Disaster Management and International Cooperation on Recent Large-scale Earthquakes / Tsunamis in the World

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Contents

1. Introduction

For those whom live in earthquake prone area in the world, reduction of damages in earthquake disaster is one of the most serious issues. Every single earthquake may cause massive damage in human lives and properties, as recently for instance, around 90,000 people were killed with the Wenchuan Earthquake that occurred in Sichuan Province of China on 12 May 2008.

The world catalogue of earthquake damages that is disclosed and continued to be revised by the International Institute of Seismology and Earthquake Engineering (IISEE) of the Building Research Institute (BRI) shows 30 disasters have occurred during these 50 years with more than five thousand casualties as shown in the Table 1. Many of them claimed their lives by being pressed with collapsed buildings particularly their own houses. Remembering the similar damages in Kobe in 1995, and other disasters, I believe that the victims have taught and are teaching us the importance of building and housing safety against the earthquake as most victims were killed by their own houses.

The Indian Ocean Tsunami triggered by the Off Sumatra Earthquake on 26 December 2004, killed in total approx. 230,000 people in 12 countries. One of the reasons why the tsunami brought so many victims lies in the tourists of Indian Ocean resorts from the Western countries at Christmas vacation who did not notice the danger of tsunami. They came up to the sea when the ocean water was ebbing and they did not climb up to the hill. The 2004 Indian Ocean Tsunami has provided a great opportunity for the Western countries to acknowledge the earthquake / tsunami disasters. The “World Conference on Disaster Reduction (WCDR)” that was held in Kobe in mid. January 2005, held only less than a month has passed after the Indian Ocean Tsunami, proved that 158 countries of UN have participated in the WCDR, more than expectation of the initial program. Then, all countries adopted the “Hyogo Framework for Action (HFA) 2005- 2015” there. This international framework that was established in Kobe exactly after 10 years of the Hanshin- Awaji (Kobe) Earthquake reflects the lessons in Kobe and the Indian Ocean Tsunami.

The impact of earthquake on livelihood of people can be reduced by measures such as to comply with earthquake resistant building design and construction standards, proper planning, education and trainings. However, the risk is still increasing as urbanization in developing countries is adding extra pressures on building construction. Although those countries have established each building control system, it can seldom function effectively due to lack of awareness on disaster risk reduction in communities as well as lack of regulatory public mechanisms for effective implementation, monitoring and reviewing. In particular, education of experts of earthquake resistant structure should be carried out continuously and long-term basis.

The IISEE of BRI is conducting one-year training courses on the modern technology for engineers and scientists of developing countries. This training has started in 1960 by the Ministry of Construction (current Ministry of Land, Infrastructure, Transport and Tourism, Japan: MLIT) and Earthquake Research Institute of the University of Tokyo under the cooperation with the United Nations Educational, Scientific and Cultural Organization (UNESCO). IISEE was established in 1962 to train and educate seismologists and earthquake engineers. Since 1970's when the UNESCO finished its support, IISEE is carrying out training in English with Japan International Cooperation Agency (JICA) in order to disseminate seismic observation and earthquake safe building technology in the world. Currently, the training has been approved as a master degree course of the National Graduate School for Policy Studies (GRIPS), Japan.

This paper firstly examines the outline situation and causes of recent large scale earthquakes and tsunamis in the world, and analyzes the responses of the on-site experts who include the ex-participants of the IISEE. Then, it shows how have they responded to the disaster, and how can we avoid the same disasters in the future based on the case studies.
At this opportunity, I cordially very much appreciate all the partner organizations in the world and in Japan as well as the lecturers who are supporting the IISEE training courses for a long time.

Fig 1: Participants of IISEE in 2009-2010 and the Minister

Reference:
Countries of the IISEE participants in 2009-2010
(in total 22 from 13 countries: all members are shown in Fig.1)

(ABC order)
Algeria, China (2), Colombia, El Salvador (3), Fiji, Indonesia (3), Nepal, Nicaragua, Malaysia (3), Myanmar, Pakistan, Peru (3), Philippines

Table 1: Earthquake / Tsunami Disasters with more than 5,000 casualties during recent 50 years (1960-2010)

by the BRI's "World Seismic Disaster Catalog"[i],[ii],[iii] and United Nation's data[iv]

	Country: Earthquake	Year	Mg	Death
1	China: Hebei (Tangshan)	1976	7.8	242800
2	Indian Ocean Tsunami	2004	9	226408
3	Haiti Eq.	2010	7	222576
4	Pakistan Kashmir Eq.	2005	7.6	73328
5	China: Sichuan (Wenchuan)	2008	8.1	69195
6	Peru: Chimbote, Huaras	1970	7.8	66794
7	Iran: Manjil Eq., Rudbar	1990	7.7	35000
8	Iran: Kerman, Bam Eq.	2003	6.7	31830
9	Armenia: Spitak Eq.	1988	6.8	25000
10	Guatemala Eq.	1976	7.5	22870
11	India: Bhuj Eq. (Gujarat)	2001	8	20023
12	Iran: Tabas Eq.	1978	7.4	18220
13	Turkey: Kocaeli Eq.	1999	7.8	17118
14	China: Yunnan Eq.	1970	7.8	15621
15	Iran: Dasht-i Biyaz Eq.	1968	7.3	15000
16	Morocco: Agadir Eq.	1960	5.7	13100
17	Iran: Buyin-Zahra Eq.	1962	7.2	12225
18	Nicaragua: Managua Eq.	1972	6.3	10000
19	India: Latur-Osmanabad Eq.	1993	6.2	9748
20	Mexico: Mexico City	1985	8.1	9500
21	China: Hebei, Ningjin Eq.	1966	7.2	8064
22	Philippines: Mindanao Eq.	1976	7.9	8000
23	Japan: South Hyogo-ken Eq. (Great Hanshin-Awaji Eq.)	1995	7.3	6432
24	Indonesia: Irain Jaya	1976	7.1	6000
24	Indonesia: Irain Jaya	1976	7.2	6000
26	Indonesia: Yogyakarta	2006	6.2	5749
27	Chile: Chile Eq. (Tsunami)	1960	9	5700
28	Pakistan: Patan Eq.	1974	6.2	5300
29	Iran: Ghir (Qir) Eq.	1972	6.8	5010
30	Equador, Colombia: Quito	1987	6.9	5000

Note: Events with gray number represent the earthquake disasters that have occurred during 1995-2010 (16 years).

2. Recent Large-scale Disasters

This Section introduces the recent earthquake and tsunami disasters. The following earthquake disasters are reported: Indian Ocean Tsunami (2004), Pakistan Earthquake (2005), Java Earthquake (2006), Peru, Pisco Earthquake (2007) and China, Wenchuan Earthquake (2008), Indonesia, Padang Earthquake (2009) and Haiti Earthquake (2010).
Though disasters in Peru (2007) and Indonesia (2009) are not included in the Table 1, most of the large scale disasters have been happened during these ten years. This paper tries to comprehensively summarize the reasons of damages and what are the lessons in terms of earthquake safety of building and housing. (Photos are provided by UN and BRI. The contributors of other photos are indicated.)

Indian Ocean Tsunami 2004

Numerous people including tourists from Europe and North America were drowned and died by Indian Ocean Tsunami caused by the Sumatra Off-shore Earthquake. Particularly Aceh Province of Indonesia was heavily affected. Indonesia is located on the "ring of fire", and as such prone to large earthquakes, volcanic eruptions as well as to tsunamis caused by seismic activity. The tropical climate with heavy rain showers during the wet season can cause floods and landslides. These natural hazards when combined with high population densities, poverty, poorly constructed buildings and deficient urban planning, inadequate warning systems and poor institutional disaster preparedness may influence to natural hazards to turn into disasters. Local governments and communities need assistance to realize the urgency to cope with these issues. From experiences in the past including in Aceh after the 2004 tsunami, many lessons can be learned. [v]

Fig. 2: Remaining Ship in the land, 2007 Aceh, Indonesia

Fig. 3 Remaining Ship on the Roof, 2007 Aceh, Indonesia

There were remaining ships in the residential area where is located a few kilometers from the coast line of Aceh. There are huge amount of construction sites of new houses in the areas. However, because of so rapid reconstruction of public facilities and houses, some houses were constructed with lower earthquake resistance and lower quality than before, or a set of completed recovery houses were still vacant in some residential zones as no infrastructure was provided in 2007. IISEE of BRI has received tsunami course's participants from Indonesia every year after the Indian Ocean Tsunami.

Pakistan Earthquake 2005

Barakot is the most heavily damaged city by the Pakistan Earthquake that occurred on 8 Oct. 2005. More than 70 % of buildings in the city were collapsed. This Kashmir area has been suffered from boundary conflict with India, and it snows in winter as located at the foot of Himalayan Mountains with 7,000 m above sea level. The evacuated people in the tent started reconstruction work in early 2006, as having improved weather in winter. Model houses were built by a Nepali NGO, National Society for Earthquake Technology Nepal- NSET, funded by HABITAT Pakistan and the local government. Since the local construction engineers and technicians are familiar with the construction system of NSET, it may be the best way to construct earthquake resistant buildings and houses in the affected areas. They had experiences to promote similar type of (reinforcement) construction system in the past in 2003 in Afghanistan, Iran (Bam 2003), and India (2001 Gujarat). There was a bamboo model house constructed by a local NGO in corporation with a Bangladeshi NGO using the bamboo imported from Myanmar, which is in high quality. (However, it has not been disseminated because of lower insulation.)

Fig. 4: Model House of bamboo, 2006 Barakot, Pakistan

Fig. 5: Earthquake damage, 2006 Barakot, Pakistan

Most of hospitals were reconstructed within two years while schools were rebuilt during five years as so many schools in the affected area. Almost 20,000 children have lost their lives because of the collapsed school building during school time. Therefore, the United Nations took initiative for a global campaign in 2006- 2007 that was entitled "Let's Begin at School" after the lessons of Pakistan Earthquake.

The seismic damage has concentrated on masonry houses. Buildings that have been constructed with basic rules such as using high quality materials and structural components are firmly connected and maintained properly, no damages were observed even in the heavily affected area. Based on the UN survey, main cause of this huge disaster basically lies in the unawareness of the risks, not only by the heavy quakes. The recovery process of the damaged houses is comparatively in a good momentum. Limited resources available to house owners to rebuild their houses, prompted partial/stage construction could be observed even though governmental supports were available.

Java (Yogyakarta) Earthquake 2006

A revenue office building as well as the "Institute SENI Indonesia" were collapsed by the May 2006 Earthquake in the south part of Yogyakarta City. In Bantul region where is the most affected area, the Islamic University of Indonesia (UII) has constructed, with some financial support from the Japanese embassy, a model house for the local people using bricks with reinforced concrete (RC) columns and beams (so-called confined masonry structure) in the damaged areas. The model was developed through the technical cooperation to UII by a BRI structural expert before the earthquake.

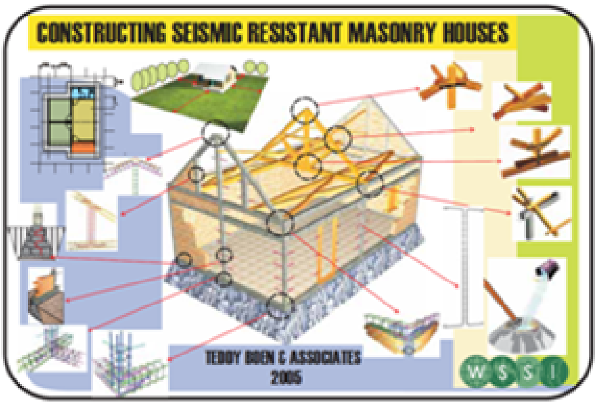
The Gadjah Mada University (UGM) in Yogyakarta has evolved several model houses (of bamboo, palm tree and/or wood) for tsunami prone and earthquake prone regions. Utilizing posters, UGM experts are conducting efforts of dissemination of earthquake resistant technologies and tips for reconstructing/ repairing houses of communities.

JICA and MLIT have been formulating a team to promote reconstruction of earthquake safe houses with Indonesian national and local government, and resulted in success.[vi]

Fig. 6: Earthquake damage, 2006 Bantul, Indonesia

Fig. 7: Specimen by BRI expert, 2006 Bantul, Indonesia

It is said that most of houses in Indonesia were constructed with timber a half century ago. After the timber became an international commodity, Indonesian people could not use timber as the price has increased at an international level, and people became to use low-cost and low quality bricks that are burnt with rice hulls. This issue resulted in a cause of heavier seismic damages in Indonesia. Therefore, Mr. Ir. Teddy Boen who graduated from IISEE in 1963 as the third course's participant and other structural experts in Indonesia are disseminating localized earthquake resistant construction methods.[vii] Japan should not forget that contrary to such critical issue in Indonesia, Japanese urban environment has been improved in terms of seismic and fire safety by constructing many RC structures utilizing plywood imported from Indonesia.



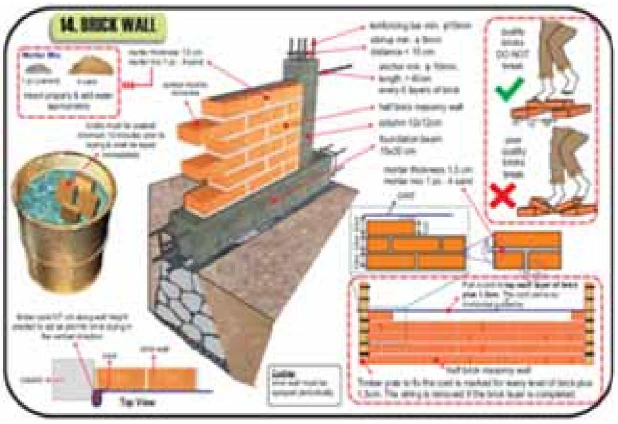


Fig. 8 & **9:** House Construction Manual by Ir. Teddy Boen

Peru (Pisco) Earthquake 2007

On 15 August 2007, an earthquake that occurred at approx. 200 km south from Lima, capital of Peru, and many adobe houses were collapsed. (Adobe: sun-burnt block made of mud) However, casualties resulted in a fewer number as the houses are built with light roof and one storey. The Japan-Peru Center for Seismic Investigation and Disaster Mitigation (CISMID) of national Engineering University (UNI) of Peru has recorded seismic waves of this earthquake by using a strong motion recorder that was installed under cooperation with BRI. This seismic record will be utilized to design structures in Peru.

In late August, 2007 an anniversary event of CISMID for its 20 years since establishment was held at CISMID, Dr. Yutaka Yamazaki, ex-Director General of BRI, Dr. Tanahashi, the 1st team leader to CISMID, Dr. Hurukawa, ex-Director of IISEE, Dr. Saito of BRI, and Prof. Otani (Prof. emeritus, the Univ. of Tokyo, Prof. of Chiba Univ.) etc. have joined the symposium and on-site investigation of the earthquake damaged areas.

Fig. 10: Damage of rural house, 2007 by UN (suburb, Ica)

Fig. 11: Boats on a street, Aug. 2007 by UN (Ica city, Peru)

BRI has been receiving participants from Peru as Prof. Julio Kuroiwa of UNI who participated in the 2nd course in 1962, before the 1970 Peru Earthquake (death: approx. 70 thousand). In order to establish CISMID as a JICA technical cooperation project, those IISEE ex-participants played significant roles. After commencement of the project, BRI and others have sent many experts to CISMID. These efforts resulted in the well managed response to the earthquake disaster in 2007, as well as more than 100 ex-participants of IISEE in Peru contributed to the establishment of technical standards and high-level education in Peru. Many people became to have strong interests in the safety of houses after the 2007 Peru Earthquake. Therefore, seismic resistant structures using RC sheer walls like Japan are used as popular structure for middle- and high-rise apartment instead of using reinforced masonry structures.

China, Sichuan, Wenchaun Earthquake 2008

By the Wenchuan Earthquake, occurred on 12 May 2008 in the afternoon, the human damage of the disaster amounted to more than 69,000 casualties except the lost, and several millions of people lost their houses. As it was just before the Beijing Olympic Game, the Chinese government quickly responded, such as the rapid provision of temporary houses. It was ten times larger in number of units within the same period compared with the case of the Great Hanshin-Awaji Earthquake. The reconstruction of houses has finished within 2, years although the original recovery plan needed 3 years. One of the factors why the recovery has been completed so fast is "Partner Assistance" system that has contributed to recovery of a heavily affected city through the support by a designated province in China. This system was applied from the initial stage to whole reconstruction and proved effective, partly because of competitive atmosphere of the system.

The affected area extended from cities that have hundreds of thousand populations to villages in the mountain regions over 500km long range of areas. In China, buildings and houses built with bricks or hollow blocks were major cause of the damages. Then, Chinese government promotes retrofit of vulnerable buildings not only in Sichuan but also in all provinces. Moreover, in addition to human damages, more than half of the economic damages that amounted to approx. 14 trillion yen (in case of Great Hanshin-Awaji Earthquake, it amounted to 10 trillion yen) were mainly due to damage / collapse of houses and buildings including schools.[viii]

Fig. 12: Damaged wooden/brick houses, 2008 (Sichuan)

Fig. 13: Damage of RC structure, 2008 by UN (Sichuan)

Chinese government carried out various recovery support measures as well as "Partner Assistant" system, referring to the experiences of the Great Hanshin-Awaji Earthquake and others. The traumatic care of victims and recovery of cultural heritages are included. Retrofitting of vulnerable buildings remains a major issue as the lesson from this disaster. IISEE and JICA conducted a group training course on Chinese seismic-safe building as the "Capacity Building project for Earthquake Resistant Buildings in China" that was initiated from exactly one year after the Wenchuan Earthquake. Two groups of training (20 participants each for two months) have been conducted. Enthusiastic participants from all Chinese regions learned high level Japanese technologies on aseismic design, assessment, and retrofit of buildings. They are now devoting themselves to seismic safety of Chinese buildings. (Details can be seen in the Section 4.)

Indonesia, Sumatra, Padang Earthquake 2009

More than 1000 people have died by the Western Sumatra (Padang) Earthquake on 30 September 2009. It is announced that the Padang earthquake hit modern city area in Indonesia for the first time. Though Indonesia had many earthquakes so far, most of the damages were caused by the collapse of low-rise houses in the rural area including May 2006 Java earthquake in Yogyakarta. The Padang earthquake in 2009 hit many RC structures in the center of Padang City where is the capital of the West Sumatra Province. The Institute of Technology of Bandung (ITB) and governmental research institutes such as the Research Institute of Human Settlement (RIHS) have sent investigation teams and found that the damages were concentrated on the hotels and other buildings that did not follow the building code in Indonesia. Some buildings were inadequately extended or rebuilt. Houses without reinforcement and non-engineered schools that were constructed without engineering design were also damaged.

Fig. 14: Damage of RC building, 2009 (Padang, Indonesia)

Fig. 15: Damage of non-engineered school, 2009 (Padang)

In the 2009 Padang Earthquake affected area BRI/IISEE is implementing a research project on seismic safety of houses in developing countries with the National Graduate Institute for Policy Studies (GRIPS), Japan as a joint research as well as the JICA capacity building project for building control administration. The detailed information is described in the Section 4. It should be noted that Indonesian ex-participants of IISEE in ITB and RIHS etc. are fully supporting these projects in every case.

Haiti Earthquake 2010

Haiti Earthquake on 12 January 2010 claimed more than 200 thousand of casualties. Main cause of the huge damage also arose from the collapse of buildings like houses and offices. It is reported that vulnerable RC or reinforced block structure enlarged the damages, because heavy construction materials are common in Haiti to resist against hurricanes.
Furthermore, modern buildings represented by the President House have been designed by foreign planners based on the building code of each planner's home country, and it seems that there is no locally adopted seismic standard and code.
Japan has dispatched the Self-defense and some experts in an international supporting team. However, it will take a long time for recovery of Haiti, since there were no human and social infrastructures. A Japanese NGO, CODE (Kobe city) is actively involved in the recovery on-site. Numerous international NGOs also sent missions to the affected areas to support to cover all possible emergency assistances.
IISEE of BRI will receive a trainee from Haiti in the next international training course on seismology and earthquake engineering that will start from latter half of 2011 for a year as the first participant from Haiti. (There is no ex-participant from Haiti, though IISEE has trained almost 1500 experts.)

Fig. 16: Damage of President Office, 2010 by CODE (Haiti)

Fig. 17: Landslide in residential area, 2010 by CODE (Haiti)

Reference:

Detailed data on the damage of 2010 Chile Earthquake is described in the "EPISTULA" Vol. 51 October 2010 that are issued every three-month by BRI, including its seismic data and tsunami propagation process as well as damages of buildings.

Reference (**Other Seismic Damages after 1995**: UN, BRI)

Fig. 18: Great Hanshin-Awaji Earthquake, 1995 (Kobe)

Fig. 20: Damage of adobe structure, 2003 (Bam, Iran)

Fig. 19: Gujarat Earthquake, 2001 by UNCRD (India)

Fig. 21: Chile Earthquake and Tsunami, 2010 (Chile)

3 Cause of Damages and Disaster Management

In each on-site observation, the collapse of buildings caused major damages in the earthquake related disasters. In order to achieve resilient social infrastructures including earthquake resistant buildings, cooperation of engineers and governments is essential. Damages to buildings and built environment from earthquakes in different parts of the world indicate the fact that earthquake risk mitigation is one of the most essential tasks for sustainable development of a city and region. Earthquake and tsunami risk mitigation requires proper disaster management measures and trained experts.
BRI has been implementing education and training of experts in developing countries at IISEE since 1962, further profound research and investigation on institutional and technical aspects need to be pursuit in analyzing earthquake damages in future.

Natural hazards such as earthquakes and typhoons occur every time. However, human society faces at the following disaster risks. The following key issues are also analyzed and identified as general reasons why disasters occur frequently in the world.

1) Rapid increase of population and urbanization;
2) Effects of poverty in least developing countries;
3) Delay of preparedness by governments / citizen;
4) Effects of eco-system degradation / global climate.

In particular, earthquakes affect not only lower society but also middle income people. The middle society covers most of the population and influences a deep impact on the national level economic activities. For instance in Indonesia, middle class people often live in a vulnerable house that was constructed without proper knowledge on brick structure, while the poorest group live in the bamboo-mat houses that are not affected by earthquakes.
The damages shown in the pervious section suggest the needs for capacity building of recovery experts who work on-site after a disaster, community workers who directly motivate people, local governmental staff who implement key policies, and policy makers at national level and so on.

Limited loss of lives from earthquakes can be observed in the United States, Japan and other developed countries that have long history of implementation of building safety compared to loss of lives in developing countries where building safety measures are not properly regulated. It is an indicator of how the earthquake risk can be reduced in cities. However, even in the countries with long history of building safety measures, inadequacies in the performance of building are often evident. Cautionary assessments after the 1994 Northridge earthquake found that "there would have been far less damage if building codes were rigorously enforced." Similar evaluation has been made after the 1995 Kobe earthquake in Japan which resulted in extensive loss of lives and properties despite of the fact that Japan has long history of practicing building safety regulations.

Most of the earthquake prone countries in the world have already established building codes and many countries have also enacted the seismic codes. However, lack of institutional mechanism, lack of complimentary implementation tools and lack of awareness about earthquake risk reduction among governmental agencies, designers, builders and general public have contributed to the poor enforcement of the building code.

(Reference 1) Year of 1) establishment and 2) enforcement of building code in earthquake vulnerable countries

Algeria	1) 1981,	2) 1988
Indonesia	1) 1998,	2) 2005
Nepal	1) 1994,	2) 2004
Peru	1) 1963,	2) 1968－70

For example, original draft of building code in Indonesia was formed in 1960's. However, it was enforced after 2004 huge disaster and whole national system were strengthened to mitigate disasters.

There has been tremendous development in science and technology of earthquake resistant building construction and this development have been translated into practical measures which are documented in building codes, regulations and standards. Despite of this advancement in knowledge base and available tools, the damages incurred in past earthquakes provide challenges on how to translate this knowledge into practices so that the loss from disasters like earthquake can be minimized. Hundreds of thousands of vulnerable buildings world-wide are waiting their fate in future earthquakes and many more vulnerable buildings are being erected.

Observation of damages from the past earthquakes have pointed out the fact that buildings perform the way it is constructed in the field and not the way it is designed.
In order to mitigate earthquake risk, all stages of building construction, from planning to construction and maintenance, are important. Properly designed buildings may not perform the way they are supposed if constructed improperly.

Awareness creation is instrumental not only in building culture of safety and resilient communities but also in creating demands for intervention in disaster mitigation. The demands ultimately help in creating conducive environment for policy intervention, in realizing institutional mechanism of code enforcement for the municipal authorities and creating demand for competent professionals.
For instance in Japan, demands for seismic assessment and retrofit of houses that follow the old seismic building code before 1981, could be realized mainly by raising awareness of people.

In order to achieve earthquake-safe buildings, it is the most important task along with capacity development and policy tools. Compliance and control have an inter-linkage and they compliment each other. Compliance can be increased and made effective by indirect control tools such as housing loans and insurance; whereas, effectiveness of control relies heavily on compliance. Despite of existence of building codes and serious intention for its effective implementation, realization of safe buildings in the field requires quality material, good workmanship and awareness in masons, builders and house owners.

(Reference 2) Challenges in building code implementation (in the case of developing countries)

1. Capacity of local government/ stakeholders
2. Lack of skill of building control officers
3. Underpaid staff
4. No professional trainings and continuing education
5. Lack of skill/ understanding in designers, contractors and artesian
6. Not enough motivation among engineers on building codes
7. Social /economic obstacles
8. Lack of awareness in public
9. Myth – high cost to follow codes
10. Large ratio of self-built construction (informal)

For example, after 2004 Tsunami, Aceh witnessed rapid growth in construction of buildings and there was influx of many development agencies competing to rapidly build largest number of buildings. This intervention in construction of houses demanded large quantity of material supply and large number of masons. However, both were in short supply. The local industry could not supply enough building materials such as bricks and cements and quality was compromised. People without previous experience in construction were involved as masons and carpenters and they were never trained about quality construction let alone earthquake resistant construction.

These issues are relevant not only in Aceh but also in other cities around the world. One sided control mechanism for implementation of building can not solve the problem and has to be integrated with socio-economic, institutional, technical and other tools at the same time in order to achieve safety of buildings and built environment against the earthquakes.

In the BRI’s IISEE training courses on seismology, tsunami and earthquake engineering, additional programs on disaster risk management, disaster risks and development assistance, disaster management policies and others are now included since 2005 under cooperation with GRIPS. All participants of the training courses are studying international framework for disaster risk reduction, international cooperation system by JICA in addition to disaster management policies in Japan.
These knowledge will help participants to pay attention how to adopt the technologies and knowledge to the society and what are the social demands as a professional or an expert of seismology, tsunami and earthquake engineering in the future in each country.

Fig. 22: Damage by Wenchuan Earthquake, 2008 (China)

4 International Cooperation of BRI

(1) International Training on Seismology and Earthquake Engineering at IISEE

The IISEE is conducting training courses on seismology and earthquake engineering for young researchers and engineers in developing countries to achieve earthquake disaster risk reduction through cooperation with JICA. IISEE is currently managing 1) "Annual Training Course: so-called Regular Course", 2) Global Earthquake Observation Course", and 3) "China Seismic Building Course" and 4) Individual courses. There are 1,481 ex-participants from 96 countries and region as of September 2010. The training activities are receiving national and international high appraisals.

1) Annual Training Course (Regular Course)
IISEE has been carrying out a one-year training course by inviting young researchers and engineers principally from developing countries, since 1962 under cooperation with UNESCO (after establishment of JICA in 1974, this training course is conducted as a part of JICA training courses).
In 2006, a new training course on "Tsunami Disaster Mitigation" was also established. The participants who finish the Annual Training Course can be awarded as master's degree since the fiscal year 2005.

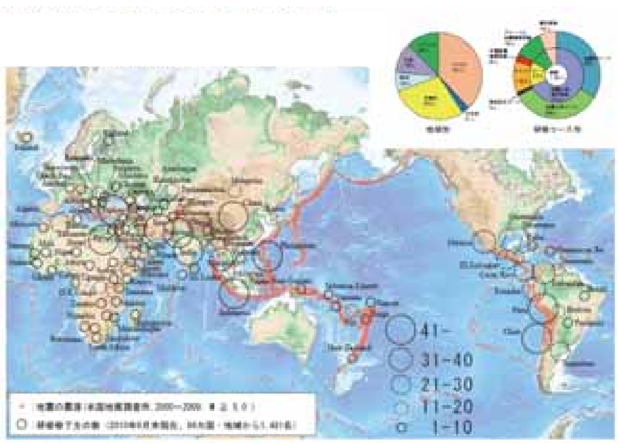
2) Global Seismic Observation Course
This course was initiated in 1995 and is conducted under cooperation with Meteorological Agency and JICA, in order to train human resources who can play significant roles in CTBT (Comprehensive Nuclear Test Ban Treaty) and its international observation system. The trainees are expected to learn earthquake observation technologies for nuclear test survey and data processing / analysis technologies to identify nuclear tests (from natural earthquakes).
This training is regarded as an international contribution of Japan to the effectuation of the CTBT. The training activity was also introduced in the CTBT Effectuation Promotion Initiative by the Japanese Foreign Minister Okada at the 6^{th} Conference on Effectuation Promotion of CTBT that was held in September 2010.

3) China Seismic Building Course
As a part of support programs for the 2008 Great Sichuan Earthquake recovery, IISEE is conducting "China Seismic Building Course" under JICA program on "China Capacity Building for Earthquake Resistant Structure" since October 2009. The training is expected to have 20 participants every year in the field of structural engineering for three years, and through training of trainers (TOT) system, finally in total 5,000 structural engineers in China will be trained.
The program on "China Capacity Building for Earthquake Resistant Structure" aims to improve ability of structural engineers in China as a part of Japanese recovery assistance. The program has started on 12 may 2009, exactly one year after the 2008 Wenchuan Earthquake. The activities include dispatch of experts, training in Japan, training in China (on-site training) and so forth as a JICA technical cooperation project with cooperation of MLIT, BRI etc. IISEE of BRI is in charge of "Earthquake Resistant Design, Assessment, and Retrofit Course" (so-called China Seismic Building Course). The first training has been conducted during 27 October and 22 December in 2009, and the second training has been held from 8 June till 3 August in 2010.

Detailed information has been summarized by the former Director of IISEE, Dr. Nobuo Hurukawa at the 2009 BRI Research Symposium as "50 Years of IISEE: Challenges to Reduce Earthquake and Tsunami Disaster Reduction in the World" (for the reference it's included in the web-site below). In addition, several basic data on the international training on seismology and earthquake engineering can be shown at the last part of this paper. The following web-site shows the most up-dated data on the training.

http://iisee.kenken.go.jp/

Fig. 23 Home Countries: IISEE Ex-participants (1481 all)



(by Year Book 2010, IISEE, BRI)

(2) Project for Earthquake Risk Reduction Centers

Japanese Government has established a series of earthquake risk reduction centers all over the world as shown in the Table 2, as international cooperation in the field of seismic disaster mitigation by combining JICA technical cooperation and grant aid. BRI has cooperated all of the projects deeply based on the know-how of international cooperation and strong supports of ex-participants in each country that has been developed and fostered at the IISEE training.

The following parts are introduction of outline of each project.

Table 2: Earthquake Risk Reduction Center Projects in the world

(JICA technical cooperation projects supported by BRI)

Country	Name (Center abbr.)	Counterpart	Terms
Indonesia	(3rd CT) Res. Inst. of Human Settlement (RIHS, PU)	RISTEK Indonesia	(1981-2003) 1993-1998
Peru	Japan-Peru Res. Center for Dis. Mitigation and Seismic Investigation (CISMID)	National Eng. Univ. (UNI)	1986-1993 (1989-2004)
# **Chile**	Eq. Dis. Reduction Tech. for Structures	Catorica Univ. Chile	1988-1991 1995-1998
Mexico	Mexico Eq. Dis. Prevention Project (Nat. Center for Dis. Prevention: CENAPRED)	Univ. of Nat. Autonomy (UNAM)	1990-1997 (1997-2001)
Turkey	Turkey Res. Center of Eq. Dis. Management	Istanbul Eng. Univ. (ITU)	1993-2000
# **Egypt**	(3rd CT) Res. Cooperation on Seismology (NRIAG)	Nat. Res. for Astro./Geoph.	(1992-1999) 1993-1996
Kazakhstan	Eq. Risk Assess./Monitoring in Almaty	Nat. Eq. Res. Inst.	2000-2003
Romania	Romanian Eq. Dis. Reduct. Plan (CNRRS/INCERC)	Nat. Inst. Eq. (INCERC)	2002-2007
El Salvador	Eq. Resist. Housing Disem. (TAISHIN) Project	Housing/Urb. Dev. Agency	2003-2008 2010-2012

#: Research Cooperation type project (+ Mini project in Kazakhstan)
Term as (1997-2001) indicates term of the 3rd country training (3rd CT)

(3) UNESCO Project (IPRED)

The United Nations Educational, Scientific and Cultural Organization (UNESCO) has established an international network that was named "International Platform for Reducing Earthquake Disaster (IPRED)" under cooperation with MLIT and IISEE/BRI in 2007. The platform aims at establishing a global network for research and training on earthquake disaster risk reduction in the field of building and housing, as well as creating an international back-up system in the case of a huge earthquake and/or tsunami.

The members of IPRED now consist of the following eight countries that experienced the past JICA projects as introduced in the Table 2. In concrete, research-related organizations in Chile, Egypt, Indonesia, Kazakhstan, Mexico, Peru, Romania, and Turkey have started the activities.

Currently, IISEE identified 15 activity areas cooperated with MLIT, Japan and UNESCO Headquarters. The activity areas include disclosure of lecture notes of IISEE, e-learning system and other activities.

5. Towards Future International Cooperation on Disaster Risk Reduction

(1) Increasing Target Countries and Demand for Training according to the Recent Change of Global Situation

Concentration of population into urbanization area and rapid improvement of social infrastructures due to the economic growth mostly in emerging countries would be common now for the imbalanced development of the world economy. Those countries where could not afford to pay attention to the earthquake disaster management before 1980's (such as Bangladesh, Nepal, Pakistan, Nicaragua) now have demand to send trainees to IISEE.
Recently, because of the 2004 Indian Ocean Tsunami caused by the huge earthquake of Sumatra off-shore, those countries where had no experience of earthquake disasters (e.g. Sri Lanka, Malaysia) now desire to send trainees, since the 2004 disaster was an opportunity to recognize the significance of earthquake and tsunami disaster mitigation.
Moreover, strong demands for training on both science and engineering in the field of earthquake and disasters are now increasing in the Central Asia and Caucasus region that were independent from the former Soviet Union, because of the transmission to the Western type research and technology systems from the former peculiar system.
As frequent earthquake and tsunami disasters during the 21st century (e.g. Kashmir Earthquake in Pakistan 2005, Haiti Earthquake in 2010) unfortunately proved such demands for training. Therefore the demands for international training on seismology and earthquake engineering continues even in the 21st century become more increasing.

(2) Strong Request to the Training on New Technologies in Japan that leads Science and Engineering in the World.

With regard to the seismology and earthquake observation technology, the global standard has changed to broad-band seismograph, digital observation technology, and ICT applied technologies from the former analogue mechanisms. The countries that have studied former technologies, are now requesting to learn new global standard technologies.
In addition, real-time earthquake mitigation and spontaneous earthquake information technology that is being developed in these years and will be the key of earthquake and tsunami mitigation measures. Earthquake-prone countries in the South- East Asia and Latin America are requiring to having training on these new technology fields.
In the field of ground motion research, demand is changing. Remote sensing technology can be applied easily and is suit for wider area risk assessment but is rather rough to evaluate risks of individual site. Then, micro-tremor allay survey technology etc. can be used as more detailed geophysical survey technologies now. (for example in Egypt, Mongolia, China).
In developing countries, it is more effective to select the site of development and construction to make the best use of good ground conditions. Proper site selection will minimize the required building strength and seismic resistant ability than the cases of developed countries where higher structural quality can be acceptable. Then, assessment technologies of ground conditions are more required in developing countries.
In the field of earthquake engineering, the most updated technologies such as base isolation, quake control, and super high-rise building are required because of the concentration of population to urban area and demand for high-rise buildings in developing countries.
Furthermore, earthquake engineering is currently changing from elastic design method using static seismic forces to elastic and fragile design method utilizing dynamic seismic forces. Then, the training on such new design methods and non-linear structural analysis technologies are required now.
Furthermore, seismic retrofitting that became popular in Japan particularly after the Great Hanshin-Awaji Earthquake, while there are few cases of retrofitting of existed buildings in developing countries hence there are quite strong demands for retrofitting technology.

(3) Accumulated Achievements of International Training on Seismology and Earthquake Engineering

The international training on seismology and earthquake engineering at IISEE has been aiming to provide scientific knowledge and technologies in geophysics and engineering related to earthquake and seismic disasters by continuous advancement applying up-dated innovation of these fields since its establishment in 1960.
During these years, countries that have succeeded to achieve development (such as Korea, Romania) became out of target countries of Official Development Aid (ODA). Moreover, the countries where international assistance with a technical cooperation project of JICA has been implemented and many trainees were educated (such as Mexico, Chile) are partners for joint research programs rather than having new trainees in these years.
On the other hand, many ex-participants of IISEE are now active as national and international leaders in the field of seismology and earthquake engineering. (e.g., Mr. Harsh Gupta of India played a role as the first President of Asian Academy of Seismology, Mr. Salah Mohamed of Egypt, the former Director of International Data Center of CTBTO, an international organization on Nuclear Test Ban Treaty, and others. These facts represent the significant achievements of the past international training on seismology and earthquake engineering at IISEE, BRI.
Furthermore, IISEE has additionally received seven trainees

from China in the regular courses, in order to cope with Wenchuan Earthquake disaster in May 2008, a new training courses entitled “China Seismic Building Course” for two months started from October 2009. In these manners, IISEE is actively promoting capacity building for young experts of developing countries in the field of earthquake safety.

(4) Research and Development in order to Strengthen and Improve the IISEE Training

IISEE has enabled 1) to provide electronic data on training reports and lecture notes of IISEE, 2) to disseminate lecture data including videos using e-learning system, 3) to issue news' letters at least once a month, 4) to introduce TV tele-conference system, basically through “IISEE Net” on the web-site (HP: http://iisee.kenken.go.jp). These actions now make it possible to directly communicate with developing countries and they were supported by the research theme on “Formulation of International Technical Network for Urban and Building Earthquake Disaster Reduction in Developing Countries” (2006-2008).

Under the research theme on “Research on Improvement and Dissemination of Earthquake Disaster Risk Reduction Technologies in Developing Countries” (2009-2011), IISEE is trying to further strengthen cooperation with developing countries and to conduct researches for improvement of appropriate technologies and dissemination of earthquake safer technologies in developing countries, based on the past achievements and changing training demands.

In concrete, earthquake and tsunami hazard (risk) assessment technologies and seismic assessment / retrofit technologies for buildings are focused. Investigation of actual conditions, identification of key issues, proposals of concrete technical cooperation and disclosure of the information for developing countries will be conducted.

As for dissemination of earthquake resistant technology, IISEE is carrying out investigation of building construction technologies mainly focusing on the most popular reinforced masonry structure in developing countries and will propose dissemination methods for earthquake safe construction.

Finally, the research outputs will be utilized in capacity building of seismic experts and engineers in developing countries including at IISEE training and its improvement, as well as wider disclosure of the information and knowledge of the research through the web-site entitled “IISEE Net”.

IISEE is going on its activities thanks to efforts and supports of many organizations, aiming to reduce earthquake disasters in developing countries as much as possible. Recently, IISEE is tackling new challenges toward four new directions as mentioned above. Finally, I would remind the following message, thanking the working circumstances to foster young experts under considerations of many supporters.

“When planning for a year, plant corn.
When planning for a decade, plant tree.
When planning for a century, train and educate people.”

(concluded)

Note:

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i 1990, World Earthquake Catalogue, Tokuji Utsu, Tokyo, 243 p.

ii Utsu, T., 2002, A list of deadly earthquakes in the World: 1500-2000, in International Handbook of Earthquake and Engineering Seismology Part A, edited by Lee, W.K., Kanamori, H., Jennings, P.C., and Kisslinger, C., pp. 691-717, Academic Press, San Diego.

iii 2004, http://iisee.kenken.go.jp/utsu/index.html

iv UNCRD http://www.hyogo.uncrd.or.jp/publication/report.html

v 2005-2010 Housing Earthquake Safety Initiative (HESI).

vi JICA, 2007-2010

vii Teddy Boen, 2009,“Constructing Seismic Resistant Masonry Houses” Indonesia.

viii UNCRD, 2009, BRI No.118 2008.