GROUP REPORT
&
ABSTRACTS

Group 5

Recovery and Reconstruction
Seismic Zonation Planning and Development

GROUP 5 REPORT
RECOVERY AND RECONSTRUCTION
SEISMIC ZONATION PLANNING AND DEVELOPMENT

Co-Chairpersons: Yoshio Kumagai and Roger Borcherdt,
Reporter: Kenneth Topping

INTRODUCTION

Seismic zonation, or the delineation of various geographic areas according to their potential for various earthquake hazards, is especially useful in recovery and reconstruction following earthquake disasters. Consensus derived from an *International Symposium on Rebuilding after an Earthquake*, Mader and Tyler, this volume, concludes "Rebuilding planning is a high-speed version of normal planning; it must be sharply focussed and realistic; it must be a function of local government; it requires accurate damage assessments, geologic data, engineering information and is especially facilitated by pre-earthquake vulnerability and/or seismic zonation studies."

Earthquakes of the last decade, especially those affecting Mexico City, Leninakan, Armenia, and the San Francisco Bay region have tragically reemphasized the importance of local geologic conditions on determining amounts of damage and life loss. The tragic losses from these events were concentrated in either the immediate epicentral areas or in areas of poor soil conditions, in some cases at distances exceeding 400 km from the hypocenter. These concentrations of losses emphasize the importance of seismic zonation in both pre- and post-event land-use planning. Specifically, these large geographic variations in earthquake vulnerability emphasize the need for maps delineating areas according to general potentials for: *a)* surface faulting, *b)* ground shaking, *c)* liquefaction, *d)* landsliding, *e)* flooding, and *f)* fire. Such maps provide an important basis for development of policies and guidelines to mitigate the effects of future earthquakes as implied by substantial mitigation planning for fire in Japan and recent California legislation (AB-3897)requiring guideline development for mapping special study zones for strong ground shaking, liquefaction, and landsliding.

RESEARCH NEEDS

Research needs pertaining to the application of seismic zonation planning and development to recovery and reconstruction following damaging earthquakes were identified according to pre- and post-event needs as follows:

I. Pre-Event Needs

1. Improvements in methodologies and guidelines for the preparation of seismic zonation maps are needed. (See Proceedings of Fourth International Confer-ence on Seismic Zonation, 4ICSZ, 1991, for detailed research recommenda-tions.)

2. Guidelines to develop standards for the preparation and interpretation of seismic zonation maps are needed to better account for geographic variations in earthquake hazards.

3. Development of improved policies for implementation of mitigation measures at the local and national levels are needed in both the United States and Japan.

4. Geographic Information System (GIS) technology provides a powerful tool for data archival and production of seismic zonation maps; however, if GIS capa-bilities are not available, then conventional geologic maps available in most urbanized seismic regions should be utilized to prepare maps identifying areas of concern for ground shaking, liquefaction, and landsliding.

5. Encouraged application of GIS technology with standardization of data formats at local, state, and national levels, and the archival of regional data sets pertaining to: geologic deposits, building inventories, lifelines, critical facilities, population distribution, interpretative seismic zonation and fire hazard maps, and response and recovery resources.

6. Improved strategies and plans need to be developed in advance at local, state, and national levels for recovery and reconstruction following disasters associated with earthquake and fire.

7. Increased pre-event training efforts regarding hazards associated with earthquakes, fire, and other natural disasters are needed for local neighborhood groups, city planners, and officials.

II. Post-Event Needs

1. Develop improved methodologies based on modern technology to *a)* rapidly assess damage distributions, *b)* identify especially vulnerable areas, *e.g.*, those with ground failures or potential failures and those identified on seismic zonation maps, *c)* and identify safe areas for immediate reconstruction efforts.

2. Conduct studies of the reconstruction process as it has occurred for earthquakes and fires of the last decade or so in order to develop guidelines for reconstruction plans for future events.

3. Encourage the utilization of GIS technology for recovery planning to more rapidly compile damage data for analyses in conjunction with pre-event data previously archived *via* GIS.

4. Utilize GIS in seismically aware communities to develop prototype examples for other communities and to serve as a political platform to inform public officials and initiate mitigation reform.

AREAS OF POSSIBLE U.S.-JAPAN COLLABORATIVE RESEARCH

1. Develop uniform set of guidelines for preparation of seismic zonation maps acceptable in both Japanese and U.S. societies. Standards for mapping need to be established for the following phenomena: *a)* surface faulting, *b)* ground shaking, *c)* liquefaction, *d)* landsliding, *e)* flooding, and *f)* fire vulnerability.

2. Identify common guidelines for implementation of mitigation measures in each society pertaining to each of the phenomena listed in "1."

3. Conduct collaborative research projects pertaining to general research needs for seismic zonation as identified in proceedings of 4ICSZ.

4. Improve application of GIS technology to recovery and reconstruction planning through: *a)* improvements in user-friendly software dedicated to application of GIS to recovery and reconstruction problems, *b)* standardization of data formats to facilitate exchange of data and data analyses software.

5 Conduct joint studies of recovery and reconstruction processes for natural disasters of last decade of mutual interest to Japanese and U.S. researchers.

6. Conduct exchange program concerning training and education materials for 1) schools, 2) public, 3) public officials, and 4) professionals.

7. Conduct cooperative research efforts to improve lifeline planning, mitigation of existing hazards, and analysis of implications for community infrastructure.

WORKING GROUP ABSTRACTS

VULNERABILITY ASSESSMENT AND DAMAGE ESTIMATION FOR EARTHQUAKE DISASTER MANAGEMENT

Yoshio Kumagai

Introduction

The seismic vulnerability assessment in the Tokyo Wards Area was announced officially in 1975 and 1984 by the Disaster Prevention Planning Department of the City Planning Bureau.

The purpose of this assessment was to provide a basis for designating vulnerable areas through scientific measurement of microzones in times of a large-scale earthquake.

Details are as follows.

1. Guidelines for creation of the disaster-proof city
2. Reference data for the selection of zones which have been given priority for earthquake disaster mitigation
3. Foster citizen awareness for earthquake disaster prevention
4. Use of the assessment to enhance disaster mitigation.

On the other hand, the earthquake damage estimation in the Tokyo Metropolis was officially announced in 1978 and 1985 by the Disaster Countermeasures Department of the General Affairs Bureau.

It is necessary for comprehensive and effective promotion of earthquake disaster countermeasures to estimate the occurrence mechanism and the scale of damages which are triggered by an earthquake. The estimation is the premise for the formulation of the local disaster prevention and mitigation plans prescribed by the Disaster Countermeasures Basic Act of Japan.

Comparison Between the Damage Estimation and the Vulnerability Assessment

The comparison between the damage estimation and the vulnerability assessment is shown in Table 1. According to Table 1, the essential difference between the damage estimation and the vulnerability assessment is that the damage estimation was undertaken for earthquake disaster mitigation/prevention measures before, during and after an earthquake disaster and the vulnerability assessment was taken for urban disaster prevention planning.

Kinds of Vulnerability Assessments

The disaster prevention/mitigation planning in regional and urban areas has many aspects. These are the control of land and building use, the construction and the arrangement of disaster prevention facilities, and the education and diffusion of earthquake disaster policy-making.

Institute of Socio-Economic Planning, University of Tsukuba
1-1-1, Tennoudai, Tsukuba-shi, Ibaraki-ken, 305, Japan

In regional and urban planning, the vulnerability assessment is a kind of seismic microzonation, and this is the microzonation in a broad sense.

I would like to discuss the difference of vulnerability assessment between a narrow and a broad sense and the application of both kinds of vulnerability assessment in regional and urban planning for earthquake disaster prevention and mitigation.

First I should define the basic concept of the vulnerability assessment in a narrow and a broad sense.

In the first stage of the vulnerability assessment in a narrow sense is classification of topography, ground conditions, and others and estimation of the seismic intensity in each microzone. And then we assess damages of buildings and facilities such as bridges, roads and others. This process should be called the vulnerability assessment in a narrow sense.

On the other hand, the vulnerability assessment in a broad sense is classification by characteristics of each microzone. We should assess secondary damages due to collapse of buildings and facilities, tsunami hazards, fire hazard, evacuation and lifeline damage. Then, we should classify each microzone. This should be called the vulnerability assessment in a broad sense.

Application of the Vulnerability Assessment

The application of the vulnerability assessment in a narrow sense is different in the developed area and the new development area. And the application in the developed area has two aspects. These are the application for the short-term countermeasures and the long-term countermeasures. Applications in each are shown as follows.

The built-up area

Short-term: Reinforcement of buildings in dangerous area

Long-term: Control of land and building use

The new development area: Designation of development sites and boundary conditions for planning

The vulnerability assessment in a broad sense is classification of zones by characteristics of each microzone. This type of assessment is very important to prevent and mitigate earthquake disasters for regional and urban planning.

To build a disaster-proof city, it is necessary to take into consideration the characteristics of the district in order to formulate countermeasures. The characteristics of the district include not only the primary damages but also the secondary damages.

Conclusion

As the conclusion of this paper, I should emphasize the necessity of the vulnerability assessment in a broad sense, especially in a developed area. Here we should formulate a redevelopment plan and control land building use and the building structure according to the characteristics of each microzone. It is necessary to establish a disaster prevention system for the whole urban area and to inform the residents.

Table I:

	The Damage Estimation	The Vulnerability Assessment
The section on charge	Department of Disaster Countermeasures, General Affairs Bureau	Department of Disaster Mitigation Planning, City Planning Bureau
1. Investigation basis	There is not a clear basis. Basic data for formulation of the Local Disaster Prevention Plan prescribed by the Disaster Countermeasures Basic Act.	The Governor has to assess and announce the vulnerability on an earthquake disaster in each district every 5 years. [The Tokyo Metropolitan Ordinance for Earthquake Disaster Prevention]
2. Purpose	Basic data for "The Tokyo Metropolitan Local Disaster Prevention Plan (Earthquake Disaster Volume)"	① Guidelines for creation of the disaster-proof city ② Reference data for the selection of zones which have to be given projects for the earthquake disaster mitigation priority ③ Foster citizens' awareness for earthquake disaster prevention ④ Turning the assessment to accountment of enhance disaster mitigation senses
3. Factor of time-series	The limitation of estimation period is important for consideration of the chain of damages.	The chain of damages is not considered. So the limitation of assessment period is not so important.
4. Scale for Evaluation	It is necessary to estimate damage volume in each item. The scale should be the absolute one.	The main purpose is the comparison in each district. So the scale is relative one.
5. Premise for Investigation	It is very important. Because damages might be estimated more than tens times in some premises.	The main purpose is the comparison in each district. So the premise is not so important.
6. Relation between items	Total volume of damages depend on the chain of damages. So it is to be desired that we can estimate the increase of damage volume caused by the chain of damages.	The main purpose is the comparison in each district. So relations between items are not so important.
7. Relation between districts	Relations between districts are very important to estimate the total volume of damages in the region.	The main purpose is the comparison in each district. So relations between districts are not so important.
8. Presentation	The volume of damages in each district and the whole area has to be estimated by numerical value.	It is to be desired to be presented by graded figures in the whole assessed area.

The Damage Estimation and The Vulnerability Assessment for the Urban Earthquake Disaster Management (In case of Tokyo)

PLANNING FOR EARTHQUAKE RECOVERY AND CONSTRUCTION

Paul J. Flores

Understanding Earthquake Recovery and Reconstruction

1. There has been significant progress in reducing earthquake hazards and improving emergency preparations at the local level in California. There remains, though, a lack of preparation and planning for earthquake recovery and reconstruction.

2. An understanding of earthquake recovery and reconstruction issues is essential in order to improve our current capability to plan and manage the process. Oftentimes, it is a lack of understanding of the complexities involved and the long-term duration of the recovery and reconstruction process that leads to technical, political and socioeconomic problems.

3. The earthquake recovery and reconstruction process is knowable and predictable. Research has shown that similar patterns and issues emerge after major damaging earthquakes that can provide the basis for planning recovery and reconstruction activities at all levels of government.

The Earthquake Recovery and Reconstruction Process

1. The study of earthquakes in California and other parts of the world has produced findings on the types of activities initiated (by government) and the time frames within which these activities are undertaken. The activities can be grouped according to three basic community objectives: the provision of emergency relief, the restoration of public and private services, and the reconstruction of lost structures and facilities. Each objective will be met within time frames that are dependent on technical, political and financial factors.

2. Three basic phases define the earthquake recovery and reconstruction process:

Phase I: Emergency Relief (from a few days to at least two months following the earthquake). Decisions and actions taken during this phase are primarily stopgap measures aimed at providing emergency relief to affected individuals and organizations.

Phase II: Short-Term Recovery (from two months to at least two years after the earthquake). Decisions and actions taken during this phase are aimed at restoring "normal" conditions including the full resumption of private and public services.

Phase III: Long-Term Reconstruction (from two years to at least ten years after the earthquake). Decisions and actions taken during this phase are aimed at replacing severely damaged structures and infrastructure, and improving the overall socioeconomic environment.

Southern California Earthquake Preparedness Project (SCEPP)
1110 East Green Street, Suite 300, Pasadena, CA 91106

3. The major decisions and activities that are taken are a direct response to the issues that emerge as soon as the shaking stops but will ultimately require long-term solutions. These issues can be grouped into five areas: structural rehabilitation and rebuilding, business recovery, housing, public facilities and services, and financing.

Planning for Earthquake Recovery and Reconstruction

1. Despite its complexity, the earthquake recovery and reconstruction process is predictable. Most of the problems that will emerge can be readily identified which makes it possible to plan, in advance, policy options and alternative solutions. The objective of advance planning for earthquake recovery and reconstruction is to avoid making hasty and irreversible decisions, often made under stressful conditions and political pressure, that can limit the opportunities for rebuilding a safer and improved urban environment.

2. Advance planning for earthquake recovery and reconstruction needs to be based on the following basic planning strategies and principles:

   a. The planning effort should be initiated with a clear commitment from the jurisdiction's elected body; a formal action by the body, directing that the planning effort be undertaken, is recommended.

   b. The planning effort should acknowledge the need to build a consensus as to who has which recovery and reconstruction responsibilities before and after the earthquake occurs.

   c. The planning effort should involve representatives from key government agencies as well as private organizations that figure to play a role in the recovery and reconstruction process.

   d. The planning effort must begin with the development of policies that can guide the identification of appropriate recovery and reconstruction actions.

3. A planning model consisting of ten basic steps has been developed by SCEPP, and its application is now being promoted throughout the southern California area. It is based on the knowledge gained from past research results, the experience of governments that have been involved in past and current recovery and reconstruction efforts, and the advance planning of the City and County of Los Angeles.

ESTIMATION OF SLOPE FAILURE AND ITS INCLUSION INTO LAND PRICE

Hiroshi Kawano[1], Kazuoh Seo[2], Takanori Samano[3]

Probably, many Japanese people believe that the most terrible natural disaster will be caused by an earthquake. However, among 4,567 people who were killed in natural disasters from 1967 to 1986, 2,632 people lost their lives in soil failures. In Japan 75% of the area is located on hills. Approximately 70,000 dangerous areas of debris-avalanche and about 80,000 dangerous areas of sharp slopes exist, but inhabitants have little concern about serious damage of soil failure because it usually occurs locally and on a small scale.

Recently, land developments, especially in Tokyo Metropolitan Area, have rapidly spread into the dangerous area of soil failures. If new regulations are not adopted, these dangerous developments may also increase, and resultant damage due to slope failures will also increase.

One solution is to reduce the profit from developments in these dangerous areas. If the cost to develop these areas is high, it will restrain interest in developing in dangerous areas.

However, today improved lands which were cut through hills are sold at a high price so that developers can recover their investments and because land for housing is very limited in urban areas. Because hazard risk is not rated in the market, these dangerous areas are traded at a high price. People who want to buy these lands don't consider the risk. It is one reason that development in dangerous areas is flourishing.

So in this paper we tried to measure slope failure risk and to weave it into land price. We chose Takatsu Ward, in Kawasaki City, Japan, as the research area. Takatsu Ward is located very close to Tokyo. Takatsu Ward has a population of 160,000. Development in Takatsu Ward began in the 1960s. At present, residential developments are remarkable there. There are many steep slopes in this Ward, and some people were killed in a slope failure several years ago.

First of all, we made a questionnaire which concerned consciousness about steep slopes to inhabitants. We distributed them near two slope areas. Next we investigated the change of land price and population in Takatsu Ward during the last several decades. We studied the relationship between the advancement of housing development and transition of land price. It will show a history of developments in dangerous areas.

We computed the degree of potential danger by looking at the history of slope failures in this Ward. And we will estimate the amount of damages that will occur if these slopes collapse. We will try to use the data of payment of insurance money to estimate the amount of damage. Last, we wanted to evaluate the corrected land price by adding the risk of slope failures.

The result of the questionnaires shows that inhabitants who live on steep slopes feel somewhat uneasy about slope failures but feel rather safe. When they buy houses they pay much more attention to convenience of transportation facilities and general location. But they don't take disaster risk into account.

Given the present circumstances, there will not be much difference between the land price in dangerous areas and that in nondangerous areas. In short, the risk of disaster does not influence the market. This paper will contribute to the formation of land prices in which the risk of disasters is evaluated with slope and failure taken into account.

1 Graduate student, Tokyo Institute of Technology, 4259 Nagatsuta, Midori-ku, Yokohama 227, Japan
2 Assoc. Prof., Tokyo Institute of Technology, 4259 Nagatsuta, Midori-ku, Yokohama 227, Japan
3 Res. Assoc., Tokyo Institute of Technology, 4259 Nagatsuta, Midori-ku, Yokohama 227, Japan

BASIC STUDY ON THE COMPUTER-AIDED MAPPING SYSTEM FOR EARTHQUAKE DISASTER MITIGATION

Murakami Suminao and Sadohara Satoru

Object

In Southern Kanto Area (central part of Japan), there is a great possibility of an earthquake because there are many plate boundaries. So far, disaster mitigation planning has been focused on preventing a large-scale disaster like the Kanto earthquake in 1923. But smaller earthquakes are supposed to break out with higher possibility. In this case, part of the area, rather than all of the area, will be destroyed and recovery action is done while maintaining normal functions in the less damaged areas. We should know the characteristics of areas in detail in order to cope with the situation. It is helpful to have a system to analyze the characteristics of areas on the map. This is a basic study to develop a computer-aided mapping system for this purpose.

Method

1. System design. Figure 1 is a component of hardware. The data are stored and displayed in three different scales: 1 to 2,500, 1 to 10,000, and 1 to 160,000. The maps include addresses. The function of software is to overlay data and displays on the map. There is a search system that can identify areas by inputting addresses.

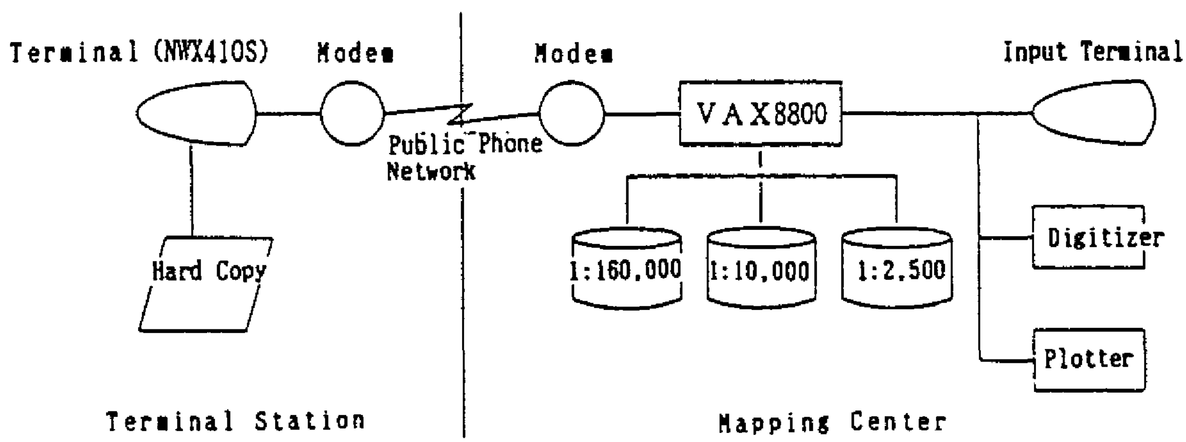


Figure 1 Hardware Components

2. Data Collection. We selected an area of about 100 km located in the center of Yokohama City (Figure 2) and a part of a suburb of Yokosuka City as a training area. Input data and output results are shown in Figure 3.

3. Result. By analyzing the data, we can get important information that is useful to developing a scenario of disaster in order to plan pre-event, event, and post-event responses and to design the social system to take suitable responses.

Yokohama National University, Department of Architecture

4. Conclusion. After this study, we are confident that this kind of mapping system is very useful for disaster mitigation. This system benefits many organizations such as the fire department, police, the municipality and so on. This method can be also applied to other areas. We hope this study will stimulate the development of mapping systems in many areas.

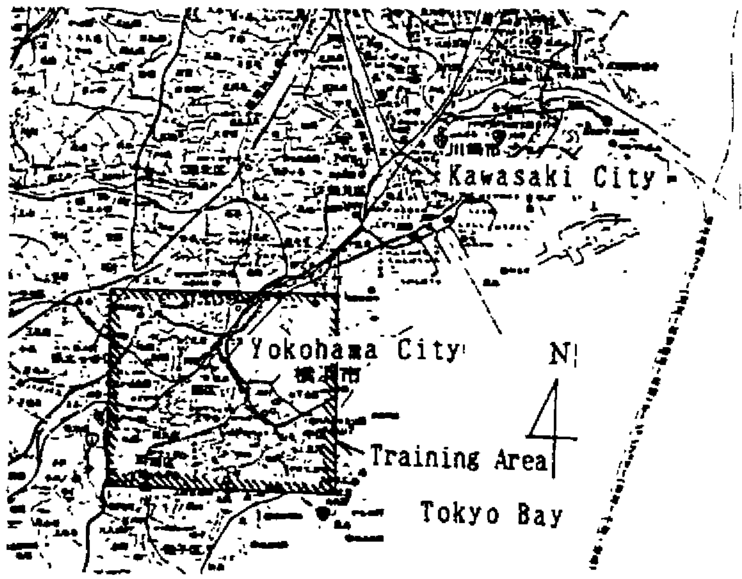
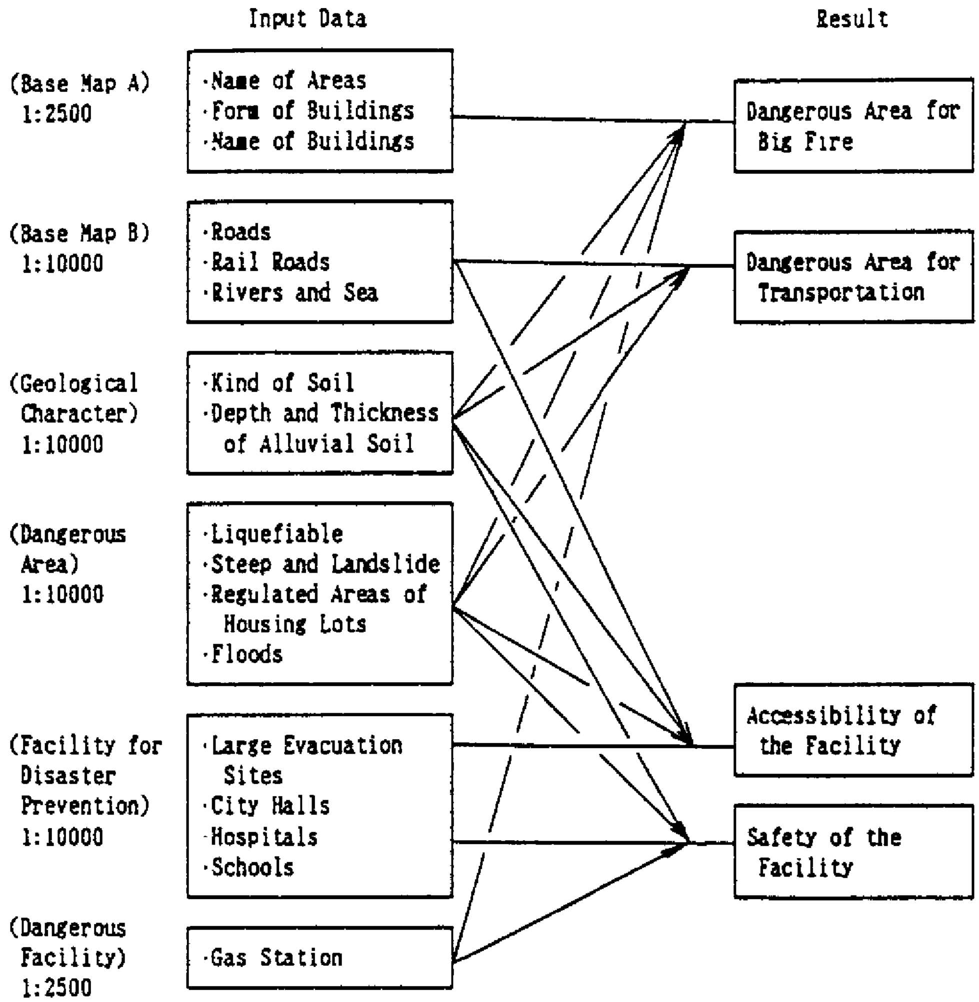


Figure 2 Training Area



Firgure 3. Input Data and Output of Mapping System

A METHODOLOGY FOR SEISMIC VULNERABILITY ESTIMATION AND ITS APPLICATION FOR THE CITY OF LIMA, PERU

Vivian Shigyo

Forward

Advances in earthquake engineering have permitted experts to rationally estimate earthquake hazards and risks to buildings, but this knowledge has not been used by city planners. Thus, the purpose of the present research is to develop a methodology on seismic vulnerability analysis for the city of Lima and the seaport of Callao for use by decision makers when evaluating and revising future development strategies and land use policies for the city. There are three specific parts in the methodology. The first part evaluates seismic hazards for the city ground characteristics and the existing building types. It integrates an existing database of past geological information, and a new database which includes ground motion characteristics and building response. The second part evaluates the seismic vulnerability of the population and the present land use pattern of the city. The third part estimates the earthquake return period probability. It relies on the available information about historical earthquakes registered since 1533.

Characteristics of the City of Lima and the Seaport of Callao

Lima and Callao are located on the central coast of Peru. This region is a desertic strip of land bounded by the Pacific Ocean and the Andean Mountains, which rise up to 4,800 meters at about 95 km. from the shoreline. Rain is very scarce, and rivers flowing to the ocean from the Andes are short in length. Surface relief in the valley is gentle. The city of Lima lies on the fluvial delta of the Rimac and Chillon rivers and three ancient tributaries: Canto Grande, Pampa Grande, and Pampa Arenal. Because of its short length, steep gradient and considerable flow, the Rimac river was able to carry in the geologic past a considerable amount of large-diameter material into its delta. The river, emerging into the Lima area a few miles to the east of the city center, meanders back and forth across a triangularly shaped area of land on which most of the city is founded, depositing the "cascajo." Cascajo is the local name for a sandy, bouldery gravel, poorly graded, but usually very dense. Particle orientation within the cascajo gives it an apparent cohesion due to grin interlocking, which allows it to be excavated with vertical cuts. The cascajo exposed along the shoreline, where cliffs 40 to 70 meters high with 70 to 80 degree slopes have remained stable for centuries. Also finer material has been carried by the Rimac river toward the districts of Barranco and Chorrillos (to the south), and Callao (to the west). These soil deposits are quite erratic, and contain layers and pockets of medium dense sand, silt, sand and fine gravel, and stiff clays. While in some areas, such as central Lima, cascajo extends from base rock to within 0.5 meters from the ground surface; in other areas, such as La Molina, the cascajo either does not exist or is deeper than 30 meters; and at Callao-La Punta it is 10 to 30 meters or more in depth. Whether a site is underlain by "cascajo" or by other materials is an important key to determinate the earthquake damage probability.

The prevalent construction practice in Lima has changed through the years; however, it is possible to classify existing urban construction into the following three basic types: adobe and/or quincha, brick and reinforced concrete. Adobe and/or quincha dwellings are typically one or two stories high with total heights of 3 and 7 meters, respectively. Dwellings of this type

University of Tokyo, Department of Urban Engineering,
3-7-1 Hongo, Bunkyo-ku, Tokyo 113, Japan

are typically 50 to more than 100 years old. The brick and concrete construction in Lima dates back some 70 years. Buildings are typically one to three stories high, and buildings in excess of 3 stories are usually of the reinforced concrete frame type[1].

The Vulnerability Analysis

$$V=F(i)\bullet D$$

The vulnerability (V) of a city is defined as the expected degree of loss due to an earthquake. This function (V), is estimated using the relation indicated above, where (F(i)) represents the probable earthquake return period and (D) the damage.

F(i), is calculated as the probability of occurrence of a potentially damaging earthquake with intensity *i*, within a specific period of time *n*, in a given area. The resulting probability is expressed on a scale from 0 to 1.

D, is the degree of damage due to the occurrence of a potentially damaging earthquake of a given intensity to a given set of elements at risk. For the estimation of *D*, the following formula was applied: $D=S\bullet(E1+E2+...En)$, for $E1+E2+...+En=10$

Where the risk (*S*), represents the damage percentage (0 to 1) of the different types of buildings in the area. *S*, is calculated from the soil and buildings response spectrums, and the percentage of damage distribution based on data of past earthquakes.

E1, E2,...En, are the elements at risk (population, public buildings, etc.) in the area.

The Seismic Vulnerability Estimation of Lima and Callao

The seismic vulnerability estimation of Lima and Callao, consists of:

1. Analysis of Lima's soil and buildings for the selected locations. To supplement the data available for constructing soil formation models, a series of microtremor measurements was conducted from December to January 1990 at three specific districts of Lima: La Molina, Callao, and El Cercado (Lima's city center). Stationary intervals of 82 seconds for each record were selected to be digitized by the A-D converter at intervals of 0.02 seconds. Fourier amplitude spectra of the microtremor records as well as available data on boring and seismic prospecting tests were used to construct the dynamic soil layer models[2]. For the estimation of the buildings' structural damage due to earthquakes (*S*), the programs that evaluate the soil and building responses in the Hachioji-shi Report[3] were applied.

2. Analysis of Lima's density distribution of the population[5] and buildings, public buildings[6] location and land use for the locations selected (*E1, E2, E3*).

3. Earthquake return period probability (*F(i)*). *F(i)* represents the return period of an earthquake with intensities from 7 to 9, for a period of "n" years determinate from the analysis of the historical data on earthquakes[4]. For Lima and intensities larger than 7, the return period that seems more appropriated in the analysis is 150 years. There are also data available corresponding to 430 earthquakes with intensities in the range of 2 through 9 in a period of 450 years.

4. Maps with the results of the influence of the soil and buildings characteristics (1) in the damage (degree of loss) to the city, and the city's physical and social structure (2) were obtained. (D=S•(E1+E2+E3))

5. The earthquake return period probability (3) was added to the resulting maps from (4) according to the formula V=F(i)•D to obtain the map of seismic vulnerability for the city.

References

1. Repetto, Arango, Bolton Seed, Influence of Site Characteristics on Building Damage during the October 3, 1974, Lima Earthquake, College of Engineering, University of California, Berkeley, September 1980, pp. 1-6.

2. Osawa, Osada, others, Evaluation of the Damage to Wooden Houses caused by the 1978 off-Miyagi Prefecture Earthquake, Natural Disaster Science, Vol. 8, Number 1, 1986, pp. 1-27.

3. Hachiojishi Bosai Kaigi, Report on the Estimation of Damages due to an Earthquake for the City of Hachioji (in Japanese).

4. CERESIS, Catalog of Earthquake for South America, Hypocenter and Intensity Data, Vol. 7B and 7C, 1985.

5. Ministerio de Vivienda y Construccion, Reglamento de Zonificacion General de Lima Metropolitana, 1979.

6. CAPECO, Reglamento Nacional de Construcciones, 7 Edicion, Agosto 1988.

MAXIMIZING ADVANCES IN RECOVERY PLANNING, SEISMIC ZONATION AND GIS

Kenneth C. Topping

Critical Issues

After catastrophic earthquakes, critical issues emerging have included the need for efficient recovery and wise rebuilding. Recovery typically takes place in an atmosphere of intense pressure to act quickly so people can resume normal activities. Businesses and governments alike are normally unprepared to deal efficiently and wisely with the flood of decisions that must be made regarding how best to recover and rebuild. In the rush to act, people are allowed to reoccupy unsafe buildings. Development is permitted in hazardous locations. Because of such expediency, loss of life and property is likely to reoccur in some future event. Such outcomes could be substantially reduced if thoughtful judgment were exercised before as well as after the event, using the latest seismic zonation and GIS advancements.

Lessons Learned

Following devastating earthquakes in recent decades, serious attention has been given to specific problems of improving post-disaster recovery performance. U.S. studies in the 1970s and 1980s provided scientific and practical foundations for improving recovery and reconstruction practices through pre-earthquake planning. Meanwhile, advances were made in seismic zonation and in the development and application of new Geographic Information System (GIS) software. Lessons learned from these investigations are leading to changes in practice in government and the private sector.

Changes in Practice

At the federal government level, improved disaster assistance and post-event hazard mitigation planning have been emphasized in conjunction with amendment of basic enabling legislation, including the Stafford Act, which amended Public Law 93-288 in 1989, and the Earthquake Hazards Reduction Act amendments of 1990. Legislation has been proposed that would aid recovery and reconstruction through provision of mandatory earthquake insurance nationwide.

Legislative enactments at the state level in California have led to statutes and administrative guidelines requiring safety elements within local government general plans, state seismic zonation for geologic hazards and mandatory unreinforced masonry (URM) buildings inventories and retrofit programs. Legislation was enacted in 1986 to enable and encourage local governments to plan and organize in advance for post-earthquake recovery and rebuilding. State emergency preparedness procedures for local governments have been supplemented by new, comprehensive pre- and post-event recovery and reconstruction planning guidelines, issued in may 1991 by the Southern California Earthquake Preparedness Project.

1196 Banyan Street, Pasadena, California 91103.

At the local government level, cities and counties throughout California have completed URM inventories and are in the process of adopting appropriate retrofit ordinances, many modeled after the previously existing Long Beach and Los Angeles programs. A unique pre-event recovery and reconstruction planning effort has been underway for several years at the City of Los Angeles, with a final draft plan being readied for public discussion in 1992. The County of Los Angeles, meanwhile, has adopted a landmark general plan safety element which sets a new professional standard being emulated by smaller jurisdictions such as Santa Monica.

Recent public sector activity in California has been matched, and in some instances exceeded, by private sector business resumption planning being undertaken with the advice and assistance of a whole new "cottage industry" of risk management and safety consultants. Stimulated by the Loma Prieta earthquake experience, business and industry emergency preparedness organizations have sponsored training workshops and seminars in pre-event recovery planning in various regions of the state.

Meanwhile, new public and private sector GIS applications have emerged which have both direct and indirect value to pre- and post-event reconstruction planning. GIS applications encompass a variety of purposes, from conversion to digital format of standard road maps to sophisticated demographic analysis which shapes day-to-day marketing and political decisions. Improved scanning of data from remote sensing and photographic data sources has increased efficiency of digital natural resource, land use and geohazards mapping. GIS is enabling the related fields of architecture, economics, landscape architecture, urban planning, urban design, real estate development, transportation planning and infrastructure engineering to interact more effectively.

Issues Needing Attention

Nonetheless, advances in knowledge and practice in pre-event recovery planning, zonation and GIS so far have not been systematically integrated. The opportunity now exists to coordinate these specialized areas in order to improve post-earthquake recovery outcomes.

Among the many issues requiring closer attention are post-event land reuse, redevelopment and reconstruction finance, infrastructure restoration, housing repair anc replacement, land reassembly and permit streamlining. Methods and techniques for mor detailed planning and programming of pre- and post-event hazard mitigation and recover decisions must evolve. More reliable methods of mapping ground shaking and instability mus be developed. Site-specific mitigation of various geologic hazards must be expanded beyor site preparation and structural strengthening to include innovative site design, land use a development rights transfer techniques. And finally, development of more cost-effective a user-friendly GIS applications is critical to facilitating improved recovery and reconstructi decision flows.

Needed Research

Additional research is needed in all of the preceding areas requiring further atten However, two critically important questions which must be faced include: 1) the integrati research between the three subject areas of pre-event recovery planning, seismic zonation GIS development, and 2) consideration of the practical perspectives and needs of pract public and private sector decision makers. Research should emphasize prototypical mod which these two needs are effectively met.

LESSONS FOR PLANNERS: RESULTS OF AN INTERNATIONAL SYMPOSIUM ON REBUILDING AFTER EARTHQUAKES

George G. Mader and Martha Tyler

Physical Rebuilding

Urban Form and Design

1. Cities and towns are almost never relocated.
2. The rebuilt city is a safer city.
3. Earthquakes offer opportunities for specific urban redesign projects.
4. Neighborhood preservation can aid personal and community recovery.
5. Preserving historic and symbolic buildings helps retain community identify.
6. Design is everybody's business.
7. Defining urban expansion areas helps.

Housing

1. Temporary housing sites often become permanent.
2. Earthquakes aggravate existing housing problems.
3. Most damaged houses can be quickly repaired.

Public Facilities

1. Essential lifelines and services are usually restored very quickly.
2. Critical facilities are quickly repaired or replaced.
3. Temporary space may be needed for public services.

Planning for Rebuilding

Nature of the Process

1. Planning for rebuilding is a high-speed version of normal planning.
2. Planning for rebuilding is dynamic.

William Spangle and Associates, Inc.
3240 Alpine Road, Portola Valley, CA 94028

3. Planning for rebuilding is like redevelopment planning.
4. Planning for rebuilding is sharply focused.
5. Planning for rebuilding is realistic.
6. Planning for rebuilding is based on pre-earthquake planning.
7. Planning for rebuilding is a local function.

Planning During Early Recovery

1. Planners' tasks begin immediately after an earthquake.
2. Demolition and clearance set the stage for planning to rebuild.

Information for Planning for Rebuilding

1. Accurate damage assessments are essential.
2. Geologic studies are essential.
3. Engineering information is needed.
4. Earthquake vulnerability studies are helpful.

Organization for Planning

1. Planning after an earthquake usually requires special organization.
2. Organization for planning may take many forms.
3. The best organization for planning is streamlined and accountable.
4. An effective organization provides for public participation.
5. The organization needs to coordinate with other public agencies.

Timing

1. Taking time to plan may delay rebuilding.
2. Planning and rebuilding can occur simultaneously.

Funding

1. Government funding is not enough.
2. Aid can inhibit recovery.
3. Ideally, a rebuilding plan guides public and private investments.
4. Rebuilding costs can be reduced by reusing materials.

Pre-Earthquake Steps to Prepare for Rebuilding

Plans and Ordinance

1. Have a clear and up-to-date general plan.
2. Be sure plans and regulations are consistent.
3. Take particular care in approving subdivisions.
4. Carefully regulate new development.
5. Participate in regional planning.

Redevelopment

1. Create the authority and plans for redevelopment.

Information

1. Create and maintain a data base.
2. Identify and evaluate geologic and seismic hazards.
3. Identify and evaluate hazardous structures.
4. Identify particularly vulnerable areas.

Standards for Rebuilding

1. Establish appropriate standards for repairs and rebuilding.

Housing

1. Designate temporary housing sites.
2. Plan for adequate affordable housing.

Procedures

1. Establish an organization to plan for rebuilding.
2. Prepare and adopt emergency ordinances.
3. Plan how to process building plans and permits.

Staff Training

1. Prepare your staff for earthquakes.
2. Learn the federal and state disaster assistance programs.