

Republic of Turkey
Ministry of Public Works and Settlement



General Directorate of Disaster Affairs

Seismic Microzonation for Municipalities
Executive Summary

February 2004

Prepared by:



Financed by:

DEZA DIREKTION FÜR ENTWICKLUNG UND ZUSAMMENARBEIT
DDC DIRECTION DU DÉVELOPPEMENT ET DE LA COOPÉRATION
DSC DIREZIONE DELLO SVILUPPO E DELLA COOPERAZIONE
SDC SWISS AGENCY FOR DEVELOPMENT AND COOPERATION
COSUDE AGENCIA SUÍZA PARA EL DESARROLLO Y LA COOPERACIÓN



Seismic Microzonation for Municipalities

Rights of Ownership by the General Directorate of Disaster Affairs, Ministry of Public Works and Settlement, Republic of Turkey. The World Institute for Disaster Risk Management, Inc., and the Swiss Agency for Development and Cooperation maintain the right to freely access this document, including the rights for use, reproduction and distribution.

This documentation is the result of a collaborative effort, led by the World Institute for Disaster Risk Management, Inc. (DRM) and the General Directorate of Disaster Affairs (GDDA), Ministry of Public Works and Settlement, Republic of Turkey, and financed by the Swiss Agency for Development and Cooperation (SDC) of the Federal Department of Foreign Affairs.

The following institutions and individuals contributed to this effort:

General Directorate of Disaster Affairs, Ministry of Public Works and Settlement (GDDA); Bogazici University, Kandilli Observatory and Earthquake Research Institute (BU-KOERI), Istanbul; Middle East Technical University (METU), Ankara; Sakarya University (SAU), Adapazari; Swiss Federal Institute of Technology Zurich - Institute for Geotechnical Engineering (ETHZ-IGT); Swiss Federal Institute of Technology Zurich - Institute of Geophysics (ETHZ-IG); Swiss Federal Institute of Technology Lausanne - Institut de Structures (EPFL-IS); Swiss Federal Institute for Snow and Avalanche Research (SLF), Davos; Studer Engineering, Zurich; Virginia Institute of Technology and State University (VT), College of Architecture and Urban Studies; University of Pennsylvania (UP), Wharton School - Risk Management and Decision Processes Center.

H. Akman (BU-KOERI), Walter J. Ammann (SLF), Atilla Ansal (BU-KOERI), Sami Arsoy (SAU), Marc Badoux (EPFL-IS), Sadik Bakir (METU), Murat Balamir (METU), Pierre-Yves Bard (University of Grenoble), Jonathan Bray (University of California, Berkeley), Juliane Buchheister (ETHZ-IGT), K. Önder Çetin (METU), Andreas Christen (ETHZ-IG), Barbara Dätwyler (SDC), A. Demir (GDDA), S. Demir (GDDA), Ekrem Demirbas (formerly GDDA, currently General Directorate of Technical Research and Application), M. Demircioğlu

(BU-KOERI), M. E. Durgun (GDDA), Muzaffer Elmas (SAU), Mustafa Erdik (BU-KOERI), Ayfer Erken (Istanbul Technical University, ITU), Donat Fäh (ETHZ-IG), Yasin Fahjan (BU-KOERI), Liam Finn (Kagawa University), Domenico Giardini (ETHZ-IG), Oktay Gökçe (GDDA), Christian Greifenhagen (EPFL-IS), A. Güldemir (GDDA), Ümit Gülerce (ITU), Polat Gülkan (METU), Jürg Hammer (DRM), Walter Hofmann (Brandenberger & Ruosch), İ. Kayakıran (GDDA), Rusen Keles (Ankara University), S. Kök (GDDA), M. Dinçer Köksal (DRM), Oliver Korup (SLF), Frederick Krimgold (DRM, VT), Howard Kunreuther (UP), Aslı Kurtuluş (ITU), Jan Laue (ETHZ-IGT), Pierino Lestuzzi (EPFL-IS), George G. Mader (Spangle Associates), Alberto Marcellini (CNR-IDPA, Milan), Roberto Meli (National University of Mexico), E. Nebioğlu (GDDA), Heinrich Neukomm (Board of the Swiss Federal Institutes of Technology), Akin Önalp (SAU), K. Özener (GDDA), Rocco Panduri (Studer Engineering), Karin Şeşetyan (BU-KOERI), Bilge Siyahi (BU-KOERI), Sarah Springman (ETHZ-IGT), Franz Stössel (SDC), Jost Studer (Studer Engineering), Mustafa Taymaz (GDDA), M. K. Tüfekçi (GDDA), Natasha Udu-gama (DRM), Robert Whitman (MIT, Massachusetts Institute of Technology), S. Yağcı (GDDA), A. Yakut (METU), Susumu Yasuda (Tokyo Denki University), U. Yazgan (METU), T. Yılmaz (METU).

Citation: World Institute for Disaster Risk Management, Inc. and General Directorate of Disaster Affairs, 2004: Seismic Microzonation for Municipalities. Executive Summary.

www.DRMonline.net

February 2004

Foreword

The Kocaeli Earthquake of August 17, 1999 revealed the devastating consequences that earthquakes can have for society and economy. In the aftermath of this earthquake, the General Directorate of Disaster Affairs started initiatives with the objective to mitigate the earthquake risk in Turkey.

The General Directorate of Disaster Affairs (GDDA), Ministry of Public Works and Settlement, undertook an endeavor entitled “Microzonation for Earthquake Risk Mitigation” (MERM).

The World Institute for Disaster Risk Management, Inc. (DRM) executed the project with financial support from the Swiss Agency for Development and Cooperation (SDC), of the Federal Department of Foreign Affairs, Switzerland.

Project design commenced in September 1999. The project was executed between March 2002 and February 2004.

This endeavor resulted in the following project documentation, under the generic title of “Seismic Microzonation for Municipalities”: (1) Executive Summary; (2) Manual; and, (3) Reference information, consisting of pilot studies, a state-of-the-art report, and supporting documentation for sustainable implementation.

DRM executed the MERM Project with Turkish and international participation:

Bogazici University, Kandilli Observatory and Earthquake Research Institute (BU-KOERI), Istanbul; Middle East Technical University (METU), Ankara; Sakarya University (SAU), Adapazari; Swiss Federal Institute of Technology Zurich - Institute for Geotechnical Engineering (ETHZ-IGT); Swiss Federal Institute of Technology Zurich - Institute of Geophysics (ETHZ-IG); Swiss Federal Institute of Technology Lausanne - Institut de Structures (EPFL-IS); Swiss Federal Institute for Snow and Avalanche Research (SLF), Davos; Studer Engineering, Zurich; Virginia Institute of Technology and State University (VT), College of Architecture and Urban Studies; University of Pennsylvania (UP), Wharton School - Risk Management and Decision Processes Center.

The present document is entitled “Executive Summary” and provides an introduction of the project as well as a summary of the available documents that are part of the complete work. Further, it gives an overview of the participating organizations and persons with corresponding responsibilities for the different tasks.

Acknowledgements

A project of such dimensions, involving local and governmental authorities as well as several university institutions of worldwide reputation, and consisting of intensely interconnected tasks, can only be accomplished with the volition of all involved parties. Special thanks to:

- The General Directorate of Disaster Affairs (GDDA) and its staff at the DRM MERM project office for their cooperation in the development and implementation of the project.
- The Swiss Agency for Development and Cooperation (SDC) of the Federal Department of Foreign Affairs for funding the project, and its project review team for valuable contributions towards the improvement of project sustainability and implementation.
- The Governors of the provinces of Kocaeli and Sakarya, as well as the authorities of the municipalities involved in the pilot studies for their assistance given to the project team.
- The members of the Technical Advisory Board for their guidance and comments on the project products, making it possible to achieve an international standard that includes state-of-the-art methodologies based on latest research results.
- All members of the project team for the constancy shown in the preparation of the assigned tasks.

Contents

Page

Foreword

Acknowledgements

1. Principles to Mitigate Earthquake Risk	1
2. Legal Basis for Public Action to Reduce Seismic Risk	2
3. Responsibilities of Municipal Government to Regulate Land Use and Building Standards	4
4. Purpose and Use of the Documentation	5
5. Summary of the Documentation	6
5.1 Manual	6
5.2 Reference Information	7
5.2.1 Pilot studies	7
5.2.2 State-of-the-Art	9
5.2.3 Sustainable Implementation Background Report	10
5.2.4 Cost-Benefit Analysis for Land Use Management to Reduce Earthquake Losses	11
5.2.5 Public Information on Land Use Management	11
5.2.6 Training for Municipalities	12
6. Project Participants	13

1. Principles to Mitigate Earthquake Risk

Earthquake casualties and physical losses are primarily the result of building and infrastructure failure induced by earthquake effects. The two principal approaches to reducing these losses are to:

1. If possible, avoid high hazard areas for the siting of buildings and infrastructure.
2. Ensure that buildings and infrastructure are designed and constructed to resist expected earthquake loads and are prepared for emergency conditions.

The first approach to seeking safe siting is related to land use management. Mapping of the relative intensity of seismic hazards in an urban area provides critical guidance to the urban planner, municipal officials and private builders on the safe siting of buildings and infrastructure, as well as a general framework upon which market decisions could safely be carried out. Determination of lands suitable for urban development for municipal expansion and direction of development to relatively less hazardous areas can be an important factor in reducing earthquake losses and reducing the cost of safe construction.

The second approach to earthquake risk reduction deals with the design and construction of individual buildings. Standards for building design and construction are established in "Specification for Structures to be Built in Disaster Areas" published by the Ministry of Public Works and Settlement of the Government of Turkey. Relevant building standards for a particular structure are defined by the macroseismic zone, soil conditions at the building site and the type of construction.

Together, municipal seismic microzonation and the "Earthquake Specification for Structures" provide for both safe siting and design of urban development. The "Earthquake Specification for Structures" was last updated in 1997. The current standards represent a generally accepted level of safety.

It was the intention of the Microzonation for Earthquake Risk Mitigation project to provide the bases for municipal seismic microzonation. Both the municipal seismic microzonation and the "Earthquake Specification for Structures" must be taken into consideration in the management of development planning and the management of building design and construction so as to ensure future earthquake safety. Rigorous application of these tools is required for all new urban planning, development and construction. The scientific and engineering basis for these tools comes from worldwide experience of earthquake damage and extensive research.

These scientifically based tools are now available to planners, developers, designers and builders. However, their application and use must be required and enforced by municipal authorities. Implementation and enforcement of these standards by municipal authorities must be the highest priority for reducing future earthquake deaths and damage in Turkey.

2. Legal Basis for Public Action to Reduce Seismic Risk

The legal foundation for disaster management in Turkey is contained in two laws:

1. The Disaster Law (7269) which dates from 1959 and is administered by the Ministry of Public Works and Settlement, and
2. The Development Law (3194), which dates from 1985 and is administered by the Ministry of Public Works and Settlement.

Historically, the Disaster Law has provided for the management of disaster response, relief and reconstruction. Primary emphasis has been placed on the organizational responsibilities for crisis management and the distribution of assistance to disaster victims. The disaster mitigation component of the Disaster Law is represented by the inclusion of “Design Principles for Buildings in Areas Subject to Disaster” and the evaluation of natural hazards as a component of urban master plans.

The Disaster Law provides for, among other topics:

- Emergency relief and operations, and the preparation of a management brief
- Principles in the determination of effects of disasters on social life
- Determination of the rights of victims of disasters
- Discounts to be made in the payment programs of the disaster victims for buildings constructed by public means
- Principles of distribution of the residual buildings and property
- Design principles for buildings in areas subject to disasters
- Principles for the valuation of the remains of damaged property

The Development Law generally governs the terms of regulation and procedure for the preparation of urban master plans and permits private construction and use of buildings.

The Development Law provides for, among other topics:

- Uniform development of urban areas
- Preparation, enforcement and revision of development plans
- Development of areas where planning is not mandatory
- Land rearrangement procedures
- Authors eligible to prepare urban plans
- Authors eligible to prepare topographical maps
- Responsibilities and liabilities on the technical personnel other than urban planners, architects and engineers
- Provision of shelters

Aside from the designated metropolitan municipalities, all municipalities are subject to the “Uniform Development Regulation” which governs all urban construction in Turkey.

It is important to note that the Development Law does not specifically ad-

dress the issues of disaster risk management or mitigation. The most effective and cost-efficient opportunities for earthquake risk reduction arise in the planning, development, design and construction phases. The topic of earthquake safety is now inadequately addressed by a combination of provisions of the Disaster and Development Laws.

A third legislative foundation of municipal disaster risk management is the Law of Municipalities (1580), which dates from 1930 and is administered by the Ministry of Interior. The Law of Municipalities establishes the responsibility of municipalities for the management of settlements and meeting the basic needs of citizens.

The Law of Municipalities provides for, among other topics:

- Procedures for the extension of municipal boundaries
- Power of construction control and permitting for building repair
- Control of unauthorized development and removal of hazardous buildings
- Cooperation with central administration on issues affecting public health
- Municipal obligation to employ appropriately trained technical staff
- Enforcement of laws and regulations related to municipal development

Current law provides for the evaluation and mapping of disaster hazards and the inclusion of hazard information in urban master plans. While formal land use management tools remain limited there are critical opportunities for the effective introduction of earthquake hazard information in the form of seismic microzonation for risk reduction in the urban development process.

A further development has been the Building Supervision Law (4708) enacted in 2001.

3. Responsibilities of Municipal Government to Regulate Land Use and Building Standards

While the Disaster Law and the Development Law assign significant responsibilities to Central Government ministries, according to the decentralization provisions of the 1985 Development Law, the primary responsibility for land use and building regulation resides at the municipal level. The Development Law requires that municipal and provincial administrations prepare development plans. Municipalities must develop and maintain urban development master plans with limited technical guidance or review from central authorities. Qualified consultants or technical staff of the municipality must develop urban development master plans. As described in the regulation concerning 'Preparation, Enforcement and Revision of Development Plans,' plans are to address the following points:

- Consistency with higher level plan decisions
- Consideration of natural constraints
- Socio-economic viability
- Compatibility of land use decisions
- Feasibility of the plan
- Applicability of the plan

While standards for seismic microzonation to guide safe development, and earthquake building standards to guide safe construction are developed by the Ministry of Public Works and Settlement within the regulation concerning 'Design Principles for Buildings in Disaster Areas,' it is the responsibility of the municipalities to administer and enforce these standards in practice.

Administration of these standards requires:

- Appropriately trained and qualified technical staff in planning and building departments to carry out plan review and inspection
- Appropriate facilities and equipment for the storage and use of map and plan materials
- Enforcement authority and administrative and political support for removal of non-conforming structures

4. Purpose and Use of the Documentation

This documentation illustrates the seismic microzonation methodology developed for the specific conditions in Turkey and its implementation in the municipal administrative framework, which remains unattended today.

The purpose of the documentation is to guide the municipalities to plan and lead the microzonation and to implement the results of these studies in their land use management frameworks. At the same time, this document contributes to a scientifically based minimum quality standard for microzonation studies in Turkey. The municipalities will commission a company, or participate in the tendering processes carried out by the central authorities to perform the microzonation study. The manual describes the technical methodology and the minimum requirements to perform this task.

The entire documentation consists of three parts:

- ***Executive Summary***: The present document.
- ***Seismic Microzonation Manual***: This consists of three main chapters:
 - Chapter 1 gives a definition of terms and explains the general methodology.
 - Chapter 2 is directed at the enterprises commissioned to perform the microzonation studies. It gives technical guidelines as well as recommendations to efficiently perform the microzonation.
 - Chapter 3 describes the tasks and responsibilities of the municipalities commissioning microzonation studies and implementing the results of these studies into their land use management system.
- ***Reference Information***: A compilation of documents intended to give additional background information as well as practical examples of a microzonation study. The reference information includes:
 - *Pilot studies*: Two pilot studies have been performed to test the methodology.
 - *State-of-the-art*: Gives an extensive overview of the state-of-the-practice.
 - *Supporting documentation for sustainable implementation*: Includes a review of the legal basis for land use management, an analysis of the land use regulatory practice, recommendations for strengthening land use management, samples of public information on land use management and a training program for municipalities.

5. Summary of the Documentation

5.1 Seismic Microzonation Manual

Chapter 1

This chapter gives an overview of the recommended general methodology when performing a microzonation study. It further defines the most important terms in earthquake engineering and describes the principal earthquake effects to be considered in Turkey, showing examples of damage in recent earthquakes.

Chapter 2

The main chapter of the documentation is mainly directed at the enterprises performing a microzonation study. An overview of the main responsibilities of the commissioned enterprises is given.

All steps of the microzonation procedure are described, with particular emphasis on data acquisition procedures with corresponding minimum requirements. Detailed comments, pointing out advantages and disadvantages, are given for the recommended data acquisition methods. Detailed descriptions and recommendations for the advised methods are found in an annex chapter.

Starting from the acquired data, the procedures for the derivation of the actual microzonation maps are described. For all considered earthquake effects, criteria for zone classification (in general three zones for each earthquake effect) are given. With this information, the derivation of microzonation maps is possible, allowing an independent check of the results based directly on the raw data. The recommended microzonation report structure described in the manual is the basis for the review and approval by the responsible agency.

Additionally, recommendations are given for the use of the microzonation maps, particularly for the development of zone-associated building regulations, but also for reducing the vulnerability of critical infrastructure and for the assessment of the capacity of intervention forces. The official procedure for the assessment of earthquake damage after an earthquake event is presented, as well as possible uses of the European macroseismic scale EMS-98.

Chapter 3

This chapter provides guidance for the application of microzonation maps in the process of municipal land use management. The material is directed primarily to municipal planners and officials. Principal responsibility for implementation of land use management and building regulation related to earthquake safety has been devolved to the municipal level. Application of available scientific knowledge to land use management and building standards to reduce earthquake risk is the best hope for the prevention and mitigation of future earthquake disasters.

The process of implementation, the legal basis for land use management and the rationale for municipal land use management for earthquake safety are presented and the land use and physical development system are re-

viewed. Guidance is provided on the management of the microzonation process from the municipal level with the understanding that this responsibility may be shared with central government authorities. Specific guidance is provided on the application of seismic microzonation maps to urban master planning and development control for earthquake safety at the municipal level. The principals for construction of relative earthquake hazard maps are presented and the application of the microzonation to specific planning and development decisions is described.

Finally, the issues for land use management administration and implementation are addressed. The effectiveness of seismic microzonation and land use management planning is totally dependent on the effectiveness of policy implementation and enforcement of zone defined development controls.

5.2 Reference Information

5.2.1 Pilot studies

Contents

Pilot studies were performed for two subject areas:

- Microzonation pilot study of Research Task Group.
- Development implementation pilot study of Sustainable Implementation Group.

Pilot Study Research Task Group

The microzonation studies were conducted in two pilot areas: (1) Adapazari, (2) Gölcük, İhsaniye and Değirmediere for the purpose of testing and demonstrating the applicability of the proposed microzonation procedure recommended in the microzonation manual.

The microzonation studies in the pilot areas were carried out with the participation of researchers from Boğaziçi, Middle East Technical, and Sakarya Universities and the General Directorate of Disaster Affairs (GDDA), Institute of Geophysics and Institute of Geotechnical Engineering of the Swiss Federal Institute of Technology in Zurich, Structural Engineering Institute of the Swiss Federal Institute of Technology in Lausanne, Studer Engineering, and World Institute of Disaster Risk Management.

The related activities concerning the microzonation studies were carried out in seven partly simultaneous and partly consecutive phases. The first phase involved the compilation of available geological and geotechnical data previously obtained for different purposes. A major portion of the available data was supplied by Sakarya University. Limited numbers of additional subsurface explorations were also carried out to supplement the available data. The General Directorate of Disaster Affairs supplied the second group of data. This data was analyzed and evaluated by the Institute of Geotechnical Engineering of the Swiss Federal Institute of Technology. Concurrently, all available geotechnical data was converted to GIS format at the General Directorate of Disaster Affairs.

The second phase of the study was the evaluation of the earthquake hazard for the microzonation study. In this phase, both pilot areas were divided into approximately 500m x 500m grids to evaluate earthquake hazard pa-

rameters for each grid. Since the region recently experienced a very severe earthquake, two types of assessments were carried out. The first assessment was the estimation of the hazard parameters with respect to the Poisson model for a probability of exceedance of 10% in 50 years. The second assessment was the estimation of the hazard parameters with respect to time dependent probability by a renewal model taking into account the recent earthquakes of 1999. Since the major purpose for the microzonation study is for land use and city planning it was decided to determine the required earthquake hazard parameters based on the Poisson model for a return period of 100 years that corresponds approximately to 40% probability of exceedance in 50 years. This third assessment methodology is adopted as the method to be used for the estimation of the regional hazard parameters for the microzonation studies carried in the pilot areas.

The third phase of the study involved microtremor measurements in the pilot areas and interpretation of the results obtained.

The fourth phase of the study was the evaluation and analysis of the available geotechnical data to determine the necessary parameters for conducting the microzonation with respect to different parameters. Representative soil profiles and site conditions for each grid were determined. Site response analysis was conducted for each grid point using the simulated earthquake time histories obtained from the seismic hazard study. However, even though it is recommended to use at least two simulated time histories for each grid point in the microzonation manual, only one simulated earthquake time history was used in site response analysis due to time constraints.

The fifth phase involved the evaluation of the liquefaction susceptibility and landslide hazard based on results obtained in the fourth phase of the study. The procedures adopted and the results obtained are explained in detail.

The sixth phase was the mapping of the results for the pilot areas considering the results obtained in the previous phases. A GIS mapping procedure was adopted to evaluate the variation of the calculated parameters in both pilot areas.

The last phase involved the final evaluation of all the findings obtained from the studies conducted for specifying the microzonation with respect to site amplification, liquefaction susceptibility and landslide hazard as summarized.

Although it may be considered beyond the scope of a standard microzonation study, since two major earthquakes had taken place in the region, an attempt was also made to evaluate and assess the damage encountered during these earthquakes for the purpose of comparison with the microzonation that was obtained. Damage data was obtained from different studies conducted in the region after the 1999 earthquakes.

*Pilot Study Sustainable
Implementation Task Group*

In the pilot study of the Sustainable Implementation task group, general information of the two municipalities of Adapazari and Degirmendere is first given. After explaining the tasks and duties of the local administration, the current conditions in Degirmendere are illustrated, including population growth and planning history.

After a review of the damage caused by the earthquake of 17 August 1999, administrative problems encountered following this event are discussed and the development implementation plan for Degirmendere is presented.

5.2.2 State-of-the-Art

Summary

The state-of-the-art report has been undertaken within the DRM-MERM project to define the primary framework for the Seismic Microzonation Manual with the aim of improving the zonation methodology in Turkey. Thus the review of the literature has been conducted taking into consideration the state-of-the-practice in Turkey. Even though significant effort has been made to conduct a thorough review, due to the multi-disciplinary nature of the topic and very large number of papers, it would be unrealistic to claim that all the literature on seismic microzonation and related disciplines have been reviewed.

The purpose is to review the literature to summarize the state-of-the-art and state-of-the-practice in seismic microzonation that may be considered to be composed of five different phases: site characterization, evaluation of the seismic hazard, estimation of the ground motion characteristics on the ground surface, assessment of liquefaction susceptibility, assessment of landslide hazard. In reviewing the literature each phase is treated separately and in sequential stages as: identification and explanation of the process, compilation of the relevant and needed databases, analysis and interpretation of the acquired databases. The investigations and suggestions encountered in the literature are reviewed in order to inform scientists and engineers in Turkey about all the stages of seismic microzonation. Therefore the necessary steps in each and all seismic microzonation components will be considered consecutively as: quantification of earthquake ground motion, determination of the necessary geological and geotechnical site conditions, analyses of the available data, and engineering interpretation of the results obtained. The findings and proposals related to all these stages will be reviewed briefly to give the reader an understanding of the whole process.

In the last section of the report some seismic microzonation case studies conducted in different parts of the world have been reviewed to give the readers a thorough overview of the seismic microzonation process.

5.2.3 Sustainable Implementation Background Report

Contents

The Background Report consists of three distinct chapters:

- Review of the Legal Basis for Land Use Management
- Analysis of Land Use Regulatory Practice
- Recommendations for Strengthening Land Use Management

The content of these three chapters is summarized below:

Review of the Legal Basis for Land Use Management

In order for seismic microzonation to contribute to earthquake loss reduction, results must be applied to the management of municipal land use. The authority of the municipality to manage public and private land use for the purpose of public safety derives from the constitution and the legal system. While the production of microzonation maps is based on scientific data gathering and analysis, the application of microzonation depends on the current laws governing development and land use. In order to produce final microzonation maps that will be useful in land use management it is necessary to fully understand the potentials and constraints of the administrative regulatory process. This will include the rules governing the administrative regulatory practice and enforcement. This chapter includes a description of the current national land use management system as a background of all local practice and an assessment of the strengths and weaknesses of the system. The chapter also reviews recent developments in land use management policy and opportunities for the incorporation of seismic microzonation in land use management practice.

Changes introduced to the land use management system since the earthquakes of 1999 are reviewed and critical issues are identified. Comment is provided on potential improvements in the macro-framework of municipal development and land use management.

Analysis of Land Use Regulatory Practice

In order to understand the context in which seismic microzonation maps will be used to reduce earthquake risks, an analysis of current land use regulatory practice at the municipal level has been undertaken in Adapazari and Degirmendere. This chapter includes a description of administrative structure and enforcement powers and practice for land use management at the municipal level. It also comments on the relationship of municipal authority with the governorate and central government authorities. The chapter reviews the powers and tools of land use management practice, professional and technical staff capacity and performance of municipal urban planning and building control offices. The chapter addresses the potential of seismic microzonation in the improvement of planning decisions.

Municipal administrative obligations for land use planning and case study materials are provided for the two pilot municipalities of Adapazari and Degirmendere.

*Recommendations for
Strengthening Land Use
Management*

This chapter includes the determination of vulnerabilities to natural hazards. It also includes formulation of methods, requirements and recommendations for the improvement of land use practices to minimize future earthquake vulnerability. The chapter provides:

- Methods for incorporating the findings of microzonation in land use management and planning processes.
- Propositions for the improvement of the regulatory system of land use management to reduce risks and provide higher levels of safety.
- Methods of reducing urban vulnerabilities and their sustainable implementation.
- Illustrative cost-benefit analyses for parts of the proposed system of land use regulatory processes.
- Evaluation of sustainability of the proposals and factors to enhance continued practice.

The effective application of seismic microzonation in determining appropriate land use and exposure in designated high hazard areas in combination with effective implementation of appropriate building standards is the key to future earthquake loss reduction.

5.2.4 Cost-Benefit Analysis for Land Use Management to Reduce Earthquake Losses

Summary

The purpose of this analysis is to demonstrate the benefit of land use management for earthquake loss reduction. An illustrative case demonstrates under what conditions the net benefit of regulated development with long-term reduction in earthquake losses is greater than the net benefit of unregulated development with greater earthquake losses.

The assessment of costs and benefits associated with a specific regulatory policy requires the careful evaluation of the particular factors related to the case at hand. For this reason the methodology is illustrated here with representative values for key factors that are based on best estimates by local experts. Critical variables in the calculation of costs and benefits of earthquake mitigation include: the probability of occurrence of damaging earthquakes affecting the area in question, the probability of damage and injury given probable earthquake occurrence, the cost of mitigation measures, the assumed effectiveness of mitigation measures in reducing damage, determination of the time period of consideration and the relevant discount rate for the period of analysis. Using the methodology presented here these variables may be adjusted to meet the reality of any given municipality.

The illustrative example demonstrates the potential benefit of land use management for loss reduction in the aggregate and for specific stakeholders. Not all stakeholders will benefit similarly. It is important to examine the balance of public and private benefits and to address issues of fairness.

5.2.5 Public Information on Land Use Management

Summary

Successful land use management for earthquake safety depends ultimately

on the understanding and support of the public. Public awareness of earthquake hazards and the measures necessary to reduce future loss is necessary to provide both informed consumers and informed citizens. Understanding of the scientific basis for seismic microzonation and the cost-benefit analysis for mitigation measures provides the basis for informed discussion and decisions. This report includes:

- A sample brochure on Seismic Microzonation and Land Use Management for Earthquake Safety.
- A sample poster illustrating Seismic Microzonation for Earthquake Safety with appropriate text.
- A sample newspaper article on the MERM project and the value of Seismic Microzonation for Earthquake Safety.
- A sample script for a TV presentation on Seismic Microzonation and Land Use Management for Earthquake Safety.

Public support for earthquake mitigation is crucial to ensure appropriate public and private development control and land use management. Earthquake risk management is a long-term responsibility for everyone.

5.2.6 Training for Municipalities

Summary

Following the development of the microzonation manual, it is necessary to provide training for municipal planning staff in the appropriate application of seismic microzonation to principal municipal land use management functions. This report includes the preparation of materials (printed and visual) for conducting seminars and briefings on the application of seismic microzonation at the municipal level.

The training plan includes:

- Identification of trainable human capital, and
- Development of methods and material for training the target groups.

The printed and visual material includes:

- A training plan
- An instructors manual
- Power Point presentations for all topics presented.

The intention is that these materials will provide the basis for training of planners in all seismically active regions of Turkey.

6. Project Participants

Participating organizations This project was funded by the Swiss Agency for Development and Cooperation (SDC) and executed by the World Institute for Disaster Risk Management (DRM). It represents a joint effort of an international scientific team and the General Directorate of Disaster Affairs (GDDA), the Turkish authority responsible for risk mitigation. An international Technical Advisory Board (TAB) counseled the project team.

DRM associated with the following institutions for this project:

- Bogazici University, Kandilli Observatory and Earthquake Research Institute (BU-KOERI), Istanbul
- Middle East Technical University (METU), Ankara
- Sakarya University (SAU), Adapazari
- Swiss Federal Institute of Technology Zurich (ETHZ), Institute for Geotechnical Engineering (IGT), Institute of Geophysics (IG)
- Swiss Federal Institute of Technology Lausanne, Institut de Structures (EPFL-IS)
- Swiss Federal Institute for Snow and Avalanche Research (SLF), Davos
- Studer Engineering, Zurich
- Virginia Institute of Technology and State University (VT), College of Architecture and Urban Studies
- University of Pennsylvania (UP), Wharton School - Risk Management and Decision Processes Center

Responsible Lead Persons Responsibilities were as follows:

- Project design, project management:
 - Dr. Jürg Hammer (DRM)
 - Dr. M. Dinçer Köksal (DRM, Resident Coordinator)
 - Prof. Frederick Krimgold (DRM, VT)
 - Dr. Jost Studer (Studer Engineering)
 - Dr. Walter J. Ammann (SLF)
- Task leaderships:
 - Research Task Groups: Prof. Atilla Ansal (BU-KOERI), Prof. Sarah Springman (ETHZ-IGT)
 - Manual Preparation Task Group: Prof. Atilla Ansal (BU-KOERI), Dr. Mustafa Taymaz (GDDA), Dr. Jost Studer (Studer Engineering)
 - Sustainable Implementation Task Group: Prof. Frederick Krimgold (DRM, VT), Prof. Murat Balamir (METU)

Tasks: Lead Persons (underlined) and Participants

Responsibilities for the tasks were as follows:

- Management, controlling: Dr. Jürg Hammer (DRM), Walter Hofmann (Brandenberger & Ruosch), resident coordinator Dr. M. Dinçer Köksal (DRM)
- Technical Advisory Board: Prof. Robert Whitman (MIT, Massachusetts Institute of Technology), Prof. Susumu Yasuda (Tokyo Denki University), Prof. Pierre-Yves Bard (University of Grenoble), Prof. Liam Finn (Kagawa University), Prof. Alberto Marcellini (CNR-IDPA, Milan), Prof. Jonathan Bray (University of California, Berkeley), Prof. Roberto Meli (National University of Mexico), Prof. George G. Mader (Spangle Associates), Prof. Rusen Keles (Ankara University)
- Geological/Geotechnical Tasks: Prof. Sarah Springman (ETHZ-IGT), Prof. Atilla Ansal (BU-KOERI), Prof. Akin Önalp (SAU), Dr. Sami Arsoy (SAU), Dr. M. Dinçer Köksal (DRM), Oktay Gökçe (GDDA), Dr. Jost Studer (Studer Engineering)
- Earthquake Hazard Tasks: Prof. Mustafa Erdik (BU-KOERI), Prof. Domenico Giardini (ETHZ-IG)
- Structural Damage Tasks: Prof. Polat Gülkan (METU), Prof. Muzaffer Elmas (SAU), Asst. Prof. Sadik Bakir (METU), Asst. Prof. Marc Badoix (EPFL-IS), Dr. Pierino Lestuzzi (EPFL-IS), Dr. M. Dinçer Köksal (DRM), Oktay Gökçe (GDDA)
- Microtremor Measurements: Dr. Donat Fäh (ETHZ-IG)
- Preparation of Manual:
 - Chapters 1 and 2: Dr. Jost Studer, Prof. Atilla Ansal (BU-KOERI), Rocco Panduri (Studer Engineering)
 - Chapter 3: Prof. Frederick Krimgold (DRM, VT), Prof. Murat Balamir (METU)
- State-of-the-Art report: Prof. Atilla Ansal, Prof. Mustafa Erdik (BU-KOERI), Aslı Kurtuluş, Asc. Prof. Ayfer Erken (Istanbul Technical University, ITU), Karin Şeşetyan, Asc. Prof. Bilge Siyahi (BU-KOERI) with the collaboration of Prof. Sarah Springman, Dr. Jan Laue (ETHZ-IGT)
- Pilot Studies:
 - Coordination: Prof. Atilla Ansal (BU-KOERI)
 - Geological/Geotechnical characteristics: Prof. Akin Önalp (SAU)
 - Seismic Hazard: Prof. Mustafa Erdik, Karin Şeşetyan, M. Demircioğlu, Asc. Prof. Bilge Siyahi and H. Akman (BU-KOERI)
 - Microtremor measurements: Dr. Donat Fäh and Andreas Christen (ETHZ-IG), with the collaboration of Ümit Gülerce (ITU) and Christian Greifenhagen (EPFL-IS)
 - Geotechnical site characterization and site response analyses: Prof. Sarah Springman, Dr. Jan Laue and Juliane Buchheister (ETHZ-IGT)
 - Soil Liquefaction: Asst. Prof. K. Önder Çetin (METU)
 - Landslide Hazard: Asc. Prof. Bilge Siyahi and Asst. Prof. Yasin Fahjan (BU-KOERI)
 - Structural Damage: Prof. Polat Gülkan, Asst. Prof. Sadik Bakır, A. Yakut, T. Yılmaz and U. Yazgan (METU) with the collaboration of Prof. Muzaffer Elmas (SAU) and Dr. Pierino Lestuzzi (EPFL-IS)

- Mapping: Dr. M. Dinçer Köksal (DRM), Oktay Gökçe (GDDA) with the collaboration of M. K. Tüfekçi, K. Özener, S. Demir, A. Demir, S. Kök, S. Yağcı, İ. Kayakıran, E. Nebioğlu, A. Güldemir, M. E. Durgun (GDDA)
- Interpretation and assessment: Prof. Atilla Ansal (BU-KOERI)
- Sustainable Implementation: Prof. Frederick Kringgold (DRM, VT), Prof. Murat Balamir (METU), Prof. Howard Kunreuther (UP), Dr. M. Dinçer Köksal (DRM), Dr. Oliver Korup (SLF)

Project Organization

Rev. 1.1

