Memorial Conference on the 2004 Giant Earthquake and Tsunami in the Indian Ocean

Period: December 14 – 15 (Part 1)
December 16 – 17 (Part 2)
Venue: Zenkyoren Bldg, 7-9 Hirakawa-cho 2, Chiyoda, Tokyo (Dec.14-16)
Akasaka Prince Hotel, 1-2, Kioi-cho, Chiyoda, Tokyo (Dec. 17)

Sponsors: Earthquake Research Institute, University of Tokyo
Nat'l Res. Inst. for Earth science and Disaster prevention
Disaster Prevention Research Forum

Preface

The earthquake and tsunami of December 26, 2004, caused tremendous damage to the countries surrounding Indian Ocean. Peoples in the heavily-stricken areas are still suffering from the disasters and the restoration process would take a long time.
This memorial conference has been proposed to hold in the occasion of about one year of passage after the Giant Earthquake and Tsunami. Historically Japan has suffered many earthquakes and tsunamis, in which a lot of lives and properties have been lost. Japanese people have made continuous efforts against the inherent and inevitable attack of the nature that usually presents us fruitful gift of natural harvest and beautiful scenery. After the tragedy of the Indian Ocean many Japanese people opened their eyes to realize the importance to share experiences against natural disasters with the people in Asian countries, where large amount of natural disasters happen. Even though the conference is a tiny step, our efforts should be sustainingly continued to establish safe and secure land to live peacefully in Asia,

The conference consists of two parts;
Part 1: International Workshop on the Restoration Program from Giant Earthquakes and Tsunami, and
Part 2: International Symposium on Proposals toward International Collaboration for Disaster Reduction Technology.

Part 1 is a kick-off workshop for the three year project “Restoration Program from Giant Earthquakes and Tsunamis.” Scientific aspects on the restoration from giant earthquakes and tsunamis, particularly from that generated in 2004 in Indian Ocean, will be discussed in concurrent sessions to integrate strategies for the future establishment of earthquake- and tsunami-proof cities around Indian Ocean.

Part 2 is a symposium to be held on the agreement at the UN World Conference of Disaster Reduction (2005 in Kobe), in which the necessity of international collaboration for restoration from the 2004 Giant Earthquake and Tsunami in Indian Ocean was addressed. The symposium is organized as a Joint Program of the Science Council of Asia and will make proposals for disaster reduction framework through holistic international collaboration among Asian countries.

Both of these meetings are financially supported by the Special Coordination Funds for Promoting Science and Technology, Ministry of Education, Culture, Sports, Science and Technology.

We do hope that these meetings will give us an opportunity to discuss new advances and to learn about research on the cutting edge of our fields due to the Sumatran earthquake to integrate effective strategies for establishing safer cities as well as developing human resources against earthquake and tsunami disasters among the countries around Indian Ocean.

Teruyuki Kato (Part 1) and Tsuneo Katayama (Part 2)

Program: Part 1

Dec. 14 (Wed.)

09:00-17:00 Registration

Session 1: Plenary – Opening Ceremony and Keynote addresses -

Chairperson: Teruyuki Kato (ERI, Japan)

09:30-09:35 Opening Address
Shuhei Okubo (ERI, Director, Japan)

09:35-09:45 Opening Remarks
Teruyuki Kato (ERI, Japan)

(Intermission)

09:50-10:40 [P1-1-1] Keynote Lecture: The Next Giant Sumatran Megathrust Earthquake: From Science to Human Welfare
Kerry Sieh (USA)

10:40-11:30 [P1-1-2] Keynote Lecture: Tsunamis –Their Coastal Effects and Defense Works－
Nobuo Shuto (Nippon University, Japan)

（lunch time） 11:30-13:00

Session 2-1: Mechanism and future probability of the 2004 Giant Earthquake and Tsunami in Indian Ocean

Chairperson: Kenji Satake,

13:00-13:15 [P1-2-1-1] Tsunami hazard and vulnerability along the Myanmar coast
Kenji Satake, Than Tin Aung, Yuki Sawai, Yukinobu Okamura, Kyaw Soe Wing, Win Swe, Chit Swe, Tint Lwin Swe, Soe Thura Tun, Maung Maung Soe, Thant Zin Oo, and Saw Htwe Zaw

13:15- 13:30 [P1-2-1-2] Coseismic uplift of the Andaman Islands associated with the Sumatra-Andaman Earthquake of 2004 and the recurrence history of gigantic earthquakes
Hajime Kayanne, Yasutaka Ikeda, Tomoo Echigo, Masanobu Shishikura and Takanobu Kamataki

13:30-13:45 [P1-2-1-3] Ongoing efforts to understand the style of deformation and the seismic/tsunami history of the Andaman-Nicobar region C. P. Rajendran and Kusala Rajendran

13:45-14:00 [P1-2-1-4] Coseismic Land-level changes caused by 26 December, 2004 Sumatra earthquake in Andaman and Nicobar Islands, India
Javed N. Malik and C.V.R. Murty

14:00-14:15 [P1-2-1-5] Macroseismic, tsunami surveys and GPS monitoring in Andaman and Nicobar Islands in the aftermath of the Great Mw9.0 earthquake of 26th December 2004 – a brief appraisal
Ashish Kumar Ghosh Roy, Prasun Jana, Sandeep Bardhan, Shaikh Rezaul Basir, Tapan Ghosh, Thiruvalluvar Saranathan Giritharan, Pranab Chakraborty and Dulal Chandra Ghosh

14:15-14:30 [P1-2-1-6] Earthquake Disaster Mitigation Initiatives in Myanmar
Than Myint

14:30-14:45 [P1-2-1-7] Current Situation on Modern and Paleo-seismology in Myanmar
Than Myint and Win Swe

14:45-15:00 [P1-2-1-8] Characteristics of Post-seismic relaxation in Andaman-Nicobar region from continuous GPS measurements
C. D. Reddy, Sanjay K Prajapati, Teruyuki Kato

（coffee break: 15:00-15:15）

15:15-15:30 [P1-2-1-9] Kinematics of the 2004 Great Sumatra Earthquake from Static Co-seismic GPS Offsets
Paramesh Banerjee, Roland Burgmann and Fred Pollitz

15:30-15:45 [P1-2-1-10] Crustal deformation associated with the 2004 Sumatra earthquake from GPS observation

	Agustan, Irwan Meilano , Yasaku Oota, Takeo Ito, Fumiaki Kimata, Dudy Darmawan, Heri Andreas, Hasannudin Z. Abidin, Mipi A. Kusuma, Didik Sugiyanto, Takao Tabei
15:45-16:00	[P1-2-1-11] Postseismic deformation of 2004 Sumatra earthquake from continuous GPS observation in Aceh Didik Sugiyanto, Yasaku Ohta, Irwan Meilano, Takeo Ito, Fumiaki Kimata, and Takao Tabei
16:00-16:15	[P1-2-1-12] Seismological Activities, Tsunami Effect and Prevention in Myanmar Myint Soe
16:15-16:30	[P1-2-1-13] The rupture process of 2004 Sumatra-Andaman Earthquake viewing from the data obtained by the strainmeters of JMA Yasuhiro Yoshida and Hidemi Ito
16:30-16:45	[P1-2-1-14] Changes in seismicity associated with the Sumatra earthquake and their implications for the stress state Masajiro Imoto, Shozo Matsumura, Shin'ichi Noguchi and Sachiko Tanaka
16:45-17:00	[P1-2-1-15] Mechanism of the 2004 great Sumatra-Andaman earthquake estimated from tsunami waveforms Yuichiro Tanioka, Sin-Iti Iwasaki, Yoshinobu Tsuji, Yuichi Nishimura, Hiroyuki Matsumoto, Syusaku Inoue, Yuichi Namegaya, and Yudhicara
17:00-17:15	[P1-2-1-16] Development of Indonesia Permanent Sea Level Monitoring Network For Supporting Indian Ocean Tsunami Warning System Parluhutan Maurung
17:20-17:50	Press Briefing

(Reception: 18:00-20:00 : DVD show by Mikio Satomura(Shizuoka Univ.))

<u>Session 2-2 (Joint):</u> <u>Human resource program for the education and outreach and Restoration program and urban design</u>

Chairperson: Hirokazu Iemura,

13:00-13:15	[P1-2-2-1] Report on the Post-Tsunami Reconstruction Condition in Sri Lanka affected by 2004 Sumatra Tsunami Osamu Murao, Hideaki Nakazato, and Nihal Rupasinghe
13:15-13:30	[P1-2-2-2] Post Tsunami Construction, Rehabilitation & Restoration Program in Sri Lanka Nihal Rupasinghe and A A Virajh Dias
13:30-13:45	[P1-2-2-3] Identification of tsunami wave loads based on damage assessment of road structures in Sri Lanka due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean Gaku Shoji, and Yoichiro Mori
13:45-14:00	[P1-2-2-4] Damage of Infrastructures Caused by December 2004 Great Earthquake and Tsunami in Aceh Region Indonesia Agussalim
14:00-14:15	[P1-2-2-5] Tsunami Questionnaires and Bridge Damage Surveys in Banda Aceh for City Restoration Planning and Urban Design Hirokazu Iemura, Yoshikazu Takahashi, Pariatmono Sukamdo, Mulyo Harris Pradono, and Rudi Kurniawan
14:15-14:30	[P1-2-2-6] The Challenge of Rehabilitation and Reconstruction of Banda Aceh City Taufiq Saidi and Elysa Wulandary, MT
14:30-14:45	[P1-2-2-7] Damage and Restoration of Lifeline in Thailand due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean Shiro Takada, Yasuko Kuwata and Arun Pieta

（coffee break: 14:45-15:00）

Chairperson: Koshun Yamaoka,

15:00-15:15	[P1-2-2-8] Human Resource Program for Education and Outreach Agenda: Possibilities in India and Sri Lanka Hirotsune Kimura
15:15-15:30	[P1-2-2-9] Restoration and Urban Design in relation to Habaraduwa Township in Galle District : A Sociological Perspective Imaduwa V. Edirisinghe

15:30-15:45	[P1-2-2-10] Community Base Action in costal forest rehabilitation in Tsunami effected area of Aceh Province, Indonesia Helmi Thomin
15:45-16:00	[P1-2-2-11] Sustaining Community Outreach Programmes : Learning from past experiences Manu Gupta, Anshu Sharma, Suman Nag and Manisha Munjal
16:00-16:15	[P1-2-2-12] Establishment Plan of Aceh Heritage Tsunami Estate (AHTE) Hasanudin Z. Abidin
16:15-16:30	[P1-2-2-13] Tsunami Risk Awareness in the Affected Communities Tetsushi Kurita
16:30-16:45	[P1-2-2-14] Strengthening Communities Through Partnership – The ADRRN Model Aishah Mohd Amin
16:45-17:00	[P1-2-2-15] Education on the Earthquake Disaster Reduction for International Students in Japan Koshun Yamaoka, Keiji Doi and Satoru Suhara

(Reception: 18:00-20:00 : DVD show by Mikio Satomura(Shizuoka Univ.))

Session 2-3 : Effective tsunami warning system and mitigation

Chairperson: Fumihiko Imamura,

13:00-13:15 [P1-2-3-1] Field Investigation of the 2004 Indian ocean tsunami on the affected coast
Fumihiko Imamura, Shunichi Koshimura, Kazuo Goto, Hideaki Yanagisawa and Yoko Iwabuchi

13:15-13:30 [P1-2-3-2] Jawa-Sumatran Tsunamis, their Modeling, and Mitigation
Hamzah Latief, Safwan Hadi, Haris Sunendar,Aditya R. Gusman, and Fumihiko Imamura

13:30-13:45 [P1-2-3-3] Forecasting of tsunami amplitudes by the Neuro-genetic algorithm
Seree Supharatid

13:45-14:00 [P1-2-3-4] Sedimentation from the December 26th 2004 South Asia tsunami in northern Sumatra, Indonesia
Andrew Lathrop Moore, Yuichi Nishimura, Takanobu Kamataki and Guy Gelfenbaum

14:00-14:15 [P1-2-3-5] Comparing the Tsunamis of 2004 and 2005 in West Sumatra, Indonesia
Jose C. Borrero, Bruce Jaffe, Brian McAdoo, Gegar Prasetya and members of the International Tsunami Survey Team (ITST)

14:15-14:30 [P1-2-3-6] Tsunami warning system in Japan
Shin’ya Tsukada

14:30-14:45 [P1-2-3-7] Effect of earthquake rupture mechanism on tsunami generation and propagation –Toward examination of a possible tsunami warning system applicable to M9 earthquakes –
Kenji Hirata

14:45-15:00 [P1-2-3-8] Offshore Tsunami Monitoring Network Design using GPS Buoys and Coastal on-site Sensors
Toshihiko Nagai

（coffee break: 15:00-15:15）

15:15-15:30 [P1-2-3-9] Proposal for Tsunami Study Program by KORDI
Sok Kuh Kang, Sung-Dae Kim, and Hee Do Ahn

15:30-15:45 [P1-2-3-10] Development of the nationwide tsunami information network in the central and south pacific ocean in Mexico
José Miguel Montoya Rodriguez and Toshihiko Nagai

15:45-16:00 [P1-2-3-11] Current Status of Indonesian Tsunami Early Warning Systems
Pariatmono and Santosa Y. Warsono

16:00-16:15 [P1-2-3-12] Tsunami Damage to Oil Storage Facilities in Aceh Province, Sumatra, Indonesia
Yozo Goto

(Reception: 18:00-20:00 : DVD show by Mikio Satomura)

Poster [P1-p-1] Learning tsunami disasters through the puppet play "The Fire of Inamura (Rice Sheaves)"
Tadashi Kojima, Mikio Satomura , Kunio Ozawa and Waniko

Poster [P1-p-2] The seismic gap south off Sumatra and active period of the seismicity along the plate boundary between India-Australian and Eurasian plates
Yuzo Ishikawa

Dec. 15 (Thu.)

9:00-14:00 Registration

Session 3: Plenary – interdisciprinary presentations –

9:00-9:15	[P1-3-0-1] Sea bottom shattered by the Sumatra-Andaman Earthquake of 26th December 2004 Wonn Soh, Yusuf S. Djajadihardja, Yudi Anantasena,Kohsaku Arai, Eiichiro Araki, Safri Burhanuddin,Toshiya Fujiwara, Nugroho D. Hananto, Kenji Hirata,Hananto Kurnio, Hideaki Machiyama, Badrul K. Mustafa,Christian Müller, Leonardo Seeber, Kiyoshi Suyehiro and Kazuki Watanabe
9:15-9:30	[P1-3-0-2] Understanding the nature of giant earthquakes and tsunamis in Sumatra-Andaman to restore and establish safer cities around the Indian Ocean Danny Hilman Natawidjaja, Kerry Sieh, Richard Briggs, Mohammed Chlieh, Jean-Philippe Avouac, Jehuda Bock, Linnette Prawirodirdjo, Robert McCaffrey, Cecep Subarya, John Galetzka, and Bambang W. Suwargadi
9:30-9:45	[P1-3-0-3] The 2004 Indian Ocean tsunami along the Indian coast: Observed sea levels, run-ups, extent of source region, and future plans S.S.C. Shenoi
9:45-10:00	[P1-3-0-4] Learning from the 2004 Indian Ocean tsunami – Buildings damage and clues for tsunami resistant design Panitan Lukkunaprasit[1)] and Anat Ruangrassamee[1)]

(coffee break: 10:00-10:30)

Session 3-1: Mechanism of the 2004 Giant Earthquake and Tsunami in Indian Ocean

Chair Person: Kenji Satake (AIST., Japan)

10:30-10:45	[P1-3-1-1] Changes in Geomagnetic Transfer Functions: Pre and Post Sumatra earthquake P B V Subba Rao and C D Reddy
10:45-11:30	Discussion

Session 3-2 (Joint): Human resource program for the education and outreach and Restoration program and urban design

Chairperson: Koshun Yamaoka (ERI, Japan)/Hirokazu Iemura(Kyoto Univ., Japan)

10:30-10:45	[P1-3-2-1] Gender and Socioeconomic Analysis of Alleviating and Preventing Tsunami Affected Society: A Case Study from Sri Lanka and India Hisae Nakanishi
10:45-11:00	[P1-3-2-2] Mitigation of tsunami impact on lifelines C. Scawthorn
11:00-11:30	Discussion

Session 3-3 : Effective tsunami warning system and mitigation

Chairperson: Fumihiko Imamura (Tohoku University)

10:30- 11:30 Discussion

(lunch time: 11:30-13:00)

Session 4 : Plenary – session summary and action plan toward future

Chairperson: Eisuke Fujita (NIED, Japan)

13:00-13:15	Kenji Satake (AIST, Japan) Summary of Subgroup and discussion
13:15-13:30	Koshun Yamaoka (ERI, Japan) Summary of Subgroup and discussion
13:30-13:45	Fumihiko Imamura (Tohoku Univ., Japan) Summary of Subgroup and discussion
13:45-14:00	Hirokazu Iemura (Kyoto Univ., Japan) Summary of Subgroup and discussion
(14:00-14:15	Coffee Break)
14:15-15:55	Free discussion and adoption of action plan

15:55-16:00 Closing address Teruyuki Kato (ERI, Japan)
Announcement for the International Symposium by Fujita

（16:00 Adjournment of the Workshop）

16:05-16:35 Press Briefing

Program: Part 2

Dec. 16 (Fri.)

10:00-10:05	Opening Address	Tsuneo KATAYAMA (NIED, President)
10:05-10:20	Guest Speech	Yuichi ONO（UN/ISDR）
10:20-10:35	Guest Speech (MEXT)	
10:35-11:05	Invited Speech [P2-0-1] Toshibumi Sakata (AESTO, Chair & CEO)	
11:05-11:50	Keynote Speech [P2-0-2] Kiyoshi Kurokawa (SCA,Secretary General)	

（lunch time） 11:50-13:00

Session 1: Disaster report and Needs of the Affected Countries

13:00-13:20	[P2-1-1] The December 2004 Sumatran Tsunami: An effort to established national hazard mitigation program Herry Harjono and Jan Sopaheluwakan
13:20-13:40	[P2-1-2] Disaster Management and Risk Mitigation: India's Experiences and Future Needs Prem P. Pangotra
13:40-14:00	[P2-1-3] Natural disasters in Bangladesh: GoB's disaster management framework for reducing damages Monirul Hoque
14:00-14:20	[P2-1-4] Thailand : After its worst tsunami Adichat Surinkum
14:20-14:40	[P2-1-5] Rapid Assessments on the Physical Impacts of the 26th Dec 2004 Tsunami along the Northwestern Coastline of Malaysia Peninsular Tajul Anuar Jamaluddin and Ibrahim Komoo

(coffee break: 14:40-15:00）

Session 2: Proposals for disaster reduction framework in view of Science & Technology

15:00-15:20	[P2-2-1] Mechanism and future probability of the 2004 Giant Earthquake and Tsunami in Indian Ocean Kenji Satake, Teruyuki Kato, Hidemi Ito, Masajiro Imoto and Sin-Iti Iwasaki
15:30-15:50	[P2-2-2] Education and promotion for increasing disaster preparedness Koshun Yamaoka, Hirotsune Kimura and Tetsushi Kurita
15:50-16:10	[P2-2-3] Effective Tsunami Warning System and Mitigation Fumihiko Imamura, Shinya Tsukada, Kenji Hirata, Norihiko Nagai
16:10-16:30	[P2-2-4] Vulnerability of Infrastructures against the Sumatra Earthquake and Tsunami and their Restoration Program Hirokazu Iemura
16:30-16:50	General Discussion

(close at 16:50)

（Reception 18:00 – 20:00）

Dec. 17 (Sat.)

Session 3: Lessons from Disaster Fields and Needs for Higher Disaster Coping Capacity

Chair Person: Haruo Hayashi (Kyoto, U., Japan)

9:00- 9:30	[P2-3-1] Not Child's Play: Taking Another Look at Vulnerability in the Light of the Indian Ocean Tsunami and Hurricane Katrina Greg Bankoff
9:30-10:00	[P2-3-2] Motivation and Capacity Building for Disaster Reduction Kenji Okazaki
10:00-10:30	[P2-3-3] Matching Goods and People: Emergency Assistance Under Uncertainty Jin Sato
10:30-11:00	[P2-3-4] Recovery of Aceh Post-Tsunami: Lesson Learnt and Challanges Saifuddin Bantasyam
11:00-11:30	[P2-3-5] Community based to disaster prevention and management Ravadee Prasertcharoensuk
11:30-12:00	[P2-3-6] Potential For Incorporating Coping Capacities In Community Based Disaster Management Manu Gupta and Anshu Sharma

（lunch time:　12:00-13:15）

13:15-13:45	[P2-3-7] Empowerment of Coastal Community in Risk Reduction - Bangladesh Experience B.M.M. Mozaharul Huq
14:15-14:45	[P2-3-8] Strategy for disaster prevention and reduction Haruo Hayashi
14:45-15:15	[P2-3-9] How to strengthen Disaster Coping Capacity of a community and a State Masayuki Watanabe
15:15-15:40	Discussion

（coffee break:　15:40-16:00）

Session 4: For Sustainable Development in Affected Countries – Needs in Research Works and Practices (Panel Discussion)

16:00-16:45	Co-chair: Tsuneo Katayama (NIED, Japan) and Greg Bankoff (Univ. of Auckland) Panelists: Haruo Hayashi (Kyoto, U., Japan), Kenji Satake (AIST, Japan), Ir.H. Sarwidi (the Islamic Univ. of Indonesia),　Jostacio Lapitan(WHO, WKC)
16:45-16:55	Proposals from the symposium　　Tsuneo Katayama (NIED, Japan)

16:55-17:00　Closing address

17:00　Adjournment of the Symposium）

[P1-1-1] The Next Giant Sumatran Megathrust Earthquake: From Science to Human Welfare

Kerry Sieh
Tectonics Observatory 100-23, Caltech, Pasadena, CA 91125 United States

My colleagues and I have used continuous and survey-mode GPS measurements, corals and other features to document uplift, submergence and horizontal motions associated with the giant Sumatran megathrust earthquakes of 2004 and 2005. Elastic dislocation models based upon these data show that the two earthquakes resulted from nearly contiguous rupture of about 1900 km of the megathrust – from about 16˚N to the Equator. The amount of slip during the 2004 rupture was up to 25 m offshore Aceh; slip was as high as 12 m under Nias island during the 2005 rupture. Repetitions of such large slips are not likely for the next century or more. Questions remain about the potential for damaging but smaller earthquakes along those portions of the megathrust that failed during the 2004 and 2005 earthquakes. But a far greater threat to Sumatra now is rupture of the megathrust farther south.

The Mentawai section of the Sunda megathrust, south of the Equator, remains unruptured and threatens to produce another giant earthquake within the next few decades. Paleogeodetic and geodetic data show that this section of the megathrust has been locked since its most recent giant earthquakes, in 1797 and 1833. Living coral microatolls show that the chain of outer-arc islands above this locked section is submerging at rates as high as a centimeter per year. Continuous GPS measurements show the islands are being squeezed toward the mainland at about 5 cm/yr. Modeling of these strains shows that these reflect elastic strains that will be relieved during future earthquakes.

Paleoseismic records of uplift during the tsunamigenic earthquakes of 1797 and 1833 reveal patterns of uplift and tilt very similar to those that occurred during the 2004 and 2005 earthquakes to the north. The 1797 event involved rupture of the megathrust from about 0.5˚ to 3.2˚ S and had a magnitude (M_w) of about 8.4. The 1833 event was caused by rupture of the megathrust from about 2.0˚ to 5.5˚ S and had a magnitude of about 8.9. Paleoseismic records also show that this 600-km-long Mentawai section of the megathrust ruptures about every two centuries; thus it appears to be nearing the end of the strain-accumulation part of the current earthquake cycle.

There are a number of scientific activities that could and will be undertaken to forecast better the nature of the coming Mentawai earthquake and tsunami. These include work aimed at continuing to measure strain accumulation rates and patterns, refining estimates of the locked parts of the megathrust, searching for precursory changes in strain accumulation or relief, and better documentation of the past one or two thousand years of rupture and tsunami effects there.

But activities that lead directly to mitigation of the destructive effects of future Mentawai earthquakes and tsunamis are desperately needed. If done expeditiously, efforts to educate the populations at risk, to make permanent changes in the infrastructure of coastal communities, and to prepare for emergency response after the inevitable events could have a significant impact in relieving human suffering and reducing loss of life. West Sumatra appears to be a crucible in which humankind is destined to test its ability and resolve to take a new approach to how it addresses natural hazards.

[P1-1-2] Tsunamis –Their Coastal Effects and Defense Works－

Nobuo Shuto
Advanced Research Institute for the Sciences and Humanities, Nihon University, 6F 2-1 Kudan-kita 4-chome, Chiyoda-ku, Tokyo 102-0073, Japan

A tsu-nami is a huge sea wave (nami) that attacks ports (tsu). If the ports are located at the bay bottom, they are well sheltered against wind waves and swells. Different from these short-period waves, a tsunami, a long wave, is small at the entrance of the bay but destructively big at the ports.

At the birth of a giant tsunami, the sea surface several hundred kilometers long and several ten kilometers wide transforms vertically by several meters. The most difficult problem in a tsunami forecasting and a hind-casting is the determination of the initial profile of a tsunami.

The initial profile of the 1960 Chilean tsunami was estimated to be 700 km long in the direction toward Japan, quite long compared with the Pacific Ocean 4 km deep. Its height was about 10 meters. The 2004 Indian Ocean tsunami was considered to be generated by the fault motion larger than that for the 1960 Chilean tsunami.

While a giant tsunami is traveling over an ocean, the Coriolis force and the phase-dispersion effects should be considered in the linear long wave theory expressed in the longitude-latitude coordinates.

Approaching the shore, a tsunami decreases its length and increases its height, because of the shoaling effect. Then, the shallow-water theory, the first-order non-linear long wave theory is applied, including the sea-bottom friction. Focusing and resonance effects, results of the sea bottom topography, work to increase tsunami height, too. The 1946 Aleutian tsunami, a typical giant tsunami, had a vertical front 30 m high and ran up to a height of 35 m.

Under some conditions, the amplitude-dispersion effect, a result of the wave profile itself, acts to develop solitons at the front. A higher order non-linear and dispersion theory should be used.

Numerical simulation is a good means to understand tsunamis, to estimate possible disasters and to establish a defense plan. In the areas where only insufficient records of tsunami inundation in the past are available, numerical simulation is used to draw tsunami hazard maps. It is, however, necessary to design a numerical simulation carefully to obtain reliable results. In order to suppress numerical instability, the KFL condition for the wave equation should be satisfied. Another condition is necessary to suppress an instability that often occurs at the wave run-up front. In order to control numerical errors, we need at least 20 grids within one wave length. Discretization of sea bottom topography and harbor configuration requires other conditions in order to reduce numerical errors.

If a researcher or an institute wishes to use a well-refined numerical scheme, TUNAMI codes, the standard scheme of UNESCO, he or it can obtain the scheme under the TIME project steered by Prof. F. Imamura, Tohoku University. It uses the leap-frog method, one of FDM, with the upwind-difference scheme for the convection term.

There are several kinds of disasters caused by tsunami. The most serious is loss of lives. The 2004 Indian Ocean tsunami claimed nearly 300,000 lives. Even if the thickness of water is 50 cm, the violent current induced by a tsunami is sufficient to wash away a person.

Wooden houses are weak for tsunami. Not only water current but also such materials transported by tsunami as boats, houses and debris are the destructive force. An earthquake-resistant reinforced concrete building is tsunami-resistant, too.

Roughly speaking, damage to fishing boats begins at the tsunami height of 2 meters, and all the fishing boats would be damaged or washed away at the tsunami height over 8 meters.

In the future, fires caused by earthquake and tsunami may devastate coastal region if they are assisted by such inflammable materials as oils stored in a large quantity.

A defense plan officially recommended in Japan is a combination of defense structures, urban planning and soft-wares in harmony with daily activity. Structures provide a direct means to protect human lives and properties against tsunamis. However, structures are not always expected to work perfectly. Urban planning strengthens coastal villages and reduces damages, although perfect protection is not expected, too. Soft-wares are essentially important to save human lives.

A typical structure is a seawall made of concrete. A coastal dike made of soil should be covered by concrete on fore-, top- and rear-faces; otherwise it will be easily scoured if a tsunami overflows. The back toe of these structures should be protected well against scouring due to overflow. A tsunami control forest can reduce tsunami-induced currents and stop floating materials if the strength and thickness of trees and undergrowth are sufficient.

Major item in urban planning is the land-use regulation. The tsunami resistibility of a coastal village should not be weakened but more and more improved before the next giant tsunami hits. Movement of residences to the tsunami-free high ground is highly recommended. Important facilities such as town office, police station and fire station should not be located in the tsunami-prone low land. Facilities for disaster weak such as hospital, home for the aged people and nursery school should be located on high ground. The tsunami-resistant building zone, i.e. alignment of substantial buildings along the shoreline, is a hopeful countermeasure in the future. This idea has no conflict to daily activity except for its high construction cost. Lifelines such as electricity, water supply, sewage system and telephone system should be well protected against tsunamis, because they are very important not only for daily life but also for surviving after a tsunami. A careful attention should be paid for the storage tanks of inflammable materials, not to trigger a catastrophic secondary disaster.

Soft-wares consist of human action to reduce tsunami damage. The best and the last way to save human lives is an early evacuation according to forecasting and warning. Disaster culture about tsunamis, tsunami disasters and tsunami defense should be learnt by people and continued to the future generation through public education. An Indonesian example in the Simeulue Island shows that continuation of the disaster culture is important and quite effective. A memory of the sad lesson that several thousand residents were killed by a tsunami 97 years ago urged residents to climb up to high ground when they saw an abnormal ebb tide, thus saved many people except for 7 people among 78,000 residents.

There are two kinds of forecasting, natural and man-made. Any violent earthquake, in case of a tsunamigenic earthquake, that causes you to fall or hold onto something to keep from falling is a natural warning. This warning has 10% exception, that is, tsunami earthquake. The man-made forecasting is based upon empirical laws and/or numerical simulations. According to a warning statistics in the Pacific for the years 1991-1997, 20 of 30 warnings were false from a practical point of view.

In order to reduce the false warning, measurements of tsunamis in the deep sea is inevitable. The conventional ocean-bottom-tsunami gauges measure the water surface change with quartz pressure sensors and the data are transmitted via satellite or through cables. A new technique, a fiber-optic sensor, is being developed. The 2004 tsunami on the Indian Ocean was recorded by the Jason 1 altimetry satellite. A research to use the high-frequency ocean radar from a shore-based observation station has just started. In the shallow sea, 50 m deep or so, the output of ultrasonic wave gauges installed on the sea-bottom is used to detect tsunamis after numerically filtered. A newly developed GPS tsunami gauge succeeded to record a tsunami of September 5th, 2004. At the shoreline, a tide gauge can record tsunamis but the output is strongly biased by hydraulic filtering. An ultrasonic wave gauge installed at the top of a pole in the air measures the distance to the water surface with the risk of scaling-out for a tsunami higher than the position of the gauge. JMA prepares for this scaling-out by installing the giant-tsunami recording system.

[P1-2-1-1] Tsunami hazard and vulnerability along the Myanmar coast

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The tsunami heights from the 2004 Sumatra-Andaman earthquake were between 0.4 and 2.9 m along the Myanmar coast, according to our post tsunami survey at 22 sites in Ayeyarwaddy Delta and the Taninthayi coast. Interviews to coastal residents indicate that the tsunami heights were lower than high tide level in rainy season, probably by storm surge. They also testified that the arrival times were between 2 and 5.5 hours after the earthquake, but the reliability may be low because nobody felt ground shaking. Much smaller tsunami than the neighboring Thai coast, where the tsunami heights were 5 to 20 m, explains relatively slighter tsunami damage in Myanmar; the casualties were reported as 61, compared to about 8,300 in Thailand.

The smaller tsunami was probably due to the fact that the main tsunami source did not extend to Andaman Islands. The tsunami travel times and maximum heights computed from a 700 km long source, estimated from tsunami travel times around the source, (Lay *et al*., 2005) are basically consistent with the observations.

For a nearby tsunami source, however, the tsunami hazard would be more significant, because the vulnerability for tsunami in Myanmar is rather high. If a tsunamigenic earthquake is not felt by coastal residents, the only way to notify people about the tsunami danger is through Tsunami Warning System. However, infrastructure to disseminate the warning information is rather poor in Myanmar. In addition, coastal residents in most surveyed localities live on flat land along the coast, especially in the Ayeyarwaddy Delta, and there is no higher ground to evacuate. In order to prevent future tsunami hazards, evaluation of earthquake and tsunami potential in the northern extension of the Sunda subduction zone is needed. Study of historic and prehistoric tsunami events would be necessary for such evaluation.

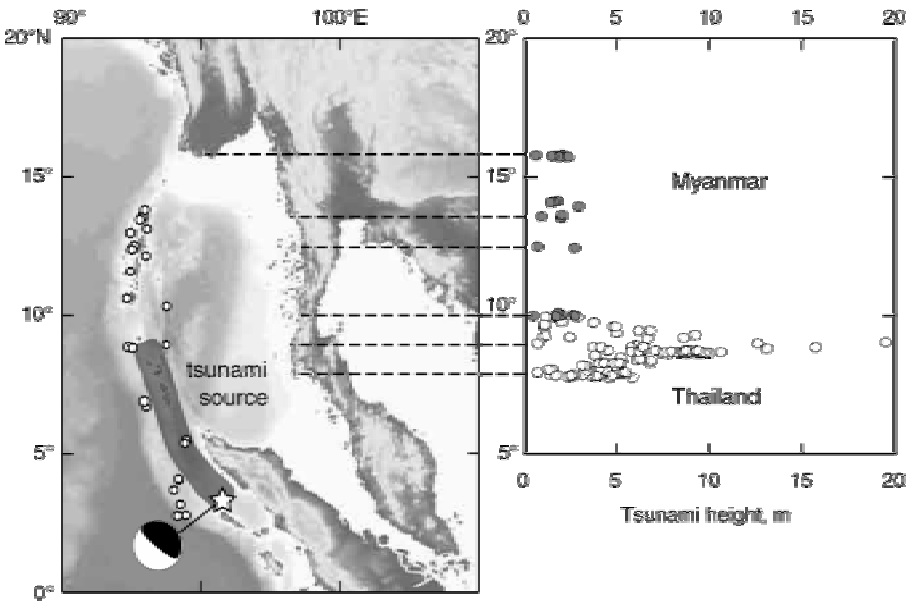

Fig. 1. Comparison of tsunami heights along the Myanmar and Thai coasts. The tsunami heights along the Thai coasts were surveyed by Matsutomi *et al.* (2005), Satake *et al.* (2005), and Tsuji *et al.* (2005). Inferred tsunami source area is shown.

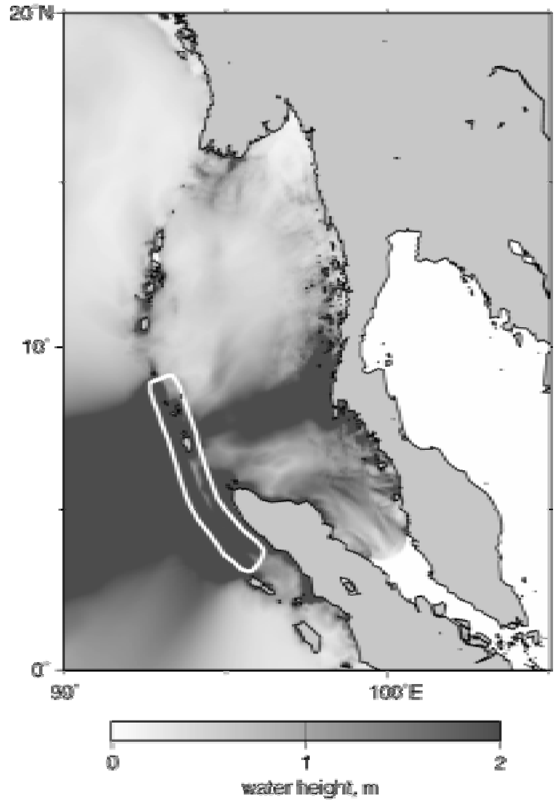

Fig. 2. Distribution of maximum tsunami heights computed from a 700 km long tsunami source (Lay *et al.*, 2005). The assumed source region is also shown.

[P1-2-1-2] Coseismic uplift of the Andaman Islands associated with the Sumatra-Andaman Earthquake of 2004 and the recurrence history of gigantic earthquakes

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The Andaman Islands are located in the northernmost part of the 1200-km-long rupture zone of the 2004 Sumatra-Andaman earthquake. Coseismic vertical displacements of these islands both in the 2004 event and in the past are a key to understand the mechanism and the recurrence history of gigantic earthquakes produced from the subduction zone. Little information, however, has been reported from the islands. In March 2005, we visited the Andaman Islands, and observed biological indicators of episodic uplift events both in 2004 and in the past. We reconstructed the distribution of vertical displacement associated with the 2004 earthquake at a resolution of 0.1 m. Paleoseismic events and their recurrence history would be reconstucted by dating fossil corals.

At Port Blair in South Andaman, coseismic subsidence of 1.0 m has been reported on the basis of tide-gauge measurement. On the other hand, in Middle and North Andaman, emerged coral reefs and oyster shell beds were widely observed (Fig 1a). At North Reef Island and Interview Island, off the southwest coast of North Andaman, amount of uplift was estimated at 1.5 m by using emerged microatolls (Fig. 1b), whose top is the best indicator of low water level before the earthquake. Based on our observation, distribution of vertical displacement associated with the earthquake in 2004 was reconstructed (Fig. 2). The displacement contours seem to pass obliquely the Andaman Islands, but parallel the trench direction.

Possible evidence for post-seismic subsidence was obtained at Mayabunder, the northeastern tip of Middle Andaman. We interviewed a fisherman, who has been fishing everyday from a tidal flat, and clearly remembered the position of high tide levels at full and new moons after the earthquake. According to his information, a gradual submergence of 1.3 m occurred in one month following the coseismic uplift, resulting in a residual uplift of 0.7 m.

At Interview Island, fossil microatolls distribute at least five distinctive levels higher than the ones emerged in 2004 with a height of 153 cm: 163 cm, 177 cm, 214cm, 221 cm and 228 cm above the present low water level (Fig. 3). Each group of microatolls (n = 3-11) is quite uniform in height within several centimeters with higher-level groups located progressively landward. These microatolls are 1-2 m in diameter and stand independently with each other. These findings suggest that (1) there were several events of episodic uplift, (2) each uplift event was followed by gradual submergence and stillstand, and (3) residual uplift of 0.1-0.4 m remained in each uplift-subsidence cycle.

To reconstruct uplift and submergence history and recurrence intervals, absolute dating together with annual band analysis of these microatolls are strongly needed. In combination with emergent signatures, survey of tsunami sediments probably buried in the mangrove forest mud behind the coral reefs (background in Fig. 3) will provide a full image of tectonic history in the Andaman Islands.

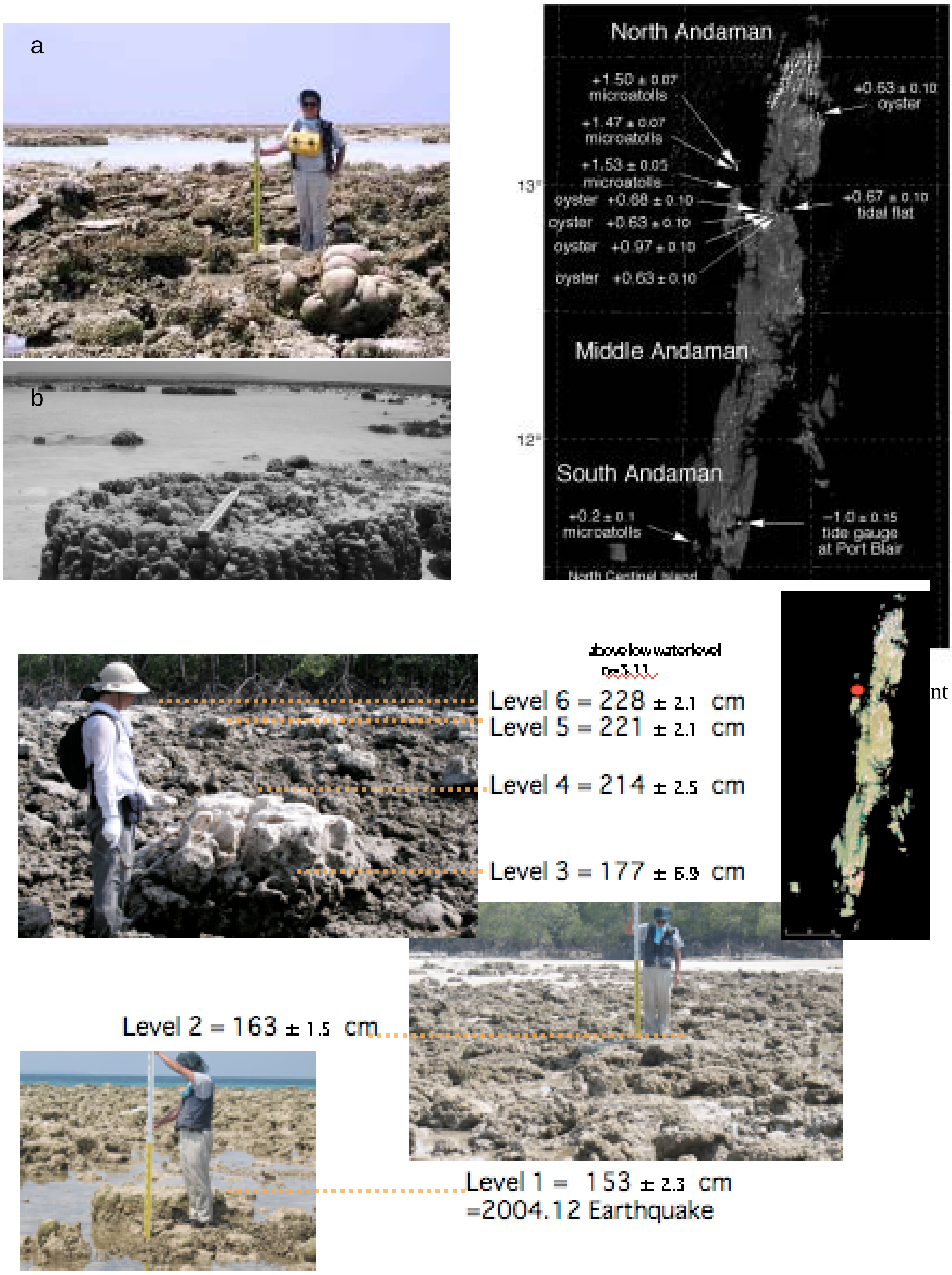

Fig. 3 Fossil microatolls distributed at different levels higher than those emerged by the 2004 earthquake.

[P1-2-1-3] Ongoing efforts to understand the style of deformation and the seismic/tsunami history of the Andaman-Nicobar region

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The December 26 2004 earthquake and the Indian Ocean tsunami provide a unique opportunity to understand the processes associated with such rare megathrust subduction zone events. This earthquake that broke a 1300-km-long subduction front of the eastern boundary of the Indian plate surprised the earthquake seismologists because of its unprecedented rupture length and the wide reach of the subsequent devastating tsunami. Many questions have been raised on this event, which may have bearing on similar tectonic zones elsewhere in the world like Cascadia and parts of Japanese coast, the probable sites of future megathrust earthquakes: a) Was this a single event or a compound event consisting of several rupture episodes; b) Was this event characterized by uniform rupture speed? c) What would be the nature of stress accumulation in the region before the earthquake? d) Why such a large amount of stress remained unspent along this zone despite the previous large local events? e) What is the temporal pattern of megathrust earthquakes and tsunamis? and f) What is the nature of pre-, co-, and post-seismic crustal deformation? Finding solutions to these problems based on a varied set of data is important to develop future scenarios in the region and other parts of the world. In an effort to address the above problems at least in part, we are acquiring geological data on previous earthquakes and tsunamis, documenting the long-term land level changes and monitoring the crustal deformation (GPS). We present here the initial advances made in the above fields. Our preliminary results indicate the possibility of earlier tsunamis in the Indian Ocean- the last similar event occurring about 1000 years ago, an assumption made on the basis of the age data of anomalous sand layers from the east coast of India and from some sites in the Andaman region. The GPS data from the Andaman-Nicobar region indicate that the coseismic offsets along the arc are non-uniform, the southern islands displaced by about 6 m in the southwest direction. The coseismic deformation indicates that while the southern segment consisting of Nicobar Islands located relatively closer to the earthquake epicenter behaved typically as described by models of deformation cycle and viscoelastic processes, the northern Andaman segment responded somewhat differently. The coseismic uplift registered on the west coast of the middle and north Andaman and the greater development of coastal terraces in this region might suggest coseismic slip partitioning onto the upper plate imbricate thrust faults. An open question concerns the implications of such deformational characteristics on the segmentation, rupture propagation and tsunami genesis.

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[P1-2-1-4] Coseismic Land-level changes caused by 26 December, 2004 Sumatra earthquake in Andaman and Nicobar Islands, India

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Abstract

The event of 26 December 2004 was the most devastating earthquake recorded so far in the span of last two centuries around the globe. This great mega-thrust earthquake occurred at 06:28:53am Indian Standard Time (00:58:53 UTC; Indonesian local time 7:58:53 am) along the subduction zone marked by plate boundary between the Indian and the Burmese Plates causing severe ground shaking at numerous locations in the vicinity of the arc. The maximum intensity of earthquake shaking along the Andaman-Nicobar Islands was about VII on the MSK scale, and along the Mainland Indian coast about V on MSK scale. Severe damage to the areas along the coastal tract was mainly due to giant tsunami triggered by this event. The overall pattern of damage and landscape changes was captured by an aerial survey over most of the Andaman-Nicobar islands. This was augmented by field investigations at the North, Middle, South and Little Andaman islands and the Great and Car Nicobar islands. Differential movements resulted in uplift and subsidence at various places along the Andaman and Nicobar Islands. The uplift along the west coast resulted into emergence of new shoreline exposing coral beds and rocky strata, the uplift could be around 1m (Figure 1a). Uplift of about 1.2m was recorded at Ariel Jetty in the North Andaman Island. Prominent subsidence was recorded all along the eastern coast of the areas stretching over South Andaman Island and along the Nicobar Islands. However, the subsidence observed was not same at all the locations. The maximum subsidence of about 3m was recorded along the southern tip of Great Nicobar Island, by about 1.2±0.2m along Car Nicobar and about 1.0m at Port Blair in South Andaman Islands. This implies that the islands closer to the epicenter of the subduction event experienced more relative subsidence than other islands to the north. Several survivors interviewed at various locations noticed immediate flooding of the areas after shaking. It is suggested that the flooding was due to coseismic subsidence followed by destructive tsunami waves of great height of about ~6-10 m.

Other than the above observations prominent deposition of massive sand about 10-20cm thick and unsorted coral clasts were observed at several locations which were deposited by tsunami waves triggered by recent event. Preliminary trench excavated along eastern coast around Port Blair which experienced subsidence during the December 2004 event revealed occurrence of present (December 2004) tsunami sand overlying the present brown clayey soil unit (S1) and another prominent sand layer overlying the brown clayey soil - S2 (Figure 1b). This sand unit (S2) shows sharp contact with respect to the underlying soil (S2) unit, probably deposited by old tsunami in the area (?). The buried sand layer probably indicates deposition during 1881 earthquake of Mw 7.9 (?) occurred close to Car Nicobar.

(a)

(b)

Figure 2: (a) Exposed coral beds and rocky strata between Flat and Anderson Islands along the western coast of Middle Andaman due to tectonic uplift caused by 26 December 2004 event.

(b) A southwall view of trench excavated along eastern coast near Port Blair in southern Andaman Island. Exposed stratigraphic succession shows occurrence of two prominent sand units. The sand unit (~10 cm) capping the sequence represent the sand deposited by recent tsunami of 26 December 2004 and another sand unit (~15 cm) overlying the buried brown soil (S2) indicated remnant of sediments deposit

[P1-2-1-5] MACROSEISMIC, TSUNAMI SURVEYS AND GPS MONITORING IN ANDAMAN AND NICOBAR ISLANDS IN THE AFTERMATH OF THE GREAT Mw 9.3 EARTHQUAKE OF 26TH DECEMBER 2004 - A BRIEF APPRAISAL.

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Abstract

At 0629 hrs (IST), December 26, 2004, a very strong shallow focus undersea earthquake occurred off the West Coast of Sumatra Island. It had not only rocked the Andaman and Nicobar Islands but was also mildly felt in the eastern and southeastern coasts of the Indian mainland. Moreover, it had generated a global tsunami, which swept away the Nicobar and Little Andaman coasts along with the southern Andhra Pradesh, Tamilnadu and Kerala coasts of India. As is now well known that thousands of people in India had lost their lives due to this tsunami which also caused extensive damage of crops and property. The present contribution aims at furnishing a summarized account of the work carried out by Geological survey of India, Eastern Region in the aftermath of the Great Earthquake/Tsunami of 26th December 2004.

Macroseismic survey (revised MSK-64) in Andaman and Nicobar Group of Islands revealed that the earthquake tremor was felt by most people, even in moving vehicles, with difficulty in standing, some felt blocking of ears and blurring of vision during the quake with development of ground fissures and profuse sand venting due to liquefaction of subsurface sandy materials, standing objects shifted and splashing out of water took place in standing water bodies. Many buildings of vulnerability Type B and C suffered Grade-2-3 damages and Type A structures suffered Grade 3-4 damages. At a few instances buildings of Type C structure has shown Grade 5 damage. In some cases, selection of unfavorable ground, use of poor construction material and faulty construction have facilitated building damage during shaking. A general Intensity of VII has been assigned for the Andaman Group of Islands with spot/local higher intensity VIII along the west coast and the adjoining islands like Interview Island. The earthquake intensity was visibly lesser in case of the eastern Islands like Havelock and Neil islands where the intensity has been fixed at VI. Hence, a broad decrease in earthquake intensity from west to east has been observed in case of the Andaman group of Islands. From the Little Andaman Island towards south, upto the Great Nicobar Island the macroseismic survey revealed that the earthquake intensity was quite high (VIII).

Tsunami waves hit the Nicobar group of islands within few minutes and reached Port Blair in South Andaman at 07:15 hrs indicating tsunami travel speed of around 700 km/hour. At least, five pulses of tsunami waves were detected by the people of the Islands. Study of the effects of tsunami on the coastal areas and the inundation aspects in some selected areas (viz. around Port Blair in South Andaman, in Car Nicobar and in Campbell Bay area of Great Nicobar) were carried out. It has been found that the effect of tsunami was profound in Nicobar Group of Islands and Little Andaman. Low lying areas both along the east and west coasts of South Andaman (e.g., Chidiyatapu, Sipighat, Guptapara, Wimberlygunj, Manjery, Wandoor, Chouldari, Collinpur etc.) those were connected to open sea through creeks and bays were inundated due to rising water levels damaging vast cultivated lands at places.

Tsunami survey in South Andaman along some selected profiles shows that the extent of run up distances varies from 100-150 m. inland with a NW^{ly} and NE^{ly} landward flow direction along east and west coast respectively. Minor deposition was also noted in these areas. The maximum tsunami run up level of 4.5 m. was recorded at Wandoor. In Hut Bay area of Little Andaman Island, water had intruded upto 1 Km from coastline. In Car Nicobar, the run up length recorded during tsunami survey along some selected profiles on the east coast varies from 1.125 Km. to

1.250 Km. with the maximum run up level (measured from land-sea contact) ranging from 5.0m. to 5.2 m. Landward flow direction in these areas were noted to be westerly as measured from the bent bolts, uprooted trees, smashed grass etc. It has also been observed that the tsunami invasion was restricted within 10 m contour along the east coast of Car Nicobar Island. In Great Nicobar Island the run up length varies from 250 m. to 550 m. at different sectors, with landward flow direction varying from NW to NE. Maximum run up level of 3.0 m. was recorded both at Campbell Bay and Joginder Nagar areas. It is probable that the inundation of land by the tsunami waves and also tsunami run up were controlled by the near shore bathymetry and the coastal geomorphology.

In order to assess the post earthquake crustal adjustment/relaxation in the aftermath of the Great earthquake off the coast of Sumatra 14 no. Of GPS stations spread over different islands of Andaman were installed. Reoccupation of some of the stations after nearly three months indicates southerly shift of most of the stations excepting one station of Middle Andaman which showed a shift towards ENE. Shifting of GPS stations within such a short time span indicates continuity of post Earthquake crustal relaxation.

[P1-2-1-6] Earthquake Disaster Mitigation Initiatives in Myanmar

Than Myint , President ,Myanmar Engineering Society.

Abstract

Myanmar indeed is earthquake prone as it lies in a major earthquake belt, called the Alpide Belt and major and minor earthquakes had being occurred throughout her history.The major fault in Myanmar is Sagaing fault which start from far north to down south to Andaman sea .Many other faults are also throughout the country. Myanmar geologist and engineers are trying their best with few resources for earthquake disaster mitigation activities. In this brief presentation ,Myanmar Earthquake Committee which was formed in year 2001 with the cooperation of concerned Government Departments, Universities, Geoscientist and Engineers is presented. Myanmar Earthquake Committee is coordinating joint research works sponsored by foreign institutions, organizing seminars and workshops , sending training abroad, attending seminars on earthquake and doing some research works in Myanmar. The zonation map of Myanmar is developed and more study on this topic is going on. Earthquake Resistant Design Code for Building is under preparation and earthquake resistant design for building is encouraged. With the cooperation of international institutions, Myanmar Earthquake Committee believes that earthquake disaster mitigation works and study on earthquake and tsunami will be developed in Myanmar.

[P1-2-1-7] Current Situation on Modern and Paleo-seismology in Myanmar

Than Myint[1] & Win Swe[2]

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Abstract

Myanmar, being located on the currently active Alpide Seismic Belt just before merging with the more active Circum-Pacific Seismic Belt in the Indonesian region to the south, is unquestionably an earthquake prone country. Local historic records of damage done to the very venerable structures like pagodas or monasteries by earthquakes complement the truth of the above contention. The Sunda Subduction, home of the recent December 26, 2004 great earthquake of Mw=9.0 to 9.3, extends northward through off-shore west of Myanmar and poses as the sole generator of similar earthquakes and the resultant tsunamis in the region, as in the past. The recent great earthquake also generated the deadliest and the most devastating tsunami in modem history in the region including the Myanmar coast although not as hardly hit as the other areas around. It is therefore evident that Myanmar is also vulnerable to tsunamis as well.

The southern segment of the Myanmar coast, the Taninthari coast, between the Sittoung River and the Patchan River at Thai-Myanmar border was protected from tsunami waves coming from the Sunda Subduction Zone by broad Myeik Shelf, Myeik Archipelago and the outer-arc submarine ridge extending from West Myanmar Ranges through the Andaman-Nicobar Island groups to the offshore islands southwest of Sumatra. The Ayeyarwaddy Delta portion of the Myanmar coast is less protected, but it is fortunate to be located inside the outer-arc submarine ridge and has a broad shelf. The western Myanmar coast is on the submerged outer-arc ridge and has some offshore islands to protect.

As far as research in the fields of seismology, paleo-seismology, tsunami, paleo-tsunami and earthquake resistant structural design engineering is concerned, Myanmar is virtually a virgin ground, rich in local legends and historic records indicating that some areas, particularly those close to the active faults, have been repeatedly rocked by destructive earthquakes in the past. So far no serious attempts have ever been made to decipher the past seismic and tsunami events in Myanmar.

Myanmar welcomes international joint research projects on studies in seismology paleo-seismology, tsunami, related instrumentation and earthquake resistant structural design engineering fields.

[P1-2-1-8] Characteristics of Post-seismic relaxation in Andaman-Nicobar region from continuous GPS measurements.

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Continuous monitoring of post-seismic crustal deformation facilitates understanding physics of the relaxation of stress perturbation, viscous rheology and modeling the crustal dynamics of the region. The mega thrust Sumatra earthquake of a magnitude 9.0 occurred on 26th December, 2004 provided an excellent opportunity to characterize the post-seismic deformation.. GPS data from four continuous sites from Andaman & Nicobar Islands viz. Campbell Bay (CAMB), Port Blair (PORT), Rangat (RANG) and Diglipur (DIGL) have been analyzed using GAMIT and GLOBK choosing ITRF2000. All these sites commenced during second half of the January, 2005 and functioning till date.

Time series of the EW components at these sites characterized by logarithmic decay function. This may suggest possible afterslip at shallow depth. On the other hand, NS component follows linear function. This style of deformation is typical of any large earthquake which helps to characterize the configuration and rheology of the deforming material in the subsurface.

All the sites found to moving in SW direction with decreasing velocity from south to north, with maximum velocity at CAMB (i.e. ~ 120 cm/yr in S 67.70° W, during January-March, 2005) which is comparable to the a site Phuket which is very close to epicenter (~ 500 km) where the velocity is about 240 cm/ yr. This indicates that the post-seismic deformation is very significant at the site CAMB and GPS data at this site is vital for this study.

The earthquake on March 28, 2005 in Sumatra region did not cause any slip in Andaman and Nicobar Islands as seen from the time series of the above sites. The direction of Coseismic and postseismic horizontal displacement vectors are in same direction indicating that both co-seismic and post-seismic slips are in the similar plane. In this paper, we attempt to extract characteristics of post-seismic deformation from the analysis of GPS data collected during January, 2005 to mid November, 2005.

[P1-2-1-9] Kinematics of the 2004 Great Sumatra Earthquake from Static Co-seismic GPS Offsets

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Abstract:

The 26th December, 2004 Great Sumatra earthquake produced static co-seismic near-field and far-field offsets recorded by GPS stations located upto 4500km distances from the epicenter. The GPS derived offsets were used to model kinematics of the earthquake rupture process, taking into account the shape and depth-varying rigidity of the earth. Modelling using GPS offsets reveals a large slip along > 1200km long rupture zone at time scale much larger than the seismically detectable period of ~1 hour. Both near-field and far-field GPS offsets demands large slip on the Andaman sector, whereas seismic slip inversion finds little slip in the northern sector. Segmentation of the slip distribution as modeled from the GPS coseismics suggest Southern Andaman, Nicobar and Sumatran section, of length near 750km slips ~15m in unison, at a depth > 30km.

[P1-2-1-10] Crustal deformation associated with the 2004 Sumatra earthquake from GPS observation

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Abstract

The 2004 Great Sumatra-Andaman earthquake ruptured the boundary between the Indo-Australian plate, which moves generally northward at 40 to 50 mm/year, and the southeastern portion of the Eurasian plate, which is segmented into the Burma and Sunda sub-plates. Underthrusting along the Sunda trench, with some right-lateral faulting on the inland Sumatra Fault, accommodates inter-plate motion along Sumatra.

We have conducted Campaign GPS observation around Aceh area from March 1-7, 2005 and May 6-16, 2005. The total numbers of observed GPS points are 30, 15 points in March and 15 in May. The old GPS was observed by BPN and BAKOSURTANAL. The observation time is vary from 4hrs to 24 hours. We use Bernese 4.2 software for GPS data calculation.

The distribution of horizontal displacement gives a first order indication of heterogeneities in slip distribution. The point closest to the epicenter, about 100 km away, only displaced about 2 m, while point in Banda Aceh displaced more than 2.6 m in average. The maximum horizontal displacement was detected Lok Nga, suggesting large slipped region, in the west coast of Aceh. Generally land subsidence more than 20 cm was observed along west coast. This in an indication that the rupture area did not reach Sumatra Island down dip.

[P1-2-1-11] Postseismic deformation of 2004 Sumatra earthquake from continuous GPS observation in Aceh

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The characteristics of strain accumulation and release down dip of subduction zone seismogenic plate of Sumatra earthquake are not well understood. Here we present evidence of aseismic moment release following Sumatra earthquake, from GPS observation. A continuous GPS system was constructed in Syiah Kuala University, Aceh, in February 2005. A Trimble 4000 receiver was screwed onto the anchored bolt in the top-roof of a reinforced-building of Syiah Kuala University. We use a Precise Point Positioning method implemented in the GIPSY/OASIS II software, for data processing. The JPL precise orbit and clock information referred to the satellite coordinates and clock information was implemented in during processing.
A crustal deformation of 18.9 cm toward south, 18.1 cm toward west and 1.8 cm uplift is detected from 10th February 2005 until 15th July 2005. The direction of calculated postseismic deformation pattern is toward Sunda trench and parallel coseismic deformation.

[P1-2-1-12] Seismological Activities, Tsunami Effect and Prevention in Myanmar

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1. Introduction

Myanmar is situated on the boundary of Alpide-Himalayan Earthquake Belt where devastating earthquakes had occurred from time to time and there is obviously the seismic risk in the country. The earthquake in this Alpide-Himalayan region have resulted in massive loss of life and untold suffering.

The Department of Meteorology and Hydrology (D.M.H) introduced seismological monitoring activities since 1963.

In 1972, D.M.H of Myanmar established a network of seismological stations.

2. Seismological Instruments in Myanmar

The Instruments currently used in the seismological stations are

(i) Analogue Seismometer 4 units (PK 101 long period and PK 101 long period, KATSUJIMA, Japan)

(ii) Strong Motion Accelerometer 10 units (Donated by OYO corp, Japan)

(iii) Broad band Digital Seismograph 2 units (Donated by China Seismological Administration)

3. Seismological Services

The establishment of the seismic network enable the following activities;

(i) Monitoring of seismic events which occurred in both local and abroad.

(ii) Development and implementation of operational procedure in detection and location of the epicenter of the earthquake event.

(iii) Collection, analyzing, compilation and publication of seismological data, advice in seismological matters to other governmental and non-governmental agencies.

(iv) Distribution of information on earthquake event and Tsunami warning.

4. Historic Strong Earthquakes in Myanmar and Sagaing fault (Major Active fault of Myanmar)

(i) Some historic strong earthquakes in Myanmar.

(Magnitude 6 and above, year recorded 1900 - 2005)

(ii) Sagaing fault (major active fault of Myanmar.

The Sagaing fault is the most prominent active fault in Myanmar ,trending roughly north -south ,from north to south it extends from south of Putao , west of Katha .through of Sagaing ,along the eastern flank of the Bago Yomas ,then through Bago, and finally into the Gulf of Mottama for a total distance of about 1500km.It is ending with a extensional horse-tail structure in the Gulf of Mottama.

5. Past Tsunami Effect along the Myanmar coast due to the December 2004 giant earthquake.

Rakhine state (Myay Bon, Kyauk Phyu)

Ayarwady Division (Pyinsalu, Laputta, Ngaputaw, Kaingthaung)

Taninthayi Division (Palontonetone)

- Some building affected

6. About the Tsunami damage which was much smaller than the neighbouring countries and vulnerability to the Myanmar coast due to Tsunami.

The effect of the Tsunamis on Myanmar minimal due to

- existence of seismic Gap
- direction of the waves
- topographic feature of seabed level
- unspoiled mangrove forests
- existence of hundreds of uninhabited islands in Myeik Archipelago

7. Planning for Tsunami prevention & mitigation

- DMH cooperation with WSSI, PTWC, JMA, ADPC, UNESCO/IOC. Asian Secretariat Office and International Organizations
- DMH cooperation with governmental departments & local organizations
- Disaster drill especially Tsunami
- Evacuation drill especially Tsunami
- Meeting, workshop, training for Tsunami prevention and mitigation
- Development of DAPHNE project in Myanmar
- Installation of Tsunami alert systems.
- Upgrading and expansion of the current communication network and sea level, Development of a seismic and Capacity building
- Develop a system that will be based on and end-to-end principle – from data collection to the provision of services and issuing of warnings
- Public Education for Tsunami Warning and Evacuation

[P1-2-1-13] The rupture process of 2004 Sumatra-Andaman Earthquake viewing from the data obtained by the strainmeters of JMA

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1. Introduction

The great Sumatra-Andaman earthquake (M9.0), which occurred on 26 December, 2004, is one of the largest earthquakes in the instrumental record. This event was so large and the duration and extent of rupture is still in discussion. Some researchers have suggested a slow slip occurred at the northern part of the rupture area. The instrument response of the strainmeter is very wide and even it can record DC components, it's a good tool to detect the long period wave in the data. JMA (Japan Meteorological Agency) has deployed volmetric strainmeters and Ishii-type 3-components strainmeters in and around Tokai area. In this study, the source time function of the event was estimated using these strainmeters.

2. Validity of the strainmeter data

The validity of strainmeter records was checked by comparing synthetic and observed data. Nias earthquake(M8.2), which occurred on 28 March, 2005, was used for this comparison because the rupture process of the main shock was too complicated to compare with. Synthetic records are calculated by the summation of earth's normal modes. The moment tensor of this event was assumed to that obtained by Harvard group and considered finiteness of the source duration (half duration=50.3s). Generally the local strain recorded by strainmeter and wide area strain is different, the calibration value for volmetric strainmeter (Kamigaichi *et al.*, 1994) and calibration matrix for Ishii-type strainmeter (Kamigaichi *et al.*, 1999) was used to calibrate strain data. The maximum amplitude difference between observed and synthetic waveforms band-pass filtered between 1000 and 100 sec is within 20%. Ishii-type strainmeters actually have 4 components for redundancy. We have checked the consistency of these four components. Four pairs of independent 3 strain components (surface and 2 shear strains) have been calculated using 3 among 4 components. The difference among 4 pairs is within several percent. Above results showed the wide area strain was well represented from the strainmeter records.

3. Estimation of the source time function

The source time function of Sumatra-Andaman earthquake has been derived by deconvolving observed data with the synthetic ones. 18 stations of volmetric strainmeter have been used in this analysis. The moment tensor solution was fixed that derived by Harvard group and both waveform data was low-pass filtered whose corner frequency is 10mHz. The source is fixed to the centroid location and only time variation of rupture process was calculated. One source time function was derived from one station. So we got 18 source time functions. The shapes of these 18 functions were resembling each other. There were 3 peaks in source time function (0 ~ 200sec, 200 ~ 400sec and 400 ~ 700sec) and the total duration was about 800sec. The seismic moment of these peaks were 3.5×10^{22}Nm, 1.0×10^{22}Nm and 0.7×10^{22}Nm. Thus the total seismic moment is 5.2×10^{22}Nm(Mw9.1). Above results were consistent with other researches (e.g. Ammon *et al*., 2005).

4. Estimation of the direction of principal stress

The direction of principal axis can be estimated using 2 independent shear strains obtained from Ishii-type strainmeter data. The direction of principal axis corresponds to that of wave propagation (Tono Geoscience Center, 2005). The wave propagation direction was stable between 200 to 500sec after P wave arrival. In this time range, the direction was gradually changing from 230 to 250deg. This has suggested the rupture propagated from south to north. This method is powerful for estimating propagation direction roughly.

5. Summary

From the analysis of strainmeter records, we can get following results. The duration of source time function is about 800sec and the total seismic moment is 5.2×10^{22}Nm(Mw9.1). The shape of the source time function is consistent with other researches. This result has showed the validity of strainmeter records for estimating temporal extent of source time function. The spatial extent of this event was estimated by the direction of principal axis. We could estimate that rupture propagated from south to north, but could not estimate extent of rupture area because the error was large. Another method is necessary to improve the spatial resolution of source process.

[P1-2-1-14] Changes in seismicity associated with the Sumatra earthquake and their implications for the stress state

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We studied the changes in seismicity prior to the giant Sumatra earthquake on 26 December 2004. In our study, we would like to clarify the stress accumulation process before the event by mapping rate changes, identifying asperities, and detecting changes in stress states. Earthquake catalogues compiled by USGS and others are adopted in the analysis. Earthquakes with magnitudes exceeding 5.0 have been located homogeneously over the source region since 1973. A preliminary analysis was conducted to detect precursory changes in the number of events and changes in the magnitude frequency relation, which have frequently been reported for large earthquakes such as the 1995 Kobe earthquake and the 2003 Tokachi earthquake. These changes should be directly observable phenomena indicating changes in the stress state in the area. Recent studies on the tidal triggering of earthquakes suggest that small earthquakes in the source area tend to occur at a specific phase angle of stresses that favors the fault slip. This could be considered as another indicator of a critical stress state in the source area. From these viewpoints, we obtained the following preliminary results.

We did not find a significant seismic gap of major earthquakes with magnitudes of 6.0 or larger in the source area during the 10 to 15 years before the Sumatra earthquake. Such a gap has been suggested but depends on event selection. In contrast, significant increases in the rates of earthquakes with magnitudes of 5.0 and larger have been detected with the Epidemic Type Aftershock Sequence (ETAS) algorithm, which considers earthquake clusters. These increases have been commonly observed for different areas and different magnitude ranges, starting in late 1999 or thereafter.

It is somewhat difficult to obtain a conclusive result for changes in the b-value of the magnitude frequency relation with a small number of sample earthquakes of magnitude 5.0 and larger. However, a chart of cumulative magnitudes indicates an increase of mean event size after 1990, which suggests larger earthquakes have occurred more frequently than smaller ones.

Using moment tensor solutions of earthquakes in the area from 1977 to 2004, we observed a characteristic pattern in the temporal variation of the tidal effect on earthquake occurrences by calculating the tidal stress component due to the solid earth tide and the ocean tide loading onto the fault slip. In the pattern, a tendency of earthquakes that approach the Sumatra earthquake to occur at the phase angle when the tidal shear stress is at its maximum and accelerates the fault slip becomes more significant with time approaching to the Sumatra earthquake.

[P1-2-1-15] Mechanism of the 2004 great Sumatra-Andaman earthquake estimated from tsunami waveforms

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Rupture process of the 2004 Sumatra-Andaman earthquake is estimated using five tsunami waveforms observed at tide gauges (Sibolga, Belawan, Colombo, Vishakhapatnam, and Port Blair) and tsunami height data obtained from two satellite altimetry data, “Jason-1” and “TOPEX/Poseidon”. The coseismic vertical deformation surveyed along the coast of Sumatra Island, Nicobar Islands, and Andaman Islands, are also used to constrain the fault model.

The source area of the 2004 Sumatra-Andaman earthquake is divided into 14 subfaults (Fig. 1).We vary the initial rupture time for each subfault and try to find the best model. The result of the tsunami waveform analysis is shown in Figure 1. The average rupture speed of the 2004 Sumatra-Andaman earthquake is estimated to be about 2 km/s from tsunami waveform analysis. The rupture extends about 1200 km toward north-northwest along the Andaman trough. The large slip of more than 20m is estimated on the plate interface off the northwest coast in the Aceh province in Sumatra. Another large slip of more than 20m is also estimated on the plate interface beneath the north of Simeulue Island in Indonesia. The other large slip of 10-15m is estimated on the plate interface near Little Andaman and Car Nicobar Inlands. The slip amount beneath North and Middle Andaman Islands are very small, about 1m. The total seismic moment is calculated to be 7.8 x 10^{22} Nm (Mw 9.2) which is similar to the other studies using seismic waves (Park et al., 2005, Ammon et al., 2005).

Our estimated slip amount off Sumatra Island is larger than the slip amounts estimated by the other studies, such as Ammon et al (2005). This large slip should be responsible for large tsunami run-up heights of about 35m surveyed along the northwest coast of Aceh province in Sumatra Island.

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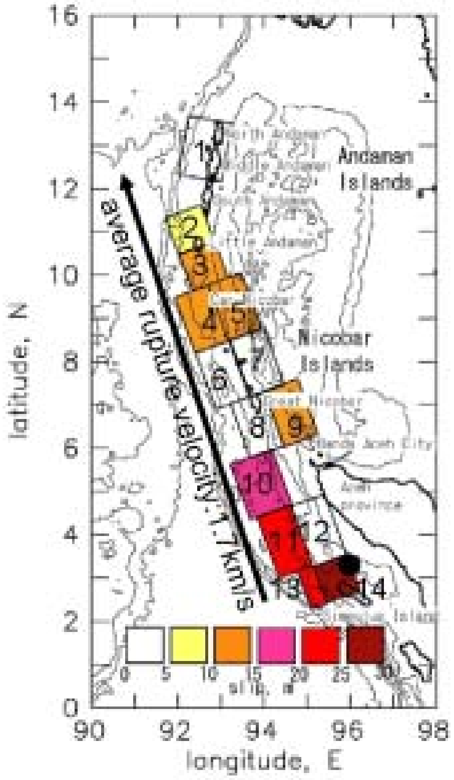
Slip distribution of the 2004 Sumatra earthquake estimated from the tsunami



subfault	slip (m)	initial rupture time (min)
1	1.2	12
2	7.1	10
3	12.8	8
4	12.8	7
5	12.9	7
6	2.2	5
7	0.0	5
8	3.3	3
9	13.0	3
10	17.3	3
11	20.5	2
12	0.0	1
13	24.0	0
14	28.7	0

total seismic moment : 7.8 x 10^{22} Nm (Mw 9.2)

Fig.1. Slip distribution of the 2004 Sumatra earthquake estimated from the tsunami waveform inversion.

[P1-2-1-16] Development of Indonesia Permanent Sea Level Monitoring Network for Supporting Indian Ocean Tsunami Warning System

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Abstract

Lessoned learned from the devastating megathrust earthquake and tsunami West Coast of Aceh Sumatra on December 26, 2004, this leads to increase people awareness on the needs for establishing a real time sea level monitoring network to support the tsunami warning system in Indian Ocean. The National Permanent Sea Level Monitoring Network of Indonesia, consisting of 60 stations and operated on behalf of BAKOSURTANAL, can be used as the existing infrastructure for supporting the warning system not only in Indian Ocean but possible in the Internal Sea Waters of Indonesia. However, more new stations as well as modernization of recording instrumentations and the provision of fast data communication are of highly required.

There were some operational stations capable of recording the tsunami wave form at a number of ports along the coastal islands facing the Indian Ocean. However the data recordings arrived at our office were very late. We derived the recording chart of those analog stations via fax sent to us after we made a request to the station operators, while those of digital stations were unfortunately incapable of recording the tsunami signals properly since the recording instrument was set to operate in an hourly data sampling rate. At the time of tsunami, our system was incapable of sending the tsunami record to national and international tsunami warning centers since the initial design of the network was aimed at providing data for survey and mapping activities of which weekly or monthly data transmission was adequate.

Efforts have been made to build joint cooperation with international and inter-related government institutions and local governments in Indonesia to have the system in place. It has been agreed that all international efforts on the establishment of the Indian Ocean Tsunami Warning System is coordinated under the leadership of the Inter-governmental Oceanographic Committee (IOC)/UNESCO. Indonesia, as the most potentially badly affected country by tsunami hazards shows a high commitment on the establishment of the system.

It is expected by the end of 2006, there will be at least 26 real time stations in place. Commitments for the establishment of the system are presently showed by German contribution with 10 stations, USA 10 stations and Indonesia 6 stations. BAKOSURTANAL and University of Hawaii Sea Level Centre installed the first real time station in Sibolga North Sumatra on April 22, 2005. The data transmission via Global Telecommunication System (GTS) operated under the World Meteorological Organization (WMO) is set to every 15 minutes but higher transmission in extreme conditions is possible. The data is now available online in internet with open access for scientific community. This reflects that the incoming tsunami warning system can also be part of an operational ocean observing system which provides fast and reliable sea level data which can be used for scientific research and various practical applications.

[P1-2-2-1] Report on the Post-Tsunami Reconstruction Condition in Sri Lanka affected by 2004 Sumatra Tsunami

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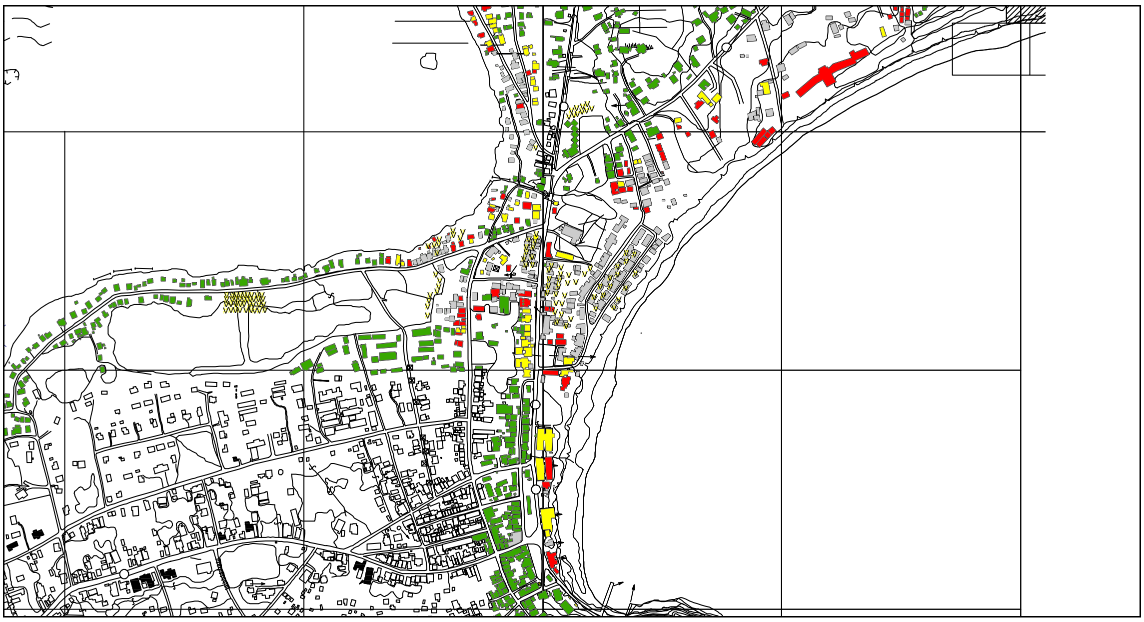
On the 26th of December 2004, tidal waves struck the coastal areas in Sri Lanka as well as other Indian Ocean rim countries. The Tsunami damaged to five provinces in Sri Lanka and more than forty thousand people were displaced and disappeared or killed within a short time.

Urban Development Authority (UDA) announced "Physical Planning Guidelines and Project Proposals for the Vulnerable Coastal Zone of Sri Lanka" in January 2005, which contains rebuilding regulations in Coastal Conservation Zone (CCZ). However many arguments have been made from the different viewpoints.

The authors conducted field surveys and interviews with residents in Galle, Matara, Hambantota, and Hikkaduwa to grasp building reconstruction conditions as of November 2005 and to clarify their problems. One of the results shows that 17.8 % of the damaged buildings had been repaired, 59.6% had been demolished, and 22.6% had still remained in Hambantota (Figure and Table). On the other hand, 44.2% of the damaged buildings had repaired in Galle. We found that each affected area has different own problems according to damage impact and regional characteristics.

Apart from the field survey, the authors visited some new towns for the victims. Houses made of brick on a quick construction system in Tangalle and a huge construction site supported by Taiwan Buddhist Zhu Chi Foundation in Hambantota will be reported.



Remain Damaged Demolished Temporary Shelter/Tent Repaired Not Damaged

Figure: Building Condition of Reconstruction in Hambantota (as of November 4th, 2005)

Table: State of Buildings in the survey field in Hambantota (as of November 4th, 2005)

	Remain Damaged	Demolished	Repaired	Not Damaged	Temporary Shelters/Tent
Zone 1 -100m landwards	11	62	8	100	15
Zone 2 -200m landwards	40	81	24	504	23
more than 200m	56	139	52	554	76
Total	107	282	84	1158	114

[P1-2-2-2] Post Tsunami Construction, Rehabilitation & Restoration Program in Sri Lanka

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Tsunami, on 26th December, 2004 overwhelming loss of life has left the entire country in a state of shock and trauma. This was the most severe natural disaster in the recent history in Sri Lanka and it demonstrated the requirement to improve the capability to deal with natural disaster mitigation, preparedness and human restoration planning to a new spectrum. The post disaster planning and management significantly depend on the accuracy of the social structure, geo-information of the effected stretch and the integrity of human interventions. The UNDP is helping the government's main agency, Task Force for Rebuilding the Nation (TAFREN),for tsunami recovery. TAFREN set up a database management system that will track the progress of donor funded projects in keeping with the state's policy of transparency and accountability in tsunami-related funding. The development community's response to the tsunami disaster has now shifted from the relief phase to the rehabilitation and reconstruction phase. About 60% of the tsunami damage occurred on the east and northeast coasts. Tsunami-related needs for rebuilding alone are estimated at $1.5 billion, based on a joint needs assessment conducted by the Government and the international donor community, including ADB.

The tsunami waves that struck over two thirds of Sri Lanka's coastline on that day left more than 31,229 persons died, 4,100 persons are missing, 516,150 persons are currently registered as tsunami-displaced in welfare centers or staying with friends and relatives. Forteen out of 28 Sri Lankan districts were affected by the tsunami. Also, 23,449 acres of cultivated land were affected, including 9,000 acres of paddy, 645 acres of other field crops, 12,928 home gardens, 559 acres of vegetable farms, and 317 acres of fruit trees according to FAO and the Ministry of Agriculture. 16,479 fishing craft were damaged or destroyed which represents 50 per cent of the Sri Lankan fleet, according to FAO and the Ministry of Fisheries and Aquaculture. The health sector suffered not only from damage to health-related infrastructure, but also through loss of services and human resources. 86 medical facilities were damaged or destroyed, not including pharmacies and other medical-related facilities.195 educational facilities including universities and vocational training centers were damaged with 59 schools totally destroyed and 117 partially destroyed. According to TAFREN 275,000 lost jobs of which nine out of ten working men and women. ILO report reveals 34 per cent of such jobs having been in the fishing industry.

Coastal courts and labor tribunals, prisons, and police stations, and district offices that contained personal and property documents were partially or completely destroyed. About 1,400 kms of the national and provincial road network, and another 1,100 kms of local and village access roads were damaged. Bridges and culverts were also destroyed or displaced and embankments were eroded by the advancing and retreating tsunami. Flooding due to tsunami further damaged the road network along the east coast. The tsunami destroyed several sections of coastal railway lines, in particular on the Southern Line between Colombo and Galle along the Southwest coast. Water supply schemes and distribution networks along the shoreline were impacted, along with at least 12,000 water wells were damaged mainly by saltwater intrusion; about 50,000 others were abandoned. Salinity contamination of stand crops in paddy and other crop fields or home gardens will limit or inhibit crop production for the next 3 to 4 years, until salinity is naturally flushed away through rain.

The highest number 8,139 of completely damaged housing units was reported from the Ampara district. This is followed by Batticaloa and Galle districts and number of completely damaged housing units of these two districts were 7,445 and 4,482 respectively. The number of completely or partially damaged buildings other than housing units was 11,000. The highest number 3,170 of such buildings damage was reported from the Galle district. The tsunami-affected population is between 1 and 2 million people, out of a total population of about 19 million. Conflict-related needs for relief, rehabilitation, and reconstruction are estimated to be double that amount, with $780 million identified for immediate needs.

The Government agreed to contribute $39.1 million equivalent toward Tsunami-affected Areas Rebuilding Project (TAARP)'s total project cost of $249.3 million, and $9.1 million equivalent toward the North East Community Restoration and Development Project II (NECORD II) 's total project cost of $55 million. The objective of TAARP is to rapidly improve the living conditions and well-being of a significant number of people in the tsunami-affected areas by restoring basic social infrastructure, community and public services, and livelihoods. The European Commission has agreed provide a grant of $53.2 million for TAARP. The Government of Sweden, through the Swedish International Development Cooperation Agency, will provide a grant of $5.9 million for NECORD II. Both projects will be implemented through project management units already established under other ongoing loans. A National Project Coordination Committee headed by the Secretary of the Ministry of Finance and Planning will be established to provide oversight and coordination. Both projects are due for completion in December 2008.

Nearly, 31,000 transitional shelters have now been completed by a variety of actors, including international and national NGOs, private groups and UNHCR, IOM and various other agencies and NGOs nationwide with some 150,000 family members now living in them. Another 9,000 transitional shelters were completed by the end of June according to TAFREN. 54,266 transitional shelters are scheduled to be completed in the coming months, housing more than 250,000 people according to UNHCR. 9,480 families were living in tents as of 8 June, according to the Head of TAFOR. Over 480,000 non-food relief items (mosquito nets, lanterns, cooking utensils, buckets, etc.) have been provided to affected families by UN agencies.

Livelihood and rehabilitation works includes 10,198 boats in total have now been repaired or replaced by government agencies and NGOs, according to FAO. 3,415 boats, 212 inboard engines and 658 outboard motors have been repaired by FAO and it enabled some 12,000 fishers to resume their livelihoods. 25 IOM sewing centres have been opened by IOM in camps to provide training and employment to tsunami-affected people and fifty-nine carpenters have been provided with IOM replacement tool kits to help rebuild their livelihoods. Cash-for-work and food for work projects by various UN agencies are on-going, including a pilot cash-for-work project, assisted by the ILO, in which two roads are being cleaned and repaired, providing 20 people some 1,600 workdays. The pilot project will provide valuable experience for ILO policy technical advice to the Rapid Income Recovery Programme (RIRP) of TAFREN. 3,109 School-in-a-Box kits have been provided for over 200,000 children and more 1,350 recreation kits have been distributed reaching some 81,000 Children by UNICEF.

The recovery effort still has a long way to go. Hundreds of thousands of people still remain homeless, and unable to work. Thousands of schools have to be built, and many of the region's children remain frightened and distressed. There are still some frustrating delays in getting government approval for contracts and for imports of machinery and materials and also few bureaucratic obstacles every day. Rehabilitation and hazard mitigation is defined as a sustained action taken to reduce or eliminate long term risk to life and property from a hazard event. The primary purpose of mitigation planning is to systematically identify policies, actions, and tools that can be used to implement those actions. The plans are needed for reusing the existing housing stock as a model for next generation so as to contribute to even greater autonomy and residential security of the society. At the same time, the rush for growth can trigger haphazard urban development that increases risks of large-scale fatalities during a disaster. The same is true in many other areas.

Authors pin point some of the key issues to be considered. Jointly prepared needs assessments have been largely important for the process of post disaster mitigation plan which itself has a huge impact both positives and negatives. Secondly, this brings the impotence and proper utility of grants and loans in time including monitoring. It shows how country should face similar patterns of natural hazards from floods, landslides, cyclones, earthquakes, droughts and tsunami often experience widely differing impacts when disasters occur.

[P1-2-2-3] Identification of tsunami wave loads based on damage assessment of road structures in Sri Lanka due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean

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Houses and infrastructures in Sri Lanka were extensively affected by the tsunami due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean. More than 200,000 totally and partially damaged houses caused more than 42,000 fatalities and missings. The road networks along the coast in Sri Lanka were affected and more than 9 bridges were severely damaged. A clarification of the damage mechanism of affected houses and infrastructures are necessary to go on the reconstruction of those structures in the country and propose the countermeasures against the tsunamis. In this study, focusing on the damage of road structures, especially bridges, the tsunami wave loads were inversely identified based on the damage assessment of the damaged bridges in Sri Lanka. From the analysis the relation of the tsunami wave velocity with the tsunami wave height was clarified.

From two times field surveys for the affected areas in Sri Lanka, more than 60 data in terms of the damaged bridges could be collected. The bridges along the road in the northeast coast in Trincomalee, and along the A2 road in the west, southwest and south coast between Colombo and Hambantota were surveyed. The position and dimension of bridges, and distance from the coastal line to the target bridge were measured. The data of tsunami wave heights on the sites were collected based on the hearing from the habitants in the area, or the measurement of the inundation heights marked near the house. The damage of the bridges was categorized to washed-out or movement of decks, severe damage of abutment, and damage of attachments upon decks such as rails and lumps.

Firstly, based on the 60 data, the damage of bridges due to the tsunami was related with the tsunami wave heights that were from 1.2m to 12.4m, and the fragility of bridges against the assumed tsunami wave heights was clarified. The 9 data among the 60 data indicates that simple spanned bridges without the suitable shear keys between the deck and its supporting pier, or abutment are fragile against the tsunami wave. Secondly, by using the data related to washed-out or movement of decks, that were 9 data, assuming that the resisting force of the deck to the tsunami wave becomes equivalent to the friction force between the deck and another structural component, the tsunami wave velocity on the site was inversely computed. Varying the dominant parameters in the computation such as the friction coefficient and the coefficient of the resisting force, the sensitivity of the inversed tsunami velocity on the tsunami wave height was analyzed. The values of the tsunami wave velocity that are 2.9m/s to 7.5m/s, related to the tsunami wave heights become higher ones than the values evaluated by the previous studies.

[P1-2-2-4] Damage of Infrastructures Caused by December 2004 Great Earthquake and Tsunami in Aceh Region Indonesia

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A December 2004 great earthquake and tsunami have hit around 260 km of Aceh West coast and East one of about 150 km effectively. This is the worst natural disaster in Indonesia after Krakatau explosion around Sunda strait in 1883. The 2004 natural disaster caused loss of more than 200,000 of life in Aceh province. Many of people houses, school buildings, health facilities, state and province's road and bridges, airports, and other infrastructures, and lifeline facilities were destroyed. The cities in West coast region such as Banda Aceh (the provincial capital), Calang as Aceh Jaya regency capital, and Meulaboh as Aceh Barat regency capital were fall flat for the area of about four kilometers from the coast line. The effect of post disaster, more than 500,000 displaced people has been occurred and till now more than a half of them still stay at tents and other temporary shelters spread around ten regencies those severely affected by the disaster. Many of international donors such as UN Agencies, non government organizations (NGO), state governments give relief services for the surviving victims. They also rehabilitate and reconstruct infrastructures, especially urgent needs of basic facilities such as houses, roads, school building and its supporting, health facilities, and local government offices.
Based on the damage survey carried out by several organizations including the University of Syiah Kuala and official authority data, the damage condition of infrastructures those are affected by the disaster in Aceh Province are explained in the following. Those damages are limited to housing, building, road and bridge, seaport, airport and lifeline. Houses were heavy damaged of 74,085 units and 178,138 units with condition of medium and slight damaged. Building of elementary and high schools are 641 units heavy damaged, 147 units of medium damaged, 359 units of slight damaged, and 3510 units are not affected by disaster. All buildings other than houses and school buildings were damaged are more than 2000 units from collapse to slight damaged. The length of state, province, and regency/city roads are 1,831 km of badly damaged, 4,841 km are moderate and slight damaged and 1,801 km are in good condition. Bridges condition of 11,211 m are good and 8,498m are heavy to medium damaged. One of heavily damage bridge is shown in Fig.1, that located at Banda Aceh – Meulaboh road in Aceh Besar region. Regarding the seaport of 18 units included ferry seaport in total, five of them are heavy damaged, 12 seaports are slightly damaged, and one of them is good condition. Airport with total number of eight are all in good condition except one of Cut Nyak Dien airport in Meulaboh was heavily damaged. The power electric company also affected by disaster. Transmission of 3440 km in length were destroyed, 16 unit of power plant are also destroyed and 6 units of office buildings are heavy damaged.
Based on the decision of Indonesia government, rehabilitation and reconstruction activities are organized and executed by Board for Rehabilitation and Reconstruction (BRR) till 2009.

Fig.1 Krueng Sarah truss bridge moved by tsunami
(Banda Aceh – Meulaboh, Aceh Besar region)

[P1-2-2-5] Tsunami Questionnaires and Bridge Damage Surveys in Banda Aceh for City Restoration Planning and Urban Design

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The fourth largest earthquake in the world since 1900 has happened on December 26, 2004, at 00:58:53 UTC (or 07:58:53 local time), off the west coast of Northern Sumatra, Indonesia. Following the disaster, Japan National Team of Tsunami and Earthquake Researchers led by the first author departed to Banda Aceh and surrounding areas from March 1st to March 6th, 2005. The survey was to study lessons from the disaster. The study is expected to provide information about the disaster and how the effect of such disaster in the future can be reduced. One of works carried out was distribution of questionnaires. The questionnaire consists of questions related to their experience during and after the earthquake and tsunami. The main aim for collecting information in the questionnaire was to get a basis for planning a safer town under earthquake and tsunami disasters. The results of the questionnaires are expected to give a broad picture of what happened and what are expected by the affected people.

One important result of the questionnaires is shown in Figure 1. According to respondents' opinion, the number of tsunami victims would have been much reduced if they had started to run away just after the big earthquake (Figures 1a and 1b). However, in some areas, the respondents said that the expected survivors would have not reach 100% even if the had run away just after the earthquake. The practical implication from this result is that education, socialization (software) and escape structures, warning system, wave resisting structures (hardware) are among important factors for people to be safer against future earthquake and tsunami attacks.

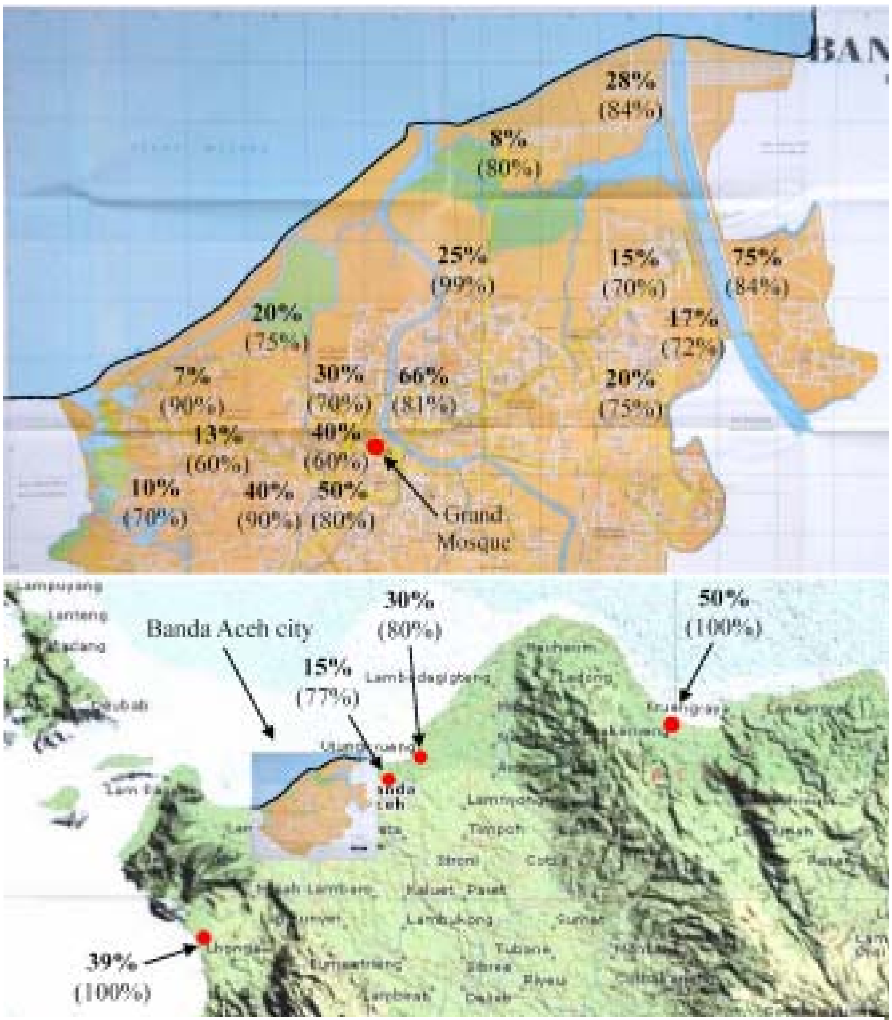


Figure 1. Percentage of survivor in (a) Banda Aceh and (b) surrounding areas (numbers in parenthesis show expected percentage of survivors if people had run away immediately after the earthquake, according to the respondents)

Another work carried out was surveying bridge damages. The survey was expected to result in a new design for bridges which can withstand earthquake and tsunami forces. Some locations of surveyed bridges are shown in Figure 2 (a satellite photo after the disaster (DLR, Satellite Based Crisis Information, http://www.zki.caf.dlr.de/applications/2004/indian_ocean/indonesia/sumatra_aceh_2005_en.html) at Meuraxa Ward (North-Western part of Banda Aceh city) where the tsunami water was coming from the North-West direction.

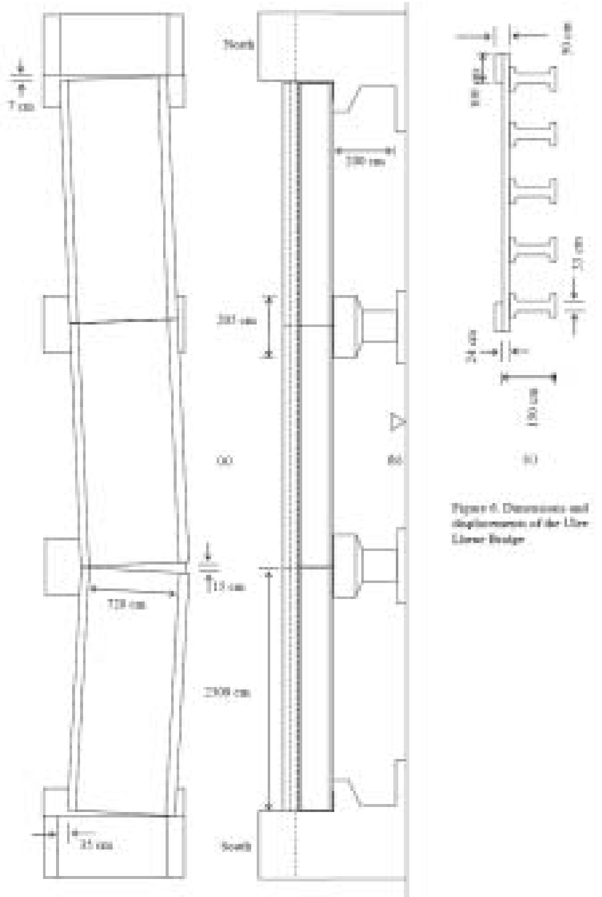
Fig. 4. Location of Damaged Bridges

The condition of Bridge No.2, Ulee Lheue Bridge, is shown in Figure 3. From the plan view (Figure 3a), it is clear that the bridge decks were severely displaced (in the direction of the tsunami water flow). Calculations were made to estimate minimum water velocity capable of displacing the decks of Bridge No. 2. The results show that the minimum water velocity is 13.3 km per hour.

Meanwhile, a study using video footage by other researchers shows that at Putri House located near Bridge No.1 the water velocity is around 21.6 km per hour. This means the decks underwent larger velocity. However, since the deck movements were not uniform in the lateral direction, they were locked to each other and were prevented from being washed away. This non-uniformity can be seen from the gap between the two decks.

Bridge No.1, Asoe Nanggroe, also underwent similar damage mechanism (Figure 4). The deck movements were not uniform and prevented from being washed away. The minimum water velocity capable of displacing the decks is calculated as 13.4 km per hour.

Bridge No. 20, Peukan Bada, a one-span bridge, also underwent similar mechanism (not shown in the figure). The minimum water velocity is calculated as 10.4 km per hour. It is smaller than the previous ones since the deck is lighter.



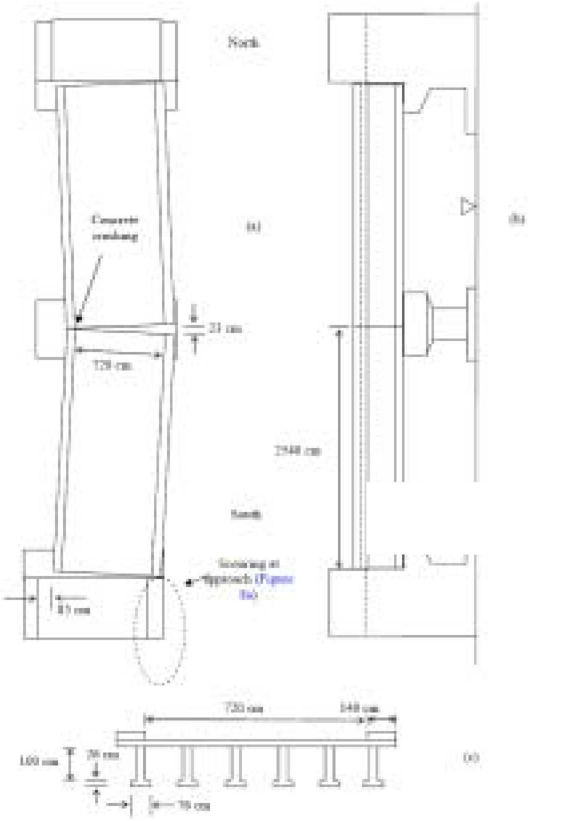


Figure 4. Displacements and Dimensions of Bridge No.1

Figure 3. Dimensions and Displacements of Bridge No.2

[P1-2-2-6] The Challenge of Rehabilitation and Reconstruction of Banda Aceh City

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Banda Aceh, a city of nearly 1000 years of age, has experienced constant changes in aspects of socio-demographic and environment. Geographically its location is unique as it is situated north of the equator, very close to the continent, surrounded by seas and susceptible to seasonal changes and regular earthquakes. Environmental conditions are thus difficult but essential for the life of its population. The 26 December 2004 earthquake and Tsunami has somewhat sunk the land surface of Banda Aceh. This consequently affects the local ecosystem, causing about 40% of the area inhabitable. Historically, it has been recorded that Banda Aceh had suffered a regular land loss in a long term, remarked by the loss of ancient cities which are now located under the sea. The reconstruction of the destroyed area - due to the Tsunami - has therefore to be directed to the land of higher altitude and moved away from the seashore. This strategy would prolong the existence of the city in the next few centuries. The main obstacle in the reconstruction of a new region lies in the area of governmental administrative borders and land ownership. The problem could however be solved by a holistic approach that as the provincial capital, Banda Aceh need to be rebuilt according to the master-plan. The rebuilding could be done by obligatory buying of the people’s land estimated at a reasonable market price. A classic problem to this strategy is the funding limitation. A comprehensive planning cannot therefore be materialized. The rebuilding then takes place at the same sites which overburden the land capacity. For the sustainability of the history of Banda Aceh, wise acts from the people are therefore needed. This would ensure that Banda Aceh would not become the loss city once again.

[P1-2-2-7] Damage and Restoration of Lifeline in Thailand due to the 2004 Giant Earthquake and Tsunami in the Indian Ocean

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1. INTRODUCTION

A huge earthquake occurred at the west coast of Sumatra Island with magnitude of 9.0 at 7:56 (local time) on December 26, 2004. This earthquake provoked tsunami damage to surrounding countries in Indian Ocean including Sumatra Island. Present paper addresses the damage and restoration process of lifelines in Thailand. The authors had a mission of field survey on lifelines of Phuket province and Phang-Nga province in Thailand, from March 7 to 15, 2005. From the interview with responsible managers of water, electric power, and telecommunication authorities and their reports, this paper summarizes the damage, emergency response, and restoration process in those lifelines and gives recommendation for tsunami countermeasures of lifelines.

2. WATER SUPPLY SYSTEM

The water system in Phuket province and Phang-Nga province is managed by Provincial Water Works Authority (PWWA). Pipe damage was concentrated at Phatong Beach and Karon Beach in the supply area of PWWA of Phuket, and at Kao Lak of PWWA of Phang-Nga. There was no significant damage in the distribution main and water supply plants, but a large number of failures in the service pipe and house pipe. Immediately after the tsunami, the emergency water tank was distributed to the disaster relieve center as well as hospital. The repair work of distribution pipeline was completed in one month. As the delay of house restoration, the complete restoration up to plumbing in the house is not finished yet.

Throughout the tsunami disaster, followings are recommended for tsunami countermeasures of water supply system:

- Some shallow buried pipelines were exposed to outside after the embankment had been scoured by tsunami wave. In the pipeline construction nearby the bridge, it would be paid attention to the embankment for tsunami wave.
- PWWA of Phuket province is going to employ a common duct system which contains pipelines and cables of electric power, telecommunication and water and waste water in a large tunnel box to the government. The lifeline in this common duct would more resist to tsunami wave and be easier to repair than underground pipeline itself.
- Damage by the tsunami wave was concentrated in the meter and house pipe, because vulnerable pipes were used. The material of house pipe is out of the regulation control so that it is customer’s own property, and its construction is based on the old standard established in 1979. This issue happened during the 1995 Kobe earthquake in Japan too. From now on PWWA is going to provide a new guideline for the use of flexible PE pipe to house pipe.
- Emergency water supply was effectively carried out by PWWA of both Phuket and Phang-Nga provinces. Complete pipe repair still required more time until the house are restored. Residents would use water from distributed water tank, water bottle or available well. There is concern that water in the well would dry up before the end of dry season.

3. ELECTRIC POWER SUPPLY SYSTEM

The electric power supply in Thailand is managed by Provincial Electricity Authority (PEA) dividing into several service areas. High voltage power with 33 kV is transferred from the north of Phuket Island to Phuket town. Low voltage power is transmitted ranging from 200 to 430 kV. In PEA of Phuket high voltage line of 880m and high voltage line of 2 km were damaged by the tsunami. A 30kVA over head transformer was flooded by the tsunami wave at Kamala Beach. Most of electric power poles within 15m from the beach were toppled from the ground scoured by the tsunami wave, or was collapsed hitting debris of houses and cars. In PEA of Phang-Nga province, the high voltage line of 36 km and the low voltage line of 27 km were damaged. 22 transformers were flooded. All of the high and low voltage lines are ready to resume power by December 28 in Phuket, while in Phang-Nga province the recovery of a high voltage line was completed on December 31, and the recovery of the branch line was completed on January 5. PEA dispatched the power supply cars and the lighting cars for the support of search and rescues operation.

Followings are recommended for tsunami countermeasures of electric power system:

- From the interview with PEA manager, the quick recovery of electric power system was made use of the experience of the typhoon of 16 years ago, which caused similar damage as this tsunami disaster.
- PEA of Phuket province is under planning the use of underground cable for both Phatong and Kamala Beaches. The reason is that the underground cable installed at the Karon Beach had no damage even though the front beach was scoured by the tsunami wave. Laying the power cable underground for better landscape of resort region reduced tsunami damage. This measure works not only resort development but also disaster countermeasures.

4. TELECOMMUNICATION SYSTEM

The telecommunication system in Phuket province is managed by several telephone companies. Telephone Organization of Thailand (TOT) is the biggest telephone company to support fixed telephone service. In Kamara Beach optical fiber cable of 2 km suffered due to the collapse of the poles. In addition 16,000 lines and exchange cabinets along the seaside road were damaged in Phatong Beach. In Phang-Nga province, the large number of telecommunication pole and cable were flooded by the tsunami wave. The damage area is within 20 km along the beach where the power outage also occurred. Fixed telephone customers of 1,700 lines were unavailable. The repair work was completed on January 10 in Phuket province, and on February 1 in Phang-Nga province. TOT established free line immediately after the tsunami.

Followings are recommended for tsunami countermeasures of telecommunication system:

- The outage of electric power disturbed the repair work of telecommunication system. As the tsunami countermeasures as well as earthquake countermeasures, the telecommunication company has to coordination with electric power company in usual as well as emergency situations.
- TOT is applying the Wireless System (WIMAX) around the beach. A small radio machine was established with 3 million BHT. Those systems in the coastal area are effective against the tsunami wave.

[P1-2-2-8] Human Resource Program for Education and Outreach Agenda: Possibilities in India and Sri Lanka

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1. Problem Setting

The disaster reduction policies to address the giant earthquake and tsunami differ from country to country. Here, I would like to propose a set of policies that may be practiced by local government that is based on the experiences of India and Sri Lanka.

The common features of India and Sri Lanka (and also Thailand), where the disaster of giant earthquake and tsunami happened, is that earthquake rarely occurs among these countries. This is with the exception of Northern India, where this natural catastrophe happens from time to time. Thus, the disaster reduction policies are restricted only against tsunamis. This means that the disaster reduction measures can be confined only along the seashore. If you go beyond 200 meters or more from the seashore, you have no much problem. There is no need for the local people within this identified area to preserve water, food, and emergency communication system for emergency purpose. Actually, people who were affected by the giant tsunami got emergency rescue (i.e., putting in order residue, supplying food, water, and kitchen utensils etc.) from neighborhood people – relatives and friends. The first rescue teams came just after the tsunami hit them. Rescue teams by NGOs and international society came 3-4 days later. And the government rescue came a bit more later.

Considering that tsunami is the result of a big earthquake, and attacking India and Sri Lankaa few hours later (and also Thailand), the major point for reducing disaster is to set the early warning system down to the community level. The possible measures can be summarized as follows:

(1) International watching system + India's watching system (like observation buoys) and the system on how to stream the early warning down to community level;
(2) The system of proliferating the knowledge on tsunami (or combined with the knowledge of Cyclone) among local people in normal time;
(3) The proliferation of knowledge concerning the preparation and rehabilitation measures need to be taken after any giant tsunami within the modes of ①Preparation at Normal Time, ② Measures at the time of Disaster, ③Emergency Measures and ④Rehabilitation & Reconstruction Measures;
(4) The next stage issue is to specify which parts of the society have to take the initiative for the proliferation of such knowledge.
(5) Concerning the infrastructure building for disaster prevention, it is necessary to make clear the theaters of participatory discussion and decision-making, with careful consideration on the cost-benefit calculation, environmental assessment, and community people's consent.
(6) The response of governments (from central level to local level) is always delayed, as experience has shown. There are always lack of coordination among central government departments, between central government and local government, between first level local government and second level local governments, between local government and civil society organizations,

especially between governments and INGOs (International NGOs). But still, it is impossible not to depend upon governments. The governments should be at the center of coordination. So, what kind of lessons and measures can we learn from the response experience of governments in each country and systematize these for the next giant tsunami?

(7) It is widely said that Japan has much experiences not only on earthquake and tsunami catastrophe, but also the necessary disaster reduction measures. Hence, the Japanese side is requested to summarize their set of policies that can be learnt and replicated in the developing countries, especially among those facing the Indian Ocean, where tsunami is likely to happen again. Secondly, what kind of measures can the Japanese arrange with these developing countries to realize them? Communicating with the bureaucrats in the government, the academe, NGO people, and the community is another thing. However, the realization of the setting of desirable policies will not be enough in the side of the developing countries. There is a need to come up with more concrete measures, which I propose below.

2. Measures to be taken

(1) How to stream the early warning down to community level

In India, people's sense of reliability to the government is low. Its Federal character, where the provincial government is autonomous, its "Nehruvian consensus" politics that allows coalition with ineffective local elite, has made this country a typical "soft state" - where the decisions made at the center have not been followed at the bottom. Communities believe that both the government and police don't work as the route of early warning system. What various people proposed during our fieldwork was to use the cellular phone. In India, cellular phone accounts to 57 million in 2005 and it is predicted to reach 100 million within two years (making this country as the second world's highest after China with 200 million at present). Every village, including the untouchable's one, around 5-20 people have cellular phones. They said: if they were informed on the coming of tsunami ahead of time and obtained precise information through emergency broadcast, they can tell other villagers and be able to run away. They believed that this very important information can't be stopped, regardless the differences of caste.

On the other hand, in Sri Lanka, the local people don't have much cellular phone. They believe that the government doesn't work during 5 pm to 7 am on weekdays and throughout the weekends. However, the police has 24 hours system, which can be the best way to inform the local people (compose of Buddhist, Muslim and Hindu), with the use of temple's loud speakers (Governments have no loud speakers).

(2) The system of proliferating the knowledge on tsunami among the people in ordinary time

The first priority in applying this measure will be schools. Every year, schools can teach children and arrange assignment so as children can talk with their family members on tsunami, including evacuation and rehabilitation measures. Both in India and Sri Lanka, village organizations are weak; though village head has a strong power. Largely speaking, they don't have neighborhood association, association of aged people, women's organized group, and etc. Although, they have fishermen's association, but the level of activity is low. The reliable association in this situation is the religious community. Other than schools, the possible way of knowledge proliferation is for the village head to organize annual training on evacuation, and education opportunities being provided by the religious community and NGOs. It is noteworthy that TVs in the developing countries are weak on education-related programs. It is, therefore, necessary to strengthen their TV programs fitting to increase the education consciousness of their own society. In Sri Lanka, the area where there is ethnic conflict, the different ethnic groups live in different communities. And all said that the ethnic conflict existing in these areas is the “world” of politicians and it doesn’t exist in the community.

(3) The infrastructure building for disaster prevention

The embankment along the seashore using concrete is not feasible because of the high cost involved. Earthen wall is not good either, because the seasonal heavy rain will throw away the earth from the wall (and from the places the earth collected). And once this earth enters into the sea, this will damage the seabed environment. Embankments by stone and mangrove are more feasible, though the land property problem has to be tackled first before engaging into mangrove planting. The biggest problem now is the settlement of fishermen’s residence along the seashore. Before the tsunami, the seashore area was prohibited to live by the government, since it was identified as buffer zone. However, because of such prohibition, people now can’t borrow money from the banks to reconstruct their houses (even though there are many exceptions). And this has become as one of the major problems in reconstructing the damaged houses in the area (not only fishermen but also ordinary houses).

Social infrastructure building is another big subject in disaster reduction. The government needs to prepare emergency command and coordination system for preventing separate operations of departments. TV companies needs to have systemic route to get the changing information on time from the authority and introduce 24 hours broadcasting system at the time of emergency. Cellular Phone companies need to have separate connection system between telephone and e-mail, in addition to “Disaster message exchange program” for inquiring about persons’ safety. Considering that the tsunami hit the fishermen’s villages, it is decisively necessary to strengthen the fishermen’s cooperative on the basis of three-tier system (national, provincial, local level), even during normal time.

[P1-2-2-9] Restoration and Urban Design in relation to Habaraduwa Township in Galle District: A Sociological Perspective

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In the morning of Dec 26th 2004, Sri Lanka faced an unimaginable crisis as giant tsunami waves plunged into its Northern, Eastern and Southern coastal belt. As a whole this catastrophe devastated more than 70% of Sri Lanka's coastline of which the total length is 1585 km. Around 2/3rd of the devastated coastline is in the war zone of the North and East. This tsunami onslaught left nearly 40,000 dead, 5240 missing and 805,978 displaced and homeless. Of the country's population of 19.4 million, about 1 million were adversely affected by the tsunami. Also 200 schools, 72 hospitals, 82 of 242 hotels were damaged. Further, 1615 km of roads and 155 km of railway were made impassable. The Department of Census and Statistics put the number of fully damaged houses at 41,393 and partially damaged houses at 36,168.

For the purpose of governance, the country's territory is demarcated into 9 provinces which in turn encompass 24 districts. Of the 24 districts, 13 located facing the sea, in 5 provinces were affected by the tsunami. The Galle district of the Southern province within which the Habaraduwa division and the township is located is bounded by about 72 km of coastal belt. The district is divided into 18 DS divisions for administrative purposes. Of the 18 DS divisions 6 facing the sea, namely Galle Four Gravets, Habaraduwa, Hikkaduwa, Ambalangoda, Balapitiya and Bentota were adversely affected by the tsunami.

The destruction caused by the tsunami to Habaraduwa township and the villages located in the strip of hinterland bordering sea to its North and South has become an insurmountable misfortune from the affected people's point of view. The shops in the township which retailed consumables to the people in the area suffered losses as a result of the goods being soaked in the sea water that gushed into them. The number of deaths and injuries in the Habaraduwa DS division were estimated to be 274 and 90 respectively. The number of people affected and displaced was 17,066 and 14,782 respectively. Two camps were setup to accommodate the displaced. The number of houses damaged completely and partially was 1,284 and 579 respectively.

The major sectors of the diversified local economy of the Habaraduwa DS division consist of industries, fisheries and tourism. Koggala Free Trade Zone to the south of Habaraduwa township is located on 228 acres of land. The labor force which exceeds 5000 in the zone consists of migrants that originate from numerous places of the southern province. Over 90% of this labor force is females. A local businessman has established a garment factory in the vicinity of the township mainly in order to fulfill the demand by female factory workers for clothes. Small scale cottage garment industry too has developed in the villages surrounding the FTZ to cater to the same demand.

As for the tourism sector, 2 hotels namely Koggala Beach Hotel and Koggala Beach Village that are classified as 3 star ones appear in the south of the Habaraduwa township. Besides a large number of guest houses and restaurants also function along the coast to the North and South of the township.

The major occupation of the people of the villages bordering sea to the North and South of the Habaraduwa township is fishing. Some of them provide labor to individuals who engage in commercial scale fishing with the use of boats. Others are self employed as fishermen.

Tsunami waves destroyed local economy and some of the schools situated close to the sea in the Habaraduwa DS division. Among the schools destroyed, Martin Wickramasighe Kanishta Vidyalaya, G.V.S DeSilva Primary School are notable. The latter had to be relocated along with its 503 students.

Restoration and Urban Design:

In the context of afore-mentioned circumstances, relief and reconstruction activity under restoration and formulation and implementation of urban design should be performed taking the nature of local economy and social structure into account. Economic modernization has made traditional social institutions such as family, kinship and caste less important in the reproduction of the network of social relations in the locality.

Problems related to Relief and Reconstruction Activity and Recommendations to rectify them:

1. The lack of consensus and clash of personalities within the government at the initial stage made relief and reconstruction difficult. Centralization of activity directly under the President's command happened to be retrogressive. De-centralization of activity and the incorporation of active participation of the comprehensive public sector bureaucracy are recommended. Under such reform activity at Habaraduwa can be placed under DS who in turn is accountable to district secretariat (government agent). At present considerable number of recipients of relief are not happy due to duplication and some facing deprivation. For instance some get boats in excess and some other who deserve are deprived. This situation generates jealousy and suspicion among affected people.
2. Although the donors have pledged US $ 3.4 Billion only 2.7 Billion have been transformed into firm commitments. Most of this financial assistance is tied to peace process. However the realization of peace process is made difficult after the Supreme Court determination on PTOMS agreement that was delivered on 15 July 2005 in response to a petition filed by JVP and JHU. Implementation of PTOMS is essential because LTTE does control sizeable extent of territory and its civilian population in the North and East.
3. The law preventing people re-building in a buffer zone of a 100 m from the shore-line in Southern provinces and 200 m in the North and East is an insurmountable difficulty for reconstruction. An estimated 56,000 houses were destroyed totally or partially in these zones. Affected people are angry because they can watch tourism related infra-structure being built in this zone. Lifting buffer zone law and organizing bank loans for affected people without collaterals are recommended as a speedy solution to the construction program. By later October 2005, only 3200 permanent houses had been built out of the 80,000 projected. As per Habaraduwa construction of houses in certain villages is threatened by the corruption of contractors. Quality of workmanship in respect of completed houses is below the accepted level.

Urban Design:

1. Pride of place should be given to tsunami resistant construction schemes that attempt to infuse traditional housing with modern building design to assure future tsunamis are less destructive.
2. Provision should be made for open public space suitable for entertainment activity.
3. A playground should be established to be used in common by the schools in the DS division.
4. Action should be taken to develop mangroves along the coastline.
5. A comprehensive network of storm water drains should be constructed enveloping the township and its vicinity.
6. The network of motorable roads spreading from the township to the interior should be repaired and maintained.

[P1-2-2-10] Community Base Action in Coastal Forest Rehabilitation of Tsunami Affected Area in Nanggroe Aceh Darussalam, Indonesia

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On the morning of 26 th December 2004 tidal wave of Indian Ocean was 10 meter or more in height and with great force caused indescribable damage to millions of hectares of coastal land in North Sumatra, Indonesia. The life in the coastal towns and villages was totally paralyzed stricken and while other Asian countries Srilanka, India, Thailand, Maldives and Malaysia were similarly affected. But the severity of the damage seems to have been the greatest in the Aceh Province (Nanggroe Aceh Darussalam), Indonesia.

The tsunami wave had wiped out the coastal forest more than 440.000 ha, consist of 240.000 ha mangrove forest and more than 200.000 ha of Cassuarina, coconut, and others forest crops in the coastal zone of Nanggroe Aceh Darussalam. By functions in protecting the tidal wave and natural ecosystem in coastal zone, mangrove is the best amongst the other crops. Mangrove has an important function, directly or indirectly, for man, as well as for other organisms associated with the ecosystem. Some of these functions include protection of the coast, trap of sediment from land, protection for particular organisms, hatching, brooding, foraging of various organisms as could be identified by the existence of various organisms in the ecosystem, including shrimps, fishs, cockles, etc. Mangrove forests also have other functions such as production of timber for various uses.

Before the tsunami, mangrove forest growth up to 358,701 ha in Aceh Province, located in 13 districts and cities. The larger part of these mangrove forests (169,580 ha) was located in Aceh Timur, Kota Langsa and Aceh Tamiang, namely in the boundaries with North Sumatera Province may have been destroyed (60%) by human activities with ponds and coal furnaces. Besides, there is a coastal forest of 20,200 ha in area. Population growth and development activities contribute a lot to ecological pressure on the coastal ecosystem, directly (e.g., logging, conversions) and indirectly (e.g., contamination by solid and liquid wastes, and oil spill).

Mangrove forests have strategic values for the people living along the coasts in general, particularly in Nanggroe Aceh Darussalam Province where almost all of its areas are located along the coasts. The experience of the natural disaster on December 26, 2004, prompted us to consider the importance of maintaining mangrove forests and coastal forests along the coastal areas.

In order that the socioeconomic and ecological functions of the mangrove system are maintained, it is necessary to prepare a mangrove forest ecosystem zone management strategy. The preparation of the strategy will first require a study of the biophysical character of the zone and an analysis of the problems within a mangrove forest ecosystem zone. The biophysical character and the problems should be identified and the principles of the management should be determined.

As provided in National Law No. 41 of 1999 on Forestry, the principles of mangrove forest management will not differ much from the management a forest in general. The forest as the national development asset has concrete benefits for the nation, including ecological, sociocultural and economic benefits in a harmonious and balanced manner. Accordingly, the forests should be properly managed and cared, protected and utilized in a sustainable manner, for the welfare of the Indonesian people of the present and future generations. In its function as a life supporting system, the forest has given an immense benefit for man, and should therefore be properly preserved.

By the model of management, the mangrove forests are categorized by industrial forest and non-industrial forests. Industrial forests are made to support production function, while non-industrial forests are made to serve conservation function. Another concept is a combination between the two, for instance timber production function and silvofishery or ecotourism as is being promoted in a number of locations.

The development of a Mangrove Zone for silvofishery purposes must consider the aspects of the coastal spatial plan besides the besides the resources of the particular coast. This aspects is provided in National Law No. 4 of 1982 on the Principles of the Environmental Management, National Law No. 5 of 1990 on Conservation of Natural Resources and their Ecosystems, and National Law No. 24 of 1992 on Spatial Plans.

The above conditions indicate the agreement and support of the people of the development of mangrove forests for the purpose of preserving the coastal areas and for sources of living. The accessibility of the people to the natural resources is an important issue in the economic development for the people. It is expected that through this step, the people will have an opportunity for the sustainable utilization of natural resources. Such an opportunity will not only contribute to increasing and maintaining the people's economy, but also encouraging the people to more actively protect the environment, through environmental-friendly utilization as well as efforts to actively keep the forest from destruction.

Besides, the people's accessibility to the potentials of the coastal areas and the sea for transportation and tourism should be increased. Efforts to increase activities and to expand employment opportunities for the local people will also be expected. The development of such sectors as tourism may encourage people's activities to participate in protecting the environment, particularly if the implementation is done in the correct time. Increasing the people's accessibility to the natural resources will be highly important because most of the coastal people have been and are still depending on natural resources.

For the people living around the mangrove forests, participation should be promoted in coastal forest rehabilitation by a silvofishery scheme of mangrove and crabs or other species that are ecologically suitable. This system requires a simple technology, does not adversely affect the existing mangrove and may be done as a side activity while in the efforts to replanting the greenbelt zone in a critical coastal area.

Comprehensive strategies for protection of the coastal environment and sustainable use of their services are needed to meet these challenges. These strategies have to meet and integrate with national, regional and International policy frameworks. It is equally important to involve communities as well as the full range of stakeholders in coastal rehabilitation actions.

[P1-2-2-11] Sustaining Community Outreach Programmes : Learning from past experiences

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The nature and scale of the 2004 Tsunami was unprecedented for the small population of Andaman & Nicobar islands in the Bay of Bengal. The memories of this disaster will be permanently etched in the history of these islands. The islands' proximity to the seismically active region also increases chances of such disasters to occur again.

For future, the real challenge would be to ensure that the learning on prevention, preparedness measures against disasters remains with both the survivors as well as incoming generations. Interventions are therefore needed in influencing aspects of the community's daily living patterns.

The community's vulnerability is defined largely by their environment and cultural traditions. The starting point for defining any intervention would be to gain a complete understanding of their existing physical and social vulnerability and their capacity. In the Andaman & Nicobar islands, the small size of the population, their remote location and sensitive ecology has unique implications on their vulnerability.

Empowering common citizens, and in particular the vulnerable groups within these islands requires design of realistic communication strategies. Based on an understanding of the local physical and social vulnerability, capacity building exercises would need to target citizens in general with focus on school children, construction workers, local government and peoples' representatives.

The international early warning efforts would fail in their objectives unless adequate capacity exists at the grassroots to be able to reach the most vulnerable. A successful early warning system would hence require developing vertical linkages that enable quick and easy transmission of information to the most vulnerable individual and the latters ability to take correct actions towards his own and his family's safety.

Sustaining capacity building efforts have to address the infrequent nature of natural disasters. Over a period of time, the effectiveness of outreach programmes may potentially be lost unless they are made part of the ongoing outreach programmes being carried out in the broader realm of sustainable development.

The proposed paper/presentation would put forth ideas and experiments based on the authors' experience of working in the Andaman & Nicobar islands after the Tsunami , and previous engagements in other disaster affected regions.

[P1-2-2-12] Establishment Plan of Aceh Heritage Tsunami Estate (AHTE)

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The December 2004 tsunami disaster has destroyed many lives, many infrastructures and many hopes. The catastrophe leaves a landmark of immense devastation. Aceh Heritage Tsunami Estate (AHTE) is planned to be established for transforming this devastation into new hopes. Suggested structure of AHTE is shown in Figure 1. The Estate has both hard and soft components. Hard component consisted of the museum, cultural center, institute and Research Park.

The institute will host the soft components of AHTE in the forms of various centers for research as well as a data & information center. Centers being considered for the institute are: center for tsunami studies; center for political studies; center for history, anthropology and culture; center for demographic studies; center for social studies & conflict resolution; center for religious studies; center for economic studies; center for natural resources of Aceh; and the data & information center. The centers are expected to have the roles of developing human resources; facilitating residencies of staff, graduate students, visiting scientists & experts; helping to build linkages with national as well as international experts; and favoring cross-fertilizations with the industrial tenants of the research park.

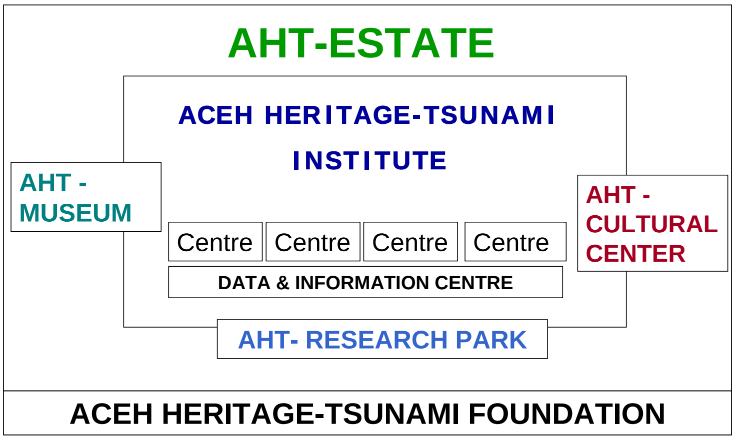

Figure 1. Suggested structure of AHTE.

The cultural center will host various types of cultural and scientific events. The museum is designed to depict the event of tsunami as an interface that links the past, present, and future of Aceh through its heritage and science. The research park is designed to attract industrial tenants linked by a long-term research, contract with one (or several) of the center(s) for research and completed by public facilities.

The project will have two phases, namely the initiation phase and the execution phase. The initiation phase consists of activities such as design and conception, fund raising and establishing the project's governance. The execution phase consists of activities such as design, implementation and commissioning of the various hard and soft components. A foundation will be made to act as an umbrella for the project execution. The board members of the foundation will consist of members from the proponents, representatives of Aceh civil society, representatives from relevant organizations, and national and international experts.

[P1-2-2-13] Tsunami Risk Awareness in the Affected Communities

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Objective

A large earthquake of magnitude 9.0 on Richter scale occurred off the Sumatra Island caused enormous tsunami damage in the coast of Indian Ocean. Death toll and missing are estimated about 300,000 and almost 1.2 million people are affected by the tsunami. It is said that the absence of early warning system in Indian Ocean like in the Pacific Ocean and lack of the knowledge about tsunami caused such great damage. However, the reason for the damage is not demonstrated by the definite sources in the present circumstances.

Based on the reason mentioned above, the authors carried out questionnaire surveys on tsunami awareness in Sri Lanka, the Maldives[1] and Indonesia on the scale of 5,000 samples. The purposes of the survey are to assess and evaluate current situation and community's capacity to respond to natural disasters, and to propose a strategy for dissemination of tsunami knowledge while raising public awareness on tsunami disaster.

Methodology

Basically the survey focused on two categories of sample groups and different methodologies have been adopted to collect data from distinctive target groups as follows.

- Residents: Questionnaires filled followed by an interview
- School children: Questionnaires filled under the instructions of a teacher

Results and Conclusions

After analyzing the results both quantitatively and qualitatively, the authors could reach the following interesting conclusions.

Residents

(1) While many residents evacuated to a higher place at the occurrence of Tsunami, a considerable number of people rushed to the sea to have a look as the sea level dropped. (2) Most of the resident’s possess very limited knowledge of a tsunami. (3) The most useful information source soon after the Tsunami was verbal communications with the family or neighbors. (4) A large number of respondents answered that the most effective ways to raise public awareness on disaster reduction were education in schools. (5) Residents consider that the establishment of early warning system for natural disasters should be promoted for disaster reduction.

School children (in Sri Lanka)

(1) Almost half of school children responded that they have never learnt about natural disasters. (2) The results revealed that approximately one third of children were still ignorant about the cause of a tsunami. (3) It is expected that disaster education in schools in turn might have a positive impact on educating adults as well.

Based on the findings of the questionnaire surveys, the following recommendations are proposed as strategies for disseminating knowledge and raising public awareness of tsunami disasters: (1) Promote disaster education at the school level. (2) Implement community-level public awareness programs.

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[1] Survey in the Maldives was conducted by ADRC for UNDP Maldives.

[P1-2-2-14] Strengthening Communities Through Partnership – The ADRRN Model

Aishah Mohd Amin - MERCY Malaysia

Introduction

Asia, the most disaster prone continent in the world experienced more than half of the world's major disasters in the last half century. As a result, economies and human societies were affected, lives were lost and nations continue to struggle to recover.

Alarmingly, these disasters are on a rising trend as a result of many factors including global climate change, rapid and unplanned urbanization, environmental degradation and depletion of water resources. As a result, there is a feverish intensification of initiatives to address disaster reduction, response and the development of total disaster risk management.

Multilevel networking and collaborations have increased among stakeholders of whom NGOs feature prominently apart from governments and international organizations. NGOs play an undeniably critical role - their actions range between humanitarian aid to complementing disaster preparedness programs by respective governments. Most importantly, community resilience had to be enhanced. This can be achieved by sharing with them knowledge on how to live with risk - encompassing early warning, preparedness and response in emergencies.

As a result, the Asian Disaster Reduction & Response Network (ADRRN) was formed. This loose body of NGOs was consolidated in December 2003 and in June 2004, the structure, content and direction of the ADRRN was clearly formulated and implemented.

Since then, the partnership proved to be successful with other Asian NGOs participation through membership in the network. The network has been put into test during the emergency response for thunderstorm in Infanta, Phillippines, and is again beneficial during the tsunami tragedy affecting Indonesia, Sri Lanka and Malaysia.

Rebuilding A Safer Aceh Workshop, April 2005

Experts from Japan, Indonesia, India, Nepal and Malaysia participated in this project. The project included a workshop in Banda Aceh on building codes, materials and techniques for building seismic resistant houses. There were 150 participants from the local government authorities, NGOs (Local and International), academicians, builders and suppliers of building materials.

In order to promote community involvement in rebuilding a better and safer Aceh, the stakeholders shared ownership of the workshop with the local government and the workshop was held at the Department of Urban and Rural planning office.

The workshop itself ended with a field “Shake Table” demonstration where two typical Acehnese model houses were built, one by conventional techniques and the other using seismic resistant reinforcements. The houses were exposed to earthquake simulations which demonstrated that the reinforced houses were resilient to damage and thus the need for “stronger” houses needed to be rebuilt. Three hundred participants witnessed the dramatic demonstration. The initial response from the community towards the need for rebuilding seismic resistant houses was mixed. Some were sceptical whether there was such a need but after the workshop and the open demonstration of the “Shake Table” where the entire village including women and children witnessed the effects of the simulation, there was widespread acceptance.

The training sessions also included a four week hands on training of masons and builders by ADRRN members. Local masons and builders were trained and some of these trainees were from the beneficiary community who would prove invaluable in the rebuilding projects.

In order to encourage participatory planning, the design of the houses was shared with the beneficiaries who gave their input. At all times, the local culture was preserved and a final output in terms of design, materials and structure was agreed upon. The beneficiaries endorsed the design before implementation of the rebuilding project.

'Inamura No Hi' – A tool for disaster preparedness post-tsunami

In order to prepare the community for future disasters especially earthquakes, typhoons and tsunamis that could result afterwards, several preparedness projects were undertaken.

We used the experiences of Japan in the "Inamura No Hi" story telling project which utilises folklore to describe the action after and earthquake which saved a large community from death from the tsunami that followed. Children's story books and adult educational books were produced and distributed to the communities vulnerable to disasters.

'Inamura No Hi' is a Japanese folklore about a farmer who burnt his rice stacks to warn the people of the impending tsunami and guided them to safety in the highlands. This project was undertaken by ADRRN funded by the government of Japan with the production of children and adult books in eight languages including English, Bahasa Indonesia, Singhalese, Bangladesh, Nepalese, Tamil, and Bahasa Malaysia. These books are widely distributed by the partner NGOs in respective countries.

ADRRN/GOLFRE Learning Workshop – Disaster Risk Reduction : Learning from Tsunami Experience

Recognising the importance of sharing the valuable experience and skills and learning from each other, an international field based programme of activities for NGOs, field workers, disaster and development managers was designed by partner members and academicians in the network. The objective of the workshop is to train them to become skilled and competent in risk reduction and disaster management. The programme deals with risk related to both natural and man made hazards in both urban and rural settings.

It is a joint program with the Global Open Learning Forum on Risk Education (GOLFRE) which runs from 22 to 30 November in University of Science Malaysia, Penang.

Conclusion

It is very important to recognise that the experience, skills and contacts of Asian NGOs working in disaster response and risk management are vital to be shared and their efforts must be consolidated and coordinated. All of them have vast experience in earthquakes, typhoons and other disasters. This has an added value of providing solidarity and understanding that there are other communities at risk and sharing their experience on managing risk and rebuilding lives would be instrumental.

[P1-2-2-15] Education on the Earthquake Disaster Reduction for International Students in Japan.

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More than 100,000 international students are learning in Japanese universities. The University of Tokyo alone has more than 2,100 international students, that is approximately 7.5% of the total number of students. In contrast to Japanese students, most of the international students have insufficient knowledge and experience in earthquakes and their disasters, and have little opportunities to learn systematically about them. The tragedy of Off-Sumatra great earthquake in December 2004 teaches us the importance of the knowledge of natural disasters such as earthquakes or tsunamis. It is one of the responsibilities for us to provide the opportunity to learn what are earthquakes and their disasters for the international students.

As well known, self-help and mutual assistance are as important as government assistance in disaster mitigation. Therefore the effort for education and dissemination should be made for non-specialists as well as specialists. In most of the assistance by advanced countries in disaster mitigation, specialists are sent to the developing countries or their specialists are invited to the advanced countries for education and dissemination. In such cases the number of specialists are limited and they cost relatively high. The aim of our project is to increase an awareness of seismic risk to non-specialist of earthquake related disasters with highly educated students. We expect that their knowledge and experience of earthquakes and their disaster reduction will contribute to increase the potential for countermeasures through companies or organizations that they will belong to after they come back to their home countries. Education to the international students can be made in most of the Japanese universities if we can make simple textbook and education manual.

This year we have started seminars on earthquake and their disaster reduction for international students in Tokyo area. Four topics are selected for the seminar. 1) What are earthquakes and tsunamis? 2) What buildings are vulnerable to earthquakes? 3) What should we do in case of earthquakes? 4) Risk of Tokyo earthquakes. Seminars in both Japanese and English are held separately for all four topics listed above. More students participated for English seminars than Japanese ones, probably because they have less opportunity to hear about earthquakes in English. Japanese seminars are also necessary though many public lectures on earthquakes and earthquake disasters are held, because special term in earthquake and disasters are not familiar to non-native Japanese speaking students.

This kind of effort should be made in collaboration among universities in the countries of advanced disaster mitigation achievement.

[P1-2-3-1] Field Investigation of the 2004 Indian ocean tsunami on the affected coast

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Field survey in the damaged area

The severest affected area of Indonesia is the Northern part of Sumatra, and it is reported that the coastal areas along the coast are completely destroyed by the strong shake and sudden attack of the big tsunami. The inland inundation mark was found up to 5 kilometers from the coast, and there were lot of debris carried out by the tsunami wave into the center of the city, which should increase the destructive power of the tsunami. The Survey by ITST (International Tsunami Survey Team) indicates that the tsunami had reached to 40 m height and 5 km inland in the northern Sumatra. The tsunami in Thailand which is located in the east part of the source, exceeds 15 m. The tsunami propagated over the Indian ocean and reach ed east and south Coast in Sri Lanka around two hours after the shake. The coast had been totally damaged, the tsunami ranging 5-15 m.

People observed some phenomena when TSUNAMI was coming, like: various sounds, blast, etc. Seawater configured with a long tidal wave horizontally and showed its “abnormality”, but people could not understand. If it could be evaluated and classified “the unusual, or abnormality’’ for TSUNAMI attack, its warning information could be established & circulated; or recognized the danger, and people could evacuate. Considering the facts and findings, this paper has focused on the direction of research, its system and the respective solutions which seems necessary for Japan for its active participation.

Impact on the environment and rule of mangrove

The 2004 Indian Tsunami gave an opportunity to evaluate the impact on the environment and to assess the role of mangrove forests in reducing impacts of tsunamis in coastal area. This should be done systematically by relevant experts and agencies with several fields. Mangrove forests, in particular, shield coastlines and protect the area behind by reducing wave amplitude and energy. Coastlines fringed by mangroves were strikingly less damaged than those where mangroves were absent or had been removed. Field reports indicate that mangroves also prevented people being washed into the sea, which was a major cause of death. In addition, mangroves trapped driftwood preventing property damage and injury to people Green belts of other trees, coastal dunes. The destruction of the mangrove should be investigated more to know the limitation of the rule.

Tsunami deposits and stones

A large tsunami can remove sediments from the sea bottom and the beach, and transport a large amount of sediments landward to form tsunami deposits. Distribution of tsunami deposits and their sedimentological characteristics (e.g., thickness, grain size, sedimentary structures) are useful information to estimate the hydrodynamic force of the tsunami wave currents during their sedimentation. Thus, we preliminary investigated the distribution and their characteristics around the Khao Lak area (Goto et al., 2005).In Pakarang Cape near Khao Lak, there were abundant tsunami stones, which were composed of fragments of coral up to 4 m in diameter. Tsunami stones are distributed from 0 to 500 m offshore from the shoreline. No tsunami stones are observed on land, suggesting that the hydrodynamic force of the tsunami wave currents have suddenly became weak near the shoreline. According to our field observation, coral rag was developed around this cape and formed very shallow and flat sea floor within 700 m offshore from the shoreline, and the water depth steeply became deep more than 700 m. We infer that tsunami waves probably impacted to the reef edge around 700 m away from the shoreline and transported fragments of coral landward.

Topics of further research and countermeasure

Due to the Indian tsunami disaster on December 26, 2004, countries around the Indian Ocean were severely damaged. Rebuilding and recovery processes have been carried out with help from both national and international agencies. Meanwhile, the efforts are still in their initial stages. Many people have yet to re-establish secure livelihoods, and continue to need relief assistance. On country levels, environmental and disaster management programs are required for protection and prevention of future disasters. Lessons of the catastrophe can be summarized into the following:

- Revising the numerical model of tsunami including the sand sediment and debris in coast and on land
- Integrated disaster mitigation program for each region to mitigate tsunamis as well as typhoons, erosion and flood
- Developing the monitoring and warning system with information technology evacuation
- Data Base to compile the all data and visual material which are obtained at the damaged area
- International network for the community, education and Hazards map in increasing the awareness

[P1-2-3-2] Jawa-Sumatran Tsunamis, their Modeling, and Mitigation

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Indonesian Tsunami catalog has been established by Latief, Puspito and Imamura (2000), and the catalog was developed into the Indonesian tsunami database by Latief et. al (2003), where the data was compiled during the period 1600-2005. Base on the catalog, at least 108 tsunamis have occurred. Ninety eight events (90.8%) of them caused by earthquakes in a shallow region at subduction region and plate boundaries, 9 events (8.3%) by volcanic eruption and one event (0.9%) by landslide. Several tsunamis where located in western part of the Indian Ocean (Jawa-Sumatran side) have been simulated by numerical model such as: the- 1797 West Sumatra-, 1833 Bengkulu-, 1883 Krakatau Volcanic-, 1935 North Sumatra-, 1992 Flores-, 1994 East Java-, 2004 Aceh, and 2005 Nias Tsunamis.
The paleo-tsunamis around the Sumatra Island were reconstructed with tsunami sources base on the paleo-coral deformation studies (Natawidjaya, 2002). However, for the modern tsunamis, their sources were estimated base on the fault parameter from seismograph data. Tsunami run-up and inundation area at the Pancer buy and the Rajegwesi bay due to the 1994 East Java Tsunami were simulated with using more detail bathymetric and topography data. Those bays were also studied the effective of mangrove reduced tsunami. Moreover a risk assessment with considered tsunami hazard and vulnerability was studied for case of the 1992 Flores Tsunami at the Maumere coastal area by GIS. This paper also will describe a future potential tsunami in Sumatra and a concept of the national tsunami early warning system which related to the tsunami modelling.

KEYWORDS: Indonesia, Jawa-Sumatra, tsunami, risk assessment, mitigation, mangrove,

[P1-2-3-3] Forecasting of tsunami amplitudes by the Neuro-genetic algorithm

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Abstract The present study investigates an application of soft-computing technique for tsunami height forecasting. This technique comprises a combination of neuron network with the genetic algorithm. Three network architectures were investigated, i.e. the Back Propagation (BP), the Time Delay Neuron Network (TDNN), and the General Regression Neuron Network (GRNN). The genetic algorithm was used to define an optimum hidden layer node for the network. It was finally found that the GRNN is the best network for this particular case study. The forecasting tsunami amplitudes were compared with the 4 real tsunami events along the North American coast from the Northwest Pacific ocean tsunami (1958 S. Kuril, 1963 S. Kuril, 1968 N. Honshu, and 1994 S. Kuril). The prediction accuracy of the GRNN is quite satisfactory. This indicates an alternative approach for the tsunami forecasting by the soft-computing technique. We are now under developing a network for the Thailand Andaman coast.

The neural network and the GRNN model

Use of neural network (NN) techniques to solve problems in civil engineering began in the late 1980s. Their applications to simulating and forecasting problems in oceanographic problems are few and relatively recent (Supharatid, 2003). Unlike other conventional-based models, NN model is able to solve problems without any prior assumptions. As long as enough data are available, a neural network will extract any regularities or patterns that may exist and use it to form a relationship between input and output. Additional benefits include data error tolerance and the characteristic of being data-driven, thereby providing a capacity to learn and generalize patterns in noisy and ambiguous input data.

The GRNN is a neural network architecture that can solve any function approximation problems in the sense of estimating a probability distribution function. The learning process is equivalent to finding a surface in a multidimensional space that provides a best fit being measured by some statistical parameters. In GRNN, nearer projected state is weighted heavier than the remotely projected state in the phase space, which is a reasonable approximation. The GRNN is a three-layer network with one hidden layer described in Fig. 1. Each layer has entirely different roles:

- The input layer, where the inputs are applied.
- The hidden layer, where a nonlinear transformation is applied on the data from the input space to the hidden space, in most applications the hidden space is of high dimensionality.
- The linear output layer, where the outputs are produced.

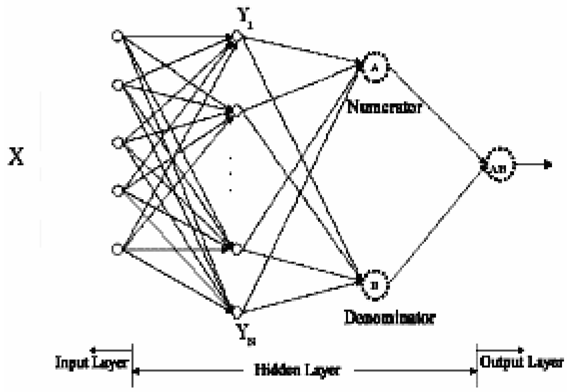

Fig. 1 GRNN architecture

The input is a state space denoted by earthquake parameters, X (Latitude, longitude, strike, dip, slip, length, width, depth, and M_w). and the desired output (Tsunami amplitude) is the measured value (Y). The computing value (O) is calculated by Eq. (1).

$$O_i = \frac{\sum_{i=1}^{N} Y_i \exp(-\frac{D_i^2}{2\sigma^2})}{\sum_{i=1}^{N} \exp(-\frac{D_i^2}{2\sigma^2})} \qquad (1)$$

where N is the number of input patterns, D_i^2 is a scalar function representing the Euclidean square from the new input pattern to the training input pattern, and σ is a single smoothing parameter which determines how tightly the network matches its predictions to the data in the training patterns.

2 Result discussions

Data used in this study were taken from Whitmore and Sokolowski, 1996 (Table 1). Fifteen hypothetical earthquakes and four real tsunami events in the Northwest Pacific ranging from M_w 7.5 to 9.0 were used for training and testing the network, respectively. The tsunami amplitudes in the hypothetical earthquakes are the numerical results from the shallow water model of Kowalik and Murty, 1993. Results from the GRNN are also shown in Table 1.

Area	Lat	Long	Strike	Dip	Slip	Length	Width	Depth	Mw	Tsunami amplitude (m)		
										Midway	Attu	Adak
Northern	39.5	143.6	182	20	90	60	37	18	7.5	0.18(0.21)	0.06(0.16)	0.12(0.14)
Honshu	41.5	142	156	20	38	200	100	43	8.2	0.3(0.35)	0.24(0.39)	0.18(0.21)
	41.3	141.8	182	20	90	650	200	73	9	1.51(1.36)	2.12(2.04)	0.73(0.72)
S. Kuril	43.3	147.5	54	76	129	70	30	44	7.5	0.12(0.19)	0(0.07)	0(0.06)
Islands	42.5	146.1	54	76	129	185	70	84	8.2	0.36(0.31)	0.18(0.19)	0.18(0.15)
	41.7	144.6	54	76	129	900	130	141	9	0.9(0.88)	1.45(1.41)	0.67(0.65)
N. Kuril/	52.7	160.6	214	30	90	60	37	21	7.5	0.12(0.24)	0.12(0.43)	0.06(0.18)
S.Kamchatka	52.7	160.2	214	30	90	200	70	38	8.2	0.56(0.37)	1.21(0.77)	0.3(0.26)
	53.2	158.5	214	30	110	650	200	103	9	1(1.02)	2.67(2.48)	1(0.93)
Kamchatka	56.1	164	214	30	90	60	37	21	7.5	0.1(0.24)	0.12(0.44)	0.18(0.19)
	56.2	163.6	214	30	90	200	70	38	8.2	0.42(0.36)	1(0.78)	0.36(0.27)
	56.6	162	214	30	90	650	200	103	9	0.79(0.98)	2.3(2.49)	1.7(0.92)
Commander	54.2	167.5	300	30	160	70	30	35	7.5	0.10(0.24)	0.18(0.45)	0.12(0.19)
Islands	53.6	169	300	30	160	200	65	69	8.2	0.24(0.39)	0.85(0.84)	0.24(0.29)
	52.2	174	300	30	160	800	100	104	9	0.42(0.88)	2.24(2.25)	0.85(0.82)
S. Kuril	44.4	148.6	225	30	90	150	70	53	8.4	0.2 (0.39)	0.2(0.64)	no data
S. Kuril	44.8	149.5	223	22	90	245	150	59	8.6	0.3 (0.73)	0.4(0.44)	no data
N. Honshu	41.5	142	156	20	38	200	100	43	8.2	0.2(0.35)	0.2(0.38)	no data
S. Kuril	42.5	146.1	54	76	129	185	70	85	8.2	0.27(0.31)	No data	no data

( ) GRNN results

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[P1-2-3-4] Sedimentation from the December 26th 2004 South Asia tsunami in northern Sumatra, Indonesia

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The 2004 South Asia tsunami flooded coastal northern Sumatra to a depth of over 20 m, deposited a discontinuous sheet of sand up to 80 cm thick, and left mud up to 5 km inland. In most places the sand sheet is normally graded, and in some it contains complex internal stratigraphy. Structures within the sand sheet may record the passage of up to 3 individual waves.

We studied the 2004 tsunami deposits in detail along a flow-parallel transect about 400 m long, 16 km southwest of Banda Aceh. Near the shore along this transect, the deposit is thin or absent. Between 50 and 400 m inland it ranges in thickness from 5 to 20 cm. The main trend in thickness is a tendency to thicken by filling low spots, most dramatically at pre-existing stream channels. Deposition generally attended inundation—along the transect, the tsunami deposited sand to within about 40 m of the inundation limit

Although the tsunami deposit contains primarily material indistinguishable from material found on the beach one month after the event, it also contains grain sizes and compositions unavailable on the current beach. Along the transect we studied, these grains become increasingly dominant both landward and upward in the deposit; possibly some landward source of sediment was exposed and exploited by the passage of the waves. The deposit also contains the unabraded shells of subtidal marine organisms, suggesting that at least part of the deposit came from offshore.

Grain sizes within the deposit tend to fine upward and landward, although individual units within the deposit appear massive, or show reverse grading. Sorting becomes better landward, although the most landward sites generally become poorly sorted from the inclusion of soil clasts. These sites commonly show interlayering of sandy units and soil clast units.

Deposits from the 2004 tsunami in Sumatra demonstrate the complex nature of the deposits of large tsunamis. Unlike the deposits of smaller tsunamis, internal stratigraphy is complex, and will require some effort to understand. The Sumatra deposits also show the contribution of multiple sediment sources, each of which has its own composition and grain size. Such complexity may allow more accurate modeling of flow depth and flow velocity for paleotsunamis, if an understanding of how tsunami hydraulics affect sedimentation can be established.

[P1-2-3-5] Comparing the Tsunamis of 2004 and 2005 in West Sumatra, Indonesia

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Abstract
Three earthquakes between December 2004 and April 2005 in the region of northern and western Sumatra produced tsunamis which affected both local and distant shores. The effects of the Mw = 9.3 December 26, 2004 earthquake and tsunami were of catastrophic proportions and widely reported in the scientific literature and popular media. This event was followed by a Mw = 8.7 earthquake on March 28, 2005 which was centered near Nias Island. This event caused substantial damage related to ground shaking and also generated a destructive local tsunami and was recorded on tide gauges throughout the Indian Ocean. A third earthquake (Mw = 6.7) on April 10, 2005 was centered further south along the Sumatra trench and generated a non destructive local tsunami which was observed in Padang, West Sumatra as well as in the northern Mentawai Islands. This presentation will disscuss the similarities and differences between the earthquakes and tsunamis as well as implications for hazard planning, warning systems and public education.

[P1-2-3-6] Tsunami warning system in Japan

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1. National Tsunami Warning System

The Japan Meteorological Agency (JMA) continuously monitors the seismic activity in and around Japan. When an earthquake takes place, JMA immediately determines the location and magnitude of the earthquake. If the earthquake occurs in ocean area with tsunamigenic potential, JMA executes the tsunami forecast operation using the database containing tsunami heights and arrival times constructed by numerical-simulation. Tsunami forecasts are categorized into two; Tsunami Warning and Tsunami Advisory, and Warning is divided into two classes; Major Tsunami and Tsunami, depending on the forecast height of the tsunami. JMA issues Warnings and/or Advisories for 66 forecast coastal regions which cover all of coastal areas of the country. The elapsed time for tsunami warning has been reduced to 3 - 5 minutes since JMA started tsunami warning service in 1952. Tsunami forecast contains the expected maximum tsunami height and the arrival time of the tsunami. Warnings and/or Advisories are provided to the national and local authorities for disaster prevention and the broadcasting media. Mayors of cities, towns or villages are responsible for giving directions to residents for evacuation from tsunami hazardous areas. JMA monitors tsunami observed by the tide gauges installed on the coasts of Japan for re-evaluation of tsunami forecast. JMA cancels Warnings and/or Advisories for the forecast coastal regions where the safety is recovered due to diminishing the tsunami heights observed.

When a large earthquake occurs at a distant area from Japan, JMA determines the location and the magnitude using seismic data from global seismological observation network. In case of possibility of tsunami generation, JMA immediately executes the tsunami forecast operation in the same manner as the local tsunami. JMA uses the database derived from numerical simulation to judge whether the tsunami affects Japanese coast. Data of tsunami observations from foreign countries are also referred for the estimation of tsunami height.

2. Northwest Pacific Tsunami Advisory Center

The establishment of regional tsunami warning centers has been discussed by the International Coordination Group for the Tsunami Warning System in the Pacific (ICG/ITSU) since 1978. With regard to the Northwest Pacific region, the Republic of Korea proposed at the 14th session of ICG/ITSU in 1993 that Japan should take the responsibility of operating a regional center for the area. At the 17th session of ICG/ITSU in 1999, JMA submitted a proposal to provide the tsunami information when a tsunami is expected due to the earthquake occurred in the Sea of Japan, and started to provide the tsunami information to Russia and the Republic of Korea in January 2001. In addition, JMA was requested by ICG/ITSU to expand its responsible regions and include the Northwest Pacific Ocean and its adjacent seas region. In response to this request, JMA developed the system to provide the tsunami information for all Northwest Pacific Ocean regions. JMA held the technical meeting in March 2005 in order to start the operation of the Northwest Pacific Tsunami Advisory Center (NWPTAC) smoothly. At the 20th session of ICG/ITSU in 2005, JMA reported that the necessary preparations had been completed, and then NWPTAC started its formal operation.

NWPTAC determines the location and magnitude of an earthquake using data from global and domestic seismological networks and estimates arrival time and height of tsunami with the tsunami forecast system based on numerical simulation technique of tsunami. Moreover, when tsunami is actually observed, the observed tsunami height is also announced. NWPTAC provides the information to the relevant countries (Russian Federation, Republic of Korea, China, the Philippines, Indonesia and Papua New Guinea) as the first phase. NWPTAC issued the information four times as of 15 November 2005.

The targeted area of NWPTAC will be expanded into the marginal seas of the Pacific including the South China Sea on a step-by-step basis.

3. Interim Provision of Tsunami Watch Information for the Indian Ocean Countries

During the UN World Conference on Disaster Reduction (WCDR) held in Kobe, Japan, in January 2005, the Regional/Thematic Special Session entitled "Promotion of tsunami disaster mitigation in the Indian Ocean" sought the way to establish the early warning system in the Indian Ocean region through international coordination from the professional point of view.

JMA commenced to provide Tsunami Watch Information to countries around the Indian Ocean in cooperation with the Pacific Tsunami Warning Center (PTWC) as an interim measure to be carried out until the tsunami early warning system in the Indian Ocean region becomes fully operational. Tsunami Watch

Information is issued in less than 20 to 30 minutes after the occurrence of an earthquake, depending on the availability of seismic data, and the Information contains earthquake information, tsunamigenic potential, and expected arrival times. Tsunami Watch Information should be regarded as a reference for taking preventive measure against possible tsunamis on the responsibility and initiative of the individual countries.

Tsunami Watch Information is provided to 26 countries and was issued eight times as of 25 November 2005.

[P1-2-3-7] Effect of earthquake rupture mechanism on tsunami generation and propagation
- Toward examination of a possible tsunami warning system applicable to M9 earthquakes -

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Tsunami warnings to coastal communities are required to mitigate tsunami disasters. First inputs to the existing tsunami warning systems are focal parameters such as the location, depth and magnitude of a large earthquake, determined by seismic observations. Recent technology makes tsunami warning systems more qualitatively (Tatehata 1997); pre-computed tsunami coastal amplitudes and travel times for numerous tsunami sources, calculated from assumed earthquake faults, are stored as a database. When a large earthquake occurs, the most appropriate tsunami source is determined from the database, and then coastal amplitudes and arrival times at a given location are forecasted. In addition, data assimilation from real-time, direct offshore tsunami observations improve the accuracy of the forecast (Gonzalez et al., 2005). The qualitative forecast system has been well functioned for large earthquakes with M~8 or less; because the source size is approximately 100 km for M~8, the total source duration is much shorter than 1 min. Tsunami generation is less affected by earthquake rupture propagation and initial tsunami profile can be considered to create instantaneously. For an M~9 gigantic earthquake with the source size of over several hundreds of kilometers, however, the long duration of the earthquake rupture propagation may affect tsunami generation.

In this study, we will focus the effect of the earthquake rupture mechanism on tsunami generation and propagation, and would like to discuss the earthquake rupture mechanism and tsunami forecast. In particular, it would be important to investigate the limitation or robustness of the existing tsunami warning (forecast) system for M~9 gigantic earthquakes. For the 2004 Sumatra-Andaman earthquake, several source models have been estimated from seismic waveform inversions (e.g., Ammon et al, 2005; Yamanaka, 2005), high-frequency seismic radiation studies (e.g., Ishii et al., 2005; Ni et al., 2005), and tsunami inversions (e.g., Hirata et al.,2005; Tanioka et al., 2005). These models show common futures with some disagreements. For an example, these studies suggest that rupture propagation velocity cannot be constrained well but possibly ranges from 0.7 km/sec to 2.8 km/sec. In the first step of this study, we will investigate how rupture propagation velocity, source size, and other parameters affect amplitudes and travel times of coastal and offshore tsunamis by using numerical simulations.

[P1-2-3-8] Offshore Tsunami Monitoring Network Design using GPS Buoys and Coastal on-site Sensors

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Establishment of the offshore tsunami monitoring network system is an urgent task for countries facing to ocean. Nevertheless, as a huge disastrous tsunami is a rare event, it is difficult to make understand the importance of maintaining and operating the network system, if the system is applicable only for tsunami events. Therefore, the network system needs to be applied to monitoring not only tsunami but also daily sea conditions such as coastal waves and tides. This presentation introduces a basic design of Japanese nationwide tsunami monitoring system, by improving the NOWPHAS (Nationwide Ocean Wave information network for Ports and HArbourS) system (Nagai, 2002), and by using the newly developed GPS buoy system (Nagai et al., 2005).

Recently, GPS buoy tsunami detection system has newly been developed (Kato, et al., 2001). And the field experiment of the GPS buoy system proved its applicability to offshore waves, tides and tsunami observation (Nagai, et al., 2004). Real-Time-Kinematic (RTK) method is used in the system with on-land reference GPS station within 20km from the buoy, which is further offshore area than the existing NOWPHAS seabed installed sensor stations.

Horizontal allocation of the sensors is also proposed. Figure 1 is the proposed offshore observation network. Offshore tsunami sensors are to be installed with intervals of about half length of the tsunami wave source zone in order to obtain offshore tsunami height distribution along the coast. Therefore, considering a possible horizontal scale of near-coast tsunami generating earthquakes (Hatori, 2004), tsunami detection stations should be installed at intervals of 50-100km along the Pacific coast as shown in the Figure 1. Small islands on the ocean are suitable points for long-distance tsunami detection, which will be helpful for international tsunami disaster reduction.

Development and improvement of the International Tsunami Monitoring System is getting more importance after the 2004 Sumatra-Off-Earthquake Tsunami disaster. This presentation intends to contribute to the international efforts to prevent tsunami disasters by using our experiences in offshore tsunami, wave, and tide observation and network data analysis. Up to present, tsunami monitoring system was developed and established based on earthquake vibration observation data only. Nevertheless, earthquake vibration data may give us incorrect tsunami forecasting, for the strength of the vibration and the tsunami energy are not exactly proportional. Therefore, offshore and coastal tsunami-wave profile observation system should be included in the monitoring system. This presentation introduced basic design of the future tsunami monitoring system using newly developed GPS buoy system and other coastal and on-site sensors. A new method of tsunami data processing system is also to be introduced.

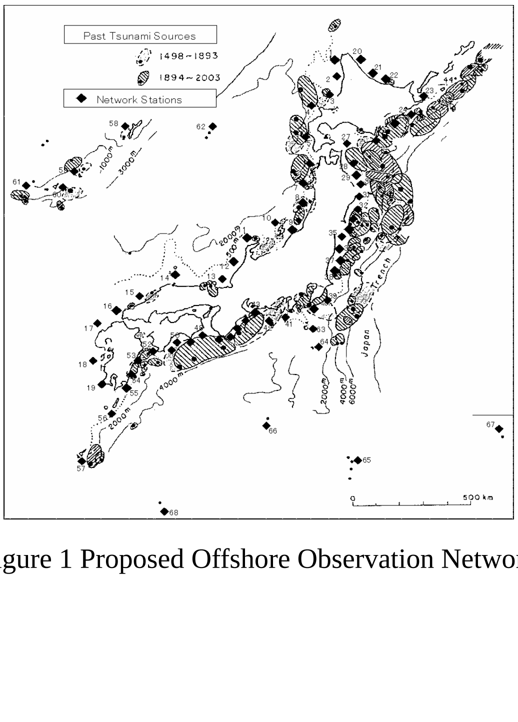

Figure 1 Proposed Offshore Observation Network.

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[P1-2-3-9] Proposal for Tsunami Study Program by KORDI

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The Korean peninsula has been thought to be relatively safe from the large tsunami damage by offshore earthquakes, even though there are some records of damages by the tsunamis occurring in the East/Japan Sea on 1983 and 1993. However, since the Sumatra tsunami on December 2004, some scientists began to recognize that a possible large tsunami in the Korean waters may take place by the propagation of the tsunami occurring in the open oceans, in addition to the tsunami in the East/Japan Sea. According to the results of the numerical model introduced by Titov et al.(2005), it took about 12 hours for the Sumatra tsunami signal to arrive along Ryukyu Island. Considering that the tidal waves reaching along the Ryukyu islands are intensified along the western Korean coasts by nearly four times, the tsunami from the open ocean deserves a special attention due to this possible amplification. Once a tsunami occurs in the Pacific Ocean, it may cause some significant impact on the Korean coasts, if the tsunami follows the route similar to tidal wave propagation, passing through the East China Sea, and propagating along the Korean coasts of the Yellow Sea and Korea/Tsusima Strait. Therefore, we pay a special attention to the tsunami in the Pacific Ocean, as well as other open oceans.

In relation to tsunamis the Korea Meteorological Agency (KMA) has been reinforcing the ability of speedy forecasting through the preparation of a database for the possible tsunami in the East/Japan Sea, while the National Oceanographic Research Institute (NORI) is in charge of sea level monitoring, which is gradually replacing the observation system as a realtime monitoring system. Meanwhile, Korea has been lacking the tsunami related research, due to its rare occurrence and relatively small damage, compared with other natural disasters. This idea among the public begins to change due to the global scale of tsunami occurrence and its huge damage, as seen in the disaster by the tsunami which occurred at Sumatra.

Recently the Korea Ocean Research and Development Institute (KORDI) starts to propose a research program with a view to examining the affect on the Korean coastal regions by the propagation and generation of a tsunami in the East/Japan Sea and the open oceans. We also came to have interests in the possibility of a tsunami occurrence in the Yellow Sea and southern region of the Korean peninsula, as well as the shelf break region of the East China Sea. In the proposal we placed stress upon the several research points as follows. First, development of an efficient numerical modeling system is needed in order to predict the propagation and attenuation of tsunamis occurring both in the open ocean and in the neighboring seas of the Korean peninsula. This modeling system needs to be based upon the accurate numerical model with an efficient model scheme. Secondly, some reinforcement of a tsunami monitoring system in the coastal areas seems to be required both for understanding the characteristics of tsunamis and obtaining data for numerical model validation. Third, the efficiency and the validity of a 30 minutes or one hour time-lagged prediction system may be checked, in addition to the existing database for the quick prediction within several minutes, as done for the submarine earthquake near the Japanese coasts of the East/Japan Sea.

[P1-2-3-10] DEVELOPMENT OF THE NATIONWIDE TSUNAMI INFORMATION NETWORK IN THE CENTRAL AND SOUTH PACIFIC OCEAN IN MEXICO

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Mexican Institute of Transport (IMT) of the Mexican Ministry of Communications and Transport (SCT, in Spanish) has been cooperated with Port and Airport Research Institute (PARI), Japan, for long years since 1984, when the technical cooperation project named as the "Mexico Port Hydraulic Center Project" started. Mexico Port Hydraulic Center Project was one of the project typed international cooperation activities financially assisted by the Japan International Cooperation Agency (JICA). The project term was in between 1984 and 1988. Irregular typed wave generators for hydraulic model experiment together with the field wave gauges were donated from Japan to Mexico during the project term. Some of those equipments are still used in the research activities of IMT now, although the Port Hydraulic Laboratory of the IMT moved from Mexico City to Querétaro City in 2001.

International Training Courses for the port hydraulic engineers in various Latin-American countries have been continuously held at IMT almost every year since 1988. Therefore, IMT serves as a Central Port Hydraulic Engineering Institute among the Latin-American countries.

IMT has been trying to establish coastal wave observation network for long years, by introducing the Japanese NOWPHAS (Nationwide Ocean Wave information network for Port and HarbourS) system. And, after the 2004 Sumatra-Earthquake-Tsunami, IMT is now intending to add tsunami information to the coastal wave information system.

The purpose of this paper is to introduce the plan of a nationwide tsunami information network in the Central and South Pacific Ocean (now under development in Mexico) as a part of the Nationwide Coastal Wave Information Network in Mexico.

The development of this plan in order to the establishment of the coastal tsunami monitoring network system rests on the follow sources and studies:

(1) Previous experiences conducted by Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE, in Spanish) in order to carry out measurements of tsunami in the Sauzal Fishery port in Mexico.
(2) Development of works in the short, medium, and long term for the nationwide coastal wave, meteorological and tsunami information network by means of installation of directional wave buoys, meteorological stations and pressure sensors respectively.

The development of the plan in the short term (2004-2006) includes the following actions:

- Development during 2004 of an historical database for a set of offshore locations distributed along the Mexican coastline by means of the WAM numerical model, taking into account the recorded wind fields from the period of 1958 to 2001.
- Development during 2005 of studies of wind and wave forecasting (in real time) for the main Mexican ports, by means of the MM5 numerical model and of the WAM and SWAN numerical models respectively.
- Installation during 2004, 2005 and 2006 of directional wave buoys, meteorological and pressure sensors for the tsunami coastal monitoring.

[P1-2-3-11] Current Status of Indonesian Tsunami Early Warning Systems

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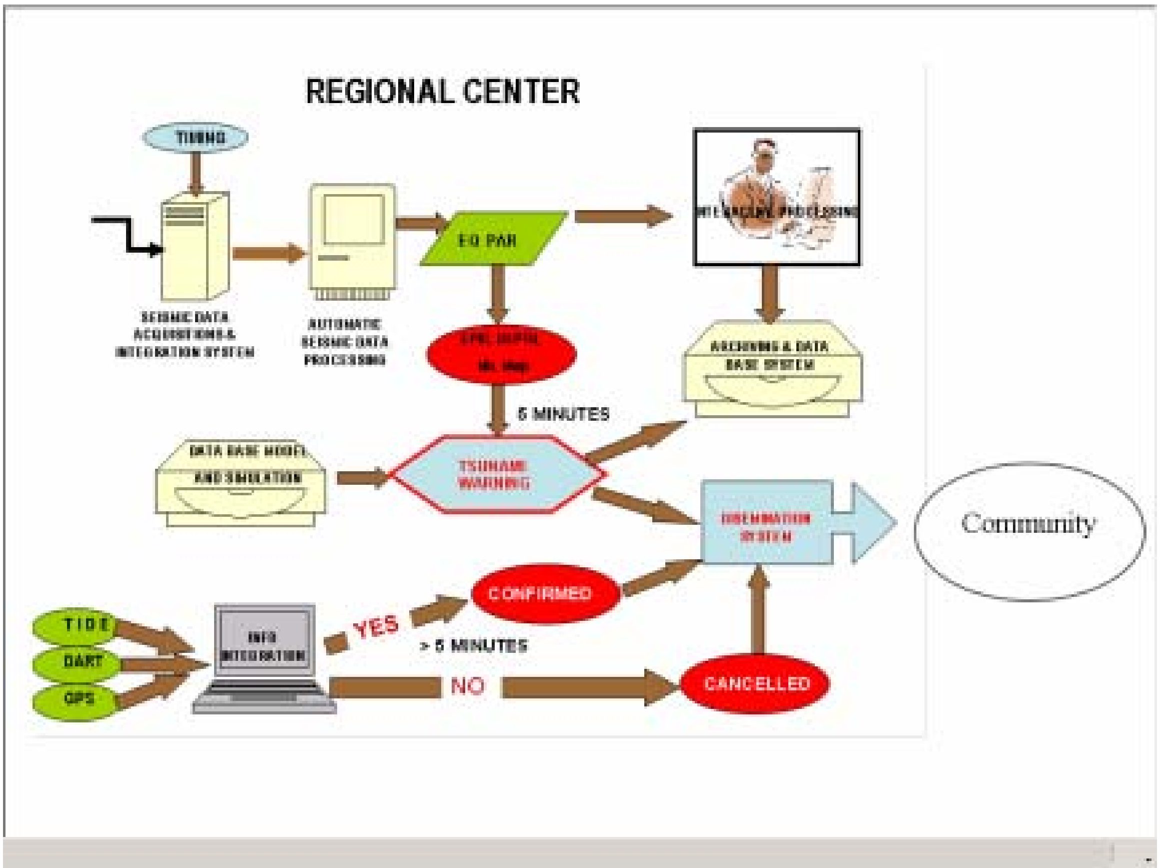
The devastating tsunami last December served as a wake-up call for disaster managers and governments especially in the Indian Ocean region, including Indonesia. Estimate on losses for the whole region stand at almost 300,000 lives and 17 billion US$ in property. Among other countries, Indonesia is most severely suffer from the disaster, which cause damages and losses totaling Rp. 42.7 trillion or US$ 4.5 billion, with more than 89 thousand people are dead, more than 132 thousand are still missing, and more than 340 thousand people are becoming refugees. Such large number of losses and sacrifices will be meaningless to the advancement of human civilization if there is no lesson learned from the catastrophe. Therefore, attempts should be taken in order to reduce the impact of the disasters should they take place again in the future.

Apart from efforts on rehabilitation and reconstruction to restore the life of the community in the disaster-affected region, the agenda on the development of tsunami early warning system has been high at the Government of Indonesia, especially at the State Ministry of Research and Technology. This presentation summarizes the work that has been carried out on the issue

The first part of the presentation describes research activities in the coastal related disaster stimulated by previous tsunami events in the country. This includes seismic activity monitoring, tsunami numerical modeling, oceanographic monitoring and crustal movement observation by GPS. Based on the existing competency, experts from various related agency develop the grand-scenario of tsunami early warning systems.

The early warning system being developed consists of three main parts, i.e. earthquake monitoring (form seismic networks), oceanographic observation and tsunami modeling (see Figure). Because the tsunami in Indonesia is of local type, the information from earthquake monitoring devices can directly trigger the issuance of warnings. The warning is then either confirmed or canceled once the results from oceanographic observation and tsunami modeling is obtained.

The grand-scenario also underlined the importance of capacity building and the development of community preparedness in mitigation efforts due to limited evacuation time available for coastal community in Indonesia in responding to the natural threat. The presentation also identify the generous assistance from foreign countries in developing such systems



Basic Design of Tsunami Early Warning Systems in Indonesia

[P1-2-3-12] Tsunami Damage to Oil Storage Facilities in Aceh Province, Sumatra, Indonesia

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In the giant tsunami on December 26, 2004, about 170,000 people were presumed dead or missing in Aceh Province of northwestern Sumatra of Indonesia. In Banda Aceh, the provincial capital, 70,000 people almost 1/4 of the population of 270,000 were killed. While a huge number of lives were lost, serious damage also occurred to road, water supplies and energy supply facilities and so on. In particular, in Krueng Raya and Lho'nga in the Banda Aceh suburbs, large petroleum storage tanks suffered unique damage: one was crushed, and another floated and was shifted a considerable distance.

It is very important to investigate these damages of tanks in order to improve rmeasures for oil storage facilities that are sited in similar condition in the world. The author visited Banda Aceh and its suburbs in March and August, 2005 to conduct damage investigations of the petroleum storage tanks of a cement factory in Lho'nga and an oil delivery terminal in Krueng Raya.

This report summarizes the result of the investigation and discusses countermeasures. The conclusions are as follows:

1) There are petroleum storage facilities all over the world, many located near the seashore and commonly without anchorage. Fortunately, neither a fire nor environmental destruction occurred in the tsunami of December 26, 2004, but it was shown that storage facilities near the seashore can suffer damage from a tidal wave. Furthermore, the possibility of world economy confusion resulting from a simultaneous damage of several major oil storage facilities cannot be denied.
2) Countermeasures that utilize tsunami early warning system against floatation are required for tanks in areas with a high risk of flooding by a tsunami. Protection measures should be taken to prevent a floating tank from crashing into nearby tanks.
3) It is hard to prevent piping on the ground surface from being moved by a tsunami. It is more effective to provide a flexible joint that enables piping to be broken off the tank side valve so that the flexible joint serves as a fuse when an unusually large force is applied to a tank from the piping. As far as a tsunami warning can be received, even during cargo work, a mechanism for positively shutting the valve on the tank side can be realized.
4) Conventional oil-spillage prevention dikes are designed for hydraulic pressure from the inner side. However, in the tsunami danger zone they should also be designed for tsunami pressure from the outer side.

Tanks of Cement Factory in Lho'nga

No. of tank	Specification of tank			Oil storage (%) in the case of the tsunami	Instal-lation year	Damage etc
	Applica-tion	Diameter (m)	Height (m)			
1	Water	23.30	14.62	100%	1981	Moved. The original shape was not maintained.
2	Distillate	23.30	14.62	75%	1981	Broke through the dike, moved and collided with neighboring structures. The original shape was not maintained.
3	Distillate	23.30	14.62	50%	1981	Broke through the dike, moved and collided with neighboring structures and was seriously deformed.
4	Distillate	11.65	10.98	50%	1981	Moved and was deformed.
5 ～ 10	Heavy fuel oil	3.05	5.719	?	1981	Moved. The deformed state was unknown. Factory ground was partially polluted with leaked heavy fuel oil.

Tanks of Oil Delivery Terminal in Krueng Raya

No. of tank	Specification of tank			Height of oil surface in the case of the tsunami (m)	Instal-lation year	Damage etc
	Applica-tion	Diameter (m)	Height (m)			
1	Gasoline	17.07	11.11	1.1	1986	Moved several hundreds of meters
2	Distillate	17.07	11.11	2.6	1986	
3	Distillate	17.07	11.11	0	1986	Moved several hundreds of meters
4	Kerosen	17.07	11.11	6.6	1986	
5	Jet fuel	10.98	6.23	2.5	1986	Moved 0.70 meters
6	Jet fuel	10.98	6.23	5.3	1986	
7	Gasolin	18.10	10.98	1.1	1990	Moved 314 meters
8	Kerosen	18.10	10.98	7.0	1990	
9	Distillate	18.10	10.98	2.4	1990	

Three tanks drifted about 300 meters and one moved 0.7 meters, Oil Delivery Terminal in Krueng Raya

[P1-3-0-1] Sea bottom shattered by the Sumatra-Andaman Earthquake of 26th December 2004

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ABSTRUCT

The Sumatra-Andaman earthquake of 26 December 2004 [seismic moment magnitude (Mw) = 9.3] broke 1,200km from northern Sumatra to Andaman Island. This earthquake is the second largest earthquake event in more than 40 years, and it caused the most devastating tsunami in recorded history. An area of particularly large and rapid co-seismic slip as one of tsunami source areas is estimated to be offshore of northern Sumatra, 200 km northwest of the beginning of the rupture at the epicenter. According to inversion of seismograms, the ocean bottom rose locally more than 5 m during the earthquake. Submarine geomorphic features and the pattern of co-seismic deformation are critical for modeling tsunami generation, yet they are poorly known. Here, for the first time, we show the deep-sea floor to be severely shattered by the M9 class earthquake.

[P1-3-0-2] Understanding the nature of giant earthquakes and tsunamis in Sumatra-Andaman to restore and establish safer cities around the Indian Ocean

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To restore the devastated areas from the December 26, 2004 tsunami we should understand what happened during the event, so then we can re-design the infrastructures accordingly. More importantly to prevent this mega human-disaster for recurring in the future we must put our best efforts to anticipate what could happen next. The 2004 Aceh-Andaman earthquake is the first giant (M_w>9.0) earthquake since the advent of modern space-based geodesy and broadband seismology. It therefore provides an unprecedented opportunity to study the characteristics of these rare events. We measure the ground displacements from near-field Global Positioning System (GPS) surveys in northwestern Sumatra, from observations of the vertical motion of coral reefs, and from analysis of satellite imageries. The earthquake was generated by rupture of the Sunda subduction megathrust over 1200 km and a width of less than 150 km. Slip on the subduction interface exceeded 20 m offshore northern Sumatra, mostly at depths shallower than 30 km. Slip diminish beneath Simelue Island at the southeastern edge of the rupture, where the earthquake nucleated and where an M_w 7.2 earthquake occurred in late 2002. This edge also abuts the northern limit of slip in the 28 March 2005 M_w 8.7 earthquake. The 2005 event produced spectacular landform changes along Simelue, Banyak, and Nias islands. About a hundred measurements of uplifted coral and two continuous GPS records reveal trench-parallel belts of uplift as high as 2.9 m on the islands and a 1-m-deep submergence trough between the islands and the mainland Sumatran coast. Physical modeling of these data yields the highest slips on the subduction interface beneath the islands – up to 13 m. The clear trenchward diminishment of uplift and slip may demonstrate the need for future slip – either seismic or aseismic – on that portion of the megathrust between the islands and the trench. Repetition of 2005-like ruptures would have to occur about every 200 to 365 years to keep up with rates of strain accumulation. The previous major earthquakes in Nias-Simelue region occurred in 1861 and in 1907. Both events had big tsunamis that killed thousands of people in Nias and Simelue. Immediately south of the 2005 rupture, from about the Equator to 0.5˚S is a short section of the megathrust that has failed by mostly aseismic slip and moderate earthquakes throughout the past 250 years. From 0.5˚ to about 5.5˚ S, the megathrust has broken repeatedly over the past 700 years during giant earthquakes. Large uplifts recorded in coral microatolls occurred in about AD mid-1300s and 1600s, and in 1797 and 1833. This suggests a reccurent interval of just over two centuries. Coral microatoll records and the Sumatran GPS Array (SuGAr) show that this large patch of the fault is currently locked. Uplift on the outer-arc islands associated with the 1797 rupture reached values as great as 1 m and extended from about 0.5˚ to 3.2˚S. The magnitude of the earthquake was in the mid-8s. Historical accounts indicate that tsunami run-up was between 5 and 10 m at Padang, a city of nearly a million people on the mainland west coast. Uplift during the 1833 earthquake ranged as high as 3 m and extended from about 2˚ to 5.5˚S. The magnitude of the event was about 8.9. Hence, the Sunda megathrust between about 0.5˚ and 5.5˚S seems to be late in its typical cycle of strain accumulation and that a future megathrust earthquake is likely within the next few decades. Last but not least, Sumatra has also a major strike-slip fault zone running along the backbone of the island.

This Sumatran fault accommodates most of parallel trench slip of the oblique plate convergence. Major earthquake magnitude 6.5 – 7.7 occurs 1 or 2 every decade. Banda Aceh city and Weh Island, the most densely populated areas in the northern part of Sumatra are located around the Sumatran fault zone. Therefore efforts to anticipate future natural disasters should also consider the danger posed by this on-land fault zone.

[P1-3-0-3] The 2004 Indian Ocean tsunami along the Indian coast: Observed sea levels, run-ups, extent of source region, and future plans

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Sea level data from seven tide gauges from the Indian coast show that the tsunami struck the Indian east coast around 0330 UTC shortly after the local high tide. The amplitude was 2.0 m above the tide at Chennai and Paradip, 1.5 m at Visakhapatnam and less than a metre at Tuticorin (Figure 1). The tsunami propagated along the west coast of India from the south to north and reached Kochi at 0541 UTC. The maximum amplitude at Kochi was about 80 cm and it was less than 10 cm at Okha in Gujarat. All these tide gauges recorded first a rise in sea level with the arrival of the tsunami, and then a sharp fall. Spectral and wavelet analysis show that the maximum energy was at a period of 35-45 min, with another maximum around 20 min. Along the Indian east coast (at Chennai, Visakhapatnam and Paradip), however, there is another broad peak between 1-2 hours within the first few hours after the first tsunami wave (Nagarajan et al., 2005).

Estimates of run-up at different locations at Andaman and Nicobar Islands and along the east coast of India showed large variations from location to location. The largest run-up occurred in the Andaman and Nicobar Islands. Malacca in Car Nicobar appears to have experienced the maximum run-up height of 7.0 m inundating up to ~ 1 km inland from the coastline. Sippighat in South Andaman Island experienced the maximum inundation of ~ 2 km though the run-up was only 2 m (Ramanamurthy et al., 2005). Along the east coast of India run-ups of 3.9 m and 3.5 m caused inundations up to a distance of 750 m and 80 m at Nagapttinam and Sathankuppam respectively, from the coastline. The maximum damage, in terms of destruction of houses and human life, occurred at Nagapattinam due to inundation on the gently sloping coastal land (Ramanamurthy et al., 2005). Another survey reports run-up height of 5.2 m at Nagapattinam (Chadha et al., 2005). The run-up height at Visakhapatanam was 2.5 m though the tide gauge installed at the port showed the tsunami height of ~ 1.4 m (Chadha et al., 2005).

Determining the length of the tsunami source region is one of the keys to understanding the complex nature of the 2004 Sumatra earthquake. Using backward ray tracing Lay et al. (2005) had estimated a 600-km length (up to ~9° N) for the tsunami source region. Adding tide-gauge data from Paradip, the northernmost of the Indian east-coast stations and therefore the most critical constraint on the northern extent of the source, the revised estimate shows that its length was greater by ~30%; ie. the source extended up to ~ 11° N (Neetu et al., 2005). This new northern extent constrains the tsunami travel time to Port Blair to ~30 minutes which is in agreement with the tide gauge report (G. A. Ramadass, personal communication).

A science plan, prepared at a workshop held at the National Institute of Oceanography, Goa, India discussed the factors that determine vulnerability of a coastal area to the marine hazards along the Indian coast. The issues that were identified in the science plan to improve India’s preparedness to face coastal hazards include (i) Identification of past storm surges and tsunamis in tide-gauge data, and their simulation; (ii) reconstruction of time series of past storm surges and tsunamis from geological record; (iii) geomorphology, nearshore bathymetry, and coastal inundation; (iv) coastal pollution; (v) seismicity; (vi) engineering; and (vii) education (Krishna, 2005).

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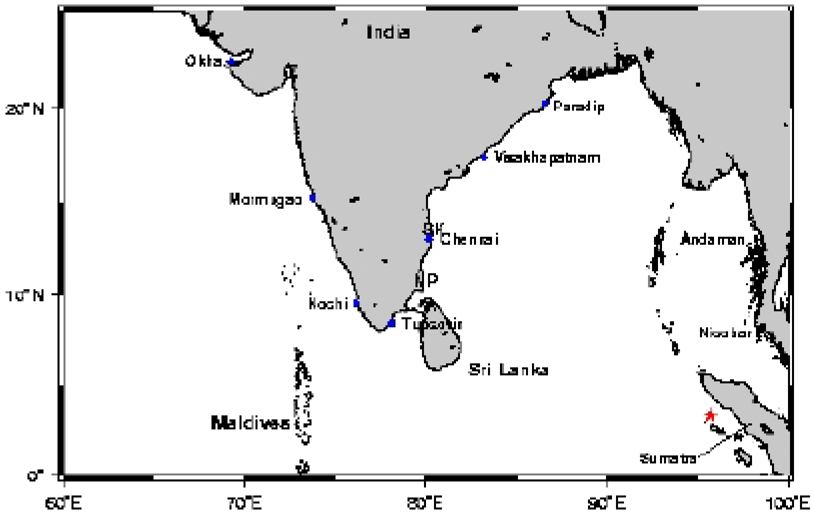

Figure 1. The locations of the tide-gauge stations operated by the Survey of India along the Indian coast (filled circles in blue). NP: Nagapattinam; SK: Sathankuppam. The red asterisk marks the epicentre of giant earth quake.

[P1-3-0-4] LEARNING FROM THE 2004 INDIAN OCEAN TSUNAMI-BUILDINGS DAMAGE AND CLUES FOR TSUNAMI RESISTANT DESIGN

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Abstract
The unprecedented devastating Indian Ocean tsunami which struck the western coast of southern Thailand on December 26, 2004 caused more than 5,300 deaths, and heavy damage to buildings in the affected areas. Valuable but costly lessons have been learned from the seismological, engineering, environmental, social and economic viewpoints. This paper touches mainly the structural damage in Southern Thailand, where run-up heights were 3-7 m above ground levels. Clues valuable for the safe and economical design of buildings against future tsunamis are also addressed.

The Indian Ocean tsunami catastrophe has instantly changed the state of natural disaster in Thailand. Prior to the event, the lack of historical records of destruction by tsunamis on Thai coastlines made the public, and even most academics, to be unaware of the possibility of tsunamis occurring along the coasts of the country. Consequently, the country was not prepared for the hazard, leading to great catastrophe and economic losses.

The damage caused by the tsunami clearly reveals inadequate design and construction of foundations, columns, joints, as well as retaining structures. Excessive damage could be attributed to the non-seismic design and construction in Thailand, featuring relatively small columns with light transverse reinforcement. The prevalent scouring of the soil supporting retaining walls and footings of buildings suggests putting buildings on piles in locations close to the shorelines or water ways. The current practice of weakly connecting infill masonry panels to the boundary reinforced concrete frames with widely spaced dowels has proved to work well in detaching the brick walls from the frames under excessive water pressure, thereby releasing the force transmitted to the building. The superior performance of brick walls with openings has been observed, and reinforced concrete frames with such walls should be advantageous in providing a sound low cost structural system with strength and robustness.

It is interesting to note that a large number of buildings, which have not been designed for seismic or tsunami loadings, have survived. This suggests that it is possible to design tsunami resistant structures with reparability performance level, pending further research.

Keywords
Indian Ocean Tsunami, Thailand, buildings, reinforced concrete, non-seismic, performance

[P1-3-1-1] Changes in Geomagnetic Transfer Functions: Pre and Post Sumatra earthquake

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Geomagnetic transfer functions are calculated from the geomagnetic field variations. These functions facilitate mapping the internal conductivity structure of the earth. In this study, we examined the changes of transfer functions obtained at Port Blair station (11.55° N, 92.70° E), associated with pre (February 1993) and post (February 2005) Sumatra earthquake (magnitude Mw 9.0, December 26, 2004 at 00:58:50 UTC, location at 3.298°N, 95.779°E, with a focal depth of about 30 km, off coast of Northern Sumatra).

As there was no way to estimate the normal field, with assumptions $Z_n << Z_a$, $X_a<<X_n$, $Ya<<Y_n$ and no correlation between Z_a and X_n & Y_n, single station transfer functions ($Z_a=AX_n+BY_n$) for a period range (8-128 min) are computed using FFT. Only nighttime variations have been used so as to avoid any contamination of the external ΔZ that originates in the ionosphere or the magnetosphere of the earth. As the measurements for the both epochs were carried out during the same time (i.e. February), the effect of seasonal changes are small.

In the present study, we observe the changes (reduction in magnitude) in the transfer functions at higher periodicity (e.g. 57-128 min) indicating that the conductivity of deeper layers has been increased due to this earthquake. This region being a major source of subduction related seismicity, having witnessed several major earthquakes in the past, the change in transfer functions could be attributed to either the intrusion of fluids (water & carbon dioxide that has been released by subducting Indian plate due to metamorphic reactions) or due to upwelling of the asthenosphere (magma intrusions).

Based on GPS constrained models of deformation above a flexed plate, the estimated uplift is less than 2 m west of Port Blair, which is within the deforming plate boundary. This uplift caused increased conductivity relative to the region east of Port Blair. This effectively reduced the observed induction response. And also, as the focal depths of the earthquakes indicates that the lithosphere beyond 10 km is conducive for stress accumulation, and can cause the dehydration of water from deeper layers and transported upwards and trapped beneath the impermeable layer, causing high conductivity.

The other possibility is that, in case of any crustal movements, the flow of concentration of induced currents takes new path resulting in the change of Induction arrows. The changes in B i.e. EW component of the transfer function (A, B) implies that significant changes took place in the induced currents flowing NS direction (along the rupture that took place about ~1200 km of the plate boundary spreading ~100 km wide). This supplements the GPS derived crustal deformation mainly in EW component.

[P1-3-2-1] Gender and Socioeconomic Analysis of Alleviating and Preventing Tsunami Affected Society: A Case Study from Sri Lanka and India

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Recently, many development assistance donors and experts have drawn attention to gender dimensions in the establishment of preventive measures for tsunami disaster and in the reconstruction of tsunami affected areas. Gender originally means the division of labor based on socially and culturally constructed differentiation not necessarily on the sexual difference. However, there has been an expanded concept of gender in the discussion and the practice of development assistance: not only women but also children, the elderly people, and the handicapped are considered the so-called "gendered group."

This study pays attention to women, children, Muslim as a minority group in Sri Lanka, and the untouchable people in India, with special focus on women. The report of the study is based on the author's field research conducted in Gaulle in Sri Lanka from August 10-15 and in the suburbs of Chennai, India from August 15-21, 2005. The author was a member of Nagoya University team which was composed by two other members, Hironobu Kimura and Atsuko Ohashi.

It is to be noted that women and girls were generally hard-hit in the tsunami. They often did not and do not know how to swim. Mothers sought to save children and the elderly people whose care were on their shoulders. Physical factors unique to women and girls, also contributed much to the reason they were seriously affected during and after the tsunami. Pregnancy, physical strength, and clothing can be identified among those factors which made women and girls more vulnerable.

Two levels of analysis, the household and the community, are made in this study. First is the household including women's place in the extended family relationship. Women usually lack of decision making in financing income at home, which means that women can not necessarily get easy access to the fund provided by the government and NGOs. For example, the government of Sri Lanka provided 5,000 ruppes to each tsunami affected family. But many women interviewees mentioned that their husbands spent the money for drinking.

Women have much burden in caring work at home and within the extended family. A representative example was found in the case in which a Muslim housewife was seriously injured in the tsunami because she had to take care of six children, and could not escape from the tsunami as quickly as her husband and other male members of her own and extended family. The three of the children were actually her sister's as her sister was working at Saudi Arabia as a housemaid in order to support her extended family.

The chronic relationship between poverty and the lack of education and skills turned out to be a source of big challenges which faced people living under poverty, particularly women in the aftermath of the tsunami. All the interviewees were fishermen and their wives. Temporary evacuation from their original residence caused much difficulty in the fishermen's going to fish as the temporary houses were often placed far from the ocean. Those who were capable of acquiring new skills such as making fishing nets and sewing cloth, were able to earn some additional income other than the government grant and/or the loan. Yet, the majority of illiterate men and women could not learn new skills.

As is often the case with developing countries such as Sri Lanka and India, the literacy rate of women and girls is much lower than that of men and boys. Moreover, fishermen do not culturally engaged in any other job other than fishing: they do not work at all during the non-fishing season. Such a cultural practice also made the life of fishermen's wives hard. They had to sell fish in the city which was far away from their community by knocking every door of the house, though women's traveling by themselves and knocking doors for the sale was socially and culturally considered negative.

The other level of analysis is the community. One of the dividing lines for social discrimination is found within the panchayat system in India. Within the same panchayat, only those who were the member of fishermen's cooperative received the government loan as the distribution of the loan was made through the panchayat leaders. Thus, those who were not the members of the cooperative as well as those who were not fishermen in fishermen's village, were excluded from such an aid. This is how the poorer in ordinary life before the tsunami, suffered more than the ones who were in the socially higher status, and more than in the post-tusnami period.

Moreover, these people were displaced very far from their original residence in the so-called temporary houses (though they have lived more than 6 months) without any job and any vocational training. Sanitary condition of those temporary houses was quite bad. Toilet facility for women was far from each household. The lack of privacy affected both men and women, particularly women and girls as the segregation of space between men and women is usually kept for religious reasons in society. .

On the other hand, some educated women have created self-help groups in which income generating projects such as shoes and handbag making were conducted. Some of them were able to utilize the government loan as seed-money for their projects. A strong leadership among educated women was observed in such activities.

An interesting case was also witnessed among the so-called untouchable women who were successfully facilitated their own business opportunity by a local NGO. The local NGO found a targeted women group which belong to the socially identified as the untouchable, and taught them coconut soap making. Their business has been subsidized by the NGO and thus the sustainbality of their business remains in question. Yet, those women were psychologically empowered and obtained self-esteem which is a key for participation in the community and society. This indicates that the socially vulnerable groups in the community and in the society can be empowered by some external actors such as local NGOs.

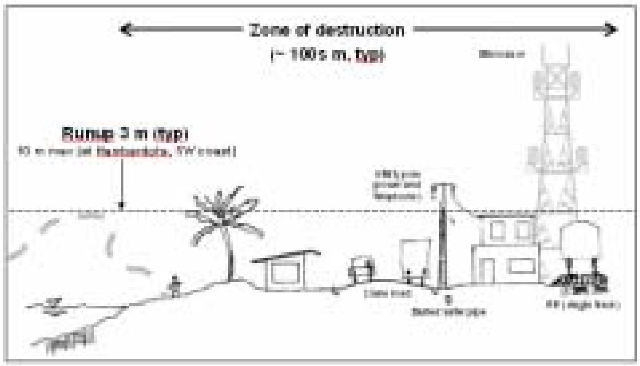
In the end of the presentation, some suggestions will be made necessary for the tsunami prevention measures and the reconstruction assistance from gender perspectives.

[P1-3-2-2] Mitigation of Tsunami Impact on Lifelines

C. Scawthorn[2]

Abstract

The 26 December 2004 Asian Tsunami caused major damage to lifelines in Sumatra, Sri Lanka, India and Thailand. In Sri Lanka the tsunami subjected a zone typically several hundred meters wide, including virtually the entire southwest, south, west and northwest coast of Sri Lanka, to a run-up averaging 3~4 m (12 max), resulting in severe damage, with many fishery harbors and anchorages, access roads, ice and cold room facilities, community centers, and electricity, drinking water and sanitary facilities destroyed or damaged. Lifeline impacts included drinking water supply and purifying plants were damaged in the south and west, causing the areas to experience severe shortages of fresh water. Electricity distribution poles and lines, including 600 km of low voltage lines, 50 km of medium voltage lines and 6500 km of service lines, as well as substations, were destroyed. The coastal road pavement was largely undamaged by the tsunami, with the exception of several locations where washouts occurred. Bridges in the coastal transportation corridor are low multi-span RC or steel trusses crossing coastal estuaries or streams - several were washed out, but most were undamaged. All damaged bridges had been replaced with temporary bridging at the time of the survey. The coastal railway line was extensively damaged, with one train washed away (over 1,000 lives lost), and 20 railway stations, 15 railway bridges, a large number of culverts and the signaling system severely affected. Telecommunications networks were damaged, but recovered quickly, replacing landlines with mobile service.



Northwestern and northern Sumatra were severely affected by the earthquake shaking and then tsunami runup that measured approximately 30 m at Lhok Nga, and 10 m at Banda Aceh, the provincial capital (popul.: 225,000). While some large buildings collapsed as a result of the earthquake shaking, most of the damage was due to the tsunami. Buried water transmission and distribution pipe was largely undamaged, with breaks occurring almost entirely at aboveground stream crossings. A number of mobile treatment plants were flown in, and water shortage was not a problem. Electric transmission line, step-down substation and diesel generating plant were outside the tsunami zone and not damaged by shaking. The tsunami carried a floating barge several kms inland, and district substations and electric utility poles in the tsunami-affected zone were generally destroyed. The port at Banda Aceh serves the fishing fleet. It was totally destroyed by the tsunami, as was much of the fleet, and was in partial operation at the time of the survey. The deep-water port for Banda Aceh is at Kr. Raya, about 20 km east of Banda Aceh, and consists of a oil cargo pier and associated tank farm, and a dry cargo pier to the east of the oil terminal.

In order to reduce tsunami impacts, tsunami-warning systems should be developed and installed in all locations of significant population bordering oceans and large bodies of water. Building codes should be changed to require that essential facilities be designed for tsunami and/or seiche in all locations bordering oceans and large bodies of water. Research should be conducted to develop methods to determine efficient design points for tsunami and seiche, new and improved

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anti-tsunami structural and urban planning designs, and emergency response techniques.

Keywords: tsunami, lifelines, damage, Sri Lanka, Sumatra, Indonesia, Aceh

[P1-p-1] Learning tsunami disasters through the puppet play "The Fire of Inamura (Rice Sheaves)"

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In December 1854, an enormous tsunami caused by the Nankai Earthquake attacked a little village on the Kii Peninsula in western Japan. The villagers, busy at home with the preparations for an upcoming festival, were unaware of its coming. Goryo Hamaguchi, a village headman spotting the threat from his hilltop location, set fire to his precious rice sheaves, the year’s harvest, to attract his fellow villagers from their homes below in order to save them from the tsunami.

Based on this historic fact, Lafcadio Hearn wrote a novel, which was revised 40 years later by schoolteacher Tsunezo Nakai and printed in state textbook under the title “The Fire of Inamura”

The puppet play production project for this story started with a proposal made by Tadashi Kojima, who himself experienced the terrors of the Great Hanshin-Awaji Earthquake. A committee was formed with the corporation of volunteer puppeteers around the area of Shizuoka Prefecture. Thanks to the support of many locals and puppet play enthusiasts, the committee compiled the play after a year of hard work and is presenting it around the country.

In the Indian Ocean tsunami disaster of 2004, children and elderly were the ones who suffered most. It is important to know what to do in a disaster. This play can help them to be aware of natural disasters. To spread this message, we will continue our plays. We wish to share Japan’s experiences with the rest of the world.

We will show the puppet play images through a DVD player in front of our poster to present this message. We will also play a short part of puppet play of Dr. Catfish (Namazu-hakase) as an entertainment of the reception of this workshop.

You can download the English scenarios of these plays from the following web page of Cabinet Office, Government of Japan

http://www.tokeikyou.or.jp/bousai/inamura-top.htm

[P1-p-2] The seismic gap south off Sumatra and active period of the seismicity along the plate boundary between India-Australian and Eurasian plates

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The seismicity changes related to the Sumatra M9 (or 9.4) earthquake were analyzed using PDE monthly, weekly and QED catalogues (USGS) from 1964 and the Utsu catalogue (released June 2002) for the historical events.

The seismic activity along the plate boundary between India-Australian and Eurasian plates was analyzed. The active and quite period has been repeated. The most recent active period started in 1997 in Tibet and spread to Iran and Sumatra. In the former active period from 1931 to 1951, the seismicity especially in the border area between China and India was very high, including three M8 events (1934 M8.3, 1950 M8.6, 1951 M8.0). The distribution of the past active period from 1889 to 1914 is similar to the recent one .

During the 20th century the mega-thrust earthquakes (M>=9.0) occurred in a time span of 13 years only (1952 M9.0, 1957 M9.1. 1960 M9.5, 1964 M9.2). Such huge events appear to have a tendency to occur focused in time.

A low seismicity region was detected in the source region of the Sumatra M9 earthquake before the occurrence of this event. The size of this low seismicity region is smaller than the one at the source region of the Sumatra M9 earthquake. Using time-space distribution diagrams along the plate boundary, it was found that a second kind of the seismic gap (Mogi, 1979) existed for about 14 years before the occurrence of the mainshock. The size of this second kind of seismic gap is similar to the one of the source region, but wider than the one of the low seismicity region.

A similar anomaly was found in the region middle south off Sumatra island. The low seismicity areas were found along the plate boundary and they coincided with the source regions of the 1833 (M8.7) and the 1861 (M8.4) events. In case of the 1861 (M8.4) event, the M8.7 earthquake occurred in the low seismic region in March after our founding. In case of the 1833 event, it coincides very well with the low seismicity area and the estimated source region defined after Natawjdaja et al.(2004). A second kind of seismic gap was also found in this region and the relation between the quiescent period of the second kind of the seismic gap and the magnitude of the future event showed that the next mega thrust in this seismic gap would occur in 2 –4.5 years.

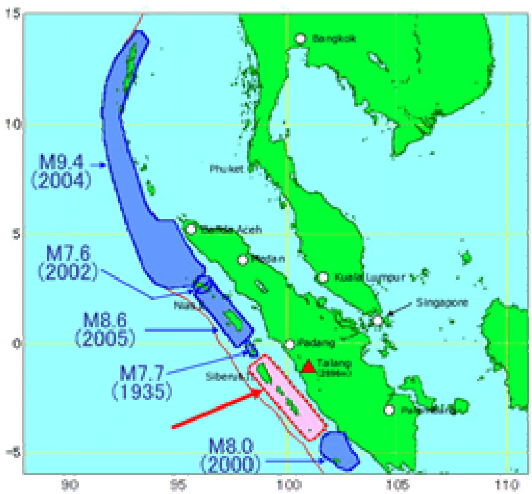

Figure: The seismic gap for the future event south off Sumatra along the IA-EU plate boundary

[P2-1-1] The December 2004 Sumatran Tsunami: An effort to established national hazard mitigation program

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Indonesia archipelago that is an active island arc is a result of interaction of three plates: Indo-Australian, Pacific and Eurasia plates. Along the plate boundaries, the deformations occur intensively and manifested by chain of volcanoes, vertical movements, active faults, and seismic activity that frequently caused the disaster. As examples the 1883 Krakatau explosion that followed by tsunami killed more than 36,000 people, and the 1992 Flores tsunami killed more than 2000 people The recent one was the December 2004 Sumatran earthquake and tsunami that killed more than 200,000 people and considered as the largest earthquake in the world since 1900.

The December 2004 tsunami catastrophe made us realized the need of national preparedness to deal with any natural hazards in the future in order to reduce the losses. The Indonesian government has been giving a particular response by established programs on the rehabilitation and reconstruction, the Tsunami Early Warning Systems (TEWS), scientific research, and science based public education and preparedness.

TEWS program makes the most of the scientific national capacity and international involvement. This is a part of Indonesian commitment to establish an end-to-end tsunami warning system as part of the Indian and Pacific oceans tsunami warning and mitigation systems. Indonesia is taking the lead in the establishment of the Indian Ocean Tsunami Warning Systems (IOTWS) and continuously improves national's abilities to cope the disaster.

In order to understand the natural hazards including any mitigation efforts to reduce the casualties for future disaster, a series of research activities to assess earthquake and tsunami hazards as well as their potential risks are crucial. Historical data and present research developments will be referred to in assessing the future hazards and risks. The Indonesia Institute of Sciences (LIPI) in collaboration with other national institutes has established an integrated hazard mitigation program involving multi-discipline research activities. The objectives of the program are to (1) identify and develop better understanding of the earthquake and tsunami process and mechanism, (2) analyze collateral hazard in earthquake and tsunami prone areas, (3) analyze impact of earthquake and tsunami on natural resources, and (4) assess public and institutional preparedness to cope with disaster.

Indeed, it needs extraordinary efforts to establish the national hazards mitigation program that cover hazard, vulnerability and risks assessments, community and government preparedness, rapid response ability and certainly research. At first, the program will be focused on the west coast of Sumatra (including several islands along the coast) that considered as the most vulnerable area. Continuous research activities with international involvement as well as science based public education and preparedness are in progress.

[P2-1-2] Disaster Management and Risk Mitigation: India's Experiences and Future Needs

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During the last ten years, India has faced three major natural disasters – the super cyclone in Orissa in 1999, the major earthquake in Gujarat in 2001, and most recently the Indian Ocean Tsunami in 2004. Large parts of India fall in earthquake-prone zones and many areas are vulnerable to cyclones, floods and draughts. Although the probability of a Tsunami in India is historically low, the Indian coastline is frequently faced with severe cyclones and floods caused by heavy rainfall. The current thinking among policymakers and experts in India is that an integrated multi-hazard approach to disaster management should be adopted, with emphasis on cyclone and Tsunami risk mitigation in coastal areas.

An important observation, based on India's experience with various types of natural disasters, is that due to high population densities, environmental degradation and growth of economic activities along coastlines, the vulnerability of many developing countries to natural disasters is increasing rapidly. Further, the poorest and the weakest population groups suffer the maximum losses in any disaster.

Another important lesson of India's experience is that the long-term economic losses due to natural disasters can be enormous. The resulting loss of livelihoods, reduction in new investments, and loss of tax revenues, becomes a major setback for development of the affected region. Keeping this realty in mind, policymakers in India have realized that development cannot be sustainable unless disaster mitigation is incorporated into all aspects of the development process.

India's approach to disaster management has a number of positive features, such as a well organized government administration, ability to mobilize relief efforts efficiently even in remote areas, and effective rescue and relief operations immediately after a disaster. On the other hand, India's record is weak on preventive measures and general preparedness of communities to handle natural disasters, high vulnerability of the poor, lax implementation of building regulations, and minimal efforts for awareness generation, capacity building, and community participation in disaster preparedness.

There is enormous scope for India, and many other developing countries, to learn from international experiences on disaster management and risk mitigation. Specifically, this should include methodologies for risk assessment and vulnerability analysis, state-of-the-art infrastructure and technologies, high-tech early warning systems, settlement planning approaches, and improving interface with international systems for disaster response from receiving information to utilizing international assistance in times of disaster.

The presentation would cover -- India's experiences in dealing with natural disasters; brief assessment of the damage suffered during the Indian Ocean Tsunami in 2004; the new policy framework for disaster management in India; and an assessment of future needs to deal more effectively and comprehensively with natural disasters. The presentation would also explore the scope and relevance of market-based instruments for risk mitigation, such as tax incentives for risk reduction and use of catastrophic insurance instruments for risk transfer.

[P2-1-3] Natural disasters in Bangladesh: GoB's disaster management framework for reducing damages

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Abstract

Bangladesh is the largest delta of the world with network of Ganges-Brahmaputra-Meghna (GBM) river system through which largest volume of land derived materials are drained to the Bay of Bengal. The country is situated well within the tropics at the head of the Bay of Bengal. The GBM delta is very active due to the close proximity of the geologic boundaries and landscape features and deltaic alluvial processes, dynamics of the river system and neotectonic activities. Bangladesh is bounded by the Shillong Plateau and great Himalayan chain in the north, by vast Indian Shield in the west, Indo-Burma range in the east and it is open to the Bay of Bengal in the south with a 710 km long coastline funneled at the GBM convergence. Because of such location, Bangladesh is one of the most highly disaster prone countries of the world. Hazard proneness and vulnerability associated with over population, low per capita income, poverty and illiteracy intensify the disasters beyond its real dimension. The country has developed one of the finest disaster management systems of the world in the last few decades for some disasters while an integrated disaster management is the situation demands.

This paper presents the nature, occurrence and extents of disasters in Bangladesh, a brief on the practices victims cope with the disasters, details on the preparedness activities taken by the Government of Bangladesh to reduce the loss and finally wrap up with the necessity and significance of the integrated disaster management.

The most devastating cyclones and floods of the world occur in Bangladesh. There are other ones too and some of them are as devastating as the cyclones and floods. For example cyclones are not as bad as storm surges, which accompany a cyclone. Drought leaves a permanent damage and encourages the desertification process that is going in some parts of the northern Bangladesh. River erosion takes away thousand of hectors of land every year where land is a most scare resource. Tornadoes swept away lives and properties without notice in the north central area of the country in every year. Earthquakes and Tsunami may cause millions lives and billions of taka (Bangladesh currency) worth of damage. The most troubling but ignored fact about the disasters is that they are all linked to each other's.

Once Bangladesh largely believed disasters as curse of God and accept those as natural punishment without adopting any remedy. In those days temporary responses from the government were restricted to relief distribution during post-disaster phase without taking the socio-economic consequences of the event. But over the last decade in the past, Government of Bangladesh (GoB) has been emphasizing on techniques to reduce soci-economic and environmental loss of disasters, through enhancing the concept for the integrated risk minimization activities identifies crucially not only disaster mitigation, but also disaster management i.e. preparedness, response, recovery and development. This concept is relatively new in Bangladesh but firmly rooted.

Disaster management plan of GoB from the national down to the union level is aimed to minimize loss of lives and economic damage through temporal removal of people and property from a threaten location and facilitates timely and effective rescue, relief and rehabilitation. GoB has given equal importance to both structural as well as non-structural disaster mitigation measures but non-structural measures are believed to support by the structural measures in order to modify or reduce effect of disaster. Success of disaster management in Bangladesh is mostly established by GoB's non-structural measures (along with other Government Organization, NGO and community people at grass-root level) like: Legislation, Policy and Plans; Training and Public Awareness;

Warning System; and Local Disaster Action Plan (LDAP). Among the non-structural measures LDAP is the ultimate and direct interface between disaster and human interest, which got the sustainability by the GoB's structural measures constructed with its won and external resources. Consideration to inter hazard link ness, consequences of hazard and knowledge 'gap' have resulted into comprehensive programming that contextualizes all elements of disaster handling within a broader risk management framework. In mid 1999 the GoB together with UNDP and other development partners agreed upon Comprehensive Disaster Management Prgoramme (CDMP), is at present nearly in its final stage through long painstaking processes to prepare concept paper, develop framework and formulate programme support document.

The GoB has been continuously trying to improve the disaster management framework under the total disaster management programme like CDMP as sufficient as possible so as to ensure sustainable development of the country as a whole. Massive community participation is required to the logical approach of the GoB to prepare the nation for her major growth and development in the world with minimum risk from natural disasters.

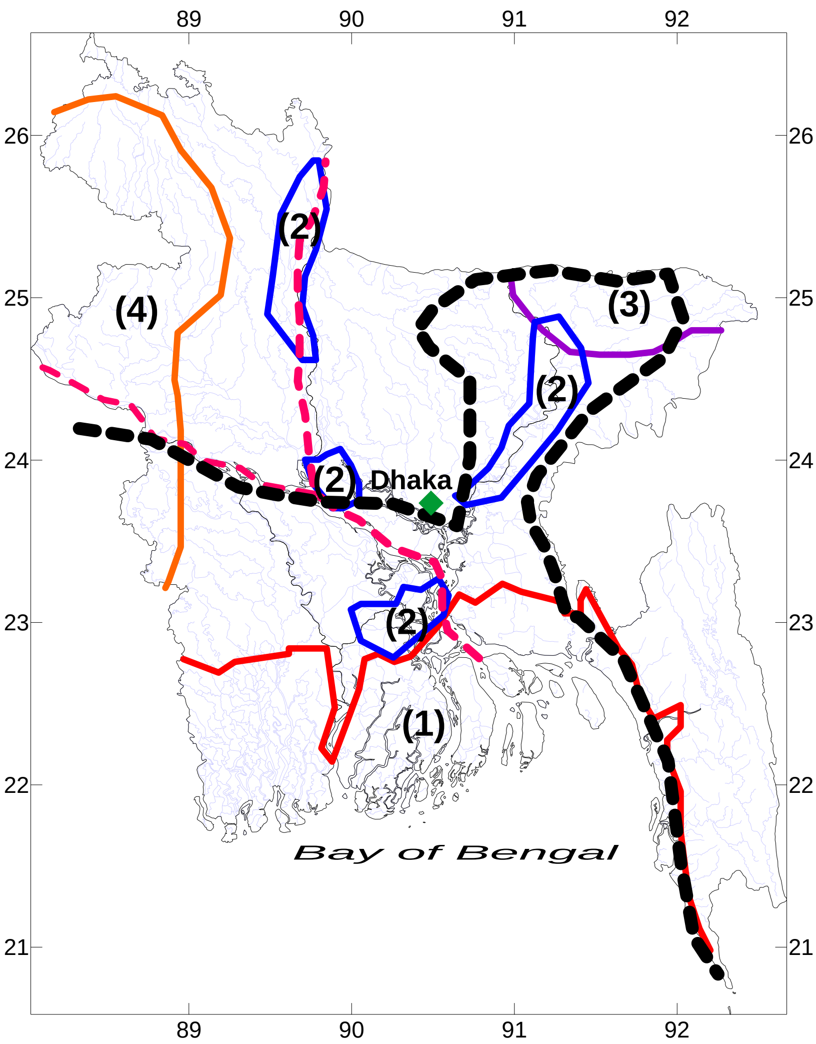

Figure: Map of Bangladesh showing approximate hazard prone areas for different natural hazards. In the figure area (1) is cyclone and storm surge prone area; (2) is flooding area for every season; (3) is area of flash flood; (4) is drought prone area; Reddish dash line represents the major rivers where bank erosion is common in wet season; and area south to the thick black dash line is the area where shallow aquifer water is contaminated by arsenic.

[P2-1-4] Thailand : After its worst tsunami

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After the Sumatra tsunami caused by the large Sumatra earthquake on December 26, 2004, Thailand has reacted in many ways to both restore the damage and take important steps on the geo-hazards management and prevention for the sake of the people .

The Department of Mineral Resources, along with other offices, rushed into the area immediately after the event trying their best to investigate and acquire information on tsunami, i.e., inundation, runs up, effects of topography. They have quickly come up with the inundation map, which was then used for the designing of tsunami evacuation route maps. Maps for Patong and Kamala beaches, in the Phuket Island, have been finished with those of other areas are being in the process. The country has also set up the National Disaster Warning Center in order to handle the national disaster warning system and mitigation. The center has successfully set up a tsunami warning system in selected beaches in Phuket and Phi Phi Island, and is now currently working on other areas that are prone to tsunami on the Andaman seaside. Meteorological Department in a co-operation with the National Disaster Warning Center is very well equipped and able to issue a tsunami warning on a national scale effectively. Considering the period of less than a year time since the tsunami event, we have made a big step in our history on not only building up the people awareness and their preparation but also capability on the disaster prevention, especially on earthquake and its consequence tsunami.

In order to have a good warning system, we definitely need to have co-operations among countries who effected by the tsunami and those with a higher experience. We are willing to work with other countries in order to tackle the problems related to tsunami and would treat this problem on the international or borderless basis. This is all for the benefit of the people to live safely in such a dynamic world where disastrous phenomenon may have occurred without much of the warning.

[P2-1-5] Rapid Assessments on the Physical Impacts of the 26th Dec 2004 Tsunami along the Northwestern Coastline of Malaysia Peninsular

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ABSTRACT

Tsunami disaster is an exceptional geological phenomenon to Malaysia. The 26th December 2004 tsunami has resulted in a great number of deaths, casualties and damages to human properties. Because this kind of disaster is a new experience to Malaysia, the nation was basically unprepared and was frantically caught in the unimaginable and unexpected impacts.

The 26 Dec 2004 tsunami struck the western coastline of the northern states of Malaysia Peninsula, notably Kedah, Langkawi, Penang, northern Perak and Selangor. The regional scale tsunami is caused by a major earthquake that occurred beneath the sea northwest of Sumatra. In Peninsular Malaysia., the devastating tsunami waves reached the western coastline of the northern states (Penang, Kedah & Langkawi Islands) between 12.30 – 1.30 p.m., c. 3 - 4 hours after the earthquake incident. Near the shoreline, the tsunami's waves were reported ranging between 3.0 to 6.0m above the mean sea level with velocities between 40 and 60km/h. In general, the run-up levels (*i.e. the estimated maximum heights of water levels on land relative to sea level by inland flooding of the tsunami's waves*) in the affected areas vary between 0.5 to 1.8 m and with an estimated velocity of c.30-40km/h. The inundation limits (*i.e. the horizontal measures of inland penetration of tsunami's waves*) in low lying areas extended for several hundred meters (up to 350m).

In Malaysia, the tsunami waves had claimed 69 lives and caused extensive destruction to the houses, fishermen jetties, boats, fish-cage farms, and other infrastructures along the shoreline. Even fish and other marine lives (shallow water shells and coral remains) were also not spared from the tsunami waves. The tsunami impacts were most devastating in the estuaries, bay areas and man-made marinas. The inundation floods also caused widespread environmental damages and intrusion of salt-water into paddy fields and fresh water wetlands in Kota Kuala Muda, Kedah. In Malaysia alone, the property damages and losses by the tsunami were estimated to be not less than RM100 million. In areas where they are sufficient muddy sediment supply (estuary area), the tsunami water was relatively thick, viscous and murky. This has resulted in widespread accumulation of a thin layer (1-5cm) of muddy sediments in the affected areas, while the retreating waves remobilized and eroded sediments on the shore. In Kota Kuala Muda Kedah however, inundation and destructive power of the tsunami's waves was efficiently reduced by the presence of irrigation trenches of the paddy fields. The existence of mangrove swamps and onshore man-made dykes had also effectively refrained the destructive power of the tsunami waves from destroying houses and other inland facilities. However, near Rebak Island in Langkawi, the wave breaker constructed for a few hundred meters offshore, has been reported to be ineffective and was overtopped by the incoming tsunami waves.

Results of this study are very important to understand the tsunami disaster and thus to provide baseline technical input to strengthen disaster preparedness mechanisms for similar tsunami events in the future. Assessments of the magnitudes and limits of the physical impacts would also be very useful in establishing the tsunami risk and hazard zonations, as well as in planning for the tsunami early warning system in the risky areas, disaster preparedness and mitigation, vulnerability reduction, post-disaster relief and reconstruction.

[P2-2-1] Mechanism and Future Probability of Giant Earthquake and Tsunami in Indian Ocean

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Geophysical studies of the 2004 Sumatra-Andaman earthquake and the associated tsunami in Indian Ocean are planned to better understand the mechanism of gigantic earthquakes and to help forecast future probability of similar events. Five projects detailed below are carried out with collaborations with research institutes from countries around Indian Ocean.

(1) Past earthquakes and tsunamis in the Indian Ocean and future probabilities

GPS measurements, satellite photographs and post-seismic field surveys indicate significant (meter-scale) coastal uplift or subsidence occurred in the source region of the 2004 earthquake. If similar gigantic earthquake had occurred in the past, evidence of sea-level changes and tsunami deposits would be preserved in coastal geologic sections and can detected by geological surveys. With proper dating techniques, recurrence of prehistoric earthquakes in Indian Ocean can be reconstructed. Such paleoseismological studies contributed for long-term forecast of gigantic earthquakes in the Pacific and Sumatra Island. We plan to carry out similar studies in Nicobar and Andaman Islands, as well as on Myanmar coasts.

(2) Mechanism of postseismic movements of the 2004 earthquake based on GPS observations

Gigantic (M~9) earthquakes in the Pacific, e.g., the 1960 Chilean and 1964 Alaskan earthquakes induced decade-long postseismic crustal deformation in the source area. Similar long-term and large scale post-seismic movements are expected for the 2004 Sumatra-Andaman earthquake, which can be detected by continuous GPS measurements as well as by campaign measurements. The obtained GPS data will be used to estimate temporal change in slip on fault or relaxation process in asthenosphere.

(3) Rupture process of the 2004 earthquake based on strain observations

Because the 2004 earthquake was such a gigantic event, conventional seismological analysis has limitations to estimate the overall size and rupture process. Various methods, including strain observations in Japan, need to be adopted to better understand the rupture process of this gigantic earthquake.

(4) Evaluation of seismicity and stress state before and after giant earthquakes

Seismicity, or activity of smaller earthquakes, indicates the stress state and its analysis can be used to monitor the stress change associated with giant earthquake. Seismicity in the source region of the 2004 earthquake is analyzed, using global seismicity catalogs, to detect seismic gap and quiescence before the mainshock, change in frequency-size relation (b-value), triggering by earth- and ocean-tides, earthquakes corresponding to asperity, and characteristic stress pattern. Preliminary analysis indicates that the seismicity was high since 1999 in the source region of the 2004 earthquake.

(5) Collections and analysis of tide-gauge records around Indian Ocean

The tsunami surveys around the Indian Ocean indicate that the tsunami heights were very variable. For documentation and better analysis, instrumental data of tsunamis, i.e., waveforms recorded on tide gauges, need to be systematically collected. The tsunami waveforms, as well as sea surface heights measured by satellite altimeter, are used to estimate the initial water height distribution in the tsunami source region. The initial water height was the largest near the northern edge of Sumatra Island, close to Banda Aceh.

[P2-2-2] Education and promotion for increasing disaster preparedness

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The tragedy of the 2004 Sumatra giant earthquake and tsunami teaches us on the importance of public awareness of earthquake and tsunami risk and necessity of basic knowledge of their mechanisms. Even if very effective tsunami warning system is deployed people's awareness for tsunami disaster should be kept for very long period of time, possibly more than 100 years. In such case education plays an essential role. This is the reason why this subproject on the education and promotion for increasing disaster preparedness was established in the research project on restoration program from giant earthquakes and tsunamis.

It is well known that effective reduction of disaster relies on good balance among self-help, mutual assistance and governmental assistance. However the way they should be promoted depends on the culture, politics or economy of the countries. Therefore we will visit the countries that the 2004 Sumatra earthquakes and tsunami hit to investigate the correct way for effective promotion of awareness for disaster reduction.

Government administrative system also differs from countries to countries. Effective dissemination of disaster information strongly depends on the system. In this subproject we visit several countries to investigate the goodness and weakness of the administrative system in each countries and propose an effective way for disaster management system. The results are used for effective training for disaster specialists as well as producing good textbooks and teaching materials.

Education is most important. In the countries of advanced disaster mitigation achievement such as Japan, most of the people are educated from their childhood about natural disasters. Advanced researches for disaster reduction contribute to very sophisticated disaster management system even though they often suffer unexpected natural disasters. The experience of the disaster-reduction advanced countries should be informed to other countries. For this research project we noticed the international students who is studying in Japanese universities are insufficiently informed with earthquake and tsunami risks. We try to have seminars with highly educated students who are non-specialists of natural disasters. We may expect them to contribute the improvement of potential for countermeasures through companies or organizations they will belong to after they come back to their home countries.

In the symposium we make brief introduction and show tentative results of our three-year plan for Japanese contribution to earthquake and tsunami disaster reduction of other countries by means of education and promotion.

[P2-2-3] Effective Tsunami Warning System and Mitigation

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2) JMA, Japan Meteorological Agency
3) JAMSTEC
4) PARI, Port and Airport Research Institute

The aims of the research are to find out the appropriate system for tsunami warning in the Indian ocean by evaluating the effective monitoring system in real time for seismic and tsunami waves, providing the suitable information on a tsunami for mitigation and for evacuation through considering the present and future available system, and recognition and awareness in the people in each region. The system consists of the monitoring, issuing information, dessemination it and evacuation in each community.
The Japan Meteorological Agency (JMA) has operated the tsunami warning over 50 years, which is one of most advanced system in the world. The practical experiences for the past tsunamis in near and far fields and technology should be shared to develop the system in Indian ocean. The quantitative forecasting system and real time observation in deep area are particularly valuable.
The process of dynamic effect of fault in generation of tsunamis would be important for a large scale and magnitude earthquake, which is not considered in the present system for tsunami forecasting. The research project will discuss the effect in the case of the 2004 Sumatra and try to include it in the system. Moreover, the utilization of real time observation data will be studied to improve the result by the quantitative forecasting system based on the seismic information only. The inversion method of measured tsunami wave form can be applied to estimate the source area and magnitude of a tsunami. The location of the monitoring in the network and data sampling, accuracy and transmission are important issue on the study.
Finally, infrastructure such as mitigation facilities, information system, evacuation, emergency management, re-settlement system are common rules for mitigation in the Asia and pacific ocean. The educational system, community based program, and platform should be developed through the experiences and lessons in the 2004 Sumatra earthquake and Indian ocean tsunami.

[P2-2-4] Vulnerability of Infrastructures against the Sumatra Earthquake and Tsunami and their Restoration Program

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The 2004 Sumatra Earthquake caused ground motion damage to relatively tall structures in Banda Aceh City, and huge tsunami killed many people and generated significant damage of infrastructures in many countries around the Indian Ocean.

In this presentation, engineering features of loss of lives and structural damages in Sumatra Island of Indonesia, Sri Lanka, and Thailand based on field investigations will be firstly shown and corresponding countermeasures and restoration programs will be reported.

Lastly, the necessary research and work in the future for earthquake- and tsunami-proof cities around the Indian Ocean will be presented.

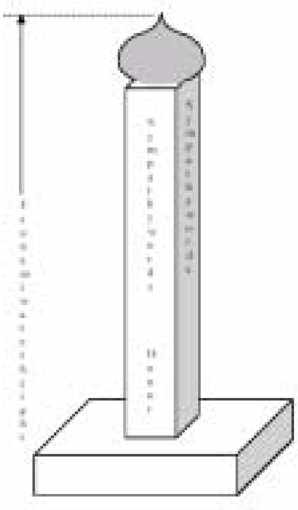

Figure 2. Tsunami Height Memorial Pole

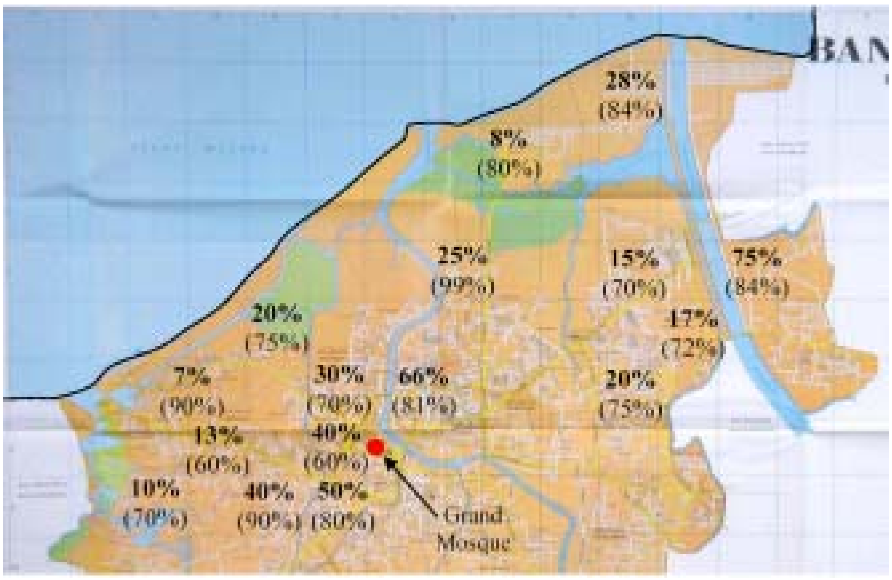

Figure 1. Percentage of survivor in (a) Banda Aceh and (b) surrounding areas (numbers in parenthesis show percentage of survivors if people had run away immediately after the

Figure 1 shows one of the results of questionnaires in Banda Aceh by the authors, in which percentage of survived people in the tsunami area is shown. In the parentheses below them, numbers are showing expected percentage of survivor if they escape immediately after the big earthquake.

According to respondents' opinion, the number of tsunami survivors would have been much increased if they had started to run away just after the big earthquake. However, in some areas, the respondents said that the expected survivors would have not reach 100% even if the had run away just after the earthquake.

This figure suggests, people in Aceh need the place to escape close to their residence, rather than the warning system, since the earthquake in Banda Aceh in from nearby fault. The earthquake it self is the warning sign that people should start running to escape once they feel big tremor in Aceh.

Based on the results above, the restoration program in Banda Aceh is to build tall buildings, hills, or mosques in the tsunami hit areas for the people to escape during a tsunami attack.

The authors are also working out a program for Aceh people to build "Tsunami Height Memorial Poles" (Figure 2) showing the distribution of tsunami height in Banda Aceh city, so that people understand the importance of tsunami preparedness and where to escape during tsunami attack in the future. The poles also serve as memorial poles.

[P2-3-1] Not Child's Play: Taking Another Look at Vulnerability in the Light of the Indian Ocean Tsunami and Hurricane Katrina

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Abstract

There is a common western folk tale read to children before they fall asleep about three pigs. How each pig built a house in a different way: the lazy one out of straw, the not so lazy one out of wood, and the industrious one out of brick. And then along came a big, bad wolf that blew down the straw and wooden houses and left only the brick structure standing. Implied in this nursery story is a strong message about what is considered best practice when it comes to risk management and disaster preparedness. The emphasis is all about applying the appropriate technology (a brick house) to withstand the perceived hazard (strong wind) that has come to constitute the dominant way in which disasters are conceived of and prepared for in Western and, I suspect, Japanese imaginings and policy. It is assumed that people are put 'at risk' from hazards because they are in the wrong spot at the wrong time; the proper response is to apply the necessary technological solution to predict or prevent the threat and so reduce the risk. The impacts of the Indian Ocean Tsunami and Hurricane Katrina, however, appear to have both reinforced and then questioned the way we think about what makes societies vulnerable. Too often our approach towards disaster management mirrors the wider divisions and cleavages between and within societies. If these devastating events following so quickly upon one another can be said to have had any 'lesson' for us, it is to suggest that developed countries may have as much to learn about disaster preparedness, management and recovery from developing countries as the latter do from the former.

[P2-3-2] Motivation and Capacity Building for Disaster Reduction

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While the twentieth century saw huge progress in development of economy and technology, the same progress was not made in reducing the number of disasters and victims of such disasters. Due to rapid population growth, rapid urbanization, and environmental change, it seems that disasters are becoming more diverse and complicated and our societies are increasingly vulnerable to disasters. Disaster Reduction is an essential precondition for sustainable development. Natural disasters severely hamper the progress and achievement of sustainable development.

Vernacular houses with adobes, bricks, blocks, and woods, which are commonly seen throughout the world, are vulnerable to earthquakes, and strong earthquakes destroy these houses, killing thousands of people almost every year. It is ironic that the shelters which must protect people from various hazards often end up killing them. Vulnerable houses also magnify the damage resulting from an earthquake and bring huge losses at the regional and national levels. In order to reduce the number of victims and damage resulting from earthquakes, it is therefore indispensable to make existing houses safer. No matter how effectively emergency management and relief activities are conducted, the lost lives can never be regained. The more resilient the existing houses are against earthquakes, the lower the death rate would be, and the less would be the disruptions to economic and social activities in the affected areas. It is one of the most important lessons from the past earthquake disasters.

Although mankind has the technologies to reduce the impact of disasters and knows what kind of regulations are necessary, our societies still remain vulnerable to natural disasters. Vulnerable houses can be retrofitted only by homeowners themselves, not by the authorities. It is thus essential to motivate local people, either residents or workers, so that they can understand the problems and can take appropriate actions and be in a position to facilitate sustainable and realistic disaster mitigation. Motivation and capacity building of people can be achieved through appropriate risk communication among the stakeholders as the risk differs from person to person, from house to house, and community to community. This risk communication should not be one way-education from experts to ordinary people, but rather multi-ways communication through which both the experts and people learn together the risks and how to reduce them. This kind of activities may be called “Co-learning” for capacity building. Since disasters greatly reflect the local conditions, such co-learning should be promoted at community level as Community Based Disaster Management (CBDM).

The choice on retrofitting is made, comparing the retrofitting cost with the expected loss by probable earthquakes. Generally, the expected loss, i.e., loss x probability (usually less than 0.1), would exceed the cost for retrofitting (usually o.1 of the construction cost). Therefore, there would be less incentive for retrofitting, economically speaking, if the life value that is protected by the house is not considered. According to Prospect Theory (Kahneman and Tversky), people are risk-seekers, i.e., tend to avoid certain losses (investment for retrofitting in this case), when the choice involves losses. Furthermore, when the uncertain risk may take place in future, or may not take place in a certain period eventually, the value of the expected loss would be much discounted. As a result, people would not invest for retrofitting, even if the life value is considered. Appropriate financial assistance should be adopted so that the people who have retrofitted their houses would gain interest at present, not in future when a big earthquake will take place. As the governments would be forced to invest a lot of resources for recover and reconstruction due to vulnerable houses after big earthquakes, this kind of financial assistance would pay off.

As a possible approach for motivation and capacity building for disaster management, the experiences of various initiatives, particularly for developing countries, are introduced and their lessons are discussed. The improvised shake table demonstration conducted in various countries is also introduced as a practical approach to motivate people for retrofitting.

Figure: Improvised shake table demonstration by UNCRD in Kabul, Afghanistan, 2003.

[P2-3-3] Matching Goods and People: Emergency Assistance Under Uncertainty

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This paper analyzes the social implications of relief efforts initiated by various actors involved in the Tsunami disaster in Thailand, particularly in the area of livelihood recovery. Its aims are (1) to document key events and observations in the first five months since the occurrence of the Tsunami, and (2) to analyze problems of recovery programs and aid deliveries to draw lessons for the future. The central question of this paper is why, despite massive donations of cash, goods and service, we hear so much complaint by Tsunami victims about the emergency assistance. A typical explanation is provided by the so called "elite capture" theory which claims that some bad people in the middle are taking away the resources that were meant to be delivered to the needy victims. This paper provides a more convincing explanation by focusing on distribution methods of goods within a camp or a village. One of the key findings is that the pre-existing social problems such as land tenure and legal entitlement of migrant laborers have strongly influenced the distribution of aid provided by outsiders. The paper demonstrates that, in certain cases, outsiders' well-intended assistance may even strengthen the pre-existing inequality in resource distribution. Also notable is that the sectionalism of the government hinders effective recovery policy. Some other issues that deserve further research are also highlighted.

[P2-3-6] Potential For Incorporating Coping Capacities In Community Based Disaster Management

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As population size, particularly in Asia, have swelled so has been their vulnerability to natural disasters. More people are now living with risk than ever before. This has resulted in increased losses of life and property. Undoubtedly, therefore the goal of reducing such losses has become even more daunting.

With each subsequent disaster, governments and humanitarian response agencies have realized that the effort to protect and save lives has essentially needed to be decentralized and driven by the people at risk themselves. Community Based Disaster Management (CBDM) now recognized as the most effective way of building local capacity for “first response” in disaster events. CBDM addresses vulnerability reduction of the individual thus building on resources and means within the individual’s local environment.

External interventions while developing community based strategies often overlook community’s own traditional as well as derived coping capacities. Communities living in areas vulnerable to disasters have traditional coping capacities that have remained in the communities’ folk-lore and other cultural activities. Also with socio-economic development – communities are better informed and therefore better prepared. The communities existing capacity should be the starting point for defining strategies for risk reduction. Ideally, such strategies should seek to strengthen existing capacities rather introduce new ones. Linking relief to development through protracted engagement with the community in building social capital, restoring livelihoods, securing shelter and improving health and education levels would bring about greater resilience to disasters. The role of external agencies is of facilitation empowering communities with the state of are in knowledge and implementation technologies.

The proposed paper would share experiences and potential of communities in small islands, in particular the Andaman & Nicobar islands in the Bay of Bengal. These islands were severely devastated in the 2004 Tsunami.

[P2-3-8] Strategy for disaster prevention and reduction

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It is common understanding among the people in disaster field to achieve disaster prevention and reduction that there is disaster management cycle which consists of the following four elements: mitigation, preparedness, response, and recovery. Mitigation can be called as Disaster resistance, and preparedness as disaster resilience. In this presentation, I would like to explore the interrelationship among these four elements from the least well-explored element, that is recovery. .It has passed almost one year since the Sumatra earthquake and the Indian Ocean tsunami disaster of December 26, 2004. Even though it may be fragmented and insufficient, I personally had a chance to be in Khao Lak region in Thailand, which has been one of the most devastatedly impacted area, in both April and November to gauge the progress of activities for response and recovery Based on the observations I had, it is my conclusion that a framework for holistic recovery should be formulated as a necessary strategy for effective disaster prevention and reduction. In what follows, a framework for holistic recovery will be introduced.

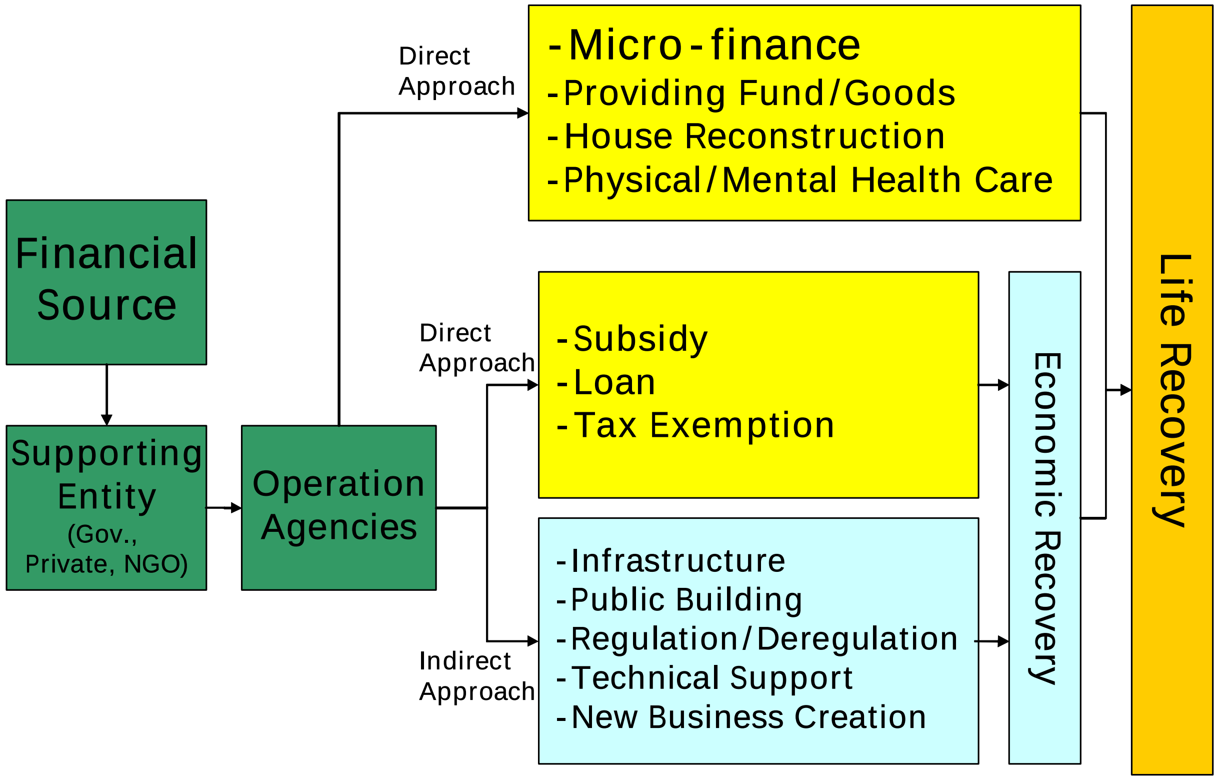
Three Goals of Long-Term Recovery

In case of the 1995 Kobe earthquake Recovery Plan, it was the first time for this plan that three goals has been set for recovery: Physical recovery, economic recovery, and life recovery. As a matter of fact, recovery plan was almost equivalent with physical recovery plan before the Kobe earthquake. There is no other recovery plan which specifies economic recovery as well life recovery as its goals. Physical recovery includes restoring both public infrastructure and private residence, as well as redesigning Urban Areas. Economic Recovery includes helping to resume local and big businesses, creating new businesses at macro level, in addition to securing job and income at micro level. Life recovery includes providing various kinds of disaster relief to restore life of victims.

Holistic Recovery Model

As for the interrelationship among three goals of recovery, it is my contention that economic recovery should be focused most as the top priority goal for recovery. Physical recovery should be regarded as a tool for economic development. Life recovery should be realized as a result of economic recovery as the ultimate goal for long-term recovery. With this priority setting, a model for holistic recovery can be described as shown in Figure in the next page.

In order to realize life recovery as the ultimate goal, there are two approaches to take. One may be called as direct approach and the other indirect approach. Measures included in direct approach for life recovery are provision of funds and goods, provision of support for the reconstruction off residence, including provision of publicly owned housing units, and provision of both physical and mental health care. Indirect approach for life recovery is facilitation of economic recovery.



In turn, in order to achieve economic recovery, there are also two approaches, both direct and indirect approaches. Measures for direct approach of economic recovery include subsidy, loan, and tax exemption. Indirect measures for economic recovery consist of direct projects for restoration of infrastructure and public buildings. There also are available more subtle measures such as setting new regulations or deregulations, providing technical support, and creating new business.

All of these measures should be combined strategically by collaboration of stakeholders such as local government, NPO/NGOs, CBOs, and private business sector. In thinking of stakeholders, it is important to differentiate “supporting entity” and “operating agencies”. Supporting entity means those organizations which supply the necessary funds for recovery projects. For example, the prime supporting entity in case of Japan is the national government in Japan and in case of the United States the federal government in the form of FEMA. In 1999 Taiwan Chichi earthquake, Buddhist organizations played a very important role as a financial resource in addition to Taiwan national government.

Operation agencies refer to various organizations through which various types of recovery projects would be implemented. For example both in Japan and the US, NPOs, NGOs, and CBOs play very important roles for implementation. As the basis for implementing recovery measures it is important to secure enough amount of fund.

[P2-3-9] How to strengthen Disaster Coping Capacity of a Community and State at Risk

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1. Vicious cycles of poverty and associated vulnerabilities to hazardous impacts

It is well known fact, through number of disaster cases, that hazardous impacts do not always result in a disaster and recovery is, if a disaster takes place, earlier in a society in which basic human right is highly respected as an universal right and considerable amount of funds are allotted for vulnerabilities reduction.

This fact and lessons are however hardly recognized and applied to the policy for disaster reduction in a society at risk, especially in developing countries.

Vicious cycles of poverty and associated vulnerabilities to hazardous impacts have been growing larger in terms of its size and rotation velocity.

1-1. The key to success in disaster reduction – the first key

The first key to success in disaster reduction is to brake the rotation of vicious cycle of vulnerabilities. As we apply the brake when we want to stop driving using foot brake and side brake, we need to apply the brake to a vicious cycle of vulnerabilities. As a result, the number of people at risk might be reduced at various level of vulnerabilities.

1-2. The key to success in disaster reduction – the second key

The second key to success in disaster reduction is to cut the links of vicious cycle of vulnerabilities. The move from a vulnerability stage to subsequent stage can be brought to a stop if proper actions are taken.

2. Total and Comprehensive Approaches to either brake of rotation of or to cut links in a Vicious Cycle of Vulnerabilities

It is also well known fact that initiatives for disaster reduction require a lot of resources. A lot of societies and civilizations had gone to wrack because of scarcity of resources for disaster reduction as a result of the depletion of natural resources including soil and forest.

Saving lives has a high political, but low economic significance in India, where labor is cheap. It is fortune that in the case of saving lives, there is this coincidence of interests between the poorest and the government. Programs that emphasize property protection are of less value for the poorest, because they have little or nothing to protect.

It is therefore most important to raise the economic status of the poor, so that they can react and respond to risk communication by making choices that safeguard both their property and their lives; rather than the present situation where they are powerless to react because of their economic impotence[1)] Total and comprehensive approaches for resources generation are therefore essential. Small fraction of income and/or resources generated can be allotted for disaster reduction.

Seminar or training or databases can be useful if they would be indispensable to the initiatives for initiatives for income generation and their sustainability. It must be clearly recognized that seminar or training or database cannot fill empty stomach of the people at risk.

Societies in Japan totally lost disaster coping capacity as a result of the war, but regained disaster coping capacity, to some extent, by neither training, seminar nor database but promoting industries in both rural and urban areas. The cases of Japan, Sri Lanka, Indonesia, India and Pakistan clearly shows there is utterly no resource to spare for a war.

3. Efforts for disaster reduction are referred to as the ones for building life boats

Efforts for disaster reduction are referred to as the efforts to build a life boat. We needs boats which are large enough to accommodate all the vulnerable people, but the hardships and shortage, some of which are referred to as vacuum, we are facing and suffering are a lot; funds, technologies, management skills, building materials, leadership and their omnipresence. There is therefore utterly no resource to spare for a war.

4. Needs for cooperation for sustainable development

We have to cooperate each other in order to respond to the demands for survival since each of us is a passenger who happened to share the same boat, a blue planet, the earth.

We had built specific mechanisms for cooperation to cope with mainly emergency phase. Cooperation for subsequence phases for larger disaster coping capacity is however still far less and ineffective than required.

A lot of people who had narrowly survived from a disaster stand despaired after the period of aid rush.

5. Two types of cooperation

There are two types of cooperation and aid; cut-flower type and arbor type. A large bouquet made of colorful cut flowers looks beautiful and luxurious, but flowers fall, wither up and die.

On the other hand, however, flowers taken root in rich soil, the cherry on the bank of the Potomac in Washington DC, for example, grow and come out. Income generation project must be the core. Projects for technologies transfer, institution building, skills training, hazards mapping and etc. must be supporting projects which cannot be implemented alone.

Fundamentals for flowers are firstly seed, secondly soil, then water and fertilizer. Property worth protecting, spirit and will for self-help, traditional and/or institutional system for safety and security and technical know-how for disaster reduction correspond to seed, soil, water and fertilizer respectively. Water and fertilizer sprinkled and applied over the soil without seeding are of no use, and a seed without water and fertilizer neither blossom nor bear fruit. It must be recognized that arbor–type assistance must be, instead of cut-flower type assistance, much more promoted

6. Community empowerment

Projects for community empowerment, based on self-help basis, along with the systems for early warnings covering both regional and nation-wide areas are essential for higher disaster coping capacity and resilience of disaster prone communities.

[P2-4] Reducing Earthquake Disaster Effects: Lesson From The Recent Earthquake Damaged Areas In Indonesia

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Abstract

The strong earthquake on December 26, 2004 having epicentre in the offshore of Aceh, Indonesia created huge tremors and gigantic tsunami afterward that hit several countries. Several Indonesia coast areas are potent to be swept by tsunamis. Moreover, wider area consisting of most territory of Indonesia is prone to earthquake shaking. Therefore, the reduction of disaster effects caused by future shaking becomes crucial.

Structures may be classified in two extreme groups, engineered and non-engineered ones. Close looking in recent damaging earthquakes in Indonesia, non-engineered structures having masonry walls (NESMW) tend to be more popular, and they were always suffered most by strong quakes.

The Islamic University of Indonesia (UII) set up field investigation teams to the earthquake damaged areas, the 1998 Blitar, 2000 Banggai, 2000 Bengkulu, 2000 Sukabumi, 2000 Banjarnegara, 2000 Pandeglang, 2001 Yogyakarta, 2001 Majalengka, 2003 Pacitan, 2004 Bali-Lombok, 2004 Aceh, and 2005 Garut earthquakes. During the field investigations, the teams not only investigated the damaged structures but also interacted with local people. Those experiences are very beneficial in (1) understanding the dynamic performance of non-engineered structures, (2) portraying the society condition and their real needs in short and long terms after the jolts, including their needs in affording earthquake-resistant houses, and consequently, (3) inspiring the special conducted programs in dissemination of earthquake resistant NESMW to fill the gap in the mitigation efforts of earthquake disasters.

This paper summarizes those experiences, and it finally gives some recommendations in how to make further effective efforts in research and practices to reduce the effects of future earthquake disasters in Indonesia, and they may be appropriate in other similar developing countries with adjustments.