DEVELOPMENT OF SOFTWARE FOR EARTHQUAKE EDUCATION DESIGNED FOR SCHOOL TEACHERS USING PERSONAL COMPUTERS

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Introduction

In order to examine the type of earthquake education that takes place in schools and to determine the kinds of teaching materials and aids that are required by teachers, one of the authors distributed 1,670 questionnaires to elementary and junior high schools in seven prefectures in Japan. Eleven hundred seventeen answers were collected (about 71% recovery). The study revealed that audio-visual materials were strongly demanded although they were not sufficiently supplied.

Videotapes and movies have been made as audio-visual teaching materials; however, they are passive and not interactive with users. The purpose of this study is to develop earthquake education software which is user-friendly, interactive and suitable for use on a personal computer. The intended users of this software are school teachers.

The Composition of the Earthquake Education System

1. Hardware

   One of the most important factors for users and developers is a system that is easy to manipulate. The Mackintosh personal computer meets this requirement. The hardware system composition is shown in Figure 1.

2. Software

   The application software of Macintosh, "Hypercard," was used to develop the education software because it has many advantages not only for the users but also for the developers.

The Options of the Earthquake Education Software

The contents of the educational software developed in this study are divided into six options. They are "Geophysics and Seismology," "Earthquake Engineering," "State of Mind and Refuge," "Information and Administration," and "Miscellaneous Matters." All the options are linked through a "Menu Card" as shown in Figure 2. This Menu Card appears first on the monitor screen after turning on the computer system.

1. Geophysics and Seismology

   This option explains how and why earthquakes occur, relevant phenomena and technical terms. In the explanation of how and why earthquakes occur, the theories of plate tectonics and continental drift are discussed. This option aims to help users understand rationally the events associated with an earthquake. There are 37 cards in this option. Figure 3 shows Card 24 which displays the plate system in the vicinity of the Japan Islands.

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2. Earthquake Engineering

   It is impossible to explain all the aspects of earthquake engineering. Therefore, the focus of this option is the explanation of liquefaction, landslides, building-ground interaction (resonant phenomenon), aseismic design, and technical terms which are used frequently when describing earthquakes, such as "magnitude" and "intensity." In addition, with schools in mind, countermeasures to prevent the spread of broken glass and overturning of fences are included. There are 48 cards in this option.

3. State of Mind and Refuge

   Teachers should play a key role during an earthquake. In order to display leadership, it is necessary to have an understanding of how children feel and react during an earthquake. Fortunately, there are many compositions which were written by students who have experienced an earthquake. Based on these compositions, the state of mind of students has been summarized. The option also recommends how to prevent the occurrence of panic and how to take refuge safely.

4. Information and Administration

   We cannot judge correctly what to do and how to take refuge in safe places after the event without reliable information. Therefore, it is very important to know how to get reliable information and how to utilize it. This option addresses these problems. Thirty-two cards explain the information networks which have been set up between administrative organs and broadcasting stations to distribute information in the event of an earthquake.

5. Past Earthquake Disasters

   In this option, the users will review typical earthquake disasters and will learn what kinds of dangers and hazards occur during an earthquake. Figure 4 shows dangerous spots in a school. This option contains 24 cards.

6. Miscellaneous Matters

   Other relevant phenomena and matters about earthquakes are treated in this option. It is divided into four sections: tsunami, fires, volcanos, and earthquake prediction. Users will learn how tsunamis are produced and why volcanos erupt, the importance of extinguishing and/or fighting fires, and the current state of the art in earthquake prediction. This option consists of 41 cards.

Summary

The software explained in this paper is the first version and is in monochrome. The present version has six options, but they are closely connected with each other. We are now updating this version by reorganizing the arrangement of the cards and by using a full-color format.

We deeply thank Messrs. K. Sakao, T. Ishikawa, H. Okazaki, N. Okazaki, Y. Kaneko, and R. Shimokawa for their cooperation in development of the system.

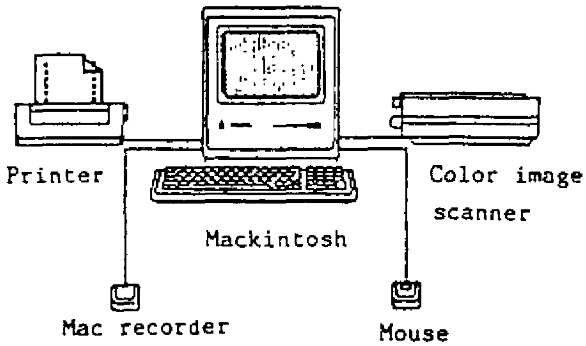
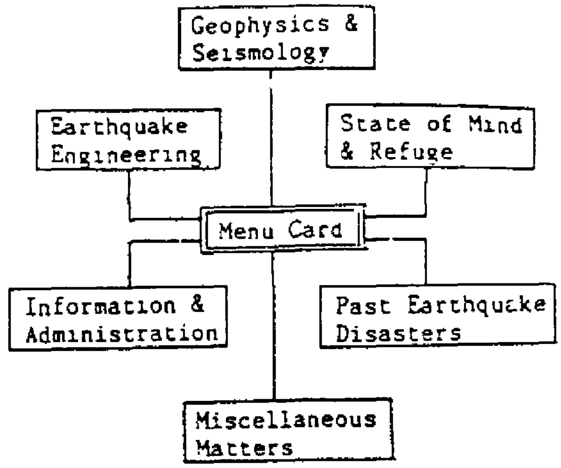


Fig.1



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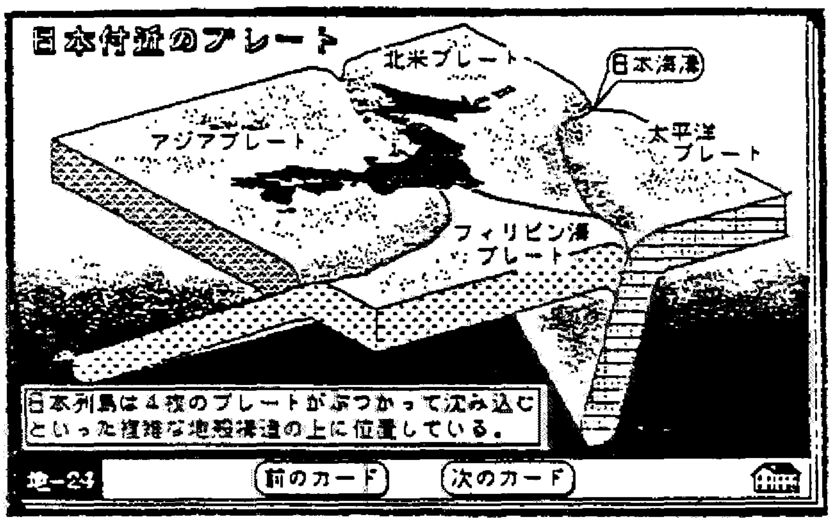

Fig.3

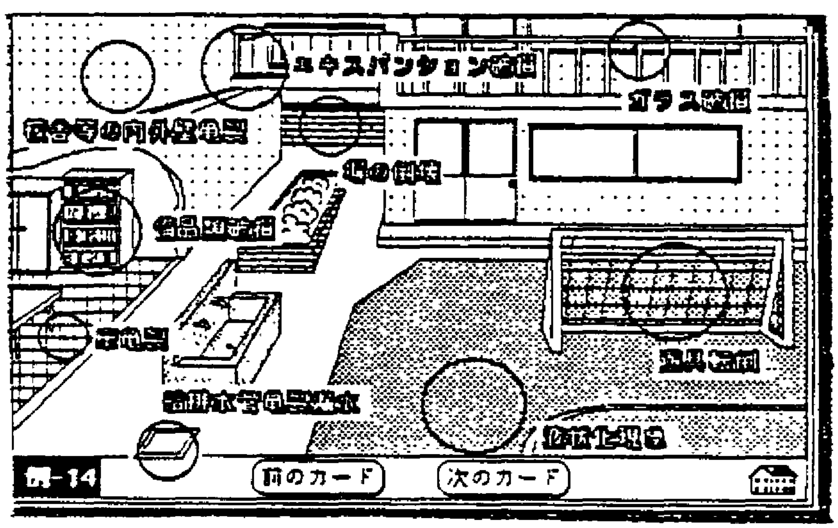

Fig.4

EARTHQUAKE HAZARD REDUCTION IN URBAN AREAS OF MODERATE SEISMICITY

Guy J. P. Nordenson

Introduction and Background

As a consequence of the 1989 Loma Prieta earthquake the U.S. is well on the way to having seismic design required for all buildings located in all but regions of low seismicity. Connecticut, New York, New Jersey, South Carolina, Tennessee are among those states considering or having adopted new requirements. Massachusetts has had a seismic code for over 15 years.

Unfortunately, the majority of the seismic codes being used have not been developed with the particularities of moderate seismicity and local construction practices in mind. Furthermore, they often differ among themselves (there are at least three reference codes available to choose from). Finally, they are being considered apart from overall macro- and microeconomics considerations, urban planning concerns and opportunities and related hazard mitigation measures.

This paper will present a listing of issues that have been raised as the author has been, since 1984, involved in the development of the awareness of seismic hazards and the evolution of mitigating measures, notably a new code for New York City and state.

Issues

Several issues, or questions, merit continued consideration as seismic design requirements are evaluated for use in places such as New York City.

- What are the maximum probable (say, with a 30-50 percent probability of occurrence in 50 years) and maximum credible earthquakes for the region, and what is the nature of the resulting ground motion at varying types of states?

- How difficult and costly is it to provide seismic resistance to buildings?

- What would the human and economic effects of an occurrence in New York City of the maximum probable or maximum credible earthquakes be, both locally and nationally?

- To what extent will improved building codes mitigate these consequences? What other measures are needed? Should these take procedure over improved building codes (e.g., post-disaster planning, upgrading medical or other emergency facilities and lifelines, abatement of hazardous buildings, etc.)?

- What corollary benefits are there to adopting seismic design requirements in improved design and construction practices?

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Clearly it is necessary to assess the need for seismic code provisions alongside other human needs. With limited resources, is it right to allocate them to seismic resistance, given the infrequency of earthquakes, as against housing or education, especially as it will affect such a small percentage of the building stock? Yet, can one ignore an event, with even a low probability, of such severe consequences?

The problem can be seen if one compares the exceedence ratios calculated from the hazards curves at increasing exposure lines (say, 50, 150 and 250 years) of Figure 1 for Boston and San Francisco. For Boston the progression is roughly 1.0, 2.0, 2.3, while for San Francisco it is 1.0, 1.04, 1.06.

Priorities and Ideas

The most difficult task is a political economic one of determining the correct allocations of resources among competing needs and hazards. It is not clear whether this task is currently in hand in the U.S. Among the concerns:

Multihazards mitigation. Severe wind, floods, fires as well as earthquakes endanger buildings. Measures to protect against one often aid resistance to others of these. On the other hand, the nature of these hazards (intensity, frequency, exceedence probabilities) and potential impact differ substantially.

Existing vs. new facilities. Should existing structures be protected, and if so by what (simple or comprehensive) methods? Can they be ordered by need (hospitals, lifelines), risk (occupancy, contents, number) or other means to establish clear bases for action (or not)? If this more or less important (or easier?) than addressing new construction? Is new construction by nature riskier/safer?

Regional and administrative boundaries. How does one achieve uniformity of practice and requirements within *seismic* regions?

Codes. Are these up to date? Are the means by which they are developed in the U.S. altogether successful? I think not.

Moderate vs. high seismicity. The difference, as noted in part herein, is substantial and should be reflected in policy, engineering practice and research in new and current technologies.

Impact studies. More studies of the economic impact of probable earthquakes, similar to the USGS/Steinbrugge studies for California, are needed in the MSZ's, for use in planning.

Instrumentative and resistance degradation assessment. Widespread instrumentation of building is important for the usual reasons as well as to permit indirect assessment of the degradation of non structural components, in particular masonry infill walls, which are essential to the stability of many structures in MSZs.

Moderate/high seismic sister cities. Boston and San Francisco, Los Angeles and New York could benefit greatly by systematically sharing knowledge on preparedness as well as resources after earthquakes.

Microzonation and land use planning. The growing ability to predict site response as well as the opponent large differences in amplification possible suggest possible refinements in planning and seismic code gradations.

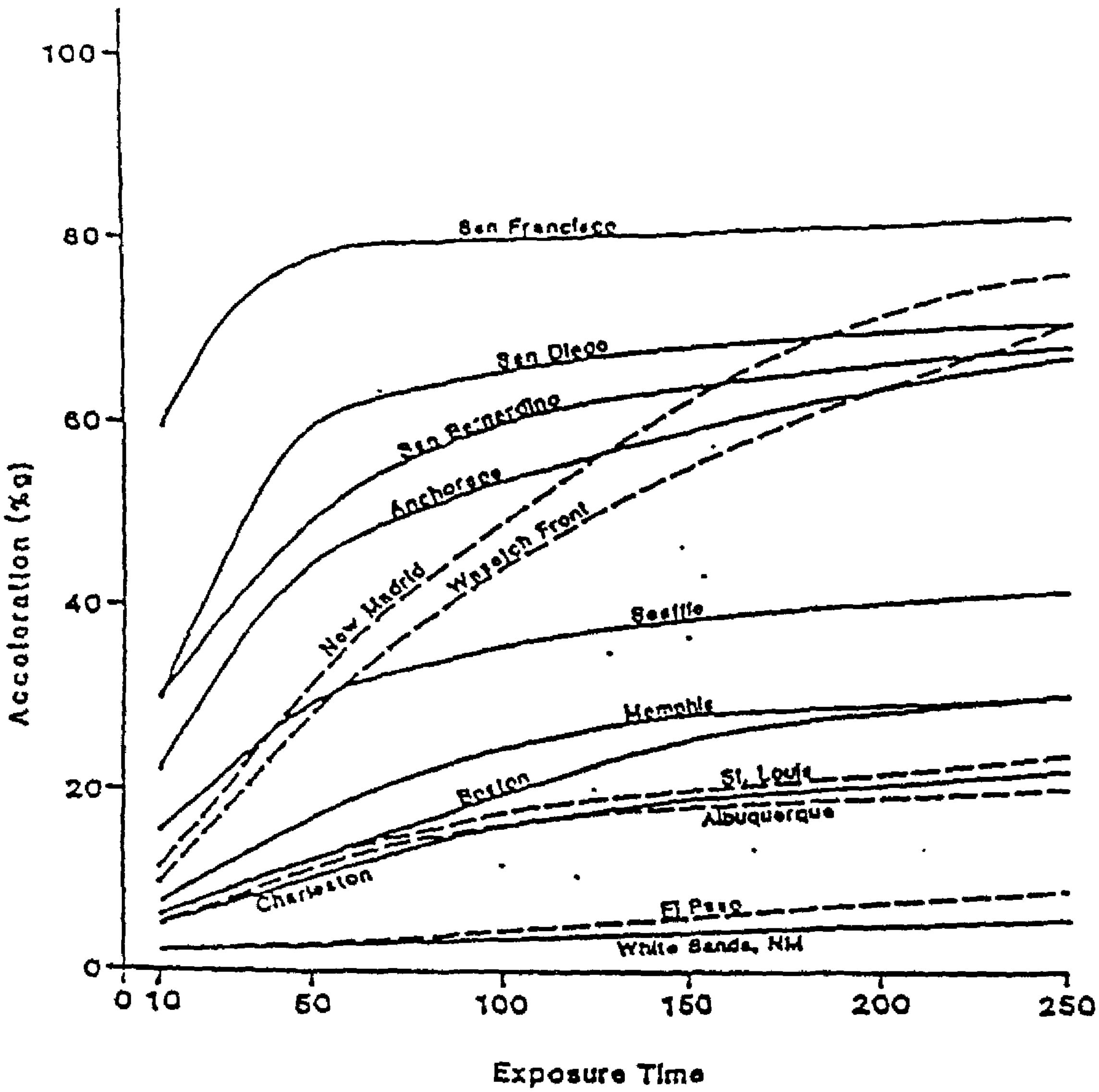

Figure 1
Comparison of the maximum expected ground acceleration in 10, 50 and 250 years at a number of sites in the United States. These data were derived from maps such as the one shown in Figure 1. The ground accelerations shown have a 10% chance of being exceeded in the time periods shown.

EARTHQUAKE RESPONSE GUIDELINES FOR STUDENT EVACUATION FROM SCHOOL BUILDINGS

Tatsuo Ohmachi

In most primary schools and high schools in Japan, evacuation drills have been held in order to protect students from damaging earthquakes. However, practical procedures for evacuating the school buildings still remain unestablished, and, thus, teachers and students will be at a loss in the event of an actual earthquake.

A questionnaire survey on the evacuation was made to investigate the present state of school earthquake preparedness and teachers' awareness. It consisted of four different situation cards and related questions. The adopted situations included a fine weather midday scenario in an ordinary classroom in which some students are lightly injured in a moderate earthquake and a rainy evening in a gymnasium in which students involved in extracurricular activities are trapped following a strong earthquake.

In the questionnaire, teachers are requested to use their personal judgment to determine the necessity of evacuating students from the school buildings and to suggest appropriate procedures for the evacuation. According to the survey, to which 83 teachers from 42 public schools and 41 private schools in the Tokyo area responded, judgments on the evacuation procedure vary from person to person.

The judgments tend to diversity when teachers encounter surprises and disorders, such as severe injuries and a blocked evacuation route. Some are likely to begin the evacuation before the ground stops shaking, and others think it better to return to their classrooms when they find their path blocked by debris. These results of the survey strongly suggest that it is urgently necessary to develop and disseminate guidelines of appropriate procedures for evacuating school buildings.

On this basis, through elaborate discussions with experts on school emergency management, the authors have developed trial guidelines for student evacuation under the above-mentioned four situations. In the guidelines, by comparing indoor and outdoor safety, more effective procedures are described for protecting students from direct and indirect earthquake hazards.

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STATE PROGRAMS AFFECTING LOCAL GOVERNMENT

L. Thomas Tobin

Introduction

Although local government in California is primarily responsible for regulating privately owned- and local government owned-structures, the state has a number of programs that encourage earthquake hazard reduction. A few selected programs are described, issues identified, and recommendations made to improve seismic safety efforts.

Description of Programs

The unreinforced masonry building law, enacted in 1986, required 336 cities and 29 counties in seismic zone 4 to prepare an inventory of unreinforced masonry buildings and adopt a hazard mitigation program by January 1, 1990. Each local government must determine how it will administer the mitigation program. As of October 1991, 262 jurisdictions have fully complied, 97 are still in the process of completing inventories and adopting programs, and 6 apparently are doing nothing. Adopted mitigation programs vary in effectiveness. Some do little but notify the owner of the situation, while others establish deadlines for retrofitting or demolishing the structures.

In 1991 the legislature adopted a measure to encourage the identification and mitigation of hazards posed by residential structures. The seller of a residential property built before 1960 must disclose to the buyer any known conditions of seismic vulnerability. A booklet will be written to address geological and seismic hazards, structural and nonstructural deficiencies, mitigation measures, and information on how to get help. Realtors will give the booklet, including a disclosure form, to every buyer so that he or she can consider seismic risk when purchasing a residence.

Similar to the residential program described above, a 1991 law requires the seller of a concrete tilt-up or a reinforced masonry building with inadequate wall anchorage to give a booklet describing the typical seismic deficiencies of these commercial buildings to the buyer. This information will assure that seismic risk can be considered during the sales transaction.

Legislation enacted in 1990 requires the State Geologist to map seismic hazard areas where there is a high potential for earthquake induced liquefaction, landslide, amplified ground motion, or inundation by dam failure, tsunami or seiche. This program is to be coordinated with the existing mapping program for active fault rupture zones. Local governments now must require geotechnical investigations in identified hazard areas before issuing a permit for new development.

The *Public Buildings Rehabilitation Bond Act of 1990*, Proposition 122, authorized the sale of up to $300 million in general obligation bonds for retrofitting state and local government-owned buildings. One percent of these bonds is for research on seismic retrofits, design provisions, and risk management and decision-making guidelines.

The new California Residential Earthquake Recovery Fund eventually will provide a payment of up to $15,000 for earthquake damage to residences after a $2,500 deduction. The program coverage increases as the fund increases, and low-cost loans for residential mitigation projects will be offered once the fund has over $1 billion. Beginning January 1, 1992, owners of residential structures will pay about $60 per year into the fund.

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Issues

Efforts to mitigate earthquake hazards in unreinforced masonry buildings underscore the social, economic and architectural issues associated with mitigation programs in all types of buildings. An investment to improve a building's ability to withstand earthquake does not necessarily improve the building's economic return, nor does it serve the short-term interests of the tenants. Income is dependent on the type of tenants, the use, the surrounding neighborhood, building features relative to other buildings, and economic conditions. The disruption during retrofitting and the resulting increased rents can wreak havoc on business tenants and low-income residential tenants who lack the options and resources to relocate or occupy more expensive, albeit safer, space. Requirements to retrofit can result in changing the appearance or even demolishing buildings of architectural or historic importance. The tradeoff between increased earthquake safety and these consequences needs further exploration.

Programs to encourage local governments to undertake mitigation programs for buildings other than unreinforced masonry bearing wall and tilt-up buildings are hampered by the lack of retrofit standards and techniques accepted as consensus standards by the professional engineers. The lack of information on expected performance of retrofitted buildings prevents owners and local government regulatory officials from making informed decisions regarding desired performance.

The building codes used in California are based on the assumption that life should be protected in even the greatest earthquake, but that building damage and loss of function is acceptable. Except for public schools, acute care hospitals and essential services buildings that are covered by alternative performance standards and enforcement procedures, commercial, residential and industrial buildings normally are constructed to the minimum requirements of the code without exploring whether it is in the best interest of the owner to invest in a higher level of performance to allow either continued functioning of the facilities or rapid restoration of functions. There is a lack of information on making these decisions and on attaining the desired level of performance.

Analyzing the expected earthquake performance of existing buildings, designing and constructing retrofit projects, and advising owners on variable levels of performance require those who practice engineering geology, geotechnical and structural engineering and architecture, local government officials who check plans and inspect construction, as well as construction workers to be knowledgeable. Unfortunately, few practicing professionals have this level of knowledge and skill. Intensive efforts are needed to improve the quality of practice in all of these professions if the lofty intentions of the programs described are going to be met.

Issues Needing Attention and Research

Consensus standards are needed for the identification of buildings that fail to meet acceptable levels of performance and to guide retrofit efforts. The lack of these standards is a major impediment to achieving improved earthquake safety in California.

Economic studies are needed since the consequence of major urban earthquakes is poorly understood and the lack of understanding impedes rational decisions regarding individual projects and governmental strategies for rapid recovery

Continuing education is needed to improve the abilities of those involved in improving earthquake safety. Earthquake safety programs cannot be carried out unless the responsible professionals have the experience and judgment needed to carry through on critical details that result in improved safety. Each project relies on a number of practitioners, all of whom must consistently produce high-quality work, if retrofit projects are to withstand earthquakes successfully.

Research priorities are clear. The focus must be on issues surrounding existing buildings, especially on nonductile concrete buildings and buildings with unreinforced masonry infill walls. Research must consider ground response and the interaction with buildings. Research is needed on decision-making techniques that allow for variable levels of performance and investment, and on the social and economic issues raised by retrofitting existing buildings.

Conclusions and Recommendations

Achieving earthquake safety is a complex quest involving a wide number of professions, government agencies, private sector organizations and laws. Accomplishing the goals of these programs requires new information and a new strategy. It is necessary for the leaders to take stock of what has been accomplished, what is to be done, and then decide how and who will do it. Strategic plans beginning at the federal, state, and local levels of government are needed to guide other key individuals and organizations in a common effort. These plans could result in an integrated strategy, one that uses what we know now to focus our limited resources on meaningful seismic safety activities. Wasted resources cannot be tolerated.

Increased international cooperation is needed. Much can be learned from those who have attempted to solve similar problems in other nations. The strategic efforts should allow for strengthened international cooperation on issues of common concern.

WHAT WE HAVE LEARNED FROM THE DISASTER OF UNZEN-DAKE'S ERUPTION

Minoru Watanabe

Preface

Ever since November of 1990, eruption activity has been occurring in Unzen-dake. As a result, more than 10,000 people have been living as refugees for almost three months in Shimabara Peninsula of Nagasaki Prefecture.

This is the first time we have experienced such a long-lasting disaster associated with warnings and evacuation procedures. Now we are facing various problems in Shimabara Peninsula.

Incidents in Shimabara Peninsula

After 198 years of silence, Unzen-dake erupted in November of 1990. Since then its volcanic activity has increased. On May 11, 1991, there were mud flows in the Mizunashi River. Following that, an evacuation advice was issued, and 461 people took refuge.

Mud flows repeated a few times, and on May 20 a lava dome had appeared. Then it started to separate and collapse, and finally pyroclastic flows occurred. In the end of May, pyroclastic flows occurred continually. Evacuation orders were repeatedly renewed and extended.

At 4:08 p.m. of July 3, a great pyroclastic flow occurred. There were 42 victims (39 dead and 3 missing as of September 8, 1991). Many of the casualties were members of the press covering the eruption on the front line and fire fighters and police who went to warn them to evacuate.

After this tragedy, on June 4, the government set up a headquarters for emergency disaster aid. On June 7 a warning area was designated according to the Disaster Countermeasures Basic Act Chapter 63, preventing entry even by residents. On June 8, another large-scale pyroclastic flow occurred and the warning area was expanded. The eruption activity has never ceased. As of September 8, more than 10,000 people had been living as refugees for more than three months.

Protracted Evacuation Problem

Many problems have resulted. The biggest problem is financial compensation of refugees. Many refugees depend on agriculture, and they have lost their livelihood by the designation of the warning area. There have been donations exceeding 4 billion yen (about $30 million) collected from all over the nation. These donations are being distributed, so residents are not suffering financially for the time being. However, there are problems with the operation of the compensation system established by the government, which helps refugees to start new lives.

Another problem centers on places of refuge. In the beginning the displaced took refuge in public facilities such as school gymnasiums. As the disaster prolonged, the government constructed temporary houses and rented hotel rooms and even rooms in ships. However, housing construction does not proceed smoothly because of the difficulty of getting

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land. There are also problems with protection of refugees' privacy and financial burdens placed on cities and the prefecture. Refugees' stress is reaching the limit because of the long evacuation, and they have started suffering psychologically.

Problems of Disaster Prevention Measures

Japan's disaster prevention measures and related systems concentrate on temporary countermeasures against floods and earthquakes. Therefore, we have a weakness against a disaster which lasts a long time. Making the best use of present laws and institutions, the government has been taking new countermeasures. Even so, these measures are not fully appreciated by refugees, the prefecture, nor the cities. It can be said that we are experiencing the limit of Japan's disaster prevention measures.

The biggest problem in the near future, as far as disaster prevention measures are concerned, may be to set up warning and evacuation area. Although it is designed to protect the safety of life, mayors of cities and towns all over Japan may hesitate to make similar decisions for fear of the burdens they will place on the individuals and institutions.

What We Have Learned from the Disaster

The disaster of Unzen-dake is still in progress. It has shown us new disaster phenomena that we have never before experienced. We have confronted new and serious disaster problems.

As for the prediction of disaster, when, where and size are the three most important elements. In volcanic disaster, "where" can be limited. So compared with the prediction of earthquakes, it is said to be far easier. However, we have learned in this disaster in Unzen that because we can limit the place it is even more important to know "when and "how big." Furthermore, we must take the fourth element of "how long it lasts" under consideration. We are now learning how to deal with a disaster that is still continuing.

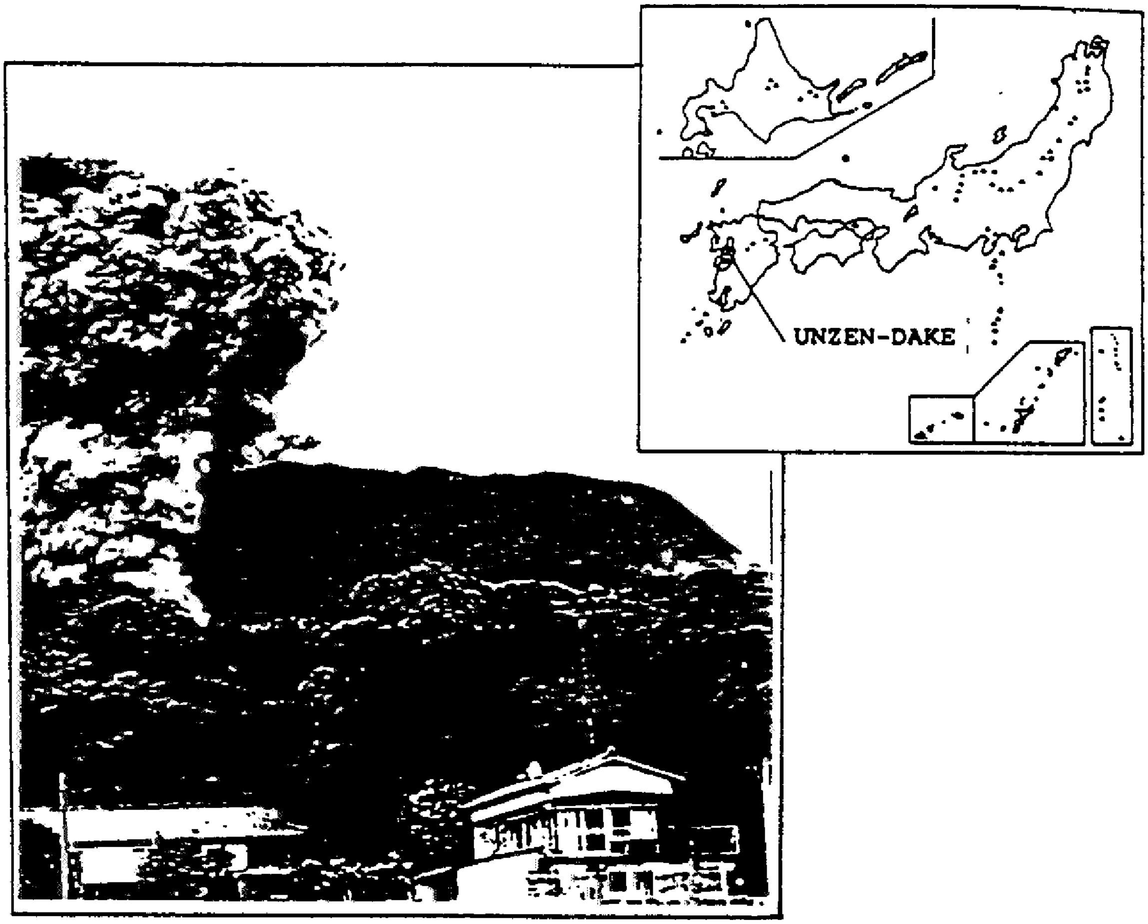

Figure 1 Pyroclastic surge attacking the houses.

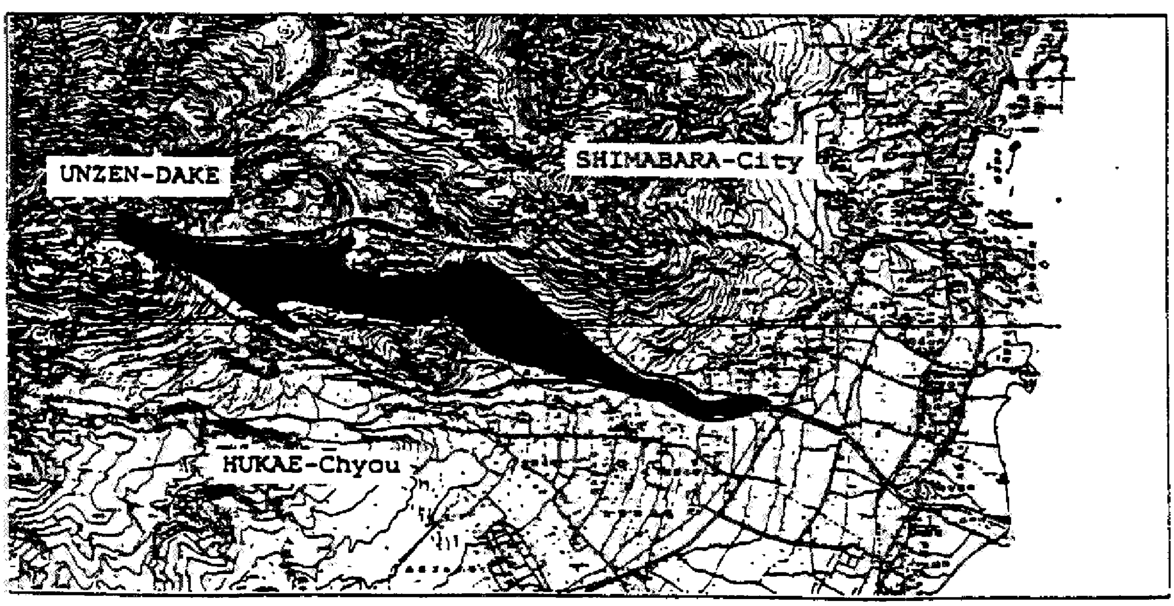

Figure 2 The influential area of Pyroclastic surge. (June 8, 1991)