REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704 0188

PB93-209443

2. REPORT DATE	December 1992	
3. REPORT TYPE AND DATES COVERED	Final Report	22-26 June 1992

4. TITLE AND SUBTITLE

Final Report: Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage, 22-26 June 1992, Yogyakarta, Indonesia

5. FUNDING NUMBERS

NSF: BCS-8820512

USAID/OFDA:
AOT-2502-G-00-2066-00

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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

The National Science Foundation of USA
U.S. AID/Office of Foreign Disaster Assistance
University of Hawaii at Manoa
Indonesia Disaster Management Center

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

unrestricted

12b. DISTRIBUTION CODE

13. ABSTRACT

The Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2) was held at Yogyakarta, Indonesia, 22-26 June 1992. The primary purpose of this conference was to bring together American and Asian researchers, practitioners and public officials who are involved in seeking ways to mitigate damage caused by natural hazards. This conference, in support of the International Decade for Natural Disaster Reduction, was a sequel to the first EMNHD meeting which was held in Bangkok, Thailand, 14-18 December 1987. Participants were from the U.S.A., Indonesia, Singapore, Malaysia, Thailand, Hong Kong, China (Taipei), Japan, Republic of Korea, Philippines, Bangladesh, Nepal, and India. Papers were limited to: earthquakes; floods; ground failures; volcanoes; and extreme winds. The technical papers were bound as the *Proceedings of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage*. A field trip to the Merapi Volcano Observatory Office and the Volcanic Sabo Technical Center (VSTC) was included in the conference program. A workshop followed the technical presentations, to delineate possible projects for mitigating damage from these five natural hazards. The *Final Report* contains the recommended projects and resolutions.

14. SUBJECT TERMS

Engineering mitigation of natural hazards: earthquakes, floods, ground failures, volcanoes and extreme winds

15. NUMBER OF PAGES

87

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
none	none	none	none

Standard Form 298 (Rev. 2-89)

PB93-209443

Final Report

SECOND U.S.-ASIA CONFERENCE

on

ENGINEERING FOR MITIGATING NATURAL HAZARDS DAMAGE

22-26 June 1992
Yogyakarta, Indonesia

Arthur N.L. Chiu • Aspan S. Danuatmodjo • Hernowo Hadiwonggo

December 1992

Final Report

SECOND U.S.-ASIA CONFERENCE

on

ENGINEERING FOR MITIGATING NATURAL HAZARDS DAMAGE

22-26 June 1992
Yogyakarta, Indonesia

sponsored by

The National Science Foundation of USA
(Grant BCS-8820512)

U.S. AID/Office of Foreign Disaster Assistance
(Grant AOT-2502-G-00-2066-00)

University of Hawaii at Manoa

The Swa Bhatara Foundation of Indonesia

Indonesia Disaster Management Center

National Coordination Board for Disaster Management
(BAKORNAS PB)

organized by

Arthur N.L. Chiu
Aspan S. Danuatmodjo
Hernowo Hadiwonggo

December 1992

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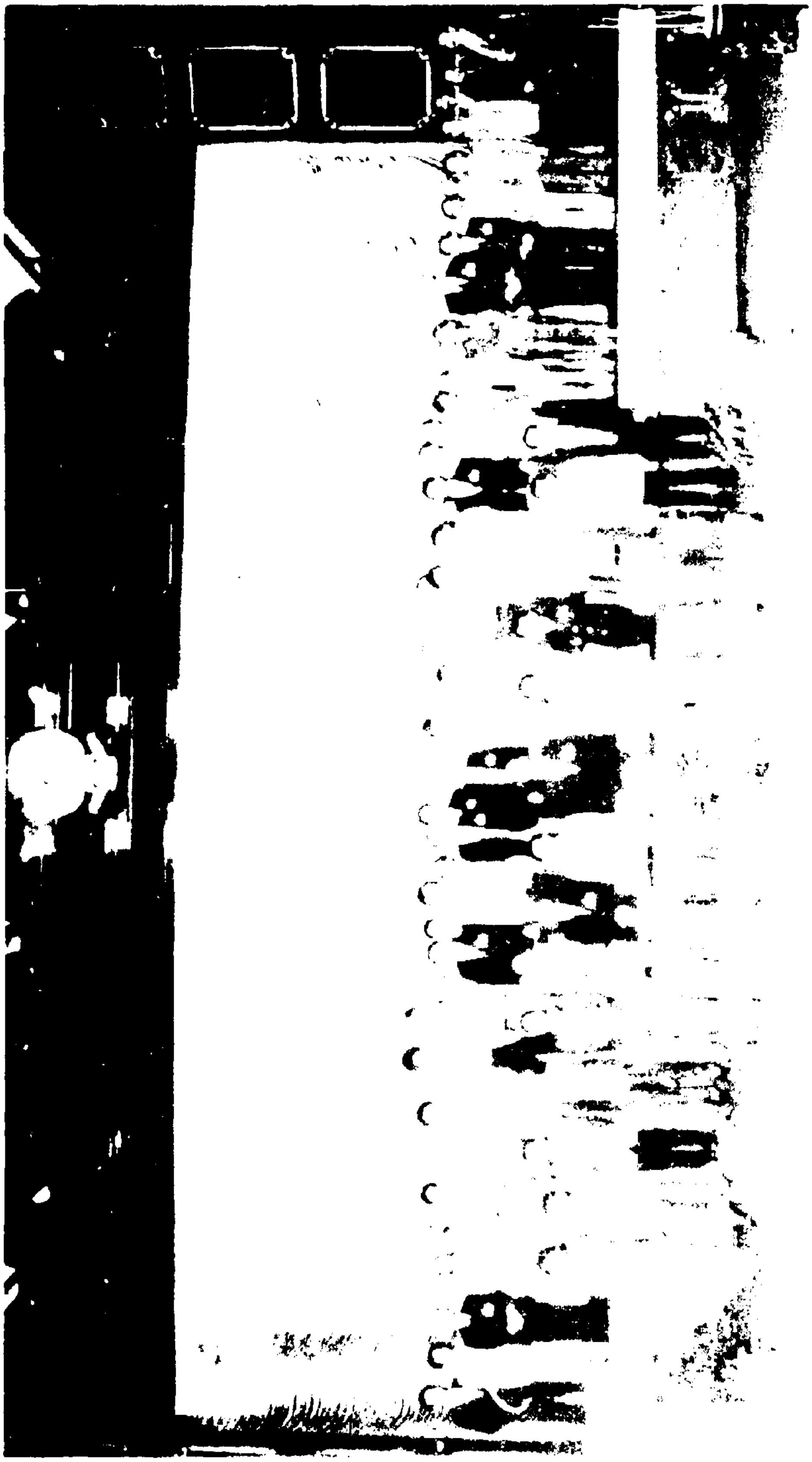

TABLE OF CONTENTS

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PREFACE

This Final Report of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2) contains an overview of the conference, the welcoming speeches given at the opening session, the reports from the five Workshop groups, the abstracts of the technical papers, the conference program and the list of registrants. The technical papers that were received on time for publication can be found in the *Proceedings of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2), 22-26 June 1992, Yogyakarta, Indonesia (ISBN 979-8355-00-8).*

Acknowledgment is made of the interest and support from the U.S. National Science Foundation (Grant BCS-8820512), the Office of Foreign Disaster Assistance of the U.S. Agency for International Development (Grant AOT-2502-G-00-2066-00), the University of Hawaii at Manoa, the Swa Bhatara Foundation, the Indonesia Disaster Management Center and the National Coordination Board for Disaster Management (BAKORNAS PB).

The untiring efforts of the EMNHD-2 Secretariat are appreciated very much. Acknowledgment is also made of the enthusiastic cooperation of all speakers in the preparation of their papers and of the active participation in the conference program by all registrants. These combined efforts were responsible for the success of the conference and the Workshop. The work of the Co-Chairmen and the Rapporteurs of the five Workshop groups in the preparation of this Final Report is gratefully acknowledged. The assistance provided by James J.K. Chia, Gregory L.F. Chiu, Adalina J.I. Chun and Nicole J. Yi in the preparation of this Final Report is also acknowledged.

Any opinions, findings and recommendations in this publication do not necessarily reflect the views of the sponsoring organizations.

Arthur N.L. Chiu, University of Hawaii at Manoa
Aspan S. Danuatmodjo, Indonesia Disaster Management Center
Hernowo Hadiwonggo, National Coordination Board for Disaster Management
(BAKORNAS PB)

December 1992

OVERVIEW

The Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2) was held at Yogyakarta, Indonesia, 22-26 June 1992. The primary purpose of this conference was to bring together American and Asian researchers, practitioners and public officials who are involved in seeking ways to mitigate damage caused by natural hazards. This conference is in support of the International Decade for Natural Disaster Reduction (IDNDR) and is a sequel to the first EMNHD meeting which was held in Bangkok, Thailand, 14-18 December 1987 (Refs. 1,2).

EMNHD-2 brought together participants from various countries for mutual exchange of information on natural hazards mitigation. It enabled American and Asian researchers to meet and to gain a better understanding of each other's natural hazards damage mitigation programs. In turn, EMNHD-2 can serve as a stimulus for promoting cooperative U.S.-Asia projects as part of the overall goal of the IDNDR.

Registrations for the conference were received from U.S.A. (16), Indonesia (13), Singapore (2), Malaysia (2), Thailand (4), Hong Kong (2), China, Taipei (1), Japan (6), Republic of Korea (3), Philippines (1), Bangladesh (2), Nepal (1), and India (4). The list of registrants is shown at the end of this report. Several committed participants were unable to attend for various reasons, notably because of the change in conference dates from those announced previously. In all, more than 100 people attended the opening session.

Opening Session

During the opening session, Mr. Hemowo Hadiwonggo welcomed the delegates to the EMNHD-2 Conference, and Dr. Arthur N.L. Chiu read the welcoming remarks from Dr. Albert J. Simone, President of the University of Hawaii and Chancellor of the University of Hawaii at Manoa.

The Secretary of the Special Province of Yogyakarta delivered the opening address on behalf of His Majesty Sri Paduka Paku Allam VIII, Governor of the Special Territory of Yogyakarta. By the ceremonial striking of a hollowed-out log (traditional local equivalent of an emergency warning system), he then declared the conference officially opened.

Program

Papers for this conference were limited to five natural hazards distributed as follows: earthquakes (13); floods (14); ground failures (9); volcanoes (6); and extreme winds (10). The detailed program is shown at the end of this report. Plenary sessions permitted longer periods for presentations of two theme papers in each topic, and shorter papers were presented in a three-phase series of two parallel sessions. The technical papers that were received on time for publication were bound as the *Proceedings of the Second U.S.-Asia Conference on Engineer-*

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1) *Proceedings of the U.S.-Asia Conference and Engineering for Mitigating Natural Hazards Damage, 14-18 December 1987, Bangkok, Thailand (ISBN 974-2808-02-8).*

2) *Final Report of the U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage, 14-18 December 1987, Bangkok, Thailand.*

ing for Mitigating Natural Hazards Damage (EMNHD-2), 22-26 June 1992, Yogyakarta, Indonesia (ISBN 979-8355-00-8). Copies of the *Proceedings* were distributed to the participants at the conference. Initially, 78 abstracts were received by the Organizing Committee. Of these abstracts, three were formally withdrawn by the authors, six were rejected by the reviewers and 17 were not submitted in final manuscript form. Two papers were not submitted in time to be included in the *Proceedings*, which contained 49 papers and one abstract. During the conference, the program was modified to include two additional papers.

In addition to the technical papers, the conference program included a field trip to the Merapi Volcano Observatory Office and the Volcanic Sabo Technical Center (VSTC), with a visit to the Merapi project site, and a two-day Workshop. The social program, on separate days, consisted of a pre-conference half-day tour of Yogyakarta, a reception, a cultural program with dinner and a closing social event.

Workshops

Following the technical presentations, the participants were grouped according to their technical expertise in one of the five natural hazards, viz.,

Earthquake Hazard
Flood Hazard
Ground-Failure Hazard
Volcano Hazard
Extreme-Wind Hazard

Each group was charged with formulating three to four possible projects that could be considered for future collaborative endeavors. Draft reports were presented by each group to the participants at a plenary session. Feedback and suggestions from the participants were considered by the groups for incorporation into their final reports which are given in the section entitled "Workshop Reports."

Closing Session

The closing session was conducted by Chiu, Danuatmodjo and Hadiwonggo. Final reports were presented by the five Workshop groups. Various resolutions were also presented to the assembly and adopted by the participants during this closing session (see section entitled "Resolutions").

All participants were thanked for attending the conference and providing input to the deliberations. There was unanimous agreement that EMNHD-2 was a successful conference, and there was strong sentiment as well as support for holding EMNHD-3 in about three years hence. It was recommended that EMNHD-3 should also include discussions on socioeconomic aspects in connection with natural hazards. The participants were encouraged to continue communicating their dialogs and to pursue the projects proposed in the Workshop Reports.

The closing social event was an informal buffet dinner that permitted participants to mingle and to cement their friendships developed during the week. After dinner, the foreign participants were taught to sing an Indonesian favorite song, "Bengawan Solo." Representatives from each country then participated in an amateur songfest. It was indeed a fitting culmination to a week of technical discussions.

Acknowledgment

Support for this conference is gratefully acknowledged from the following: U.S. National Science Foundation (Grant BCS-8820512); U.S. AID/Office of Foreign Disaster Assistance (Grant AOT-2502-G-00-2066-00); the University of Hawaii at Manoa; the Swa Bhatara Foundation; the Indonesia Disaster Management Center; and, the National Coordination Board for Disaster Management (BAKORNAS PB).*

* B·dan Koordinasi Nasional Penanggulangan Bencan

RESOLUTIONS

The following resolutions were proposed for discussion by the participants at the closing plenary session. Each resolution was unanimously adopted by the assembly.

- The Organizing Committee expresses its sincere appreciation for the contributions of the participants from the following countries in providing valuable information and dedicating their time, expertise and efforts to make this conference a success:

Bangladesh	Malaysia
Hong Kong	Nepal
India	Singapore
Indonesia	Thailand
Japan	China (Taipei)
Republic of Korea	United States of America

- The conference participants wish to thank the following organizations for providing financial and administrative support:

  The National Science Foundation of USA;
  U.S. AID/Office of Foreign Disaster Assistance;
  University of Hawaii at Manoa; and
  The Swa Bhatara Foundation of Indonesia.

- The participants wish to acknowledge and thank the local organizing committee for its excellent arrangements and for its hospitality. Particular reference is made to Prof. Arthur N.L. Chiu, Mr. Hernowo Hadiwonggo, Mr. Aspan S. Danuatmodjo and their supporting colleagues.

- The participants note with satisfaction that the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2):

  a) has provided an excellent forum for participating countries and individuals to exchange their ideas, expertise and future directions;

  b) has delineated the commonality and uniqueness of various natural hazards;

  c) has focused its attention on the concept of integrated risk management in multiple natural hazard risk mitigation; and

  d) has prepared and adopted reports from five working groups.

- Therefore, this Plenary Session on 26 June 1992 resolves that the activities discussed at this conference and suggested for implementation in the Final Report be encouraged and promoted. It is further resolved that:

  a) An EMNHD Conference be organized henceforth every three years by rotation among different countries within the region.

b) Improved communication links between individuals and nations be encouraged through:

Electronic Mail,
Exchange of information and technical data,
Special workshops and lectures.

c) An organizational structure in the form of a Center at a convenient location be set up. This Center should provide a focus for training, information exchange, data and a software library. The Center should also provide organizational support and advocacy leadership for natural hazard research discussed at this conference.

d) Due to the importance of this conference to achieve the goals of the International Decade of Natural Disaster Reduction (IDNDR), the results of deliberations of this EMNHD conference should be conveyed to the steering committee of IDNDR in Geneva and to each participating country's representative to IDNDR.

WELCOMING ADDRESS

by

Hernowo Hadiwonggo
Co-Chairman, Conference Organizing Committee

Bapak Sekwilda yang kami hormati, the Secretary of the Special Province of Yogyakarta, honorable guests from ministries and local government officials, police officials, distinguished participants, ladies and gentlemen:

As the Chairman of the Organizing Committee, I would like to convey my sincere welcome to all of you participants of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage to Indonesia, particularly to Yogyakarta, which is known as the historical and cultural city. This conference is scheduled to be held until June 26, including a one day field trip to the Merapi area. It is important to mention that about 40 participants of this conference are from the Asia and Pacific countries of South East and East Asia and the U.S. Local participants from Indonesia are officials from various ministries and experts of the universities. According to the list of participants taking part in the conference, we will arrive at convincing results by the end of this conference.

On this opportunity, I would like to express my sincere appreciation to Professor Chiu from the University of Hawaii at Manoa, who is the Chairman of the Steering Committee. He has supported the Organizing Committee with his hard efforts to make this conference possible and well-organized.

I also would like to convey very many thanks to the Secretary of the Special Province of Yogyakarta who shared his valuable contribution and full assistance in facilitating us to make this conference possible. My sincere gratitude goes to the officials of the local government of the various ministries and the honorable guests who are attending the opening session of this conference. Finally, I respectfully ask the Secretary of the Special Province of Yogyakarta, representing on behalf of the government, to deliver his address and to officially open this conference.

Thank you.

WELCOMING REMARKS

by

Albert J. Simone
President, University of Hawaii and
Chancellor, University of Hawaii at Manoa

On behalf of the University of Hawaii, I am very pleased to send a message of welcome to the organizers, participants and distinguished guests in attendance at the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage.

It seems a very short time ago that I had the pleasure of sending greetings to the first conference, held in Bangkok in 1987. Professor Chiu told me then that if that conference was successful, further conferences would be considered. This second conference pays tribute to the excellence of the first meeting as well as to its timeliness, especially since the United Nations has designated the 1990s as the International Decade for Natural Disaster Reduction (IDNDR).

Major earth and climate disturbances have challenged us since 1987. Volcanic eruptions and earthquakes have racked many of us here in the Pacific. The effects of the dramatic explosion of Mount Pinatubo are said to be affecting weather around the world. And the Pacific weather changes that we call El Nino are bringing drought to areas normally wet and heavy rains to areas normally dry. There is still much more for us to learn about the earth and about how to protect ourselves from its less predictable moods.

No nation alone can hope to find the answers we need to mitigate natural hazards. But together, working collaboratively as Pacific and Asian partners, we can help each other to understand past natural events and protect ourselves against them in the future. We need, in particular, to continue to share the engineering expertise to build structures that can withstand the forces unleashed by weather and earthquakes. I am very pleased to note that this conference has attracted even wider geographical participation than the first. This is important, and we hope that the next conference in the series will be even larger.

The University of Hawaii is deeply pleased and honored to have supported both this conference and the one before. We are very pleased that activities stemming from the first conference have been undertaken in the nations represented. We look forward to further accomplishments.

This conference, then, is of vital importance to our region. The faculty, administration and students of the University of Hawaii join me in wishing you a highly successful meeting.

OPENING ADDRESS

by

Sri Paduka Paku Alam VIII,
Governor of the Special Province of Yogyakarta

delivered by
Mr. Suprastowo, The Secretary of the Special Province of Yogyakarta

Ladies and Gentlemen, delegates of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage:

Regretfully, I have to inform you that Sri Paduka Paku Alam VIII, Governor of the Special Province of Yogyakarta could not attend the meeting today. He has been called on another assignment outside of Yogyakarta. For this reason we ask for your permission to read his speech on his behalf.

Ladies and Gentlemen:

Today is a very happy day for me because, once again, Yogyakarta has the honorable and pleasant opportunity to host an international conference which will be of considerable importance to human lives. Today marks the opening of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage for which I would like to thank and also to welcome the delegates to Yogyakarta.

This meeting has a very important impact on human lives because natural disasters cause great damage, but their occurrences cannot be avoided. Our best effort then is to find ways to avoid a bigger loss, or, forecast what will happen in the future so as to reduce these losses. In this conference, you will discuss many ways to overcome natural disasters such as methods that are now used to protect the earth from soil erosion, flooding and the environment.

The presence of many participants from various countries will provide the delegates the opportunity to discuss many types of natural disasters, and we hope the participants will be able to formulate strategies that are most effective for protecting the environment.

Meanwhile, we hope that the efforts of the deliberations as well as the methods for decreasing natural disaster impacts are not just discussed till the end of the conference. The more important thing is the follow-up ensuring that the results formulated at this conference are implemented in each region for the benefit of human lives.

Good luck with the conference and may God be always with you. Finally with the guidance of Allah Subhannahu Wata'alla, I pronounce the Second U.S.-Asia Engineering for Mitigating Natural Hazards Damage open.

Paku Alam VIII
Governor of the Special Province of Yogyakarta

SUMMARY OF WORKSHOP

The participants were involved in a Workshop during the final two days of the conference program. Five groups were formed, one for each of the conference theme topics. The objective of each of these groups was to develop a report which would identify three or four cooperative research projects of high priority and great interest to participating countries.

The projects identified by the groups have the following common attributes:

- The projects enhance the flow of information and experiences across national and geographic boundaries;
- The projects provide demonstrable results, within the period of performance, that clearly advance engineering understanding and are implementable into practice;
- The projects have a critical mass of investigative capabilities and commitments; and,
- The projects provide an efficient use of local and regional expertise and information bases.

The titles of the projects recommended by the five groups are listed below; the full reports are presented in the following chapters.

EARTHQUAKE HAZARD

1. Seismic Hazard Definition and Zoning
2. Vulnerability and Damage/Loss Information for Risk Management
3. Strategies for Fatality Reduction in Domestic Dwellings
4. Communication of Earthquake Risk Management Issues with Banking and Financial Institutions

FLOOD HAZARD

1. Asian Rim Information Center for Flood Hazard Modeling
2. Evaluation of Flood Forecast, Warning and Response Mechanism
3. Joint Occurrence Probability of Flood and Other Hazards

GROUND-FAILURE HAZARD

1. Relationships Among Precipitation, Pore Pressure and Slope Failure
2. Modeling of Debris/Mud Flows
3. Landslide Mitigation by Biotechnical Methods

VOLCANO HAZARD

1. Collaborative Observation of Selected Volcanoes
2. Exchanges in Hazard and Risk Mapping
3. Topical Research
4. Satellite Observations

EXTREME-WIND HAZARD

1. Improved Design/Construction Provisions for Housing, Shelters and Community Buildings
2. Strong Wind Damage Analysis
3. Development of Building Code and Design Guidelines Related to Severe-Wind Hazard
4. Improved Definition of Wind Characteristics in Severe Storms

ADDITIONAL PROPOSED PROJECT

Establishment of an International Natural Hazard Information Network
(This project cuts across all the hazards and hence is proposed separately from the group reports; it was formulated by the Flood Hazard Group, but it was also endorsed by all participants.)

EARTHQUAKE HAZARD WORKSHOP REPORT

Co-Chairmen: H. Shibata
P.C. Thenhaus
Rapporteurs: A.H-S. Ang
K. Muniandy

The earthquake hazard working group reviewed proposed projects from the initial U.S.-Asia Conference, convened 14-18 December 1987, Bangkok, Thailand. The proposed projects from that conference remain valid and are important topics of research. However, the group's initial concern was to ask why so little progress had been made in implementing the previously proposed research and in reducing the earthquake risk. It is felt that to achieve earthquake related loss (structural, economic, life loss, etc.) reduction, an integrated risk management strategy needs to be developed.

Almost 85 percent of all deaths due to natural disasters occur in Asia and the Southwest Pacific. As the societies develop their economies and urbanization increases, the risk to lives and property continues to increase. Past research has developed a large resource of scientific and technological knowledge but utilization of this knowledge in earthquake hazard mitigation appears to be slow and inefficient. Technological and scientific innovations alone cannot reduce the level of risk. What is needed is a fresh and bold look at an integrated approach to risk management.

Planners, scientists, and engineers have studied and have suggested various solutions for investigating earthquake risk. However, there is relatively very little effort spent on an integrated approach. Such an integrated approach requires a global look at risk management strategies, and application of those strategies in an "appropriate" mix to achieve maximum benefits at minimum cost and time. These strategies span a whole spectrum of disciplines, from engineering to communication, from earth sciences to finance and insurance. Application of any, or a combination of these strategies may bring some benefits. However, to achieve the most efficient global and implementable approach, one needs to look at all the strategies in an integrated manner and to identify barriers that must be addressed to optimize the adoption of scientific and technological approaches. Impact assessment and loss reduction planning are complex issues that require a synergistic and integrated approach. Global management of earthquake risk demands proper understanding of all the risk reduction options and selection of those options in conformance with the socioeconomic, political, technical and scientific environment of the region being considered. These options may be different for various countries depending upon the physical risk, level of economic development, mix and age of constructed facilities and economic institutions involved in development and maintenance of constructed facilities.

Earthquake risk can be managed. The time to understand and implement an integrated approach to risk management is now. In light of this, several study topics are proposed, all of which are intended to generate the necessary technical information that can be directly useful for an integrated risk management of earthquake hazard.

Project 1

Seismic Hazard Definition and Zoning

Regionally uniform assessments of the strong ground-motion hazard from earthquakes is nonexistent in many Asian countries. Assessments that are available and used in some countries are antiquated and in dire need of updating for use in modern engineering design. Primarily responsible for this situation is the lack of expertise in Asian countries in developing such hazard-mitigation products, even though well-defined methodologies have existed and have been widely used in the United States for the past 15 years. The need for training in these standard methodologies is clear.

A short-term goal is to maximize the use of available geological, geophysical and seismological information to produce uniform estimates of the strong ground-motion hazard for applications in modern engineering design and in the implementation of zoning for building code regulations. Because the geologic/tectonic systems that give rise to the seismic hazard in the Asian region cross many countries' borders, international cooperation is required in sharing basic seismological, geological and engineering data used in the development of regional maps.

Longer-term goals are to develop critical databases and instrumentation for refining the predictive capabilities of strong ground-motion. Specifically: 1) assess the technology used for strong ground-motion measurements at the existing instrument stations and upgrade the technology to be capable of measuring broad-band earthquake spectra. 2) Supplement the existing instrumentation so that the database includes a wide range of surficial geologic settings, both in the near- and far-field, to characterize site-response. 3) Develop broad-band, low-maintenance and strong-motion instrumentation that is robust and reliable in the adverse tropical climate.

The tectonic systems in the Asian region are the largest, most complex and most seismically active in the world. Yet, the understanding of the development and the rates of crustal deformation along these systems lags far behind those of Western countries as, for example, the San Andreas fault of western California. Rapid expansion of recently developed techniques of paleoseismological investigation of faults is needed to quantify the rate of deformation and seismic potential along major faults of this region, such as the Sumatra and Philippines fault systems. Refined geodynamic models of plate and microplate interactions are needed to place local fault-deformation rates into a regional geodynamic context. Concomitantly, refined hypocentral locations of earthquakes are required to more clearly define active geologic structure. These integrated studies would lead to a wide range of ground-motion hazard products useful in mitigating earthquake damage to constructed facilities.

Project 2

Vulnerability and Damage/Loss Information for Risk Management

Basic engineering information for risk management must include vulnerability data. These may be developed on the basis of field data from past earthquakes and analytical models of damage and fatality assessment. Different levels of sophistication will be necessary depending on the relative potential consequence of failure -- e.g. in the case of ordinary housing, empirical vulnerability measures may be appropriate, whereas for high-rise buildings, or major industrial facilities and infrastructures, system-specific damage assessment methods may be required to generate the loss information. In the latter cases, condition assessment of existing structures or systems is essential for proper damage evaluation.

To be useful, the generated information must be in a form and based on language easily understood by the financial community. The information should include the economic loss that can be expected (and associated uncertainty or variance) as a function of different earthquake intensities.

The same information may also be generated to show the effectiveness of different degrees of retrofitting or strengthening. The potential benefit from such a study is to provide technical information useful for intelligent decision-making by financial institutions, such as insurance companies and government disaster reduction planning agencies.

Project 3

Strategies for Fatality Reduction in Domestic Dwellings

In many developing countries, domestic dwellings are masonry structures. Furthermore, in some of these countries, like China and Indonesia, there is a move to house people in low-cost, low- to medium-risk reinforced concrete frame apartment blocks. For maximum life-saving potential, it appears necessary that effort has to be directed to make these types of dwellings "earthquake-safe."

Work on this project will involve developing an assessment model for earthquake vulnerability and fatalities from existing dwellings, existing dwellings which are strengthened and dwellings which have earthquake protection incorporated. Efforts towards the development of low-cost methods of strengthening existing domestic dwelling, low- to medium-rise apartment blocks, and incorporation of earthquake protection into the code of practice for low-cost housing are envisioned in this project.

Also, fatality in densely populated areas must consider secondary earthquake effects such as tsunami, landslide, spread of earthquake-induced fire, and other related hazards.

Project 4

Communication of Earthquake Risk Management Issues with Banking and Financial Institutions

Over the past three decades, many engineering and scientific strategies have been developed to mitigate losses due to earthquake. However, implementation of those known strategies have been less than successful. One reason for this less than desirable success has been that knowledge generators and knowledge users are not communicating in the same language. As an example, two important segments of the risk management groups that have not been involved in research or implementation are the financial and the insurance industries. Even though these two sectors deal with the enormous consequences of earthquakes, their expertise, their needs, and their input have not been integrated with other professional and scientific sectors. It is difficult to judge at this time how much more success the earthquake community of knowledge generators would have achieved in mitigating earthquake losses, had they involved the financial and the insurance industry knowledge users, but arguably it can be said that there have been large opportunity losses.

This project will involve working with financial, banking, and insurance/reinsurance industries in Singapore and Indonesia on developing risk management strategies. Such a communication not only will help in articulating the mitigating strategies for economic losses, but will also provide an advocacy group that can help in implementing other structural and nonstructural options for mitigating earthquake risk.

TRAINING

For many parts of the world, including many countries in Asia, the proper implementation of available state-of-the-art knowledge and technology will have the greatest benefit in mitigating potential losses to earthquake hazard. This will necessarily require training of professionals and technicians in the available technology. However, training should also include education and public awareness of the threat of earthquake, and the publication of simple illustrative steps that individuals can undertake in the event of an earthquake.

The four projects described above will require different levels of efforts among research, implementation and training as shown in the following table.

PROJECTED DIVISION OF EFFORTS

Project	Research	Implementation	Training
1	0.1	0.45	0.45
2	0.5	0.25	0.25
3	0.5	0.2	0.3
4	0.1	0.6	0.3

Earthquake Hazard Workshop Participants

A.H-S. Ang
T. Balendra
M.P. Gaus
E. Kertapati
K. Muniandy
T-C. Pan
H.C. Shah
H. Shibata
K. Shiono
P.C. Thenhaus

FLOOD HAZARD WORKSHOP REPORT

Co-Chairmen: A. Nishat
J.M. Wright
Rapporteurs: M.R. Peart
K.L. Hiew

Flood hazard mitigation options include structural measures and nonstructural measures. Structural measures such as dams and reservoirs, dykes, levees and flood walls, flow diversions, flood detention, improvement of channel conveyance, river training, induced groundwater recharge, pumping, afforestation, etc. are aimed at modifying and altering the extent and nature of flooding. Nonstructural measures such as flood plain zoning and other land use controls, watershed management, flood proofing, evacuation and shelter management, flood forecasting and warning, etc. are aimed at reduction of loss of lives and properties due to flooding. Despite these efforts to control flooding and to reduce susceptibility to it, floods occur with serious adverse consequences to individuals and communities. A third strategy of mitigating flood loss is to modify impacts through flood insurance, awareness creation program and post-flood recovery measures.

Floods can result from various factors such as heavy rainfall, dam and levee failures, storm surges and tsunamis, drainage congestion, rising of sea level, etc. Efforts are going on in flood prone regions/countries to mitigate damages through various measures. In recent years approaches in dealing with floods have changed dramatically mainly due to introduction of environmental considerations in planning, better understanding of relationships between flooding and the flood plain and recognition of the need of integrated management of natural and ecological resources. New approaches to flood risk and flood plain management are being formulated and development of the best mix of mitigation measures to be applied to unique local circumstances is being highlighted.

The Workshop participants (list annexed) deliberated and identified the following three priority projects which could be of immediate benefit to participating countries. The main considerations in arriving at the projects include implementability, resources needed and the time frame. It was emphasized that there is a need to exchange experiences on new and innovative steps/approaches on flood hazard management. Effective measures are required to update the level of technological tools such as numerical and hydrodynamic modeling, risk assessment and awareness creation programs, and development of better understanding of the physical phenomena of other hazards related to flood such as river bank erosion, river migration and storm surges, etc. It is felt that the proposed projects will foster and encourage cooperation among participants and support and financing through sponsoring agencies.

Project 1

Asian Rim Information Center For Flood Hazard Modeling

Project Goals

To establish a "clearing house" for collection and dissemination of information on computer models by:

(a) Collecting and updating on a periodic basis, existing models (software) and manuals for flood hazard mitigation studies; and

(b) Providing advice and assistance on application of such models for specific problems of the potential users.

Needs

Computer modeling capacity have been developed in various countries for flood hazard engineering analysis. These knowledge and experience should be shared or disseminated through a Regional Center. Examples of such models are:

(a) Meteorological models - typhoon models, global warming models, intense rainfall models, etc.

(b) Hydrological models - flood frequency models, rainfall- runoff models, radar-rainfall models, GIS models, etc.

(c) River mechanics models - hydrodynamic models, sediment transport models, etc.

(d) Coastal engineering models - sea level rise models, storm surge models, tsunamis models, etc.

Benefits

Technological transfer in the form of:

(a) Supply of information and copies of computer software to potential users in the region

(b) Training on the use of computer models available

(c) Expert advice on the application of these models for specific problem solving

(d) Provide feedback to model developers

Time Requirement

3 years

Possible Project Leaders/Coordinators

R. Harboe, Bangkok
K.L. Hiew, Malaysia

Funding and Collaborating Agencies

DANIDA (Denmark)
JICA (Japan)
GTZ (Germany)
ADB (Manila)
U.S. AID
U.S. Army Corps of Engineers
WMO (HOMS)

Project 2

Evaluation of Flood Forecast, Warning and Response Mechanism

Project Goals

The goals of this project are:

(a) To review the current usage and effectiveness of flood forecast/warning systems and flood risk mapping in participating countries;

(b) To identify improvements to existing flood forecast/warning systems or the design of new systems to maximize hazard mitigation benefits; and

(c) To identify measures to improve public awareness and responsiveness to flood hazards through usage of flood risk maps, effective media communication and citizen participation.

Why Needed

Currently the participating countries are in various stages of technological awareness with regard to flood forecasting/warning systems and flood risk mapping techniques. It has been seen that even when forecasting/warning systems have been operated effectively, the message is not reaching the target group or in a form that elicits the desired response. Similarly, many flood-risk maps have not achieved their planned objectives because of lack of communication between engineers, land use planners, decision makers and the general public.

Benefits

The project will enable participating countries to learn from each others' experience in flood forecasting/warning and flood risk mapping/awareness. It will also contribute to evolution of technology for effective long-term flood plain and coastal management.

Time Requirement

3 years

Possible Project Leaders/Coordinators

A. Nishat, Bangladesh
J.M. Wright, USA

Sponsors

National Science Foundation (USA)
Equivalent organizations in participating countries
Universities
U.S. AID

Project 3

Joint Occurrence Probability of Flood and Other Hazards

Project Goals

The goals of this project are:

(a) To review the use and effectiveness of existing magnitude/frequency models for analysis of flooding due to multiple causes, such as riverine and storm surge flooding; and

(b) To examine whether existing approaches for the management of flood-prone areas give sufficient attention to multi-hazards, including sea level rise.

Why Needed

(a) Magnitude/frequency plots may be deficient when more than one extreme event combine to produce a flood, e.g., tsunamis and riverine flooding in Japan. In such cases, magnitude may be underestimated. They are also deficient when an independent event occurs at the same time which exacerbates the flooding.

(b) Non-stationarity consequent upon global warming/sea level change may affect the accuracy and validity of existing magnitude/frequency analysis.

(c) To encourage the consideration of a multi-hazard approach by authorities involved in the management of flood-prone areas.

Benefits

(a) Focus attention on multi-hazards, especially in Southeast Asia.

(b) Evaluate the appropriateness and application of magnitude/frequency hazard models.

(c) Ensure consideration be given to selecting appropriate thresholds for multi-hazard events.

Time Requirement

3 years

Possible Project Leaders/Coordinators

Y. Kawata, Japan

Sponsors

National Science Foundation (USA)
Universities
U.S. AID
Equivalent organizations in participating countries

Project Title

Establishment of an International Natural Hazard Information Network

Project Goals

The goals of this project are:

(a) To establish a formal process to maintain a continual channel of communication regarding activities (projects) proposed by Conference delegates including progress reports and needed follow-up measures; and

(b) To gather information on natural hazard mitigation projects and other activities being carried out by governments/organizations/institutions and individuals that may be of benefit to Conference delegates, sponsors and other users (U.S., Asia and even international).

Why Needed

(a) To establish a mechanism to ensure follow-up of proposals, to assess and measure progress and to determine additional actions needed, including identifying who should carry out required initiatives.

(b) To share experiences and activities with delegates and with the broader network so that interested parties may benefit from state-of-the-art expertise, knowledge, research, programs, policies, etc.

Benefits

(a) Ensures monitoring and follow-up.

(b) Establishes a users network among the U.S., Asia and possibly global applications/uses.

(c) Promotes exchange of information within the discipline.

(d) Promotes inter-disciplinary networking among related hazards.

Time Requirement

Establish by January 1, 1993 and continue to develop until the next Conference (3 years) where the network can be evaluated.

Possible Project Leaders/Coordinators

University of Hawaii (Professor Chiu)
National Science Foundation (USA)
Agencies for International Development
Natural Hazard Research and Application Information Center
(University of Colorado) USA
Other similar centers in sponsoring countries -
- both governmental and academic
UN Scientific Committees

Flood Hazard Workshop Participants

G.T-J. Chen
Y. Fujita
R. Harboe
K.L. Hiew
Y. Kawata
A. Nishat
M.R. Peart
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GROUND-FAILURE HAZARD WORKSHOP REPORT

Co-Chairmen:	B.B. Deoja
	R.L. Schuster
Rapporteurs:	P. Kumar
	T.H. Wu

Definitions

In this report, the term "ground failure" will be restricted to the failure of slopes. Slope failures consist of downward and outward movement of slope materials -- rock, soil, or artificial fill. This movement is triggered by other natural processes, such as heavy precipitation, earthquakes, volcanic activity, or erosion. In some cases, landslides result from the activities of man, typically excavation or irrigation of slopes.

Slope failures range from slumps and slides through falls, avalanches and flows. The general category of slope failure will be referred to by its common term "landslide."

Socio-economic Effects of Landslides

Annual economic losses due to landsliding have been estimated to exceed US$ 1 billion each in India, Japan, Italy and the United States. For example, the U.S. National Academy of Sciences has estimated that landslide losses in the U.S. are US$ 1-2 billion annually (Committee on Ground Failure Hazards, 1985). Landslide losses in most Asian nations are not as well documented as in Japan and India, and are not as large as in those two countries. However, losses in the Himalayan nations, China, Taiwan, the Asian parts of the former Soviet republics, Indonesia, Papua New Guinea and New Zealand are large, with some of them exceeding US$ 100 million per year. In addition, the urban areas of Hong Kong have experienced extremely costly landslides.

Numbers of deaths due to catastrophic landslides are large and have grown in this century because of burgeoning populations. Although data on the precise number of deaths due to landslides are not easy to obtain, during the period 1971-74 nearly 600 people were killed annually by slope failures worldwide (Varnes, 1981). About 90 percent of these deaths occurred in countries in or on the margin of the Pacific basin; a significant proportion of those deaths took place in Asian nations. Data accumulated by the Japan Ministry of Construction (1983) indicate that landslides killed an average of 150 people per year in Japan. In the United States, about 25-50 people are killed annually by slope failure, mainly rockfall and debris/mud flows.

The greatest recorded lost of life in any single group of landslides occurred in Ningxia and Gansu provinces, China, in 1920, when approximately 100,000 people were killed by earthquake-triggered landslides in loess. Another disastrous Asian landslide occurred in 1949, when an earthquake in the Tien Shan Mountains of Soviet Tadzhikistan triggered a series of landslides that buried 33 population centers, killing an estimated 12,000 to 20,000 people. In 1970, 20,000 people were killed by an earthquake-induced rock avalanche in Peru, and in 1985 the eruption of Ruiz Volcano in Colombia resulted in a lahar (debris flow) that killed 22,000 people in the town of Armero.

Among industrialized nations, Japan has suffered the greatest continuing loss of life and property from landslides. Casualties have been particularly great in heavily populated urban areas at the bases of steep mountain slopes. For example, in 1945 in the City of Kure, 1,154 people were killed by debris flows generated by typhoon rains (Nakano et al., 1974).

Organization of Report

The Ground-Failure Hazard Working Group has selected three landslide research projects that it feels have potential of high return and significance in landslide hazard mitigation. The main goal of the proposed projects is to increase the effectiveness of landslide hazard mitigation in Asia and the United States, with particular emphasis on the developing nations of Asia. However, we feel that these projects will provide valuable approaches and results that will be used by natural hazard researchers and managers worldwide. Each of these projects represents one of the following aspects of natural hazard management: (i) failure prediction, (ii) damage prediction, and (iii) mitigation methods.

Project 1

Relationships Among Precipitation, Pore Pressure and Slope Failure

Project Goal

The goal of this project is the development of quantitative relationships among precipitation, pore-pressure generation in geologic materials and landslide initiation.

Background and Justification

Because rainfall-induced landslides are the most frequent mode of slope failure, understanding the mechanism is required for prediction of the occurrences and consequences.

Empirical correlations developed between rainfall and landslides in past studies have tended to be qualitative and specific to particular sites or regions. Real-time pore-pressure measurements can provide a quantitative measure of groundwater response and possibly can improve the accuracy of predictions of slope failure. However, research is needed in various regions and under various conditions of terrain, geology, moisture and groundwater before pore pressure can be used for predicting high-risk and high-frequency landslides.

Strategy

In order to develop the necessary relationships, comprehensive studies involving the following are needed:

- Collection of precipitation data, pore-pressure measurements, and geologic, hydrologic, and geotechnical characteristics from sites in different climatic and geologic environments.

- Measurement of strength and moisture-retention characteristics of geologic materials at instrumented sites, including slope-stability analysis.

- Quantitative evaluation of

  (a) the influence of measured pore-pressure response on slope stability;

  (b) influence of antecedent rainfall on pore-pressure generation and landslide initiation; and,

(c) threshold rainfall levels (i.e., rates/amounts of precipitation at which slope failures are induced) for various geologic and climatic conditions.

Benefits

This research will lead to greater reliability in prediction of high-frequency rainfall-triggered landslides and in assessment of consequential risks.

Time Requirement

3 years

Research Participants

International agencies such as ICIMOD (International Center for Integrated Mountain Development) in collaboration with national organizations, such as the Geotechnical Control Office of Hong Kong or a University, such as Ohio State University, are suggested for implementation of the project. International, regional and local experts are to be hired under short-term contracts by the implementing agency.

Project 2

Modeling of Debris/Mud Flows

Project Goals

The goals of this project are:

(a) To model debris-flow characteri·tics;

(b) To identify conditions and topographic features conducive to debris flow;

(c) To predict the extent of run-out zone;

(d) To determine risk to population and property; and

(e) To simulate the flow process by a computer model.

Background and Justification

Debris flows (including mud flows) cause significant damage to life and property. Effective protection against such ground failures can be provided if the extent of the run-out zone can be predicted.

In a debris flow, a large bulk of debris is washed down the slope. It mobilizes significant amounts of loose material during its downslope journey. The debris and loose material uproot, bury and destroy everything in their paths. The run-out zone is essentially the region that is covered by a debris flow. Roads, bridges, communication facilities and human settlements may vanish within a matter of seconds. Such failures usually occur during or after heavy precipitation.

Strategy

This study may be conducted either experimentally, for example, through centrifuge modeling or numerically by solving flow equations. The finite-element method of analysis may be employed to solve flow equations.

In the first stage of this study, an extensive literature survey will be done to collect data from reported case histories. This exercise will be used to isolate the variables of significance.

Methods will be developed to model the essential features of slopes and debris. Feedback will be sought from a companion project that seeks to establish relationships among precipitation, pore pressure and slope failure.

Experimental facilities are proposed to be developed to simulate debris flow. A solution of this problem by numerical means appears straightforward as techniques such as finite-element method are well established, and it appears possible to develop the required software.

Extensive graphic support will be needed in a meaningful presentation of the results of analysis.

Benefits

(a) This exercise forms the first step toward risk assessment/management against debris flows. Computer simulation will enable parametric studies by varying critical parameters.

(b) Based on such studies, it should be possible to determine suitable locations of all hill-area developments.

(c) The model may also be used in the development of an effective management/warning system for debris flows.

(d) Although the present study addresses debris flows, the same model (with suitable modifications) can also be applied to study lava flows from volcanic eruptions.

Time Requirement

4 years

Research Participants

International agencies such as ICIMOD (International Centre for Integrated Mountain Development), Nepal; Directorate of Environmental Geology, Bandung, Indonesia; Disaster Prevention Research Institute, Kyoto University, Japan; and the Central Building Research Institute, Roorkee, India

Project 3

Landslide Mitigation by Biotechnical Methods

Project Goal

The object of this study is to establish limits on feasibility of biotechnical stabilization.

Background and Justification

The use of live plants as soil reinforcement to improve slope stability has had a long history. At present, biotechnical slope stabilization is being promoted by soil conservationists and natural-resource people who often fail to consider the engineering principles involved. It is necessary to establish the mechanism of soil-root interaction in order to determine the conditions in which biotechnical construction can be expected to be successful.

Strategy

We propose to conduct pilot projects at two or three sites on natural and/or cut slopes. The most promising local plant species will be used. Instrumentation will be installed in the slopes to observe the physical processes of infiltration of precipitation and of slope movement. The instrumentation at each site will include piezometers, moisture probes, inclinometer tubes and a meteorological station. Observations will be made on slopes with and without biotechnical stabilization to provide data for comparison. We will periodically excavate to determine the growth rate of roots and to measure root depth and diameter.

The results will be used to evaluate the effects of the species on soil infiltration and to determine amounts of plant evapotranspiration. This will be used to predict the effects of plants on pore-water pressures. The measured depth and size of roots will be used to predict the strength of the soil-root system.

Time Requirement

5 years

Research Participants

The International Centre for Integrated Mountain Development (ICIMOD) in Nepal, a scientific consortium of eight Himalayan countries, would be a logical choice to manage the project. ICIMOD is in a position to solicit funds and hire competent researchers for short-term assignments. Ohio State University currently conducts research on biotechnical slope stabilization and can cooperate with ICIMOD. Banaras Hindu University, India, has studied environment regeneration and could serve as advisor on selection of plant species. Other possible participants are Silsoe College (UK) and the Geotechnical Control Office (Hong Kong), both of which have considerable experience in biotechnical slope stabilization.

Reference List

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Nakano, T., Kadomura, H., Mizutani, T., Okuda, M., and Sekiguchi, T., 1974, Natural hazards--report from Japan. In White, G.F. (ed.), Natural Hazards--Local, National, Global: Oxford University Press, New York, N.Y., Chapter 28, pp. 231-243.

Varnes, D.J., 1981, Slope-stability problems of the Circum-Pacific Region as related to mineral and energy resources. In Halbouty, T.M. (ed.), Energy Resources of the Pacific Region: American Association of Petroleum Geologists Studies in Geology, No. 12, pp. 489-505.

Ground-Failure Hazard Workshop Participants

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VOLCANO HAZARD WORKSHOP REPORT

Co-Chairmen: B. Voight
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Rapporteurs: A. Nasution
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More than 1,300 volcanoes are known to have erupted during the past 10,000 years, with about half of these active in recorded history. Two thirds of the active volcanoes are located along the tectonic plate boundaries in the Circum-Pacific.

It is estimated that 360 million people - about ten percent of the world's population - live on or near potentially dangerous volcanoes. With the rapidly expanding world population, mostly in the already densely-populated developing countries, millions of people more will be threatened by volcanic activity in the future. Since the total abandonment of volcanic areas is not realistic, the scientific community and civil authorities face a chronic and increasingly acute problem in coping with hazards from future eruptions.

Volcanic hazards can be substantially mitigated if:

(1) National and local governments are committed to mitigating volcanic hazards and have the will to enact appropriate hazard management decision,

(2) Scientists responsible for such mitigation know how to collect and interpret geological, geophysical, geographical and geochemical data about volcanoes,

(3) sufficient equipment (and maintenance support) for monitoring (and coordinating laboratory work on age dating, etc.) is available to these scientists,

(4) field studies are conducted long before eruptions occur, and

(5) coordination with civil authorities is established before a crisis begins. An existing database and response capability is necessary because of the extremely short lead time often available (about one day in half the cases) between the onset of symptoms warning of volcanic unrest and a dangerous eruption.

Efforts to mitigate hazards in the Asia-Pacific area include some studies of past eruptions; studies of eruption products essential for preparation of volcanic hazards zonation maps and identification of site-specific hazardous processes maps; surveillance of active volcanoes, to warn of increased unrest or imminent eruption; and research on geologic processes, to improve capabilities for eruption prediction/detection or warning, and to improve schemes for hazard mitigation.

Our group considered ideas for cooperative work, some encompassing works already initiated, and others entirely new. The nations having hazardous volcanoes are Indonesia, Philippines, Papua New Guinea (PNG), Japan, Russia (Kamchatka) and the United States (Aleutians). Our group concentrated on areas involving the first three (developing) nations because these nations have needs most closely aligned with the goal of this workshop. Japan, the U.S., France, Australia and New Zealand are nations most likely to provide technology sharing, collaboration and external funding to the developing nations.

Volcanic risk mitigation cooperation between the U.S. and Japan are considered elsewhere under an existing science and technology agreement between those two nations.

General types of cooperative projects include the following:

A. Information Exchange

The obvious goal is to use available expertise and technology in order to gain the greatest impact in risk mitigation.

1. Topical seminars with field visits, e.g., comparisons of similar volcanoes and groups of volcanoes in Asia.

2. Traveling lecturers to universities and government labs, e.g., foreign expert scientists/engineers to Indonesia, Philippines, or PNG, and vice versa. Exchange between the Philippines and Indonesia is funded by UNESCO/ROSTSEA (Jakarta).

3. Exchange of faculty and students for training.

4. Technology sharing:

   a. Sharing designs and prototypes of equipment for use in hazardous locations in less-developed countries. New developments of hardware and software, in seismic, airwave, hydrophonic data acquisition and processing infrasonic monitoring of explosions, radar monitoring of pyroclastic flows, ash clouds and lahars, lightning detectors as indicators of tephra clouds.

B. Collaborative Research Projects

Although it is essential to use existing technologies, this approach alone will not fully solve the problem of high-risk volcanoes. Volcanic processes vital to the prediction and detection of dangerous eruptions are still poorly understood; and thus, research remains an extremely important part of volcano risk mitigation. The existing state-of-the-art is simply not sufficient to provide a truly effective standard-of-practice.

1. Collaborative observations of selected volcanoes:

   a. Intensive multidisciplinary team study of selected active volcanoes for several months, including geologist to identify eruptive history, seismologists, deformation specialists, gas geochemists and others, for documentation and identification of baseline signals and precursors to elevate activity.

   b. Long range multidisciplinary collaborative studies, either by team collaboration, or by data and interpretation sharing between separately-financed and organized groups and agencies. An important goal to work toward is to improve sharing of data and ideas between separate groups; this goal emphasizes the need for "open door" sharing of information, in contrast to the "competitive" attitudes or bureaucratic "vertical structuring" that often impedes working-level cooperation between scientists or engineers. It is vital in the interests of saving lives and mitigating of regional economic losses for us to work together.

c. All volcanoes are candidates for such efforts, but we assigned highest priority to Decade Volcano (IDNDR) in developing countries, emphasizing on-site project training, and improvement in equipment and laboratory analysis capability. Decade Volcanoes for Asia include Merapi (Indonesia), Taal (Philippines), Ulawun (PNG), and Unzen and Sakurajima (Japan).

2. Exchanges in hazard and risk mapping. Assistance with GIS technology to analyze and portray hazard and risk and other state-of-art (SOA) hazard mapping research. Integration of geologic, hydrologic, and geographical and geochemical data. Volcanologists have been slow to take advantage of potential advantages of GIS and other electronic databases.

3. Topical research. A wide variety of projects could be proposed and justified. The list presented here is in random (i.e, non-prioritized) order.

   a. Internal structure and processes of stratovolcanoes, calderas, domes, and hazard implications of each.

   b. Correlation and process implications of continuously recorded (or frequently-monitored) gas emission and other geochemical changes. Use of SOA gas sensing instrumentation. Investigating gas accumulation and release from volcano lakes (Dieng Plateau, etc.); hydrothermal eruptions.

   c. Quantitative characterization of eruptions in progress. What new tools to apply?

   d. Relation of groundwater and crater lake regimes on unrest and eruption processes.

   e. Pyroclastic flow and lahar processes, deposit characterization and relation to process and hazard potential.

   f. Lahar generation from pyroclastic flows; morphology, source characteristics, mobilization, flow characteristics.

   g. Eruption precursors. Models and tests of interpretation and reliability. Study of current activity, review of old data files interpreted using modern concepts. Rates of "false alarms" in relation to pattern recognition of precursors.

   h. Windborne-ash tracking, wind profiling using SOA radar to predict tephra directions and aircraft hazards.

   i. Earthquake source and transmission processes. Distinguish volcanic earthquakes from earthquakes of tectonic character. Influence of source and path on signature. Use of SOA recording and processing, correlation with observed events and other monitoring data.

   j. Tremor and long-period earthquakes as promising long- and short-term precursors to explosive eruptions. Modeling and tests of competing models. Frequency spectrum, correlation with specific events, significance toward eruption prediction, and false alarm statistics. Dense network experiments at selected lively "volcanoes."

k. Fundamental causes, triggers, precursory warnings for collapsing volcanoes (Mount St. Helens-style collapse, eruption). Effect of hydrothermal weakening on volcano stability.

4. Satellite observations

a. Remote sensing for monitoring (GPS, plume tracking, SO_2 etc.)

b. Remote sensing for mapping and volcano risk assessments

c. Data telemetry platforms

5. Prediction experiments, before and during unrest, including:

a. Instrument development to "catch" precursors.

b. Testing hypotheses about actual processes and precursors suggesting eruptions.

c. Possible topics include:

1. Precursors for reactivation of long-dormant volcanoes, vs. those for "frequently erupting" volcanoes;

2. Earliest precursors of eruptions (to 10 years before);

3. Degassing processes preceding eruptions;

4. Innovative ways to anticipate types and magnitudes of impending eruptions.

In summary, a large number of potential projects and unanswered questions have been identified. Funding seems essential for most of this work. A wide range of projects is proposed, recognizing that not all can be undertaken at once, and opportunities for funding are difficult to predict. Projects have been mentioned for which little or no funding is currently available, in hopes that such projects may be undertaken in the future.

C. IDNDR Decade Volcanoes

Work on the Decade Volcanoes comprises our highest priority, involving one each for the Philippines, Indonesia and Papua New Guinea. These sites are particularly appropriate locations for study of many of the topical research items listed above, and are in addition sites of particularly high risk to local inhabitants.

1. Cooperative investigation at Decade Volcano Merapi, Java.

a. Goal: to investigate processes and eruption precursors at a highly active explosive volcano; to mitigate risk in a densely populated region.

b. Why needed: Merapi is one of the world's most dangerous volcanoes. With an eruption occurring once every 3 to 7 years, it ranks 15 on the Yokoyama scale for high-risk volcanoes. The high activity implies that important data are particularly likely to be obtained here, preceding and during periods of explosive volcanism. The lessons learned from these studies can be applied to other volcanoes of similar type worldwide. Many topical subjects previously identified can be studied here.

c. Required Time: Throughout the remainder of the Decade. Subtopics may have specific time limitations as appropriate to justify funding. Combinations of long-term baseline studies and short-term topical investigations.

d. Benefits: Critical information is likely to be obtained on generation of various long-period, tremor, and short-period earthquakes, edifice deformation, gas geochemistry, dome growth (excellent opportunities for terestrial photogrammetry), pyroclastic flow processes, lahar generation, deposition and impact.

The importance of this volcano has led to important prior studies (e.g. carefully-observed eruption history, acquisition of seismic, deformation, and geochemical data bases) that give a strong foundation for future efforts, and increase value of new observations and the likelihood for success of Decade Projects. Investments of funds, equipment and manpower should yield important and cost-effective returns to volcanology and risk mitigation.

e. Potential Collaborating Organizations/Contact Individuals: Volcanological Survey of Indonesia, Bandung, (Dr. Wimpy Tjetjep); Merapi Volcano Observatory (Dr. S. Bronto); Gadjah Mada University, Yogyakarta, Dept. of Physics (Dr. Kirbani); Dept. of Chemistry; Technical Faculty, Geology, Geodesi; Faculty of Geography); Volcanic Sabo Technical Center, Yogyakarta (W. Suharjono); U.S. Geological Survey (T. Casadevall, C.D. Miller) Pennsylvania State University, USA (B. Voight and K. Young); University of Stuttgart, Germany (R. Schick); University of Pembangunan Nasional, Yogyakarta (B. Pratistho); Institute Technology National, Yogyakarta (Ir. Er. Budiadi); French Government Agencies (J-P. Sabroux, P. Allard, M. Kasser); others in Japan, Australia, etc.

2. Cooperative Investigations at Decade Volcano Taal, Philippines.

a. Goal: to investigate process and eruption precursors at an intra-caldera stratovolcano with a crater lake.

b. Why Needed: Taal has had 33 recorded eruptions since its earliest recorded outburst in 1572. Its largest historical eruption killed over 1,300 people, and succeeding eruptions have been extremely violent, including powerful 20-km high eruption columns, fatalities to 10-km radius, and production of laterally expanding ring-like clouds (base surges). It is a Yokoyama scale high-risk volcano.

The volcano is currently experiencing unrest, and thus is most appropriate for Decade study. Results can be applied to local severe risk mitigation at Taal (evacuation of 50,000 in 1965 drained the calamity fund of the national government), and lessons learned applied to crater-lake volcanoes elsewhere.

c. Required Time: Throughout the Decade, combination of long-term baseline studies and short-term topical investigations.

d. Benefits: Critical information on volcano and eruptive process in a crater-lake environment: seismic characterization of precursors, geochemical precursors, volcano topography. Risk reduction to local inhabitants. Training of student/future scientists.

e. Potential Collaborating Organizations/Contact Individuals: Philippines Institute of Volcanology and Seismology (PHIVOLCS), Quezon City (R. Punongbayan), U.S. Geological Survey (C. Newhall, C.D. Miller, T. Casadevall), University of Illinois at Chicago (K. Rodolfo), University of California, Santa Barbara (R.V. Fisher), University of Hong Kong, Dept. of Geography and Geology (Susan Donoghue).

3. Cooperative Investigations at Decade Volcano Ulawun, PNG.

a. Goal: to investigate processes and eruption precursors at an active stratovolcano.

b. Why needed: Ulawun is one of the highest-risk volcanoes in the Bismarck Arc, as rated on the Yokoyama scale (see also Geological Survey PNG, Report 83/13, map scale 1:100,000, C.O. McKee Author, 1983). Justification similar to Merapi but for volcano of different eruptive styles.

c. Required time: Throughout the remainder of Decade.

d. Benefits: Approximately as for Merapi.

e. Potential Collaborating Organizations/Contact Individuals: Geological Survey of PNG, Rabaul Volcano Observatory (B. Talai, C.O. McKee), U.S. Geological Survey (C.D. Miller), Geological Survey of Australia (R.W. Johnson), Macquarie University, North Ryde, Australia (R. Blong); others.

4. Volcanic Hazard Mapping for Quaternary "Dormant" Volcanoes, in Indonesia, Philippines and Papua New Guinea.

a. Goals: To provide:

1. Baseline volcanological data for each volcano, in order to provide the capability for short-term hazard response.

2. Preliminary volcanic hazard zonation maps. The maps are required by scientists and hazard management personnel in time of crisis, and by local governments to guide them to do planning for volcanic areas in advance of crisis.

b. **Why Needed** : One or several "dormant" volcanoes erupt each year, increasing the number of "known active" volcanoes. Such volcanoes are extremely hazardous, because

   1. They are seldom considered in pre-crisis hazard planning (they may not even be recognized as a volcano).

   2. Typically they have been ignored for basic geologic studies; thus, if hazard maps are suddenly required in time of crisis, no factual basis exists to enable the rapid construction of hazard maps.

   3. A long-repose period is commonly associated with large, highly explosive eruptions. Examples of such devastating eruptions of dormant volcanoes in recent decades include Pinatubo, Philippines, 1991, El Chichon, Mexico, 1982, and Bezymianny, Kamchatka, 1956.

c. **Required time**: Ten years.

d. **Potential Collaborating Organization/Contacts Individuals**: Volcanological Survey of Indonesia (Dr. Wimpy Tjetjep); Directorate of Environmental Geology; PHIVOLCS (R. Punongbayan); Rzbaul Volcano Observatory, Geological Survey of PNG (B. Talai); Institute of Indonesian Sciences [LIPI] (Dr. H. Harjono); U.S. Geological Survey (C. Newhall; C.D. Miller); agencies or universities in host countries (e.g. BPPT, University of Gadjah Mada, ITB, UNPAD, University of the Philippines, etc.); others.

Volcano Hazard Workshop Participants

M. Alzwar	A. Nasution
S. Bronto	B. Voight

WIND HAZARD WORKSHOP REPORT

Co-Chairmen: D.C. Perry
A.P. Jeary
Rapporteurs: K. Seetharamulu
T. Maruyama

The group drew from the experience of its members and from the recommendations promulgated at the EMNHD-1 conference held in Bangkok, 14-18 December 1987. Whilst there was a recognition that the engineering aspects were important, there was also an awareness that the dissemination of information to the populace at large, and to the people who make decisions about construction practice is critical for the output from the group.

Concerns were expressed about the ability of the lesser developed communities, and their ability to learn from the experience of the more developed countries, or at least from those whose quality of information could be transferred to other communities.

The group took the view that the development of criteria for the use of builders or specifiers of construction for domestic housing were a primary target group. It was observed that the mitigation of damage to "non-engineered" or "semi-engineered" structures was an area that represents an achievable goal in the medium-term future. Little has been done in this area, and a large impact can be made at little cost.

The group identified four major projects which it deemed of crucial importance. These can be summarized as follows:

1) Residential housing study.

2) Storm damage analysis.

3) Code development.

4) Wind speed assessment.

Specifically, the reasons for an interest in pursuing these areas of study are caused by an appreciation of the following factors relating to each of the proposed projects:

1) The question of the ability of domestic housing to withstand the effects of severe windstorms and tropical cyclone activity is not well treated, neither is it well researched. Entire community viabilities are prejudiced, not by the failure of engineered structures but more by the failure of a community to be able to house its population, or perhaps because of the resultant death of livestock or crop losses on which the communities ability to be self-sufficient is dependent. The additional question of whether shelters should be provided and of where these should be sited is of considerable strategic importance.

   The ability of some areas of the world to pass on relevant experience gained in this consideration is of considerable importance, but has yet to be exploited.

2) It is clear that there is an enormous amount of information which could be garnered were there to be a specific modus operandi available for the systematic collection of data relating to the ability of structures to withstand severe winds (or conversely their failures in this circumstance). The rigorous criteria for such an assessment in the immediate post event scenario would facilitate such an ability. Further, the availability of a team of international

experts who would be prepared at short notice to investigate the post storm damage and meteorological surface data, prepare a report, and quickly make that report available to interested parties is clearly a world resource that should be developed. The data would be used for the establishment of a damage-susceptibility index, which may be implentable through an expert system approach.

3) Considerable difficulties currently exist in the comparison of building codes across national or state boundaries. It is considered that a framework for the passing of information across such boundaries should be established for the region.

   This would involve the parametric comparison of approaches to codification in order that appropriate comparisons can be made and that the experience gained in one region can be usefully translated to another.

4) The development of analytical methods using wind tunnels and super-computers has far outstripped the database's development on which those models have been based. The correlation of wind structure models with the comportment of wind in the real world is therefore of immediate concern and is a database which needs urgent establishment.

   In this case, there is the necessity of an approach which involves both meteorological and wind engineering inputs.

   In particular, the establishment of wind characteristics at cyclone landfall, both in the vertical and the horizontal planes, together with the variations of parameters such as wind speed and turbulence intensity urgently need assessment for the critical landfall situation. The group considered that the methodology is currently available, but the cost is relatively high for some lesser developed regions. The ability to convince organizations that the establishment of such a database is in their best interests is of crucial importance to the success of the project.

Finally, there is a theme that crossed the boundaries of several of the projects introduced above. This theme is that there is an urgent need to disseminate information to the general public so that a greater understanding of the dangers and some of the simple mitigating actions that are available may be appreciated more widely.

The distillation of complex information so as to be easily understood by the intelligent layman is a project which should not be underestimated, and is recommended by the Extreme-Wind Hazard group as a possible subject for inclusion in the next conference. The success of such an approach would be dependent on the interaction of engineers and scientists with sociologists who may be in a better position to advise on efficient methods of putting over such a message.

Project 1

Improved Design/Construction Provisions for Housing, Shelters and Community Buildings

Project Goals

The goal of this project is to save lives and properties of the residents in wind-hazard areas. It is essentially a "region based" exercise. The approach will achieve an integrated planning by suitably combining private houses, shelters and community buildings. Information dissemination is crucial for help and cooperation from government and voluntary agencies. The following are the specific goals:

(a) To develop sheltering for different regions.

(b) To study construction practices (mainly private houses) in respect of

(1) Materials and

(2) Construction techniques.

(c) To collate experiences in different regions and to arrive at suitable design/construction methodologies appropriate to the regions.

(d) To suggest construction guidelines, prepare design/construction manuals for improved housing. For proper dissemination, video explanation may be attempted.

(e) To conduct cost benefit analyses for alternatives.

(f) To plan layout of housings, shelters and community buildings.

(g) To develop evacuation and rehabilitation strategies.

Benefits

(a) Saving lives and minimizing property damage.

(b) Improving building practice appropriate to the regions.

(c) Safeguarding livestock through shelters.

Time Requirement

2-3 years from resourcing

Project Leaders/Communicators

A.P. Jeary, Hong Kong
T. Murayama, Japan
D. Perry, USA
K. Seetharamulu, India
J. Shanmugasundaram, India

Project 2

Strong Wind Damage Analysis

Project Goal

The goal of this project is to develop a strong-wind damage index for a community using currently available data. Strong-wind data obtained from future storms would be used to validate and refine the index. Future projects would correlate the damage index to a measure of wind hazard to complete a strong-wind risk assessment method.

Implementation

The development of a damage index for a specific type of damage and a given community will entail the following tasks:

(a) Investigate structural systems and methods of construction by region.

(b) Study types of loss and damage caused by strong winds.

(c) Document and catalog current knowledge of damage which different types of structures experience when subjected to strong winds.

(d) Model wind-fields which cause the damage.

(e) Identify specific post-disaster local and international team members for post-disaster responsibilities and define their roles. Teams would include:

- Wind Engineer
- Structural Engineer
- Meteorologist
- Hydrologist
- Social Scientist

Benefits

(a) The results will be used as a component of strong-wind risk-assessment systems. These systems are envisioned as using an expert-system approach to evaluate the expected damage which would result from a given strong wind; thus, providing a means of planning for and mitigating damage which would result from future strong-wind storms.

(b) The determination of data that should be and should not be collected in the future to refine damage estimates and risk assessment models.

Time Requirements

- Phase I → 1.5 - 2 years
  - Criteria Development
  - Implementation Plan
- Phase II → 1.5 - 2 years
  - Primary Damage Data Analysis
  - Prototype Risk Assessment System
- Phase III → Ongoing
  - Damage Data Collection
  - Catalog Damage Data
  - Catalog Wind Field Data
  - Creation of an International Library
  - Damage Index Validation

Project Leaders

G. Chen, Taiwan
A.N.L. Chiu, USA
A.P. Jeary, Hong Kong
J. Katsura, Japan
M. Powell, USA
G. Reardon, Australia
K. Seetharamulu, India
J. Shanmugasundaram, India
P. Sparks, USA
G. Walker, Australia
Philippines representative (to be determined)
China representative (to be determined)

Project 3

Development of Building Code and Design Guidelines Related to Severe-Wind Hazard

Project Goals

The development, adoption and enforcement of codes play an important role in mitigating the loss of life and property damage produced by severe wind events. The actual provisions adopted vary widely from country to country.

The goal of this project is to review the wind load provisions in the U.S.-Asia region and propose a uniform code structure suitable for analysis and design throughout the region. Five specific tasks are proposed to accomplish this objective as follows:

(a) Identification of the various code parameters used in the assessments of wind loads on a region-by-region basis;

(b) Development of an inter-code parametric conversion translator that will permit the provisions of one code to be applied to another;

(c) Sensitivity analyses of the various code parameters as related to the assessment of wind loads for typical buildings and structures;

(d) Development of a "regional" U.S.-Asia uniform building code; and

(e) Development of a simplified code applicable for the design/ construction of housing and simple low-rise buildings.

Benefits

The end results of this project will be a rational design methodology based on the current state of knowledge that will encourage the adoption and enforcement of appropriate wind code provisions for mitigating the effects of severe wind.

Time Requirement

It is anticipated that the above five tasks will require a minimum of three years for completion. This time frame will permit proper communication among those responsible for the promulgation of code provisions for each country, practicing engineers and researchers; a review of the results of the parametric analyses; and incorporation of the end results of tasks (a) - (c) into the development of a uniform regional code.

Project Leaders

E.D.H. Cheng, USA
A.P. Jeary, Hong Kong
T. Ohkuma, Japan
D.C. Perry, USA
K. Seetharamulu, India
J. Shanmugasundaram, India

Project 4

Improved Definition of Wind Characteristics in Severe Storms

Project Goals

The goals of this project are:

(a) To improve the diagnostic model of low-level windfield in tropical cyclones before and after landfall;

(b) To improve understanding of the boundary layer wind characteristics in various types of severe storms; and

(c) To improve understanding of wind distribution in vertical plane over water and over land.

Implementation

(a) SURFACE INSTRUMENTATION - A large number of appropriately instrumented measurement towers (30 m to 100 m). System of stations chosen based on a high frequency of hits from Storms/Tornadoes/Tropical Cyclones.

(b) WIND PROFILERS (wind data in the vertical) [also a few Doppler Radars] - These sensors should be sited on islands, or near a coastline; we also require wind-measuring stations along the coastline and in critical areas of the Continental USA subject to severe thunderstorm phenomena.

(c) Requires adequate spacial and temporally-resolved surface and upper level data (reconnaissance aircraft, and profilers, or extra radiosounde sites).

(d) Data analysis, synthesis and interpretation-develop refined diagnostic and conceptual models of windfield in severe storms.

Benefits

(a) Improved input to diagnostic and prediction models.

(b) Improved understanding of severe storm structure and behavior.

(c) Improved basis for assessment of windloads.

(d) For model verification and validation and subsequent model improvements.

Time Requirement

3-5 years

Project Leaders

A.N.L. Chiu, USA
J. Golden, USA
P. Krishna, India
K. Mehta, USA
K. Seetharamulu, India
P. Sham, Hong Kong
J. Shanmugasundaram, India
Japan representative (to be determined)

Wind Hazard Workshop Participants

A.N.L. Chiu
G.L.F. Chiu
J.H. Golden
M. Ito
A.P. Jeary
T. Maruyama
D.C. Perry
K. Seetharamulu
J. Shanmugasundaram

ABSTRACTS

Abstracts of the papers from the registered participants are presented in this chapter. They are arranged in alphabetical order by authors' surnames in the following groups:

A. Earthquake hazard
B. Flood hazard
C. Ground-failure hazard
D. Volcano hazard
E. Extreme-wind hazard

The papers that were received in time for publication are contained in the *Proceedings of the Second U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2) 22-26 June 1992, Yogyakarta, Indonesia*. A limited number of single copies are available from Prof. Arthur N.L. Chiu, Department of Civil Engineering, University of Hawaii at Manoa, Honolulu, Hawaii 96822, U.S.A.

A. EARTHQUAKE HAZARD

DAMAGE ASSESSMENT OF EXISTING BRIDGE STRUCTURES WITH SYSTEM IDENTIFICATION

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A method for estimating the damage of existing bridge structures is developed using results of system identification. For damage assessment, structural properties must include the nonlinear parameters, which may be evaluated through system identification. Dynamic behavior of damaged structures is represented by a nonlinear hysteretic moment model. To incorporate the variability of the structural properties and the effects of stochastic excitations, response statistics are obtained through random vibration and damage is represented as random quantities. A numerical example is illustrated for a bridge structure subjected to earthquake excitations.

GIS-A CONVENIENT TOOL FOR NATURAL HAZARD STUDIES AND ANALYSIS

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GIS systems and data formatted for use in such systems are becoming readily available at a relatively modest cost due to the wide applicability of these systems. This provides a new tool and opportunity for application of this tool as a part of a macro engineering approach for natural hazard problems. A brief description of some of the features of GIS systems and data available are provided. Two examples, one in a planning stage and the other almost developed to an operational level are described. The first example concerns the opportunities for display and manipulation of wind data and the other example concerns a GIS-based regional risk approach for bridges subjected to earthquakes.

SEISMICITY AND ITS RELATION TO THE VOLCANIC'S ACTIVITY IN INDONESIA

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The seismicity in Indonesia related with the Benioff zones which subduct in different directions with heterogent dip angles. Many trenches found in this region indicated subduction zones. The tectonics structure in the eastern Indonesia more complex than in the western Indonesia.

The Indonesian region is an active seismic area, it is recorded that on the average about 460 earthquakes per year with the magnitude equal and greater than 4 in Richter scale.

The subduction zones of 180 km depth are founded from Sumatra to West Java, and begin of Central Java to Flores reaching 665 km depth. In the Banda Sea region, the subduction zones are face to face and have a convec form with decreasing depth from west to east: from 650 to 96 km. In the other case, around Molucca area the tectonic plates descend to the west reaching 658 km depth, and to the east into the depth of about 275 km forming a concave. The aseismic zones of 80 - 282 km width can be found between Central Java and Flores, and about 223 km width the south of Mindanao.

In the simple subduction of Sumatra, the distribution of volcanoes correspond to the end of the subduction plate. In Java, up to Banda Sea area, the volcanoes have not direct relation to discontinued zone. In South Molucca the activity of volcanoes correspond to the end of subduction zone, but in Central Molucca it is found that the volcanoes are above the active seismic area.

ATTENUATIONS OF SEISMIC WAVES

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Far-field displacement components in vibration problems of multilayered isotropic elastic and viscoelastic half spaces, taken as the idealized models of the earth media, are presented in closed forms for three simple fundamental problems: a homogeneous half space, a homogeneous full space, and two different half spaces perfectly bonded together. Results for transient waves are also presented.

TECHNOLOGY TRANSFER IN EARTHQUAKE ENGINEERING RESEARCH*

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There is a widespread view in the United States that a major impediment to earthquake hazard reduction is not the lack of new knowledge but rather the delayed application of available knowledge. Technology transfer is therefore being given greater emphasis by those federal and state agencies responsible for mitigating the earthquake hazard.

The National Center for Earthquake Engineering Research was established by the National Science Foundation in 1986 for the express purpose of conducting systematic research in earthquake engineering and to improve the rate of transfer of research results in practice. Accordingly, the Center is actively engaged in technology transfer by a variety of means. These activities may be grouped under "traditional" and "special initiative" headings.

Traditional technology transfer mechanisms include: (a) publication of technical reports, (b) conduct of conferences, workshops and seminars, (c) conduct of short courses for the professions and (d) development of design aids and user-friendly computer software.

However, traditional methods are passive by nature and need to be supplemented by special initiatives. Pro-active strategies, which the Center has found to be successful, include methods that improve the usefulness of the research product and provide improved access to research results and related information.

Techniques for improving the usefulness and quality of research include using multidisciplinary research teams, placing end-users on research teams and sponsoring demonstration projects. Improved access is provided through a new Information Service, the development of expert systems and the placement of qualified researchers on code committees.

This paper summarizes these activities and illustrates their potential benefits by describing a case study in the seismic vulnerability of a water delivery system.

* Theme Paper

THE USE OF NATURAL RUBBER BEARINGS TO PROTECT A SMALL APARTMENT BLOCK FROM EARTHQUAKE DAMAGE

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Rubber Research Institute of Malaysia
Kuala Lumpur, Malaysia

K.N.G. Fuller
Malaysian Rubber Producers Research Association
Hertford, England

H.R. Sidjabat
Research Institute of Human Settlements
Bandung, Indonesia

Seismic isolation is a novel technique of earthquake protection which involves mounting the building or structure on laminated rubber-steel bearings. The horizontal stiffness of the bearings is designed to give the mounted structure a horizontal natural frequency of about 0.5 Hz. This is below the frequency range in which most of the energy of earthquakes for rock and stiff soil sites is typically concentrated. The building is thus detuned from the ground motion occurring during an earthquake, and the accelerations it experiences are much reduced. Furthermore, the mounted structure will behave predominantly as a rigid body with little amplification of the base acceleration at other levels. Seismic isolation is superior to conventional methods of strengthening because not only is damage to the primary structure minimised, but secondary structural features, building contents and occupants are protected.

The technical and economic feasibility of applying seismic isolation to a small building in a country such as Indonesia is currently being assessed by means of a project involving the construction of a small four-storey building on a site near Pelabuhan Ratu in S.W. Java. The area has a reasonable degree of seismic activity thus providing the possibility of a direct assessment of the technical performance of the building. The paper gives details of the building and outlines the principles of seismic isolation and how the design of the isolation system is approached. As well as technical aspects, economic factors and appropriateness of this technology for countries such as Indonesia are discussed.

ANALYSIS AND DESIGN OF A BASE-ISOLATED BUILDING

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Nanyang Technological University
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University of California
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A.H. Muhr
Tun Abdul Rajak Laboratory
Hertford SG13 8NL, England

This paper presents the preliminary analysis and design of the first base-isolated building located in Shantou City, China. Based on the column load distribution, circular isolation bearings of 600-mm diameter and 190-mm thickness are proposed. The bearings are designed for a 120-mm design displacement and a 240-mm maximum displacement. Supported on 23 bearings, the isolated building has a 0.5 Hz natural frequency. Subjected to the site-specific spectrum of 0.2g peak ground acceleration, the maximum acceleration response is 0.16g for the isolated building compared with 0.43g for the fixed-base building. The maximum displacement response at the base level of the isolated building is 105 mm.

ZONING METHOD: ONE OF TECHNOLOGY TO LIVE WITH GEOLOGIC HAZARD AREA

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Tectonically, Indonesia is situated in the active area. It is called an island arc, as indicated by an arcuate shape of the island chains, trenches, active volcanoes and earthquake activity and the chain of islands. On the other hand some part of the eastern Indonesia region is more complicated. Consequently, the area will be vulnerable to some hazard such as earthquake, volcanoes and landslide. The third one is also caused by thick soil due to strong weathering processes, and heavy rain in the tropical region.

Zoning is technology which divide an area in some region according to the hazard level. Earthquake zoning map will divide the area based on possible damage or ground motion criteria, volcanic zoning map will divide the region based on the hazard level due to volcanic products from the crater of volcano. Landslide zoning map will delineate the area according to possible landslide hazard. Indonesia is the fourth country in the numbers of population in the world. Because of this, in some places people have to live in the geologic hazard area. Population condition force the people to live in these hazards areas. Therefore the zoning map should be used as much as possible in any landuse planning of the area. Even in the danger area, if there is some advantage the region could still be utilized with the same boundary condition.

RISK MANAGEMENT FOR NATURAL DISASTERS: A GLOBAL PERSPECTIVE

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Almost 85 percent of all deaths due to natural disasters occur in Asia and the Pacific Rim. As the urbanization of major cities and communities increase at a spectacular rate, the risk to lives and property continues to increase. It is no wonder that in spite of major technological and scientific innovations, the level of risk in many parts of the world is not decreasing.

Planners, scientists, and engineers have studied various natural hazards and their mitigation strategies. However, there is relatively very little work done on an integrated approach to risk management. As an example, earthquakes cause many types of losses. They can be categorized as follows:

* Life and injury;
* Property damage;
* Business interruption;
* Lost opportunities;
* Building contents and damage;
* Long-term social, economical and political implications;
* Other losses.

Even for this specific natural hazard, very limited effort is spent in developing a balanced resource allocation strategy to maximize benefits and minimize the above mentioned losses.

Two important segments of the risk management groups that have not been involved in research or implementation are the financial and the insurance industries. Even though these two sectors deal with the enormous consequences of natural disasters, their expertise, their needs and their input have not been integrated with other professional and scientific sectors. In short, the scientific and technological communities (knowledge generators) do not communicate with the financial-banking and insurance-communities (knowledge users). The result is that less than optimum strategies are used to manage risk.

This paper will review the current state-of-art in earthquake risk management. It will then provide elements of integrated risk management strategies to mitigate the effects of earthquake hazard. The suggested strategies and how they should be implemented in developing and developed nations will be discussed. The goals of IDNDR and means for achieving these goals will be presented.

DISASTER ESTIMATION CAUSED BY FAILURE OF CRITICAL FACILITIES DUE TO NATURAL HAZARD*

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This paper will deal with the necessity of estimating a procedure of the secondary disaster caused by failure of critical facilities such as petrochemical engineering plants, oil storages, nuclear facilities and so on. The secondary disasters are caused by diffusion of poisonous gas, blasting and burning of flammable gas in urban area mainly. This paper will discuss how to generate the scenario of the secondary disaster and how to estimate the failure of such facilities under destructive earthquake conditions; that is, how to estimate the failure probability of equipment and piping systems in such facilities, and finally how to estimate the diffusion of poisonous and flammable gases to the populated area. Main part of the discussion will emphasize on how to estimate the failure probability of facilities distributed in an urban area.

* Theme Paper

AN ASSESSMENT MODEL FOR EARTHQUAKE FATALITIES

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By integrating existing knowledge in seismology, earthquake engineering, and injury epidemiology, we developed a computer model for the estimation of expected fatalities in any given earthquake. Our design purpose for this model was to provide adequate information applicable to the development of safety plans for the reduction of earthquake casualty. We used a very limited range of input variables in order to enhance the model's applicability. Required in the estimation were earthquake magnitude, epicentral position, and three regional data of population, building type, and ground condition. We tested the performance accuracy of the model using the data collected from 16 significant disasters between 1962 and 1986.

PROBABILISTIC SEISMIC HAZARD ESTIMATES IN NORTH SULAWESI PROVINCE, INDONESIA

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I. Effendi and E. Kertapati
Geological Research & Development Center
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Earthquake ground-motions in North Sulawesi on soft soil that have a 90 percent probability of not being exceeded in 50 years are estimated to be 0.46g (46 percent of the acceleration of gravity) at Palu, 0.31g at Gorontalo, and 0.27g at Manado. Estimated ground-motions for rock conditions for the same probability level and exposure time are 56 percent lower on average than the hazard estimated on soft soil. The hazard estimates are obtained from seismic sources that model the earthquake potential to a depth of 100 km beneath northern and central Sulawesi. Significant seismic sources include the Palu fault zone of western Sulawesi, the North Sulawesi subduction zone and the southernmost segment of the Sangihe subduction zone beneath the Molucca Sea. An attenuation relation derived from Japanese strong-motion data and considered appropriate for subduction environments of the western Pacific was used in the determination of expected ground-motions.

B. FLOOD HAZARD

TO IMPROVE HEAVY RAINFALL FORECAST: TAIWAN AREA MESOSCALE EXPERIMENT (TAMEX)

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TAMEX is a research program to improve, through better understanding, the forecasting of heavy precipitation events that lead to flash floods. The program was proposed to the National Science Council and meteorological community in Taiwan in 1983. After about 4 years planning, the field phase was carried out successfully in May - June 1987. A 5-year follow-up research plan to cover both the basic and applied researches started right after the field phase in 1988. The Post-TAMEX Forecast Exercise, to be carried out in May - June 1992, is planned to complete this 10-year TAMEX program. The objective of this Forecast Experiment is to apply the scientific results and forecast techniques generated by the TAMEX program and to develop nowcasting (0 - 3h) and very-short-range forecasting (3 - 24h) capabilities in the heavy rainfall forecast in the Mei-Yu season. An overview of this 10-year program is given in this paper.

PROCESSES OF RIVER BANK EROSION DURING FLOODS

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Y. Yahiro
Chubu District Construction Bureau
The Ministry of Construction

Bank line retreat of a low water course caused by hydraulic scour and collapsing/slipping process has been observed since 1980 at a site in the Uji River, a middle reach of the Yodo River, in Kinki District, Japan. The bank erosion processes are discussed with a local bed scour at a toe of side slopes and its stability is evaluated by a simplified Junbu method of slope stability analyses. Local bed scour near the bank of the low water course causes bank slope instability and the slip failure is predicted to take place after overbank floods.

FLOODS EXPECTED DUE TO GLOBAL WARMING

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Global warming will affect future floods; therefore, careful consideration of all parameters involved is necessary. Changes in temperature, precipitation and solar radiation are given by three global circulation models (GFDL, GISS and UKMO) assuming a scenario of doubling of carbon dioxide (CO_2). The effects of these changes on runoff can be predicted using a rainfall-runoff model like the Sacramento Model which considers all these parameters. Calibrating these models presents large difficulties so that the results can only be considered as preliminary.

Some results show increase in floods of a certain annuity due to increased precipitation. In other cases the increased temperature, solar radiation and potential evapotranspiration decrease runoff and soil moisture. Definite conclusions as to whether floods are increased or decreased by global warming cannot be drawn at this stage.

A small catchment (Maetaeng River) in northern Thailand served as a case study. This tropical catchment (1765 km^2) is in a natural condition, without human influence. The maximum flow is about 700 m^3/s in rainy season; average flow is around 22 m^3/s. The mean annual precipitation is 1350 mm.

Future studies should try to predict more accurately the meteorological changes and the dates when they will occur. Further, improved rainfall-runoff modeling should yield more reliable prediction of floods.

FLOOD HAZARDS MITIGATION IN MALAYSIA

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Flooding is a significant natural hazard in Malaysia. Some 29,000 sq km or nine percent of the total land area of Malaysia is flood prone affecting about 2.7 million people. The average annual flood damage is estimated at M$100 million. After the disastrous flood of 1971, the Government has taken positive steps to deal with the flooding problems. The strategies adopted comprise institutional development, implementation of structural and nonstructural measures and a pro-active approach of comprehensive catchment planning and management. The Government's commitment is reflected in the increasing public expenditures on flood mitigation works. All these measures are aimed at creating a favorable environment to support and promote socio-economic development in the country.

INTEGRATION OF NONSTRUCTURAL MEASURES INTO FLOOD CONTROL PLANNING

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The nonstructural approach to flood control was introduced in the United States to supplement costly dams, levees, and channels to control floods. When flood damages were still increasing despite an extensive structural program, the use of nonstructural measures was seen as a way to cut costs and reduce the environmental disruption of constructing large facilities. However, nonstructural methods shift much of the cost burden to the private sector by making land less productive and construction more expensive. The structural/nonstructural balance is particularly important in developing countries because both large flood losses and large development costs can retard economic growth.

The middle way is to combine measures in programs that help people improve their lives despite flooding. Each floodplain is unique, and each situation requires a separate analysis to choose the best measures and provide for their effective implementation and efficient operation. This paper discusses the measures, their assessment, and their combination. Of the nonstructural measures, flood proofing helps where the floods are shallow; land management is more appropriate with deeper flooding; and contingency programs provide backup during major disasters.

EFFECTS OF THE WAR ON FLOOD DAMAGES IN HIROSHIMA DUE TO TYPHOON 4516

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Just after the Second World War, typhoon 4516, which landed on Makurazaki, Kyusyu Island on 17 September 1945 with the atmospheric pressure of 916.4mb, generated severe damage in Hiroshima. The nationwide loss of lives due to the typhoon was 3128, and two-thirds of the dead were counted in Hiroshima. The factors that enlarged the damage in Hiroshima are (1) lack of proper meteorological observation systems, (2) delay of debris and flood control works and (3) A-bombed wide area. They were all influenced by the war which reduced disaster prevention potential. Due to the war, the government cut down the budget of land development and the draft of civil engineers affected the continuity of the public works programs.

FLOOD ACTION PLAN OF BANGLADESH: A CRITICAL REVIEW*

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Flood is a recurring phenomenon in Bangladesh. Recently, Bangladesh developed an approach of formulating a long-term plan, which would provide a comprehensive solution to the recurrent flood problem and create a climate for sustainable program for economic and social improvement. The approach, called the Flood Action Plan (FAP), will lead to projects which will be technically sound, socially acceptable, environmentally sustainable, economically feasible, and financially implementable. The key elements of the FAP are the concept of control flooding which would allow the desired level of inundation over flood plain but prevent damages, the approach of integrating structural and nonstructural flood mitigation measures, and the concept of compartmentalization for effective flood management. The Action Plan's present activities, covering the five year period 1990-1995, is the first of several stages in the project formulation process. Over the last two years, regional plans are being formulated at prefeasibility level. A number of supporting studies are being undertaken to improve database, develop understanding of the beneficial as well as adverse impacts of flood control projects through evaluation of completed projects, and conduct pilot level activities to try out new concepts and approaches. The FAP is taking a cautious approach in project formulation and their subsequent implementation that will lead toward development of an effective flood disaster mitigation program.

* Theme Paper

FLOOD HAZARD IN THE COASTAL LAND RECLAMATIONS OF HONG KONG

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The distribution of the flood hazard in Hong Kong including reclaimed areas is described, and case studies are used to illustrate the severity of the hazard. Some observations on the major causes of flooding that include rainfall and storm surges are made. The current flood warning system operated by the Royal Observatory is described and future developments discussed. Engineering practices in relation to flooding are outlined and current projects reviewed. This includes modifying drainage systems to cope with reclamation.

UNDERSTANDING FLOOD FORMING MECHANISM FOR BETTER FLOOD HAZARD PREVENTION AND MITIGATION

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Floods cause deaths and destroy properties. The flood hazard can be minimized by building dams, river normalization, etc., but attained at very high costs. However, floods do occur in developed countries, where funds are available, and therefore raise ambiguity in the methods used for flood preventions or mitigations.

Flood disaster occurs when accumulated river water from rainfall exceeds its channel discharging capacity. The streamflow is affected by rainfall characteristics, basin hydrological conditions, and basin physical parameters, which vary in time and space. However, all discharge calculations disregard detailed basin physical parameters involved. The basin is approached as a unit to simplify the complexity of flood flow calculations. Hence, this approach provides limited information on flood flow mechanism which determines flow discharge at a particular time and location.

The basin segmented "finite-element" approach provides flood flow forming mechanism. Moreover, it can define the lesser from greater influential basin physical parameters on flood flow forming, and therefore provide better solutions to prevent or mitigate flood disasters.

POST-CYCLONE RELIEF AND REHABILITATION

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The coastal areas of Bangladesh are frequently battered by cyclones and their associated storm surges. With a rapidly increasing population, large numbers of people are now settling on lands which are hazardous to habitation. This has increased human and livestock deaths and damage to property. In the absence of any meaningful Land Use Policy, the government has not been able to restrict habitation in the hazardous zone. As a result, post-cyclone relief and rehabilitation requirements have increased beyond the

capacity of the local administration, and every time there is a major storm the central government has to play a major role and, often, international effort is required to save the situation. Relief usually reaches the affected areas 12 to 48 hours after the storm. This causes immense suffering because food stocks have been washed away or damaged, and sources of potable drinking water are grossly inadequate. Aerial relief has been tried out, but this is very expensive and sometimes counter-productive. The only viable solution seems to be to strengthen local administration and local NGO's to distribute relief materials immediately after the storm has abated. Similarly with rehabilitation, outside effort is usually expensive and the solution may be a system by which donors and international relief agencies use the District Administration and local NGO's as their ground-level partners.

MITIGATING FLOOD IMPACTS: APPROACHES AND EXPERIENCES IN THE UNITED STATES*

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Approaches to dealing with floods in the United States have changed dramatically during the latter half of this century. There are several reasons: changes in policies and attitudes resulting from the Nation's experience with actual flood events, development of better trained and more experienced professionals, improved analytical techniques and forecasting measures, and increased capabilities to assess the economic and natural resource losses associated with various uses of the floodplain.

The author reviews current philosophies, policies, and practices for reducing these losses in coastal and riverine floodplains in the United States. Some promising mitigation approaches are presented, based on an extensive 5-year study of progress towards developing a unified national program for floodplain management.

* Theme Paper

C. GROUND-FAILURE HAZARD

MOUNTAIN RISK ENGINEERING FOR LINEAR INFRASTRUCTURES

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A simple and systematic technique for hazard and risk assessment at the prefeasibility and feasibility stage of an infrastructural project, such as roads and canals in the mountain terrain, is a first step toward engineering for mitigation of natural hazards influencing the road or canal. Roads in the mountainous region of Nepal have indicated that traditional engineering in planning and design of roads result in (i) either very expensive rehabilitations from frequent failure, or (ii) massive environmental deterioration from indiscriminate slide clearance, hill cutting, and spoils disposal due to cost and time constraints. Mountain Risk Engineering concepts and methods developed and applied so far have been presented with examples in Nepal.

CURRENT METHODS OF SLOPE PROTECTION IN TAIWAN*

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Taiwan has more than 75% of its land occupied by mountains, hilly lands, and lateritic terraces. Landslides, debris flows, and erosion of slope surfaces have long been the most frequent natural hazard in Taiwan.

Traditional methods of slope protection, such as reinforced-concrete retaining walls, earth anchors, gabion walls, drainage systems, etc., remain popular in engineering circle. However, the high costs and environmental conflicts involved in use of these methods have caused concern and opposition from the general public and environmental-protection agencies.

Since 1983, the National Science Council has sponsored research projects on landslides. Emphasis is partly given to developing methods of slope protection which are not only effective and economical, but also are in harmony with the environment. Vegetation, reinforced earth with geotextiles, surface treatments, soil improvements, and hybrid methods have been developed. Some full-size experimental slopes have been constructed in the field to demonstrate the superiority of the methods developed.

* Theme Paper

MITIGATION OF GROUND FAILURES IN THIRD WORLD COUNTRIES WITH SPECIAL REFERENCE TO INDIA

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In view of the population explosion in the third world countries and in the name of development, the hazard prone areas will continue to be inhabited leading to a heavy loss of life during a disaster. It appears appropriate to embark upon a mitigation programme to reduce damage to public utilities and loss of human life. The disaster under examination is ground failure. Various forms of ground failures are classified and a link between environment degradation and ground failures is established. The Indian scenario on environment degradation, possible solution strategies and hurdles are described. A general mitigation programme against mass ground movement is outlined. Finally, cost-effective structural systems are described to minimize environmental damage and to discourage further mass ground movement.

THE SUSCEPTIBILITY TO LANDSLIDING IN THE ENREKANG AREA, SOUTH SULAWESI, INDONESIA

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In order to mitigate the impact of landslide hazards it is important to determine its potential for sliding and to present the results into a map of the area.

A method for recognizing the potential of susceptibility has been introduced by the CTA-108 in Bandung. This scheme is based on factors and parameters of geology and especially lithology, slope inclination and landslide evidences, and other factors, such as rainfall, land use and seismicity.

Based on the parameters and the safety factor of the soil, the Enrekang area can be divided into four landslide susceptibility zones: very low landslide susceptible zone, low landslide susceptible zone, moderate landslide susceptible zone, and high landslide susceptible zone.

The critical angles of the soil of various rocks are: 16° for shale, 34° for conglomerate, 35° for sandstone, 42° for metamorphic rock and 44° for breccia.

RETENTION SYSTEMS FOR SLOPE STABILIZATION: ENGINEERING INNOVATIONS IN THE UNITED STATES*

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This paper reviews stabilization of rock and soil slopes in the United States utilizing innovative earth retention systems. New computerized approaches are being used in design of rock nets, fences, walls, benches, attenuators, and ditches for rockfall control. Placed and in-situ internal reinforcement systems are used to stabilize soil slopes and embankments. New and waste materials are being used as lightweight backfills in slope-failure repair.

* Theme Paper

MONITORING OF BENDOWULUH LANDSLIDE IN BANJARNEGARA REGENCY, JAWA TENGAH

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The Bendowuluh landslide is one of the landslide-prone areas in Banjarnegara Regency, Jawa Tengah, Indonesia. The landslide covers an area about 480,000 m^2, 800 m long and 600 m wide. The crown of the landslide is located at the western slope of Pawinihan Mt. and the toe is situated at the Simpar River.

The landslide area is built up by rocks of the Merawu Series, which are overlain by quarternary volcanic rocks. The Merawu Series consists of calcareous and marly claystones, and the volcanic rocks are made up of lavas, breccias, and lahar deposits.

Since 1989, the Bendowuluh landslide has been monitored using eight monitoring points which are measured from fixed points at Lumbung Mt. The result of measurements in 1991 shows that the landslide has moved the rocks horizontally as well as vertically. The horizontal movements range from 0.02 m to 0.60 m to the southwest, and the vertical movements vary from -0.17 m and -1.41 m.

In order to study the movement of the landslide, eight new points were added, and fixed points at the Bondan Mts. were established in 1991.

LANDSLIDE POTENTIAL OF THE HALANG FORMATION IN THE WALED AREA, CIREBON REGENCY, WEST JAVA, INDONESIA

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The constituent rocks of the Halang Formation (Tmh) generally consist of turbiditic deposits with clear sedimentary structures. The upper part consists of claystone and marl, the middle part is built up by coarse limy sandstones, and the lower part consists of conglomeratic limestones.

Landslides in the Halang Formation include debris slides and creep of 25 m to 45 m width in an investigated area about 50 km^2. These landslides occur especially along the boundary with volcanic rocks, frequently forming an elongated landslide scarp reaching a scarp height of 25 m to 75 m.

Landslides frequently occur in clayey soils which originate from the weathering of claystones. These soils have characteristic properties such as swelling and are sticky and crumbly when wet.

Tests on dry samples in the Soil Mechanics Laboratory yielded an average effective cohesion of c_{dry} = 0.05 g/cm^2, a dry unit weight, (γ_d) = 1.58 ton/m^3; and an angle of effective internal friction (ϕ) = 21.63°. The safety factor (SF = 1.2) gave the critical angle value of slope in this area at 20°.

The Halang Formation is widely distributed in the southwestern part of the Waled Sub District, so that this area is considered to be highly potential in landslides.

PREDICTION AND MAPPING OF LANDSLIDE HAZARDS

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The paper outlines a methodology for prediction and mapping of landslide hazard in shallow soils on hillside slopes. The principal steps are estimation of infiltration and groundwater response, estimation of failure probability, mapping and updating with results of landslide inventory.

D. VOLCANO HAZARD

THE VOLCANIC HAZARDS OF HYDROTHERMAL AREAS IN INDONESIA, AND MITIGATION EFFORTS

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In Indonesia there are 21 fumarolic and solphataric fields related to the geothermal systems of active volcanoes. The disturbance of such hydrothermal systems, e.g., by triggering tectonic activity, may result in phreatic eruptions or gas emissions. Occurrences of disastrous phreatic or gas emission events in historic time e.g. Mt. Papandayan (West Java, 1772), Suoh Antatai (Lampung, 1933), Dieng Plateau (Central Java, 1928, 1939, 1944, 1964, and 1979) and Mt. Gamalama (North Maluku, 1775). Hazards related to such events include primary lahars, phreatic surges, tephra fall and release of poisonous gases.

Some fumarolic fields have been developed for hydrothermal power, e.g., Kawah Kamojang and Mt. Salak (West Java), Lahendong (North Sulawesi), and Dieng Plateau (Central Java). However, these areas are still dangerous. Integrated investigations, e.g., hazard mapping and zonation, monitoring, and risk assessment are needed to reduce risk. Such investigations include geologic, geothermal and volcanological mapping, geochemical and geophysical (including microseismic method), and tectonic analysis, with the aim to identify hazard-prone areas caused by increasing hydrothermal activity.

VOLCANOES AND THEIR VOLCANIC HAZARD MAP PREPARATIONS

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Indonesia is known to have many volcanoes that have been active since 1.8 million years ago (Quaternary in age). Until recently, only 128 volcanoes were considered to be active, but the total number of active volcanoes was increased to 129 after Anak Ranakah Volcano erupted in 1987. The youngest rock of pre-1987 eruption was dated in 14,570 + 320 years BP. In the Philippines, Pinatubo Volcano erupted in 1991 after over 600 years' dormancy. These two volcanoes are not listed in the available Catalogue of Active Volcanoes in the World. In addition, other destructive eruptions such as Mt. St. Helens (1980) and Unzen Volcano (1990-1991) have occurred after very long repose times (more than 200 years). These suggest that it is necessary to inventory not only volcanoes having recorded historical eruptions and volcanic manifestations but also all Quaternary volcanoes.

Volcanic eruptions vary in magnitude from small (e.g. Slamet, Semeru and Gamalama Volcanoes) through moderate (Mt. St. Helens, Pinatubo Volcano) to large scales (Tambora in 1815 and Krakatau in 1883). So far, we cannot predict whether a volcanic activity will produce small, moderate or big eruptions. In the mean time, available volcanic hazard maps in Indonesia are only for overcoming small scale volcanic eruptions, in which the danger zone covers an area less than 20 km in diameter. The 1991 Pinatubo eruptions affected areas about 50 km in diameter, and, damaged areas caused by the 1883 Krakatau eruption reached over 100 km in diameter. These suggest that volcanic hazard maps for moderate and large scale eruptions must be provided besides those for the small eruptions.

Damage from volcanic eruptions occur not only on the ground but also in the air. The Galunggung eruptions in 1982 forced Boeing 747 Jumbo Jets of the British Airways (BA09) and Singapore Airlines (SQ21A) to make emergency landings at Jakarta International Airport. Another Boeing 747 (KLM 747-400 aircraft) entered a cloud of volcanic ash from Redoubt Volcano, Alaska, in 1989. Although the aircraft landed successfully, extensive and costly repairs were required. Recently, the Pinatubo eruptions affected 14 big airplanes and caused the temporary closure of Manila International Airport. These incidents suggest that preparations of volcanic hazard maps for aviation safety are necessary.

In addition, submarine volcanic eruptions might threaten sea transportation. Further detailed studies are needed in order to prepare volcanic hazard maps of the volcanoes.

THE POTENTIAL HAZARD OF SECTOR COLLAPSE OF ALTERATION FROM MT. ILI LEWOTOLO, NTT

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Some facts show that a sector collapse of volcanic flank is a potential hazard for the people who live in surrounding of a volcano. It can be caused by lack of flank stability of active hydrothermal alteration. The alteration is now clearly shown by eastern peak and flank of Ili Lewotolo and as a weakness area. The volume of alteration materials (blocky lavas and pyroclastic rocks) in a Lewotolo crater is about 400,000 cubic meters. These will becomes a potential hazard if a collapse sector occurs in the future. The collapse can be triggered by an earthquake, a crypto dome activity or a magmatic eruption.

THE 1991 MT. PINATUBO ERUPTIONS: VOLCANIC HAZARDS AND IMPACTS

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The June 1991 Mt. Pinatubo eruptions is considered as one of the biggest eruptions this century by world class standards. Its paroxysmal phase on 15 June 1991 produced an approximate volume of 7-11 cu. kms. of pyroclastic flow deposits and extensive air fall tephra, the thickest portions averaging 50 cms at 2-9 kms from the summit caldera. This caldera, formed during the 15 June 1991 eruption, measures about 1.5 kms and 300 m. deep. It is the site of numerous post-eruption ash ejections, the last on 02 September 1992. After almost a year from its June 1991 eruptions, volcanic activity have been mostly characterized by tectonic adjustments probably due to rocks adjusting within and around the vacuum caused by the removal of a big volume of magma beneath the volcano. However, equally threatening hazards are present and are still expected:

a. Lahars. During the 1991 rainy season, about 10-15% of pyroclastic flow deposits and most of the thick tephra fall deposits were washed down as lahars. Drainage systems where these flows occurred were: O'Donnell-Tarlac, Sacobia-Bamban, Abacan, Pasig-Potrero, Porac, Gumain, Marella-Sto. Tomas, Maloma, and the highly complex Bucau-Maraunot-Balin-Baquero river systems. Flows may have a highly erosive to channel-filling character while in the distal ends, may silt up or flood low lying areas. Our estimate is that the threat from lahars will continue until about 40% of the pyroclastic flow deposits have been washed out by annual precipitations. Worst-case scenario maps were prepared and distributed which delineated pyroclastic flow sources, areas already affected and/or buried and areas which will continue to be affected or at risk within the next several years.

b. Secondary Explosions. Temperatures of the very thick (maximum of 220 kms) pyroclastic flow deposits are expected to cool down within four to five years time. These deposits, when rained upon, caused secondary explosions whose heights could be as high as 10 kms and could cause light to heavy ashfall in nearby areas.

c. Volcano-tectonic Quakes. Tectonic adjustments are still occurring. Epicentral locations are along several areas around the volcano with maximum depths of 15 kms. Magnitudes vary from less than 1 to 4. The bigger and shallow ones are usually felt over a limited area.

d. Secondary Pyroclastic Flows. At least three significant secondary pyroclastic flows have been documented. These are when previously deposited pyroclastic flow deposits are remobilized by rainwater seeping into and generating the sliding block, occurrence of local and moderate magnitude earthquakes, or a combination of the two.

VOLCANIC HAZARD MITIGATION IN INDONESIA*

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Volcanic hazard mitigation program in Indonesia constitutes volcanic monitoring, hazard map preparation, public education, engineering construction and public awareness. In the last 200 years, 175 thousand people were killed by volcanic eruption. The number has significantly decreased due to intensive implementation of the program. Six eruptions that occurred in the last 10 years claimed 38 lives in comparison with 5870 persons killed in the previous eruptions at the same volcanoes.

The advances in volcano monitoring technology haves also been important contributors to the success of the volcanic hazard mitigation program.

* Theme Paper

VOLCANO MONITORING AND ERUPTION PREDICTION: STRATEGY, TECHNIQUES, AND LIMITATIONS*

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The capability to monitor volcanoes and to warn of impending eruptions has improved over the years. This paper presents a critical appraisal of the state-of-the-art. The most useful monitoring tool is seismic monitoring, the determination of earthquakes per unit time, their energy release, and source characteristics. Deformation monitoring has proven useful at some volcanoes, and gas monitoring has been conducted with variable success. Field observations must not be omitted. From these data, predictions are traditionally developed by pattern recognition, augmented by interpretation of evolving processes. Where data values accelerate prior to eruptions, the "materials science method" may be helpful. However, volcanoes are such extremely complex systems that with all techniques, warning of impending eruptions is difficult and not necessarily reliable, even under optimal circumstances.

* Theme Paper

E. EXTREME-WIND HAZARD

COMPUTATIONAL METHODS FOR ESTIMATING EXTREME WIND SPEEDS

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In order to provide a better method of estimating extreme winds at an ungaged site, computational methods of estimating 50-year or 100-year extreme winds from short-term data collected at various weather stations in a large region are being developed. In the current state-of-the-art, there are four approaches for estimating extreme wind speeds from short-term records. The first approach is based on the analysis of the largest monthly wind speeds of at least three years' data. The second approach is the determination of extreme wind speeds from a parent distribution. The third and fourth approaches are simulation models based on short-term continuous hourly wind speed records. Application of the methods will be presented.

DETERMINATION OF WIND EFFECTS ON AND AROUND TALL BUILDINGS

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In this paper, an aeroelastic model which simulates the shear flexure mode using distributed mass and stiffness is described. In order to obtain the distribution of loads along the height of the building, an experimental technique is presented herein where the fluctuating pressures from the aeroelastic model are sampled simultaneously from two tappings at a time. The measured data are later converted into the frequency domain in the form of auto and cross power spectral densities for the computation of modal forces. From which, the acceleration at any height and hence the variation of shear and moments along the height of the building are determined.

RELIABILITY-BASED WIND-RESISTANT DESIGN OF TRANSMISSION TOWERS

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This study is intended to develop probability-based design wind loads as well as reliability-based LRFD criteria for transmission towers based on the investigation of the safety levels of various types of towers designed by the current design practice in Korea. In the study, the AFOSM reliability method and an Importance Sampling Technique are

used for the element and system reliability evaluation of actual transmission towers subjected to weather-related loadings. Based on the selected target reliabilities, a set of load and resistance factors for the LRFD criteria are calibrated using the AFOSM and the code optimization technique.

NEW TECHNOLOGY APPLICATIONS FOR IMPROVED SEVERE STORM WARNINGS

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We shall treat some of the current and future technologies in weather forecasting, especially as related to extreme winds and floods. The importance of accurate forecasting and the warnings issued for mitigating damage and fatalities from these two natural hazards have often been underestimated. In the United States, flash floods account for more deaths and damage on an average yearly basis than any other natural hazard, including tornadoes and hurricanes. The National Weather Service during the decade of the 1990's has begun an ambitious Modernization and Associated Restructuring Program. The cornerstone of this program is the field deployment, now underway, of some advanced technological tools that will permit increased staff productivity and more accurate and timely forecasts and warnings. These new technologies include the Next Generation Radar (NEXRAD, WSR-88D Doppler), wind Profilers, Automated Surface Observing Systems (ASOS), and an interactive processing and display system, AWIPS-90. The capabilities and limitations of each of these systems are assessed, along with examples of actual data sets from recent windstorms and flood events. Planned future enhancements to these observing systems will also be described. Some specific potential applications to the improved tracking and warnings of typhoons and flash floods will be described. The importance of establishing "ground truth" networks of automated sensors, especially anemometers and rain gauges, along with trained storm spotters will be highlighted from recent experiences in the U.S. and elsewhere.

STRONG WIND DAMAGE TO HOUSES IN YANAGAWA CITY BY TYPHOON 9119

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Typhoon 9119 struck the northwest area of Kyushu Island, Japan, during the afternoon of September 27, 1991. Significant damage occurred throughout the city of Yanagawa due to strong wind. Time-variations of damage to roofs were investigated using video camera records. The primary weakness of tile or sheet-metal roofing designs was clarified. It is estimated that the velocity of the maximum peak gust was at least 40 m/s at 6 m above ground level at the height of the eave of houses.

HOLISM, EUROCODES AND NATURAL HAZARDS IN THE PACIFIC RIM*

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This paper discusses the risk of damage to housing throughout the Pacific area, from the passage of cyclones and typhoons. Construction techniques throughout the area are considered and the experiences of different communities are highlighted. The appearance of changes to the traditional paths of cyclones has severe implications for regions not traditionally associated with cyclone activity. Interestingly, the communities most at risk appear to be located in richer countries.

* Theme Paper

NEEDS FOR DISASTER MITIGATION RELATED TO NON-ENGINEERED AND PARTIALLY ENGINEERED BUILDINGS SUBJECTED TO WIND STORMS

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Coastal zones of many countries, namely Australia, Bangladesh, China, Hong Kong, India, Philippines and U.S.A., frequently experience severe cyclones apart from high velocity inland storms. Cyclones are generally followed by heavy rain and storm surge resulting in loss of lives, crops, animals and severe damage to structures specially dwellings leaving thousands homeless. In most of the wind storms, the damage to non-engineered or marginally engineered buildings is considerably larger compared to engineered buildings. This is partly because scant attention is paid to details in case of the non-engineered buildings and partly due to the lack of comprehension and application of information available regarding wind effects on structures. Today there is great awareness for the need to mitigate disasters due to hazards including wind storms. The prime need is to coordinate the efforts being made to study the influence of storms on structures in wind tunnels as well as through post-disaster surveys in the field, innovations in design ideas and the technology being followed at the "grass roots" level. The relief and rehabilitation work needed will reduce sharply, if disaster preventive measures are taken up in earnest. The present paper puts together some ideas on the developmental and training needs required for reducing wind disasters.

ON THE QUESTION OF THE ROLE OF BUILDING CODES AND STANDARDS IN MITIGATING DAMAGE DUE TO HIGH WINDS*

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Although our basic understanding of the nature of wind and its effects on buildings and structures has improved dramatically during the past three decades, the translation of this knowledge into codes of practice continues to present a formidable task. The after-

maths following the passage of recent hurricanes in the United States have served as reminders that we are not doing enough to address the wind threat. Wind damage in the U.S. on an annual basis now exceeds that induced by all other natural hazards.

Following each major wind event, the following statement is frequently heard:

"The wind climate was predictable and most of the damage was preventable."

What then, are we doing wrong? The answer is not a simple one, but is rooted in the complex manner in which building codes are promulgated, adopted and enforced. The issue of affordability vs. risk is always centerstage and the political/economic systems in place in some jurisdictions in the U.S. do not always permit the adoption of proper strategies for mitigating damage.

The objectives of this paper are to:

- review current practices in the United States with regard to the wind threat,
- discuss the adequacy of wind load provisions currently in place to mitigate damage, and
- suggest what new measures should be adopted to reduce wind damage to acceptable levels while at the same time safeguarding the economy.

* Theme Paper

INTEGRATED APPROACH AGAINST CYCLONIC WIND HAZARD AND ROLE OF VOLUNTARY AGENCIES

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The natural disasters in India are mainly caused by earthquakes, floods and severe winds. In India the damage caused by tropical storms is very high as compared with tornadoes, local storms and thunder storms. An integrated approach is directed against the hazards caused by cyclonic winds. The cyclones on the eastern coast of India occur in the months of April and May, and between October and December. The cyclones that originate in the Bay of Bengal affect the coastal belts of Tamilnadu, Andhra Pradesh, Orissa and West Bengal, whereas, those originating in the Arabian Sea affect Konkan and Saurashtra coast. The cyclones on east coast are amongst the most destructive of all the natural disasters. These cause destruction to man-made structures meant for housing and shelters. It is not feasible to economically design the housing and community structures that are fully resistant to cyclones and therefore safe against loss of life and damage to material assets. There are three categories of structures, (a) storage structures for safe storage of household goods, (b) community structures and shelters for livestock and local population and (c) large span shopping and distribution complexes away from the cyclone affected areas. The structures belonging to the categories (b) and (c) may be designed to safely resist the cyclones. Such a system with a proper warning system may result in practically fully safe against loss of life and damage to material assets. It is therefore equally important, if not more, to mobilize assistance from voluntary agencies alongside the affected population and the government agencies for mitigating the hazards. The other measures may include (a) dykes and sea walls and (b) shelter belts and land use zoning. The paper discusses an integrated approach for cyclone disaster.

ENGINEERING OF STRUCTURES FOR WIND HAZARD REDUCTION

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Every year a large number of buildings, industrial structures, and houses ranging from well-engineered type to non-engineered type, are severely damaged by tropical cyclones in many parts of the world. Mitigation of the effects of cyclone disaster is a problem of international importance. Assessment of wind loads due to cyclones and prediction of structural response of different structures subjected to such wind forces are highly complex to be dealt with using theoretical models alone. The present level of understanding of characteristics of cyclonic winds and causes of damage to houses, buildings, towers and other wind-sensitive structures is far from satisfactory. Post-disaster field surveys on structural damage provide invaluable information that will help in understanding the modes of failure of structures and in developing cyclone-resistant designs. The paper deals with the details of the post-disaster surveys and assessment of structural damage caused by the two recent severe cyclones which hit Kavali and Guntur regions of Andhra Pradesh in India. Based on the observations of typical modes of failures of structures, and assessment of causes of such failures, methodologies for improvement of designs of structures are discussed. Emphasis is also laid on training to be imparted to design and field engineers with a view to achieving transfer of R&D results to reduce cyclone hazard to structures.

PROGRAM

2nd U.S.-Asia Conference on Engineering for Mitigating Natural Hazards Damage (EMNHD-2)
Yogyakarta, Indonesia
22-26 June 1992

Monday, 22 June 1992

08:00 - 09:00	Registration - in front of Roro Jonggrang Room, Ambarrukmo Palace Hotel
09:00 - 09:30	**Opening Ceremony - Roro Jonggrang Room (7th floor)**
	Co-Chairmen - Arthur N.L. Chiu; Aspan S. Danuatmodjo; Hernowo Hadiwonggo
	Welcoming Address - Mr. Hernowo Hadiwonggo, Co-chairman, Organizing Committee
	Welcoming Remarks - Dr. Albert J. Simone, President, University of Hawaii and Chancellor, University of Hawaii at Manoa
	Opening Address - His Majesty Sri Paduka Paku Alam VIII, Governor of the Special Territory of Yogyakarta
09:30 - 10.00	Coffee Break
	Plenary Session I - Roro Jonggrang Room
	Themes: Volcano and Earthquake Hazards
	Chairman: M. Ito
10:00 - 10:30	Volcanic Hazard Mitigation in Indonesia - A. Sudradjat
10:30 - 11:15	Volcano Monitoring and Eruption Prediction: Strategy, Techniques, and Limitations - B. Voight
11:15 - 12:00	Technology Transfer in Earthquake Engineering Research - G.C. Lee and I.G. Buckle (presented by M.P. Gaus)
12:00 - 12:45	Disaster Estimation Caused by Failure of Critical Facilities Due to Natural Hazard - H. Shibata
12:45 - 13:45	Lunch - Borobudur Restaurant
	Plenary Session II - Roro Jonggrang Room
	Theme: Ground-Failure Hazard
	Chairman: T.H. Wu
13:45 - 14:30	Retention Systems for Slope Stabilization: Engineering Innovations in the United States - R.L. Schuster
14:30 - 15:15	Current Methods of Slope Protection in Taiwan - J-J. Hung (presented by G.T-J. Chen)
15:15 - 15:30	Coffee Break

Plenary Session III - Roro Jonggrang Room
Theme: Wind Hazard
Chairman: T. Balendra

15:30 - 16:15 Holism, Eurocodes and Natural Hazards in the Pacific Rim - A.P. Jeary

16:15 - 17:00 On the Question of the Role of Building Codes and Standards in Mitigating Damage Due to High Winds - D.C. Perry and W.L. Beason

18:30 - 20:00 Cocktail Reception - Sinar Bulan Room (8th Floor)

Tuesday, 23 June 1992

Plenary Session IV - Roru Jonggrang Room
Theme: Flood Hazard
Chairman: M.R. Peart

08:30 - 09:15 Mitigating Flood Impacts: Approaches and Experiences in the United States - J.M. Wright

09:15 - 10:00 Flood Action Plan of Bangladesh: A Critical Review - A. Nishat

10:00 - 10:15 Coffee Break

Simultaneous Session IA - Roro Jonggrang Room
Volcano, Earthquake and Ground-Failure Hazards
Co-Chairmen: P. Karasudhi and M.P. Gaus

10:15 - 10:30 Volcanoes and Their Volcanic Hazard Map Preparations - S. Bronto
10:30 - 10:45 The Volcanic Hazards of Hydrothermal Areas in Indonesia, and Mitigation Efforts - M. Alzwar
10:45 - 11:00 The Potential Hazard of Sector Collapse of Alteration from Mt. Ili Lewotolo, NTT - A. Nasution
11:00 - 11:15 Mitigation of Ground Failures in Third World Countries with Special Reference to India - P. Kumar and N.S. Bhal
11:15 - 11:30 Monitoring of Bendowuluh Landslide in Banjarnegara Regency, Jawa Tengah - U. Sudarsono and S. Kartoatmodjo
11:30 - 11:45 Prediction and Mapping of Landslide Hazards - T.H. Wu

Simultaneous Session IB - Mataram Room (2nd floor)
Wind and Flood Hazards
Co-Chairmen: A.P. Jeary and J.H. Golden

10:15 - 10:30 Reliability-Based Wind-Resistant Design of Transmission Towers - H-N. Cho, J-C. Shin and S.J. Lee
10:30 - 10:45 Integrated Approach Against Cyclonic Wind Hazard and Role of Voluntary Agencies - K. Seetharamulu and V.R. Sharma
10:45 - 11:00 Engineering of Structures for Wind Hazard Reduction - J. Shanmugasundaram, S. Arunachalam and T.V.S.R. Appa Rao
11:00 - 11:15 Computational Methods for Estimating Extreme Wind Speeds - E.D.H. Cheng and A.N.L. Chiu
11:15 - 11:30 Strong Wind Damage to Houses in Yanagawa City by Typhoon 9119 - H. Ishizaki, J. Katsura, Y. Taniike and T. Maruyama
11:30 - 11:45 Determination of Wind Effects on and around Tall Buildings - H.F. Cheong, T. Balendra and S.L. Lee

11:45 - 13:00 Lunch - Borobudur Restaurant

	Simultaneous Session IIA - Roro Jonggrang Room
	Volcano, Earthquake and Ground-Failure Hazard
	Co-Chairmen: P.C. Thenhaus and K. Muniandy
13:00 - 13:15	Mountain Risk Engineering for Linear Infrastructures - B.B. Deoja
13:15 - 13:30	Landslide Potential of the Halang Formation in the Waled Area, Cirebon Regency, West Java, Indonesia - I.B. Sudjarwo, Suranta and Y.O.P. Siagian
13:30 - 13:45	Attenuations of Seismic Waves - P. Karasudhi
13:45 - 14:00	An Assessment Model for Earthquake Fatalities - K. Shiono
14:00 - 14:15	Analysis and Design of a Base-Isolated Building - T-C. Pan, A.H. Muhr and J.M. Kelly
14:15 - 14:30	The Susceptibility to Landsliding in the Enrekang Area, South Sulawesi, Indonesia - S. Nitihardjo
	Simultaneous Session IIB - Mataram Room
	Wind and Flood Hazards
	Co-Chairmen: A. Nishat and J. Shanmugasundaram
13:00 - 13:15	Processes of River Bank Erosion During Floods - Y. Fujita, Y. Muramoto and Y. Yahiro
13:15 - 13:30	Effects of the War on Flood Damages in Hiroshima Due to Typhoon 4516 - Y. Kawata, T. Oka and Y. Tsuchiya
13:30 - 13:45	Flood Hazards Mitigation in Malaysia - K.L. Hiew and K.F. Law
13:45 - 14:00	To Improve Heavy Rainfall Forecast: Taiwan Area Mesoscale Experiment (TAMEX) - G.T-J. Chen
14:00 - 14:15	Post-Cyclone Relief and Rehabilitation - H.E. Rashid
14:15 - 14:30	Floods Expected Due to Global Warming - R. Harboe and Z. Ahmad
14:30 - 14:45	Coffee Break
	Simultaneous Session IIIA - Roro Jonggrang Room
	Volcano, Earthquake and Ground-Failure Hazards
	Co-Chairmen : S. Bronto and T.H. Wu
14:45 - 15:00	Risk Management for Natural Disasters: A Global Perspective - H.C. Shah
15:00 - 15:15	Probabilistic Seismic Hazard Estimates in North Sulawesi Province, Indonesia - P.C. Thenhaus, I. Effendi and E. Kertapati
15:15 - 15:30	Seismicity and Its Relation to the Volcanic's Activity in Indonesia - G. Ibrahim and M. Ahmad
15:30 - 15:45	Damage Assessment of Existing Bridge Structures with System Identification - A.H-S. Ang and W-J. Kim
15:45 - 16:00	The Use of Natural Rubber Bearings to Protect a Small Apartment Block from Earthquake Damage - K. Muniandy, K.N.G. Fuller and H.R. Sidjabat
16:00 - 16:15	Zoning Method: One of Technology to Live with Geologic Hazard Area - D. Santoso
	Simultaneous Session IIIB - Mataram Room
	Wind and Flood Hazards
	Co-Chairmen: R. Harboe and H.E. Rashid
14:45 - 15:00	Understanding Flood Forming Mechanism for Better Flood Hazard Prevention and Mitigation - L. Polo
15:00 - 15:15	Flood Hazard in the Coastal Land Reclamations of Hong Kong - M.R. Peart and W.W-S. Yim
15:15 - 15:38	New Technology Applications for Improved Severe Storm Warnings - J.H. Golden
15:38 - 16:00	GIS-A Convenient Tool for Natural Hazard Studies and Analysis - M.P. Gaus and S.H. Kim
16:00 - 16:15	Wind Engineering on Long Span Bridges in Japan - M. Ito

Wednesday, 24 June 1992

08:00 - 17:30	**Field Trip**
08:00	Buses will be in front of Ambarrukmo Palace Hotel
08:00	Leave Hotel for Merapi Volcano Observatory Office
08:20	Arrive at Merapi Volcano Observatory Office
09:00	Leave for VOLCANIC SABO TECHNICAL CENTER (VSTC)
09:30	Arrive at VOLCANIC SABO TECHNICAL CENTER
10:30	Leave for Merapi Project site at Bebeng
11:00	Arrive at Salam Village, thence by minibuses to the project site
11:30	Arrive at the project site
12:15	Return to Salam Village, thence by bus to Borobudur Temple
13:15	Arrive at Borobudur Temple and direct to DAGI Restaurant (located at Borobudur) for lunch
14:30	Visit Borobudur Temple
16:00	Return to Yogyakarta
17:30	Arrive at Ambarrukmo Palace Hotel
19:00 - 21:00	Dinner and Cultural Program

Thursday, 25 June 1992

Plenary Session - Roro Jonggrang Room
Co-Chairmen: Arthur N.L. Chiu
Aspan S. Danuatmodjo

08:30 - 09:00	A Hard-fought Victory in the Philippines, but Losing Big in the Andes: The State-of-Practice in Pacific Rim Volcano Crisis Management as Revealed by Pinatubo and Armoro - B. Voight
09:00 - 09:15	General Discussion on Workshop Format and Goals
09:15 - 09:30	Coffee Break
09:30 - 12:00	**Workshop Sessions**

Theme: Volcano Hazards - Roro Jonggrang Room
Co-Chairmen: B. Voight and S. Bronto
Rapporteurs: A. Nasution and M. Alzwar

Theme: Ground-Failure Hazards - Roro Jonggrang Room
Co-Chairmen: R.L. Schuster and B.B. Deoja
Rapporteurs: P. Kumar and T.H. Wu

Theme: Earthquake Hazards - Roro Mendut I
Co-Chairmen: H. Shibata and P.C. Thenhaus
Rapporteurs: A.H-S. Ang and K. Muniandy

Theme: Wind Hazards - Roro Jonggrang Room
Co-Chairmen: A.P. Jeary and D.C. Perry
Rapporteurs: K. Seetharamulu and T. Maruyama

Theme: Flood Hazards - Roro Mendut II
Co-Chairmen: J.M. Wright and A. Nishat
Rapporteurs: M.R. Peart and G.T-J. Chen

12:00 - 13:30	Lunch - Borobudur Restaurant
13:30 - 15:00	**Workshop: Continue Discussions**
15:00 - 15:15	Coffee Break
15:15 - 16:30	**Workshop: Draft Reports and Proposals**

Friday, 26 June 1992

08:30 - 09:45	**Plenary Session - Roro Jonggrang room** Co-Chairmen: Arthur N.L. Chiu Aspan S. Danuatmodjo Hernowo Hadiwonggo Draft Reports by Workshop Groups
09:45 - 10:00	Coffee Break
10:00 - 12:00	**Workshop: Revise Draft Reports - Roro Jonggrang Room**
12:00 - 14:00	Lunch - Borobudur Restaurant
14:00 - 15:30	**Plenary Closing Session - Roro Jonggrang Room** Co-Chairmen: Arthur N.L. Chiu Aspan S. Danuatmodjo Hernowo Hadiwonggo Final Reports by Workshop Groups Resolutions Closing Remarks
15:30 - 16:00	Coffee Break
18:00 - 21:30	Closing Banquet - Sinar Bulan Room

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