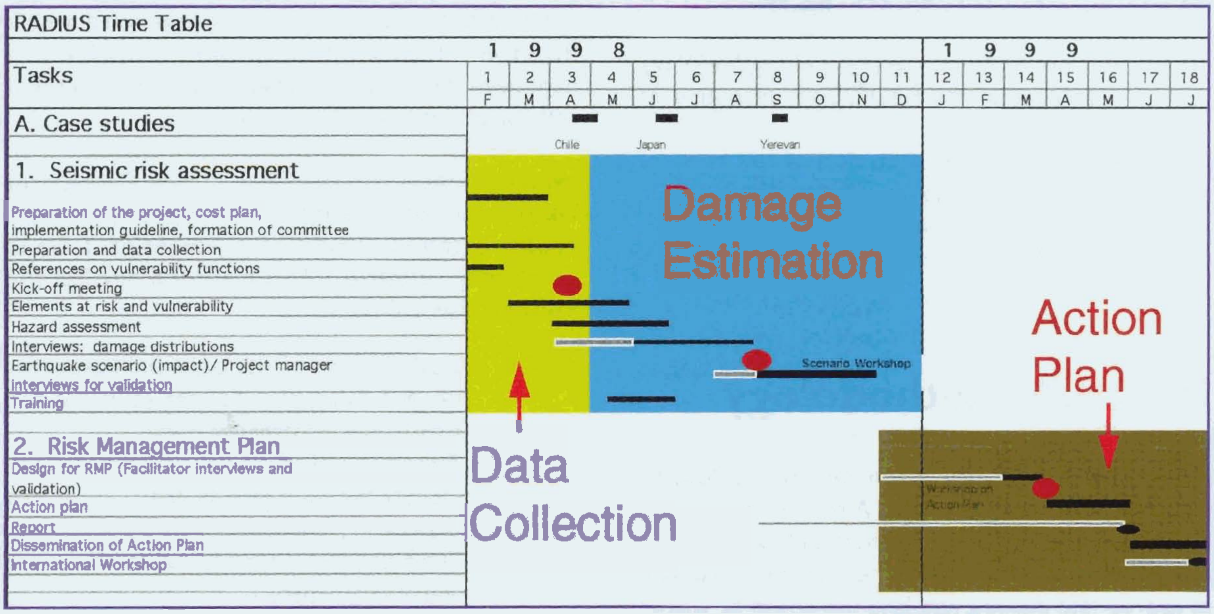

Figure 1: Detailed programme of activities for the RADIUS initiative case studies

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.

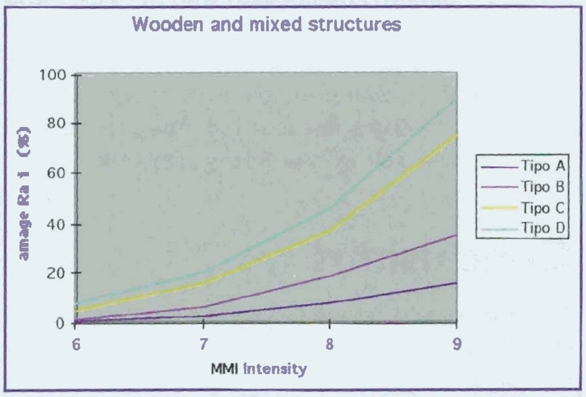

Figure 2. Example of vulnerability functions for the estimation of building damage. ("Tipo" = "Type")

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

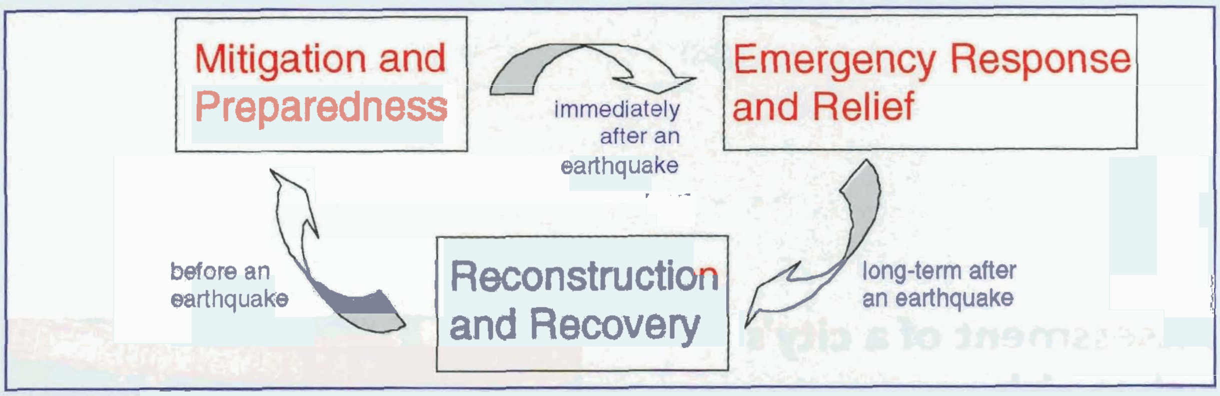

Figure 5. The planning phase considers all the stages of the "disaster cycle".

Preparing a plan to reduce seismic risk

The results of the damage estimation and the ideas for risk management activities produced during the scenario workshop were used for the preparation of an action plan that, if implemented, would reduce the city's seismic risk. Regular working meetings were held with the institutions that would be in charge of implementing risk management activities in order to define the objectives, tasks, schedules, and budgets of the activities to be included in the plan.

These activities address the three stages of the disaster cycle. These stages are the following: (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 time from the disaster is most important. A preliminary action plan was prepared for presentation to the community during the action plan workshop.

The results of the workshop were then used to prepare the final version of an action plan that was submitted to the city authorities. Summaries of the plan were then prepared and distributed to the community.

The guidelines describe in detail the following steps to prepare a risk management plan:

- Assessment of the current level of risk management preparedness
- Formulation of risk management activities
- Formulation of a strategy for implementation
- Designation of the institution that would implement the plan
- Implementation of the action plan workshop
- Preparation of an action plan
- Publication and dissemination of the action plan

Implementation

Besides describing the main activities of risk assessment and planning, the guidelines discuss how to set up the conditions that will allow these activities to be implemented. The following are among the suggestions presented by the guidelines:

- Involve all sectors of the community through the selection of a representative local advisory committee and the implementation of well-attended workshops;
- Inform the community about the project through collaboration with the local media to keep the community informed on the advances and achievements of the project; and
- Approach potential donors such as local industries, financial and insurance sectors, and international aid organizations.

Conclusions

Since these guidelines will be widely disseminated by the United Nations, they have been written in a language that can be easily understood by a wide range of readers including local governments, the technical community and the general public. While these guidelines are expected to provide valuable information for implementation of risk management projects, readers should keep in mind that there are many other technical, financial, institutional, political, and even circumstantial requirements that need to be taken into account.

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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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The following figures are examples of typical interactive windows seen using the tool:

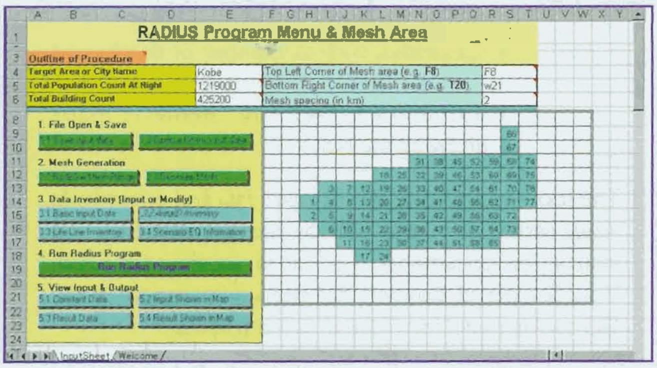

Figure 1: Preliminary definition of the target area.

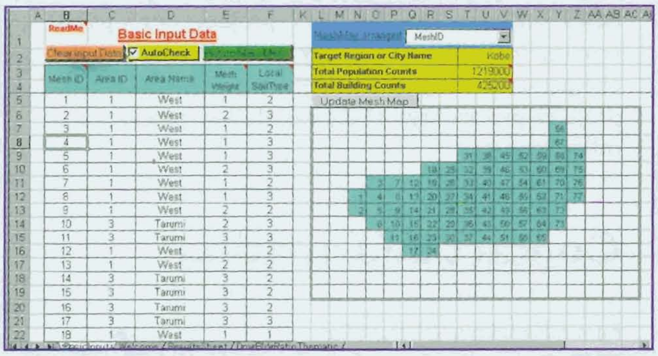

Figure 2: Basic data input.

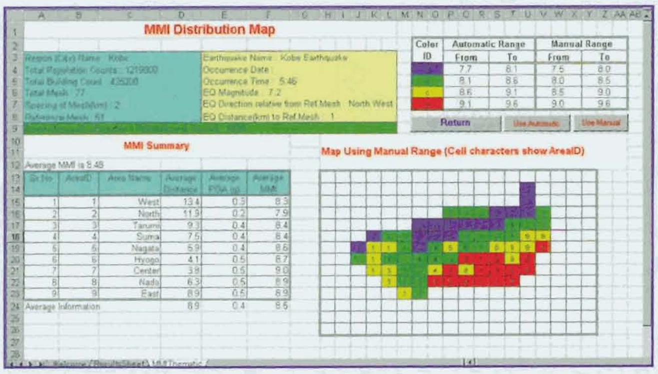

Figure 3: Seismic intensity distribution map.

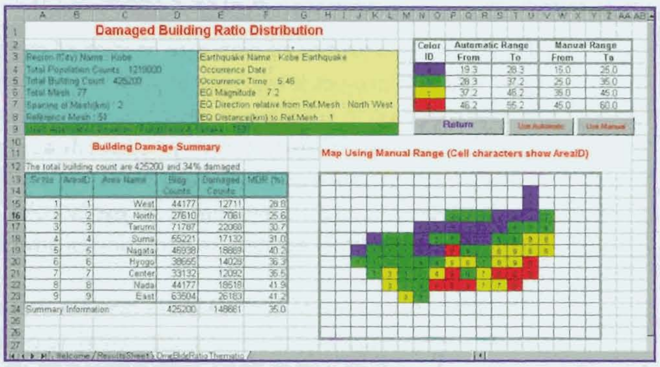

Figure 4: Thematic map of building damage distribution.

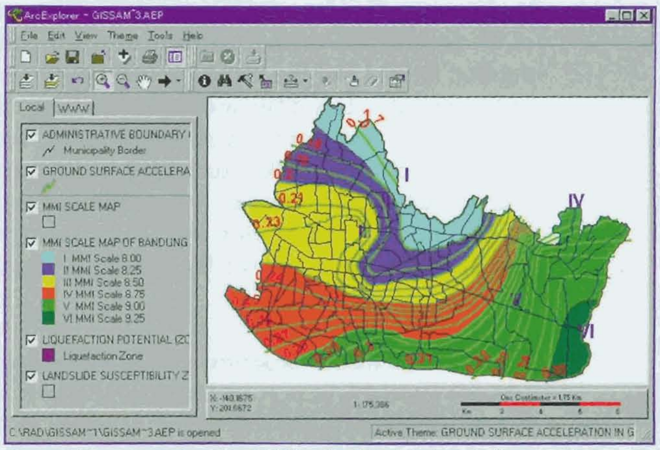

Figure 5: Seismic intensity of MMI with PGA distribution (Bandung).

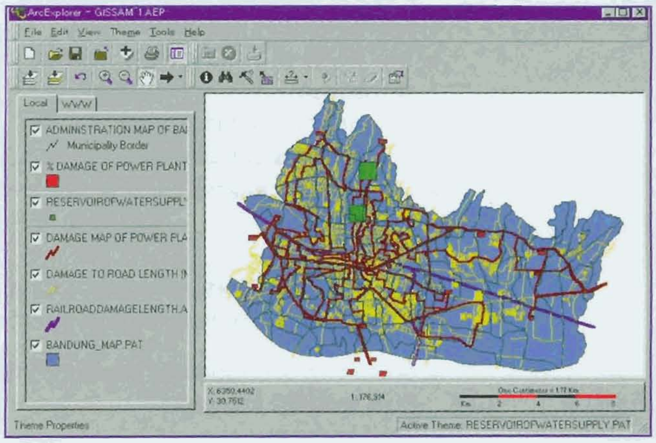

Figure 6: A sample of damage estimation for power facility (Bandung).

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.

These cities are:

Algiers, Algeria
Bogota, Colombia
Bucharest, Romania
Dehra Dun, India
Dhaka, Bangladesh
Gilgit, Pakistan
Guadalajara, Mexico
Gyumri, Armenia
Kampala, Uganda
Kathmandu, Nepal
Pimpri, India
Quito, Ecuador
Rome, Italy
San Juan, Argentina
San Salvador, El Salvador
Santiago, Chile
Skopje, Macedonia
Sofia, Bulgaria
Tehran, Iran
Ulaanbaatar, Mongolia

Background

The Earthquake Disaster Risk Index (EDRI) provided a framework for the UUSRAW project's worldwide comparative urban earthquake risk assessment. The EDRI compares metropolitan areas according to the degree and nature of their earthquake disaster risk, using five main factors: hazard, vulnerability, exposure, external context, and emergency response and recovery.

Project design

In the UUSRAW project, the EDRI methodology offered a useful structure with which to conduct a systematic discussion of earthquake risk, including issues in all disciplines of interest to academics and practitioners in all regions of the world. The project involved city representatives through two principal components:

- The gathering of information required to develop an earthquake risk profile and gain a better understanding of a city's earthquake risk; and
- The sharing of experiences in gathering information and comments on the form and usefulness of the project's methodology in general.

Data collection

The project coordinators created worksheets requesting earthquake risk information necessary to determine EDRI values for each city. Information was requested about earthquake risk management efforts undertaken, comments on the gathering of data, the usefulness of the EDRI, and project design and management. The worksheets were distributed to the city representatives, who completed and returned them.

Compilation and analysis

The project coordinators entered the earthquake risk information into a database and distributed this database to city representatives for their comments. Project coordinators also compiled a database of earthquake risk management information and comments on the EDRI methodology and the project. The risk assessment analysis, risk management information and comments are incorporated into the project's final report, along with city profiles that systematically describe the key elements of each city's risk and risk management efforts.

Internet forum

Throughout the project, an internet forum provided a way for city representatives, project coordinators, and international advisers to share questions and comments about the information-gathering process, the proposed methodology, and urban earthquake risk and risk management in general. The forum, an e-mail group list, was moderated by the project coordinators.

Worldwide Web page

A Web page was also established to provide information about this project to non-participants. The Web page included project documents, a list of member cities, articles and reports from member city participants, and other relevant information.

Project final report

The final products of the UUSRAW project are included in the final report, which will be published and disseminated by the United Nations. The report includes a summary of the assessments of earthquake risk and risk management in the participating cities, city profiles, specific risk management efforts made in the participating cities, and a summary of feedback received from project participants throughout the project.

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.

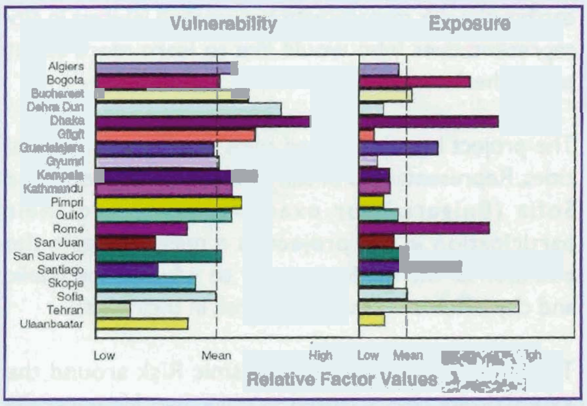

Figure 2: Sample results of exposure and vulnerability factor values for the twenty cities actively involved in all phases of the project. While Dhaka (Bangladesh) shows the highest vulnerability factor value of the sample, Tehran (Iran) has the highest exposure factor value. Results are relative to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

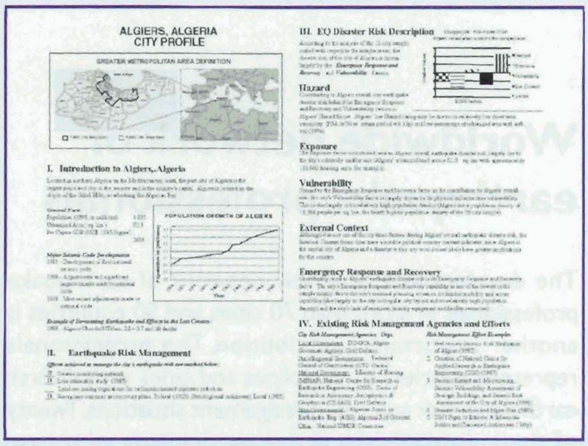

Figure 3. Example of a city profile for Algiers, Algeria.

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.

Worldwide network of earthquake professionals

The development of a new network of earthquake professionals in more than 70 cities and 50 countries is another important contribution. The professionals represent a variety of disciplines and cities with diverse earthquake risk and risk management situations. Twenty of the individuals are active participants who have established a basis of understanding through this project, gained experience collaborating via e-mail, and met at the RADIUS symposium in October 1999. This network will be an important resource for formal projects, either following up on the UUSRAW project or for similar work. It will also provide valuable contacts for informal interaction, particularly for representatives of cities that do not have a great deal of internal earthquake risk resources.

Conclusions

The UUSRAW project involved 74 member city representatives working worldwide mostly via the internet in order to gather information that would help participants better understand the magnitude and different causes of their city's risk, as well as compare these results with those of the other participating cities.

One of the biggest challenges of the project was obtaining data, even directly from city representatives who have access to local sources. Several cities in the sample are undergoing periods of social and economic transition, and it has been difficult to obtain reliable economic data for these cities. In addition, it was difficult to ensure that all 74 representatives were able to participate actively in all phases of the project.

Another shortcoming was the lack of unlimited access to the internet. For the most part, participants agreed that the Internet was a good vehicle for implementation of projects such as this. Providing a forum in which project participants could voice their ideas about the project, the proposed methodology of earthquake risk and earthquake risk management in general, the internet brought together earthquake professionals worldwide.

A notable achievement is the large amount of information collected by the project. In addition to earthquake risk data, the information gathered on earthquake risk management has sparked interest in city representatives who would like to learn more about each other's work.

The project has also helped raise awareness in several cities. Representatives of San Salvador (El Salvador) and Sofia (Bulgaria) for example, have used their participation in the project as a means to gain the attention of the media in order to educate the public and city officials on earthquake risk in their cities.

The Understanding Urban Seismic Risk around the World project has achieved its objectives. However, the methodology used for this study still needs to be improved. All project participants have learned from the challenges and agree that this effort is only a first step in a long-term process shared by cities worldwide to mitigate earthquake risk.

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Chapter 8

Evaluation of the RADIUS Case-Studies Project

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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.

The third objective, *to create local institutional support needed to sustain the earthquake risk mitigation plan,* was met to a certain extent. It is not known whether the support will be sustained. Institutional support was developed through use of steering and advisory committees and the involvement of representatives from government, science, business, and academic areas. The scenarios appear to have successfully communicated earthquake risk to decision makers.

The fourth objective, *to promote multidisciplinary collaboration among the local government and between government officers and scientists,* was met. Responses indicated that working relationships between government officials and scientists were improved. Steering and advisory committees engaged people from a variety of disciplines in an effort to solve a common problem.

The fifth objective, *to promote worldwide interaction with other earthquake-prone cities to share their valuable experiences,* was met. Opportunities for face-to-face interaction were limited. However, contact with international institutes and regional advisers, and attendance at training workshops and the Tijuana symposium facilitated interaction. The RADIUS home page and IDNDR highlight reports helped cities share information.

Process evaluation

The process used for the RADIUS case studies involved building relationships, crafting strategies, sharing expertise, providing loss estimation methodology, preparing scenarios and action plans, and recommending planning procedures. The strategy to use the prestige and leadership of the United Nations and the expertise of international institutes and regional advisers, sponsor workshops and symposia, provide limited amounts of money and empower local experts is sound. The requisite products, a scenario and plans, were completed.

Conclusions

1. The case studies met their goals to complete scenarios and risk management and action plans. They appear to have met their main objectives to raise awareness, transfer technology, create local institutional support and promote multidisciplinary collaboration. The tools provided to estimate and manage urban seismic risk were useful.

2. A continuing effort involving the case-study cities should be defined and undertaken before the momentum developed is lost. Risk reduction and management are long-term efforts that require a continuous commitment of the public and private sectors within the cities. The success to date may not last unless an ongoing commitment is institutionalized within the communities. Until then, an effort is needed to maintain a high level of awareness and to implement the action plans.

3. A careful review of the RADIUS case-studies project should be undertaken within a year. It should consider the results of implementation efforts in the nine cities, determine whether the planning process promoted seismic risk reduction and raised public awareness, and whether support for implementing the action plans has been sustained.

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