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للتربية والعلم والثقافة

联合国教育、
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MAKE THE PEOPLE A PART OF THE SOLUTION

UNESCO-IPRED-ITU Workshop

6-7 July 2009

ITU Civil Engineering Faculty
Istanbul-TURKEY

INTERNATIONAL PLATFORM FOR REDUCING EARTHQUAKE DISASTERS (IPRED)

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FOREWORD

The UNESCO-IPRED Workshop on “Make the Citizens a Part of the Solution” hosted by the Istanbul Technical University (ITU) and supported by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Japan International Cooperation Agency (JICA) gave the opportunity to advance international cooperation in the evaluation, prevention and mitigation of earthquake disasters. The meeting took place against the backdrop of the appalling loss of human lives and the wholesale destruction of communities and infrastructure as a result of major earthquakes. The Wenchuan earthquake in Sichuan, China and the one in Padang, Indonesia, followed after the Workshop by the large-scale devastating earthquake in Haiti and the one in Chile, came as a tragic reminder of the urgent need for nations to make optimum use of knowledge and technology in order to reduce the risk of disasters. Efforts must be pursued so that all realistic measures are taken in order to realize more resilient communities.

Natural disasters including earthquake disasters do not recognize geographical borders. Since the magnitude of the problem communities face is clearly recognized, an encouraging continuous process of making all the citizens a part of the solution is necessary. This needs core people who are conscious, educated, trained and very well prepared. UNESCO is ready to lead this initiative but will need to count on a broad consortium of partners to further develop and implement the Platform. The ultimate objective is to pool knowledge, share ideas and experience, and build the critical momentum needed to achieve an alliance of expertise. This alliance should expand the knowledge base on earthquakes, build capacities in earthquake engineering and improve mobilization in the event of an earthquake. To this end, scientific knowledge, technological know-how and international collaboration need to be encouraged.

In July 2008 UNESCO has launched the International Platform for Reducing Earthquake Disasters (IPRED) programme in order to identify gaps and priorities through the sharing of scientific knowledge and experience in the field of seismology and earthquake engineering, and to support the development of political will and public awareness, for the purpose of ensuring better preparation against earthquakes and building a culture of safety for the people in the world. The responsibilities of local authorities and community leaders such as governors, mayors and other administrators are obvious and critical when the probability of occurrence of any kind of disasters starts to increase. Earthquake is one of the major expected disasters especially for the metropolitan areas located in seismic zones all over the world. The UNESCO’s IPRED programme is intended to further partnership and networking and to help draw lessons from earthquake disasters.

Participants of the Workshop contributed by considering ways and means to serve, in their fields of competence, their respective communities which are located in earthquake-prone areas. Indeed, it is vital that all concerned stakeholders combine their forces and competencies in dealing with natural hazards. The Workshop held in Istanbul, and its outcomes, which are compiled in this publication, are steps in the acceleration of cooperative work for quick implementation of new findings in rehabilitation techniques as well as in new construction. The Workshop was very successful, especially in light of the fact that it gave a fresh push in a coordinated manner toward the initiatives for public preparedness and rehabilitation of existing buildings taken by individual institutions. The outcomes of this Workshop will contribute to the reduction of earthquake losses, and to the health and safety of the millions of people worldwide.

UNESCO wishes to express its gratitude to all those who have contributed to the success of the Workshop. UNESCO thanks ITU and JICA for their cooperation in the implementation of the Workshop and for the production of this book. The commitment and hospitality of the ITU have made the meeting a successful event. UNESCO extends the Organization’s gratitude to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan, whose generous financial and technical support has enabled the Platform to become a reality. Special thanks also are due to the Building Research Institute (BRI) of Japan, and its International Institute of Seismology and Earthquake Engineering (IISEE), which serves as a Centre of Excellence for this Platform.

Badaoui Rouhban
Director, Section for Disaster Reduction
UNESCO, Paris

MAKE THE PEOPLE A PART OF THE SOLUTION

Rapid industrialization and associated rapid urbanizations became one of the major reasons of vulnerable buildings appeared around big cities. Rehabilitation of these huge amounts of hazardous buildings is a real problem which needs to be taken a lot of realistic scientific and administrative decisions as quickly as possible for having more resilient cities. These decisions need to be made jointly by both engineers and policy makers, and they should be made above all political agendas as far as the urgent rehabilitation of vulnerable structures in seismically active zones are concerned.

Although this is a must, unfortunately instances of such cooperation are few and far between. This becomes much more difficult if there is lack of reliable data and proper retrofitting techniques suit to the social and economical background of the country.

After having evaluated the present situation in Istanbul/Turkey, a new concept and a new strategy to implement, is being presented in this workshop. The success of the proposal, which is based on several realistic assumptions, needs first to bridge the *gap that exists between engineers and policy makers*.

It has been understood that the seismic hazard of big cities such as Istanbul cannot be lessened unless it is done with the *participation of the citizens*. There are thousands of simple reinforced concrete buildings, precast buildings and historical buildings in need of retrofitting, and this can't be done in a short period of time only with the help of municipalities and governments. First, people should be made aware of this. Second, everybody should know that the possibility of a destructive earthquake with an intensity equal or bigger than 7 hitting Istanbul is very high. There is neither the time nor the resources to carry out long term retrofitting projects. Instead, buildings that are easier to retrofit sufficiently to prevent loss of life and property, of which there are many, should be prioritized. For instance, *more plastic deformations can be allowed* on hundreds and thousands of ordinary buildings *without developing total collapse.*

It is not difficult to prove that by simple prescriptive solutions ordinary low rise – low cost buildings can be retrofitted even by the owner of the building.

Data Collected and Research Recently Completed

The recently accelerated systematic data collection and research activities carried out by municipalities and research institutes, revealed a lot of valuable information for engineers. *Regional seismicities and soil conditions, building stocks, structural characteristics such as structural deficiencies and material properties* are statistically well known. *Cost effective retrofitting techniques* have been developed depending on experimental and complementary theoretical works.

These works should be kept going on to complete the information still needed while the other activities are organized.

In addition to that, the experience gained by engineers and administrators after the 1992 Erzincan, 1995 Dinar, 1998 Adana Ceyhan and 1999 Kocaeli Earthquake Rehabilitation Projects were extremely important not only for researchers and practitioners but for the realization of the strategy to be proposed below as well.

Basic Assumptions Done

The two following assumptions are important for proposing a simple strategy to retrofit the existing low rise – low cost un-engineered buildings which are not classified as important buildings by existing earthquake resisting design codes;

i. ***Assume that none of the vulnerable buildings have earthquake resistance****.*
Sufficient amount of earthquake resistance will be provided by new simple interventions to be defined by engineers. For that purpose the as is drawings of critical stories of buildings are needed. This will be the first accomplishment of the proposed strategy. All the authorities

including local and metropolitan municipalities, universities, trained people and technicians, even trained army corps can cooperate for this purpose utilizing the most recent available technology. There is no need for any kind of detailed assessment in this procedure and there is no need for material tests as well.

ii. Soil conditions of region are known.

At least for Istanbul, it is known that this has already been done.

Strategic Fields of Cooperation Needed and a Proposal

It is known that pre-earthquake measures are assumed more effective than any kind of post-earthquake measures. Therefore, within the framework of a comprehensive preparedness program four important issues should be covered and be implemented by the consortiums of scientists and administrators.

Training the Trainers and Training the People; all kinds of instruments such as professionally prepared documentaries, specially prepared earthquake simulation rooms, hands on experiments, any kind of written documents, courses for training the trainers and training the people using every single opportunity obtained is essential. People should be informed by means of laboratory and field tests conducted by specialist and the experts of the topics. The support of international organizations and universities can be obtained for that purpose.

Changes in Regulations; the existing legislative regulations should definitely be updated to let the retrofitting is done easily depending on the votes of majority among the owners of the building. The individuals even the minorities among the owners should not be able to block the retrofitting of a building.

The code defined rehabilitation targets for ordinary buildings such as deformation limits, redesign load levels etc., should realistically be modified so that sufficient earthquake resistance becomes an achievable target for low income people. Retrofitting should be promoted as much as possible. For that purpose the compulsory disaster insurance sources should be exploited to create sufficient amount of fund.

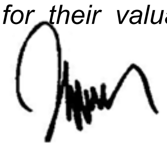
Support for Research Projects; considering that research is a continuous effort coming up with new findings making the life easy and more secure, it should be supported. The urgent research needs should be defined and prioritized jointly by scientists and administrators.

Establishments of Engineering Aid Services**;** Utilizing all the available data recently obtained and the research findings which are enough to expand the retrofitting activities for most of the ordinary buildings in metropolises by the help of people living and working in these vulnerable buildings. The experimentally proven theoretical back ground of the proposal which aims to prevent total collapse, is ready. An internet base Engineering Aid Service should be established by the consortiums and local municipalities and individuals should be encouraged by promotions to send the structural plans of their buildings to this center. After having processed the information obtained, the prescriptive solutions found by experts for that particular building should be forwarded to the owner.

Conclusions

A consortium consists of scientists and administrators should focus on training activities to make the people a part of the solution. For that purpose training facilities and training instruments should be created. The urgent data which is essentially the structural as is drawings of existing buildings should be collected. In addition to that urgent research needs should be satisfied and an Engineering Aid Service to help people should be established

We would like to express our appreciation to UNESCO, JICA, ITU and Metropolitan Municipality of Istanbul and to all of the participants for their valuable contributions to make this initiative and workshop highly successful.



Faruk Karadoğan
On Behalf of the Organizing Committee

Monday, July 6th 2009

	9.00-10.00	**Registration**
SESSION I	10.00-10.15	**Melike ALTAN** (ITU – Head of the Civil Engineering Department) **Gaye ONURSAL DENLİ** (ITU-Dean of the Civil Engineering Faculty) -
	10.15-10.45	**Faruk KARADOĞAN** (ITU) Opening Speech : "Make the People a Part of the Solution "
	10.45-11.00	**Takashi IMAMURA** (UNESCO) Opening Speech : "UNESCO's Role in Earthquake Disaster Reduction"
	11.00-11.10	**Mete TAPAN** (ITU) "Historical Buildings-Renovation Works-Earthquake Risk"
	11.10-11.25	**İbrahim BAZ (**Metropolitan City of İstanbul)
	11.25-11.40	**Kadir TOPBAŞ** (Mayor of Metropolitan City of İstanbul)
	11.40-11.55	**Muammer GÜLER** (Governor of İstanbul)
	11.55-12.10	Representative of government
	12.10-12.30	Visit to Structural and Earthquake Engineering Laboratory (STEEL)
	12.30-13.30	**Lunch**
SESSION II **Chairs** **Metin AYDOĞAN, Anita FIRMANTI**	13.30-13.45	**Nihan ERDOĞAN** (UN/OCHA) "Humanitarian Response and Coordination in Earthquake Disasters"
	13.45-14.00	**Haluk EYİDOĞAN** (ITU) "Seismicity and Seismic Hazard in the Vicinity of Istanbul"
	14.00-14.15	**Nozomu YAMASHITA** (JICA /Turkey) "JICA's Approach in Earthquake Disaster Reduction – Turkey's Case"
	14.15-14.30	**Cemal Gökçe** (IMO) "Safe Structure Production, Engineering Services and Building Inspection"
	14.30-14.45	**Gökhan Kazım ELGİN** (ISMEP-Project)) "İstanbul Seismic Risk Mitigation and Emergency Preparedness (ISMEP) Project"
	14.45-15.15	**Alessandro MARTELLI** (ENEA, Italy) "Lessons Learned from Recent Earthquakes in Italy: From The San Giuliano di Puglia Trajedy in 2002 to the Collapses in Abruzzo in 2009"
	15.15-15.30	**Discussion**
	15.30-15.50	**Coffee break**

SESSION III Chairs Zekai CELEP, Carlos GUITERREZ	15.50-16.20	**Zekai CELEP** (ITU) “Experiences of the Research and Application Centre for Structures and Earthquakes (Istanbul Technical University) on Seismic Assessment and Retrofitting of Buildings since 1992”
	16.20-16.35	**Alper İLKİ** (ITU) , Korel ERAYBAR, Yılma KARATUNA, Kenji OKAZAKİ (GRIPS-Tokyo) “Seismic Risk Perception in İstanbul”
	16.35-16.50	**Kenji OKAZAKI** (GRIPS-Tokyo), A. ILKI , N. AHMAD, R.C. KANDEL, K. PRIBADI, R. SINHA, D. ZOLETA-NANTES, J. BOLA, M. UMEMOTO “Seismic Risk Perception Consuming Housing Safety”
	16.50-17.05	**Miktat KADIOĞLU** (ITU), Derin URAL, Hikmet İSKENDER, Center of Excellence for Disaster Management, “Reducing Risk of Earthquake Disaster by Education”
	17.05-17.20	**Hidehiko SAZANAMI** (UNCRD-Tokyo) “Study on Sustainable Development Strategy for Hanshin Region in Japan”
	17.20-17.35	**İsmet GÜNGÖR** (Turkish Catastrophe Insurance Pool (TCIP)) “Doğal Afet Yönetiminde DASK”
	17.35-17.50	**Yılmaz GÜRLEK,** Zeki HASGÜR (ITU) “The Earthquake Insurance Business in Turkey and in the World”
	17.50-18.10	**Discussion**
	18.10-20.00	**COCKTAIL**

Tuesday, July 7th 2009

SESSION IV Chairs Gülten GÜLAY, Mihai IANCOVICI	9.00-9.20	**Ernesto F. CRUZ** (Universidad Catolica de Chile, Chile) “Present Status of Earthquake Preparedness Activities in Chile”
	9.20-9.40	**Salah M. MAHMOUD** (NRIAG, Egypt) Adel M. El-Shahat, Ahmed Deif “Egypt’s Efforts to Prevent the Collapse of Existing Buildings by Earthquakes”
	9.40-10.00	**Ercan YÜKSEL** (ITU) “Recent Experimental Works in ITU”
	10.00-10.20	**Anita FIRMANTI** (RIHS, Indonesia) L. FAISAL “Indonesia’s Efforts to Prevent the Collapse of Existing Buildings by Earthquakes”
	10.20-10.40	**Nobuo HURUKAWA** (IISEE, Japan) “IISEE’s Efforts to Train Experts in Evaluating and Retrofitting Existing Buildings, Including the Newly Established China Project”
	10.40-11.00	**Coffee break**

SESSION V Chairs Erkan ÖZER, Carlos ZAVALA	11.00-11.20	**Erkan ÖZER** (ITU) "Development of Turkish Seismic Design Codes and the 2007 Code"
	11.20-11.40	**Yasuo KATSUMI** (MLIT, Japan) "MLIT's Efforts to Prevent the Collapse of Existing Buildings by Earthquakes"
	11.40-12.00	**Shin KOYAMA** (BRI, Japan) "BRI's Efforts to Prevent the Collapse of Existing Buildings by Earthquakes"
	12.00-12.20	**Rafael ALALUF,** Ahmet Emre TOPRAK (EQRM International, Inc) "Review of Procedures Used for Seismic Strengthening of Existing Public Schools and Social Services Buildings in Istanbul, Turkey"
	12.20-13.30	**Lunch**
SESSION VI Chairs Feridun ÇILI, Salah M. MAHMOUD	13.30-13.50	**Feridun ÇILI** (ITU) "Repair and Strengthening of Historical Buildings"
	13.50-14.10	**İhsan Engin BAL** (EUCENTRE, Pavia, Italy) H. Crowley, R. Pinho "Displacement Based Loss Assessment for an Expected Scenario Earthquake in Istanbul"
	14.10-14.30	**Carlos ZAVALA** (CISMID, Peru) M. DIAZ, L. IGARASHI, L. CARDENAS, E. ARELLANO "Peru's Efforts to Prevent The Collapse of Existing Buildings by Earthquakes"
	14.30-14.50	**Yılmaz AKKAYA,** Mehmet Ali TAŞDEMİR (ITU) "Turkish Experience in Concrete Construction Industry and Infrastructure"
	14.50-15.10	**Yuji ISHIYAMA** (Hokkaido University) "IAEE Guidelines for Earthquake Resistant Non-Engineered Construction"
	15.10-15.30	**Coffee break**
SESSION VII Chairs Zeki HASGÜR, Ernesto F. CRUZ	15.30-15.50	**Zeki HASGÜR,** Beyza TAŞKIN (ITU) "Code Compatible Artificial Earthquakes"
	15.50-16.10	**Mihai IANCOVICI** (CNRRS, Romania) "Current Status Toward Seismic Risk Reduction in Romania"
	16.10-16.30	**Tanatkan ABAKANOV** (Institute of Seismology, Kazakhstan) "Kazakhstan's Efforts to Prevent the Collapse of Existing Buildings by Earthquakes"
	16.30-16.50	**Carlos GUTIERREZ** (CENAPRED) "Contributions to the Evaluation and Mitigation of Seismic Risk in Mexico"
	16.50-17.00	**CLOSING CEREMONY**
	17.00-18.30	**IPRED2 meeting (by IPRED members)**

Declaration of Participants in the
UNESCO-IPRED-ITU Workshop

Istanbul, 7 July 2009

This declaration is a reflection of the presentations and discussions made by during the UNESCO-IPRED-ITU Workshop on "Make the People a Part of the Solution" hosted by the Istanbul Technical University (ITU) and supported by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Japan International Cooperation Agency (JICA). The Workshop was held in Istanbul on 6 and 7 July 2009 at the Conference Hall of Civil Engineering Faculty of ITU Maslak Campus, as part of the decennial memorial of the earthquakes which occurred on 17 August 1999 in Kocaeli and 12 November 1999 in Düzce.

Summary of the Workshop

The Workshop was attended by high-ranking officials of the Turkish local authorities as well as local scientists mainly from the ITU and guests of nine other earthquake-prone countries (Chile, Egypt, Indonesia, Italy, Japan, Kazakhstan, Mexico, Peru and Romania). Representatives of UNESCO, UN-OCHA and JICA Turkey Office also participated and made presentations on their activities relating to earthquake disasters.

The Workshop considered the responsibilities of local authorities and community leaders such as governors, mayors and other administrators in view that the role they play is pronounced when the probability of occurrence of any type of disaster starts to increase. Earthquakes are one of the major expected disasters, especially for the metropolitan areas located in seismic zones worldwide.

Istanbul and its vicinity is recognized by the international community as a mega-settlement where the safety of critical facilities such as schools and hospitals as well as residential buildings should be ensured as a top priority. Efforts must be pursued so that all realistic measures are taken in order to realize more resilient communities. Since the magnitude of the problem communities face is clearly recognized, an encouraging continuous process should be initiated as quickly as possible for the purpose of making all of the citizens a part of the solution. This needs core people who are conscious, educated, trained and very well prepared.

The Workshop especially intended to give a fresh push in a coordinated manner toward the initiatives for public preparedness and rehabilitation of existing buildings taken by individual institutions.

International Background

Prior to the Workshop, the Second Session of the Global Platform for Disaster Risk Reduction was held on 16-19 June 2009 in Geneva, and the UN Secretary-General, Ban Ki-moon, in his message called for a target to halve the losses of lives from disasters by 2015, when the term of the Hyogo Framework for Action concludes. Accordingly, in the Chair's Summary, the following specific targets were proposed as catalysts for cutting deaths and economic losses brought on by disasters:

1) By 2011, a global structural evaluation of all schools and hospitals should be undertaken, and by 2015 concrete action plans for safer schools and hospitals should be developed and implemented in all disaster-prone countries. Similarly, disaster risk reduction should be included in all school curricula by the same year.
2) By 2015, all major cities in disaster prone areas should include and enforce disaster risk reduction measures in their building and land use codes.

The following recommendations are in line with the efforts of the international communities, and in all cases, the national and local governments have to play extremely important roles.

Recommendation to the Governments

In Turkey, national and local governments have made great efforts to reduce earthquake disasters, including the "Earthquake Master Plan for Istanbul" prepared in 2003 with the assistance of four local universities and the Metropolitan Municipality of Istanbul based on a JICA Development Study. These and some other works carried out by universities are milestones on our way to safer cities. It is time now to accelerate cooperative work for quick implementation of new findings in rehabilitation techniques as well as in new construction.

The participants of the Workshop sincerely hope and recommend that the following actions are to be considered by the governments:

1. Strengthen the enforcement system of mandatory building codes as well as monitoring system of their performance including actions to deal with illegally-constructed buildings;
2. Make sure all the critical facilities such as schools and hospitals can withstand the possible earthquakes, by utilizing advanced techniques such as seismic isolation when applicable, so that they will continue to function immediately after the earthquakes;
3. Promote the development and utilization of affordable retrofitting techniques to prevent the total collapse of low-cost low-rise residential buildings by reconsidering the code requirements;
4. Develop and disseminate a quick screening method as well as a detailed evaluation method of physical vulnerability of buildings;
5. Reduce social vulnerability by such measures including the integration of disaster risk reduction into education system, and raise awareness of the citizens so that they will respect the building codes and invest for the retrofitting to prevent the total collapse of buildings;
6. Examine the current insurance system against earthquake and consider the modification to enlarge the coverage and to link with the building control system. The attention should be part for preparedness activities rather than disaster management activities.
7. Provide technical trainings for professionals including building officials, architects, engineers, supervisors, masons and carpenters;
8. Create necessary legislative instruments for proper urban planning and develop land use zoning and master plans taking into account the areas prone to be affected by hazards such as landslides and liquefaction triggered by earthquake activities.

Keeping in mind that the probability of having a destructive earthquake is getting higher and this is not in the proper place of political agenda. In fact cooperation between the researchers and policy makers above the political agendas is a must.

The data collected and the retrofitting techniques developed in last 10 years should definitely be utilized as initial input of a long-term strategy to be prepared. Engineering aid units consist of trained engineers in assessment and cost effective retrofitting techniques should be established to evaluate the as built structural drawings of low-rise low-cost buildings. To obtain the as built structural drawings is the main issue to be considered seriously by the local authorities. People should be convinced and should be made a part of this problem. For that purpose documentaries should be prepared in a professional way; science and community parks should be built and strategies are needed to enlighten and to help the owners of buildings.

Takashi Imamura and Faruk Karadogan

On Behalf of the Organizing Committee

IPRED stands for the International Platform for Reducing Earthquake Disasters. It was launched in July 2008 by UNESCO with the support of the Ministry of Land, Infrastructure, Transport and Tourism of Japan. It aims at identifying gaps and priorities through the sharing of scientific knowledge and experience in the field of seismology and earthquake engineering, and supporting the development of political will and public awareness, for the purpose of ensuring better preparation for earthquakes and building a culture

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UNESCO'S ROLE IN EARTHQUAKE DISASTER REDUCTION

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ABSTRACT

Risk of disasters is increasingly caused, or aggravated, by human behaviour and attitude, including urbanization in developing countries which adds extra pressure on building construction. Whereas hazards may be inevitable, disasters are not. We can break the link by proper prevention and disaster preparedness. UNESCO is engaged in the study and mitigation of natural hazards since 1960s. Its scope of work concerns promoting knowledge and education aimed at enhancing disaster prevention and preparedness. UNESCO is an active partner in the International Strategy for Disaster Reduction (ISDR) system. The mission of the UNESCO's IPRED programme is to identify gaps and priorities through the sharing of scientific knowledge and experience in the field of seismology and earthquake engineering, and to support the development of political will and public awareness, for the purpose of ensuring the better preparation against earthquakes and building a culture of safety for the people in the world. UNESCO intends to contribute to the creation of safer built environment, through its network including the IPRED, by advocating important issues on building codes and promoting education for disaster risk reduction as well as school safety.

KEYWORDS
IPRED, disaster risk reduction, earthquake, building codes, education, school safety

INTRODUCTION

The risk of natural disasters is on the rise. The risk is ever increasing as urbanization in developing countries adds extra pressure on building construction. Earthquakes are not directly related to the climate change, but the risk is increasing because of population increase, growing urbanisation, continuous unregulated construction of buildings. But, more importantly, we still have many existing buildings which may not withstand the future earthquakes.

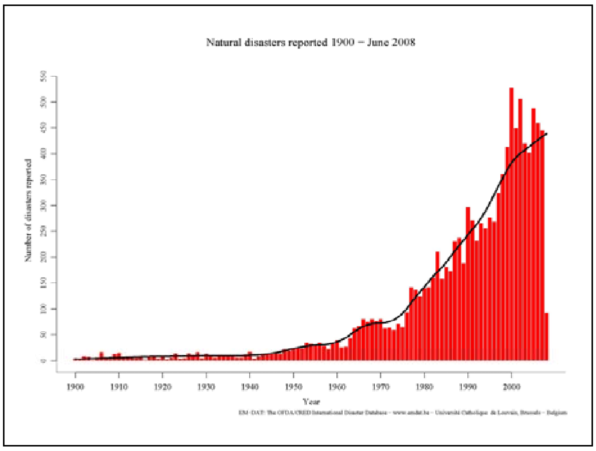

Figure 1. Natural disasters reported (EM-DAT)

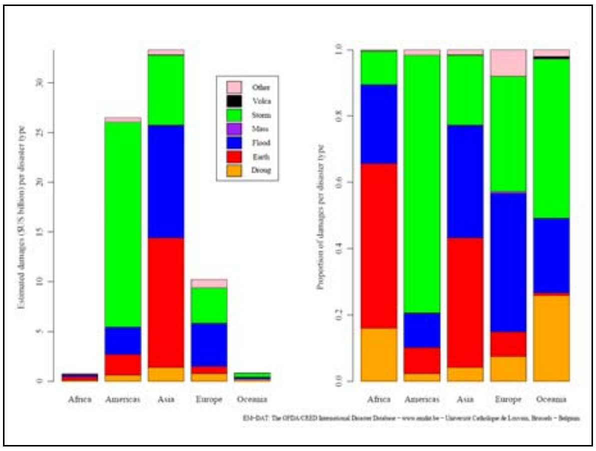

Figure 2. Estimated damages per disaster type by regions (EM-DAT)

Over the past months and years images of death and destruction caused by various natural disasters worldwide are still with us. The tragedy caused by the Wenchuan earthquake in China in May 2008 and the floods in Haiti in the autumn are a dramatic reminder *(Note: The Haiti earthquake in January 2010 occurred after the IPRED workshop in Istanbul)*. We have also witnessed how fires and floods can disturb a nation like Australia. According to the EM-DAT, it is clear that the number of natural disasters has increased dramatically since the beginning of the last century. And more clearly, since 1950, and in particular during the last 20 years, the rate of disaster increase is very high as shown from the steep incline in this curve.

It may be no exaggeration to say that major disasters are not behind us and clearly, today, natural disasters are becoming increasingly a global issue: because of increasing vulnerability and exposure, because of population increase, growing urbanisation, continuous unregulated construction of buildings which often are not resilient to natural disasters, environmental degradation and poorly planned development, and also because of the implication of global climate change which may be behind further extreme climatic events.

UNESCO is engaged in the study and mitigation of natural hazards since 1960s. Its scope of work concerns promoting knowledge and education aimed at enhancing disaster prevention and preparedness. The purposes of the Organization are to promote a better understanding of earthquakes and other hazards, and to enhance preparedness and public awareness through education and training. UNESCO is an active partner in the International Strategy for Disaster Reduction (ISDR) system.

Long-term Goals of DRR (Disaster Risk Reduction)

- Promotion of better understanding of earthquakes and other hazards
- Enhancement of public awareness through education and communication
- Promotion of disaster-resistant building codes and safer construction
- Support development of hazard risk mapping
- Observation and early warning networks of natural hazards
- Integration of DRR into education
- Protection of cultural monuments and sites

Figure 3. UNESCO's Long-term Goals of DRR

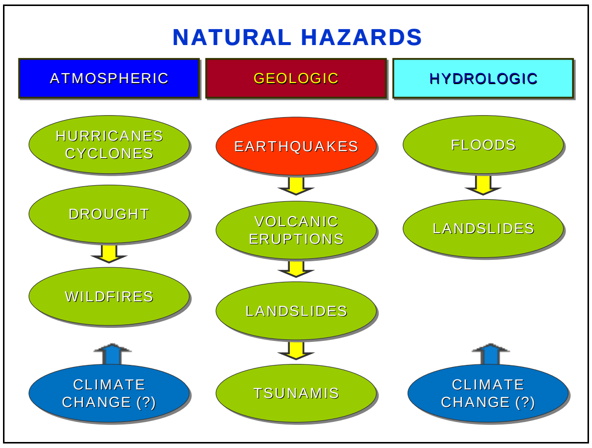

Figure 4. Natural hazards UNESCO is tackling

When we look at the disaster cycle, we unfortunately observe that the majority of resources for disaster-related activities are spent at the occurrence of disasters and for the emergency response phase and relief operations. Much less funding and effort are devoted to investing in the other phases of the cycle, namely the mitigation, the disaster preparedness or more generally the pre-disaster phase. This trend must be reversed in order to reduce losses in a true sense.

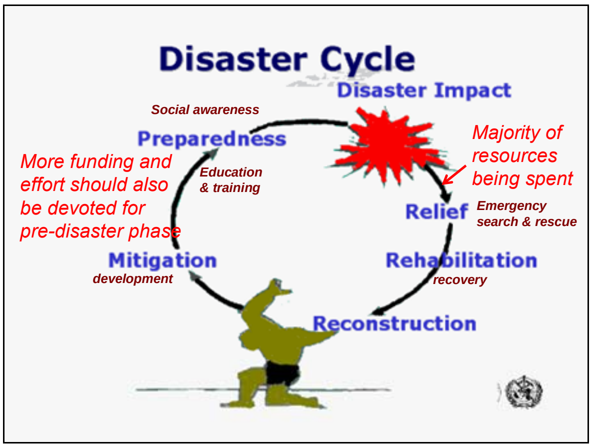

Figure 5. Disaster Cycle

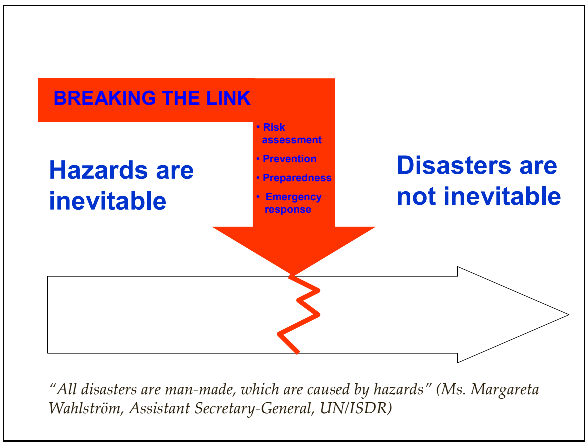

Figure 6. Hazards vs Disasters

Disasters are increasingly caused, or aggravated, by human behaviour and attitude. Whereas hazards may be inevitable, disasters are not. We can break the link by proper prevention and disaster preparedness. Regarding earthquakes, the earthquake hazard itself does not kill people, but buildings and other infrastructure kill them and make it the disaster. We can prevent disasters by making safer environment.

As regards research and expertise on earthquake risk, UNESCO established the International Platform for Reducing Earthquake Disasters (IPRED) in 2008, with the support of the Government of Japan. It aims at setting up an international network for collaborative research, training, and education regarding seismology and earthquake engineering, including the establishment of a system for post-earthquake field investigation. The International Institute of Seismology and Earthquake Engineering (IISEE) of Japan acts as the “Centre of Excellence” of this Platform.

In addition, UNESCO has been jointly carrying out workshops devoted to promote a programme for reducing earthquake losses, in cooperation with the U.S. Geological Survey (USGS) and earthquake science organizations in the Mediterranean and in South Asia Region, etc. These workshops offer a forum for scientists and engineers from countries presenting a diversity of political contexts to work together under UNESCO’s umbrella and discuss regional approaches to improve collaboration in earthquake data exchange and analysis.

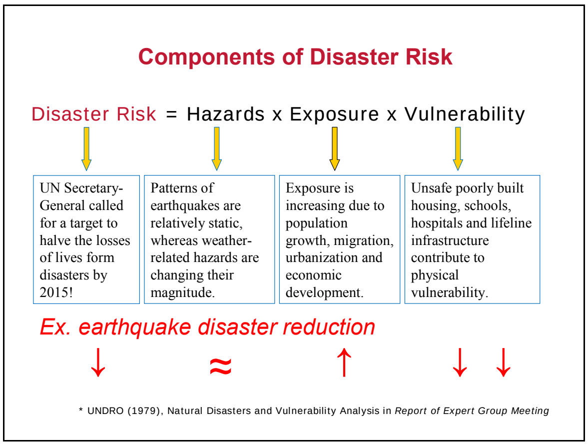

Figure 7. Components of Disaster Risk UNDRO (1979)

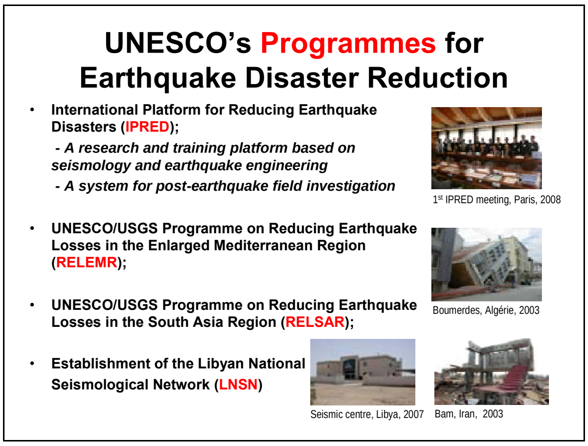

Figure 8. UNESCO’ programmes for earthquake disaster reduction

BACKGROUND OF THE IPRED

Buildings, especially housing, should protect human beings from natural disasters. When buildings are themselves damaged by earthquakes, the impact on the lives of the occupants is enormous. Damage to buildings caused by disasters can also seriously hinder relief and repairing efforts. For example, major hospitals and other facilities may become unable to function, roads may be blocked by wreckage, and there may be massive refugee flows.

In January 2005, the United Nations World Conference on Disaster Reduction (WCDR) was held in Kobe, Japan and the WCDR adopted the Hyogo Framework for Action (HFA) 2005-2015: Building the resilience of nations and communities to disasters. At one of the Conference Sessions, it was discussed that it is important to improve the safety of buildings and housing as a basic and vital priority for the world’s disaster reduction efforts. It was then proposed that the “Building Disaster Reduction Network” should be established.

Such a network is especially needed for earthquakes in order to activate and share data of invaluable experience of each country, as it is difficult for a single country to experience and verify the effects of measures. As Japan has experienced many large earthquakes since ancient times, earthquake disaster reduction has been researched and studied quite extensively. UNESCO has recognized and supported these Japanese efforts and expertise concerning earthquake risk reduction.

In 1960, the Government of Japan launched international training courses on seismology and earthquake engineering. In 1962, UNESCO participated in a joint venture with the Building Research Institute (BRI) of Japan when the Government of Japan established the IISEE. Since then, the IISEE has conducted international training courses on seismology and earthquake engineering for researchers and engineers from foreign countries. UNESCO provided financial support to the training courses from 1963 to 1972.

Since 2005, the curricula of the training courses are conducted as the Master Program on Earthquake Disaster Mitigation at the National Graduate Institute for Policy Studies (GRIPS) of Japan, and in 2006, UNESCO provided funds in support of it. Today, supported by the Japan International Cooperation Agency (JICA), more than 1,400 researchers and engineers (a total number since 1960) from almost 100 countries have graduated from the training courses.

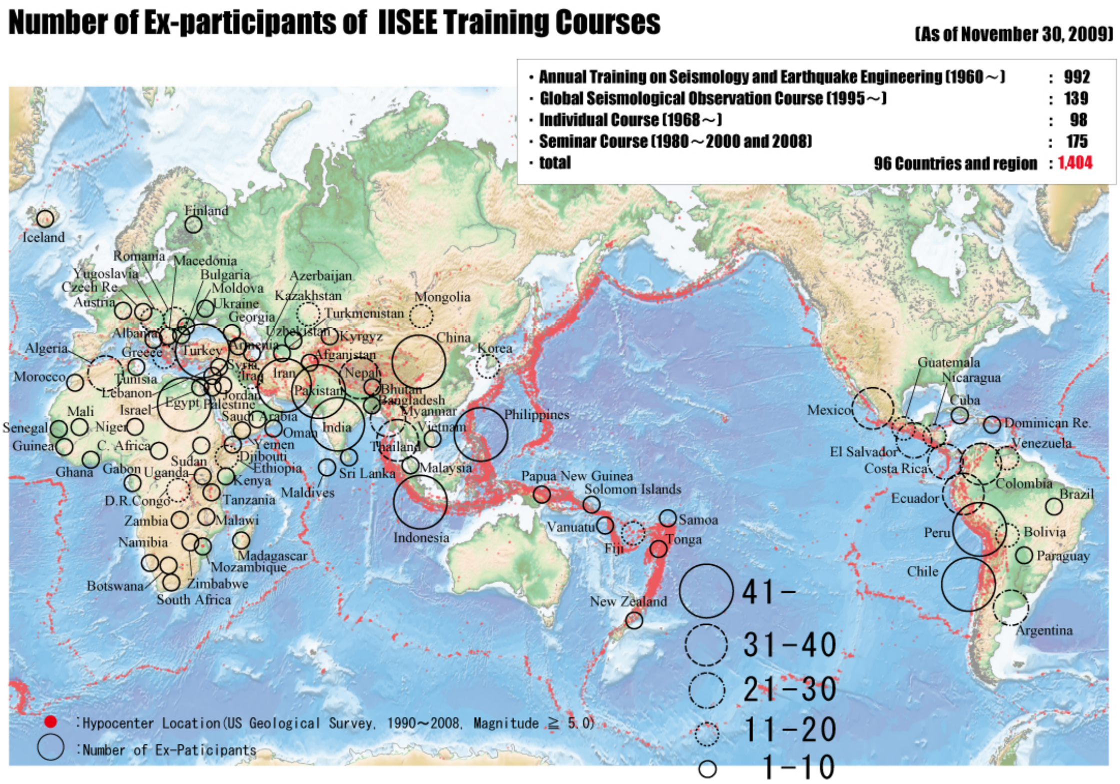

Figure 9. Worldwide ex-participants of UNESCO-supported IISEE Training Courses

ESTABLISHMENT OF THE IPRED (http://www.unesco-ipred.org)

Against the above-mentioned background, and in order to address policy-relevant issues related to earthquake risk reduction and better prepare for the future earthquakes in the world, UNESCO and the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) of Japan, in cooperation with the BRI of Japan, agreed to promote and expand an international platform regarding earthquakes, including a research and training platform for earthquake disaster reduction based on seismology and earthquake engineering.

Figure 10. Kickoff meeting (Tokyo, June 2007)

The kickoff meeting of this initiative was held in June 2007 in Japan jointly organized by UNESCO, MLIT and BRI, and supported by Japanese National Commission for UNESCO, the Ministry of Foreign Affairs of Japan and other related organizations. The meeting was attended by representatives of the UNESCO Headquarters, nine countries (Chile, Egypt, Indonesia, Japan, Kazakhstan, Mexico, Peru, Romania, and Turkey) with experiences of JICA projects regarding earthquake disaster reduction in the past and related organizations.

At the end of the kickoff meeting, the participated members adopted the resolutions including the establishment of an international platform to promote earthquake risk reduction of buildings, and the formal name of this initiative was later agreed as the "International Platform for Reducing Earthquake Disasters (IPRED)."

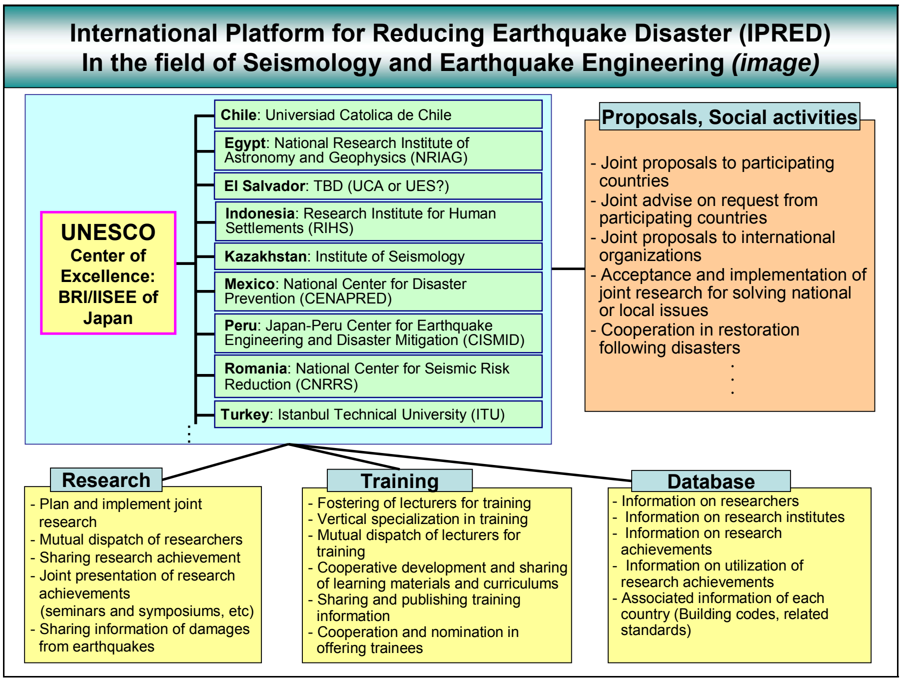

Figure 11. Activities of the IPRED

The first IPRED meeting was held in July 2008 at the UNESCO Headquarters in Paris. The meeting was attended by representatives of nine earthquake-prone countries (Chile, Egypt, Indonesia, Japan, Kazakhstan, Mexico, Peru, Romania, and Turkey) as well as a guest expert from a Chinese university and the several observers from the Permanent Delegations to UNESCO. At the meeting, quick reports and lessons learned from recent devastating earthquake disasters were shared, and the Action Plan (see below) was discussed. During this meeting, Prof. Dr. Karadoğan proposed that the next session of IPRED be held in Istanbul, Turkey in July 2009, inviting local government and policy-makers to a workshop. The proposal was welcomed with a round of applause by all the participants.

THE MISSION AND OBJECTIVES OF THE IPRED

The mission of the IPRED is to identify gaps and priorities through the sharing of scientific knowledge and experience in the field of seismology and earthquake engineering, and to support the development of political will and public awareness, for the purpose of ensuring the better preparation against earthquakes and building a culture of safety for the people in the world.

The principal objectives of the IPRED are as follows:

a. To exchange information and propose plans on collaborative research, training, and education regarding seismology and earthquake engineering in order to reduce earthquake disasters, especially on buildings and housing;
b. To address policy-relevant issues related to the reduction of earthquake disaster risks and implementation of the Hyogo Framework for Action, including making recommendations on priorities in the International Strategy for Disaster Reduction (ISDR) system;

c. To establish a system to dispatch experts to an earthquake stricken country in order to carry out post-earthquake field investigations and draw lessons for future risk reduction, by utilizing the worldwide network of ex-participants of IISEE international training courses;
d. To support and cooperate with the IISEE in its activities including implementation of international training courses on seismology and earthquake engineering aiming at earthquake disaster reduction;
e. To propose and organize specific enquiries regarding seismology and earthquake engineering in order to investigate and address priority matters to the governments and regional or international communities;
f. To advise the IPRED members on scientific and technical issues regarding seismology and earthquake engineering; and
g. To assist and coordinate scientific and technical activities within the ISDR system, including the initiatives of the ISDR Global Task Force on Building Codes coordinated by UNESCO.

Figure 12. Mr. Koïchiro Matsuura, then Director-General of UNESCO launches the IPRED

Figure 13. The 1st session of the IPRED (Pairs, July 2008)

> ***"Natural disasters including earthquake disasters do not recognize geographical borders. Knowledge about earthquakes must be shared for the benefit of all."***
> *– Mr Koïchiro Matsuura, then Director-General of UNESCO, during the 1st Session of the IPRED*

THE IPRED ACTION PLAN

- ***Action 1***: *Development of database to contribute to field investigations (database related to anti-seismic performance, etc.) (http://www.unesco-ipred.org/database/)*
- ***Action 2***: *Establishment of a system for post-earthquake field investigations*
- ***Action 3***: *Development of educational materials database (for the e-learning system, etc.)*
- ***Action 4***: *Promotion of international joint research programmes*
- ***Action 5***: *Promotion of international cooperation with universities*
- ***Action 6***: *Promotion of sharing engineering data on structural testing, soil properties, etc.*
- ***Action 7***: *Promotion of ground motion observation network and the data sharing*
- ***Action 8***: *Training of trainers through the IISEE follow-up trainings, follow-up workshops, etc.*
- ***Action 9***: *Development of the portal website (http://www.unesco-ipred.org/)*
- ***Action 10***: *Establishment of the "IISEE-UNESCO Lecture Notes Series" (http://iisee.kenken.go.jp/lna/)*
- ***Action 11***: *Development of the microtremor array exploration techniques*
- ***Action 12***: *Dissemination of activities through International and/or regional events related to seismology or earthquake engineering*
- ***Action 13***: *Planning of international workshops to raise IPRED's awareness*
- ***Action 14***: *Information dissemination by distribution of printed materials*
- ***Action 15***: *Translation of building codes into other languages*

THE IPRED POST-EARTHQUAKEE FIELD INVESTIGATION

One of the important objectives of the IPRED is to establish a system for post-earthquake field investigation. It is recommended that, before the occurrence of major earthquakes, UNESCO and the IISEE as the Centre of Excellence of the IPRED prepare the register of names and email addresses of members who may be able to cooperate with and/or participate in the post-earthquake field investigations. In principal, at the initial stage, it would be a good idea to utilize the worldwide network of ex-participants of IISEE international training courses.

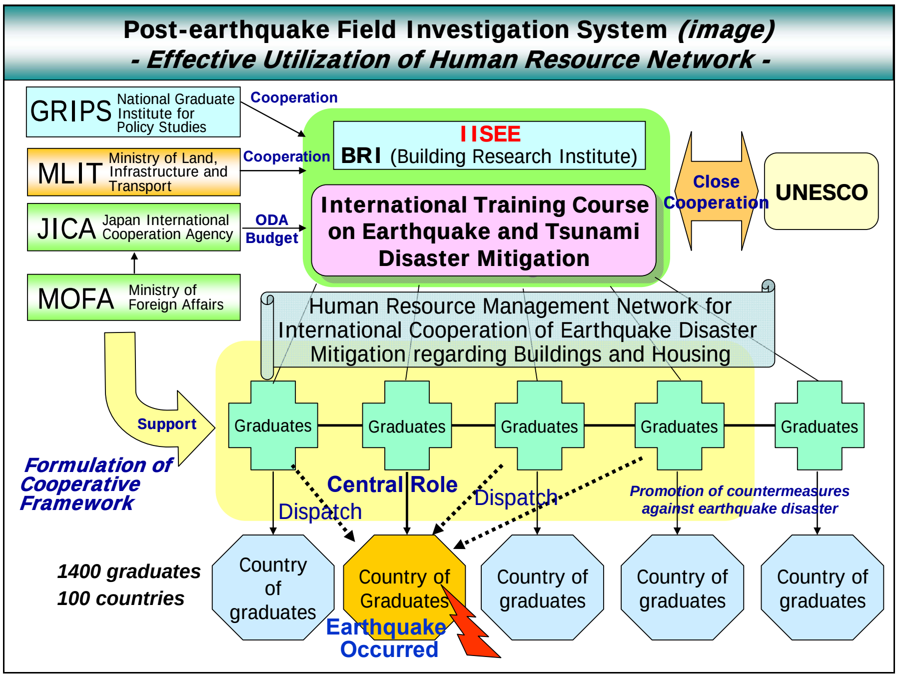

Figure 14. Image of IPRED post-earthquake field investigation system

Based on the IPRED Action Plan, UNESCO and the IISEE have developed the database to contribute to post-earthquake field investigations regarding building codes, materials and guidelines, etc. and it is being upgraded. (http://www.unesco-ipred.org/database/)

If and when a major earthquake occurs, UNESCO and the IISEE are supposed to gather information on its scale and damages, and dispatch the information to the registered members via the Internet and/or emails. If the post-earthquake field investigation is judged as necessary, UNESCO and the IISEE will promptly establish the field investigation team in cooperation with the registered members.

Some principal criteria of the judgment of the necessity of the field investigation would include the following:

i. Severe Damages have occurred to many engineered buildings, or characteristic damages have occurred to non-engineered buildings;
ii. Lessens on seismology and/or earthquake engineering regarding plans, designs and construction works can be obtained;
iii. There are no major difficulties in the situation of public safety in order to carry out the field investigation.

It would be important to synthetically take into account widely distributed construction methods, languages, customs and livelihood in the earthquake-stricken area as well as any difficulties in carrying out the field investigation including humanitarian issues. In order to carry out the field investigation as effectively and efficiently as possible, and not to cause annoyance to the victims or rescue teams in the earthquake-stricken area, the field investigation team shall be arranged not to overlap too much with other field investigations dispatched by other organizations.

In order to take effective actions, it would also be necessary to develop some manuals regarding how to proceed with field investigations. The primary aim of field investigations would be to grasp the overall situation of damages to buildings and to record such information for academic/scientific purposes. Therefore, it would be difficult to offer detailed examinations and/or advices on seismic retrofitting, etc. for a specific building during such field investigations. However, it would also be possible to contribute to the earthquake-stricken area later on, by reporting to local governments on results of the field investigation, advising a future reconstruction plan, introducing the state-of-the-art knowledge/technology, etc.

After field investigations, UNESCO shall upload the quick report on its website. As occasion demands, UNESCO may make plans for a meeting on the quick report, publication of the field investigation results, etc.

In principle, each individual member of the field investigation team shall bear the traveling expenses of the investigations. However, UNESCO will facilitate the funding of this mechanism through its own programme and budget or by mobilizing extrabudgetary resources, provided such resources are available. At any rate, at the request of the field investigation team, UNESCO will consider the support of all or part of the expenses within the limits of its budget according to the situation. UNESCO may also offer convenience to the member, including the request of prompt grant of a visa to the affected county and other arrangement with the relevant organization in the affected country.

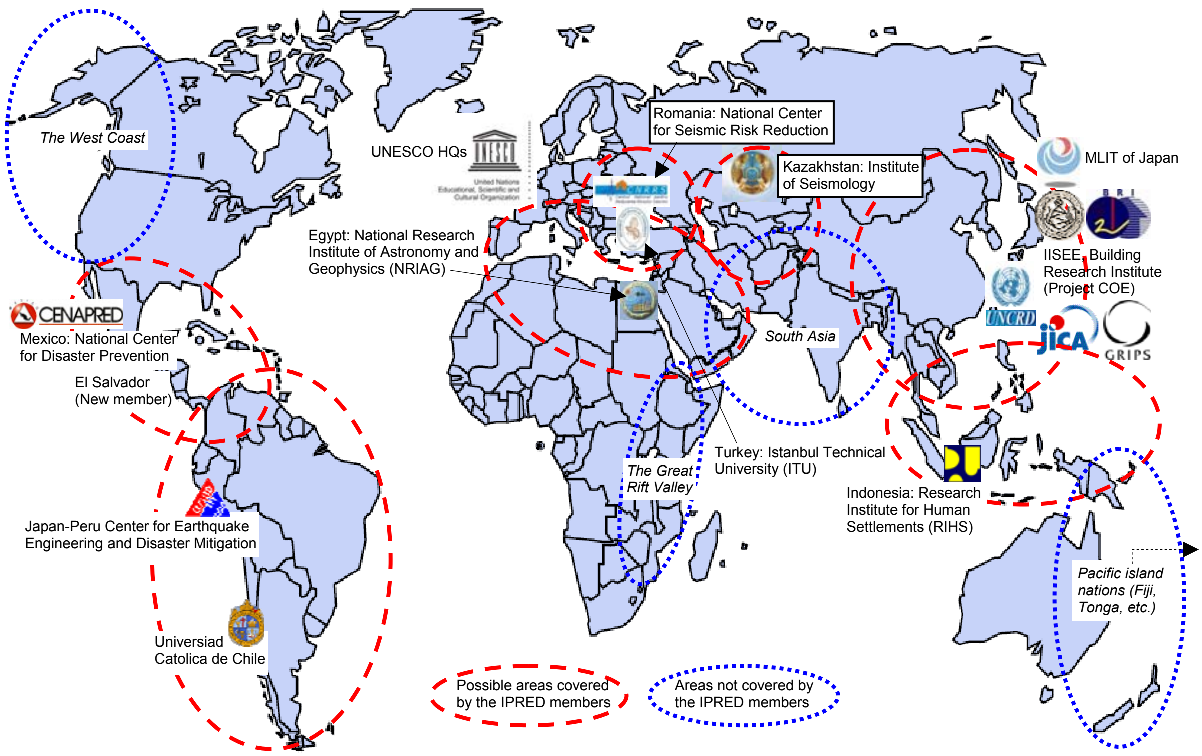

Figure 15. Possible regional network under the IPRED programme

When a foreign government dispatches a field investigation team to the country affected by a major earthquake, it is the ordinary procedure that the government of the affected country first makes an official request to the foreign government on this matter through the diplomatic establishments in the said affected country. However, it may not be easy for the government to make such a request smoothly under the confusion in the wake of the earthquake.

On the other hand, when a foreign nongovernmental organization such as an academic society dispatches a field investigation team to the country affected by a major earthquake, there may be no such ordinary, formal procedure. However, it may not be easy for them to obtain a visa to the affected county.

Therefore, UNESCO as a United Nations organ proposes to make prior arrangements with related governments and organizations to facilitate post-earthquake field investigations. It would be the good first step if a Memorandum of Understanding (MoU) regarding cooperation on the post-earthquake field investigation be concluded between UNESCO and each key IPRED member institute or university in cooperation with the IISEE. *(It is planned to arrange such a MoU on the occasion of next IPRED meeting in Padang, Indonesia in July 2010.)*

Figure 16. The 2nd Session of the IPRED (Istanbul, July 2009)

Figure 17. Agreement signed between BRI of Japan and NCSRR of Romania

EDUCATION FOR DRR & SUSTAINABLE DEVELOPMENT (INCLUDING SCHOOL SAFETY)

The dramatic increase in human and economic losses from disasters in recent years is alarming. In particular, natural disasters continue to often strike hardest at some of the world's poorest communities, which are the least well placed to defend themselves or to recover afterwards. While natural hazards are not a new phenomenon, sadly, they tend only to attract attention when they manifest themselves as disasters. Despite the ample available body of knowledge and know-how on the assessment of natural hazards and the attenuation of their consequences, reducing and mitigating disaster risks is still not high on many governments' agenda.

We need to make a major conceptual shift from a focus on disaster response, to an emphasis on disaster prevention. The implementation of the Hyogo Framework for Action is, more than ever, an imperative in pursuing the substantial reduction of disaster losses. Operating as it does at the interface between education, the sciences, the social science, culture and communication, UNESCO is committed to play a vital role in contributing to constructing a global culture of disaster resilience.

Figure 18. Collapsed junior high school buildings in Yingxiu (2008 ©T. Imamura)

Figure 19. The left-side school building driven up 2 meters by the fault in Bailu (2008 ©T. Imamura)

For decades, the Organization has been actively engaged in the study of natural hazards and in building capacities to mitigate their effects. As an active partner in the International Strategy for Disaster Reduction (ISDR), UNESCO promotes international and regional networks of systems and expertise for the monitoring, exchange and analysis of hazards data, in particular data related to earthquakes, tsunamis, floods, droughts and landslides.

Figure 20. Heavily damaged hospital surrounded by debris in Hanwang (2008 ©T. Imamura)

Figure 21. Collapsed elementary school buildings in Beichuan (2008 ©T. Imamura)

As a United Nations specialized agency with EDUCATION inscribed in its name, UNESCO is also concerned with the integration of education and disaster risk reduction as well as with the protection of educational buildings and cultural monuments and sites in hazard-prone areas. It is an intrinsic element of the UNESCO-led United Nations Decade of Education for Sustainable Development (UN DESD). The decade proposes a vision of education handling the issues of environment, democracy, economy, human rights, culture, parity, etc., in a transdisciplinary approach.

The decade will promote:

- An education empowering people to commit themselves to sustainability, transforming people in responsible citizens with creative and critical thinking and others skills: oral and written communication, collaboration and cooperation, conflict management, decision-making, problem-solving and planning using appropriate ICTs;
- An education that fosters responsible citizens and promotes democracy by allowing individuals and communities to enjoy their rights and fulfill their responsibilities, to learn to live together in peace and tolerance;
- An education at all levels of education systems and in all social contexts (family, school, workplace and community)

Hyogo Framework for Action 2005-2015
– *Building Resilient Communities*

- Policy and Governance;
- Risk identification, assessment, monitoring and early warning;
- Knowledge management and education;
- Reducing underlying risk factors;
- Preparedness for effective response and recovery.

Figure 22. HFA Priority of Action

UN-ISDR
(International Strategy for Disaster Reduction)
Thematic Platform on Knowledge and Education
UNESCO is one of the active agencies

- Creation of a forum to exchange knowledge;
- Dissemination of good practices and examples;
- Mainstreaming of disaster risk reduction into school curricula and school safety.

Figure 23. UN-ISDR Thematic Platform on Knowledge and Education (TPK&E)

Of course UNESCO does not and cannot do this alone and it has to form part of a network of UN agencies, inter-governmental groups, and non-governmental or civil society organizations that are teamed together as part of the ISDR. In this sense, UNESCO serves as the "convener" of the UN multi-stakeholder platform concerned with the knowledge and education for disaster reduction.

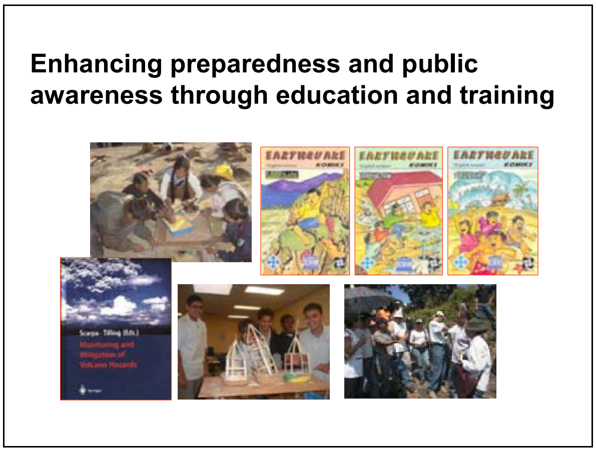

Figure 24. Promotion of education and training

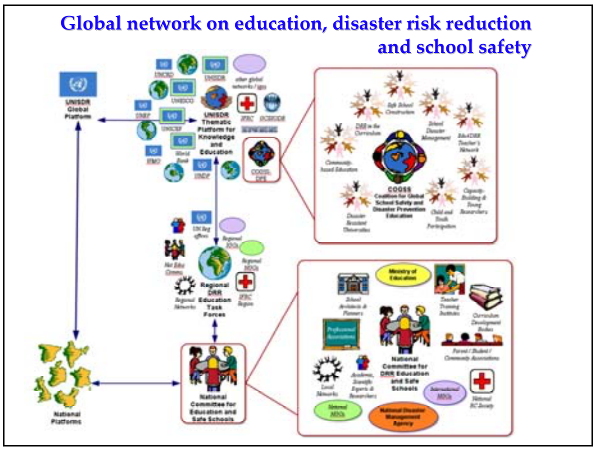

Figure 25. Global network on DRR education and school safety (http://cogssdpe.ning.com/)

WAY FORWARD

In June 2007, the First Session of the Global Platform for Disaster Risk Reduction (GP) was held in Geneva for the purpose of assessment and implementation of the HFA. The GP takes place every two years, and offers the global forum for accelerating world-wide momentum on disaster risk reduction. As the primary gathering for the world's disaster risk community, it brings together Governments, UN, international regional organizations and institutions, NGOs, scientific/academic institutions and the private sector. In line with the United Nations General Assembly (A/RES/62/192), the purpose of the Global Platform is to

- assess progress made in the implementation of the Hyogo Framework for Action;
- enhance awareness of disaster risk reduction;
- share experience and lessons from good practice; and
- identify remaining gaps and recommend targeted action to accelerate national and local implementation.

During one of the side events of the GP in 2007, the importance of enforcement, implementation and dissemination of building codes was highlighted. As a result, it was proposed to establish the "ISDR Global Task Force on Building Codes (initially called as Taskforce Group on Building Code)," and UNESCO offered to act as the secretariat. (http://www.unesco-ipred.org/gtfbc/)

The GTFBC consists of worldwide experts in the field of building codes and practices: UN agencies (UN-ISDR, UN-OCHA, World Bank, UNDP, UN-HABITAT, UNESCO, UNICEF, UNCRD, UNU, etc.), international organizations and NGOs (IFRC, IAEE, IAWE, IG-WRDRR, ICC, ADPC, ADRC, EERI, Build Action, RICS, DWF, EMI, Plan, INEE, COGSS-DPE, Risk Red, etc.), national governments and institutions, universities, building officials, architects, engineers, seismologists, etc.

Figure 26. Side event during the GP in 2007

Figure 27. Special event during the GP in 2009

Building codes already exist in most of disaster-prone countries, but the biggest challenge would be how to enforce, implement and disseminate building codes. Therefore, it is not only the technical matters, but the more important point is how to translate our scientific knowledge to be understood by policy-makers and non-scientific communities.

As a group of experts on seismology and earthquake engineering, with its expertise in the field of buildings and housing, the IPRED would be able to greatly contribute to the GTFBC discussions. *(Note: After the Haiti earthquake in January 2010, the GTFBC gathered a number of useful materials, guidelines, etc. which could be utilized for the reconstruction of safer buildings and houses in Haiti, and it is supporting efforts made by the Shelter Cluster in Haiti.)*

The Second Session of the GP was held in June 2009 in Geneva, and the session witnessed a dramatic increase in political will to manage disaster risk compared to the first session in 2007. Many tools and successful pilot projects exist. But the main challenge is to scale up these actions and systematically modify development programmes and budgeting to reduce the risk in all sectors. The context of increasing urban risk and depleted ecosystems, coupled with the role of local governments and local partnerships to address this and transform policies and knowledge into concrete actions are crucial factors to be tackled.

The benchmarks set out in the Chair's Summary of the second session of the 2009 session will serve as basis for the agenda of the Third Session in 2011. It focused on five main areas:

1. To urgently harmonize the frameworks for both disaster risk reduction and climate change adaptation in the broader context of poverty reduction and sustainable development;
2. To reduce risk at the community and local levels, through collaborative partnerships based on recognition of the mutual dependence of central and local governments and civil society actors and the promotion of the role of women as drivers of action, with special consideration to youth and children's roles;
3. To move from isolated actions and pilot projects to full implementation of the Hyogo Framework for Action, the Global Platform proposed targets in specific areas. Among these were national assessments of the safety of existing education and health facilities to be undertaken by 2011 and concrete action plans for safer schools and hospitals be developed and implemented in all disaster-prone countries by 2015.
4. To scale-up action and funding from national budgets and international sources with significant support for targeting the equivalent of 10 per cent of humanitarian relief and recovery expenditure, and at least 1 per cent of all national development and development assistance funding to risk reduction measures, as well as starting to measure the effectiveness of investment in risk reduction.
5. The Global Platform acknowledged the important role of the Strategy system in supporting Governments and civil society organizations, and considered that the planned midterm review of the Hyogo Framework for Action would require ownership on the part of Governments, the close involvement of civil society, and strengthened regional capacities for coordination and support.

Figure 28. The 2nd Session of GP

Figure 29. 2009 Global Assessment Report on Disaster Risk Reduction

Again, as described in 3 above, the following specific targets were proposed as catalysts for cutting deaths and economic losses brought on by disasters:

1) By 2011, a global structural evaluation of all schools and hospitals should be undertaken, and by 2015 concrete action plans for safer schools and hospitals should be developed and implemented in all disaster-prone countries. Similarly, disaster risk reduction should be included in all school curricula by the same year.
2) By 2015, all major cities in disaster prone areas should include and enforce disaster risk reduction measures in their building and land use codes.

This Chair's Summary was based on the message by the UN Secretary-General, Ban Ki-moon, which called for a target to halve the losses of lives from disasters by 2015, when the term of the Hyogo Framework for Action concludes.

Under the ISDR system, we have made efforts to raise awareness and commitment for sustainable development practices as a means to reduce disaster risk and to increase the wellbeing and safety of citizens – with "invest today for a safer tomorrow" as a slogan. We have promoted the World Campaigns for Safer Schools (2006-2007) and Hospitals (2008-2009), but there remain many tasks to carry out. The next 2-year World Campaign (2010-2011) is on "Making Cities Resilient" – to enhance awareness about the benefits of focusing on sustainable urbanization to reduce disaster risks.

GLOBAL PLATFORM ENDS WITH CALL TO HALVE DISASTER RELATED DEATHS BY 2015

<<TARGET>>

- By 2011, a global structural evaluation of all schools and hospitals
- By 2015, concrete action plans for safer schools and hospitals developed and implemented in all disaster-prone countries, and DRR included in all school curricula
- By 2015, all major cities in disaster-prone areas to include and enforce DRR measures in their building and land use codes

Figure 30. Target proposed in the Chair's Summary

The next World Campaign (2010-2011) « Making Cities Resilient»

- Building codes may be the weakest link.
- This is not about the technical issues; This is about how the importance of investing for safer buildings is understood and carried out by decision-makers, communities and citizens.

"People check the brake before buying and driving a car; Why not for our houses, schools, hospitals, churches and other buildings to make sure they can withstand potential hazards?" (Mr. Salvano Briceño, Director of UN/ISDR Secretariat)

Figure 31. World Campaign on Making Cities Resilient (2010-2011)

The Campaign will seek to engage and convince city leaders and local governments to be committed to a checklist of *Ten Essentials for Making Cities Resilient* and to work on these together with local organizations, grassroots networks, private sector and national authorities. UN/ISDR and its partners have developed this checklist – not to be exhaustive – to serve as a starting point for all those who want to join in the Campaign. Equally important is that commitments to these *Ten Essentials* will empower local governments and actors to implement the Hyogo Framework for Action. Making cities safer to disasters means sustainable urbanization. When successfully applied, resilient cities help reduce poverty, provide for growth and employment, more social equity, business opportunities, balanced ecosystems, better health and improved education.

The *Ten Essentials* also include the enforcement of building codes as well as issues of DRR education and school safety. This initiative is perfectly in line with the IPRED objectives, and the IPRED can and should contribute to this advocacy.

TEN-POINT CHECKLIST – ESSENTIALS FOR MAKING CITIES RESILIENT

1. Put in place **organization and coordination** to understand and reduce disaster risk within the local government, based on participation of citizen groups and civil society - build local alliances. Ensure that all departments understand their role and contribution to disaster risk reduction and preparedness.

2. **Assign a budget** for disaster risk reduction and provide incentives for homeowners, low-income families, communities, businesses and public sector to invest in reducing the risks they face.
3. Maintain up-to-date data on hazards and vulnerabilities, **prepare risk assessments** and use these as the basis for urban development plans and decisions. Ensure that this information and the plans for your city's resilience are readily available to the public and fully discussed with them.
4. Invest in and maintain **critical infrastructure** that reduces risk, such as flood drainage, adjusted where needed to cope with climate change.
5. Assess the **safety of all schools and health facilities** and upgrade these as necessary.
6. Apply and enforce **realistic, risk-compliant building regulations and land use planning principles**. Identify **safe land for low-income** citizens and develop upgrading of informal settlements, wherever feasible.
7. Ensure that **education programmes and training** on disaster risk reduction are in place in schools and local communities.
8. **Protect ecosystems and natural buffers** to mitigate floods, storm surges and other hazards to which your city may be vulnerable. Adapt to climate change by building on good risk reduction practices.
9. Install **early warning systems and emergency management** capacities in your city and hold regular public preparedness drills.
10. After any disaster, ensure that the **needs of the survivors are placed at the centre of reconstruction** with support for them and their community organizations to design and help implement responses, including rebuilding homes and livelihoods.

CONCLUDING REMARKS

The UNESCO's IPRED programme may still be in the early stages. However, as a group of experts on seismology and earthquake engineering, with its expertise in the field of buildings and housing, it has a great potential of contribution by promoting the following objectives among others:

a. To exchange information and propose plans on collaborative research, training, and education regarding seismology and earthquake engineering in order to reduce earthquake disasters, especially on buildings and housing;
b. To address policy-relevant issues related to the reduction of earthquake disaster risks and implementation of the Hyogo Framework for Action, including making recommendations on priorities in the International Strategy for Disaster Reduction (ISDR) system; and
c. To establish a system to dispatch experts to an earthquake stricken country in order to carry out post-earthquake field investigations and draw lessons for future risk reduction, by utilizing the worldwide network of ex-participants of IISEE international training courses.

Building codes already exist in most of disaster-prone countries, but the biggest challenge would be how to enforce, implement and disseminate building codes. Building codes are not the enemy; they should be respected and complied. They can save lives. It is not only the technical matters, but the more important point is how to translate our scientific knowledge to be understood by policy-makers and non-scientific communities.

It is proposed by the international community that by 2011, a global structural evaluation of all schools and hospitals should be undertaken, and by 2015 concrete action plans for safer schools and hospitals should be developed and implemented in all disaster-prone countries. Similarly, disaster risk reduction should be included in all school curricula by the same year. It is also proposed that by 2015, all major cities in disaster prone areas should include and enforce disaster risk reduction measures in their building and land use codes. We need to act now; we should not just wait for disasters.

Such international initiatives including the World Campaign on *Making Cities Resilient* (2010-2011) are perfectly in line with the IPRED objectives. The IPRED can and should contribute to the creation of safer built environment in the world.

MAKE THE PEOPLE A PART OF THE SOLUTION AND PREVENT TOTAL COLLAPSE

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ABSTRACT

Not only the tens of thousands of vulnerable low rise residential buildings located on earthquake prone areas but industrial type prefabricated structures should be realistically upgraded also in order to have more resilient cities as far as destructive earthquakes are concerned. Seismically very active zones such as North and East Anatolian fault zones have many rapidly grown industrial and residential settlements where the risk of having severe earthquake damages is very high. The results of the two groups of both experimental and supplementary theoretical researches conducted in the *Structural and Earthquake Engineering Laboratory of Istanbul Technical University* have been put together for the sake of completeness in this paper with a supplement of administrative difficulties society faced to. A realistic proposal has been submitted in this paper to overcome the *technical, economical and psychological* problems that exist among the people. The proposal presented herein is essentially based on the following experimentally and theoretically investigated technical matters: *i- conversion the non- structural partitioning walls to the structural walls to resist earthquake effects by using low and high strength integrated bricks, CFRP-sheets glued over the partitioning walls and different configurations of simple light steel bracings for existing low rise residential buildings, ii-partial CFRP and/or reinforced jacketing of precast columns* and the following administrative matters: *i-conversion of prejudice ideas exist among the people against the inevitable necessity of retrofitting ii-convincing the people that the risk of having a destructive earthquake within the next a couple of decays is very high and if people become a part of the solution this will be the only way to overcome the difficulties and to live in a resilient environment.*

KEYWORDS:
Earthquake, reinforced concrete building, vulnerable buildings, total collapse, retrofitting.

INTRODUCTION

After the destructive 1992 Erzincan Earthquake, research and administrative activities for the rehabilitation works for existing buildings have been accelerated in Turkey in all aspects. New assessment techniques, experimentally verified new retrofitting techniques, new re-design procedures have been developed (Karadogan et al., 2007), (Karadogan, 2009). National and international collaborative research works has rapidly increased. *New Earthquake Resistant Design Code* (1997) become effective first and it has been updated depending on new experimental and theoretical findings in 2007. 1995 Dinar, 1998 Adana-Ceyhan and the two successive earthquakes occurred in 1999 in Kocaeli and Duzce were several other catastrophes they all kept provoking not only the people but the researchers and administrators as well. They carried out a lot of field works, legislative works etc. Although the accumulated information and the valuable experience obtained is extremely important, still it is not enough to overcome the difficulties that exist, just simply because of the size of the problem that community faced.

The probability of exceedence of having an earthquake within next 30 years with 7 or bigger magnitude around Istanbul for instance, is 41 ±14 % which is a very high possibility, (Parsons, 2004). There are thousands of buildings in need of retrofitting and the speed of rehabilitation is not enough to cover all buildings in a relatively short time. The lack of financial sources is simply not sufficient.

In this presentation it is intended to share the achievements in the field of rehabilitation of vulnerable buildings and the major road blocks that still exist, in order to protect especially the low income citizens and the small and medium investors who are providing jobs for those people. Almost all developing countries located in earthquake prone areas share the similar difficulties and they suffer the similar problems.

All in all it can be said that unless the people is not made a part of the problem and solution the final goal which is, the resilient environment, will never be reached.

COMMON DIFFICULTIES

Rapid industrialization and in connection with that the rapid urbanization is probably the biggest reason of having millions of vulnerable newly constructed low–cost , low–rise buildings of metropolitan cities. The narrow streets of metropolises make almost impossible the work of rescue after earthquakes, Figure 1.

Unfortunately it is known that there are buildings which are hardly bare the gravity loads only, Figure 2.

If the present well known assessment techniques are referred to see the risk of those buildings, it would be necessary to demolish and rebuilt them. In fact it will be cheaper namely to demolish and reconstruct them prior to the earthquake. This needs time and can only be done partially.

The lack of financial sources to be allocated for rehabilitation purposes, insufficiency in education of people, insufficiencies of training the trainees for rehabilitation and rescue works, insufficiency of awareness and consciousness, probably are among the major common difficulties shared by the earthquake vulnerable societies.

Since it is impossible to stop the life totally in residential and industrial buildings for rehabilitation works, proper locally developed techniques which are not bothering either the inhabitants or workers are urgently needed. For that purpose new administrative provisions and organizations which are taking into consideration the present data collected in the field and the new technological findings etc., have the upmost importance.

Figure 1. Narrow Streets of Istanbul

Figure 2. Zumrut Apartment Building in Konya /Turkey collapsed due to gravity loads

COMMON DEFICIENCIES

The assessment and rehabilitation works already carried out indicates that the low–cost, low–rise RC buildings have more or less similar deficiencies which are roughly summarized in Figure 3. Among the common structural deficiencies one can count the beam–column connections which have not been constructed very well and hence they are most critical regions of the structural systems, the lack of lateral rigidity and the structural alterations done in improper ways etc.

The basic material characteristics of those buildings are statistically estimated in Turkey. For instance, the compressive strength of concrete is very low and only around 10 MPa, (Uyan et al., 1999).

On the other hand the simple precast industrial factories have generally weak beam–column connections and they have been designed with higher ductility ratios which are not easy to be reached always. Therefore there should be reliable cost effective ways of strengthening them and making them more rigid preferably without interrupting the operations in the factories.

The regional soil characteristics which cannot be obtained easily by the owners of simple structures should be made available by local authorities as it is done in Istanbul, see Figure 4. Then it means that almost all the information needed except *the structural drawings* for proposing *prescriptive solutions* are available to prevent the total collapse of vulnerable buildings as shown in Figure 5.

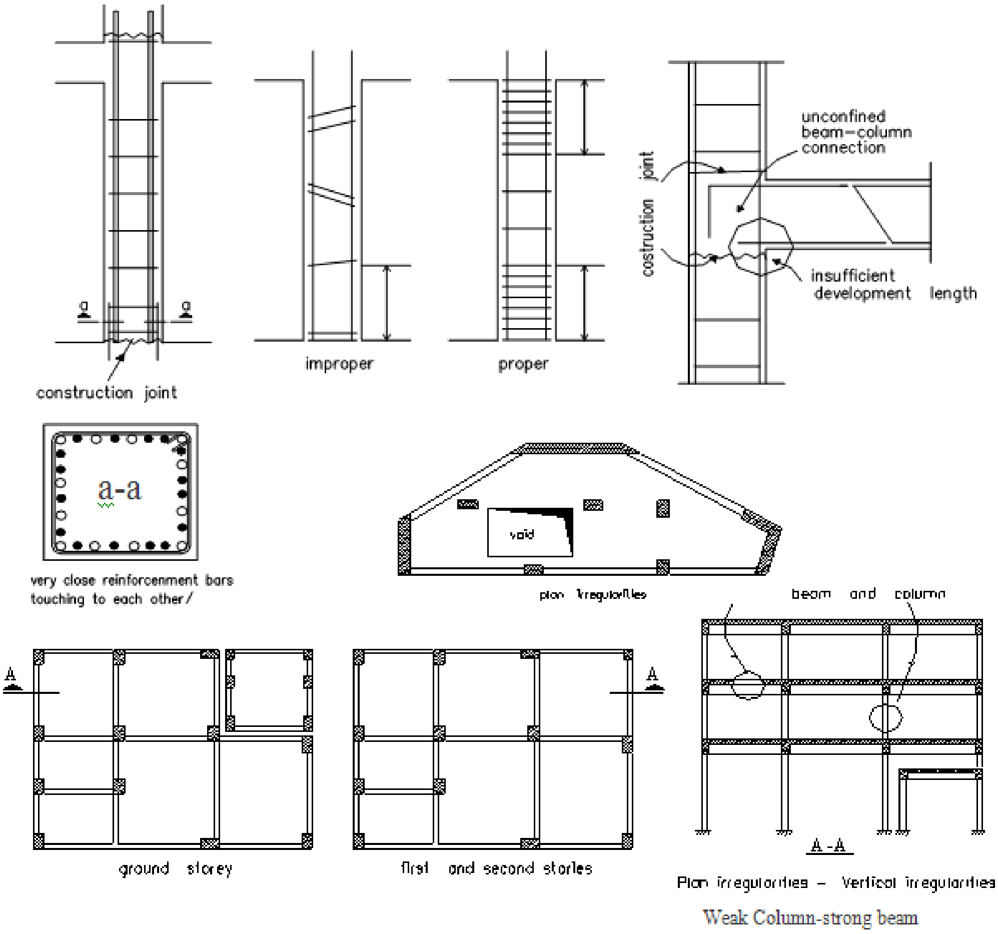


Figure 3. Various structural deficiencies observed

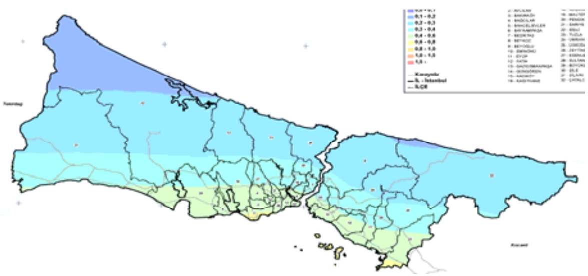


Figure 4. PGA map of Istanbul

Figure 5. Total collapse of low cost–low rise reinforced concrete buildings

The important structures specified by codes should be better kept out of this topic. School buildings, hospitals major administrative buildings which are important structures should be assessed and should be strengthening if it is required, according to the present codes regardless the cost of rehabilitation.

On the other hand for the simple structures which are in some cases the vast majority of all buildings, practically *need no assessment* but just simple strengthening to keep them in upright position, let to survive the inhabitants and go out even heavy damages occurred in these building.

This is possible in relatively low cost. Several techniques proposed down even applicable by the owner itself. The engineering decisions can be provided by local administrators and those will be discussed in the following paragraphs. In order to have real quick results, it is a must to collaborate with the people. If the support of the people cannot be obtained then some of the practical, physical, psychological and social resistance might be expected. This may became a real road block.

The updated structural drawings of existing buildings are essential for any kind of engineering judgment but unfortunately they are not available in most of the cases. Solutions for this problem should be developed to obtain the drawings together with the people leaving or working in those buildings. Psychologically these people should be convinced that they are in real danger and rehabilitation of their buildings will make it more valuable afterwards in contrary to common believe among the unconscious people.

For all those reasons and necessities mentioned above the people should be made ***a part of the retrofitting related problems and a part of the solution as well.***

Right at this point UNESCO might have an important international humanistic role. UNESCO can be more active in terms of developing strategies and polices and providing the necessary documentaries such as movie films, pamphlets, books, even doing real demonstrations on buildings, creating specific mobile contemporary science museums prepared by the experts of the topics and moving from country to country etc.

The same seismic hazard exists for the industrial type simple precast buildings shown in Figure 6, where most probable the people who are living in low–cost, low–rise buildings mentioned above, works. For finding simultaneous solution of these socially related two topics, the simplified rehabilitation works of industrial type precast buildings are partially dealt with, in this paper as well (Yuce et al, 2007), (Taskin et al., 2006).

Figure 6. Industrial type simple precast buildings

RETROFITTING TECHNIQUES TESTED

The following three prejudice ideas against retrofitting could be changed and the people can be convinced for being collaborators of the solution;

i - Retrofitting is not possible,
ii - Retrofitting is difficult,
iii - Retrofitting is expensive.

For that purpose experimental and theoretical works have been carried out to remove those roadblocks on the way of rehabilitation.

Even the very short summary for the recent selected experimental studies presented below, indicates that *retrofitting is possible* and *it can be done in a very cost effective way* especially if the prevention of total collapse of ordinary buildings, are targeted.

Reinforced Concrete Frame Type Buildings

The lateral rigidity of brittle partitioning walls is generally ignored since they are cracked easily during the very first cycles of seismic excitation and they fall down. Tests indicate that if they are integrated with the peripheral RC elements and if their lateral load carrying capacities are increased they turn to lateral load bearing structural elements. Only ***four*** of either those type of modified partitioning walls or newly introduced any kind of lateral load resisting walls can be placed so that they may modify the torsional and flexural behavior of the building and they increase the lateral load resistance of the building to the required performance level. Properly chosen ***three*** walls always can be an alternative to ***four*** walls at the periphery. And it should not be forgotten that the damping capacity of existing buildings is higher than the new one and the probability of having the same magnitude earthquake excitation is smaller in the old building. Those should be considered in the re–design stage for having cost effective solutions together with the assumption that the foundations of new shear walls better be elastically supported against rotation.

The backbone curves of the cyclic response of a *one story – one bay* ½ scale RC bare frame is being compared with the response of a similar frame firstly with an ordinary infill wall, secondly with an integrated infill wall and thirdly with an integrated damaged infill wall strengthened by two sided wire mesh and shotcrete (Yuksel, 1998), Figure 7- 8.

Figure 7. Integrated damaged infill wall and two sided wire mesh with shotcrete

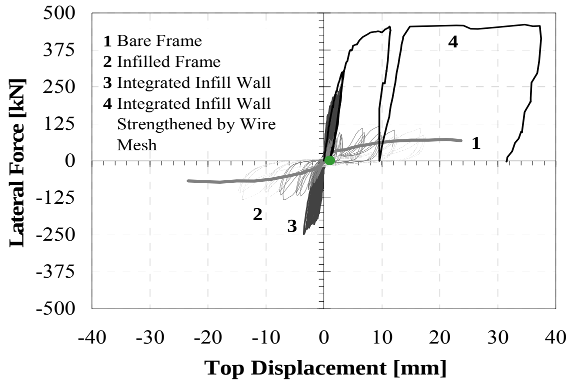
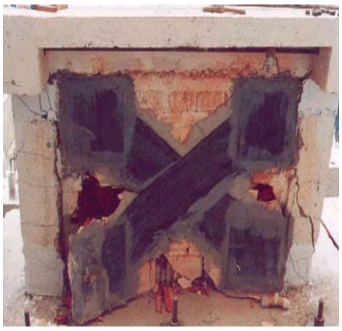


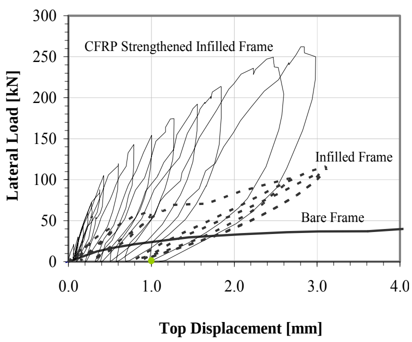
Figure 8. Several load-deflection curves

Slightly damaged integrated wall with no plaster has been strengthened by CFRP diagonals as shown in Figure 9a and tested again in a consistent way, see Figure 9b. The results achieved are presented in Figure 9c, (Karadogan and Yuksel, 2001).

a) Integrated infill frame with pasted CFRP before testing



b) After testing, failure mode



c) Lateral Load Capacities

Figure 9. Integrated wall and strengthening by CFRP strips

The success achieved from the early tests of specimens strengthened by CFRP induced the research for making similar test with other alternative solutions such as CFRP *sheets connected to RC elements*, CFRP *on wall* only and CFRP *on wall bonded only at the corners,* Figure 10. The backbone curves of cyclically induced specimens are presented in Figure 11, (Erol et al., 2008).

The results were very promising and the same technique with minor alterations has been employed in two storey one bay specimens, see Figure 12a-b-c. The results obtained are presented in Figure 13, (Yuksel et al., 2006).

Specimen N2 Specimen N3 Specimen N4

Figure 10. Different CFRP applications on infilled RC frames

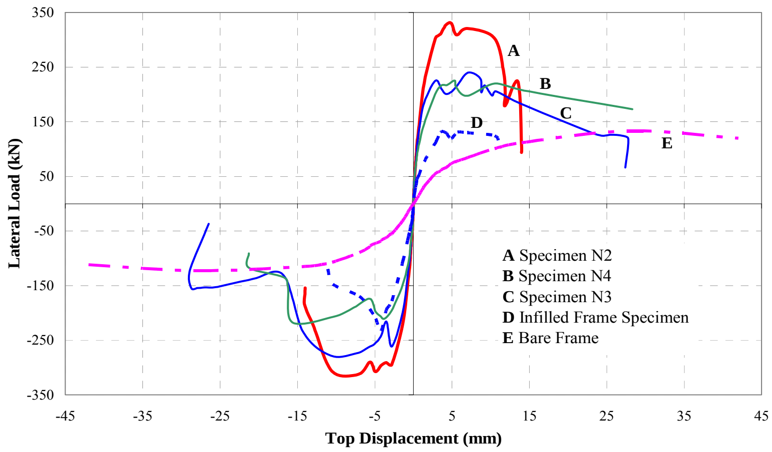


Figure 11. Test results of three different CFRP applications

a) Infilled RC frame b) Strengthening by CFRP strips on the infill wall c) Observed damages at the end of testing

Figure 12. Two story - one bay specimens

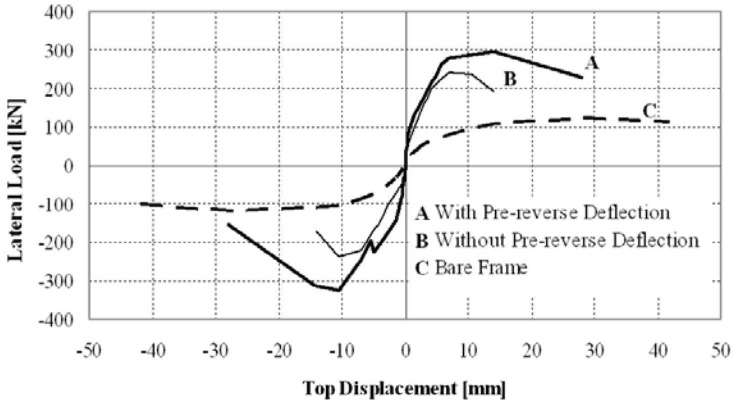


Figure 13. Lateral load - top displacement envelopes two story - one bay specimens

Two other techniques shown in Figure 14-15, are providing sufficient amount of strength and ductility, see Figure 16a-b. Shear studs chemically connected to the peripheral columns and the beam are used to integrate the infill made of shotcrete and 3D wire mesh in Figure 14 and the high strength brick wall in Figure 15, (Mowrtage, 1998), (Yucesan, 2005).

The interesting point for the specimen shown in Figure 17 is the cumber introduced to the beam in upward direction which is released after having cured the infill made of shotcrete and ordinary wire mesh creating normal stresses on the infill. It is expected to have more shear capacity of infill due to certain amount of normal stresses on lateral infill sections. The results given in Figure 18 are satisfactorily good, (Cili et al. 2008).

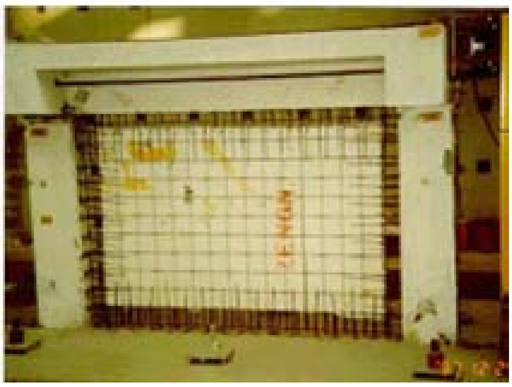
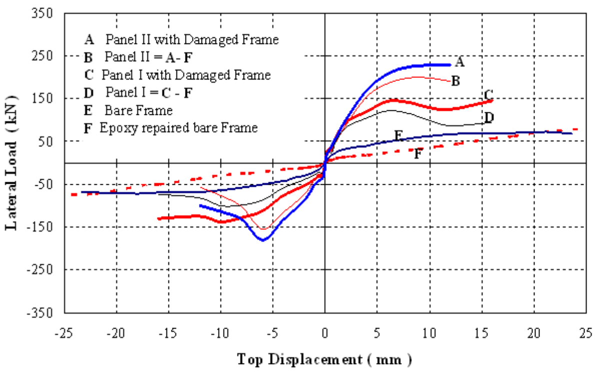
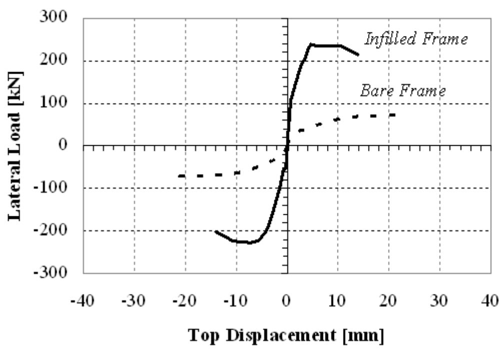


Figure 14. Strengthening of an epoxy repaired bare frame by 3D wire panel

Figure 15. Strengthening of a bare frame by integrated high strength brick wall



a) 3D wire mesh retrofitting



b) High strength brick wall retrofitting

Figure 16. Lateral load - top displacement envelopes

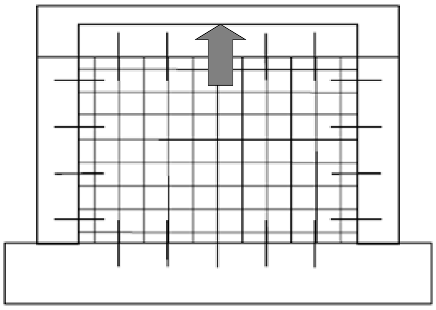


Figure 17. Strengthening by shotcreted 2D wire mesh

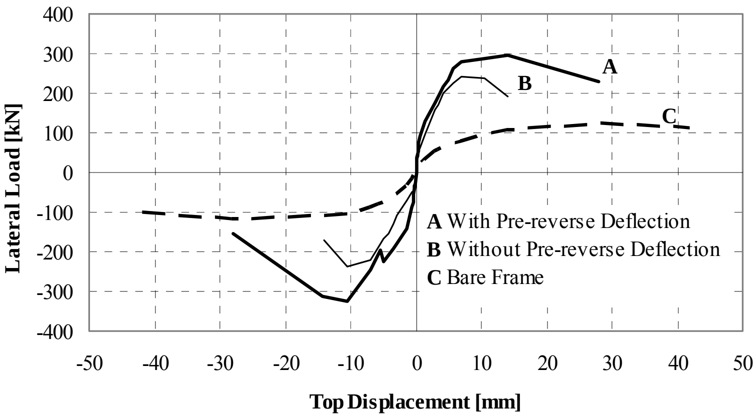


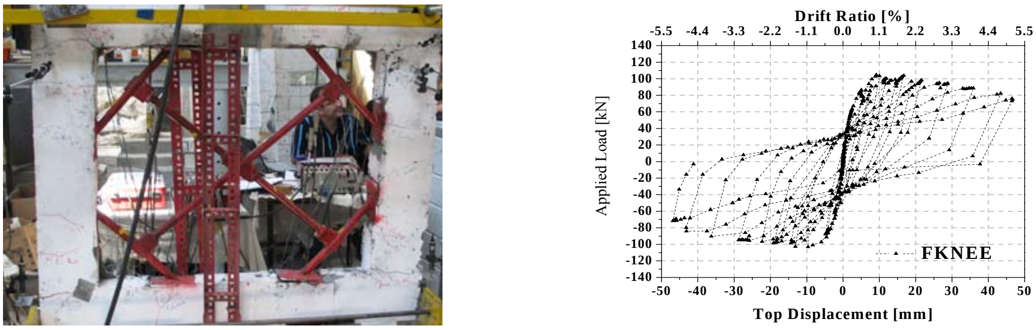
Figure 18. Lateral load - top displacement envelopes for shotcreted 2D wire mesh retrofitting

The basic philosophy behind the RC specimens strengthened by different configurations of steel diagonals is to create more sections with reserved capacity either on existing RC elements or in steel elements to dissipate more energy imparted to the structure by seismic excitation see Figure 19, (Taskin, 2010). The steel diagonals are not blocking totally the flexural behavior of individual RC elements in the inelastic excursions and they can be mounted or renewed very easily if they experience excessive plastic deformations during severe displacement reversals. The proposal took part in Figure 19a and b cause relaxation in stress concentrations in *weak beam - column connections* which are the sensitive zones of *low-cost, low-rise* buildings. The other two energy dissipative simple bracing systems are presented in Figure 19c-d. Special attention should be exercised on the modification of hysteresis curves as far as energy consumed is concerned within each displacement cycle in specimen. Tests reveal the following results;

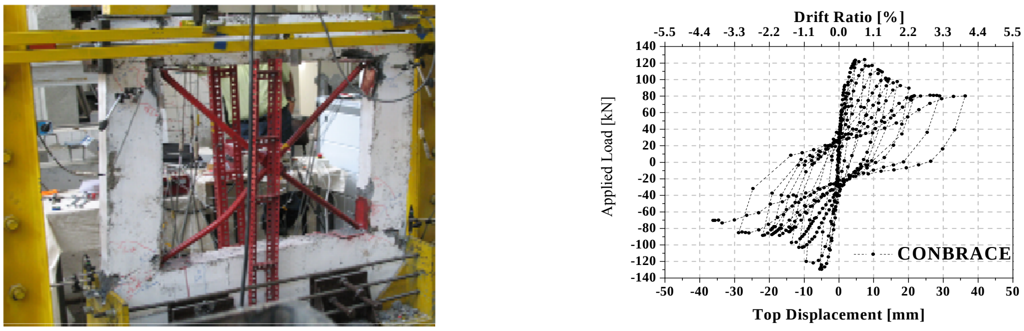
i. The more steel sections introduced the more energy consumption and more stable structural behavior is achieved.
ii. Knee bracings are effective as much as other bracings as long as the lateral load resisting capacities are concerned
iii. Connection details between steel bracings and RC elements are not effective on the results as they are expected
iv. On the other hand bracing systems are very effective on changing the sections where plastic deformations are accumulated in bare frame.

It should be noted that none of the steel diagonals will be connected to the connections where structural deficiencies are expected in retrofitting stage of an actual building.

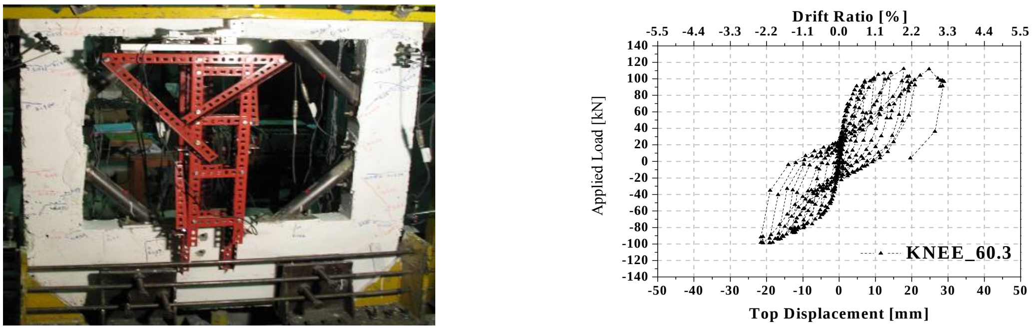
The envelope curves of the specimens are given in Figure 20.



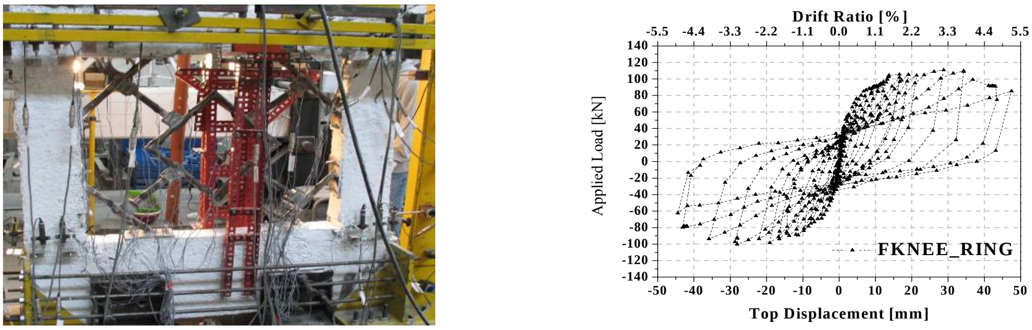
a) Four knee braces and two diagonal braces and load-displacement cycles



b) Concentric two diagonal braces and load-displacement cycles

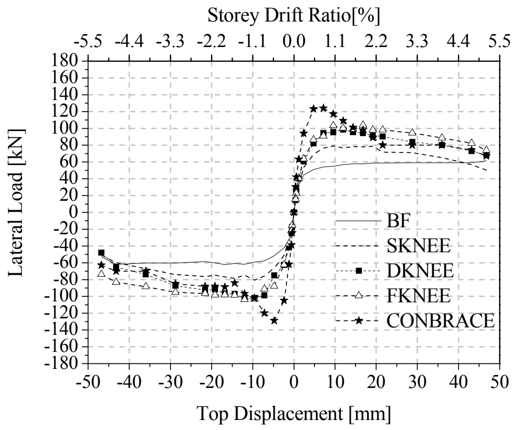


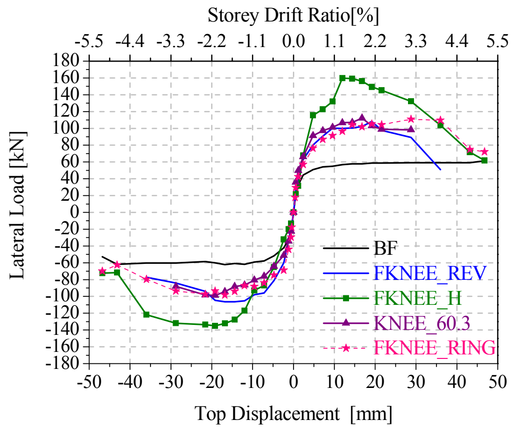
c) Four knee braces and load-displacement cycles



d) Four knee braces, two diagonal braces with disposable frame and load-displacement cycles

Figure 19. Energy dissipating simple bracing systems and load displacement cycles



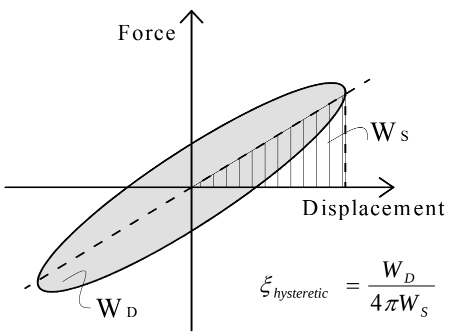


a) Specimens in Figure 19a and b etc.

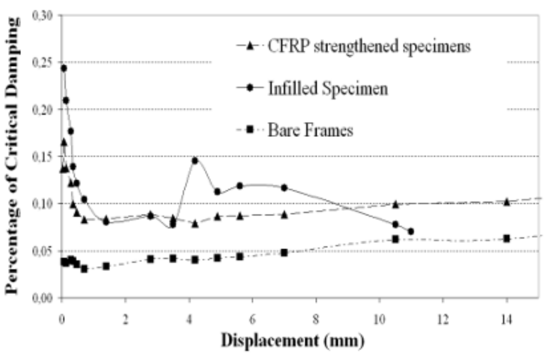
b) Specimens in Figure 19c and d etc.

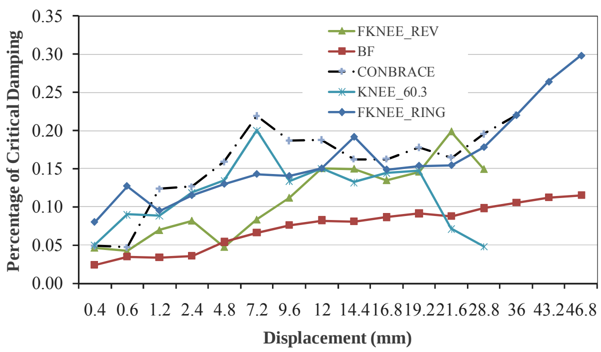
Figure 20. Envelopes of load displacement curves of test specimens

Hysteretic damping ratios calculated for each cycles of load-displacement curves are presented in Figure 21a for the selected three different infill wall specimens and in Figure 21b for different steel bracing configurations. It should be noted that this curves are changing roughly between 5-10% for the first set, 5-20% for the second set which are all bigger than 5% of critical damping. Figure 21b also indicates that not only the damping ratios but the energy consumption by steel bracing increases from type *a-bracing* to type *d bracings* shown in Figure 22.



$$\xi_{hysteretic} = \frac{W_D}{4\pi W_S}$$





a) Selected three samples from infill wall tests

b) Steel bracing configurations given in Figure 19a-b-c-d.

Figure 21. Hysteretic damping ratios for each displacement reversals

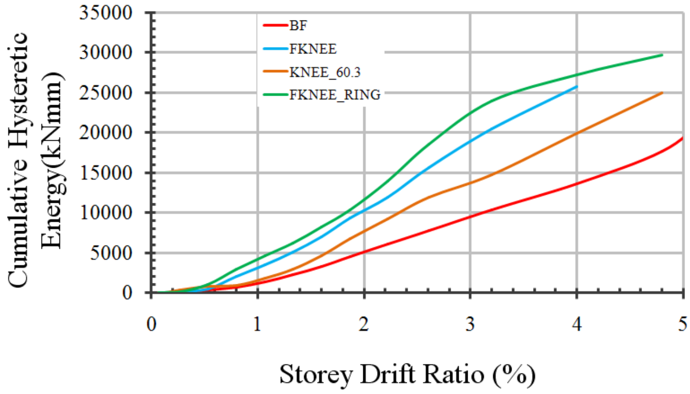


Figure 22. Energy Dissipation Graph of test specimens

Industrial Type Precast Structures

Four of the previously tested 13 precast columns (Karadogan et al., 2006) have been partially jacketed using self leveling concrete, Figure 23, and subjected to cyclic lateral displacements, (Yuce et al., 2007). Even the heavy damage exists in the most critical regions of the columns, Figure 24, they have been recovered very well in terms of strength and ductility, Figure 25. The flexibility gained by partial jacketing is important for the rehabilitation works of heavily equipped running precast factory buildings.

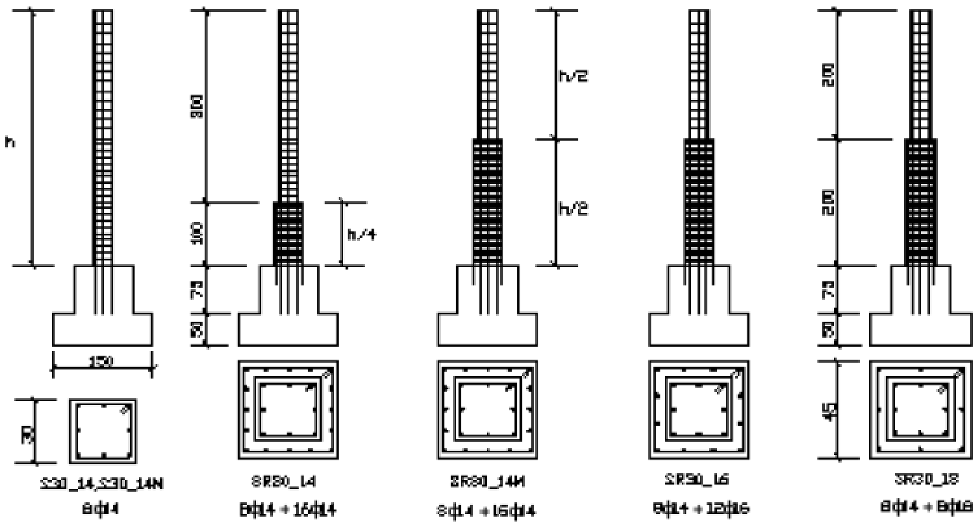


Figure 23. Partially jacketed industrial type precast columns

Figure 24. Damages observed in partially jacketed columns

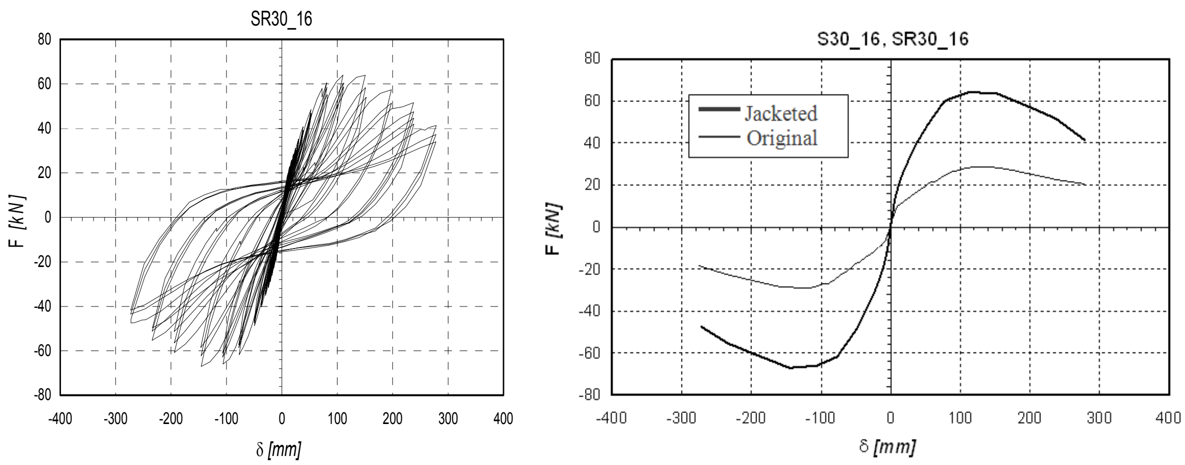
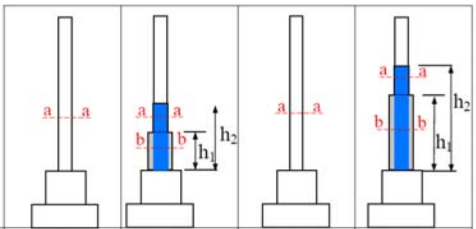


Figure 25. Load-displacement reversals and envelop curves of the columns

The promising results achieved at the end of these four tests have been exploited by utilizing CFRP sheets in order to expend the efficiency of retrofitting beyond the reinforced concrete jacketed region, Figure 26, (taskin et al., 2006). For that purpose two more columns have been partially jacketed after they are flexurally strengthened by CFRP and tested referring to cyclic displacement reversals. Self leveling concrete was used for jacketing in these specimens as well. Shrinkage of the surrounding concrete layer around the CFRP sheet pasted on clean concrete surface has important contribution on the efficiency of CFRP layers. The damages observed at the end of the test are presented in a compact form in Figure 26. The backbone curves are given in Figure 27.



NAME		SPEC1	SPEC2	SPEC3	SPEC4
h_1			1m		2m
h_2			2m		3m
Section a-a		35 x 35 cm	35 x 35 cm	35 x 35 cm	35 x 35 cm
Section b-b			50 x 50 cm		50 x 50 cm
Test Type		CYCLIC	CYCLIC	CYCLIC	CYCLIC
Reinforcement	Longitudinal	8 Ø 18	10Ø 18	8 Ø 20	8 Ø 20
	Stirrup	Ø8/10-15	Ø8/5	Ø8/10-15	Ø8/5

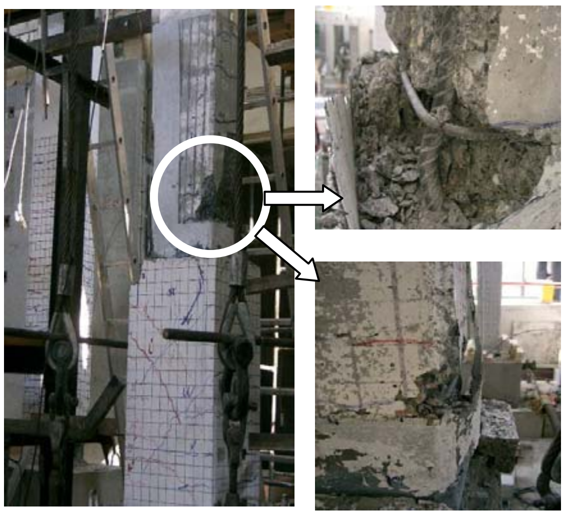


Figure 26. CFRP applications on precast columns and a sample of damage observed at the end of the test

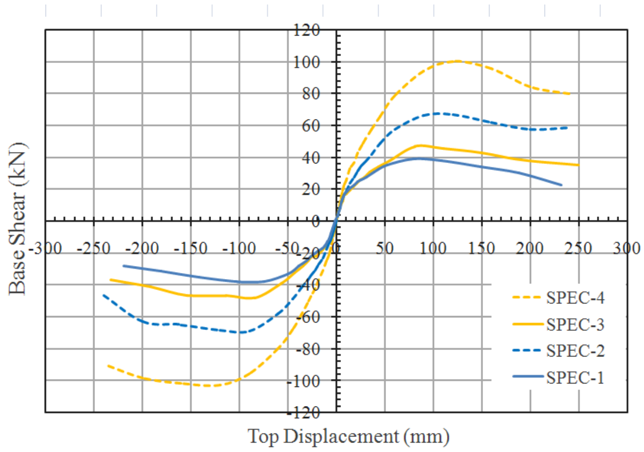


Figure 27. Test load-displacement curves of precast columns with CFRP

HYPOTETHICAL STRUCTURE STRENGHTHENED BY STEEL DIAGONALS

The five storey RC 3D building given in Figure 28 which has been used earlier to demonstrate the efficiency of conversion the non-structural walls to structural walls (Karadogan, 2009), has been chosen here once again to exemplify the efficiency of the retrofitting techniques based on *simple steel bracings* tested and presented above.

Some of the features of the structural models and the assumptions done for this purpose are listed below;

- Building is a skeleton type structure which consists of beams and columns. Dimensions of beam and column elements are given in Figure 28 and Table 1, they all have 0.5% and 1% reinforcement, respectively. The compressive strength of concrete and tensile strength of the reinforcement bar used are 10 MPa and 220 MPa in a respectively.
- The contribution of slabs to the flexural characteristics of beams is limited with the effective widths of slabs. Hence beams may develop perfect plastic hinges with limited rotational capacities.
- Infill walls have no contribution to the lateral stiffness and strength of the structure. They are simply considered as a part of the mass of the structure.
- Column foundations are fixed for all cases. Beam-column connections are perfectly rigid and very well prepared.

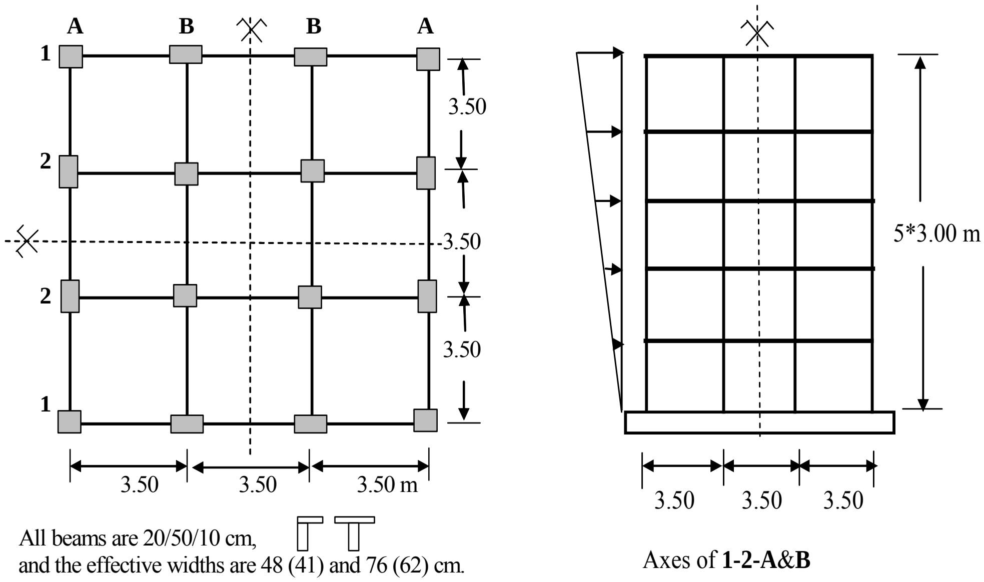


Figure 28. Hypothetical Structure

Table 1. Column dimensions of Hypothetical Structure

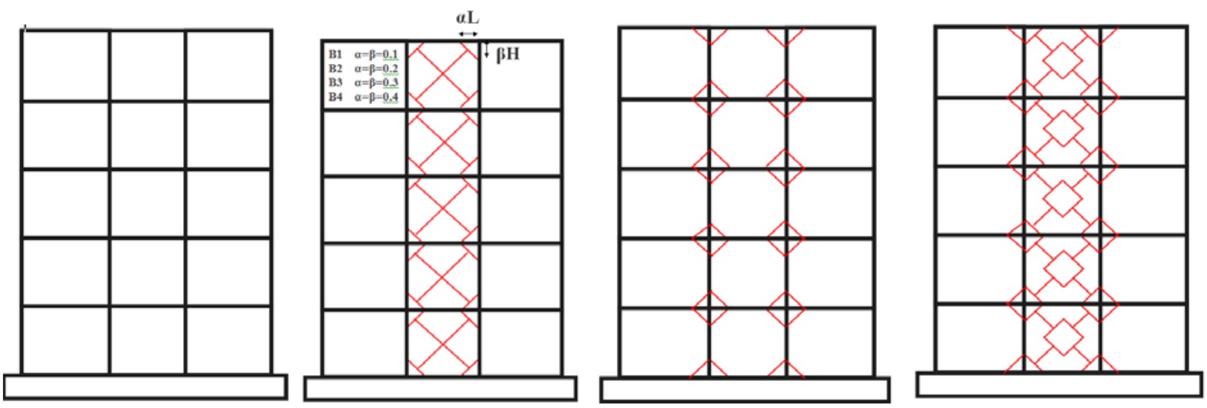
Storey	Axe 1		Axe 2		Axe A		Axe B	
	Axe A	Axe B	Axe A	Axe B	Axe 1	Axe 2	Axe 1	Axe 2
1 - 2	25*25	25*35	35*25	40*40	25*25	35*25	25*35	40*40
3 - 4	25*25	25*30	30*25	35*35	25*25	30*25	25*30	35*35
5	25*25	25*25	25*25	30*30	25*25	25*25	25*25	30*30

The simple steel bracing types employed in the following parametric analysis are given in Figure 29 and Figure 30 together with a reference frame given in Figure 29a. It should be noted that in all steel brace configurations the cross-sectional area of the bars is only three times bigger than the cross sections used in the experimental work where the scale factor was 1/3. It is obvious that bigger elements can be utilized according to the expected performance levels.

The results of push over analyses for *three different bracing* configurations are given below in Figure 31a and b. The parametric work indicates that not only the size of the bars but the points where steel braces connected to the RC elements is important on the overall of response of the structure. In all cases the strength and the ductility of the structure can be improved to satisfy the code requirements if the premature failure of columns due to the bracing are prevented. The examples based on Figure 30c and 30d have been prepared accordingly, see the pushover curves in Figure 31b. Special attention should be exercised to the knee elements placed in adjacent spans to prevent the early failures of the existing columns. It is known that RC beams integrated to slabs cannot easily develop plastic hinges.

Steel bracing were placed first in mid spans of *four* peripheral frames at each level to minimize the harmfully affects of torsion, Figure 30. If this is not possible *three* sides of building could be used for this purpose. The second group of examples has been prepared accordingly.

The pushover curves of the alternative systems generated from Figure 29b are given together in Figure 31a. Figure 31b consists of the pushover curves calculated for the bare and the three alternative retrofitted systems defined in Figure 29. Two configurations of steel braces named D1 and D2, see Figure 30, are evaluated.



a) b) c) d)

Figure 29. Bare frame and three different steel brace configuration

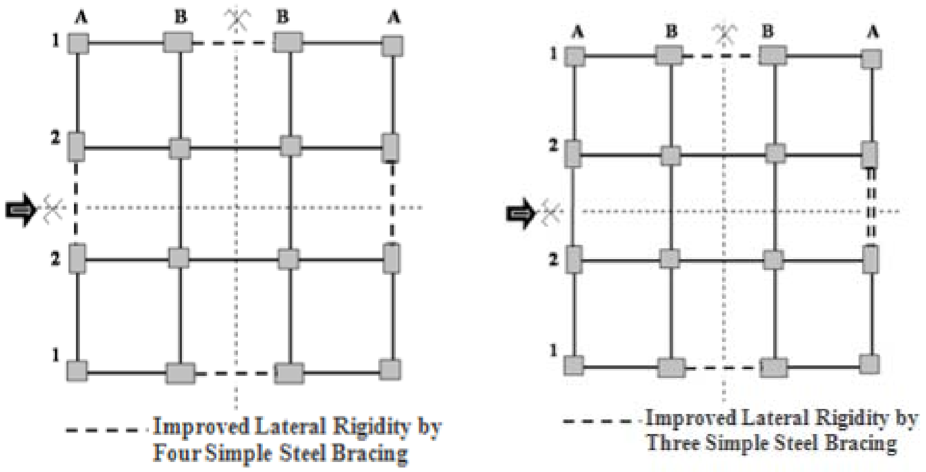


Figure 30. The locations of lateral load resisting elements

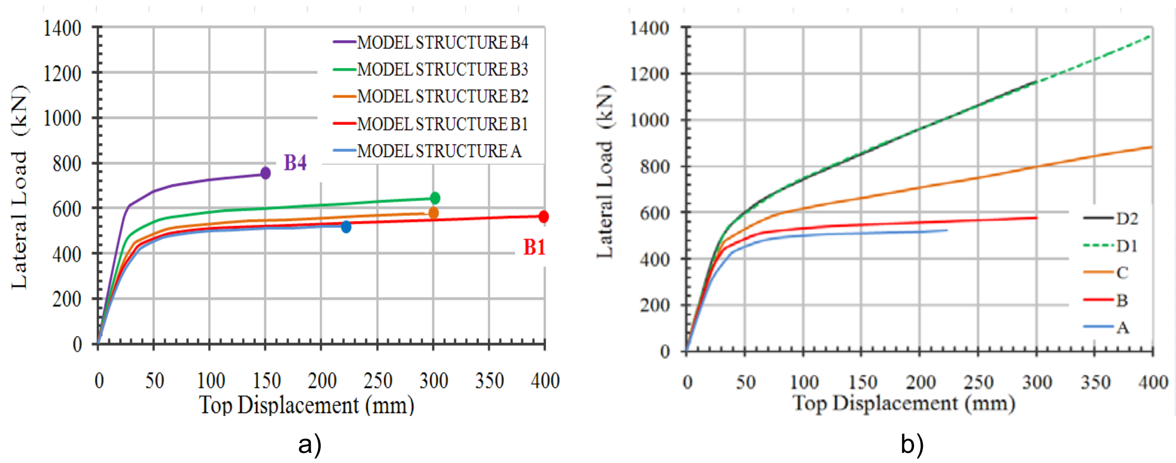


Figure 31. Lateral load-top displacement relations of the systems given in Figure 29.

OTHER IMPORTANT ISSUES AND CONCLUSIONS

All the technical information provided above aims to prove that

i. ***retrofitting*** *for existing conventional RC buildings and precast simple industrial factory buildings not only* ***is possible,***
ii. *but efficient retrofitting* ***can be done in cost effective ways*** *easily also.*

These scientific results are extremely important in order to remove the prejudice ideas which are the real road blocks against implementation of new findings and they are spreading among the peoples who are including even the administrators and decision makers who are responsible against societies. ***Scientists, administrators and people in danger*** should be made working together first in order to overcome this difficulty. The success of the proposal which is based on several realistic assumptions given below, needs first to bridge the gap that exist between engineers and policy makers and special attention should be exercised on the following issues:

- Rehabilitation of the huge amount of hazardous buildings is a real problem which needs to be taken a lot of realistic scientific and administrative decisions as quickly as possible for having more resilient cities. And these decisions need to be made jointly by both engineers and policy makers, and they should be placed above all political agendas. Although this is a must, unfortunately instances of such cooperation are few and far between. This would be worse if there was lack of reliable data and proper retrofitting techniques suit to the social and economical back ground of the country.

- It has been understood that the seismic hazard of big cities such as Istanbul cannot be lessened unless it is done with the participation of the citizens. There are thousands of simple RC buildings, precast industrial buildings and historical buildings in need of retrofitting, and this can't be done in a short period of time only with the help of municipalities and governments. People should be made aware of this. And everybody should know that the possibility of having a destructive earthquake hitting Istanbul is very high. There is neither the time nor the resources to carry out long term retrofitting projects. Instead, buildings that are easier to retrofit sufficiently to prevent loss of life and property, of which there are many, should be prioritized. After having evaluated the present situation in Istanbul / Turkey, a new rehabilitation concept and a new strategy to implement it, is being summarized in this paper.

  Shortly it can be said that properly placed four lateral load resisting elements could be sufficient to prevent total collapse of low rise-low cost buildings. Theoretically three of them will be enough to prevent total collapse. New lateral load resisting elements are placed on top of each other in every storey. Design of these elements is the duty of new aid unit. Tested types of new elements can only be constructed under the supervision of trained personnel. Technical Staff will be trained first to serve in these units. They will produce and send the technical retrofitting drawings to the owners of the buildings. Technical supervision will be provided by local authorities. It is not difficult to prove that by these simple prescriptive solutions, ordinary low rise–low cost RC buildings can be retrofitted even by the owner of the building and industrial precast simple factory buildings can be upgraded.

- The recently accelerated systematic data collection and research activities carried out by municipalities and research institutes, revealed a lot of valuable information for engineers. Regional seismicity and soil conditions, building stocks, structural characteristics such as structural deficiencies and material properties are statistically well known. Cost effective retrofitting techniques have been developed depending on experimental and complementary theoretical works.

- This works should be kept going on to complete the information still needed while the other activities are organized.

The two following assumptions were utilized for proposing the simplified strategy to retrofit the existing *low rise–low cost* un-engineered buildings which are not classified as important buildings by existing earthquake resisting design codes;

  a. Assume that **none of the vulnerable buildings have enough strength and ductility to resist earthquake effects:** Sufficient amount of earthquake resistance will be provided by new simple interventions to be defined by the help of technical staff. For that purpose the as is drawings of critical stories of buildings are needed. This will be the first accomplishment of the proposed strategy. All the authorities *including local and metropolitan municipalities, universities, trained peoples and technicians, even trained army corps can* cooperate for this purpose utilizing the most recent available technology. There is no need for any kind of detailed assessment in this procedure and there is no need for material tests as well.

  b. ***Soil conditions of*** regions ***are known.*** At least for Istanbul, it is known that this information has already been scientifically collected.

- Emphases have been put in this paper on pre-earthquake measures which are assumed more effective than any kind of post-earthquake measures. Therefore within the framework of a comprehensive preparedness program the following four important issues should be covered and be implemented by the consortiums of scientists and administrators. The experience gained by engineers and administrators after the 1992 Erzincan, 1995 Dinar, 1998 Adana Ceyhan and 1999 Kocaeli Earthquake Rehabilitation Projects was extremely important and was needed for making real the strategy proposed below;

  a. *Training the Trainers and Training the People*; All kind of instruments such as professionally prepared documentaries, specially prepared earthquake simulation rooms, hands on experiments, any kind of written documents, courses for training the trainers and training the people using every single opportunity obtained is essential. People should be informed by means of laboratory and field tests conducted by specialist and the experts of the topics. The support of international organizations and universities can be obtained for that purpose.

b. *The Code Defined Rehabilitation Targets;* for ordinary buildings such as deformation limits, redesign load levels etc., should realistically be modified so that sufficient earthquake resistance becomes an achievable target for low income people. Retrofitting should be promoted as much as possible. For that purpose the compulsory disaster insurance sources should be exploited to create sufficient amount of fund.

c. *Support for Research Projects*; Considering that research is a continuous effort coming up with new findings making the life easy and more secure, it should be supported .The urgent research needs should be defined and prioritized jointly by scientists and administrators.

d. *Establishments of Engineering Aid Services*; Utilizing all the available data recently obtained and the research findings which are enough to expend the retrofitting activities for most of the ordinary buildings in metropolises should be used by the help of people living and working in these vulnerable buildings. The experimentally proven theoretical back ground of the proposal which aims to prevent total collapse, is ready. An internet base Engineering Aid Service should be established by the consortiums and local municipalities and individuals should be encouraged by promotions to send the structural plans of their buildings to these centers. After having processed the information obtained the prescriptive solutions found by experts for that particular building should be forwarded to the owner.

All in all, it can be said that a consortium consist of scientists and administrators should, focus on training activities to make the people a part of the solution. For that purpose training facilities and training instruments should be created .The urgent data which is essentially the structural **as is** drawings of existing buildings should be collected .In addition to that urgent research needs should be satisfied. And an ***Engineering Aid Service*** to help people should be established. Long term strategies built in basic state policies and planning above daily political agendas are musts to increase the scientific approaches and to create high level of concitiousness. It should not be forgotten that untrained people generally prefer to become prejudiced people for any reason. ***Educated and trained people will bring the solution.***

REFERENCES

Cili F., Pala S., Yuksel E. And Teymur P. (2008). "Retrofitting of Low Ductile Reinforced Concrete Frames with Shotcrete Walls", *TUBITAK Engineering Research Grant Group Project 106M075* Istanbul. (In Turkish).

Erol G., Karadogan H.F. and Cili F. (2008). "Seismic Strengthening of Infilled RC Frames by CFRP", *The 14th World Conference on Earthquake Engineering:* PN12-03-041 Beijing.

Karadogan H.F. and Yuksel E, (2001). "Some Experimental Studies Performed on Infilled RC Frames", *Symposium on the Retrofitting of Existing Structures* organized by Avcilar Municipality.

Karadogan H.F., Aydogan M., Girgin K., Yuksel E. and Ozer M.N. (2003). "Low Rise RC Buildings and the Current Engineering Problems of Seismic Rehabilitation, Third European Workshop on the Seismic Behaviour of Irregular and Complex Structures", *International Conference in Earthquake Engineering*, Skopje & Ohrid, R. Macedonia.

Karadogan H.F., Yuksel E, Yuce S, Taskin K. and Saruhan H, (2006). *Experimental Study on the Original and Retrofitted Precast Columns*, Technical Report (in Turkish), Istanbul Technical University.

Karadogan H.F., Pala S., Ilki A., Yuksel E., Mowrtage W., Teymur P., Erol G., Taskin K. And Comlek R., (2009). "Improved Infill Walls and Rehabilitation of Existing Low Rise Buildings", A. Ilki, F. Karadogan, S.Pala, E. Yuksel (Eds.), *Seismic Risk Assessment and Retrofitting with Special Emphasis on Existing Low Rise Structures,* pp. 387-426, Springer, ISBN:978-90-481-2680-4.

Mowrtage W., Yuksel E., Ilki A. and Karadogan H.F. (1998). "Strengthening and/or Upgrading the RC Frames by Means of Special Shotcreted Diaphragms", *Second Japan-Turkey Workshop on Earthquake Engineering* 1:318-326 Istanbul.

Parsons T, (2004). "Recalculated probability of M>=7 earthquakes beneath the Sea of Marmara", Turkey. *J. Geophysical Res. Solid Earth* 109(B5): Art. No. B05304.

Turkish code for earthquake resistant design (1997). Ministry of Public Works and Settlement Ankara.

Turkish code for earthquake resistant design (2007). Ministry of Public Works and Settlement Ankara.

Taskin K., Yuksel E., Karadogan H.F., Yuce S.Z. andYardımcı N., (2006). "Retrofitting of Precast Columns", *First European Conference on Earthquake Engineering and Seismology*, Geneva, Switzerland.

Taskin K., (2010). *Knee Type Retrofitting Technique of Medium Rise RC Buildings For Earthquake Damages*, Ph.D. Thesis Submitted to Graduate School of Istanbul Technical University, (in Turkish).

Uyan M., Akyuz S. and Yildirim H. (1999). "A Statistical Evaluation on Concretes Produced in Istanbul and around". *J Turkish Ready Mixed Concrete Association 6*.

Yuce S.Z., Yuksel E., Bingol Y., Taskin K. and Karadogan H.F., (2007). "Local Thin Jacketing for the Retrofitting of Reinforced Concrete Columns", *Structural Engineering and Mechanics*, Vol.27, No.5, 589-607.

Yucesan B., (2005). *High Strength Brick Walls for Retrofitting of RC Frames*, M.Sc. Thesis Submitted to Graduate School of Istanbul Technical University, (in Turkish).

Yuksel E (1998). *Nonlinear Analysis of 3D Large Structures with Certain Irregularities*, Ph.D. Thesis submitted to Graduate School of ITU Istanbul, (in Turkish).

Yuksel E., Ilki A., Erol G., Demir C. and Karadogan H.F. (2006). "Seismic Retrofit of Infilled Reinforced Concrete Frames with CFRP Composites", *NATO Workshop Advances in Earthquake Engineering for Urban Risk Reduction*: 977231 Istanbul.

LESSONS LEARNED FROM RECENT EARTHQUAKES IN ITALY: FROM THE SAN GIULIANO DI PUGLIA TRAGEDY IN 2002 TO THE COLLAPSES IN ABRUZZO IN 2009

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ABSTRACT

The lessons that, in the opinion of the author, were learned or not in Italy from seismic events are outlined. To this aim, remarks are reported on the seismic risk in Italy and particular attention is devoted to the effects of the last two significant earthquakes which struck this country: that of Molise and Puglia of October 31, 2002, and that of Abruzzo of April 6, 2009. Information is also provided on the features of the latter, on the development of national seismic design rules and on the progress of the use of seismic isolation, energy dissipation and other anti-seismic systems and devices in Italy and some further countries where there are important applications of Italian devices. In particular, this paper stresses the features of the new national seismic code (which became of obligatory use only after the Abruzzo quake) and some very recent decisions of the Italian Government aiming at promoting the use of the aforesaid systems and devices, to enhance of the seismic safety of schools and other structures. Special attention is devoted to the seismically isolated buildings, but some information is also provided on the use of other SVPC systems and devices and applications to structures different from buildings.

KEYWORDS
Passive control, seismic isolation, energy dissipation, SMADs, STUs, new constructions, retrofit, schools, hospitals, dwelling buildings, cultural heritage, industrial plants and components.

INTRODUCTION

Since the end of the years 1980s, great efforts have been devoted by ENEA[1], the Italian GLIS association[2], the EU/WEC Territorial Section of *ASSISI* [3]and EAEE-TG5[4] to the development and application of Seismic Vibration Passive Control (SVPC) systems and devices and other innovative technologies, in the framework of extensive collaborations with the Italian Civil Defence Department (*Dipartimento della Protezione Civile* – DPC) and further national, regional and local institutions (Dolce et al., 2006, Martelli et al., 2008, Sannino et al., 2009, Martelli, 2009a-b, Martelli and Forni, 2009a). Such collaborations also include support to DPC for emergency and post-emergency management, as well as re-construction, in the case of earthquakes. In particular, this support was provided after the 2002 Molise and Puglia earthquake and has been provided in Abruzzo since the event of April 6, 2009.

The SVPC systems and devices, which allow for strongly enhancing the seismic safety of all structure kinds (see, for instance, Dolce et al., 2006, Martelli et al., 2008), are Seismic Isolation (SI) and Energy Dissipation (ED) systems, Shape Memory Alloy Devices (SMADs) and Shock Transmitter Units (STUs). Recent information on their development and implementation was provided in some successful conferences that were organized or coorganized by GLIS, ENEA, *ASSISi*, its EU/WEC Territorial Section and EAEE-TG5. The proceedings of such conferences were published by Martelli et al. (2008), Santini and Moraci (2008), Sannino et al. (2009), Phocas et al. (2009), Mazzolani (2009), JSSI (2009) and Zhou et al. (2009). Numerous GLIS members and ENEA researchers actively

[1] ENEA recently changed its full name from Ente per le nuove Tecnologie, l'Energia e l'Ambiente (namely Italian Agency for New Technologies, Energy and the Environment) to Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile (namely Italian National Agency for New Technologies, Energy and Sustainable Economic Development).
[2] The full name of GLIS is GLIS - Isolamento ed altre Strategie di Progettazione Antisismica (namely GLIS – Isolation and Other Anti-Seismic Design Strategies).
[3] The EU/WEC Territorial Section of ASSISi is the Territorial Section for the European Union and Other Western European Countries of the Anti-Seismic Systems International Society. GLIS has been a corporate member of ASSISi since the foundation of the latter in 2002.
[4] EAEE-TG5 is Task Group 5 on Seismic Isolation of Structures of the European Association for Earthquake Engineering.

participated in special sessions dealing with the previously cited topics in the aforesaid conferences and other important recent events that were more generally devoted to seismic engineering and seismology (Martelli, 2008a-b & 2009a-e, and Martelli and Forni, 2008a-b & 2009a-b); part of these sessions were organized by the author of this paper (Martelli et al., 2008, Santini and Moraci, 2008, Katayama et al., 2008, Sannino et al., 2009, Phocas et al., 2009, Mazzolani, 2009).

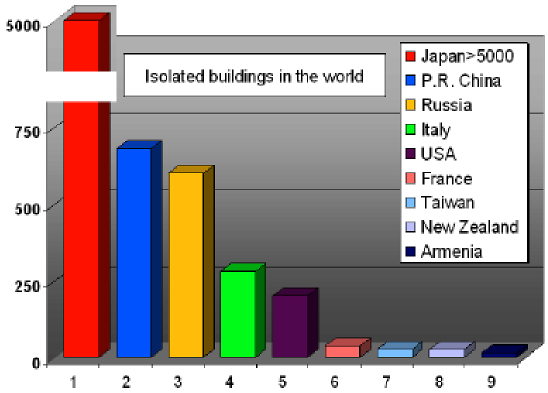

Figure 1. Overall number of building applications of SI in the most active countries

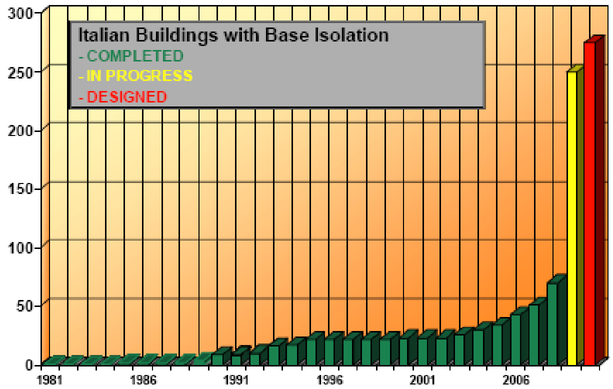

Figure 2. Overall number of building applications of SI in Italy during years

As witnessed by the proceedings of all the above-mentioned conferences, at present there are over 10,000 structures in the world that are protected by SVPC systems and devices. These structures are located mostly in Japan, but they are more or less numerous in about 30 further countries too (Figure 1), in particular in the Peoples' Republic (P.R.) of China, Russian Federation, USA and Italy, which follow Japan for the number of applications (however, as pointed out by JSSI, 2009, should such a number be normalized to that of the residents in each country, Armenia and New Zealand would be those immediately following Japan). Everywhere, the number of the aforesaid structures is increasing more and more, although the extent of the use of the SVPC systems and devices is strongly influenced by earthquake experience and the features of the design rules used. Applications concern both new and existing structures of all types: bridges and viaducts, civil and industrial buildings, industrial components and installations (including some high risk plants like nuclear reactors, other nuclear facilities and Liquefied Natural Gas – LNG – storage tanks) and cultural heritage (monumental buildings, museums, ceilings of archaeological excavations, museum display cases and single masterpieces). Those to civil constructions include not only the strategic ones (civil defense centers, hospitals, important bridges and viaducts, etc.) and the public ones (schools, churches, commercial centers, hotels, airports, etc.), but also many dwelling buildings and even several small private houses.

This paper contains parts of that of Martelli and Forni (2009a), which was partly based on the extended abstract written by Martelli (2009b) for the Istanbul UNESCO-IPRED Workshop of July 5-7, 2009; more precisely, some remarks are reported on the seismic risk in Italy, the 6.3 magnitude earthquake which struck the Abruzzo Southern Italian region (in particular, the town of L'Aquila and several surrounding villages) on April 6, 2009 and the lessons that were learned or not in Italy from seismic events. Information is also provided on the development of national seismic design rules and on the recent progress of the use of the SVPC systems and devices in Italy and some further countries where there are important applications of the Italian devices. In particular, the paper stresses the features of the new national seismic code and some very recent decisions of the Italian Government promoting the use of the aforesaid systems and devices, to increase the seismic safety of schools and other structures. Special attention is devoted to the isolated buildings, but some information is also provided on the use of other SVPC systems and devices and applications to structures different from buildings.

More details on the adoption of the aforesaid systems and devices in Italy and worldwide may be found in the books of Dolce et al. (2005 & 2006), Martelli et al. (2008) and Sannino et al. (2009), in the recent DVD of Zhou et al. (2009), as well as (for Italy) in the recent paper of Martelli and Forni (in press).

SEISMIC RISK IN ITALY

In spite of a significantly lower seismic hazard with respect to other countries or areas (e.g. Japan, P.R. China, California), Italy is characterized by the highest seismic risk in the European Union (EU) and by one of the highest in the industrialized countries (see Dolce et al., 2005 & 2006, Martelli, 2009d, and Table 1). In fact, the seismic vulnerability of the Italian constructions is such that more than half of them (including 75,000 strategic and public buildings) is incapable to bear the seismic actions to which they may be subjected.

This situation is due not only to the fact that Italy owns a very large part of the cultural heritage existing in the world and that there was a significant evolution of knowledge concerning seismology and seismic engineering (and, consequently, of seismic classification of the national territory and seismic codes) during the last decades, but also to a poor conscience that both the institutions and people had, at least until recently, that severe earthquakes are real events in Italy too, although they are less frequent than in other countries.

Table 1. Number of victims expected in both in high seismic hazard Italian areas, as well as (for an equal population) in Japan and (in average) at worldwide level (Dolce et al., 2005 & 2006)

Event of magnitude M = 7.0		
	Dead	Wounded people
Southern Apennines	5,000÷11,000	≥ 15,000
World (average)	6,500	20,500
Japan	50	250

Event of magnitude M = 7.5		
	Dead	Wounded people
Calabria	15,000-32,000	≥ 37,000
World (average)	18,500	75,000
Japan	400	2,000

Paradoxically, the problem of Italy has been that severe earthquakes are not sufficiently frequent in this country and that, in any case, their return periods are much longer than the duration of its governments (see Table 2). In the past, the consequence was that, when a severe earthquake occurred, the government in office at that time strictly limited its action to emergency management, without investing any resources in prevention, and that seismic risk was soon forgotten even in the struck areas. It has been estimated that the overall cost of this lack of prevention policies has already been almost 3 times larger than the overall amount of money which would have been necessary to adequately seismically upgrade all the existing Italian constructions (apart from the avoidable thousands of victims).

Table 2. Violence of earthquakes in Abruzzo and of the most recent Italian events

Event of magnitude M = 7.0		
	Dead	Wounded people
Southern Apennines	5,000÷11,000	≥ 15,000
World (average)	6,500	20,500
Japan	50	250

Event of magnitude M = 7.5		
	Dead	Wounded people
Calabria	15,000-32,000	≥ 37,000
World (average)	18,500	75,000
Japan	400	2,000

LESSONS LEARNED FROM THE SAN GIULIANO DI PUGLIA TRAGEDY IN 2002

With regard to the evolution of knowledge (Dolce et al., 2005 & 2006, Erdik et al., 2007 & 2008, Martelli et al., 2007 & 2008, Sannino et al., 2009), it is noted that 70% of the Italian territory is now defined as seismic, while this percentage was estimated to be only 45% prior to 1998 and 25% prior to 1980 (seismic classification begun in Italy after the 1908 Messina and Reggio Calabria earthquake, but, to the middle of the years 1970s, the Italian areas were classified as seismic only after having been struck by an earthquake). In addition, although the present seismic hazard map was already known and had already been proposed by the Italian seismologists in 1998, it became official only in 2003, after the collapse of *Francesco Jovine* primary school at San Giuliano di Puglia during the 2002 Molise and Puglia earthquake, which killed 27 children, including all the youngest (those born in 1996): it has been officially recognized that the earthquake was not guilty for this collapse (Figure 3), which was mainly caused by bad construction and an even worse rising of the school.

The aforesaid seismic reclassification was enforced by an ordinance of the Italian Prime Minister, published in May 2003 (OPCM 3274/2003), just because of the inertia shown by the normally responsible national and local institutions (Ministry of Constructions and Regional Governments). Thanks to this ordinance a new seismic code was also enforced (although not yet obligatorily), which was fully different from the previous (very old and inadequate) one: while the latter was prescriptive, the new one was based on performance, consistently with Eurocodes. In addition, the new Italian seismic code freed and even simplified the use of SI, ED and other modern SVPC systems and devices. In fact, it cancelled the previously existing need for submitting the designs of structures protected by such systems and devices to the approval of the High Council of Public Works of the Ministry of Constructions and allowed to partly take into account the decrease of the seismic forces acting on the superstructure caused by SI, when designing the superstructure itself and the foundations. With regard to the need for submitting the aforesaid designs the approval of the High Council of Public Works, it is worthwhile stressing that, due to the very complicated, time consuming and uncertain approval process, such a need, instead of correctly being a check of the adequacy of the new technologies, had hindered their development and extensive application, although they aim at saving human life and minimizing damage. Finally, OPCM 3274/2003 prescribed that the seismic safety of all strategic and public structures should have been checked by the responsible national or regional institutions within five years.


Figure 3. Collapse of the *Francesco Jovine* primary school of San Giuliano di Puglia (Campobasso) during the 2002 Molise and Puglia earthquake and search of survivors amid the debris

The enforcement of OPCM 3274/2003 (which was later improved by two subsequent OPCMs, then by decrees of the Ministry of Constructions in 2005 and 2008) can be considered as the birth of a real prevention policy in Italy. In particular, thanks to this ordinance, the use of the SVPC systems and devices soon significantly increased in Italy (Figure 2), especially for the protection of schools (as a consequence of the San Giuliano di Puglia tragedy): SI of the new *Francesco Jovine* at San Giuliano di Puglia, which was opened to activity in September 2008, was followed by that of further 16 schools (4 of these were completed in 2009, see below).

LESSONS NOT YET LEARNED PRIOR TO THE ABRUZZO EARTHQUAKE OF APRIL 6, 2009

The change of attitude towards the prevention of seismic risk caused by the San Giuliano di Puglia tragedy was, however, only partial. The consolidated general convincement that earthquakes are not a major problem in Italy was not fully cancelled. For instance, only half of the new Italian hospitals designed after OPCM 3274/2003 included SI, although this kind of protection is now indispensable to ensure their full integrity and operability after an earthquake. In addition, since the use of the new code was not obligatory, many (not only designers, but, unfortunately, also some institutions owning public buildings) accelerated the completion of the designs of even strategic and public buildings and/or of the related approval processes just to make sure that they were allowed to use the old, less stringent, code, which implied lower construction costs.

Moreover, the verifications of seismic safety of the existing strategic and public constructions went much slower than planned; even now it is far from being completed and no interventions have been undertaken, yet, in several cases, even when the problems detected are not limited to the seismic safety, but also concern the static one. Such unexpected, very worrying, situations were numerous, especially in Southern Italy, even for reinforced concrete (r.c.) buildings (Figure 18). Finally, the obligatory use of the new seismic code was deferred year by year, thus also causing a lot of confusion: even in February 2009 it had been postponed from the end of June 2009 to that of June 2010 and only thanks to the polemics following the Abruzzo quake this further extension was cancelled during Summer 2009 (also thanks to a resolution of the Commission on Environment, Territory and Public Works of the Italian Chamber of Deputies drafted with the collaboration of the author of this paper).

REMARKS ON THE ABRUZZO EARTHQUAKE OF APRIL 6, 2009

The earthquake which struck the L'Aquila town and 48 further municipalities in Abruzzo on April 6, 2009 (Figure 4), had a magnitude Mw = 6.3 and an epicentral depth of 9 km. It occurred at 3:33 local time at about 5 km south east from L'Aquila (seismic zone 1, according to the 2003 seismic re-classification of the Italian territory). It caused 298 dead, 1,600 wounded and 36,000 homeless people. Costs of 8.5 billion Euro have been foreseen for reconstruction. Table 3 shows the Peak Ground Acceleration (PGA) values versus return period (T) which were expected in the aforesaid area according to the Italian seismic classification, which is based on Probabilistic Seismic Hazard Assessment (PSHA).

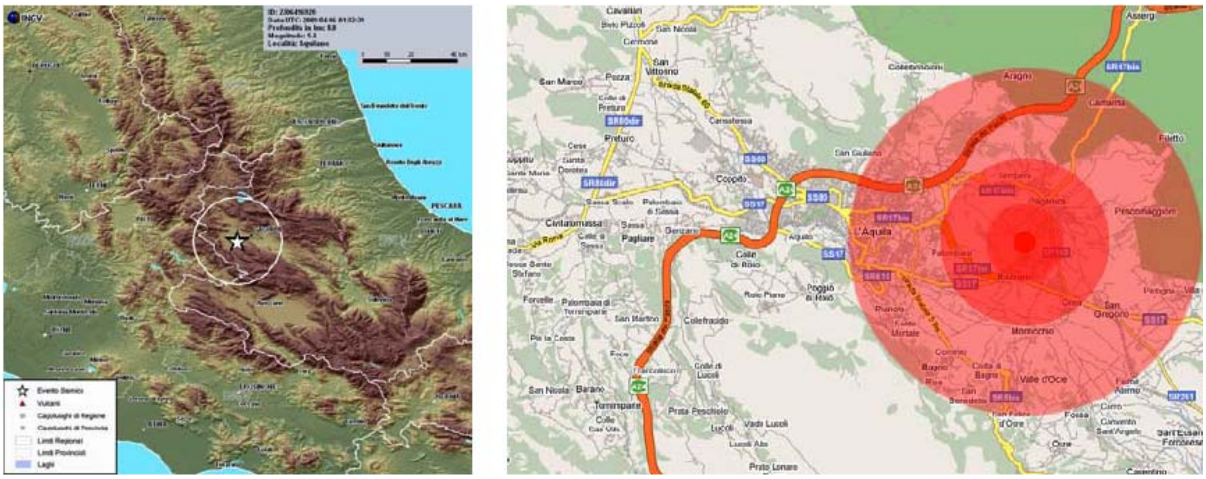

Figure 4. Epicenter of the Abruzzo earthquake of April 6, 2009, and area struck by this earthquake

Table 3. Seismic hazard at L'Aquila, as predicted according to PSHA

T (years)	PGA (g)
475	0.261
975	0.334
2,475	0.452


Figure 5. L'Aquila (April 2009): aerial views of some parts of the town where buildings collapsed or were heavily damaged

Thanks to the seismic monitoring systems which had been installed in the area, a large amount of data was made available by this event: in fact, there were 55 recordings of DPC and 114 of the *Italian Institute for Geophysics and Volcanology* (*Istituto Nazionale di Geofisica e Vulcanologia* or INGV), at epicentral distances varying from 4.3 km to 280 km. These recordings form the largest amount of seismological data ever obtained in Italy. The following results of these measurements shall be mentioned:
• a PGA value larger than 1 g was measured in one station;
• a residual maximum vertical displacement of 15 cm was detected close to the fault (zero distance);
• amplification of the seismic motion at 0.6 Hz was also detected in the epicentral zone (namely at zero distance from the fault and less than 10 km distance from the epicenter);
• the attenuation laws which are available in the literature underestimated the PGA values at small epicentral distances and overestimate those at large distances;
• the measurements in the epicentral zone were strongly influenced by source effects;
• the recordings of the main shock showed a clear directivity effect towards south-east;
• most recordings in the epicentral zone showed PGA > 0.3 g and in one station (*del Moro* station, close to Pettino) even > 1 g;
• the response spectra ordinates were particularly large especially in the range 2÷10 Hz (0.1÷0.5 s), which contains the natural frequencies of most buildings of the region;
• the duration of the most energetic part of the acceleration records was only 2÷5 s (in one station almost 60% of the energy was released in the first 3 s; this led to a strong impulse at high frequency, even for the vertical earthquake component, which struck buildings with a moderate number of cycles but of large amplitude;
• very large local amplifications were measured, which stresses the presence of rather poor soils.

Figure 6. L'Aquila (April 2009): collapse of the town collapse of the prefecture, a symbol of lack of prevention

Figure 7. L'Aquila (April 2009): Santa Maria Paganica Church

Figure 8. The Cathedral of Santa Maria di Collemaggio, a rare example of Abruzzo Romanic style, prior to the earthquake and the collapse of its roof in its baroque (not yet retrofitted) part. The façade, which had been protected by some elastic-plastic dampers (EPDs) installed on the roof some years ago (see Figure 25), survived the earthquake (however, a steel scaffold, recently erected for an already planned retrofit, certainly helped)

Thus, most structures that were not ductile nor built according to reasonable engineering requirements, the nonreinforced masonry buildings (including cultural heritage monuments) and a significant part of the other buildings which were characterized by limited ductility and insufficient seismic resistance (due to poor designs or construction problems) were unable to withstand the earthquake (Figures 5÷12). Some bridges were also damaged and several masterpieces (e.g. at L'Aquila Museum) were destroyed or heavily damaged (Figure 29).

Figure 9. L'Aquila (April 2009): pillars in the San Salvatore Hospital, heavily damaged due to very inadequate steel reinforcement and poor concrete quality (no inert materials are visible in the pillar upper part)

Figure 10. L'Aquila (April 2009): heavily damaged beam-pillar nodes of private buildings

Figure 11. L'Aquila (April 2009): partly collapsed and heavily damaged private buildings

As far as cultural heritage is concerned, over 1,000 ancient monumental buildings were heavily damaged and partly collapsed, largely due to their previous incorrect or incomplete retrofit (Figures 7 and 8). The collapse suffered by numerous r.c. buildings (like the *Student House*) or their heavy damage (including some further public or strategic buildings) was due to very inadequate reinforcement and poor concrete quality (Figures 6 and 9÷11). The importance of good maintenance was evident: similar equally old buildings suffered only limited or even zero damage if they had been adequately maintained, while they were heavily damaged in case of absence of maintenance.

Luckily, several buildings suffered mainly non-structural damage: many of them may be retrofitted by means of SI (see, for instance, Figure 12) or ED systems. To this aim, the experience achieved through the retrofit of a 3 storey house at Fabriano (Ancona) after the 1997-98 Marche and Umbria earthquake will be very useful: this house (Figure 22) had suffered severe non-structural damage in the earthquake and was retrofitted by subfounding it and inserting *High Damping Bearings* (HDRBs) in the new underground floor (as mentioned by Dolce et al., 2005 & 2006, the cost of this retrofit allowed for saving 20% of construction costs with respect to a conventional reinforcement). Obviously, SI will also be used to reconstruct collapsed buildings or those being so damaged that they shall be demolished.

Figure 12. L'Aquila (April 2009): headquarters of ANAS (the Italian Agency for roads construction and maintenance), which suffered mainly non-structural damage (with the exception of two pillars, which, however, are reparable – see right) and might be retrofitted by means of SI

LESSONS (HOPEFULLY) LEARNED FROM THE ABRUZZO EARTH-QUAKE OF APRIL 6, 2009

Obviously, the not yet obligatory use of the new seismic code was not guilty for the damage and collapses occurred during the 2009 Abruzzo earthquake. However, the latter were caused by the same reasons for which some builders (thanks to the support of a senator) had tried to postpone the beginning of the obligatory use of the aforesaid code: again the convincement that earthquakes are not a major and real problem in Italy. In fact, a part from the damage of ancient buildings (which cannot be fully avoided, although it can be strongly reduced), a large part of collapses and damage was caused (as mentioned) by bad construction (poor concrete, absent, inadequate or insufficient steel reinforcement, especially for stirrups), not consistent with any code (even the oldest), and/or by lack of adequate maintenance.

Hopefully, after the Abruzzo earthquake, both Italian institutions and public opinion are fully convinced that seismic prevention is indispensable and that the related policy shall be strengthened and accelerated; in particular, that the presently best available techniques (such as SI and ED) shall be extensively used for the reconstruction and retrofits in Abruzzo: this not only for the strategic and public buildings, but also for the dwelling ones. The additional construction costs (if any) are quite limited and safety is much higher. This will strongly reduce casualties and damage during the next shocks, which, by the way (according to history and also to some recent seismological studies), might unfortunately occur in Abruzzo rather soon. In addition, such a kind of prevention policy shall be extended to the entire Italian territory, because, if the earthquake of April 6, 2009 had taken place elsewhere in Italy, the consequences would not have been significantly different.

With regard to the seismic protection of existing structures, although the work to be done and money to be spent are enormous (because nearly nothing was done in the past), the efforts shall be much increased. Several old buildings shall be demolished and reconstructed with safe features, instead of being all considered as cultural heritage, as done to date in Italy after a 50 years life (not all constructions are comparable to the Coliseum!). The interventions shall be scheduled based on priorities, namely beginning from the most risky structures in the areas characterized by the highest seismic hazard. The latter shall be assessed by means of not only the currently used PSHA, but also of the deterministic approach, which should be considered (as it is, in the author's opinion) as complementary and already proved to be quite reliable (Dolce et al., 2005 & 2006, Sannino et al., 2009, Martelli, 2010).

Reliable seismic engineering technologies and seismological methodologies exist: thus, there is no more excuse not to widely use them. However, in applying modern technologies like SI, great care shall be paid to the selection of the devices, their installation and their protection from external causes of damage and some further construction details, as well as to an adequate maintenance (Martelli, 2009f). In particular, in order to ensure a real safety of the isolated structure, correctly qualified, checked and protected devices shall be installed and adequate inspection and maintenance shall be performed during the entire structure life to ensure that the SI features remain unchanged. Otherwise, these devices, instead of largely enhancing protection in an earthquake (as SI does, if properly applied), will expose both human life and the entire SI technology to a great risk: in fact, since the Italian seismic code (contrary to the Japanese and U.S. ones) allows for "lightening" both the superstructure and foundations when a SI system is installed, the inadequate performance of the latter would make an isolated building less safe than a conventionally founded one (Martelli, 2009f).

APPLICATION OF THE SVPC SYSTEMS AND DEVICES IN ITALY

As mentioned by Dolce et al. (2005 & 2006), Martelli et al. (2007) and Martelli and Forni (2009b), the first applications of SVPC systems in Italy date 1975 for bridges and viaducts and 1981 for buildings, namely 4 years before those in Japan and the USA (Figure 2). They concerned the Somplago viaduct of the Udine Tarviso freeway and, respectively, a suspended steel-structure fire-command building in Naples. Thanks to its SI system (formed by sliding devices on the piles and rubber springs between the deck and the abutments), the Somplago viaduct survived the second main shock of the 1976 Friuli earthquake (when one of the decks had already been installed) without any damage, contrary to most other structures similarly located in the epicentral area; for the Naples building, which had been conventionally designed before the 1980 Campano-Lucano earthquake (when the site was not yet seismically classified), the insertion of Neoprene Bearings (NBs) at the top (to isolate the suspended structure) and, inside, that of floor dampers and STUs, allowed for not fully modifying the original design, in spite of the classification of the Naples area in seismic category 3 after the aforesaid earthquake.

Figure 13. Sketch of the new isolated *del Mare* Hospital, during its construction in Naples, nowadays in seismic zone 2, and view of some of its 327 HDRBs. Several new Italian hospitals being or to be erected in seismic areas now include the use of SI

The excellent behavior of the Somplago viaduct, in the years of construction of the Italian freeway system, caused an immediate rapid extension of the application of SVPC systems to the new Italian bridges and viaducts.

Those protected by such systems were already 150 at the beginning of the years 1990s: this ensured the worldwide leadership to Italy for the number and importance of the applications in this field. As to buildings, the extension of applications was slower in the first years, but the trend had become very promising, in this field too, at the beginning of the years 1990s (Figure 2), after the erection of the Telecom Italia Centre of Marche Region in Ancona on 297 HDRBs and the impressive on-site tests performed on one of its 5 buildings (their safety was later certified by the first author of this paper, as mentioned, for instance, by Dolce et al., 2005 & 2006).

Figure 14. The main building (being erected on 10 HDRBs of 1 m diameter, see 2 of them on the right, covered provisional protections) and the adjacent service building (isolated by HDRBs and steel-PTFE *Sliding Devices* or SDs) of the Emergency and Management Operative Centre of the new Civil Defense Centre of Central Italy in Foligno (Perugia). Their safety will be certified by A. Martelli. The Foligno Centre will be formed by at least 7 isolated buildings (3 of them have already been completed). Its site was reclassified from seismic category 2 to seismic zone 1 in 2003, but no design changes of the structures and foundations were necessary, thanks to SI (an increase of the diameters of isolators was sufficient, as demonstrated by a study performed by ENEA)

On the contrary, the use of the SVPC systems and devices became very limited after such an application (Figure 2): in fact, the Italian Ministry of Constructions, by recognizing that no specific rules for structures provided with said systems and devices were included in the Italian seismic code in force at that time, on the one hand decided that all designs of such structures had to be submitted for approval to the already mentioned special commission of the Ministry, but, on the other hand, did not make any specific design guidelines available until the end of 1998. Moreover, such design guidelines, when they were published, resulted to be inadequate and the approval process remained uncertain, very complicated and time consuming.

Figure 15. The new *Francesco Jovine* primary school and *Le Tre Torri* Professional and University Centre, erected in San Giuliano di Puglia (seismic zone 2 since 2003) on an unique seismically isolated slab, and its SI system (61 HDRBs and 12 SDs) during construction. The isolators were donated by the Italian ALGA, FIP Industriale and TIS manufacturing companies, SI design by a team of experts coordinated by the GLIS and *ASSISi* member P. Clemente of ENEA and tests by the University of Basilicata. Safety was certified by A. Martelli and the GLIS member C. Pasquale in September 2008

Figure 16. The first new school building of Mulazzo (Massa Carrara), protected by *Lead Rubber Bearings* (LRBs) and SDs (right) and the new primary and secondary school of Gallicano (Lucca), protected by HDRBs and completed in September 2009. They are two of the 5 schools reconstructed (3) or being reconstructed with SI in Tuscany, in seismic zones 2 (safety of the Mulazzo school will be certified by A. Martelli)

Thus, in spite of its long tradition, Italy was only fifth, at least for the number of seismically isolated buildings in use, prior to the 2009 Abruzzo earthquake, with over 70 isolated buildings already opened to activity and about 30 further applications of this kind in advanced progress. Some tenths of Italian buildings had also already been protected by ED systems or SMADs (19 at the end of 2007) or STUs (28 at the same date). Moreover, there were already over 250 bridges and viaducts provided with SVPC devices and important applications of such devices, completed or planned, to worldwide known cultural heritage (Upper Basilica of St. Francis at Assisi, damaged by the 1997-98 Marche and Umbria earthquake, statues of the Bronzes of Riace and other structures and masterpieces like, for instance, those shown by Figures 25÷28). Finally, Italian SVPC devices had been installed in several constructions in other countries too (Dolce et al., 2005 & 2006, Martelli, 2009b).

In the last years, however, there has been a large increase of the number of applications completed and, especially, of those in progress or under design (Figures 2 and 13÷27). This change was due at first to the new Italian seismic code, enforced in May 2003, which (as mentioned) freed and simplified the adoption of the SVPC systems, then, very recently, to the Abruzzo earthquake.

Figure 17. The new school of Marzabotto (Bologna), in seismic zone 3, under construction on HDRBs and SDs. Its safety will be certified by A. Martelli

Figure 18. *Romita* High School for scientific studies of Campobasso (hosting about 1,300 students), in seismic zone 2, which is at last now being partly demolished and will be reconstructed with SI, due to its very poor concrete quality (as demonstrated by a study of ENEA, performed after the 2002 Molise and Puglia earthquake). Safety of the new seismically isolated buildings will be certified by A. Martelli

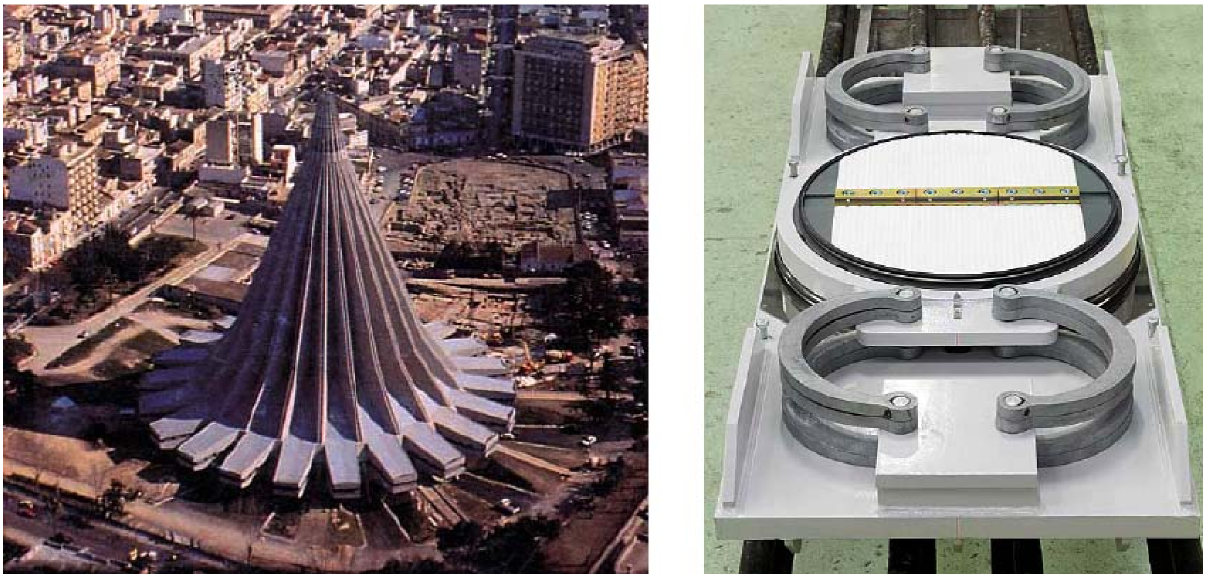

Figure 19. Sanctuary of *Madonna delle Lacrime* in Syracuse (seismic zone 2), which may contain up to 11,000 persons: it was retrofitted by uplifting the dome (22,000 tons) and replacing the previously existing rubber supports by EPDs in 2006 (right).

Figure 20. Left: Headquarters of the association *Fratellanza Popolare – Croce d'Oro* in Grassina (Florence), in seismic zone 2, isolated by means of SDs and Viscous Dampers (VDs); it is a L-shaped building to be used for civil defense certified as safe by A. Martelli in 2007. Right: NATO Centre of South Naples, in seismic zone 2 (399 HDRBs and ~20 dissipative SDs), during construction in 2007.

Figure 21. The 4 r.c. dwelling buildings of the new *San Samuele Quarter* of Cerignola (Foggia), in seismic zone 2, first application of the new Italian seismic code to isolated dwelling buildings, completed with 124 HDRBs (right) in May 2009, with safety certification of A. Martelli.

Figure 22. Three storey r.c. private house in Fabriano (Ancona), in seismic zone 2, damaged by the 1997-98 Marche and Umbria earthquake, first EU application of SI in a sub-foundation, the retrofit of which was completed with 56 HDRBs of 3 sizes in 2006, with safety certification of A. Martelli.

As already mentioned, the enforcement of the new Italian seismic code was largely a consequence of the collapse of the *Francesco Jovine* school during the 2002 Molise and Puglia earthquake. This school was recently reconstructed: the new *Francesco Jovine*, opened to activity in September 2008 (Figure 15), is the first Italian isolated school and has been judged as "the safest Italian school". It is being followed by 16 further applications of this kind (4 have already been completed). Seismic protection of schools by means of SI, in addition to that of hospitals, other strategic structures and cultural heritage (Figures 25÷29), was a "priority 1" objective in Italy even before the Abruzzo earthquake. After this event, this kind of protection is being further extended and planned for the dwelling buildings too, in the framework of the retrofit / reconstruction program in Abruzzo, which should make a large use of SI and ED systems.

Figure 23. Left: dwelling building in San Giuliano di Puglia, isolated by 13 HDRBs and 2 SDs with the collaboration of ENEA, completed in 2007. Right: SI formed by LRBs and SDs of an 8-storey building under construction at Messina, in seismic zone 1 (its safety will be certified by A. Martelli)

Figure 24. One of the 184 seismically isolated pre-fabricated houses erected at L'Aquila for the homeless residents and a *Sliding Isolation Pendulum* (SIP) device installed to isolate its supporting slab

Figure 25. Internals of the Cathedral of *Santa Maria di Collemaggio* at L'Aquila (Figure 8) prior to the 2009 Abruzzo earthquake and view of one of the EPDs which had been installed on the roof at the beginning of the years 2000s to prevent overturning of the façade.

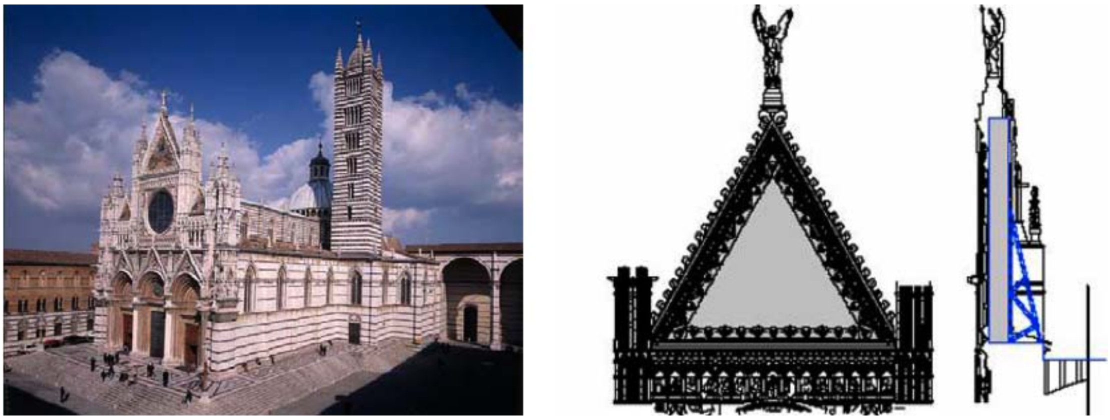

Figure 26. The Dome of Orvieto and position of the re-centering VDs which were inserted some years ago to prevent overturning of its façade

Figure 27. The wooden Roman ship excavated at Ercolano (Naples), in seismic zone 2, which was recently protected in the local museum by means of three-directional (3D) isolators formed by 3 spheres and a recentering rubber cylinder for the horizontal SI and a spring and a VD for the vertical one

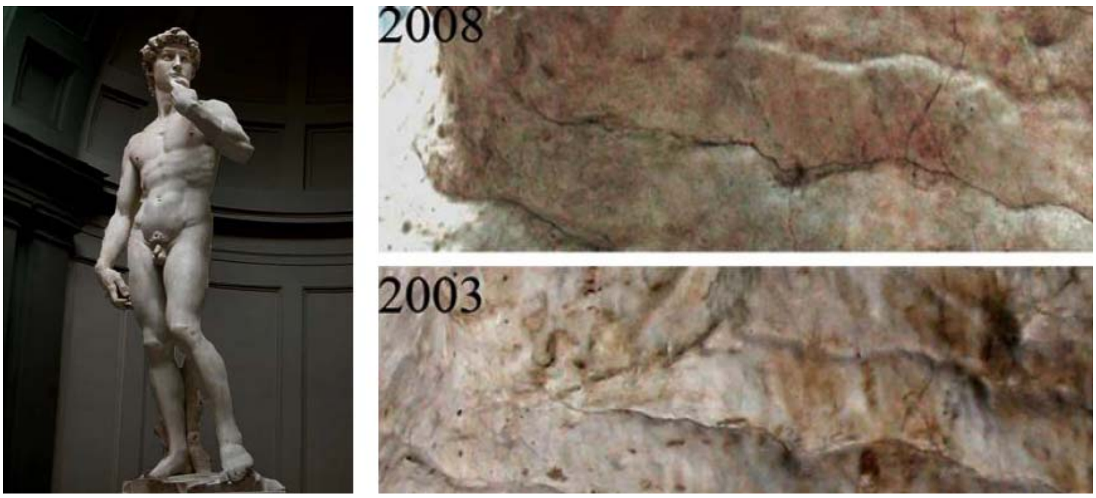

Figure 28. The marble statue of David of Michelangelo, exhibited in the *Galleria dell'Accademia* in Florence and evolution of the fissures at its ankles during the recent years, which make it very vulnerable to both seismic and environmental vibrations. For this reason a study to evaluate the feasibility of SI of the masterpiece has been proposed by Prof. Antonio Borri of the University of Perugia and the first author of this paper (Dolce et al., 2005 & 2006, Martelli, 2009a), although without much success

Figure 29. Collapse of statues at the Museum of L'Aquila, caused by the 2009 earthquake, which should make the opponents of the development and installation of an adequate seismic protection system for David of Michelangelo think it over.

In particular, the construction of 184 pre-fabricated houses of various materials (wood, concrete, steel), each erected on a 21 m x 57 m, 50 cm thick r.c. platform supported by 40 steel or r.c. columns with *Sliding Isolation Pendulum* (SIP) devices manufactured in Italy (by ALGA and FIP Industriale) at the top, is nearly completed (December 2009): these houses (Figure 24) will host first about 17,000 people who remained homeless after the earthquake and later, in some years, students. It is noted, however, that the SIP isolators (besides needing for a very careful protection from dust and humidity) had never been previously used in Italy. Building applications of similar SIP isolators existed in other countries, like Greece and Turkey, but such devices had been manufactured in Germany (Figures 30 and 31), namely using a sliding material different from the Italian ones. Thus, a debate was promoted in Italy by the author of this paper (as GLIS chairman) on the need for submitting the Italian SIP isolators to a very detailed experimental verification campaign, including two-directional (2D) simultaneous excitations in the horizontal plane, representing real earthquakes, at the laboratories of the University of California at San Diego, similar to those performed for the German ones and, previously, for the U.S. Friction Pendulum System (FPS) devices, from which the SIP isolators derive. This debate is still ongoing (the aforesaid 2D tests are required neither by the Italian code nor by the European one, although they had been found necessary for both the FPS and the German SIP isolators), but a first positive result has already been achieved: in fact, the SIP isolators of FIP Industriale were recently submitted to the aforesaid 2D tests, with excellent results.

APPLICATIONS IN OTHER COUNTRIES

As far as the application of the SVPC systems in other countries is concerned, Italy is now followed by Taiwan, Armenia, New Zealand, South Korea, France (including its Martinique island), Mexico, Canada and Chile (Dolce et al., 2005 & 2006, Martelli, 2009a, Martelli and Forni, 2009b).

In France SI systems based on the use of NBs as main components were developed in the years 1970s and applied not only to civil buildings, but also to nuclear structures and other industrial equipment. The nuclear applications were performed both in France itself (to the *Pressurized Water*

Reactor – PWR – of Cruas, spent nuclear fuel storage pools at La Hague, etc.) and in other countries (to the PWR of Koeberg, in South Africa). Nowadays, in the mainland, SI is being used to protect the *Jules Horowitz Reactor* and has been planned for the *ITER* plant for the controlled fusion (based on a design developed by an international team, including Italian experts), while, in the Martinique island, the use of SI is obligatory for schools and other public constructions.

Figure 30. The *Söğütözü Congress & Commercial Centre* in Ankara (Turkey), isolated by means of 105 German SIP devices in 2007 (left), and the *International Broadcasting Centre* in Athens (Greece), isolated by means of 292 Italian HDRBs in 2003 (right)

Figure 31. Recent Greek applications: the *Onassis Centre at Athens*, with the *Acropolis Museum*, isolated by 94 German SIP devices in 2006 (left), and *Onassis House of Letters and Fine Arts*, during its construction, again with German SIP devices, in 2007 (right).

Furthermore, some years ago, important applications also began in Turkey (after the 1999 *Kocaeli* and *Duzce* earthquakes) and in other European countries, like Greece, Portugal, Cyprus, Macedonia, etc. (see Figures 30÷33 and Martelli, 2009a). In Greece and Turkey both U.S. FPS and (as mentioned) German SIP isolators have been adopted in some cases, but many of the aforesaid applications make use of SVPC devices manufactured in Italy (e.g. in Turkey, Greece, Cyprus and Portugal) or also Italian designs too (e.g. in Cyprus). Italian devices have also been installed in several other countries, like Taiwan, South Korea, Venezuela, Algeria, Indonesia and even the USA and Canada.

With regard to Macedonia, it is worthwhile citing that it hosts the first modern application of SI in the world, that to the *Johan Heinrich Pestolazzi* school at Skopje, erected after the destructive earthquake of 1963: its original poorly laminated and very deteriorated *Low Damping Rubber Bearings* (LDRBs), which had been donated by Switzerland, were replaced by HDRBs in 2007 (Figure 33).

Figure 32. The *Shakolas Park Commercial Centre* at Nicosia (Cyprus), designed by the Italian GLIS and *ASSISi* member G.C. Giuliani and his son, formed by 2 buildings with mixed r.c. and steel structure, with 164 Italian HDRBs at top of the basement columns (left), and *La Luz* new hospital at Lisbon (Portugal), which was baseisolated, together with a residence for old people, by means of 315 Italian HDRBs in 2006 (right)

Figure 33. The isolated *Pestalozzi* school at Skopje (Macedonia), erected in the years 1960s, a very degraded original *Low Damping Rubber Bearing* (LDRB) and a new HDRB, close to not yet replaced original LDRBs

LEGISLATIVE MEASURES RECENTLY ADOPTED IN ITALY TO PROMOTE THE USE OF THE ANTI-SEISMIC SYSTEMS AND DEVICES

Coming back to Italy, it shall be stressed that the Italian Government, besides making the use of the new seismic code at last obligatory (in the framework of the law for the reconstruction in Abruzzo), recently decided some legislative measures (largely based on proposals of GLIS and, in particular, of the author of this paper) to favour the extension of the adoption of the anti-seismic systems and devices (especially of SI). For instance, economic incentives have been included in the new so-called "*Quality House*" national law for those adopting such technologies and even more favourable measures should be soon decided by the Regional Government of Sicily.

With regard to the seismic protection of schools, it is worthwhile reporting a translation of the whole text of an "agenda" (consistent with the declaration of UNESCO-IPRED-ITU, 2009) which was proposed by the President of the Commission on Environment, Territory and Public Works of the Chamber of Deputies (Alessandri et al., 2009) in the framework of the vote of the 2009 Financial Law on December 16, 2009, and was immediately accepted by the Italian Government (Italian Chamber of Deputies, 2009):

"The Chamber of Deputies, considering that:

• paragraph 229 of article 2 of the bill under examination contains measures aimed at guaranteeing the safety of schools and, in this framework, in order to ensure the maximum quickness for the completion

of the interventions necessary to put the school buildings in safe condition and to seismically retrofit them, prescribes, in particular, that, within thirty days from the date of enforcement of the financial law itself, the interventions which can be immediately undertaken shall be the first to be identified;
• it shall be stressed in such a framework that, among all construction types, the school buildings, together with hospitals, should be the most protected from earthquakes, which are the events characterized by the highest risk in Italy;
• for such buildings the objective shall be the full safety of the students and the other present persons;
• to this aim, besides preventing the collapse of school buildings in the case of earthquakes (which is the requirement foreseen by the seismic codes, including the new Technical Norms for Constructions), it is also indispensable to guarantee their full integrity, with no damage even to the non-structural elements and the objects contained;
• furthermore, the level of the seismic vibrations transmitted by the ground to the buildings shall be minimized, to prevent panic;
• the aforesaid objectives cannot be achieved by the conventional anti-seismic design, which is based on the «robustness» of structures, while they can be fully achieved thanks to base seismic isolation and can be achieved to a large extent by inserting energy dissipation systems inside the structures themselves;
• more than half of the school buildings existing in our country result to be inadequate to withstand the earthquakes to which they may be subjected;
• for many of such buildings retrofits able to guarantee a sufficient seismic safety are very difficult or too costly, either because they are monumental buildings (thus also subjected to the conservation requirements), or because they are rather old;
• in the first case it would be desirable to assign the buildings to a different use and move the school functions to other structures, possibly of new construction; in the second the best solution would be demolition and subsequent *ex novo* reconstruction;
• for the new school buildings there are no obstacles of technical nature against their construction with seismic base isolation (in Italy 5 new isolated schools have already been completed and further 12 are under construction); in favour of this technological solution there are, besides the largely higher safety level with respect to a conventionally founded construction, the overall economic balance too (which takes into account not only the construction costs, but also those of demolition and repair, removal and storage of the debris, displacement of the school activities) and the evident environmental and energetic benefits;
• with regard to the sole construction costs, it is worthwhile noting that, in Italy, the school buildings have a limited number of storeys and usually do not need for an underground storey; thus, although the new Italian seismic code allows for lightening the superstructure and foundations of seismically isolated buildings, for school buildings with base isolation some additional construction costs due to the use of such a protection (isolators, an additional storey above them, etc.) are sometimes to be foreseen;
• for interventions on existing school buildings, seismic isolation may be used only if the room necessary for the «rigid body» motion which characterizes the building part supported by the isolators exists or can be created around the building; the related costs may be even significantly lower than those characterizing a conventional retrofit, because it is possible to avoid stripping the structure, strengthening pillars and beam-pillar nodes and inserting shear walls;
• when seismic isolation is not applicable, it is usually possible to seismically improve the buildings by inserting dampers inside them; in this case the cost of dampers is usually largely balanced by the possibility of avoiding stiffening of the structure;
• in Italy the most famous seismically isolated building is the new Francesco Jovine or «Angels of San Giuliano», school; such a school was the first, among those protected by seismic isolation, to be completed in Italy, in September 2008; the isolation system was designed by a team of experts co-ordinated by ENEA and the structure was subjected to inspections during construction and safety certification of an expert of the Agency; ENEA also contributed to the design of the seismic isolation system and/or certified or will certify the safety of further new schools, in Marzabotto (Bologna), Campobasso, Vado (Bologna) e Mulazzo (Massa); to be cited are also the design and safety certification of 4 further new seismically isolated schools in Tuscany, performed in the framework of the Protocol of Agreement on «Applications of seismic isolation and other modern anti-seismic technologies to constructions and buildings, in particular for educational use» signed by Tuscany Region, ENEA and GLIS in 2004;
• previously other existing schools had been seismically improved by means of energy dissipation systems, first of all at Potenza and its province, then in the Marche Region too: among the latter it is worth citing the Gentile

Fermi school in Fabriano, of rationalist architecture, which, due to the damages suffered during the 1997-98 Marche and Umbria earthquake, was seismically improved by means of visco-elastic dampers developed in the framework of the EU-funded project REEDS promoted by ENEA;
• ENEA, in the framework of school building, may profitably contribute in its specific competence fields, among which:
- the development of new anti-seismic devices and, by means of its experimental equipment, tests on such devices and mock-ups of structures protected by them;
- the definition of seismic input, also by means of on-site seismic tests, and analysis of local seismic response and seismic micro-zoning, with definition of site-specific spectra and/or acceleration timehistories;
- the evaluation of the seismic vulnerability of existing buildings, also by means of experimental tests on the materials and structures, with the identification of the most suitable techniques for the seismic retrofit of the structures;
- specialist consultancy in support to the structural design, with particular reference to the sizing and verification of the modern seismic protection systems, for both new buildings and retrofits of existing buildings;
- specialist consultancy in support to the installation of the anti-seismic devices;
- inspection during construction and final safety certification of the buildings;
- seismic monitoring of the structures,

Commits the Government
In the framework of the realization of the provisions of paragraph 229 of article 2 of the bill under examination, to evaluate the opportunity of involving ENEA and, in the affirmative, to draw up specific agreements, as to define interventions for the seismic safety of schools which are not only highly effective, but are also both the most advanced with regard to the construction technologies to be adopted and as advantageous as possible as far as costs, safety and functionality are concerned."

CONCLUSIONS

Italy follows Japan, P.R. China, Russian Federation and the USA for the number of structures protected by SI or ED which are already in use, thus being leader in Western Europe (and probably worldwide for the use of SVPC devices – mainly SMADs and STUs – for protecting cultural heritage). Its applications are being significantly extended after the 2009 Abruzzo quake. Italian SVPC devices have been applied in several other countries too.

In Italy and worldwide, SI is now recognized as particularly beneficial for the protection of strategic constructions like civil defense centers and hospitals (by ensuring their full integrity and operability after the earthquake) and for schools and other highly populated public buildings (also because the large values of the superstructure vibration periods minimize panic). Some codes (e.g. the Italian one) allow for taking advantage of the reduction of seismic forces operated by SI: their use makes SI attractive for the dwelling buildings too, because the additional construction costs (if any) are very limited.

In order to really strongly enhance the seismic protection of our communities, an extensive application of the anti-seismic systems is necessary: to achieve this objective, legislative measures and economic incentives, such as the first ones that were recently decided in Italy, may considerably contribute, especially in the countries which are not yet sufficiently conscious of the seismic risk.

Hopefully, the use of SVPC systems (in particular SI) will strongly increase for the protection of cultural heritage and high risk plants, as well. With regard to the latter, SI has a great potential not only for nuclear structures, but also for chemical components like LNG tanks, for which, to date, only very few applications exist (in South Korea, China, Turkey, France, Greece and – soon – Mexico: in fact, detailed studies have shown that SI is indispensable for such components in highly seismic areas (Dolce et al., 2005 & 2006, and Martelli, 2009a). However, it shall be kept in mind that the use of SI in countries like Italy, where the designers are allowed by the code to decrease the seismic forces when adopting this technology, a very careful selection, design, installation, protection and maintenance during the entire life of the isolated structure is required for the SI devices: otherwise, safety would be lower than that of the conventionally founded structure.

REFERENCES

Alessandri, A., Rainieri, F. and Lanzarin, M. (2009). "Ordine del giorno n. 9/2936-A/50 (Agenda nr. 9/2936-A/50)", *Atti Parlamentari, XVI Legislatura – Allegato A ai Resoconti – Seduta del 16 Dicembre 2009 – N. 259*, Rome, Italy, pp. 51-53.

Italian Chamber of Deputies, *Atti Parlamentari, XVI Legislatura – Allegato A ai Resoconti – Seduta del 16 Dicembre 2009 – N. 259*, Rome, Italy, pp. VII-VIII.

Dolce, M., Martelli, A. and Panza, G. (2005). *Proteggersi dal Terremoto: le Moderne Tecnologie e Metodologie e la Nuova Normativa Sismica (Let's Protect Ourselves from Earthquakes: the Modern Technologies and Methodologies and the New Seismic Code)*, 2nd edition, 21mo Secolo, Milan, Italy (in Italian).

Dolce, M., Martelli, A. and Panza, G. (2006). *Moderni Metodi di Protezione dagli Effetti dei Terremoti (Modern Methods for the Protection from Earthquake Effects)*, Special edition for the Italian Civil Defense Department, A. Martelli ed., 21mo Secolo, Milan, Italy (in Italian).

Erdik, M. et al., eds. (2007). *ASSISi 10th World Conference Isolation, Energy Dissipation and Active Vibrations Control of Structures, May 28-31, 2007, Istanbul, Turkey – Abstract Book*, TASI, Istanbul, Turkey.

Erdik, M. et al., eds. (2008). *Isolation, Energy Dissipation and Active Vibrations Control of Structures – Proceedings of the ASSISi 10th World Conference, May 28-31, 2007, Istanbul, Turkey (DVD)*, TASI, Istanbul, Turkey.

JSSI (2009). *Proceedings of the International Workshop Celebrating the 15 Years Anniversary of JSSI (DVD),*Tokyo, Japan.

Katayama, T., Chen, J. et al., eds. (2008). *14th World Conference on Earthquake Engineering (14WCEE) –Conference Proceedings – Oct. 12-17, 2008 – Beijing, China (DVD)*, CAEE & IAEE, Beijing, P.R. China.

Martelli, A. (2008a). "Recent progress of application of modern anti-seismic systems in Europe – Part 1: Seismic isolation", 14WCEE – Conference Proceedings – Oct. 12-17, 2008 – Beijing, China (DVD), CAEE & IAEE, Beijing, P.R. China.

Martelli, A. (2008b). "Recent progress of application of modern anti-seismic systems in Europe – Part 2: Energy dissipation systems, shape memory alloy devices and shock transmitter units", 14WCEE – Conference Proceedings – Oct. 12-17, 2008 – Beijing, China (DVD), CAEE & IAEE, Beijing, P.R. China.

Martelli, A. (2009a). "Progress of the application of passive anti-seismic systems", Earthquake Resistant Engineering Structures VII, Wit Press, Southampton, U.K., 281-293.

Martelli, A. (2009b). "Lessons learned from recent earthquakes in Italy: from the San Giuliano di Puglia tragedy in 2002 to the collapses in Abruzzo in 2009", Extended Abstract Volume, UNESCO-IPRED-ITU International Workshop on "Make the Citizens a Part of the Solution, Istanbul, Turkey.

Martelli, A. (2009c). "Anti-seismic systems: state of the art of development and application", Modern Systems for Mitigation of Seismic Action – Proceedings of the Symposium Held at Bucharest, Romania, on October 31, 2008, AGIR Publishing House, Bucharest, Romania, 41-70.

Martelli, A. (2009d). "Development and application of innovative anti-seismic systems for the protection of cultural heritage", Proceedings of the PROHITECH 2009 International Conference, CRC Press – Taylor and Francis Group, Leiden, Netherlands, 43-52.

Martelli, A. (2009e). "Application of seismic isolation in Italy and other countries", Proceedings of the International Workshop Celebrating the 15 Years Anniversary of JSSI, Tokyo, Japan, 4 and 13-20.

Martelli, A. (2009f). "Edifici isolati, effetto traino dell'Abruzzo – Le recenti applicazioni dei sistemi antisismici e le raccomandazioni della comunità scientifica internazionale per il loro corretto utilizzo (Isolated buildings, dragging effect of Abruzzo – Recent applications of anti-seismic systems and recommendations of the international scientific community for their correct use)", Rivista degli Ingegneri del Veneto (FOIV), 27, 38-44 (in Italian).

Martelli, A. (2010). "On the need for a reliable seismic input assessment for optimized design & retrofit of seismically isolated civil and industrial structures, equipment and cultural heritage", Pageoph Topical Volume on Advanced Seismic Hazard Assessments, Pure and Applied Geophysics Topical Volumes; see also Proceedings of the Advanced Conference on Seismic Risk Mitigation and Sustainable Development, ICTP, Trieste, Italy.

Martelli, A. and Forni, M. (2008a). "State of the art of development and application of antiseismic systems in Europe and other countries", Proceedings of the MERCEA'08 International Conference, American Institute of Physics, Danvers, Massachusetts, USA, 1020(2), 1272-1293.

Martelli, A. and Forni, M. (2008b). “Prevention and mitigation of seismic risk of strategic, public and residential constructions, cultural heritage and industrial plants and components by means of seismic isolation and energy dissipation in Italy and worldwide”, IDRC Davos 2008 – Short and Extended Abstracts (DVD) and IDRC Davos 2008 – Short Abstracts, Global Risk Forum GRF Davos, Davos Dorf, Switzerland, 299.

Martelli, A. and Forni, M. (2009a). “State of the art on application, R&D and design rules for seismic isolation, energy dissipation and vibration control for civil structures, industrial plants and cultural heritage in Italy and other countries”, Proceedings on DVD of the 11th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures, Guangzhou, China; November 17-21, 2009; Book of Abstracts, 93-94, University of Guangzhou, P.R. China.

Martelli, A. and Forni, M. (2009b). “Recenti applicazioni dei sistemi di controllo passivo delle vibrazioni sismiche – Parti 1, 2 e 3 (Recent applications of passive control systems of seismic vibrations – Parts 1, 2 and 3)”, Proceedings on DVD of the 13th National Congress “L’Ingegneria Sismica in Italia”(“Seismic Engineering in Italy”), Italian National Association for Earthquake Engineering (ANIDIS), Bologna, Italy, 250-252 (in Italian).

Martelli, A. and Forni, M. (in press). “Recenti applicazioni dei sistemi di isolamento sismico in Italia (Recent applications of seismic isolation in Italy)”, Ingegneria Sismica (Seismic Engineering), Milan, Italy (in Italian).

Martelli, A., Rizzo, S., Davidovici, V., Forni, M., Fuller, K.N.G., Hubert, F., Indirli, M., Komodromos, P., Phocas, M., Renda, V., Santini, A. and Sollogoub, P. (2007). “Current status of application of seismic isolation and other passive anti-seismic systems to buildings, cultural heritage and industrial plants in Italy and worldwide”, Proceedings of the 10th World Conference on Seismic Isolation, Energy Dissipation and Active Vibrations Control of Structures, CD Rom, and Abstract Volume, Istanbul, Turkey, 2.

Martelli, A., Sannino, U., Parducci, A. and Braga, F. (2008). Moderni Sistemi e Tecnologie Antisismici. Una Guida per il Progettista (Modern Anti-Seismic Systems and Technologies – A Guide for the Designer), 21mo Secolo, Milan, Italy.

Mazzolani, F., ed. (2009). Proceedings of the First International Conference on Protection of Cultural Heritage (PROHITECH 2009), CRC Press – Taylor and Francis Group, Leiden, Netherlands. Phocas, M., Brebbia, C.A. and Komodromos, P., eds. (2009). Earthquake Resistant Engineering Structures VII, Wit Press, Southampton, UK.

Sannino, U., Sandi, H., Martelli, A. and Vlad, I. (2009). Modern Systems for Mitigation of Seismic Action – Proceedings of the Symposium Held at Bucharest, Romania, on October 31, 2008, AGIR Publishing House, Bucharest, Romania.

Santini, A. and Moraci, N., eds. (2008). Proceedings of the 2008 Seismic Engineering International Conference Commemorating the 1908 MEssina and Reggio Calabria EArthquake (MERCEA'08)., American Institute of Physics, Danvers, Mssachusetts, USA, 1020.

UNESCO-IPRED-ITU (2009). Declaration of participants in the UNESCO-IPRED-ITU Workshop, Istanbul, 7 July 2009, Paris, France.

Zhou, F.L. et al. (2009). Proceedings of the 11th World Conference on Seismic Isolation, Energy Dissipation and Active Vibration Control of Structures, Guangzhou, China, November 17-21, 2009, DVD, and Book of Abstracts, University of Guangzhou, P.R. China.

EXPERIENCES OF THE RESEARCH AND APPLICATION CENTRE FOR STRUCTURES AND EARTHQUAKES (ISTANBUL TECHNICAL UNIVERSITY) ON SEISMIC ASSESSMENT AND RETROFITTING OF BUILDINGS SINCE 1992

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ABSTRACT

Turkey is situated on an active earthquake zone. Strong earthquakes during the last two decades showed that the existing building stocks are significantly vulnerable to seismic hazard. There are a large number of buildings, including schools, hospitals commercial and residential buildings having very low seismic safety in high seismicity regions. In the recent earthquakes numerous reinforced concrete and masonry buildings were damaged. In the aftermath of these earthquakes extensive works were carried out for the inspection, strengthening and supervision of the constructions of the damaged buildings by the research centers of the Turkish universities, including that of Istanbul Technical University in collaborations with the Ministry of Public Works and Settlement. In this paper, the work done by the Research and Application Centre for Structures and Earthquakes of Istanbul Technical University is summarized.

KEYWORDS
Earthquake damages, assessment, strengthening of buildings,

INTRODUCTION

In recent earthquakes, numerous reinforced concrete and masonry buildings were damaged in various degrees of level in Turkey. Following these earthquakes, comprehensive works were carried out for the inspection of the damaged buildings; their strengthening and supervision of the constructions were accomplished by the research centres of the Turkish universities, Istanbul Technical University, Middle East Technical University and Bosporus University. In this presentation, the work done by the Research and Application Centre for Structures and Earthquakes of Istanbul Technical University is summarized.

RECENT EARTHQUAKES

Turkey is situated on an active earthquake zone constituting the regions along the North Anatolian Fault (NAF), East Anatolian Fault (EAF), North East Anatolian Fault (NEAF) and West Anatolian Fault (WAF). The major tectonic movement of the Anatolian plate comes into being as a result of north-ward motion of the Arabian Plate and African Continent. A brief summary of the characteristics of the most recent earthquakes are given Table 1. Unfortunately, the earthquakes listed in Table 1 occurred in the populated areas of Turkey. In fact the last two earthquake is took place in the Marmara region where the most industrial facilities of Turkey are located. These two earthquakes caused a decrease around 20 billion US dollars in the economic power of the country and up to 20 000 life lost, although the official numbers are below them. In these events, a large number of structures were collapsed or damaged heavily, although the Turkish Seismic Code states requirements for design and construction of earthquake resistant buildings having adequate stiffness, strength and ductility. The Turkish Seismic Code has concepts and requirements which can be found in the most modern codes. Furthermore the code is updated periodically to include development in the earthquake resistant design. Its most recent version has been issued in 2007.

The Turkish Seismic Code has been updated in 1975, in 1998 and most recently in 2007. There are major changes between the versions of the Code of 1975 and that of 1998. In 1998, the seismic forces are increased, additional reinforcement details are added and the concept of the capacity design is adopted. In 2007, a new chapter related to the seismic assessment and strengthening of the existing buildings is added. All these modifications and additions in the code can be seen as an attempt to increase the seismic safety level of the new buildings.

Damages in buildings were due to lack of inspection and supervision at the design and construction stages. Consequently, various structural design deficiencies and construction mistakes caused collapse and heavy damages in reinforced concrete buildings. For the main design deficiencies, irregular structural system, poor and non-ductile details, soft and weak stories, short columns, strong beams-weak columns and large and heavy overhangs can be stated. On the other hand poor concrete quality and applications not complying to the design documents are the most common the construction deficiencies. In general the major weaknesses are in the enforcement of seismic and related codes and in shortcoming of an effective supervision system in design and construction stages.

After each of these major earthquakes, a wide effort was generated for the seismic safety evaluation and the strengthening of the damaged buildings. The members of the Research and Application Centre for Structures and Earthquakes of Istanbul Technical University actively participated in the rehabilitation work following the earthquakes of Erzincan (1992), Dinar (1995) and Adana-Ceyhan (1998). Furthermore, the centre participated actively to rehabilitation works after Kocaeli Earthquake (1999) and Düzce Earthquake (1999) as well. The members of the centre inspected damaged buildings and developed the strengthening methods in general terms and they also participated in strengthening of individual buildings in design and application stages.

Table 1. Recent earthquakes in Turkey

Earthquakes	**Date**	**Intensity Io**	**Magnitude Ms**	***Accelerations***			**Death**	***Buildings damaged***			**Total lost 10^6×US$**
				EW	***NS***	***V***		***Heavy***	***Medium***	***Minor***	
Erzincan	*13.03. 1992*	*VIII*	*6.8*	*0.49g*	*0.39g*	*0.25g*	*653*	*6 702*	*9 108*	*15 384*	*750*
Dinar	*01.10. 1995*	*VIII*	*5.9*	*0.26g*	*0.30g*	*0.11g*	*94*	*4 909*	*3 276*	*6 709*	*100*
Adana-Ceyhan	*27.06. 1998*	*VIII*	*6.2*	*0.22g*	*0.27g*	*0.09g*	*250*	*10 675*	*20 788*	*50 663*	*500*
Kocaeli	*17.08. 1999*	*IX*	*7.8*	*0.22g*	*0.16g*	*0.12g*	*17 480*	*15 389*	*13 548*	*13 381*	*13 000*
Düzce	*12.11. 1999*	*VIII*	*7.5*	*0.51g*	*0.41g*	*0.34g*	*845*	*6 702*	*9 108*	*15 384*	*750*

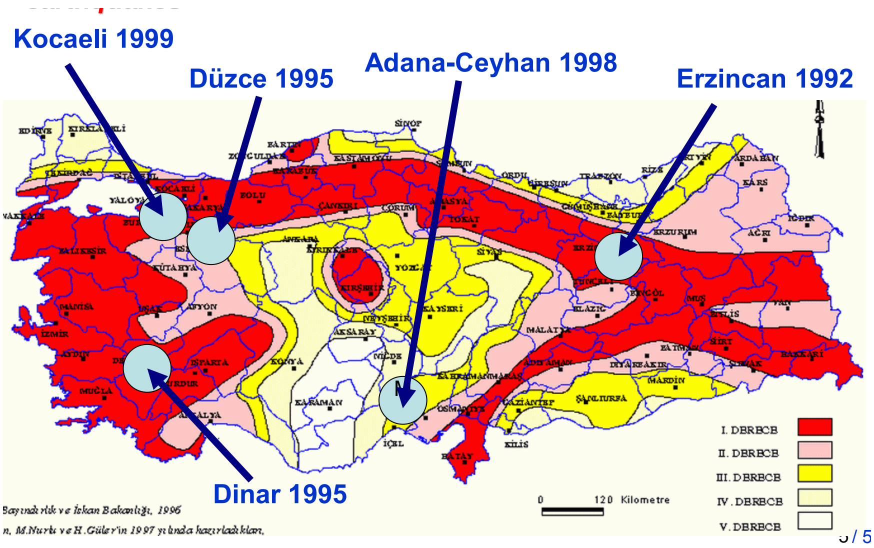

Figure 1. Seismic risk map of Turkey and locations of the recent destructive earthquakes

DAMAGES AND SEISMIC ASSESSMENTS OF BUILDINGS

In Turkey, the typical construction type for commercial and residential buildings is accomplished by adopting reinforced concrete frame structures. There is also relatively small number of masonry buildings in small towns. In Erzincan there was a large number of reinforced concrete buildings and a small number of buildings which can be classified as masonry. However, in Dinar and Adana-Ceyhan, there was a significant number of stone or brick old masonry buildings. Kocaeli and Düzce Earthquakes affected the whole Marmara region where all types of buildings can be observed.

Generally, buildings are classified as reinforced concrete and masonry. On the other hand, there were buildings which can not be grouped into either of these two categories. They are in between two categories. These are low-rise buildings which have column-beam frame systems. However, they are constructed almost without receiving any civil engineering attention, although officially they are considered as reinforced concrete buildings. In these recent earthquakes reinforced concrete and masonry buildings were damaged to various degrees. Some of buildings collapsed and some of them were damaged so heavily that there was no chance to strengthen them. At that stage, the authorized officers of the Ministry of Public Works and Settlements inspected these buildings and they classified them into three categories, such as; buildings having minor, medium and heavy damages. Officially, minor damaged buildings are assumed that they maintain the acceptable level of the seismic safety, medium damaged buildings are assumed that their seismic safety is significantly lowered due to the earthquake damage and they can not be used, however they can be strengthened economically.

Heavy damaged buildings are the buildings which can not be strengthened or it is not economical to strengthen them. Since the inspections of the buildings have to be done in a short time, the inspectors of the ministry used some simple scoring techniques in yes/no format to decide on the fate of the buildings. On the other hand, since the number of the damaged buildings was very high, it was difficult to find technical personal capable of evaluating the buildings in detail. In addition, there were complains by the building owners about the category of their buildings. At that stage, the research centres of the Turkish universities including the Research and Application Centre for Structures and Earthquakes of Istanbul Technical University started to work as a consultant of the ministry. Since most of the buildings heavily damaged were torn down already at the early stages of the seismic event, the remaining buildings were investigated once more carefully in order to decide, whether they need some strengthening or not. Development of one of these two conclusions was the most difficult part of the assessment procedure. The decisions were made by using scoring techniques, which however does not always lead to a definite conclusion which can be accepted easily. This means that often discussions of the faculty members took place on the decision of the fate of the numerous reinforced concrete and masonry buildings.

Reinforced Concrete Buildings

The decision, whether a building requires strengthening, were done by using scoring techniques. Main parameters which yield negative scores were:

a. Low concrete quality; cracks and damage in columns, beams, and beam-column joints,
b. Irregularity and discontinuity in structural system in elevation and in layout, number of storeys,
c. Low ratio of total cross section area of columns to the area of the building in the layout in the two orthogonal axes.

There are a large number of damaged low-rise concrete buildings with inadequate frame system having a very low moment resisting capacity. They are assumed to be reinforced concrete buildings; however they had resisted to seismic forces due to the infill walls within the beam-column frame plane. These infill walls can not be regarded as masonry, since they display brittle behaviour and have very low tensile strength and poor mortars having low shear strength. However, the contribution of these walls to the seismic safety of the building is significant, because the frame system is considerably weak. Consequently, in many cases, the infill walls within the beam-column frame have increased the lateral strength and stiffness of the building. Infill walls have also improved the performance of the buildings and decreased the damage.

Masonry Buildings

A similar scoring technique was employed for masonry buildings as well, by using different types of parameters. Main parameters which yield negative scores were:

a. Cracks and damages in masonry walls,
b. Low quality of material in masonry units and mortar; low quality workmanship in walls and deterioration in masonry walls,
c. Discontinuity and irregularity in masonry walls in elevation and in layout,
d. Non-rigid slabs which connect the masonry walls,
e. Low ratio of total cross section area of masonry walls to the area of the building in the layout in the two orthogonal axes; number of story.

Furthermore, it is worth to state that there are a significant number of low and mid-rise and tall buildings which displayed an acceptable seismic performance during the recent earthquakes, since they were designed and constructed at least by following the main requirements of the Turkish Seismic Code valid at the construction time of the buildings.

STRENGTHENING OF BUILDINGS

Reinforced Concrete Buildings

To determine the seismic deficiency of damaged or existing buildings, general data of the building is collected including the geometry of the structural system and the proportions of the structural elements. Observed cracks and damages are also noted. By taking core samples, concrete quality and by checking some selected columns, reinforcement details in the columns are determined. This information is also of prime importance for the decision of the extent of the strengthening in the building. After developing a strengthening intervention, sufficiency of the strengthened system is checked by applying the force ans displacement requirements of the seismic code. The principles adopted in strengthening of the reinforced concrete buildings can be given as follows (Celep, Özer 1998):

a. A large portion of the base shearing force should be resisted by the added shear walls, since the existing structural frame system has several uncertainties, in terms of the concrete quality as well as the quantity and the amount of reinforcement (In Erzincan 80% ratio is adopted, however later, the ratio is lowered in order to take into account the contribution of the existing structural system more realistically and to avoid large foundations).
b. At least two shear walls in each direction are added in the existing beam-column plane (In Erzincan, the shear walls were added without removing the infill walls, whereas later shear walls were added to the beam-column plane by removing the infill walls).
c. The damaged columns are jacketed to improve their ductility and capacity. Often number of jacketing of the columns is kept to be minimum by selecting the shear walls close to the damaged columns.
d. New local foundations are constructed under the shear walls to transfer the axial force and bending moment safely to the soil (In Erzincan the additional foundation was laid on the existing foundation, whereas in the strengthening intervention after the other earthquake strengthening, the local foundations were constructed by combining the existing footings, so that possible decrease in the height of the basement is avoided).

Figure 2 shows details of a strengthening shear wall added to a frame. Shear walls are used for their large lateral load capacity. On the other hand they provide large lateral stiffness to the existing structural system. However, the stiff shear walls increase the seismic demand as well. It is important that the shear walls are integrated to existing system so that the force path is ensured. Anchorage bars between the added shear wall and the existing beams and columns can be seen in Figure 2. Figure 3 shows the use of the shear walls in a residential building. As it is seen, the two shear walls at the front face of the building have openings for the windows. These openings decrease the lateral stiffness and capacity of the wall, whereas its ductility is increased by assuming that proper detailing is provided. The boundary elements of the shear walls are developed by jacketing of the neighboring columns. The longitudinal reinforcement of the walls is placed in the boundary elements, so that they transfer the force between the stories. However for the two shear walls in *x* direction the additional boundary elements can not be provided and the longitudinal reinforcements have to go through the beams for the continuity. Details of the strengthening shear wall are shown in Figure 4, where the continuous boundary reinforcements at the two ends and the lateral and vertical web reinforcement can be seen. Here it is important that the reinforcements at the two ends of the wall are properly anchored to the foundation. Figure 5 shows the foundation configuration designed for the added strengthening walls. The new and the existing foundations are connected to each by the anchorage steel bars.

Table 2. Selected strengthening works after Kocaeli (1999) and Düzce Earthquake (1999)

Location	***Buildings / Housing units***	***Total construction area (m2)***
Marmara and Aegean Regions (2000-2004)	*İş Bank branch office buildings and apartments provided for employees (161 buildings)*	*211 000*
Yelkenkaya/Bayramoğlu, Istanbul) (2000)	*İş Bank resort buildings*	*13 000*
Esenkent Boğazköy Istanbul) (2000-2004)	*Buildings for social housing*	*295 000*
Yeşilköy, Istanbul (2000-2002)	*Buildings of General Directorate of State Airports Authority of Turkey*	*200 000*
Marmara Region (2000-2001)	*Buildings of General Directorate of Tobacco and Tobacco Products*	*205 000*
Marmara Region (2001-2003)	*Buildings of General Directorate of Distribution of Electricity*	*115 000*
Marmara Region (2000-2001)	*Buildings of AKSA Acrylic Chemical Industries*	*95 000*
Marmara Region (2001)	*Buildings of General Directorate of Post*	*17 000*
Istanbul (2000-2001)	*Buildings of General Directorate of Production of Electricity (Ambarlı Plants for electricity production from fuel oil natural gas)*	*129 000*
Izmit (2001)	*Sabancı Cultural Center*	*4 500*
Istanbul (2001-2004)	*Building of Istanbul Stock Exchange*	*30 000*
Istanbul (2002-2003)	*School buildings of Ministry of National Education (78 primary schools and 16 gymnasiums)*	

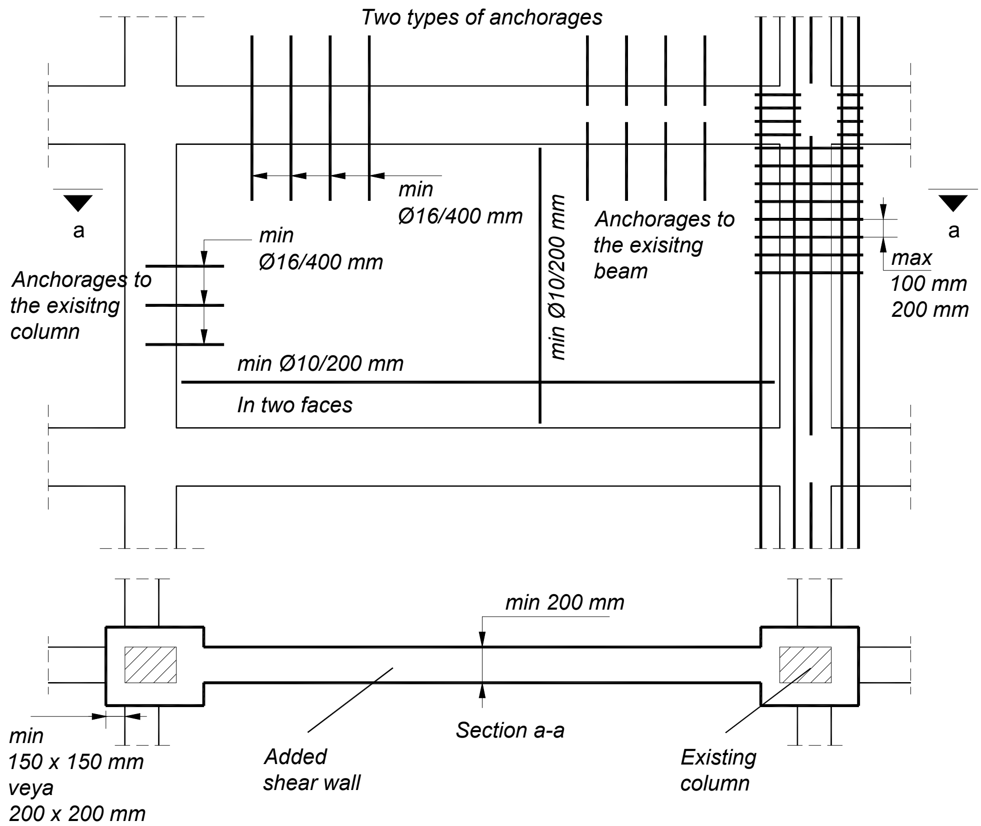

Figure 2. Details of a strengthening shear wall between columns

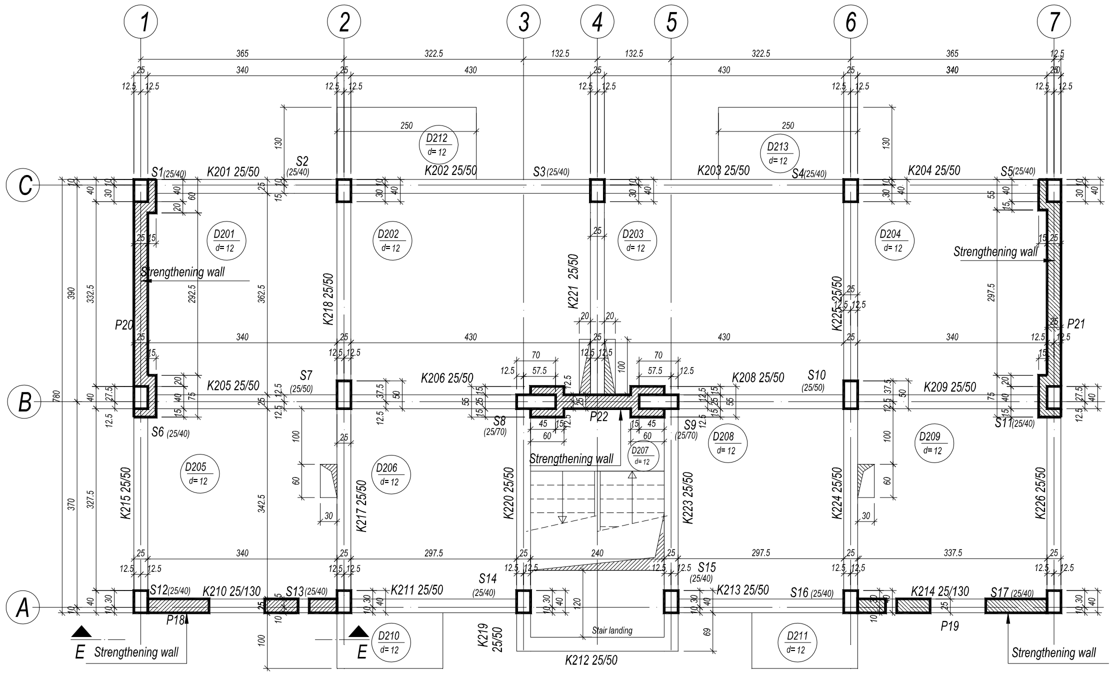

Figure 3. Configuration of strengthening walls in a residential building

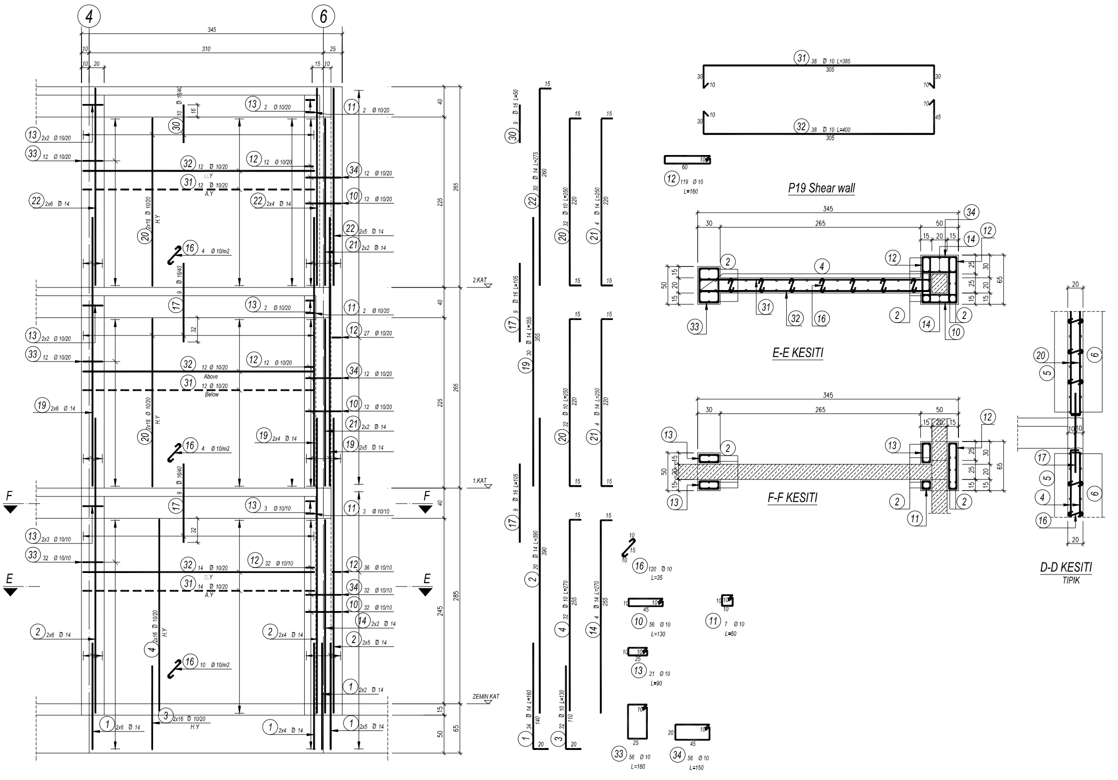

Figure 4. Details of a strengthening wall in elevation and sections

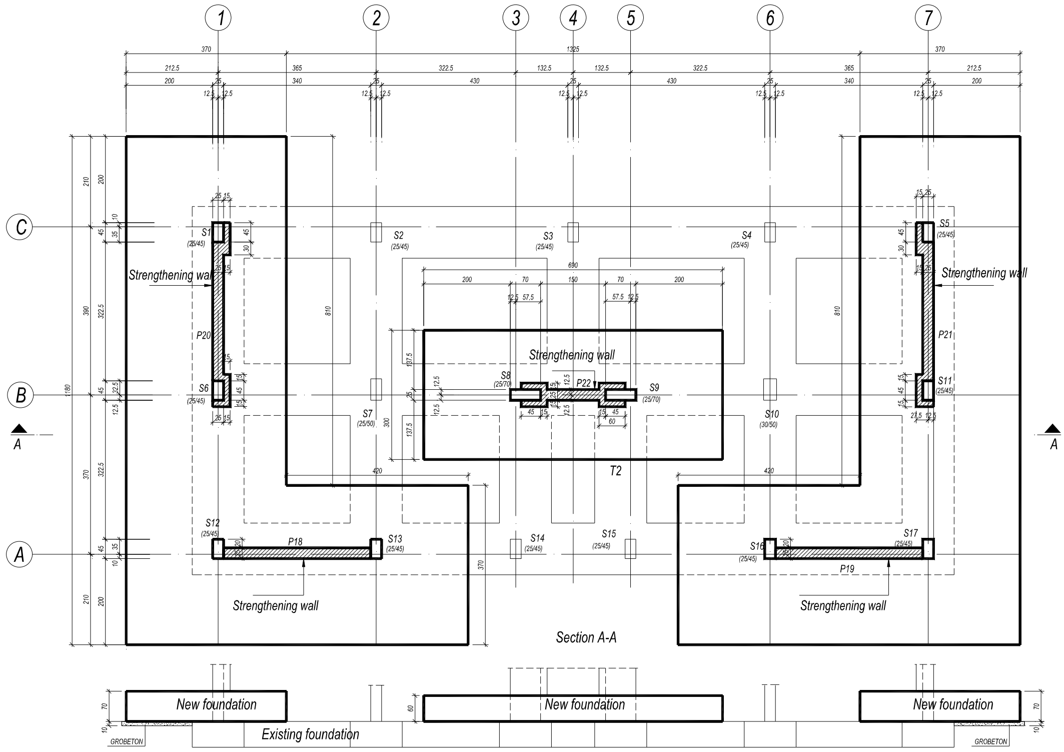

Figure 5. Added foundations for the strengthening walls on the existing foundation

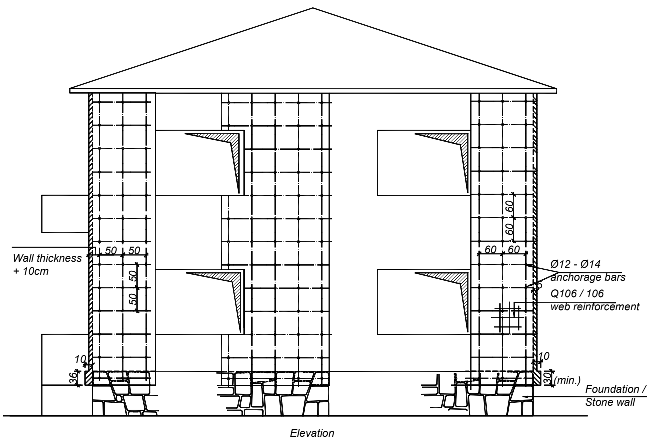

Figure 6. Strengthening of a masonry building by adding reinforcement and concrete layer

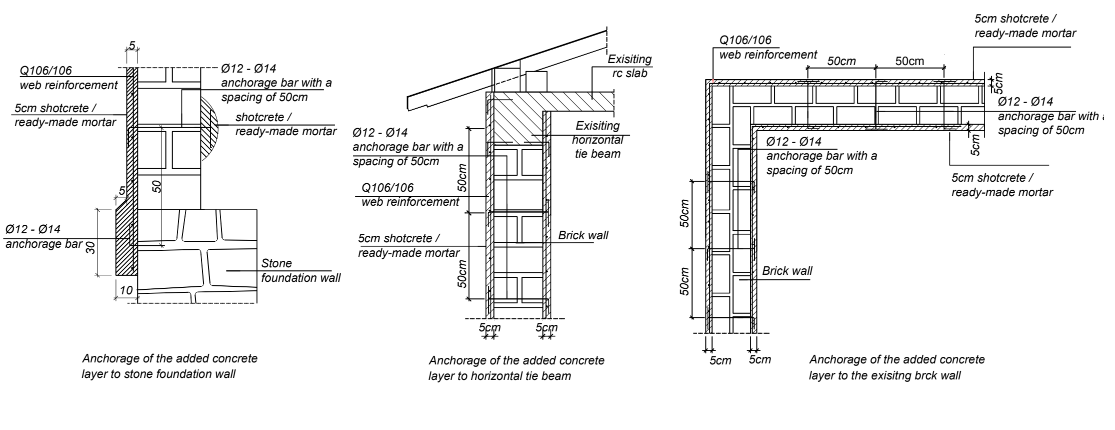

Figure 7. Details of a strengthening of a masonry building by adding reinforcement and concrete layer

Masonry Buildings

Extent of the strengthening is determined by evaluating the general data of the building including geometry and layout of the masonry walls, observed cracks and damage and quality of masonry units and mortar. After developing type of strengthening intervention, its sufficiency is checked by applying the requirements of the seismic code. The principles adopted in strengthening of the masonry buildings can be summarized as follows (Celep 1998):

a. Providing additional thickness to the existing walls by applying shotcrete after steel web reinforcement is anchored to the inside and/or outside face of the existing walls. In the indoor applications ready-made repair mortar can be was applied instead of shotcrete,
b. Increasing the shear capacity of the existing walls by filling in some door and window openings with masonry units,
c. Improving the shear capacity of the damaged walls by removing the damaged part of the walls and repairing them by using new units and repair mortar.

Low Rise Buildings

In Turkey there are a large number of low rise buildings which do not conform to the requirements of the code given for the concrete buildings. They do comply with the requirements of the masonry buildings as well. On the other hand, they often are considered as reinforced concrete buildings, since concrete slabs, beam and columns exist. They are constructed mostly without consulting to any civil engineer and receiving any professional service. They have reinforced concrete slabs supported by beams (or tie beams) on the walls and columns (or vertical ties) in corners of buildings. Generally, neither beams and nor columns do not have any adequate section and reinforcement conforming to the requirements of the code. Mostly they have four reinforcements with ties having a large spacing.

The beam-column joints do not have any proper detailing. Many buildings were prevented from collapse by the presence of “non-structural” infill walls, which acted as shear walls despite not being designed for this purpose. Because of these, it is recommended seismic safety evaluation of these buildings should be carried out by using the principle applied to the masonry buildings by assuming beams and columns to be horizontal and vertical ties. Similar logic can be applied in the strengthening process of these buildings. Consequently, it is not advisable to add shear walls to a low-rise building as it is done in medium or high rise reinforced concrete buildings. It is not a good engineering application to concentrate the seismic load in some specific location, since the transfer of the seismic load from the elements of the building to the shear walls may produce problems in the weak frames. It is not feasible and economic to jacketing columns as well, because almost all columns may require jacketing. These buildings do not have proper foundations as concrete frame buildings have. Therefore strengthening of the foundations will be required as well, which is very difficult to do.

However, these low-rise concrete buildings with inadequate frame system having a very low moment resisting capacity can be strengthened relatively easily as it is done in masonry buildings. Since the low-rise buildings are very rigid, their seismic capacity can be evaluated by using strength based analysis, instead of displacement based. Although they resist to seismic forces due to the infill walls within the beam-column frame plane, these infill walls can not be regarded masonry, since they display brittle behavior, have very low tensile strength and poor mortars. On the other hand the contribution of these walls is significant, because the frame system is considerably weak. Consequently, in many cases, the infill walls have increase the lateral strength and stiffness of the buildings, improve also the seismic performance and decreased the expected damage. In most cases strength evaluations of low-rise buildings before and after strengthening by using sophisticated methods are of very controversial nature due to assumptions used in the analysis.

Figure 6 shows strengthening of a masonry (low rise) building by adding concrete layer and web reinforcement. The details of the connection of the concrete layer to the tie beam, to the foundation and to the brick wall is illustrated in Figure 7. These details are developed to ensure integration of the existing and added element and to provide force paths. Because seismic forces are transferred to the foundation by a number of the walls, often no foundation strengthening is required in the masonry strengthening.

CONCLUSIONS

The members of the Research and Application Centre for Structures and Earthquakes of Istanbul Technical University actively participated in the rehabilitation work following the earthquakes of Erzincan (1992), Dinar (1995) and Adana-Ceyhan (1998). After Erzincan Earthquake (1992) strengthening projects have been prepared and their constructions inspected for approximately 400 medium damaged buildings for approximately 3000 housing units. The similar intervention activity has been carried out for approximately 1000 housing units having a total construction area of 100 000m^2 in Dinar Earthquake (1995). After Adana-Ceyhan Earthquake (1998) strengthening projects have been prepared and their constructions inspected for a total construction area of 250 000m^2. The members of the centre participated actively to rehabilitation works after Kocaeli Earthquake (1999) and Düzce Earthquake (1999) as well. However it was a very wide activity spread in a very large area. Some of the selected strengthening work carried out is given in Table 2.

The members of the Faculty of Civil Engineering participated in the preparation of the Master Plan for the Seismic Preparedness of the Istanbul Metropolitan Area and in the development of the Turkish Seismic Code as well.

By recalling the evaluation and strengthening applications for concrete and masonry buildings, the following points deserve to be mentioned:

- **a.** Strengthening procedure is not an easy and straightforward task and not a mathematical problem having only unique solution.
- b. Complex and sophisticated seismic safety evaluation and strengthening techniques should not be considered for buildings having a very low level structural knowledge, due to the inherent uncertainties in the structural system and the poor workmanship in general.
- c. Strengthening system applicable very easily by using local material and workmanship should be selected. It should be cost-effective as well.
- d. Seismic forces come into being in the existing system. In the development of strengthening system adequate attention should be paid that these forces have to be transferred safely to the added structural system. In order to maintain the seismic force transfer, integration of the existing and the added strengthening systems have to be provided.
- e. In order to provide economical results, seismic safety level should be selected in between the life-safety or prevention of the total collapse for the existing residential buildings having low construction quality, because of the lateral load capacity of the buildings can not be evaluated accurately enough.
- f. The principles used for reinforced concrete buildings should be applied to non-engineered structures with care. It is not logical to strengthen non-engineered buildings by applying column jacketings, because the beams are very weak and the buildings do not have proper frame systems. Furthermore these buildings can not be strengthened by adding shear wall which may require a large foundation.
- g. Generally low-rise concrete buildings which do not conform to the requirements given for the reinforced concrete buildings should be strengthened by adopting the rules used for masonry buildings.

REFERENCES

Celep, Z., Özer, E. (1998) Post earthquake rehabilitation of moderately damaged reinforced concrete structures. Repair & Strengthening of Existing Buildings, Second Japan-Turkey Workshop on Earthquake Engineering, Istanbul Technical University, Faculty of Civil Engineering, 61-72.

Celep, Z. (1998) Post earthquake rehabilitation of moderately damaged masonry structures. Repair & Strengthening of Existing Buildings, Second Japan-Turkey Workshop on Earthquake Engineering, Istanbul Technical University, Faculty of Civil Engineering, 73-90.

Celep, Z., Kumbasar, N. (2004) Introduction to Earthquake Engineering and Earthquake Resistant Design, Beta Publications, Istanbul (in Turkish).

Turkish Seismic Code (2007) Ministry of Public Works and Settlements, Ankara, 2007

Turkish Design Code for Reinforced Concrete Structures (2000), TS500 Requirements for design and construction of Reinforced Concrete Structures, Turkish

SEISMIC RISK PERCEPTION IN ISTANBUL: COMPARISON OF AVCILAR AND BAKIRKOY DISTRICTS

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ABSTRACT

This study is prepared as an outcome of the "Earthquake Disaster Risk Perception in Developing Countries and Earthquake Safe Housing Project" which is conducted in international level by the collaboration of United Nations Center of Regional Development (UNCRD), Building Research Institute of Japan (BRI), National Graduate Institute for Policy Studies of Japan (GRIPS) in between the years 2006-2009 where Istanbul Technical University (ITU) represented Turkey. In the first phase of the project (2006) - which makes up the basis of the study – survey methodology was used in order to understand the earthquake risk perception of the residents in two districts of Istanbul (Avcilar and Bakirkoy). The reason behind choosing Istanbul as the study area was that she is the most vulnerable metropolitan city of Turkey in terms of proximity to main fault line (North Anatolian Fault Line), population, economy and trade, and existing building stock. Furthermore, choosing Avcilar and Bakirkoy districts as the study areas was based on the facts that both districts have almost equivalent seismic risk and seismic vulnerability, whereas they have significantly different social structures. Avcilar (Center) is a newer residential area with respect to Bakirkoy (Yesilkoy Quarter), and people living in Avcilar generally have much lower income with respect to habitants of Bakirkoy. It should be emphasized that both districts can be regarded as the most vulnerable districts of Istanbul among others. Consequently, main aim of the study is to compare seismic risk perception survey results of these districts that have similar seismic vulnerabilities but different socio-economic structures.

KEYWORDS
Earthquake, seismic risk, perception, Istanbul.

INTRODUCTION

Istanbul is a city that experienced many catastrophic earthquakes in the past. In spite of this concrete fact, the city is not in a well prepared state both in terms of physical built environment and attitudes of the people. This may stem from two basic factors; short memory of people, particularly about bad events and a large number of newcomers to Istanbul city, who do not have sufficient information about past catastrophic experiences.

In this survey study, 865 individuals were asked questions for understanding their perception of disaster risk in terms of awareness of the risk, preparedness and mitigation. The individuals are from two different districts of Istanbul, namely Avcilar and Bakirkoy. These two districts are very close to each other on the Southwest part of Istanbul, with Marmara Sea in the South. The number of surveys in Avcilar and Bakirkoy are 426 and 439, respectively. Both districts have almost equivalent seismic risk and seismic vulnerability, whereas they have significantly different social structure. Avcilar is a newer residential area with respect to Bakirkoy, and people living in Avcilar generally have much lower income with respect to Bakirkoy. It should be emphasized that both districts can be regarded as the most vulnerable districts of Istanbul among others. This data was compiled by using the census carried out in year 2000.

BRIEF INFORMATION ABOUT TURKEY

Location of Turkey

More than being located on one of the cradle of the crescents (Anatolia) and its thousands of years history (old capitals of Byzantine and Ottoman Empires), Turkey is located between 36°-42° Eastern meridians and 26°-45° Northern parallels with a noticeable geography on the world map. Especially, it can be mentioned as a bridge between Europe and Asia which brings an economic importance of the global capital. Figure 1 shows the location of Turkey on the world map and location of the capital city Ankara and largest metropolitan city Istanbul which also makes up the basis of our study.

Figure 1. Location of Turkey and its important cities

Our study –as an outcome of "Earthquake Disaster Risk Perception in Developing Countries and Earthquake Safe Housing Project"- gives the results of seismic risk perception of the residents of two districts (Bakirkoy and Avcilar) of the largest metropolitan city of Turkey: Istanbul. Firstly, socio-economic structure of Turkey should be analyzed with the comparison of other countries and/or regions that have similar high seismic vulnerability. Figure 2 shows the mentioned situation by comparing Turkey against Japan, European Union (EU), and United States of America (USA) in terms of area of the country, population growth rate, GDP per capita, and GDP growth rates. The results show that Turkey is a developing country with its high population growth and GDP growth rates. While Japan and EU are stable of population growth, Turkey and USA grow rapidly with the rates 1.09 and 0.92 respectively.

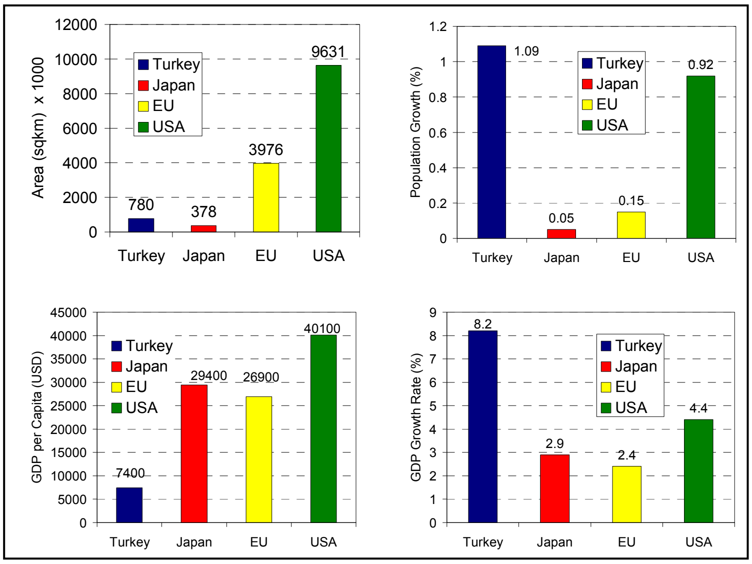

Figure 2. Socio-economic comparison of Turkey, Japan, European Union, and United States of America

Istanbul city which is located on the north-west of Turkey is also located in Marmara Region that is the most developed region by being the industry centre of the country. By having approximately 13 million population (which corresponds the 1/5 of the whole country), Istanbul is the trade and economy centre of Turkey.

Seismicity of Turkey and Istanbul

Turkey is located on a highly active Eurasian Geological Plate which has caused numerous big scale earthquakes throughout the history. The earliest earthquake records date back to 411 B.C. There have been nearly 100 earthquakes with magnitudes 7.0 or greater in Turkey. There exist three main fault-line systems in Turkey which are: North Anatolian Fault (NAF) – which caused 1999 Izmit and Duzce Earthquakes resulting enormous number of deaths, injuries, and economic losses; East Anatolian Fault (EAF), and Western Turkey Graben Complex (I). Fault line system can be observed according to the Earthquake Hazard Map of Turkey as deemed in Figure 3. This shows the reality that approximately 96% of the country is under the threat of earthquakes and approximately 98% of the population lives with this risk.

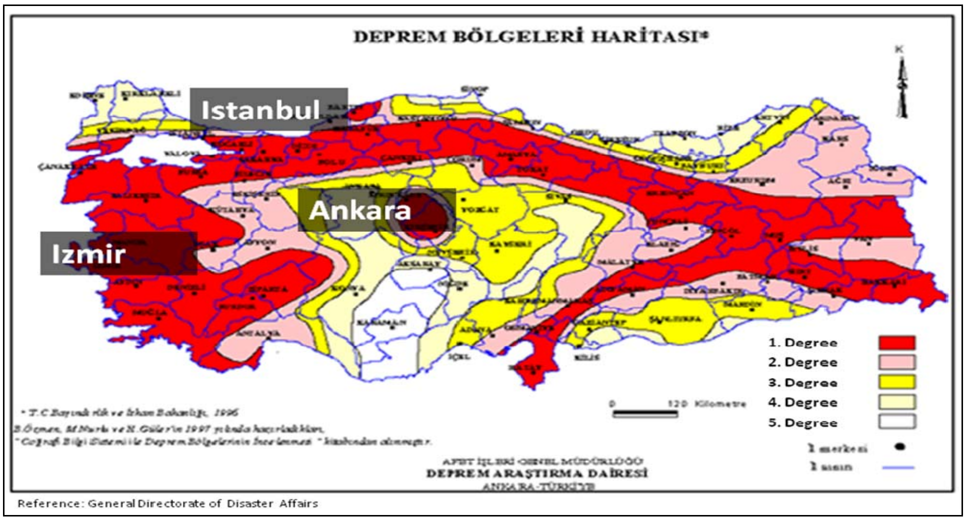

Figure 3. Earthquake hazard map of Turkey

The most catastrophic disaster of the last century for Turkey was 1999 Izmit Gulf Earthquake which was followed by Duzce Earthquake just only few months later. Izmit Gulf Earthquake was occurred on 17 August 1999 with magnitude 7.4, caused 17.840 casualties and 43.953 injuries where also 16.649 collapsed and heavy damaged buildings. Similarly, Duzce Earthquake was occurred on 12 November 1999 with magnitude 7.2, caused 845 casualties and 4.948 injuries where also 15.389 collapsed and heavy damaged buildings. These two earthquakes can be mentioned as the milestones of "earthquake perception" of Turkey by affecting a whole geographical region (Marmara). Istanbul was also suffered from these earthquakes. Especially Izmit Gulf Earthquake caused damage of buildings in Avcilar district of Istanbul which is selected as the study area of this paper. The region faced with major earthquakes during the history. The most catastrophic earthquakes of Marmara Region is illustrated in Figure 4.

Figure 4. Historical earthquakes in Marmara region

Istanbul has experienced earthquakes equal or greater than intensity nine at least 14 times in historical years. This means that Istanbul has suffered damage due to earthquakes every 100 years, on average.

Survey Methodology

In this study, two districts (Avcilar and Bakirkoy) of Istanbul were selected in order to understand the risk perception of the residents. The basic rationale of selecting Avcilar (Center) and Bakirkoy (Yesilkoy Quarter) districts (with similar seismic risk but different social structure) was to highlight the relationships between seismic risk perception and social structure, as well as effects of personal assets such as financial income and academic qualification levels. Firstly, interviews that were prepared in English by GRIPS were translated to Turkish slightly modified by considering Turkish culture and daily life practices concerning ethical, social, religious, administrative, economic and legal issues. All interviewees were randomly selected male or female adults. All interviews were carried out by visiting the interviewees in their houses through face to face communication. The questionnaires were filled by the surveyors according to the answers of respondents. The questionnaire was developed to learn the respondents' past experience of disasters and perception of seismic risk in future, if they think their house is safe against earthquakes, how they want to avoid the risk, how they know about retrofitting, and so on. In addition, demographic characteristics, which are thought to potentially play a role on risk perception of people are included in the questionnaire such as their sex, age, number of family members living together, household income, occupation, as well as house related information such as address, floor areas, structural types, cost, and ownership. After all on site survey study was finished, data were proceeded into computers in digital format and flowingly, evaluation of data process was carried out by using Microsoft Office - Excel and Statistical Package for the Social Sciences (SPSS) soft wares. Survey results were evaluated under the subjects of "basic data about communities and housing characteristics" and "data about disaster risk perception and mitigation". Some major conclusions derived at the end of the survey study on seismic risk and mitigation perception of people in Avcilar and Bakirkoy districts of Istanbul.

EVALUATION OF THE STUDY AREA

Located on the south-west of Istanbul, Avcilar and Bakirkoy both have high seismic risk according to the Earthquake Hazard Map of Turkey and further studies such as Disaster Prevention/Mitigation Plan for Istanbul. In the year 2002, Istanbul Metropolitan Municipality, Japan International Cooperation Agency (JICA) and universities prepared a disaster mitigation plan for Istanbul. As deemed in Figure 5, both districts have high heavily damaged or collapsed building ratios at Izmit 1999 Earthquake according to the Disaster Prevention/Mitigation Plan for Istanbul (DPMPI).

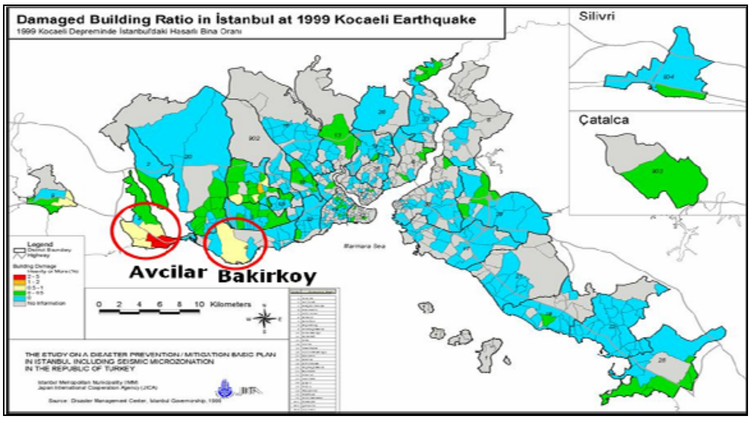

Figure 5. Damaged building ratio in Istanbul at 1999 Izmit Earthquake

Three scenarios were prepared according to DPMPI. In Scenario A -which is acknowledged as the most probable earthquake by the authorities- Avcilar and Bakirkoy districts are under high seismic threat as deemed in Figure 6.

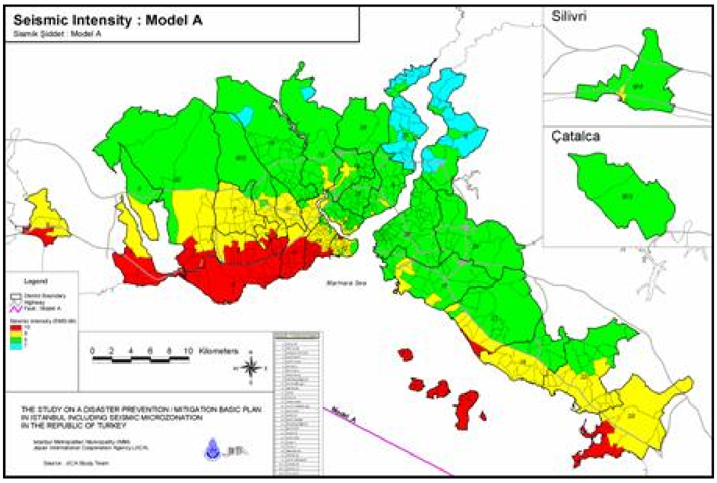

Figure 6. Estimated seismic intensity according to the most probable earthquake (DPMPI-2002)

Istanbul city has 33 districts in total. Although Avcilar and Bakirkoy have small areas when evaluated in citywide, their population density in person/building is higher and population density in person/ha is lower than the averages in Istanbul as shown in Table 1.

Table 1. Population by district

District	Area (ha)	Population	Buildings	Population density (person/ha)	Population density (person/building)
Avcilar	3861	231799	14030	60	17
Bakirkoy	2951	206459	10067	70	21
Istanbul	98981	8831766	724609	89	12

Building density in terms of building/ha in Bakirkoy and Avcilar is about half of Istanbul average (Table 2).

Table 2. Building distribution by district

District	Area (ha)	Population	Buildings	Building density (building/ha)
Avcilar	3861	231799	14030	4
Bakirkoy	2951	206459	10067	3
Istanbul	98981	8831766	724609	7

Table 3 reflects the theoretically positive situation that the building structure type most common in Istanbul is reinforced concrete frame buildings (74.4 %). Despite higher RC frame building type ratios, their proximity to the fault line and their ground features make Avcilar and Bakirkoy vulnerable against earthquakes. Remarkably, RC frame building ratios in Avcilar district (93.9%) and Bakirkoy district (89.2%) are much more than the average of Istanbul (74.4%).

Table 3. Building structure type by district (%)

District	Buildings	RC frame	Masonry	Others
Avcilar	14030	93.9	5.4	0.7
Bakirkoy	10067	89.2	7.4	3.4
Istanbul	724609	74.4	21.7	3.9

Appearance of a typical reinforced concrete frame building is shown in Figure 7 in order to evaluate the structure type of the survey study areas.

Figure 7. Appearance of a typical reinforced concrete frame building in the survey area

RESULTS OF EARTHQUAKE RISK PERCEPTION SURVEY

This section of the paper consists of the results of the earthquake risk perception field survey study of Avcilar and Bakirkoy districts. Firstly, family sizes of the surveys were asked. In both of the districts, family size is 4 in common (33% in Bakirkoy and 29% in Avcilar) where followed by 3 (28% in Avcilar and 25% in Bakirkoy). In the survey area, 58% of Avcilar and 57% of Bakirkoy family residence is observed with 3-4 family size as deemed in Figure 8.

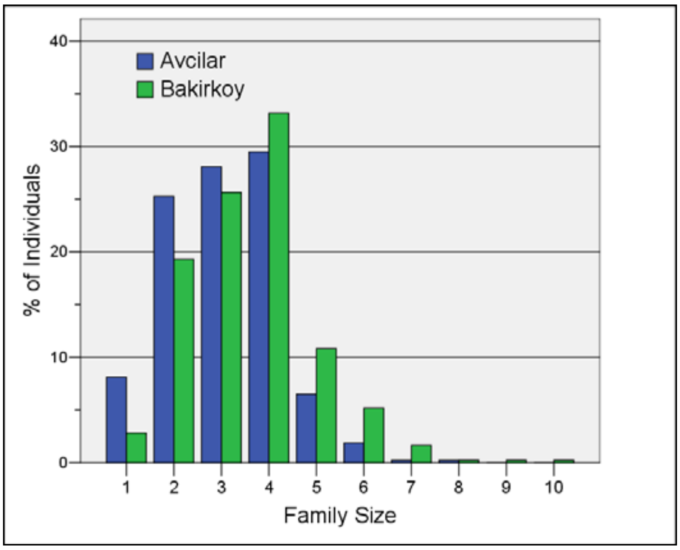

Figure 8. Family sizes of Avcilar and Bakirkoy study area

When the residents of our survey study were asked about their expectation of a big earthquake, 38% of the people that live in Bakirkoy have no idea while 28% of Avcilar and 23% of Bakirkoy await the earthquake within 10 years (Figure 9). At a total of 69% of Avcilar and 54% of Bakirkoy residents expect a big earthquake within 50 years which shows that more than half of the community are aware of the earthquake reality which will cause Istanbul to be faced while only a minority neglect (8% in Avcilar and 7% in Bakirkoy).

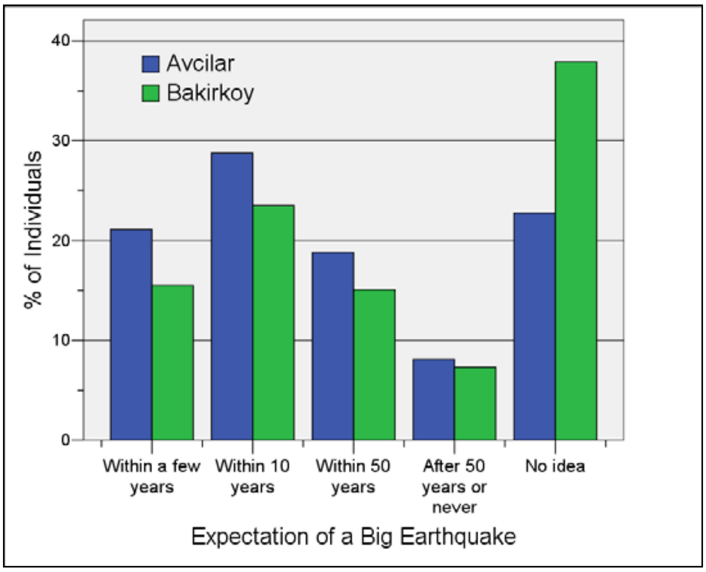

Figure 9. Expectation of a big earthquake of the residents in Avcilar and Bakirkoy

In our survey study area, building floor areas most vary between 80 m^2 and 160 m^2 as seen in Figure 10. In Avcilar 57% of the buildings are between 80-120 m^2. Noticeably, as having family type characteristics (with 3 and 4 people family size) buildings have the areas that supply the needs of the families.

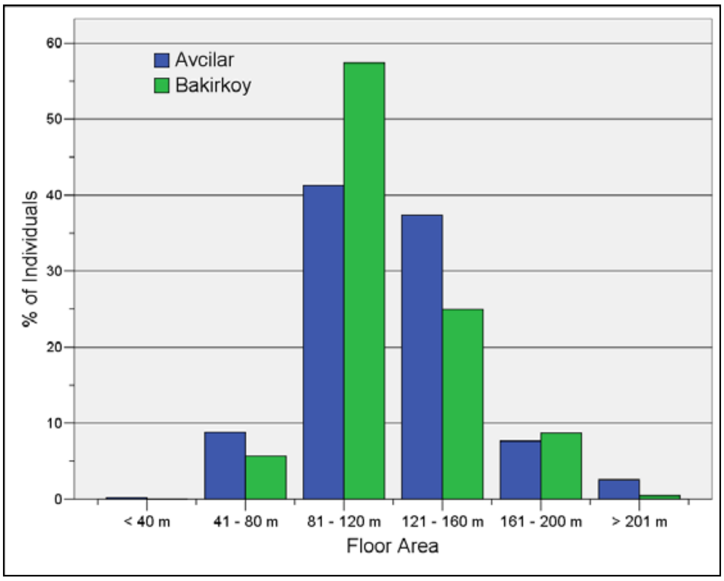

Figure 10. Floor areas in Avcilar and Bakirkoy

Two districts in the survey study are split up from each other about their number of floors. Buildings in Avcilar are mostly 5 stories (27%) and 6 stories (15%) which provides to be identified as middle-height buildings. Contrarily, buildings in Bakirkoy have 6 (17%), 7 (13%), 8 (10%) stories at a total of 40% (Figure 11).

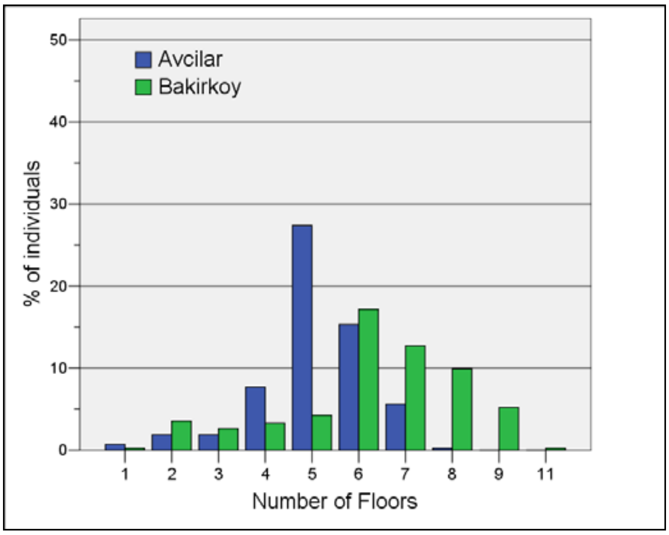

Figure 11. Number of floors of the buildings in Avcilar and Bakirkoy

Majority of the residents of our study have their own or houses of their families (78% in Avcilar and 70% in Bakirkoy respectively). In spite of that, minority of them live in rent houses (21% in Avcilar and 25% in Bakirkoy respectively) as deemed in Figure 12.

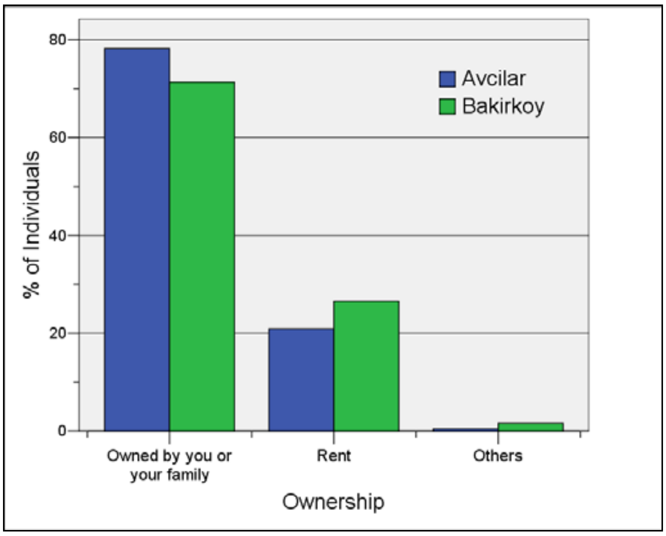

***Figure 12*.** Ownership of the houses in Avcilar and Bakirkoy

When residents in our survey study are asked about whether they have any knowledge about available techniques for strengthening of houses against earthquakes, the great majority are unenlightened (51% in Avcilar and 58% in Bakirkoy respectively) as Figure 13 reflects. In both districts, approximately 20-25% of the residents report that they have and/or partial knowledge about retrofitting techniques for the houses against earthquakes.

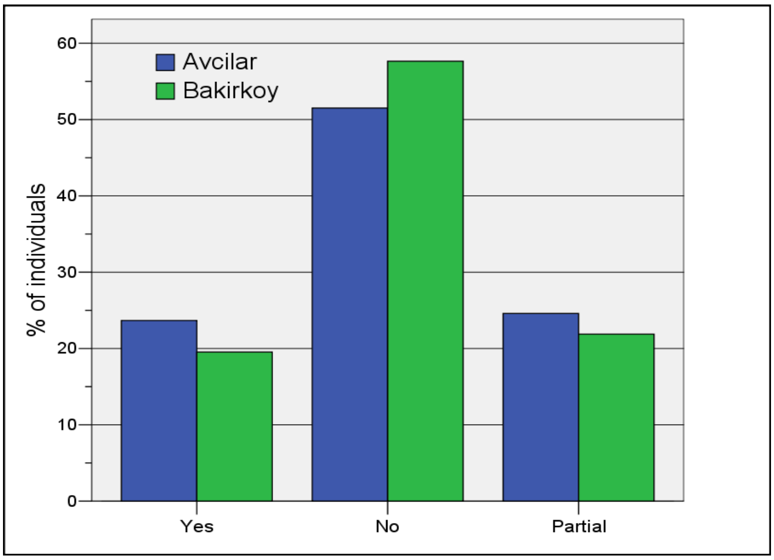

Figure 13. Answers of the question "do you have any knowledge about available techniques for strengthening of houses against earthquakes?"

Most of the residents in Avcilar and Bakirkoy estimate that 3500 USD to 14000 USD should be spent in order to protect their houses against earthquakes. Figure 14 shows the fact that, about 1/3 of the residents in Avcilar and 1/4 of the residents in Bakirkoy are pessimistic about this issue as they think that 14000 USD should be spent.

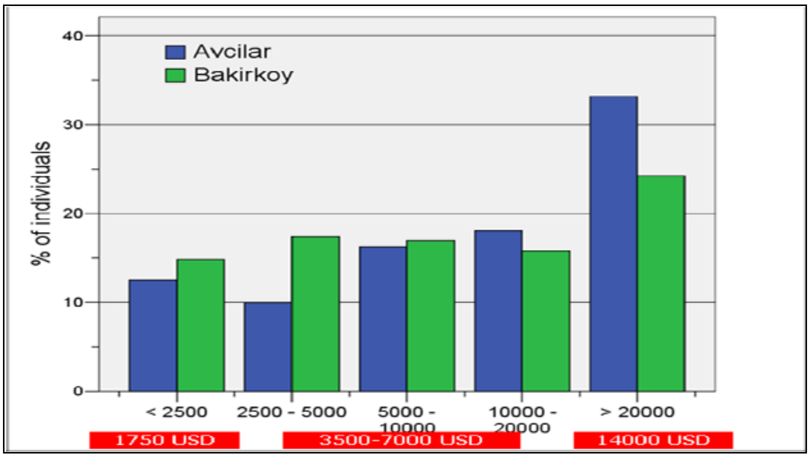

Figure 14. Answers of the question "how costly do you think it is to protect your house from earthquakes?"

Figure 15 points out an important implication of our study that although Bakirkoy district is wealthier than Avcilar, 32% of the residents in Bakirkoy are contended to spend less than 1 month of their household income to protect their house/property from a big earthquake. The result for Avcilar is more balanced although 23% of the residents in this district view in the same was as the residents in Bakirkoy do. People in Avcilar report that they can spend 3 months to 2 years of their household incomes a total percentage of 27. Interestingly, 12% of the residents of Avcilar are volunteer to spend more than their 5 years household income to protect their houses against earthquakes.

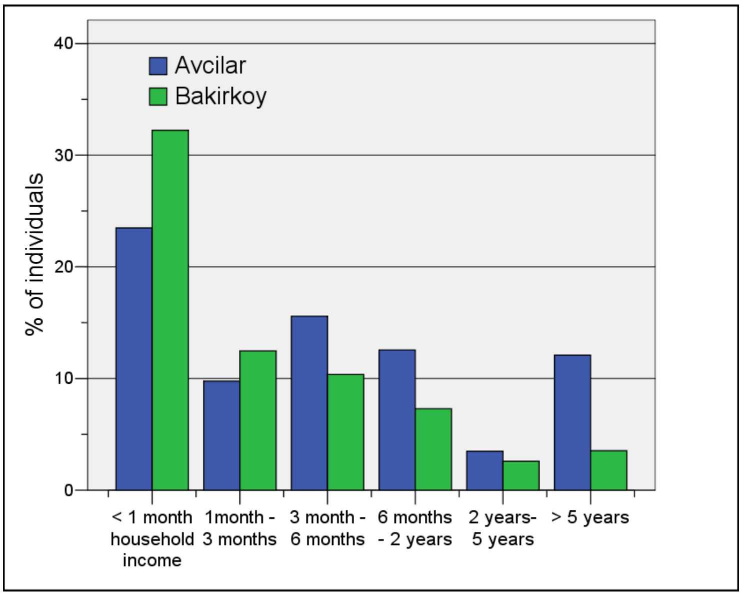

Figure 15. Answers of the question “how much can you spend to protect your house/property from a big earthquake? “

When the surveys are asked about how much they could spend to protect their family members from a big earthquake, %17 of the residents of Avcilar and 21% of the residents in Bakirkoy state that they could spend less than 1 month of their household income while 27% of Avcilar and 28% of Bakirkoy residents could spend more than 5 years household incomes as impressively seen in Figure 16.

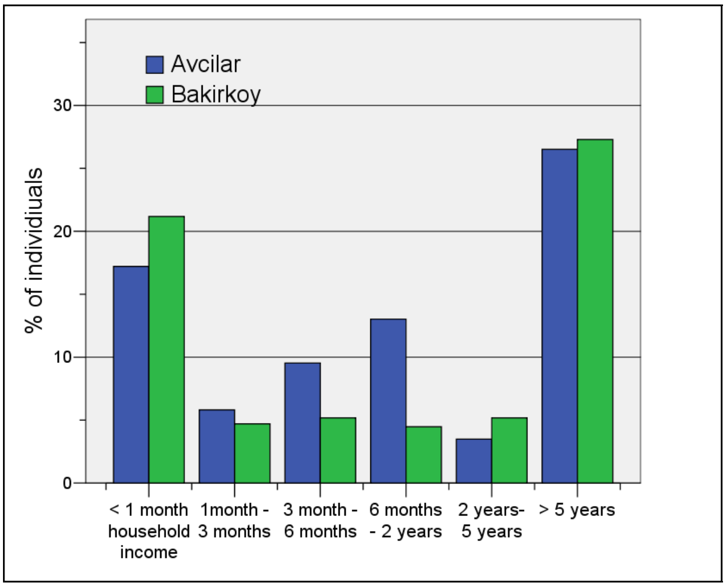

Figure 16. Answers of the question “how much can you spend to protect your family members from a big earthquake?“

Results of our survey indicate that while 21% of the residents in Avcilar and 22% of the residents in Bakirkoy plan to resist their houses against earthquakes, majority of the two districts (33% of Avcilar and 41% of Bakirkoy) have no plan for a safer home as seen in Figure 17.

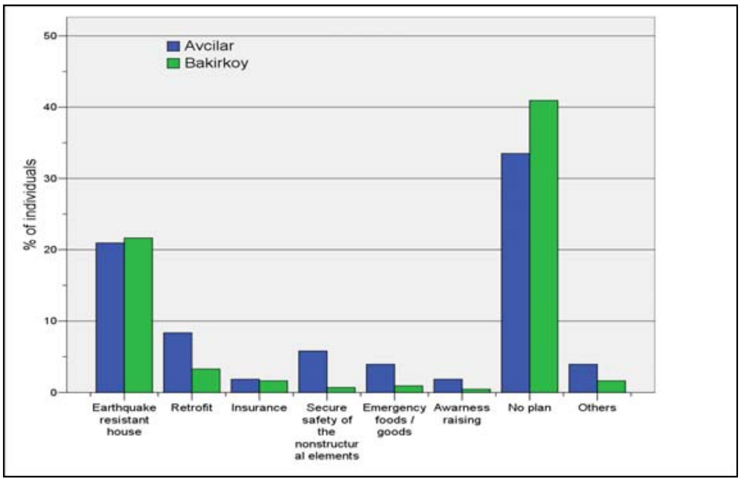

Figure 17. Answers of the question “what is your plan for safer home?“

Loan with low interest with 22%, subsidy with 18%, and free technical support with 13% are the implications of the residents in Avcilar of our survey when they were asked what kinds of support would make them decide to invest for strengthening or retrofitting their houses. Residents in Bakirkoy district put their expectations forward, by changes in the percentages, in our study (Figure 18). According to the 21% of the residents of Bakirkoy, subsidy is the most advantageous support to invest for strengthening or retrofitting their houses.

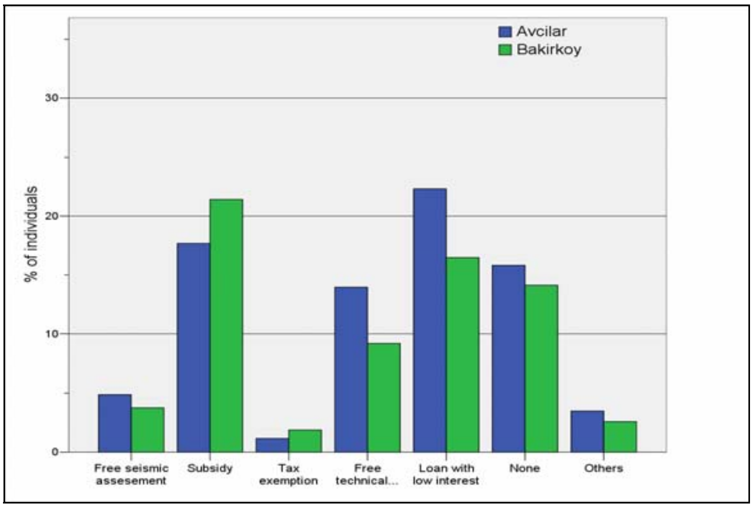

Figure 18. Answers of the question “what kinds of support would make you decide to invest for strengthening or retrofitting your house?”

Builders of the houses are accepted as the guiltiest if the houses would collapse and some of family members would kill due to a big earthquake according to 33% of the residents in Avcilar and 36% of the residents in Bakirkoy districts. The other blaming focus is the “state” with 21% in Avcilar and 20% in Bakirkoy respectively. Remarkable result of this survey question is that, 18% of the attendants of our survey study in Avcilar and 22% of the attendants in Bakirkoy would blame no one in case of a life-loss due to a big earthquake as seen in Figure 19. This result can be associated with the fact of faith in Turkey which refers to “fatalism”.

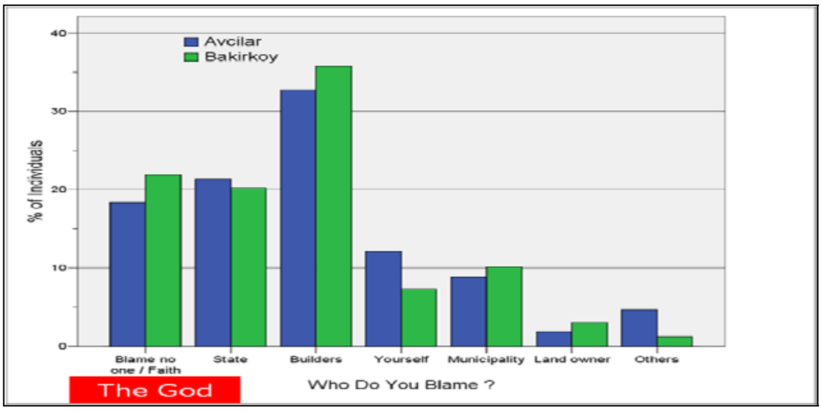

Figure 19. Answers of the question "if your house would collapse and kill some of your family members due to a big earthquake, who would you blame?"

CONCLUSIONS

People in Avcilar and Bakirkoy districts of Istanbul are aware of the seismic risk; the majority of the respondents think that a big earthquake will occur in the survey area within 50 years (around 62 percent of total). Although the social structure of Avcilar and Bakirkoy are significantly different, basic trends in terms of seismic risk perception and mitigation are surprisingly similar, with minor differences. In terms of plans for a safer house, seismic strengthening is the preference of only a small minority (around 8 percent of total) and relatively simple and cheap measures like earthquake insurance, awareness studies in family and non-structural mitigation are not preferred by the majority either. Around 49 percent of the respondents do not have any plan for a safer house. The most preferred method for safer houses in these highest income and academic qualification groups is purchasing a new earthquake resistant house (around 34.8 and 43.1 percent of total). This shows that people do not trust seismic strengthening.

Another remarkable finding of our study is that, protection of family members seems significantly more important than protection of property for a great majority of respondents. Yet, this can not urge people to make plans for safer houses. It seems that for reduction of future losses, one of the main objectives should be development of easy and economical seismic strengthening techniques for upgrading many existing vulnerable buildings to life safety level and introduce these strengthening techniques to people living in vulnerable housing units, as well as trying to build new structures with sufficient seismic resistance.

In case of a big earthquake occurrence and life-loss of family members, about 35 percent of the residents in Avcilar and Bakirkoy each blame the house builders. Noticeably, fatalist character of Turkish people is reflected by our survey study as the attendants indicate that they would blame no one in case of devastating earthquake, it is the work of God.

The results of this study were explained elaborately in "Eraybar K., Okazaki K., and Ilki A., 'An exploratory study on the perception of seismic risk and mitigation in two districts of Istanbul', Disasters: The Journal of Disaster Studies, Policy and Management (accepted to be published)".

ACKNOWLEDGMENTS

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REFERENCES

Eraybar K., Okazaki K., Ilki A. (2010). “An exploratory study on perceptions of seismic risk and mitigation in two districts of Istanbul”, *Disasters*, 34(1), 71-92.

Eraybar K., Ilki A., Okazaki K. (2007). “Seismic Risk Perception in Avcilar”, *Proceedings of Turkish Sixth National Conference on Earthquake Engineering*, Istanbul, Turkey, 2, 41–51.

National Graduate Institute for Policy Studies (GRIPS), (2008). “Report on Seismic Risk Perception (Data Analysis)”, Tokyo, Japan.

(I) http://www.usc.edu/dept/civil_eng/structural_lab/eq-rp/seismicity.html
(Retrieved: 12 June 2009)

SEISMIC RISK PERCEPTION CONCERNING HOUSING SAFETY

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ABSTRACT

In most earthquake-caused deaths, people are killed by their own houses. Most of the world's population lives in vernacular houses that are built of adobe, brick, stone, or wood, and are non-engineered and thus vulnerable to earthquakes. Non-engineered houses can be strong when they are constructed with appropriate and practical techniques that are affordable to ordinary people. A big challenge, however, is that the house owners lack the motivation to invest to secure the safety of their houses, particularly to retrofit existing vulnerable houses. It is thus crucial to convince them that the investment in safer housing will eventually prove to be worthwhile. In order to better understand the seismic risk perception of residents, government officers, and masons/builders, who are directly responsible for securing housing safety, we have conducted a joint survey in 8 countries with the partner institutions. Based on the collected data, we analyze how they perceive seismic risk and how the risk perception is different from country to country. The findings of this study will be useful for the governments to develop disaster risk management policies and initiatives, and for NGOs to develop strategies that would raise awareness and disseminate technologies for safer housing at community level, and convince people to invest in housing safety against earthquakes.

KEYWORDS
Disaster reduction, Earthquakes, Houses, Risk perception,

INTRODUCTION

In most earthquake-caused deaths, people are killed by their own houses. Most of the world's population lives in vernacular houses that are built of adobe, brick, stone, or wood, and are non-engineered and thus vulnerable to earthquakes. Because earthquakes cannot be predicted precisely even by the most advanced science and technology, it is essential to make these houses safer in order to reduce the number of people harmed and the amount of severe damage caused by future earthquakes. The more resilient the existing houses are against earthquakes, the lower the death rate will be in the event of an earthquake, and the less drastic will be the disruptions to economic and social activities in the affected areas. No matter how effective emergency management and relief activities are, lost lives can never be regained. No matter what effective technologies are developed, the non-engineered houses will not be safer unless these technologies are applied. Non-engineered houses can be strong when they are constructed with appropriate and practical techniques that are affordable to ordinary people. A big challenge, however, is that the house owners lack the motivation to invest to secure the safety of their houses, particularly to retrofit existing vulnerable houses. The stakeholders such as the house builders / masons and the government officers, who are directly involved in construction of houses or related policies and regulations, also lack interest in securing sufficient safety mainly because house owners are not concerned with the safety of their houses. It is thus crucial to convince the stakeholders that the investment in safer housing will eventually prove to be worthwhile. Choices and decisions regarding housing safety are made, not based on the actual risk, but on the perceived risk. Therefore, we conducted surveys on risk perception of the residents, masons/house builders, and the government officers, to better understand their seismic risk perception from 2007 to 2008 in Indonesia, Nepal, Pakistan, Turkey, Fiji, India, the Philippines, and Japan. The survey results will help the governments develop disaster risk management policies and initiatives and help NGOs develop strategies that would raise awareness and disseminate technologies for safer housing at community level, and convince people to invest in housing safety against earthquakes.

SURVEY METHOD

Partner Institutions

The survey was conducted as a joint survey between GRIPS and the following institutions.
- Indonesia: Professor Wayan Sengara, Prof. Krishna Pribadi, Ms. Harkunti Rahayu
Center for Disaster Mitigation, Institute of Technology Bandung (ITB),
- Nepal: Mr. Amod Dixit, Mr. Ram Kandel
NSET-Nepal
- Pakistan: Project manager Najib Ahmad
Preston University
- Turkey: Associate Professor Alper Ilki, Mr. Korel Eraybar, Mr. Yilma Karatuna
Istanbul Technical University (ITU)
- Fiji: Mr. Josefani Bola, Mr. Lasarusa Vuetibau
Centre for Appropriate Technology & Development (CATD)
- India: Professor Ravi Sinha
Indian Institute of Technology Bombay (IITB)
- The Philippines: Professor Doracie B. Zoleta-Nantes, Associate Professor Marqueza Reyes
Philippine Geographical Society (PGS)
- Japan: Associate Professor Michitaka Umemoto,
University of Tsukuba

Survey of the residents

The surveys of the residents were conducted from 2007 to 2008 in Indonesia, Nepal, Pakistan, Turkey, Fiji, the Philippines, and Japan, using the similar questionnaire developed by Okazaki, GRIPS. The questionnaire was slightly modified by the partner institution to reflect the local conditions. The survey was conducted in two different kinds of communities in each country for the purpose of comparison. The partner institution in each country decided what two kinds of communities should be selected in that country. For example, Indonesia and Pakistan selected one community which was severely hit by a recent earthquake and the other community which was not. Nepal selected one community where a community based disaster management activities are implemented and the other where such activities are not implemented. Fiji selected a community from urban areas and the other from rural areas.

Approximately 400 households were randomly selected in each community so that the sampling error should be less than approx. 5 percent. The trained surveyors visited the selected houses to conduct an interview with the head of each household (or spouse) and filled in the questionnaire through an interview. The questionnaire asks whether the respondents think their house is safe against earthquakes, how they want to avoid the risks of damage to their house and harm to their family, what they know about retrofitting, and so on, in addition to questions about their sex, age, number of family members living together, household income, occupation, and house-related information such as floor area, structural type, cost, and ownership (see Table 1). The questionnaire was pre-tested in October 2006 in Nepal by the National Society for Earthquake Technology (NSET)-Nepal.

Figure 1. Indonesia

Figure 2. Nepal

Table 1. Questions in the questionnaire

Attributes of the respondents	Risk perception and behavior of the respondents
Q3. Sex Q4. Age Q5-1. Family members living together: Total number Q5-2. Family members living together: Number of members < age 15 Q5-3. Family members living together: Number of members > age 60 Q6a. House: How long have you been living in this house? Q6b. House: Ownership Q6 c . House: Floor area Q6d.House: Type of house Q6e. House: Major structure Q6f-1. Cost of house in local currency: Purchase Q6f-2. Cost of house in local currency: Self-built (total cost) Q6f-3. Cost of house in local currency: Rent (per month) Q7. Have you ever experienced any disasters? If yes, what kind(s) of disaster(s) you have experienced? [Multiple answers] Q13. Who built your house? Q30. Are any community based associations or organizations working for disaster risk reduction in this area? Q33. What is your academic qualification? Q34. What is your occupation? Q35. How much is your monthly household income (approx.)?	Q8. What do you think will most severely affect your life? Q9. What kind of disaster do you think will most affect your life? Q10. Do you think a big earthquake will occur in the area where you live in the future? Q11. What kinds of impacts do you anticipate due to a big earthquake? [Multiple answers] Q12. What have you done to reduce the impacts of earthquakes? [Multiple answers] Q14. Do you think your house is strong enough to withstand a big earthquake? Q14a. [if answered “No” in Q14] Do you plan to make your house safer? (Or do you plan to move due to the unsafe house?) Q14b. [if answered “No” in Q14a] Are you worried about the collapse of your house due to earthquakes? Q15. Whom do you rely on for a safer house? Q16. If your house collapses and kills some of your family due to a big earthquake, who would you blame? Q17. If your house would be severely damaged by an earthquake, what would be the causes for the weakness of the house? Q18. Are you concerned if your neighbors’’ houses are highly vulnerable? Q19. Do you think information on the seismic risk of houses in the neighborhood should be shared among people? Q20. Do you have any knowledge about the available techniques for strengthening houses against earthquakes? Q21. How costly do you think is it to protect your house from earthquakes? Q22. [only to house owners] How much could you spend to protect your house/property from a big earthquake? Q23. [only to house owners] How much could you spend to protect your family members from a big earthquake? Q24. [only to house owners] What is your plan for a safer home? Q25. [only to house owners] What kinds of support would make you decide to invest for strengthening or retrofitting your house? Q26. [only to house renters] How much of an increase in your rental fee could you accept to protect your house/property from a big earthquake? Q27. [only to house renters] How much of an increase in your rental fee could you accept to protect your family members from a big earthquake? Q28. [only to house renters] What is your plan for a safer home? Q29. What facilities do you think should be protected with high priority? [Choice of three answers] Q31. Have you ever participated in any initiatives/activities for disaster risk reduction? Q32. How long do you plan to live in this house?

Figure 3. Pakistan

Figure 4. Turkey

The photos (Figure 1 - 4) show some typical houses which were targeted for the interview in Indonesia, Nepal, Pakistan, and Turkey.

Survey of the house builders / head masons

The targeted house builders or head masons were those who were actually constructing the conventional or common houses, particularly in urban areas. Approximately 50 house builders or head masons were asked with the questionnaire in each country. In many cases, the interviewers visited them to conduct the questionnaire interview. This survey was conducted in Nepal, Pakistan, Indonesia, Turkey, Fiji, the Philippines, and India in 2008.

Survey of the local government officers

The targeted local government officers were those responsible for disaster risk management or safer building construction at local level. The local governments were cities and towns that are responsible for disaster management and building control. The local governments were selected from the Capital region, or randomly nation-wide. Approximately 30 local government officers were targeted in each country. In many cases, the interviewers visited them to conduct the questionnaire interview. This survey was conducted in Nepal, Pakistan, Indonesia, Turkey, Fiji, the Philippines, and India in 2008.

RISK PERCEPTION OF RESIDENTS

Attributes of the respondents

While about half of the respondents in Nepal and Fiji were male, male respondents were dominant in Pakistan (96%), Japan (73%), and Indonesia (71%) as shown in Figure 5. On the contrary, female respondents were dominant in Turkey (64%) and the Philippines (69%). It may simply reflect when (either weekdays when many men work outside or the weekend when they stay home) the survey conducted. With regard to age, while younger people are dominant in Nepal, senior people are dominant in Japan. The other countries have similar composition (Figure 6).

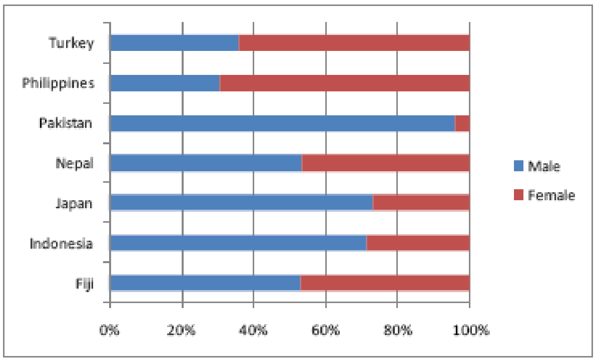

Figure 5. Sex

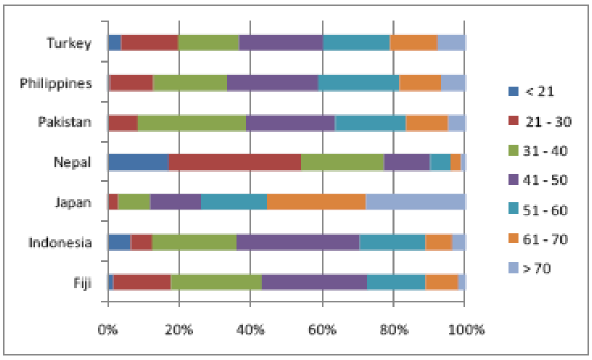

Figure 6. Age

With regard to the period of living in the current house, the majority answered „less than 25 years” in Indonesia (93%), Pakistan (50%), and Nepal (38%) (Figure 9). Figure 8 shows the ownership of the house. Almost all the respondents (98%) owned their houses in Pakistan. In the other countries, owned houses are dominant except in Nepal, where only half of the respondents in Nepal owned their houses and the remaining half were renting.

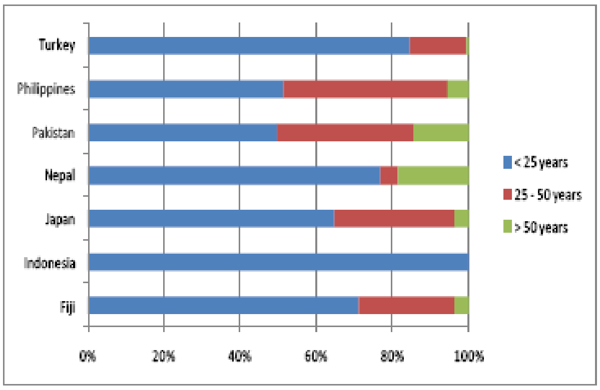

Figure 8. Ownership

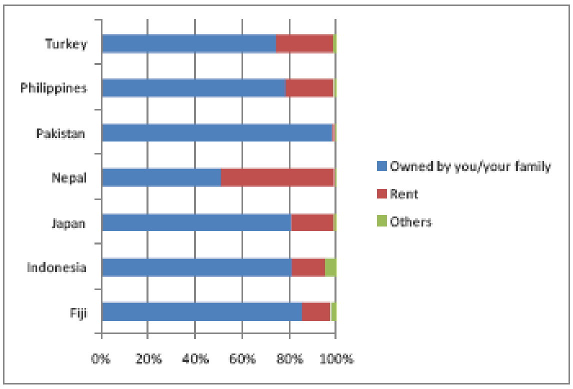

Figure 7. How long have you been living at this house?

Figure 9 shows house types. Detached houses were dominant in Fiji, Japan, Philippines, and Indonesia, while townhouses or flats were dominant in Nepal and Turkey. Figure 10 shows the structure of the houses. “Bricks with Reinforced Concrete (RC) frame” was the dominant structure in Indonesia (74%) and Nepal (72%), while almost all the buildings in Turkey were RC structure. There were also many “bricks without RC frame” structures in Nepal. Timber is dominant in Japan and Fiji. The majority in Indonesia and Turkey purchased their houses while the majority in Pakistan built their houses by themselves. Most respondents in Indonesia purchased their houses with less than US$5,500, while respondents in Turkey paid more than ten times that amount to purchase a house. The majority of respondents in Pakistan built their houses with US$800–1,600. In Nepal, the monthly rental fee of US$15–30 was the majority.

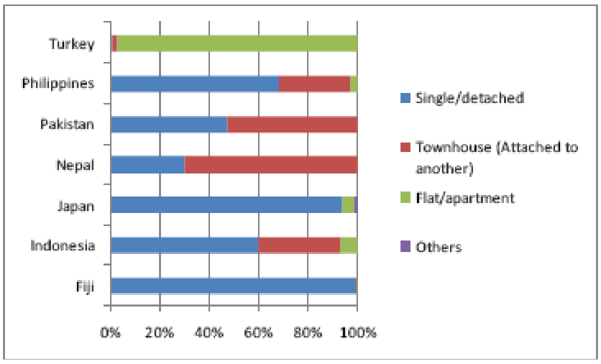

Figure 9. Types of the houses

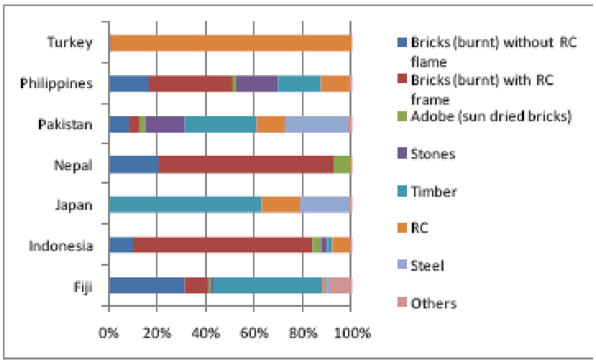

Figure 10. Major structure
(*Multiple answers in Pakistan)

As shown in Figure 11, local masons were the dominant means of house building in Indonesia (61%), Pakistan (90%), and Philippines (47%) while contractors were dominant in Turkey. As shown in Figure 12, most respondents in Turkey, Pakistan, and Indonesia had experienced earthquakes in the past. Figure 13 shows the educational attainment of the respondents. School education was the attainment level of the majority in Indonesia, Pakistan, and Turkey while many respondents attained college/university level in Philippines and Nepal. The illiteracy rate was comparatively high in Pakistan and Nepal.

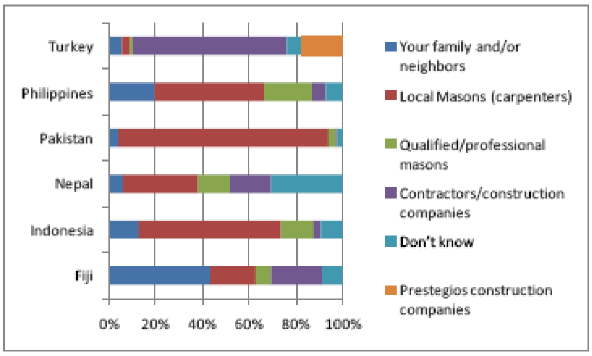

Figure 11. Who constructed your house?

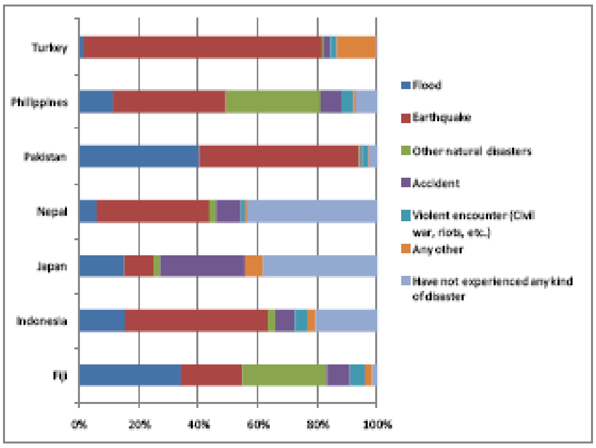

Figure 12. Have you ever experienced any kind of disasters in your lifetime?

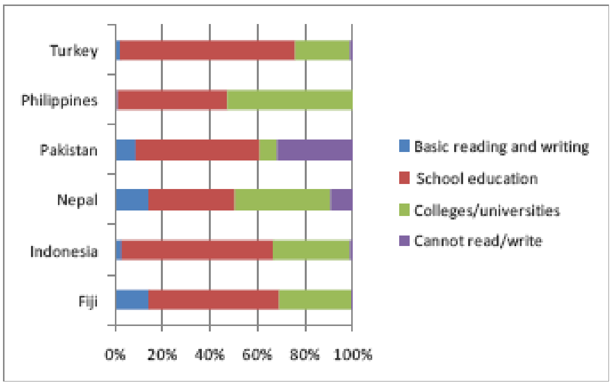

Figure 13. What is your academic qualification?

Risk perception and behavior

(1) Future risk which may affect life

There were two questions about future risk which might affect the life of the respondents: "What do you think will most severely affect your life" and „What kind of disaster do you think will most affect your life?" In Indonesia, Pakistan, Turkey, and Fiji, respondents were most afraid of disasters while respondents in the other countries were afraid of disease and/or unemployment (Figure 14). Among the disasters, all the respondents were most afraid of earthquakes, particularly in Japan, Turkey, Pakistan, and Nepal, except Fiji where people were more afraid of storms, as shown in Figure 15.

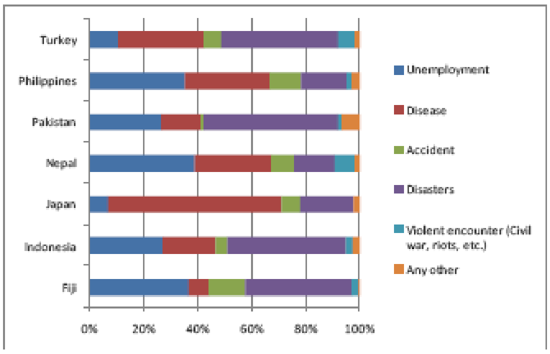

Figure 14. What do you think will most severely affect your life?

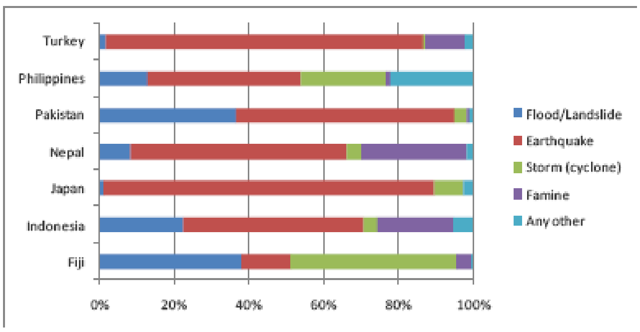

Figure 15. What kind of disaster do you think will most affect your life?

(2) Estimated damage by earthquakes

In response to the question "What kinds of impacts do you anticipate due to a big earthquake?, respondents anticipated both loss of themselves/family and loss of their house/property to the same extent, except Japan where people anticipated less deaths and more injuries (see Figure 16). While few Japanese anticipated deaths, many anticipated loss of the house/property.

(3) Actions to reduce the impacts of earthquakes

In response to the question "What have you done to reduce the impacts of earthquakes?", the majority of respondents in Pakistan and Nepal had done nothing in particular while the majority of Philippines, Indonesia, and Fiji had strengthened their house (Figure 17). More than half of the respondents in Turkey had insured their houses. It should be noted that this ratio should be higher in Turkey according to its obligatory disaster insurance system.

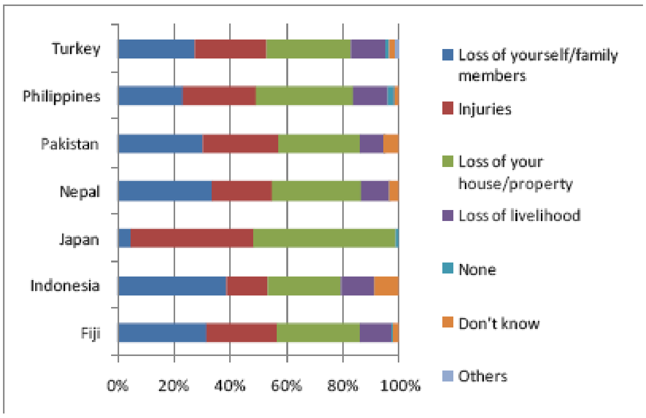

Figure 16. What kinds of impacts do you anticipate due to a big earthquake? (Multiple answers)

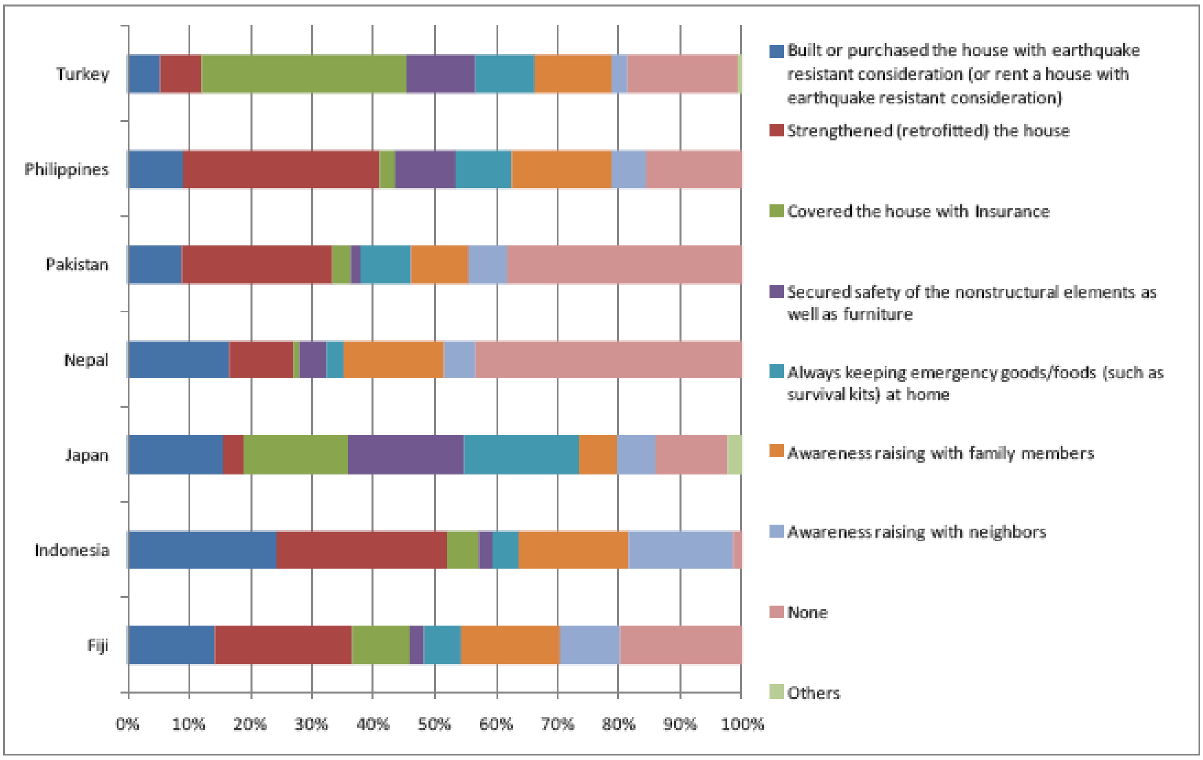

Figure 17. What have you done to reduce the impacts of earthquakes? (Multiple answers)

(4) Safety of the house

In response to the question "Do you think your house is strong enough to withstand a big earthquake?", most respondents in Turkey and Philippines answered "yes", while the majority answered "no" in Indonesia (71%), Pakistan (94%), Nepal (62%), and Fiji (69%) as shown in Figure 18. To those who answered "no", an additional question was asked: "Do you plan to make your house safer? (Or do you plan to move due to the unsafe house?)" The majority in Indonesia, Turkey, Philippines, and Fiji answered "yes", while two thirds in Nepal answered "no". To those who answered "no" to the question about a future plan to make the house safer, one more question was asked: "Are you worried about collapse of your house due to earthquakes?" More than half of the respondents in Indonesia answered "no" while most of the respondents in the other countries answered "yes".

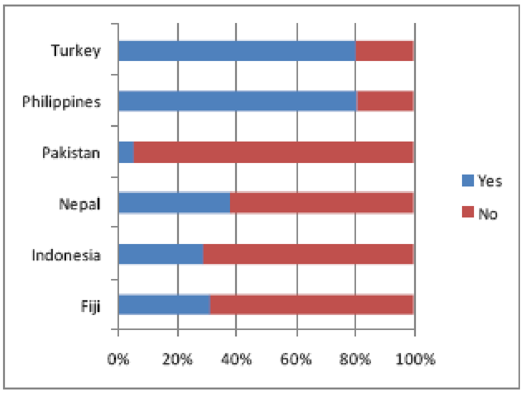

Figure 18. Do you think your house is strong enough against a big earthquake?

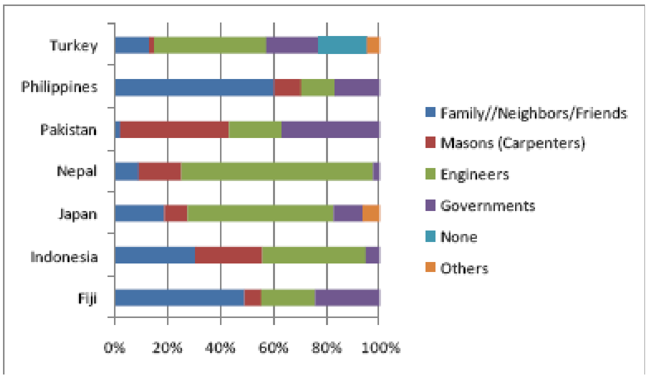

Figure 19. Whom do you rely on for a safer house?

(5) Responsibility for housing safety

In response to the question "Whom do you rely on for a safer house?□, the majority answered "engineers" in Indonesia (39%), Nepal (72%), Japan (55%), and Turkey (42%), while the majority in Pakistan (41%) answered "masons", and the majority in Philippines (60%) and Fiji (49%) answered "family/neighbours/friends" as shown in Figure 19. Respondents in Indonesia, Nepal, and Japan did not appear to rely on the government for safer housing. In response to the question "If your house collapsed and killed some of your family due to a big earthquake, who would you blame?", the majority in Indonesia, Pakistan, and Japan answered "don't know", while the majority in Nepal (42%) and Fiji (37%) answered "Myself", and the majority in Turkey answered "house builders" (34%) and "government" (30%) as shown in Figure 20 ("Gods" was replaced by "Faith" in Turkey). In response to the question "If your house would be severely damaged by an earthquake, what would be the causes for the weakness of the house?", the majority in Philippines, Pakistan, Nepal, and Fiji answered "poor construction materials/work" while respondents in Indonesia tended to answer "built without design/supervision of engineers" and the respondents in Turkey tended to answer "cost cut" as shown in Figure 21.

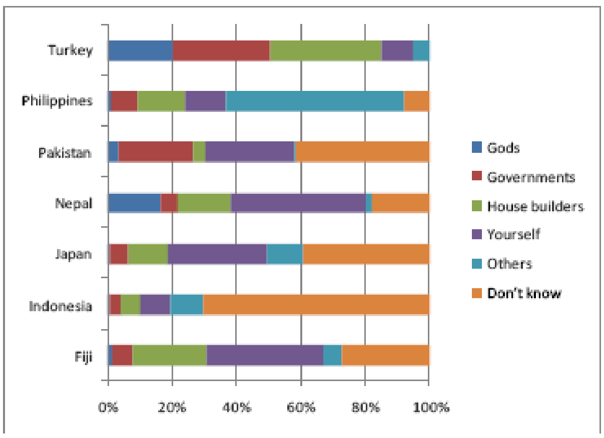

Figure 20. If your house would collapse and kill some of your family due to a big earthquake, whom would you blame?

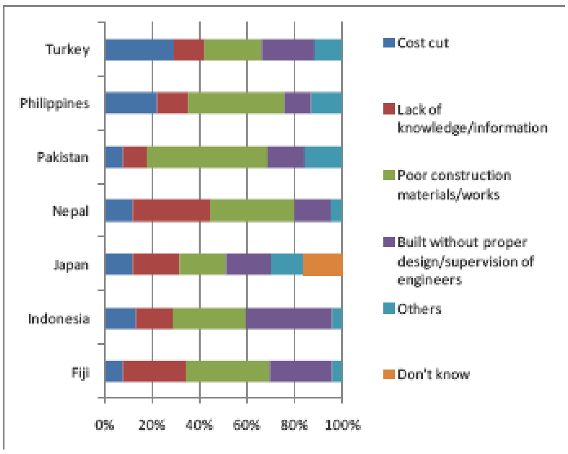

Figure 21. If your house would be severely damaged by an earthquake, what would be the causes for the weak house?

(6) Willingness to pay for safer housing

With regard to willingness to pay for safer housing, the respondents were asked two similar questions: “How much could you spend to protect your house/property from a big earthquake?” and “How much could you spend to protect your family members from a big earthquake?” The difference between the two questions is whether the concern is house/property or the life of family members. Regarding the question on protecting the house/property (Figure 22), the majority in Indonesia (45%) and Pakistan (82%) answered “more than 5 years” household income”. In contrast, the majority in Turkey (38%) and Philippines (53%) answered “less than 1 month’s income”. Similar questions were asked to house renters. In Indonesia, Nepal, and Philippines, the majority answered “less than a 5% increase in my rental fee would be acceptable”, while the majority in Turkey and Fiji answered “an increase in my rental fee would not be acceptable”. In answering the question on protecting the family, the majority in Indonesia (34%) and Pakistan (33%) answered “2–5 years’ income”, as shown in Figure 23. Compared with the former question, the amount decreased, meaning that they would pay less to protect their family than their house/property. On the contrary, the majority in Nepal answered “3–6 months’ income” and the respondents who answered “more than 5 years’ income” doubled. In Turkey, the majority (38%) answered “more than 5 years’ income”. Compared with the former question, the amount increased, meaning that they would pay more to protect their family than their house/property.

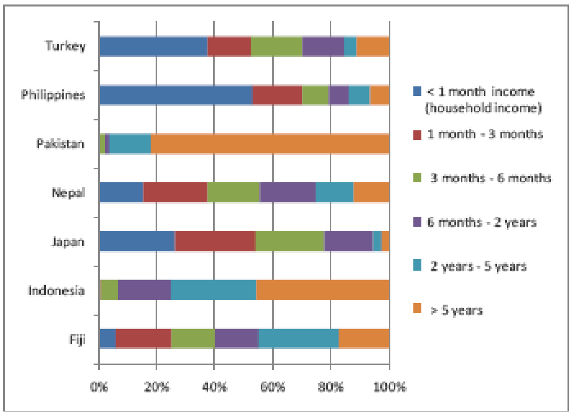

Figure 22. How much can you spend to protect your house/property from a big earthquake?

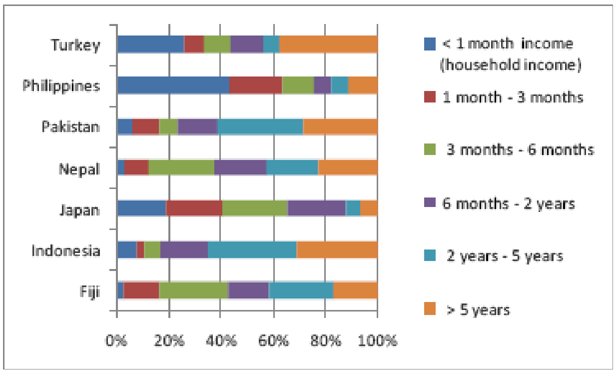

Figure 23. How much can you spend to protect your family members from a big earthquake?

In response to the question „What kinds of support would make you decide to invest for strengthening or retrofitting your house?”, the majority in Turkey, Pakistan, Japan, Indonesia, and Philippines answered “subsidy while the majority in Fiji answered “free technical support”. Many people also answered “loan with low interest rate” in Turkey, Nepal, Indonesia, and Fiji as shown in Figure 24.

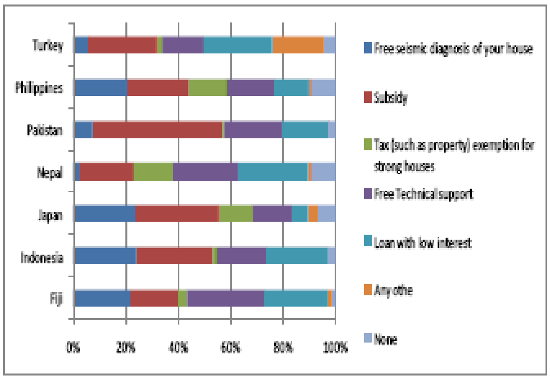

Figure 24. What kinds of support would make you decide to invest for strengthening or retrofitting your house?

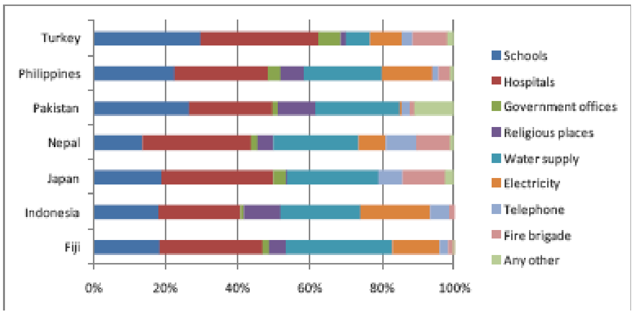

Figure 25. What facilities do you think should be protected with high priority? (Choose three answers)

(7) Community issues

Several questions were asked concerning the risk of the communities. In response to the question “What facilities do you think should be protected with high priority?”, the majority in all the countries answered “schools”, “hospitals”, and “water supply” followed by “electricity” as shown in Figure 25. The other facilities such as “government offices”, “religious places”, and “telephone” did not have high priority in the all countries. In response to the question "Are any community based associations or organizations working for disaster risk reduction in this area?", many people (though less than half) answered "yes" in Philippines, Pakistan, and Indonesia, and Fiji (Figure 26). In response to the question "Have you ever participated in any initiatives/activities for disaster risk reduction?", the majority in the all countries did not participated in any initiatives. Comparatively many people participated in Philippines, Pakistan, and Indonesia (Figure 27).

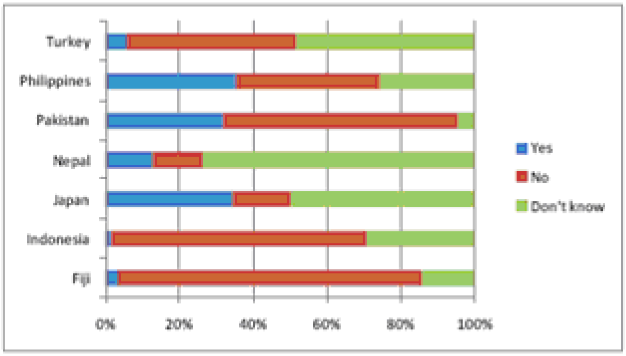

Figure 26. Are any community based associations or organizations working for disaster risk reduction in this area?

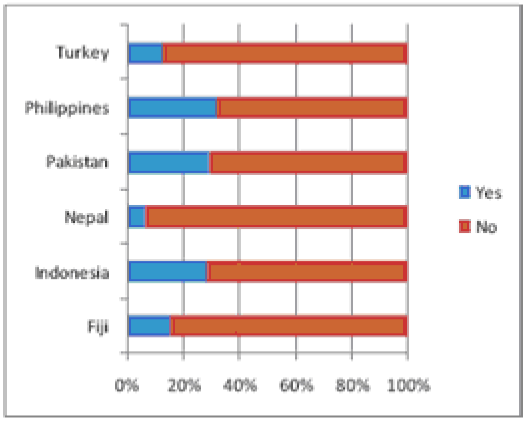

Figure 27. Have you ever participated in any initiatives/activities for disaster risk reduction?

RISK PERCEPTION OF HOUSE BUILDERS/MASONS

(1) Safety of the house

We asked the mode of service to the house builders / masons. With regard to "What is mode of service you provide in building construction?", the majority in Nepal (92%), Indonesia (72%), and India (42%) answered "Labor contract" while the majority in Philippines (54%), Pakistan (54%) answered "Labor and material contract" as shown in Figure 28. In response to the question "How do you think a big earthquake will affect the houses you constructed?", the majority in Turkey and India answered "No (or little) damage", and the majority in Philippines, Pakistan, and Indonesia answered "Light damage", while the majority in Nepal and Fiji answered "Heavy damage" or "Collapse" as shown in Figure 29. In response to the question "Do you know about the details of the building code / housing guidelines developed by government?", the majority in Turkey, Pakistan, Nepal, and Indonesia answered "Have not heard" or "heard but don't know the details", while the majority in Philippines, India answered "Have been applying its provision" as shown in Fig. 30.

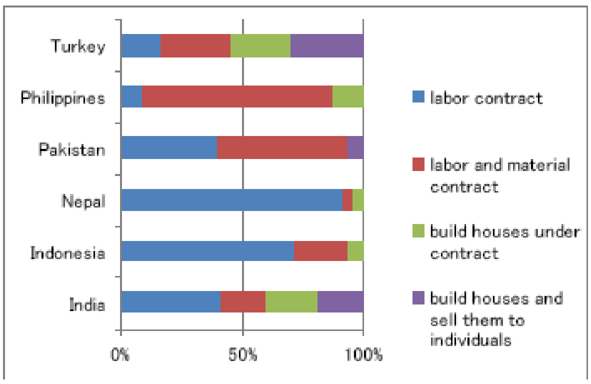

Figure 28. What is mode of service you provide in building construction?

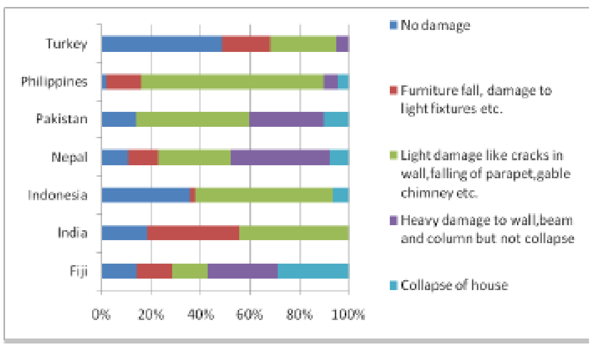

Figure 29. How do you think a big earthquake will affect the houses you constructed ?

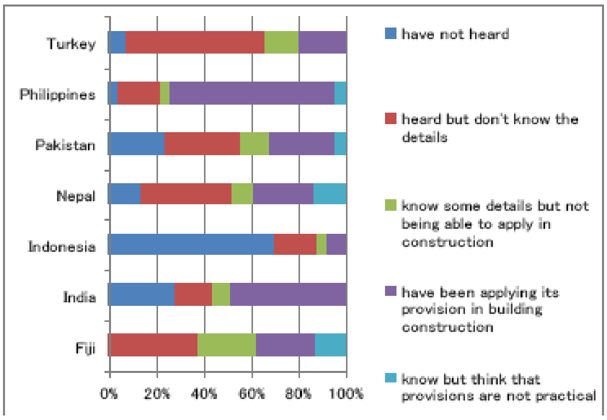

Figure 30. Do you know about the details of the building code / housing guidelines developed by government?

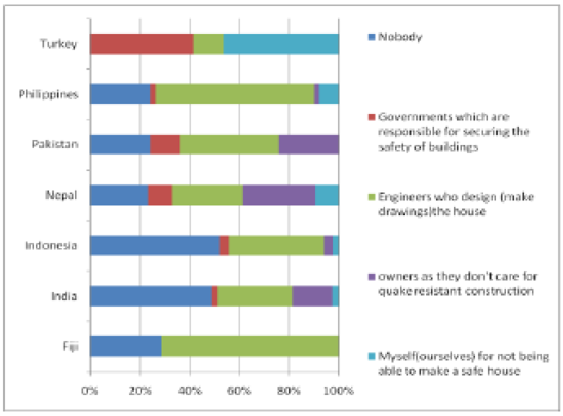

Figure 31. If the building you constructed collapse in a big earthquake, who should be blamed the most ?

(2) Responsibility for housing safety

In response to the question "If the building you constructed collapse in a big earthquake, who should be blamed the most?", the majority in India (49%) and Indonesia (52%) answered "Nobody", and the majority in Philippines (64%), Pakistan (40%), and Fiji (71%) answered "Engineers", while the majority in Turkey (46%) answered "Myself" as shown in Figure 31.

RISK PERCEPTION OF GOVERNMENT OFFICERS

(1) Issues of the government

In response to the question "What do you think is the biggest problem in your city in terms of urgency and importance?", the majority in Pakistan, India, and Fiji answered "Lack of infrastructure (water supply, transportation, traffic, etc.) ", and the majority in Nepal and Indonesia answered "Environmental problems". The issue of "Natural Disaster" is particularly minor in Pakistan and Indonesia as shown in Figure 32. In response to the question "What is the most difficult issue in enforcing building code effectively?", the majority in all the countries answered "Unwillingness of general public to abide the code", rather than "Low number of building control staff", "Lack of financial resources to implement the code", or "Low level of professional skill of engineers or architects in the city" as shown in Figure 33.

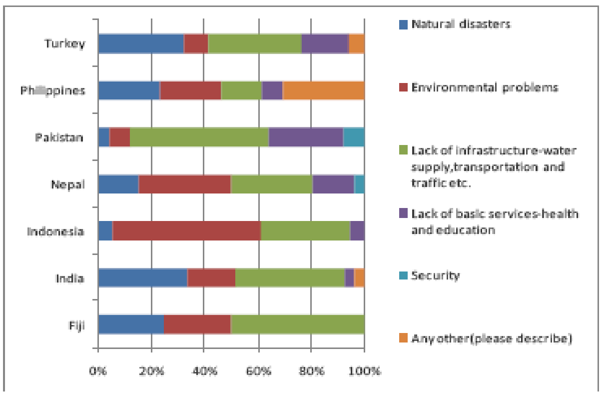

Figure 32. What do you think is the biggest problem in your city in terms of urgency and importance?

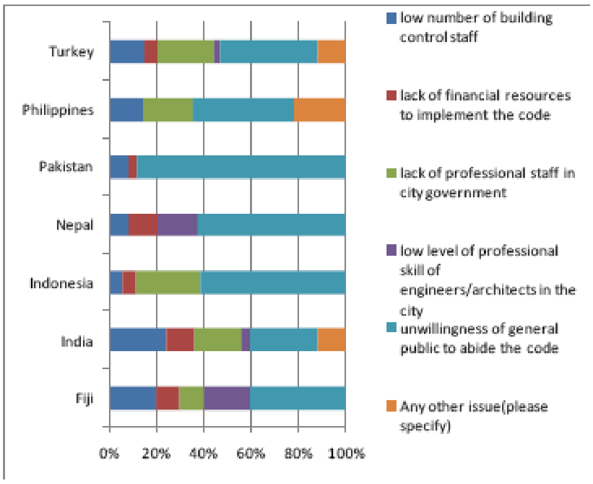

Figure 33. What is the most difficult issue in enforcing building code effectively?

(2) Responsibility for housing safety

We asked a question "Who do you think would be considered most responsible for damage of buildings and loss of lives due to future earthquakes?", which is similar to the question asked to the residents and the house builders / masons. The majority in all the countries answered "Individual household for ignoring the safety of their own houses" except Turkey where the majority answered "Government officers (national and local)" as shown in Figure 34. The result is quite different from the result of the residents or the house builders / masons. In response to the question "Which stakeholders or members/group can contribute most towards improvement of building safety in your city? ", the majority in Turkey (33%) and Nepal (54%) answered "City and national government" while the majority in Philippines (60%) and India (46%) answered "Design engineers and architect", and the majority in Pakistan (40%) and Indonesia (53%) answered "Builders, petty contractors, and masons" as shown in Figure 35.

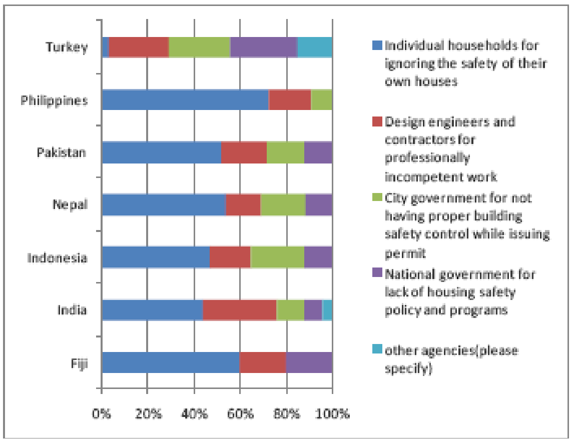

Figure 34. Who do you think would be considered responsible for damage of buildings and loss of lives due to future earthquakes?

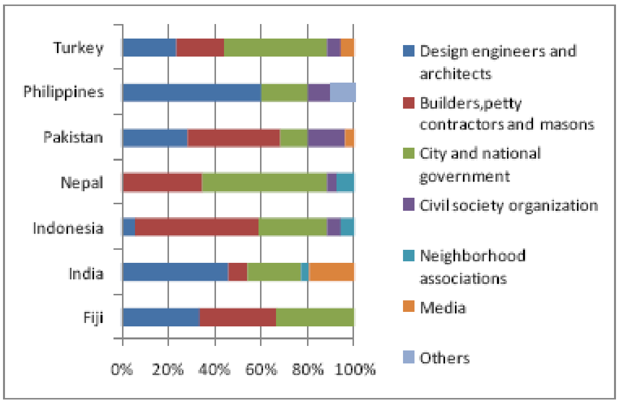

Figure 35. Which stakeholders or most members/group can contribute most towards improvement of building safety in your city?

IMPLICATIONS

This study on the residents has revealed that seismic risk perception differs from country to country, and from community to community. The findings of this study will be useful for the governments to develop disaster risk management policies and initiatives, and for NGOs to develop strategies that would raise awareness and disseminate technologies for safer housing at community level, and convince people to invest in housing safety against earthquakes. For example, given that many people rely on engineers for housing safety in Indonesia, Nepal, Japan, and Turkey, policy implementation involving engineers would be effective in these countries. However, because people do not rely on the government in Indonesia and Nepal, it would not be effective for government to spearhead housing safety campaigns in these countries. People rely on masons and the government in Pakistan, so housing safety campaigns through these actors would be effective in that country.

Perceptions as to who should take the responsibility for housing safety also differ from country to country. For strengthening (retrofitting) of houses, an effective strategy would be to target those who should be blamed if houses collapse, i.e., those who must take responsibility. In order to develop policies to promote retrofitting of houses, consideration should be given to the ability of residents to afford such measures, as well as what kinds of support would make residents decide to invest to strengthen or retrofit their houses. Many people tend to overestimate the cost of retrofitting, so disseminating information on practical and affordable technologies for retrofitting would be important.

A certain number of people understand that their houses are not safe against earthquakes, and are willing to improve housing safety. A strategy targeting such people as a first step for retrofitting would be very effective. In order to motivate residents to retrofit their houses, the probable loss of their house or property should be emphasized in some countries like Indonesia and Pakistan, while the probable damage of their families should be emphasized in some other countries. In risk communication with community people, this should be also taken into account.

In most countries, house builders /masons are confident about the safety of the houses which they constructed although many masons/builders do not know the building codes. In most countries, they do not think that they are responsible for the vulnerability or collapse of the houses they constructed.

Training/education would be effective to enhance the feeling of their moral responsibility and understanding of the building codes.

For many government officers, disaster risk reduction would not be the highest priority, compared with the development of infrastructure or environmental issues. The government officers tend to think that the individuals are responsible for noncompliance with the building codes and the damage or collapse of the houses in case of earthquakes. Again, training/education would be effective to enhance the feeling of their responsibility to develop and enforce the building regulations. The expectation as to which stakeholders can contribute most towards improvement of building safety also differs from country to country, reflecting the local conditions and culture. The policies for earthquake risk reduction should take into consideration such understanding of the government officers.

ACKNOWLEDGMENTS

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REFERENCES

Korel Eraybar, Alper Ilki, Kenji Okazaki, “Seismic Risk Perception in Avcilar”, Proceedings of Turkish Sixth National Conference on Earthquake Engineering, October 2007, Istanbul, Turkey, Vol. 2, p. 41 – p. 51

Kenji Okazaki “Incentives to Encourage Investment in Earthquake Safer Housing”, Proceedings of International Conference on Earthquake Engineering and Disaster Mitigation (ICEEDM08) April 2008, Jakarta, Indonesia, p.47-57

Kenji Okazaki et al, “Seismic Risk Perception of People for Safer Housing” 14th World Conference on Earthquake Engineering, October 12-17, 2008, Beijing

Korel Eraybar, Kenji Okazaki, Alper Ilki “An exploratory study on perceptions of seismic risk and mitigation in two districts of Istanbul” (p 71-92) “Disasters” Volume 34 Issue 1, January 2010

NATURAL DISASTER PREVENTION STRATEGY HANSHIN-AWAJI REGION RECOVERY PROGRAM

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ABSTRACT

Fifteen years have passed since Hanshin-Awaji Region Great Disaster in January 1995. This paper consists of two parts; general work system for disaster protection and its actual cases Hanshin-Awaji Regional Recovery Program. The Disaster Recovery works for Hanshin-Awaji Region gave unique lessons not only to Japan but also the rest of the world.

KEYWORDS
Disaster prevention strategy, emergency relief, risk management, local governments and community residents, volunteers activities, temporally housings, urban polity for sustainable society, Hanshin-Awaji Great Earthquake.

DISASTER PREVENTION STRATEGY

Risk Mitigation

To reduce disaster damages, the legal control is quite effective. For example, revision of building codes by the central government in order to strengthen anti-disaster functions of buildings, houses, urban facilities and infrastructures and upgrade their control standards.

The land use control by the prefectural and local governments is essential to protect buildings and houses from disasters. The risk map against natural and an-made disasters should be prepared by the local government and be shown openly to the general public.

The local government is responsible to take out risky objects and enforce anti-disaster measures to the public buildings and housing. The private enterprises are also asked to strengthen anti-disaster works for their facilities. For private housing, house owners are asked to strengthen anti-disaster functions. Regarding to the old apartments, special repair works would be requested for the short, medium and long terms after disaster occurred.

Risk Preparedness

The Central Government should revise the risk management policies and measures responding to the changing economic and social situations. The special organizations should be set up to execute crucial issues related to the natural disasters. The prefectural government should make the risk management programs and execute them effectively through training necessary staff management. The private enterprises are asked to make the BCP (Business Continuation Program) in relation to disaster management. The community people are requested to take drills for mass evacuation in case of large scale natural disasters. The individuals should check risky goods in their living areas and stock the emergency goods by themselves.

Emergency Response

For emergency response against a great disaster, the prefectural government plays the most crucial roles for emergency relief activities including human life relief and delivery of relief materials. The local government works for delivery of relief materials and building the temporary houses for refugees. The private enterprises collaborate with the relief works through providing necessary personnel, materials and funds. The communities should organize associations to check and revise the recovery plans through participation by local residents.

Recovery Work

The Central Government assists the recovery works such as reconstruction of damaged infrastructure and providing public housing and necessary funds to refugees. The prefectural government executes public works such as providing temporary shelters and housing for refugees and assisting industrial recovery by the private enterprises. The local government is responsible to take care of refugees by providing the temporary housing and assisting the enterprisers to recover their industrial and commercial activities. The private enterprises also collaborate to the public institutions for promoting the recovery works in addition to rebuilding their business functions. The community residents should organize the association to provide the pleasant neighbourhood district through proper support by the public institutions.

HANSHIN-KOBE GREAT DISASTER RICOVERY WORKS

Introduction: Outline of Disasters caused by Hanshin-Awaji Great Earthquake

The Hanshin-Awaji Great Earthquake occurred in the early morning, Jun. 17th 1995 with 7.2 Magnitude. The damages caused by this Great Earthquake were quite serious; 6,401 fatalities and 40,092 persons injured. 316,678 people were caused by evacuated. 104,906 buildings, houses and apartments totally collapsed and 137,289 buildings, houses and apartments were partially destroyed.

Damages		Total	Hyogo Pref.	Kobe city
Human (person)	Dead	6,434	6,401	4,571
	Missing	3	3	2
	Injured	43,792	40,092	14,678
	Evacuees (peek)	320,000	316,678	236,899
Houses (buildings)	Totally collapsed	111,123	104,906	67,421
	(families)	(191,617)	(186,175)	(-)
	Partially collapsed	144,274	137,289	55,145
Emergency Response (buildings)	Publicly dismaintained houses	108,672 (Total 136,730)	87,289	61,392
	Temporary houses	49,800	48,300	32,346

Figure1. Damage of Hanshin-Awaji Earthquake (Total, Hyogo and Kobe)

Emergency relief and recovery measures

After the Earthquake Disaster in Hanshin-Awaji Region, emergency relief activities for the buried alive were conducted immediately for 3 -7 days after the Disaster by the public and private sectors such as local governments, Engineering Corp of the Defence Force dispatched by the Central Government and the private volunteers. The Defence Force was also engaged in clearing activities for highways and roads buried by the broken pierces of destroyed buildings and houses. At the same time, the enterprises including construction companies cleared the roads for emergency services. Around one year after the Great Disaster, the main infrastructures such as roads, railways and urban utilities such as water, electricity, gas and sewage were finally repaired and reconstructed. Thus, the fundamental and comprehensive issues related to rehabilitation were solved in terms of 5 to 7 years after the Great Disaster. Among sufferers, over 1 million persons found difficulties to live in their own houses and 320,000 persons, one-third of the total, evacuated to the public shelters such as the primary and middle schools and the rest of two third sufferers evacuated urgently to the acquaintances, relatives or connections in the companies. At the final stage, over 49,600 emergent temporary houses were constructed by using the open spaces and vacant lands in the reclaimed areas and the suburban areas. There were cases that some temporary houses remained vacant by the unfavourable location problems. Based on these facts, the Hyogo Prefectural Government and Japan Housing Corporation revised the housing scheme to provide a rehabilitation plan for public housing near the stricken areas of the suffered families.

In case of the great natural disasters in the world, especially in the developing countries, the relief works such as medical treatments and food supply were generally executed by the local governments in collaboration with the United Nations and International institutions and volunteers. It was also recognized that in case of the Hanshin Region the private enterprises made prompt responses effectively through non-paid supply of stocked commodities in their storages or shops. Also, lunch and rice balls were urgently made and delivered. Such commodities as blankets and pocket warmers were delivered by air.

	3days	7days	1 ~ 2weeks	1 ~ 3months	after 3 months
Country	Establishment of relief system by Defense Force and Firefighting Agency	Supplying the food, Medical treatment to injured. Disposal of destroyed buildings and houses to clear road.	Provision of emergency road.	Repairing urban utilities (water, electricity, gas and toilet).	Demolition of destroyed buildings and houses including the partially destroyed ones Assistance of Industrial recovery.
Prefecture	Relief work for buried people. Delivery the relief materials and goods,	Supplying the food, Medical treatment to injured. Disposal of destroyed buildings and houses to clear road.		Repairing urban utilities (water, electricity, gas and toilet).	Demolition of destroyed housing including the partially destroyed .Assistance of Industrial recovery
Local Government	Relief work for buried people.	Supplying the food, Medical treatment to injured. Disposal of destroyed buildings and houses to clear road.		Repairing urban utilities (water, electricity, gas and toilet)., Provision of the temporary housing and rehabilitation housings.	Demolition of destroyed housing including the partially destroyed.
Enterprise	Provision of skilled people, goods and fund,	Provision of skilled people, goods and fund, Disposal of the destroyed houses to secure the road.	Provision of skilled people, goods and fund,		Industrial recovery measures.

Figure 2. Emergency relief and recovery measures

1-Importance of Risk Management

It is pointed that the risk management was quite insufficient in case of Hanshin-Awaji Disaster. The Central Government, the Prefectural and Local Governments, other public bodies, the private enterprises and the community residents were unprepared against such Great Earthquake. Especially, the response delay of the Central Government at the early period disclosed the defects by the vertical administration systems and metropolitan disaster rehabilitations measures.

The rehabilitation measures for Hanshin-Awaji Earthquake Disaster were basically executed by the Local Governments whose areas were severely stricken by the Great Earthquake Disaster. In case of difficulty to solve the issues by the Local Governments, the Prefectural Government assisted in collaboration with the Central Government. In case of the Hanshin-Awaji Great Earthquake Disaster, enormous amounts of subsides and supports by the Central Government were provided for rehabilitation works.

2-Two-steps system for district rehabilitation plan initiated by the association of Community Residents

To promote the actual rehabilitation works at the district level, the afflicted residents organized the citizen’s organizations in collaboration with local business associations, co-operative institutions, NPOs and town planning advisers including academic people and the private consultant firms. The recovery works for the disaster stricken areas were quite difficult issues for public and private institutions and associations. Therefore, the two-steps system was adopted for the District Readjustment Plan; the first step was the master plan –making for district rehabilitation by the local government and the second step was the examination of the residential rehabilitation plans in relation to the master plan initiated by the above-mentioned citizen’s organizations with the related associations and institutions. Thus, the revised master plan was presented by the local government to the Prefectural Government for authorization.

3- Education and training

Disaster prevention work needs professional staff in the various fields. Therefore, it is quite important to educate and train them through regular and ad-hoc courses provided in school or in workplace. The community people are also trained how to evacuate the disasters through drill organized by the local government and the fire brigade in their city. The public and private institutions can improve and upgrade the disaster prevention techniques through such mass drill.

4-Volunteers Activities

In case of Hanshin-Awaji Region Great Disaster, volunteers over 1.2 million man-days all over Japan participated in the relief works such as classification and distribution of relief goods and materials, taking care of aged-people and infants though those young volunteers were not generally professional, there were around 200 ~ 300,000 professionals in the fields of housing, building enterprises and business management worked for relief services. Most of them came from the neighboring areas of the Hanshin-Awaji Region. Besides, many prefectural and local governments outside the Hanshin-Awaji Region dispatched their medical experts and administrative staff to the disastered Region. How to effectively organize these professional and general volunteers to the disaster stricken areas was the crucial issue.

5-Temporary Housing

In the Hanshin-Awaji Region, about 40 % of residents who were aged- or injured (handicapped) people used the emergent temporary housing. They had strong demand to remove to the aged-people homes with care services. Today, demands of aged and injured people home are quite strong in big, medium-sized or small cities, towns and villages in Japan.

The emergency temporal houses are generally not so economical. The new types of emergent houses such as trailer houses, log houses, tents should be fully examined. Furthermore, not only physical but also financial measures should be examined. In U.S.A, the rent-subsidy coupon tickets are issued by the public authorities to the suffered families who look for the existing residential facilities instead of the temporary houses.

6- Urban Policy for Sustainable Society

The lessons gained by the Hanshin-Awaji Great Disaster are directed not only to issues related to physical matters but also social, economic, political and administrative systems in Japan. In particular, urban policy should be directed to the formation of sustainable society.

a) Preference of environmental preservation and stopping the fatal environmental destruction, Water-front area is often occupied by Port and business facilities. At the same time, there are the extra areas used for citizen's recreation activities. It is strongly recommended that Kobe City Government implements "Kobe Cultural City Plan" adjacent to Kobe Port,

b) To stop the enlargement and expansion of metropolis, to promote self-independence of satellite towns and to attract the population to the inner-cities where traffic movement is minimized as few as possible. Reduce the urban traffic by private cars and encourage public transportation,

c) Secure the open space such as forest, agricultural land, parks, especially green land.

Hyogo Prefectural Government's Recovery Programs

The basic concepts for the recovery program for Hanshin-Awaji Great Earthquake were directed to the following 3 objectives:
a) Promotion of welfare, culture and industry,
b) Promotion of security and safety,
c) Formation of Netted Multi-Nuclear-Cities.

Five or six action plans were formulated to each of these objectives. These action plans were designated for the short term (3 years) and the medium term (10 years) and recovery of the infrastructure and housings were taken as the major objectives.

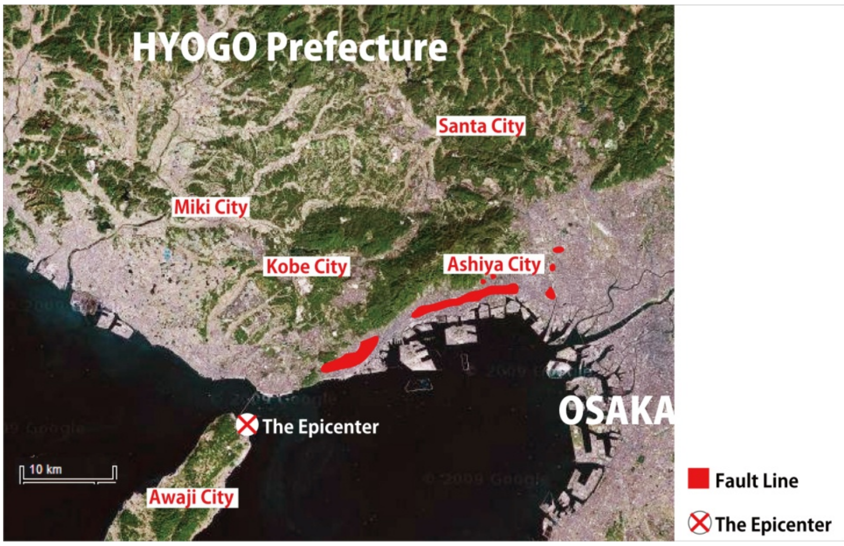


Figure 3. Epicenter and Fault Line of Hanshin-Awaji Great Earthquake

These basic objectives are generally undertaken by not only Hyogo Prefectural Government but also other Local Governments. The most important item is how to select the action plans for provision of the infrastructures and formation of Network of the Multi-Nuclear-Cities and how to execute them based on the rehabilitation plan of the Hyogo Prefectural Government.

1- East and West Harima areas - East Harima Information Park City in Miki and West Harima Technopolis in Kouto area

Hyogo Prefectural Government made a unique strategy to mobilize the East Harima Information Park City (fig.4) and West Harima Technopolis with the object of constructing the large-scale emergency relief bases. In the Information Park City, 3 dimensional full-scale earthquake testing facilities were constructed in January, 2005. Hyogo Prefectural Government also worked for developing further “West Harima Technopolis” in Kouto area where Hyogo Prefectural University’s Science Department and Prefectural Support Center for the most Advanced Science and Technology are located.

Figure 4. East Harima Information Park City

Kobe City Recovery Program

Regarding to the recovery plan for Kobe City, the biggest issue was reconstruction of the disaster districts in the urban built-up areas where took linier development pattern with the North East- South West Axis formed by the three railway lines; JR (public), Hanshin and Hankyu lines(private). The built-up area is bounded by the “Rokko Mt.” in the north east and the seaside area including Kobe Port and three Islands in the south west. The rehabilitation strategies for the built-up areas were focused on the main stations’ quarters of the above-mentioned 3 railway lines. For instance, the area around

"Sannomia" Station of JR line is located in the main C.B.D (Central Business District) of Kobe-Hanshin Region and the area around "Nishinomiya" Station of JR and Hanshin lines and the area around "Shinnagata" Station of JR line in the western part also located in the subordinate C.B.D. and other areas around the middle and small sized stations of 3 lines among these main stations formulated the rehabilitation core points. As for the development of new Nuclear City District, the following four areas were selected;

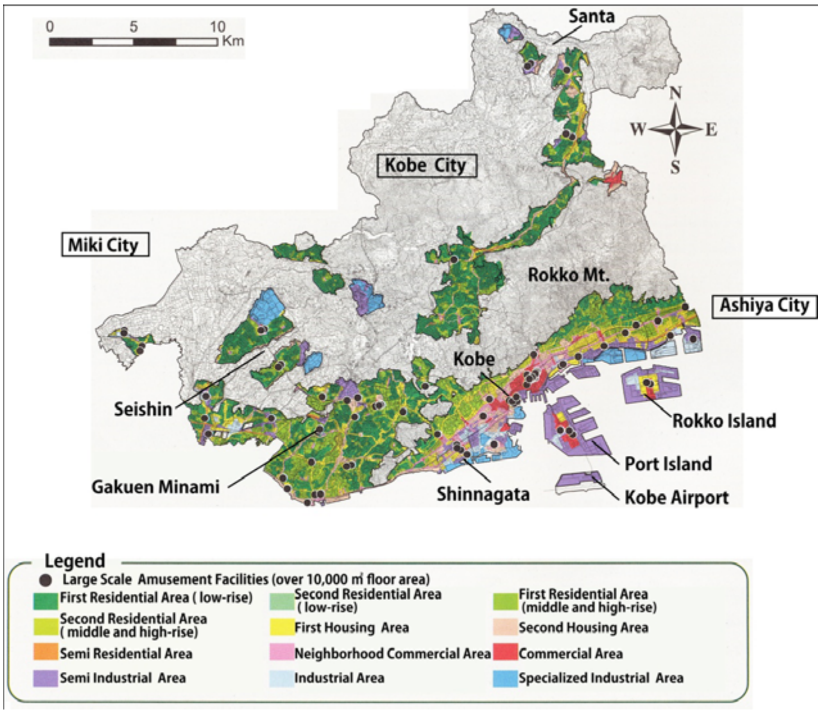


Figure 5. Kobe City Land Use Map

1- Seaside areas- New Core City in the north eastern Kobe, Marine city, "Port Island (2nd term) ", "Rokko Island", and New Air Port Island

a) New Core City; Kobe New north-eastern City Center represents vigorous activities undertaken by the public and private institutions after the Great Earthquake; new construction of the high-storied public housing, Comprehensive Medical Center, Prefectural Museum of Art and International Co-operation Center which accommodates Asia Disaster Reduction Center and UNCRD (United Nations Center for Regional Development) Hyogo Office. This district is quite unique by accommodating various functions. The "Meriken Park" is located to the south western side of Kobe Port. In January 2010, Kobe Disaster Recovery Memorial Park was opened in this area. The destroyed piers and banks by the Great Disaster were preserved for the memorial purpose in the park.

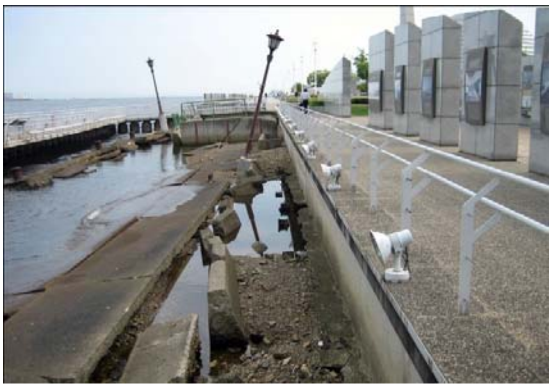


Figure 6. Destroyed piers and banks preserved in "Meriken Park"

b) Port Island; The Construction of Port Island was started in 1966 initiated by Mayor T. Miyazaki and was completed in 1981 with the total area of 436 ha. The second construction work of the Port Island took 9 years (1987 to 2005) with the total area of 390 ha through strong support by Mayor S. Sasayama, successor of Mr. T. Miyazaki. After the Great Disaster in 1995, Kobe City Government made a plan to develop the second construction district as the Comprehensive Medical Centers and redevelop the berths area in the eastern part of the first construction district for inviting 4 universities' departments.

c) Rokko Island; Rokko Island was constructed by reclaiming the coastal area of 131 ha near the Kobe Port. It took 20 years to complete the work and was opened in September 1992. Rokko Island City aims at the City of Information Technology with internationalization activities. At the same time, the City provides better living environment for the aged-people. Ample recreation facilities for old and young people are also provided by the public and private institutions. There are two international schools opened to both Japanese and foreign students.

d) New Air Port Island; The Kobe Air Port construction plan was made by Ministry of Transport in May 1969. Unfortunately, the noise problem caused by airplanes was a big issue in 1970s and the Kobe City Assembly rejected the Ministry's proposal. However, the situation changed in 1980s and Kobe City Assembly endorsed the Air Port construction plan in May 1982. After the Great Earthquake Disaster, Kobe Air Port Construction Plan was included in the Kobe Recovery Plan in May 1995 and the construction work to reclaim the area of 272 ha was started in September 1999. The Air Port was finally opened in February 2006. Today, Kobe Air Port is still a small air port with one runway of 2500 m. However, it is expected in future, this air port will be one of the main air ports in Japan because of its favorable location.

2- Inland areas- "Ashiya" city

Figure 7. Collapsed houses in "Ashiya"

Figure 8. Recovery Park in "Ashiya"

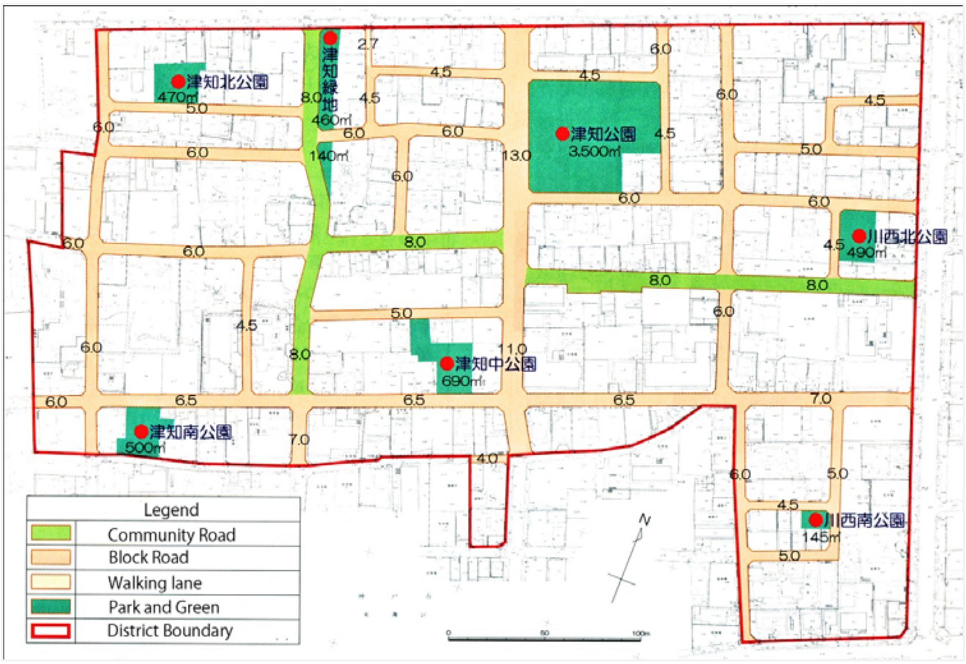


Figure 9. Recovery Plan for "Ashiya"

The inner areas in Hanshin Region are occupied by the small wooden houses, which were heavily destroyed and damaged by the Great Earthquake and the successive big fire. How to rebuild them was one of the big issues in the Hanshin and Kobe recovery measures. The existing urban land readjustment technique was completely revised by the requests of community residents' associations. They discussed and examined thoroughly the plan proposals prepared by the local governments.

"Ashiya" city, one of the cities in the Hanshin-Awaji Region with population of 80 thousands and the total area of 17.3 k ㎡ was well known as the good residential areas occupied by the number of high and middle income families houses. "Ashiya" city was heavily damaged by the Great Earthquake; 427 fatalities and 4,722-houses and apartment units were totally destroyed and 4,060 houses and apartment units were partially destroyed. "Ashiya" City Government worked hard to reconstruct its disaster areas. The Urban Land Readjustment Technique was taken to rebuild and redevelop their disaster districts. The main reconstruction works were executed to widen narrow streets and build public rehabilitation housing and small parks and green.

3- Awaji area- Awaji Island International Park City

Awaji International Park City was constructed by Hyogo Prefectural Government in collaboration with Ministry of Construction, Park and Green Division after the Great Disaster. "Awaji Yumebutai (Dream Stage)" provides the main cultural and resort facilities designed by architect T. Ando in March 2003, where is located in the "Awaji Park" occupying about 28 ha. Mr. Ando designed a quite unique park accommodating the international hotel, the botanical garden and the outside theater in the area. This park is really a symbol of recovery to the Great Earthquake. This international park was built by converting the devastated areas stricken by Hanshin-Awaji Great Earthquake. The area was selected to develop a new urban nuclear-city.

Figure 10. "Awaji Yumebutai" designed by Tadao Ando

CONCLUSIONS

The counter-measures and rehabilitation activities against Hanshin-Awaji Great Disaster have been significantly executed and development of information technology has contributed greatly in reducing the human victims and destroyed infrastructures and buildings.
We could learn greatly from the Hanshin-Awaji Rehabilitation activities. Some lessons are as follows;

1- Warning announcement system

In Japan, the Mythological Agency is responsible to promptly announce the Risk Scale and Degree of Natural Disasters when they occurred and the N.H.K transmits these news to the general public through television, video and I.T. There has been great progress of warning announcement system through positive collaboration of risk management activities undertaken by both the public and private institutions.

2- Use of Defense Force

It is the good news that Japanese Government quickly mobilized the Defense Force to the Great Disasters in Haiti in February, 2010. The Central Government sent the Engineers Corps of Defense

Force numbering 350 persons for 10 months to Port au-Prince, Haiti. Their tasks are; assist recovery works such as removal of rubbles caused by demolished buildings and houses and repair the broken roads and drainages in the cities including Port au-Prince. In Turkey, the Ministry of Army worked effectively for dispatching the defense forces for relief works including provision of military tents after the Great Earthquake in 1997. It should be clearly recognized that importance of international collaboration for emergent relief activities to the disaster stricken countries.

3- Disaster Risk Management

Within a few weeks after Hanshin-Awaji Great Disaster, the Prefectural Government and the local governments in collaboration with over 800,000 people organized the special task forces for disaster management. These organizations were set up to strengthen the disaster management system. Also the education sector's activities related to research and training on rehabilitation activities against the Hanshin-Awaji Great Disaster are expected to contribute enormously in reducing disaster damages in future.

4 -Earthquake Disaster Insurance System

To execute the recovery plans against a big disaster costs enormously. Therefore, financial measures to cope with the great disaster should be properly examined by both the public and private sectors. The counter-disaster insurance system has been gradually adopted by the developed countries including Japan. In order to promote the disaster insurance system, more favorable financial measures should be taken by the government and institutions concerned.

5- Special Economic Zone and Industrial Development Policy

In case of Hanshin-Awaji Great Disaster, the central government rejected the proposal for the special economic zones submitted by Hyogo Prefectural Government in early 2000. However, the Area Vitalization Plan and the Special Zones for Economic Structure Reform were authorized by the Central Government in 2006. It is greatly acknowledged that the rehabilitation activities in the Hanshin-Awaji Region undertaken by the public and private institutions and the local communities contributed greatly in promoting disaster management measures and furthermore, the new direction for economic and social sectors such as establishment of the special economic zone and the community participation in regional and city development planning should be encouraged. The economic activities give crucial impacts on the public and private sectors. Therefore, the industrial development policy should be carefully formulated to cope with the hard international trade competition in the world.

6- New Direction

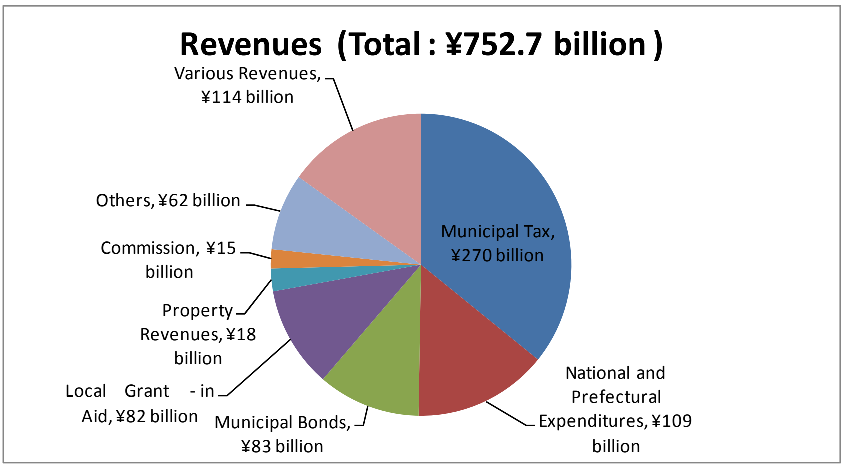
It is essential that the Central Government collects promptly information for the disaster-afflicted areas and sets the emergency relief action plans including dispatch of the Defense Force and Medical Staff to relief and rehabilitation works abroad.

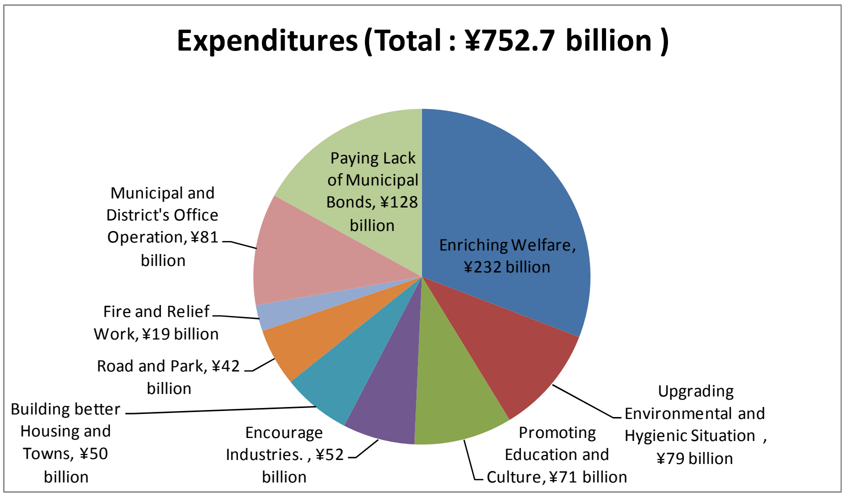
The prefectural and local government systems in Japan have made a significant contribution in economic and social development since the Meiji Restoration in 1868. Today, Japan has entered into the new era in relation to population structure; more aged-people and less children year by year. We didn't fully recognize the grave impacts caused by the significant change of the population. The slogan such as "City of Safety and Security" advocated by Hyogo Prefectural Government and the local governments in Hanshin-Awaji Region was very popular until 10 years or so after the Great Disaster. Later, the situations changed. Today, the local people in general have more keen concerns with the future generation of Japan and Hatoyama Government is positively promoting the reform of political and administrative systems to overcome the economic and social issues such as economic depression and unemployment in Japan.

The globalization of economic activities is clearly recognized all over the world. It is a crucial issue for both developed and developing countries how to co-ordinate social systems in economic system. The Natural Disaster Management is a good subject to promote international collaboration by both developed and developing countries.

Appendix

Kobe City Budget in 2009





Total Damaged Amounts directly caused by Hanshin- Awaji Great Disaster	
Item	Amounts
Buildings	about 5,800,000,000,000
Railways	about 343,900,000,000
Expressways	about 550,000,000,000
Public Facilities related to Civil Engineering(except Expressways)	about 296,100,000,000
Port	about 1,000,000,000,000
Reclaimed Land	about 6,400,000,000
Education Facilities	about 335,200,000,000
Forestry and Fishery	about 118,100,000,000
Health, Medical and Welfare Facilities	about 173,300,000,000
Sewage Facilities	about 4,400,000,000
Running Water Facilities	about 54,100,000,000
Gas and Electricity	about 420,000,000,000
Communication and Broadcasting Facilities	about 120,200,000,000
Commerce and Industries	about 630,000,000,000
Other Public Facilities	about 75,100,000,000
Total (Estimated by Hyogo Prefectural Government)	about 9,926,800,000,000

COMPULSORY EARTHQUAKE INSURANCE SYSTEMS IN TURKEY AND THE WORLD

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ABSTRACT

After the 17 August 1999 Kocaeli Earthquake the resource needed from the huge damage in houses forced the limits of Turkey and it is required to establish an off-budget guaranty system. It is also obvious that in the future it is necessary to immediately stop the increase of foreign-source dependency; **DASK** (**D**oğal **A**fet **S**igorta **K**urumu - Foundation of Natural Hazard **I**nsurance) is established even though 147 countries scanned regarding the compulsory insurances implementations and any system similar to DASK is not found. The possibilities of the next epicenter of the earthquake will be the Sea of Marmara, and the heavily damaged region will be Istanbul led an anxiety about the fact that the economic loss will hardly be compensated even with foreign aids; the amount of resource need is clearly calculated after the loss assessment. Regarding the examined data, here we have come into conclusion that estimating the possible number of damaged estates as equal to 213.850, which the number of damaged estates in 17 August Earthquake, will be an optimistic approach. The optimistic scenario of amount of loss calculated is 1.973.000, 00 EUR. In order to have little bit of improvement in this situation, the compulsory insurance is required. The state can participate in insurance works, can leave it to the private businesses and only control it, or can carry on both of these implementations. It is estimated that the loss amount of expected Marmara Earthquake calculated with a most optimistic scenario will be greater than the capacity of compulsory earthquake insurance fund.

KEYWORDS
Damage, Earthquake Insurance, Seismic Hazard, DASK

INTRODUCTION

General conditions of Turkish Insurance are formed according to those in developed countries. Because of the geological and general situation, some additional coverage is then included. Generally, the insurance regulations are developed in accordance with the one in England. The formation of earthquake insurance business is started with the fact that earthquake guaranty is given as an addendum to the fire insurance policies.

It is obvious that the insurance awareness is so low in the community and that insurance guaranty need is on the bottom of the people's necessity list. In order to have little bit of improvement in this situation, the compulsory insurance is required in Turkey today and it can be seen that only 10 % of the risks available to be insured have already been insured. In other words, it is seen that a very little part of the current potential can be used.

The state can participate in insurance works, can leave it to the private businesses and only control it, or can carry on both of these implementations.

The most common system in the world is that state's performing this service by establishing a separated control mechanism. The issue that distinguishes DASK from other classical implementations is the fact that its business has been handed over to a private company with a tender. One of the most important problems of insurance business in Turkey is the fact that the insurance concept has not become popular among community and that the need for insurance is not felt enough. Last earthquakes have had this situation gain a converse acceleration. Insurance is directly related to the education level of the society. It can be seen that in countries where level of education and income is higher, the insurance is so common and is progressing day by day.

In the recent years, the insurance advertisements in radio, television and media broadcasts have been effective in arousing insurance consciousness in people. Especially because of the loss occurred after the 17 August and 12 November Earthquakes, the compulsory earthquake insurance has gained importance.

THE CASES OF EARTHQUAKE IMPLEMENTATIONS AROUND THE WORLD AND AN OVERVIEW TO TURKISIH IMPLEMENTATIONS FROM FOREIGN SOURCES

An Evaluation of Compulsory Insurances

147 countries are scanned regarding the compulsory insurances implementations. It is searched whether the earthquake insurance in these countries are compulsory or not.
Any system similar to DASK implementation in Turkey is not found and it is only seen that it is compulsory to include earthquake insurance coverage in the fire insurance policy in New Zealand.
Although the results of this study is like we have mentioned, the information published in the official website of DASK is like the one stated below, and it is thought that there is a need for referring to this information in this article.

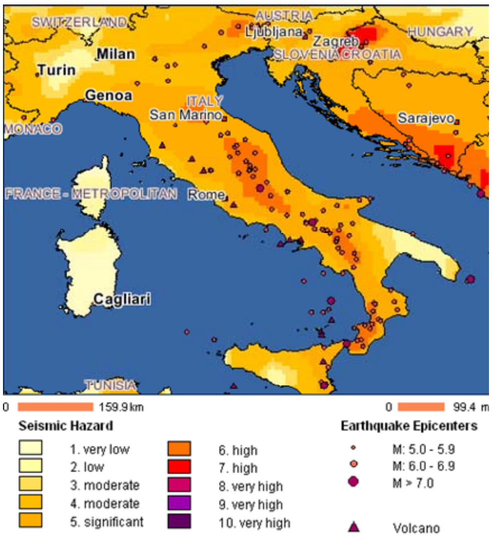

Figure 1: Earthquake Risk Map of Italy.

Italy

As it is shown in Fig.1, despite of the potential risk, the earthquake coverage is not sold that much in Italy. This coverage is usually suggested only to the commercial and industrial insured and it is estimated that the 30 % of the risks is covered. There are no pool or disaster funds in the country.

United States of America

The percentage of house holders, who had Housing insurance, is high. According to the research conducted by Insurance Research Council in 1998, 96 % of the house owners around country had standard insurance policy.

CEA-California Earthquake Authority:
The CEA is established in 1994 as a result of the fact that the private insurance companies in California avoided presenting earthquake coverage after 1994 Northridge Earthquake in order to present earthquake coverage for estates. The CEA is not only a public institution but also is financed by the private funds excluded tax like DASK. Still, about 70 % of earthquake coverage for estates in California is presented by CEA.

Also, although the insurance business is not so greater than the one we have, as addition to the market mechanism there are some other systems in developed countries regarding the natural disasters, except earthquakes, which are formed by public usually after huge natural disasters. The

Japan earthquake Reassurance Company (JER), USA National Flooding Insurance Program (NFIP) and French Natural Disasters Compensation Program can be considered as examples for this case.

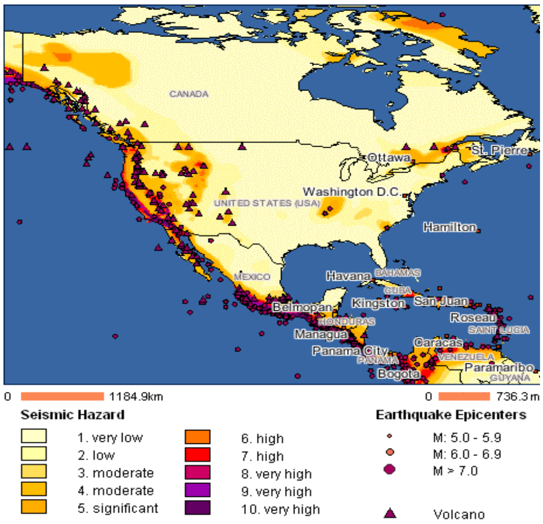

Figure 2: Earthquake Risk Map of the USA.

According to the DASK sources, there is a compulsory implementation in California State. As it is exhibited in Fig.2, earthquake risk is high in western part of USA; each state needs to prepare its own disaster plan by using the provided funds.

Japan

As it is shown in Fig.3, Japan is highly active as a one of the earthquake prone country, the earthquake risks of the houses insured by the insurance companies are reinsured only by the Japan Earthquake Reinsurance Company and shared with the Japanese Government.

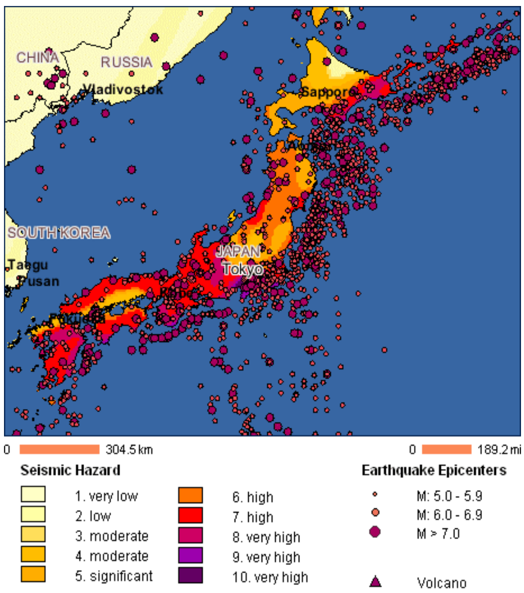

Figure 3: Earthquake Risk Map of Japan.

NZEQC-New Zealand Earthquake Commission:
EQC which is established as a fund after the huge earthquake disaster in 1941 and which got its current form as an independent public institution in 1993 presents precisely housing oriented insurance coverage especially for earthquake and then for other natural disasters. Likewise in Turkey, the insurance companies selling the fire insurance for estates have to give the earthquake coverage that provides a limited compensation. EQC is the only institution that provides earthquake coverage for estates in New Zealand.

Before the regulations about compulsory earthquake insurance are made, its other implementations in developed countries, especially those in USA-California and New Zealand whose earthquake risks are similar to Turkey , have been examined in detail and the best system in accordance with the conditions in Turkey is aimed to be formed

Overview to Turkey from Foreign Sources

Although the buildings constructed in accordance with the last regulations give a feeling of being safe for earthquake, the insurance companies do not see the buildings had constructed before 1999 different than the new ones and apply the same policy conditions for all of them due to the highly active earthquake zones shown in Fig.4. At the end of 2004, two million flats are insured, and there is a huge difference between this amount and the aimed 10 million, and the total number of houses in the country.

Government's statements about the fact that they would help house holders who do not have insurance financially interrupt the DASK to become widespread.

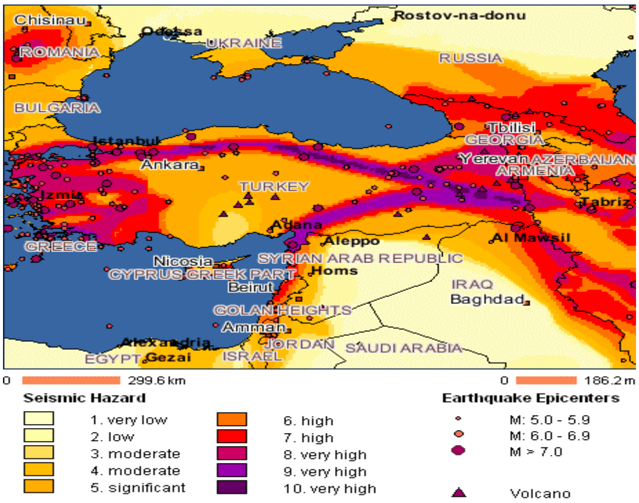

Figure 4: Earthquake Risk Map of Turkey.

THE FORMATION OF DASK AND ITS LEGAL BASIS

The formation of DASK

17 August 1999 is a kind of turning point since it caused an enormous loss of lives and damage on an area, as shown in Fig. 5 which is financially seen as the heart of the country. The resource need resulted from the damage in houses forced the limits of state and had it get foreign help.

After the earthquake, there are serious problems in firstly searching-rescuing and providing services and then in meeting the need for shelter and providing food aids. The earthquake led not only the physical and psychological health problems and financial troubles but also caused problems, such as unemployment and immigration, those would take the issue from regional problem to countrywide social problems.

The complaints of people, whose houses had damaged in the earthquake, about the compensatory damages' being limited with the budged opportunities and economic crisis produced the need to establish a concrete assurance system that has no relation with state's budget opportunities.

The most important factors that enable the formation of the DASK are the facts that the financial aids that would console citizens after the psychological breakdown of earthquake could not be provided soon and accurately, the size of possible resource need is so large and this resource need pushed the limits of the state and required it to get foreign help.

When we look at the features of house stocks in terms of seismicity of Turkey, it is obvious that it is necessary to prevent the increase in foreign-source dependency. Düzce Earthquake occurred in November 12, soon after the 17 August Earthquake, highlighted the need for handling this subject immediately.

The possibilities of the next epicenter of the earthquake will be the Sea of Marmara, and the heavily damaged region will be Istanbul led an anxiety about the fact that the economic loss will hardly be compensated even with foreign aids.

Figure 5: Earthquake 1999 Gölcük / Turkey

The amount of resource need is clearly calculated after the loss assessment

The studies conducted in the scope of World Bank project by Turkish Prime Ministry Undersecretaries of Treasury Insurance Directorate General and covering the examination of its implementations in various countries are accelerated after 17 August 1999 Marmara Earthquake and end up with the formation of DASK. The new insurance system, at this stage, only covers earthquake within natural disasters and bears qualification of being compulsory.

The Compulsory Earthquake Insurance implementation is got off the ground in September 27, 2000. in respect of geological location, since Turkey, one of the earthquake prone country is laid on the Alpine-Himalayan seismic belt. In the circumstances, it is necessary to perceive the fact of earthquake as a reality and as a national problem that we have to learn how to live together, and to determine what can be done for this case in terms of insurance business.

The main proposes of DASK can be stated as to get all houses covered by Compulsory Earthquake Insurance (CEI) under insurance coverage in exchange for a payable amount of premiums, decrease the state's economic burden arising from the earthquakes, enabling risks sharing as a means of insurance, utilizing from insurance system to construct healthy buildings, providing the long term resource savings n order to compensate the earthquake loss.

With this insurance, the financial damages on the buildings and on their foundations (including fire, explosion, landslide occurred because of earthquake) that would directly arise from the earthquake are guaranteed amounting with the sum insured.

The financial resources of Natural Disasters Insurance Association and Compulsory Earthquake Insurance basically consist of three factors. These are the gathered premiums, reassurance conservation, and finance that will be obtained from World Bank in case of damage. Among these resources, the most important item is the "reassurance conservation" that can be obtained from the international reassures.

The independent parts included in law of property ownership with law no. 634, buildings constructed as a housing on the real estates that are registered to land register and that are subject to exclusive properties, businesses, offices, and other independent parts used for the similar proposes, and also estates constructed by state or thanks to the given loans because of the natural disasters are subject to the compulsory earthquake insurance.

The buildings belong to public institutions and constructed on the village build-up areas are not subject to the compulsory earthquake insurance within the scope of this Decree law.

The compulsory earthquake insurance policy is taken out by the property owners or, if available, by beneficial owners for the independent parts and buildings covered in this decree law.

The compulsory earthquake insurance policy has to be taken out in a month beginning from getting occupancy permit or living inside of the independent parts and buildings that will be constructed as housing after the promulgation of this decree law on condition to get construction permit within the frame of applicable legislation.

Those who have to take out the insurance are determined by the Association. During this process, the Association utilizes the records of related governorate or municipality and real estate registration office. The public institutions do not transact anything, including land registration works, related to the buildings subject to the insurance unless there is evidence for their insurance has been taken out and premiums have been paid.

The Association obtains enough conservation from reassurance, capital and similar markets by considering its total obligations arising from the insurance and its resources in accordance with the requirements of insurance business. However, if the insured loss is higher than the expected amount and than the capacity of Association resources and the obtained conservation amount, the loss will be compensated according to the proportion of sum of Association resources and conservation amount to total compensation amount required in compulsory insurance.

Recently, the rate of number of policies made for DASK in comparison with the total number of houses in Turkey is about 20 %.

The information obtained from the DASK sources in 2006
Even though the direct obligations are used during the process of making natural disasters insurances as compulsory, the preferred methods are generally indirect obligations. The most basic example is the fact that if the some insurance policies stated in the law is bought, then some other coverage related to the natural disaster risks have to be bought.

This implementation is generally used in the countries where the insurance business sector has already well developed and where the main insurance policies that will make the compulsory natural disaster coverage be bought have high selling rates. New Zealand, France, Spain, Norway and Sweden can be stated as examples for case.

<u>The indirect compulsion mechanism can be operated in reverse direction.</u> For example, there is an obligation for insurance companies in California to give earthquake coverage in the appendix of the home insurance policies.

However, this obligation is only limited with the insurance companies and this implementation is not something that can be seen frequently.

Whether the obligation is direct or indirect, almost in all countries where there is a national sized implementation of compulsory disaster insurance, various institutions are organized by the public authority. These institutions can both serve as a reassurance company, such as Japanese Earthquake Reassurance Company (JER), and serve as an insurance company such as Consorcio de Compensacion in Spain or DASK in Turkey.

There is not any other implementation in the world similar to DASK. Of course, its being the first one does not mean that it is defective. Maybe, a system that will serve as a model for the world has been out into practice in Turkey. The most important thing in this case is that the reliability of the system can be proved after a huge earthquake. For this strengthening the system and enabling it to be active are so important. Otherwise, people's leaning towards a similar implementation in the future and participating in it will become difficult.

COST OF THE DAMAGES DUE TO THE RECENTLY OCCURRED EARTHQUAKES IN TURKEY

According to the official information gathered from Ministry of Public Works about how much the state spent for the compensation of the damages in Erzincan, Dinar and Ceyhan Earthquakes as a recently occurred big earthquakes in Turkey is evaluated and the data updated according to the inflation rates of the last year are stated below.

1992 Erzincan Earthquake
The amount of expenditure by the state after the earthquake is 1.415.367,00 TL. The updated amount based on the current inflation is 484.525.515,00 TL and its equivalent in European Union sort of money calculated over the current exchange rate is approximately 294.000.000,00 EUR.

1995 Dinar Earthquake
The amount of expenditure by the state after the earthquake is 10.750.000,00 TL. The updated amount based on the current inflation is 604.558.500,00 TL and its equivalent in European Union sort of money calculated over the current exchange rate is approximately 366.000.000,00 EUR.

1998 Ceyhan Earthquake
The amount of expenditure by the state after the earthquake is 18.353.297,00 TL. The updated amount based on the current inflation is 170.208.476,00 TL and its equivalent in European Union sort of money calculated over the current exchange rate is approximately 103.150.000,00 EUR.

August 17, 1999 Marmara Earthquake
Estate Damage Situation
In a publication prepared by National Reassurance INC by considering the data of Prime Ministry Crisis Management Counter, it is stated that after 17 August 1999 Earthquake in the region affected by the earthquake there are 213.850 damaged estates in total including 66.441 heavily damaged, 67.249 moderate damaged and 80.160 slightly damaged. Although different data can be found in different resources, in the report prepared by Turkish Earthquake Foundation in June 2000 very similar numbers are seen. (In total 210.967,00 damaged estate including 66.032 heavily damaged, 66.155 moderate damage, 78.780 slightly damaged)

The suggested loss by the insurance companies is low because of the exemption and joint insurance implementations. In response to damage files over a number of 15.000, there is loss that is paid and expected to be paid only for about 570.000.000,00 USD (Approximately 420.000.000,00 EUR). In this case, the proportion of the number of damage files to number of damaged houses is about 7 %.

November 12, 1999 Earthquake
The number of buildings that are immediately needed to be pulled down after the earthquake is determined as 3.395. Also, 12.939 buildings and 2.450 workplaces broken down or heavily damaged are determined. The loss compensated by the insurance companies is estimated as about 50.000.000,00 USD (approximately 37.000.000,00 EUR) including over 1.700 damage files. In this case, the proportion of the number of damage files to number of damaged houses is about 13 %. If the same rate will be considered for the 17 August Earthquake which occurred just before this one is 7 %, it can make us think that the disaster occurred after 17 August earthquake increased the number of insured houses in the region affected by the 12 November Earthquake.

EXPECTED MARMARA REGION EARTHQUAKE AND THE ESTIMATED AMOUNT OF ESTATE DAMAGE

Damage Parameters

It is an expected situation that the earthquake will result in a huge demolition. In order to analyze the size of this demolition in terms of different viewpoints, many scientific researchers have been conducted and presented to the public. The issue that will be handled in this study is how to compensate the financial requirements of the permanent sheltering needs that will be arise after re-construction of the heavily damaged buildings by being pulled down and repair of the medial damaged buildings.

The thing required to be done before finding the pecuniary resource is to determine the estimated damage amount that might arise from earthquake. For this purpose, firstly the expenditures of the state for the previous are examined. The regions effected by previous earthquakes (Erzincan, Dinar and Ceyhan) is not seen so appropriate to be used as a base because of the huge differences between these regions and the region estimated to be effected by the expected Marmara Earthquake in terms of not only population density and housing, but also economic structure.

Then, the data gathered about two big earthquake occurred in Marmara Region in 1999 is examined in terms of the insurance sector. The fact that the rates of damaged estates and the files opened by the insurance companies in the regions are so low (7 – 13 %) has made us think that using this data as a base for estimated loss amount will not be appropriate.

The industrial damages in the 17 August Earthquake are also examined because the epicenter of this earthquake is close to the one of the expected Marmara earthquake. It is known that industrial structures are ones that got more engineering service. The damages occurred in commercial and industrial businesses consist of different dimensions like machines, merchandise, job loss etc. And because most of the time the damages excluding building are greater than the damages of building itself, it is thought that an approach to determine an estimated loss amount for estates by considering the industrial damages data may produce a greater value than the expected loss amount.

An absolute data about the damage occurred in estates and compensated by the insurance companies in 17 August 1999 Earthquake. In addition, it is known that there are some implementations effecting compensated damages like joint insurance, exemption, under insurance negatively.

It is thought that it would be more realistic to make an evaluation by considering the DASK legislations and criteria for damage calculation while the possible amount of loss that DASK has to pay is being calculated. That's why, the assumptions stated below is done.

The number of damaged estates

In order to determine the number of damaged estates, firstly it is necessary to determine the region that will be affected most by the expected earthquake. When it will be examined thorough the maps of the fault lines in the Sea of Marmara, in Fig.6 and its coast which are broken in the previous earthquakes, it can be seen that there is a high possibility for a new broke on the Northern Anatolia Fault Line between offshore waters of Mürefte and İzmit Bay, in Fig.7.

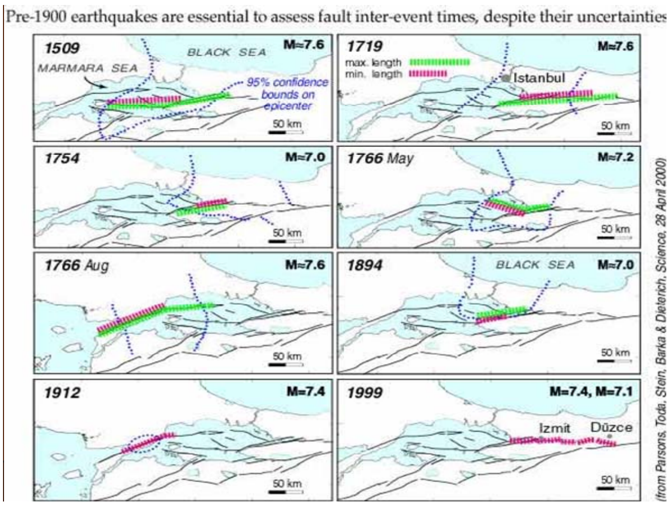

Figure 6: Chronology of earthquakes occurred in The Marmara Sea.

Of course, the structure of this fault line and breaking type will determine the possible effects of the earthquake. However, the thing seen in these maps is that the coasts of Marmara will be the first region affected from the earthquake.

Figure 7: North Anatolian Fault Zone

In a publish of Istanbul Branch Office Chamber of Construction Engineers, the biggest ground accelerations that will be arise with the possible earthquake scenario, in Fig.8 and, accordingly, the diffusion of the intensity are examined in Fig.9.

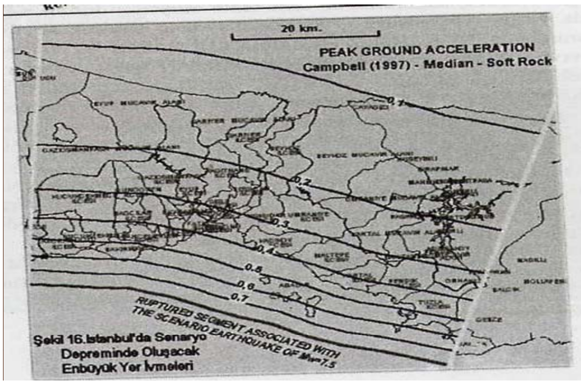

Figure 8: Scenario Eartquake Ground Accelaration Map for Istanbul

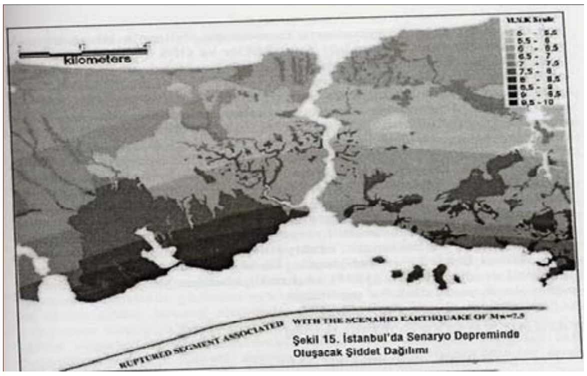

Figure 9: Scenario Earthquake Intensity Map for Istanbul

If these maps are matched with the maps of population density and reinforced concrete building intensity, the region between the Büyükçekmece Lake in European side of Istanbul and Bosporus will be affected by the earthquake decreasingly toward northwest direction, in Fig.10,11.

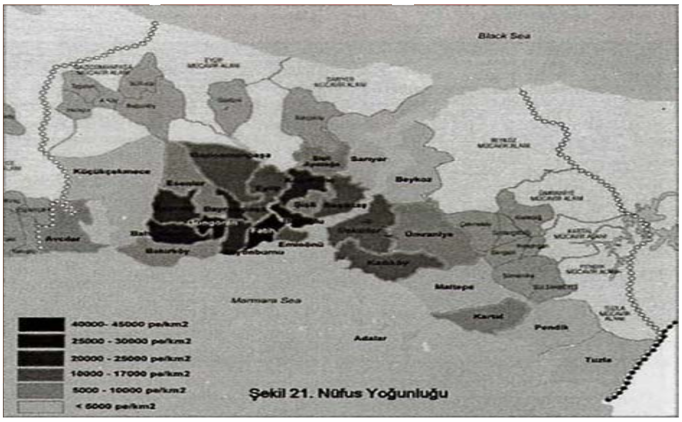

Figure 10: Population Map of Istanbul

It should not be overlooked that in this region, Avcılar County, there are 1736 heavily damaged, 5061 moderate damaged and 3621 slightly damaged estates. The expected earthquake will probably affect Avcılar from a closer epicenter than the one in 1999.

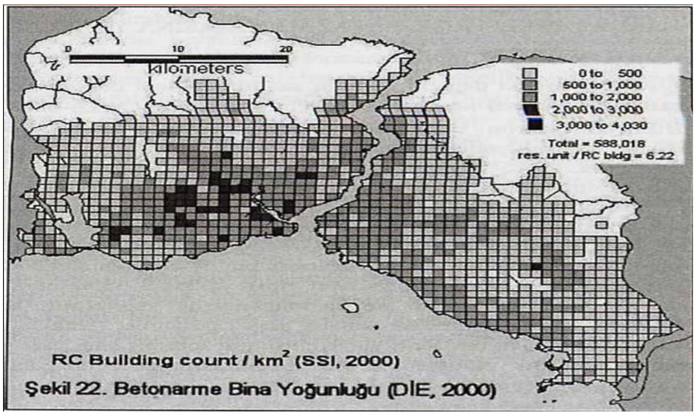

Figure 11: Building Map of Istanbul

In the earthquake report prepared by Istanbul Metropolitan Municipality and published in its official website, the map of the fire risk, in Fig.12 and the possible roads that may be closed because of the demolished buildings have been also presented.

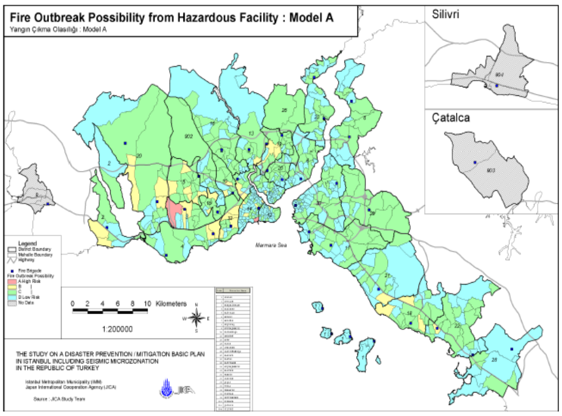

Figure 12: Fire Possibility Map of Istanbul for the scenario earthquake

Because DASK will compensate the fire loss that will arise from the earthquake, the risk map is a significant data. However, in order to prepare an estimated loss analyze with the most optimistic scenario, we will consider the possible damage that may arise only from the earthquake. In other words, the regions showed in the road risk map are those have highest possibility to be damaged after the expected earthquake, in Fig.13.

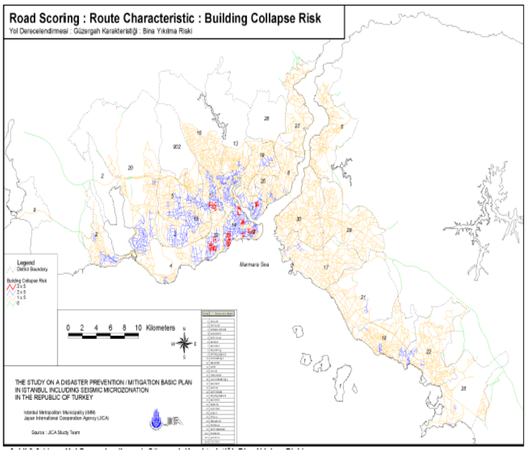

Figure 13: Building Collapse Risk Map of Istanbul for the scenario earthquake

When other maps are matched with the result of the research, again the same result stands out. Istanbul's region that has most intensive reinforced concrete structuring is the one expected to be affected and damaged from the earthquake primarily.

Instead of considering the expected effects of the earthquake on Istanbul, it is essentially necessary to consider its effects on Marmara Region. According to the risk map (Marmara Risks Map/Le Pichon) prepared as a result of a study conducted for this purpose, in Fig.14, the regions that had damaged estates in 17 August 1999 earthquake are still at risk for the expected Marmara earthquake. In addition, because it is expected that the epicenter of the earthquake will shift towards the inside of the Sea of Marmara, the regions from the Coasts of Marmara towards the inward of the land, including the coastline between Istanbul and Tekirdağ, and beyond Tekirdağ to the direction of Gelibolu Peninsula, are at risk.

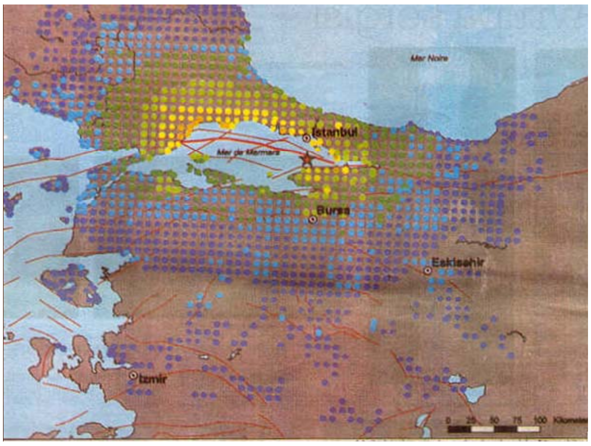

Figure 14: Risk Map of the Marmara region for the scenario earthquake.

Regarding the examined data, here we have come into conclusion that estimating the possible number of damaged estates as equal to 213.850, which the number of damaged estates in 17 August 1999 Earthquake, will be an optimistic approach. According to the evaluations of Istanbul Governorate, the licensed estates in Istanbul is 850.000, the number of estates became legal with the remission of reconstruction is 750.000; number of unlicensed estates (shanty) is 400.000.

It should be considered that 213.850 estates that are estimated as the total number of estates at risk of getting damaged in the expected Marmara Earthquake may be the total number of damaged estates only in Istanbul after the expected earthquake. It is supposed that the data that would give the most optimistic approach is being used.

Damage Levels

While considering the data of 17 August Earthquake to determine the estimated number of damaged estates, it is found to be acceptable to consider the data of the dame earthquake to determine the slight, moderate and heavy damage levels of estates. The calculation will be done by considering heavily damaged 66.441 estates, moderate damaged 67.249 estates, and slightly damaged 80.160 estates.

Weighted Damage Percentages

This rate will be considered as 100 % for the heavily damaged estates. For the moderate damaged estates, this percentage will be calculated as 30 % and for the slightly damaged estates it will be 5 %. When we consider the fact that moderate damage level has the range of 20% and 50%, it will be seen that estimated average damage percentage for the moderate damaged estates has been chosen as a value below the percentages of upper and lower limits.
For the slightly damaged estates, a value below the range of the average of upper and lower limit values has been determined.

Value of Unit Area

According to the construction class that went into effect by being determined by Secretariat of Treasury and being promulgated, the unit area values are presented on the chart 6-2. According to the this chart, which is in effect currently, the unit areas value for the reinforced constructed buildings is 410,00 TL/m²'.

Gross Closed Area

According to a research conducted by State Planning Organization, size of 40 % of shanties is about 75-99 m², 35 % is about 50-74 m² though.
It is found to be acceptable to assume, by considering the estate structure and intensity of Marmara Region and basically of Istanbul, that there is average 90 m² gross closed area in cluster and licensed estates that are covered by DASK.

Exemption Implementation

The amount that will be deducted from the loss amount explained in detailed on the part 6.6.2 above is a blanket clause determined with a decree law as 2 % of the sum insured of DASK. It is also possible to state 0,02 as a multiplier in the calculation of amount of exemption deduction.

Calculation Method

For the calculation of possible loss amount, the formulation stated below will be used.

DDA= (GCA x UAV) x WDP – (GCA x UAV) x 0,02 (1)

Here, **DDA** refers to **DASK Damage Amount**, **GCA** refers to **Gross Closed Area**, **UAV** refers to **Unit Area Value, WDP** refers to **Weighted Damage Percentage**. The chart prepared by using this formulation is presented below.

The Expected Damage Scenarios for Estates

Optimistic Scenario

For this scenario, the assumptions and calculation methods made while the chart below is being prepared have been summarized above. The estimated loss amount calculated as an additional operation on the Table1 has been stated as EUR over the current exchange rate.

Table 1: Optimistic calculation of house loss for the scenario earthquake

Approximate Estimation by Considering 17 August 1999 Earthquake Number of Damaged Estates (213.850) (1 EUR=2,1659 TL)										
Damage Level	***Rate (%)***	***Number of Damaged Estates (Item)***	***Damage Rate (%)***	***Unit Area Value (TL/m2)***	***Gross Area (m2)***	***Sum Insured (TL)***	***Exemption Deduction (%2)***	***Net Loss Amount (TL)***	***Net Loss Amount (EUR)***	***Total Loss Amount (EUR)***
Heavily Damaged	31,07	66.441	100	550	90	49.500	990,00	48.150,00	22.397,16	1.488.089.436,26
Moderate Damage	31,45	67.249	30	550	90	49.500	990,00	13.860,00	6.399,19	430.338.953,78
Slightly Damaged	37,48	80.160	5	550	90	49.500	990,00	1.485,00	685,93	54.959.878,11
Total:							**1.973.388.268,16 EUR**			

Pessimistic Scenario

For the expected Marmara Earthquake, while preparing the pessimistic scenario for analyze of estimated loss amount that may arise in estates, only the number of the damaged estates has been changed. That number is considered as equal to the number of existing DASK insurance policies in the Marmara Region. In a case of that all of the citizens, who became conscious after the earthquakes and had insurance policies, prefer to open a damage file, in the Table 2 about the pessimistic scenario damage level criteria has been presented below.

Table 2: Pessimistic calculation of house loss for the scenario earthquake

Approximate Estimation by Considering 17 August 1999 Earthquake Number of Damaged Estates (213.850) (1 EUR=2,1659 TL)										
Damage Level	***Rate (%)***	***Number of Damaged Estates (Item)***	***Damage Rate (%)***	***Unit Area Value (TL/m2)***	***Gross Area (m2)***	***Sum Insured (TL)***	***Exemption Deduction (%2)***	***Net Loss Amount (TL)***	***Net Loss Amount (EUR)***	***Total Loss Amount (EUR)***
Heavily Damaged	31,07	382.891	100	550	90	49.500	990,00	48.150,00	22.397,16	8.575.672.673,69
Moderate Damage	31,45	387.574	30	550	90	49.500	990,00	13.860,00	6.399,19	2.480.159.139,16
Slightly Damaged	37,48	461.885	5	550	90	49.500	990,00	1.485,00	685,93	316.680.778,57
Total:							**11.372.512.591,42 EUR**			

The Capacity of DASK

The DASK financial resources consist of three items: the gathered premiums, reassurance protection, and the finance that will be received from the World Bank. The most important item is the "reassurance protection" received from the international reassures. If the insured loss is higher than the expected amount and then the capacity of Association resources and the obtained conservation amount, the loss will be compensated according to the proportion of sum of Association resources and conservation amount to total compensation amount required in compulsory insurance. In the annual report of DASK, it is stated that for the period between 01.11.2008 and 31.10.2009, 1.250.000,00 EUR reassurance conservation in total is obtained.

EVALUATION AND RESULTS

Although all of the predictions about the effect of the damage, which will arise from the expected Marmara Earthquake, on estates are like estimation, it is known that the damage that may occur in the insured estates is needed to be compensated by the compulsory earthquake insurance fund.

The information gathered from the website and the current data shows that the DASK system has not been tested with an episode like expected Marmara Earthquake, yet. It is estimated that the loss amount of expected Marmara Earthquake calculated with a most optimistic scenario will be greater than the capacity of compulsory earthquake insurance fund. This scenario has been planned ignoring the possibility of occurrence of two huge earthquakes in different regions of Turkey in shorter intervals.

When we consider that the Northern Anatolia Fault Line does not pose a risk only for Marmara Region, we have reached a conclusion that the compensation capacity of DASK should be increased.

The increase of Damage compensation capacity depends on increasing the insurance premium income and providing more reassurance guaranty.

In order to increase the number of insured estates, to make having insurance policy obligatory is a significant approach. However, although the state makes having policy obligatory by doing some legal regulations, it is no so effective in practice.

The only enforcement supporting the obligation is not transacting in the offices of land registry unless there is a policy. Because of this implementation, DASK insurance policy goes down in a value just as a document needed for estate buying and selling process. It is thought that if it becomes obligatory in the works like making agreements for the infrastructure services like electricity, water, telephone, natural gas, paying real estate tax, making rental agreement, changing residence records, then the citizens will immediately have policy. The most important justification for the need to examine the effect of the obligation in this level is the necessity for an immediate high rate increase in the damage compensation capacity.

In order to widen the obligation, it is necessary to increase the insurable number of buildings included in this law. However, when we consider the rate of unlicensed buildings which is about 70 %, according to the existing regulations increasing the number of insurable estates seems both difficult and risky.

The consciousness of having policy is needed to be widespread, besides while increasing the effect of obligation, it is also necessary to increase the number of insurable buildings. Of course, it will not be economically an appropriate to include the highly risky estates that may decrease the damage compensation capacity of the fund in the system

When we look at the issue from a sociological point of view, if the buildings ignored from the DASK coverage get damaged, the social state approach requires compensating this damage and it will bring extra burden for the state. Thus, we have reached the conclusion that unlicensed structuring should not be allowed.

According to DASK records, approximately 25 % of the proposed production has been actualized. When the proposed number of policies is reached, it seems possible to increase the reassurance power to a level of approximately 4.000.000.000 EUR. In this case, the thing needed to be done primarily is to increase the number of estates covered by the system despite of the all risks.

When the number of policies is examined in terms of the geographical regions of Turkey and the rate of increase in comparison to the previous years, it can be seen that there is a good acceleration in its increase. The average of increase in insured estate rate in Turkey decreases because of Marmara Region which is seen as the most risky region. Also, the increases in the other regions are evaluated to be affected from the compensations paid by DASK after small-scaled earthquakes and they are believed to have an advertisement effect on this increase.

The earthquake risk should be remained on the agenda of community of Marmara Region; however this effort is not enough. Since, there should be country-wide participation, and citizens living in the less risky regions should support the system by having policies. In this case, rather than informing people it is more important to get people more conscious. Living in a less risky region does not mean not having social responsibility. It is predicted that if the damages that will occur in highly risky regions cannot be compensated by the central system, then the whole state will have to afford it, and, in that case, citizens who are living even in the less risky regions will need to participate in the earthquake compensation finance indirectly due to neither new taxes nor the increasing external debts. It is known that this approach will not lead an injustice, since while the earthquake insurance premiums are calculated the criteria of the earthquake areas of Turkey are taken into consideration, that’s, while people living in the less risky areas are buying earthquake coverage they are not required to pay high premiums.

One way to increase the number of estates and to accelerate the processes of repairing or strengthening is also to make the earthquake insurance obligatory on the basis of buildings instead of the basis of independent parts. The uninsured estates in a building may interrupt general repair of a building if the property owner has financial problems.

Another factor that effects the situation that there are uninsured estates on building basis is people’s beliefs about the fact that the state will provide financial support for its citizens in any way. If the state keeps on constructing new estates after the earthquakes, it will not be possible for the system to get stronger.

In the law of the establishment of DASK, the situation that the resources of the organization fail to satisfy the needs has been ruled with item 17. That’s, it is thought that the fund would fail to compensate the possible damages. The referred resources here are possibly the reassurance power provided by the organization. Within the scope of the related item, the total loss amount will be determined, and it has been also ruled that in a case of an exceeding the resources of the organization, the beneficiaries would be paid in a degree of the ratio that the organization resources over total loss amount.

In this kind of periods, making damage assessment for all estates in a short time is considerably difficult. In case of any objection, this time will get longer. In this kind of situation, all policy owners will have to wait for the conclusion of the assessment process.

The difference between the engineering approach and approach of insurance regulations towards the issue during damage assessment process after earthquake caused problems in the past. The content of fire insurance law in effect in the period before DASK, did not include a rule about necessity to repair according to the regulations forced by public authority. Nowadays this problem is overcome due to DASK regulations. Not conducting the damage assessments after earthquakes from a single center did also pose a problem.

Unless the required legal regulations and formation of organizations are made immediately not only in terms of insurance business but also in terms of interruption in judicial remedy stem from assessing the damage and approving the assessment after a check, the courts will probably unable to deal with the case burden after the first huge earthquake.

There is not any other implementation in the world similar to DASK. Of course, its being the first one does not mean that it is defective. Maybe, a system that will serve as a model for the world has been out into practice in Turkey. The most important thing in this case is that the reliability of the system can be proved after a huge earthquake. For this strengthening the system and enabling it to be active are so important.

REFERENCES

Acınan, H., 2005. "The Basic Principles of Insurance, Istanbul", Insurance Supervision Council – Report of Insurance activities in Turkey in Year 2002.

Çipil, M., 2004. "The Compulsory Earthquake Insurance Interventions in the World and an Investigation of its Turkish Examples".

Ekener, H. & Sevener, B., 1979. "The Role of Insurance Business in Turkish Economy", Association of Turkish Insurance Law, Ankara.National Reassurance TAŞ, Reassurer, Volume:18, p.12.

Ererdi, H. C., 1998. "Fire Insurance Business, 2nd Publication", Istanbul. National Reassurance TAŞ, Reassurer, Volume: 21, p. 14-15.

Gürlek, Y., 2006. "Earthquake Insurance Interventions in Turkey and in The World", Master Thesis (in Turkish), Istanbul Technical University.

Nomer, C., 2000. National Reassurance TAŞ.

Nomer, C. & Yunak H., 2000. "The Basic Principles of Insurance", Ceyma Publications. Official Gazette, Date: 19. 07. 2003, Volume: 25173.

Yunak, H., 2002. Compulsory Insurance Types , National Reassurance TAŞ., Istanbul.

T.A.C the Bulletin of Association of Actuaries , 1995, p. 22, Istanbul.

American National Geological Information Center

Publications of Chamber of Construction Engineers Istanbul Branch Office

Official website of Istanbul Municipality

http://zonesismiche.mi.ingv.it/class2004.html

http://www.swissre.com ,Swiss Re CatNetTM

http://www.dask.gov.tr

http://www.eksperlerdernegi.com

RECENT EXPERIMENTAL WORKS IN ITU

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ABSTRACT

A brief history and the current experience of Structural and Earthquake Engineering Laboratory of Istanbul Technical University are presented in this paper. Development of the alternative retrofitting techniques for the existing vulnerable buildings is the main research topic of the laboratory since the last devastating earthquakes experienced in Turkey. The achieved studies are collected into two groups as the experimental works on material characteristics and the experimental works on system behavior. The pseudo-dynamic testing technique is used in the system tests as well as the cyclic quasi-static loading.

KEYWORDS
Laboratory, Experimental study, Structural testing, Earthquake engineering.

INTRODUCTION

Structural and Earthquake Engineering Laboratory (STEEL) of Istanbul Technical University which has been a local and worldwide leading institution in the field of structural and earthquake engineering, was established in 1970's and re-activated in 1993 with the support of Japanese International Cooperation Agency (JICA).

STEEL is established on a special building having 1800 m2 floor area for testing and other activities. The building has high capacity reinforced concrete test floor and reinforced concrete and steel reaction walls. The laboratory is equipped with the contemporary devices which enable force and displacement controlled static and pseudo dynamic tests on structures or structural components.

The research works performed in STEEL have been supported mainly by the private institutions, Istanbul Technical University (ITU), the Scientific and Technological Research Council of Turkey (TUBITAK), NATO, European Union (EU), JICA, State Planning Organization (DPT) and Turkish Earthquake Foundation (TDV).

Since the beginning, the main research theme has been experimental studies on the specimens representing the existing classical reinforced concrete residential buildings and precast structures, and also new retrofitting techniques for them.

The recent experimental works carried out in the laboratory are summarized in a few words in the subsequent sections.

EXPERIMENTAL STUDIES ON MATERIAL CHARACTERISTICS

The compression and various types of shear tests have been carried out on masonry units made of different types of bricks, Fig. 1. Also, the cylindrical cores taken from the members of existing structures have been tested to determine some characteristics of materials.

Figure 1. Compression and various types of shear tests

The square shaped masonry units which are similar to the one defined in ASTM (1981), have been fabricated using various types of bricks, Fig. 2. Distinct retrofitting techniques have been applied on the specimens. The diagonal tension tests pointed out that shear force carrying capacities of the specimens increased considerably by the way of retrofitting.

EXPERIMENTAL STUDIES ON SYSTEM BEHAVIORS

After having tested a typical nearly half scale one bay-one story reinforced concrete bare frame for certain displacement reversals, Fig. 3, different type of interventions have been made into the similar frames and they have been tested for the same loading protocols, Ilki et al. (2009). This group of tests started with the specimen in which full integration between the wall and frame has been achieved. This specimen was strengthened by means of fine wire mesh and shotcreted on both sides of specimens. Wire-cage with a styrofoam sheet in the middle plain has been shotcreted from both sides for having cost effective strengthening.

Figure 2. Diagonal tension (pure shear) tests on the original and the retrofitted specimens

Figure 3. A number of tests on one bay-one story reinforced concrete infilled frames

Carbon fiber reinforced polymer (CFRP) strips were bonded on both faces of the infill wall without having any connection to the reinforced concrete members, as a first attempt in Turkey in 2001 for strengthening purpose of brittle walls. Depending on the observations about the response of the specimen, the new specimens with different connection details of CFRP strips have been prepared and tested in the laboratory. After having inserted steel shear keys into the beams and columns of the bare frame, a wall made of high strength bricks have been constructed leaving gaps between the two adjacent columns and the beam. Afterward concrete has been cast all around the wall to provide full contact between the wall and peripheral reinforced concrete elements. Another set of tests have been achieved to see the possible effects of camber introduced to the beams on the shear wall which was produced as shotcrete panel.

Six typical half scale one bay-two story reinforced concrete frames; two bare, two infilled and two with CFRP retrofitted infill walls were tested under constant vertical and reversal cyclic lateral loads, Fig. 4. The test results were evaluated in terms of strength, stiffness and obtained failure mechanisms

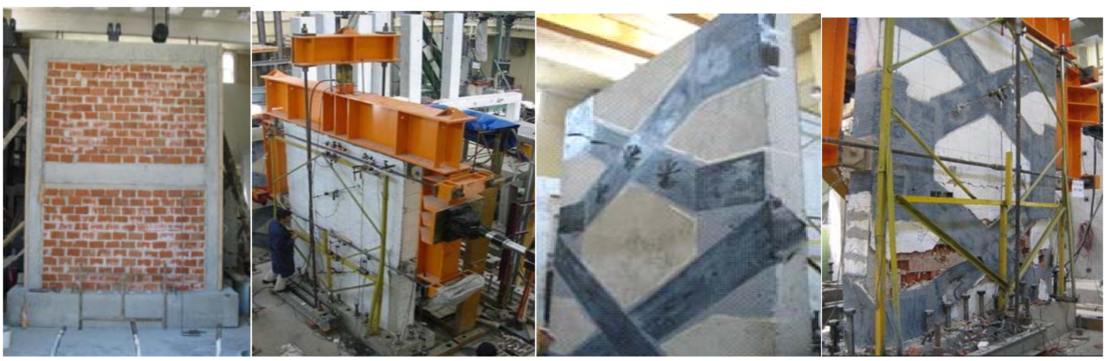

Figure 4. Tests on one bay-two story reinforced concrete infilled and retrofitted frames

A number of full-scale precast columns were subjected to constant axial load and lateral displacement cycles with gradually increasing amplitude, Fig. 5. After achieving the original column tests, the damaged columns were retrofitted by alternative techniques such as reinforced concrete jacketing, CFRP wrapping and steel angles jacketing, Yuce et al. (2007).

Figure 5. Full scale original and retrofitted column tests

An experimental study focusing on the improvement of the behavior of reinforced concrete members built with low-strength concrete, insufficient transverse reinforcement and plain bars has been completed. The study consists of nearly-full scaled captive columns, concrete panels and full-scaled beam-column joints. For retrofitting, carbon or glass fiber polymers and high performance steel fiber reinforced cementitious composite plates were either attached or wrapped to the surface of the specimens with different details, Bedirhanoglu (2009), Fig. 6.

The study on behavior of reinforced concrete columns with plain and deformed reinforcing bars corroded at different levels is ongoing in the laboratory, Fig. 6.

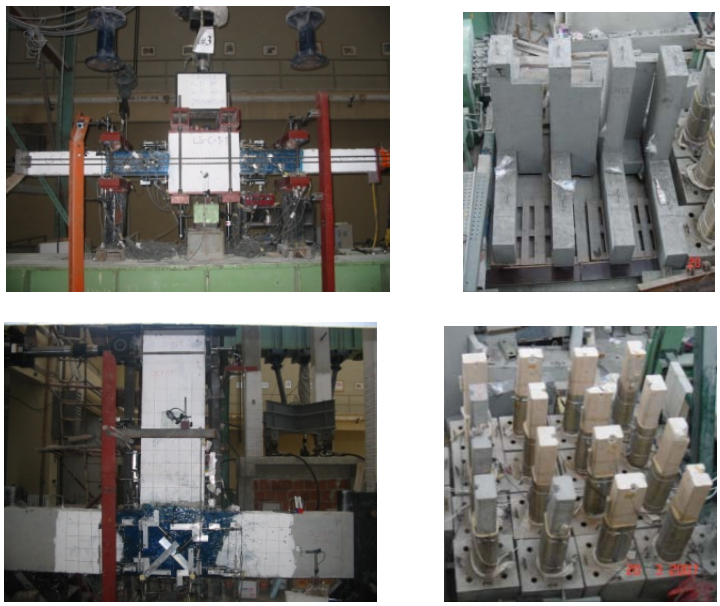

Figure 6. Column and beam-column joint specimens, and accelerated corrosion test specimens

The pseudo-dynamic test technique has been adapted and utilized successfully in the numerous tests on 1/3 scaled vulnerable reinforced concrete frames retrofitted by CFRP, Fig. 7. The testing facility consists of a manually-controlled hydraulic system maintaining the axial load and a servo controlled hydraulic system applying the lateral loading which is positioned at the tip of the test specimen. It has been made comparisons between the results of quasi-static tests performed by using different loading protocols and pseudo-dynamic tests, Bastemir (2009).

The study on 1/3 scaled vulnerable reinforced concrete frames directly braced by steel X and knee braces is another ongoing research work in the laboratory, Fig. 7.

Figure 7. Pseudo-dynamic testing facility and the specimens

REFERENCES

ASTM C 1391-81 (1981) Standard test method for diagonal tension (shear) in masonry assemblages, USA.

Bastemir, I. (2009) Retrofitting of Infilled Reinforced Concrete Frames Subjected to High Inertia Forces by using Fiber Reinforced Polymers, M.Sc. Thesis submitted to Graduate School of ITU.

Bedirhanoglu, I. (2009) The Behavior of Reinforced Concrete Columns and Joints with Low Strength Concrete under Earthquake Loads: An Investigation and Improvement, Ph.D. Thesis submitted to Graduate School of ITU.

Ilki, A., Karadogan, F., Pala, S., Yuksel, E. (Eds.) (2009) Seismic Risk Assessment and Retrofitting with Special Emphasis on Existing Low Rise Structures. Series: Geotechnical, Geological, and Earthquake Engineering Vol. 10, ISBN: 978-90-481-2680-4.

Yuce, S., Yuksel, E., Bingol, Y., Taskin, K., Karadogan, F. (2007) Local Thin Jacketing for the Retrofitting of Reinforced Concrete Columns, Structural Engineering and Mechanics, Vol.27, No.5, pp.589-607.

DEVELOPMENT OF TURKISH SEISMIC DESIGN CODES AND THE 2007 CODE

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ABSTRACT

A major part of Turkey is located on an active seismic zone. As a result of this situation, extensive building damages and great human losses have been experienced following major earthquakes. In an effort to transfer the lessons learned from past earthquakes into practice, Turkish seismic codes have been constantly changed and incrementally improved.

In the first part of this study, the development of the Turkish earthquake regulations over the past 70 years is summarized. Following the major earthquakes of 1992 Erzincan, 1999 Adapazarı-Kocaeli and Düzce that have caused great damage and loss of life, it has been evident that the majority of existing building stock did not possess sufficient seismic safety. This situation necessitates the seismic performance and safety evaluation of existing buildings, and strengthening or renewal of those that do not have sufficient safety, with priority given to high seismic risk areas. Based on these requirements, a new chapter on the seismic evaluation and strengthening of existing buildings has been incorporated into the 2007 Turkish Seismic Code. In the second part of this study, the main features of the 2007 Turkish Earthquake Code are described. Finally, possible future developments to the current seismic code and other related regulations are discussed.

KEYWORDS
Turkish seismic codes, base shear coefficient, seismic assessment, performance based evaluation, retrofitting of structures, capacity design principle.

INTRODUCTION

Turkey is located on a series of very active fault lines and has suffered in the past, from major earthquakes which resulted in extensive damages to buildings and caused human losses. Based on lessons learned from past earthquakes, Turkish seismic design codes are improved continuously.

In this paper, the development of Turkish seismic codes, their basic features and contents are reviewed. Then, the new 2007 Turkish Seismic Code and its main characteristics are explained. Outlook on future seismic codes and related standards are also discussed.

DEVELOPMENT OF TURKISH SEISMIC DESIGN CODES, BASIC FEATURES AND CONTENTS

Several seismic design codes and related material had been in effect before the new Turkish Earthquake Code was issued in 2007. These are outlined below.

After 1939 Erzincan earthquake, Italian Building Regulations was issued by the Ministry of Public Works of Turkish Government. This document gives design and construction rules for masonry, timber and reinforced concrete structures. Also, basic analysis requirements for earthquake resistant buildings are given.

In the following years, Seismic Zones Provisional Building Regulations, which are generally based on Italian Building Regulations with some modifications, went into effect. This code required all new buildings, regardless of their locations, to be analyzed and designed for an earthquake load equal to 10% of the building seismic weight, which is defined as sum of dead loads and half of live loads.

First seismic zoning map of Turkey was issued in 1945 and revised in 1947. This map divides Turkey into three zones, which are first and second degree seismic zones and the zone without seismic risk.

In 1947 seismic code (Turkish Seismic Zones Building Specification), equivalent earthquake loads are defined in terms of seismic zone in which the building is located. Base shear coefficients (total equivalent seismic load divided by building seismic weight) of 10% for first degree seismic zone and 5% for second degree seismic zone are adopted. Besides, a 25% increase in allowable stresses is permitted for earthquake loading combined with gravity loads.

In 1948, a scientific committee on earthquake engineering issued a report which proposed substantial decrease in base shear coefficient.

Based on this proposal, in revised version of 1947 seismic code dated 1949 and in 1953 seismic code (Specification for Structures to be Built in Seismic Zones) base shear coefficient was reduced considerably, as compared with previous codes and applications. Depending on the soil classes, base shear coefficients varies between 4% and 2% for first seismic zone and 3% and 1% for second seismic zone. Furthermore, 50% increase in allowable stresses is permitted for earthquake loading combined with gravity loads.

1961 seismic code (Specification for Structures to be Built in Disaster Areas, 1961) defines the base shear coefficient with respect to building height. Therefore, the base shear coefficient is determined by

$$C = C_0 \, n_1 \, n_2 \qquad (1)$$

where C_0 is the nominal base shear coefficient which varies with the building height, that is, C_0=0.06 up to 16.00 m building height, then increases 0.01 for every 6.00 m up to 40.00 m and 0.01 for every 3.00 m thereafter, n1 is a coefficient ranging from 0.6 to 1.0 depending on the soil class and building material, n2 is a coefficient that is equal to 1.0 for first degree seismic zone and 0.6 for second degree seismic zone. This code also gives design and construction rules for reinforced concrete, masonry and timber structures.

In 1963, 1972 and 1996 Turkish seismic zones map was revised and number of seismic zones was initially increased to four and then to five, including the zone without seismic risk.

One of the main characteristics of 1968 seismic code (Specification for Structures to be Built in Disaster Areas, 1968) is the introduction of design rules for reinforced concrete structures with regards to member dimensions and minimum reinforcement requirements such as spacing of transverse reinforcement in columns.

The base shear coefficient defined in this code is still low and is given by

$$C = C_0 \, \alpha \beta \gamma \qquad (2)$$

where C_0 is the site coefficient that varies between 0.06 and 0.02 for first, second and third degree seismic zones, α is the seismic soil coefficient which is between 0.80 and 1.20 depending on the soil class, β is the building importance factor with a maximum value of β=1.50 and γ is the building dynamic coefficient defined by the following formulae

$$\gamma = 1.0 \quad \text{for} \quad T \leq 0.5 \text{ sec} \qquad (3a)$$

$$\gamma = \frac{0.5}{T} \quad \text{for} \quad T > 0.5 \text{ sec} \qquad (3b)$$

where T is the first natural period of the structure. The total equivalent seismic loads are distributed to the stories of the building, in proportion with the story weights and the elevation of floor levels.

In 1975 seismic code (Specification for Structures to be Built in Disaster Areas, 1975), similar to the 1968 code, the base shear coefficient is defined by

$$C = C_0 \, K \, S \, I \qquad (4)$$

where C_0 , K and S are the site, structural system and spectrum coefficients respectively and I is the importance factor. Site coefficient varies between 0.03 and 0.10 for four seismic zones defined in 1972 seismic zones map. Structural system coefficient has values in the range of 0.60 to 3.00 in accordance with the type of the structural system and the building material. The maximum value of importance factor is 1.50 for buildings of immediate occupancy. The spectrum coefficient, such that $S \leq 1$, is determined in terms of the first natural period of the structure and the characteristic period of the soil. The lateral distribution of equivalent seismic forces throughout the building height is assumed to be in proportion with the story weights and the elevation of floor levels. Similar to previous seismic codes, the allowable stresses of material and soil, except weak soil conditions, are increased 33% for gravity loading combined with earthquake.

In the 1975 code, more extensive design requirements for reinforced concrete buildings regarding ductile design, are provisioned.

The main characteristics of 1998 seismic code (Specification for Structures to be Built in Disaster Areas, 1998) are the adoption of capacity design principle and structural system behaviour factor concept. In order to take into account the nonlinear behaviour of the structural system, the elastic seismic forces and effects, that are determined through the use of elastic design acceleration spectrum, are reduced by a coefficient which is a function of the structural system behaviour factor and the first natural period of the structural system. Structural system behaviour factor for building structures varies between 3 and 8, depending on the type and material of the structural system and the system ductility.

The elastic spectral acceleration coefficient A is determined by

$$A = A_0 \, I \, S\left(T\right) \qquad (5)$$

where A_0 is the effective earthquake acceleration coefficient that ranges from 0.10 to 0.40 based on the seismic zones, I is the importance factor and S(T) is the spectrum coefficient that is calculated in terms of the first natural period of the structure and the characteristic period of soil.

1998 seismic code incorporates dynamic analysis methods, such as method of modal superposition and linear time-history analysis, in addition to equivalent earthquake force method.

The capacity design principle is widely used in 1998 seismic code, especially for reinforced concrete design. Strong column-weak beam design principle, shear capacity check of beams and columns, capacity design of beam-to-column connections are examples of capacity design applications.

2007 TURKISH SEISMIC CODE

Both in Turkey and in other countries, mainly in the United States, the devastation caused by recent earthquakes has created the need to develop new design and evaluation methods that utilize deformation based performance criteria which are more realistic than strength based performance criteria.

In response to this demand, extensive research have been carried out by Applied Technology Council (ATC) and Federal Emergency Management Agency (FEMA) in the United States and several reports such as ATC 40 and FEMA 273,356 have been published. On the other hand, Eurocode standard 8.3 on the assessment and retrofitting of structures covers the results of the latest academic and engineering developments on the performance based evaluation of existing structures.

Recent earthquakes experienced in Turkey during the last decades, such as 1992 Erzincan, 1999 Adapazarı-Kocaeli and Düzce earthquakes, have demonstrated that the majority of existing building stock had insufficient seismic capacity. Therefore, it is apparent that even an earthquake with a relatively small magnitude may cause significant building damages and losses of life. Based on this experience, it is aimed that, starting from high risk earthquake zones, seismic performances and capacities of existing buildings be evaluated and buildings without sufficient capacity be either strengthened or renewed.

Considering the above facts, efforts have been focused on the addition of a new chapter to the seismic code, that deals with the seismic evaluation of existing buildings and strengthening of buildings with insufficient seismic capacity. This work has been completed and the new 2007 Turkish seismic code (Specification for Buildings to be Built in Seismic Zones, 2007) has been issued.

Main highlights of 2007 Code are explained below.

a) The first six chapters of the code, similar to 1998 seismic code with some modifications, deal with earthquake resistant design of new buildings. On the other hand, seismic performance and safety of existing buildings should be determined through special rules and methods. Chapter 7 of 2007 Code covers these special rules and methods.
b) Three seismic hazard levels are defined for seismic assessment of existing buildings. These are, service earthquake (50% of probability of exceedance in 50 years, with a return period of 72 years), design earthquake (10% in 50 years – return period: 475 years) and maximum earthquake (2% in 50 years – return period: 2475 years).
c) Multi-level performance objectives, that is, different performance objectives under different seismic hazard levels are introduced for seismic assessment of existing buildings. Minimum target performance levels for different building types are also included.
d) In addition to linear assessment methods, nonlinear static and dynamic methods, such as incremental equivalent earthquake load method, incremental modal superposition method and nonlinear time-history method are introduced.
e) Damage limit states for reinforced concrete members are defined in terms of unit deformations (strains) of concrete and reinforcing steel, rather than plastic hinge rotations.
f) General principles of strengthening of existing buildings lacking sufficient seismic safety are given. Several strengthening methods for reinforced concrete structures, either in structural member level or system level, are explained.
g) Capacity design principle, which leads to ductile design of structural systems and their members while preventing brittle failure modes, is introduced. Several practical applications of capacity design principles especially for steel structures, namely, design of steel beam-to-column connections and other connection details, design of steel columns under amplified seismic axial loads, as well as, limitation of width-thickness ratios for compression elements, are given.
h) Prequalified steel beam-to-column connection detail examples with adequate rotation capacity are given for practical use of engineers.
i) Considering the variation of earthquake direction, seismic internal forces are determined under the combined effect of seismic forces acting on both horizontal directions, even for buildings with orthogonal structural systems.

SUMMARY AND CONCLUSION

2007 Turkish seismic code provides structural engineers state-of-the-art analysis and strengthening methods for seismic assessment and retrofitting of existing building stock. In this scope, nonlinear static and dynamic analysis methods are incorporated.

Furthermore, in 2007 Code, the provisions for steel structures have been improved by adopting capacity design principles.

The following recommendations may be presented for the future enhancement of the codes and standards related to the seismic design and evaluation of buildings.

a) Design methods that utilize deformation based performance criteria may similarly be applied to seismic resistant design of new building structures. In this direction, Istanbul Tall Buildings Specification is currently under development for performance based design of tall buildings.
b) It is expected that the evaluation and strengthening methods developed for reinforced concrete structures are extended to cover the existing steel structures.
c) Since the 2007 seismic code covers advanced design approaches such as capacity design, current Turkish design standards for reinforced concrete structures (TS500) and steel structures (TS648) need to be updated accordingly.

REFERENCES

Aydınoğlu M.N. (2007) From seismic coefficient to performance based design: 40 years of earthquake engineering from an engineer's viewpoint (in Turkish), 6. National Conference on Earthquake Engineering – Conference Proceedings, Invited Lectures, 15-41, Istanbul, October 16-20, 2007.

Ministry of Public Works (1940) Italian building regulations for buildings to be built in seismic zones (in Turkish), Ankara.

Ministry of Public Works (1944) Seismic zones provisional building regulations (in Turkish), Ankara.

Ministry of Public Works (1947) Turkish seismic zones building specification (in Turkish), Ankara.

Ministry of Public Works (1953) Specifications for structures to be built in seismic zones (in Turkish), Ankara.

Ministry of Public Works and Settlement (1961) Specifications for structures to be built in disaster areas (in Turkish), General Directorate of Housing, Ankara.

Ministry of Public Works and Settlement (1968) Specifications for structures to be built in disaster areas (in Turkish), Earthquake Research Institute Headquarters, Ankara.

Ministry of Public Works and Settlement (1975) Specifications for structures to be built in disaster areas (in Turkish), General Directorate of Disaster Affairs, Ankara.

Ministry of Public Works and Settlement (1998) Specifications for structures to be built in disaster areas, Ankara.

Ministry of Public Works and Settlement (2007) Specifications for buildings to be built in seismic zones (in Turkish), Ankara.

Özer E. (2006) Design regulations, Production of Buildings in Turkey and Greece, Athens, September 28-29, 2006.

Özer E. (2007) Capacity design principles and Turkish earthquake code (in Turkish), 6. National Conference on Earthquake Engineering – Conference Proceedings, Invited Lectures, 257-266, Istanbul, October 16-20, 2007.

Pampal S. and Özmen B. (2007) Development of seismic zone maps and seismic design codes of Turkey (in Turkish), Ankara.

ESTIMATION OF SOCIAL AND ECONOMIC LOSSES IN ISTANBUL FOR TWO SCENARIO EARTHQUAKES

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ABSTRACT

Loss assessment is a first step mitigation application that can provide a clearer insight to the level of the expected losses as well as its spatial distribution within a given region for an expected earthquake or for a given seismicity. An application of the Displacement-Based Loss Assessment Methodology, DBELA, is presented in this work with the aim of providing some clues about the economical and social losses in case of two scenario earthquakes with magnitude M_w=7.2 and M_w=7.5 occurring along the North Anatolian Fault. Two types of loss assessment analyses have been conducted: pre- and post-event assessments. The purpose of the use of pre-event loss assessment calculations is to construct an overall strategy based on the expected monetary loss level and its spatial distribution. This aim is achieved by using the MDR (Mean Damage Ratio) which allows a direct correlation between the expected physical damage and direct economical loss. Post-event assessment calculations have been provided to obtain a clearer insight to the expected social losses and spatial distribution of the physical damage. Post-event outputs are useful for the authorities due to the fact that the level of the disaster and the most affected areas have to be defined in a very short time range following an earthquake so that limited search and rescue teams can be effectively used.

KEYWORDS
Loss assessment, financial losses, economical losses, DBELA.

INTRODUCTION

It is long known that Istanbul will experience a strong earthquake in near future. The megacity has grown without taking into account this danger seriously, thus, anti-seismic precautions have not been put in action. Authorities are keen on taking necessary actions, as much as possible; however, time and financial sources are not enough to ensure a minimum damage in the city.

Loss assessment studies can provide a clear idea about the amount and the spatial distribution of social and financial losses. This helps the authorities to comprehensively approach the risk so that they can manage their limited sources more efficiently. There are of course other uses of loss assessment studies, such as helping to define earthquake insurance premiums, or calibration of an earthquake resistant design codes, but the main focus in this paper is given to finding social and financial losses.

DISPLACEMENT-BASED LOSS ASSESSMENT (DBELA) PROCEDURE

The methodology

The procedure uses mechanics-derived formulae to describe the displacement capacity of classes of buildings at three different limit states. These equations are given in terms of material and geometrical properties, including the average height of buildings in the class. By substituting this height through a formula relating height to limit state period, displacement capacity functions in terms of period are attained; the advantage being that a direct comparison can now be made at any period between the displacement capacity of a building class and displacement demand predicted from a response spectrum. The intersections between the displacement capacity curve and the displacement spectrum, for a given limit state, provide the boundaries where demand and capacity coincide. The concept is illustrated in Figure 1, whereby the progressive nature of the method is explained. The procedure is repeated for each imaginary building in the building pool so the ratio of each damage state per building class has been reached. The building pool is created by using the statistical information extracted from the real building stock (see Bal et al., 2007 and 2008a). The damage ratios are then superimposed onto the cumulative distribution function of building stock of find the proportion of buildings failing the given limit state.

The displacement-based calculations that are used as the backbone of the DBELA methodology were first proposed by (Pinho et al., 2002, Glaister and Pinho, 2003) and then put in a comprehensive framework by (Crowley et al., 2004; Crowley et al., 2006, Bal 2008). The method is based on Displacement-Based Design rules introduced by Priestley et al. (1997 and 2007). According to this, a substitute structure (Shibata and Sözen, 1976) has to be found to represent the considered buildings. Key aspects of the SDOF substitute structure are:

- Limit state period
- Limit state displacement capacities and relative limit state ductility values
- Limit state damping
- Displacement demand at the effective height for the relative limit state

Once these parameters are obtained, displacement capacity for the first limit state can be compared with the related demand. If the demand exceeds the capacity, then the second and third limit states will be checked successively, until the demand no longer exceeds the capacity, so, the damage state of the building can be defined. The building is assumed to collapse if the demand also exceeds the third limit state displacement capacity. This procedure for three different limit states can be seen schematically in Figure 1.

This displacement-based approach characterizes the structure by secant stiffness, K_{LS}, at the limit state displacement, Δ_{LS}, (see Figure 2) and a level of an equivalent viscous damping, representative of combined elastic damping and hysteretic energy absorbed during inelastic response. The limit state displacements are calculated by using a) by choosing the appropriate displacement-capacity equation based on the expected mechanism of the frame (either column- or beam-sway mechanism), and b) by using the relevant displacement-capacity equations with geometry and material strain limits inserted in it (see Crowley et al., 2006 and Bal 2008). Geometrical and material strain parameters used for the Turkish building stock are given in Table 1 and Table 2.

Regarding the displacement capacities, as shown as S_{di} in Figure 1, an over-damped spectrum is used to calculate the spectral displacement demand for a given limit state, corresponding to the secant limit state period of the structure. Being modified by η_i spectrum correction factors, different spectrum is used for each limit state check. (see Equation 1).

$$\eta_{LS} = \sqrt{\frac{7}{2+\xi}} \qquad (1)$$

ξ, the damping value of each limit state, is found as a function of the limit state ductility, μ_{LS}, according to the equivalent viscous damping equations provided by Priestley et al. (2007) (see Equation 2 for RC frame structures). It should be noted that the Equation 2 is proposed for frame structures.

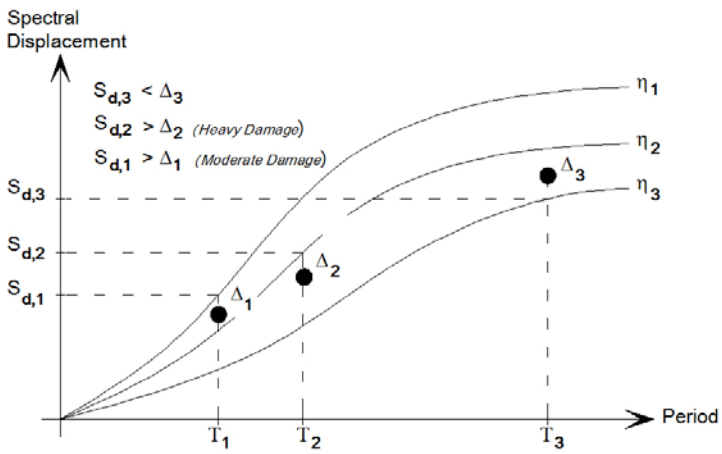

Figure 1. Comparison of demand with capacity in DBELA methodology (Bal, 2008)

Classical MDOF base shear – top displacement representation has to be modified to "F_M/α versus Δ_M/β" (see Figure 2) representation in order to do the transformation to the behaviour of an equivalent SDOF system. In this MDOF to SDOF transformation, α is the modal mass coefficient and β is the modal participation factor, as shown in Equations 3a and 3b. The SDOF representation allows the user to have a direct comparison of the displacement capacity at the effective height with the displacement demand obtained from the related over-damped SDOF displacement spectrum.

The α and β coefficients in Equations 2.3a and 2.3b are similar to PF_1 and α_I, respectively, in FEMA440 (ATC, 2005). In these equations, n is the total number of floors, w_i is the total weight of the i^{th} storey, and ϕ_{i1} is the value of the normalized modal displacement at the i^{th} floor for the 1^{st} mode.

$$\xi_{eq} = 0.05 + 0.565\left(\frac{\mu - 1}{\mu\pi}\right) \qquad (2)$$

The limit state period of the structures has to be calculated in order to insert this value into the over-damped displacement spectrum to obtain displacement demand values. Crowley et al. (2006) use the elastic-perfectly plastic behaviour for existing structures so that 2^{nd} and 3^{rd} limit state periods can be simply related to the yield period. In this case, the calculation of the demand is basically related to the calculation of the yield period, as a function of height and determination of ductility at the considered limit state (see Equation 9).

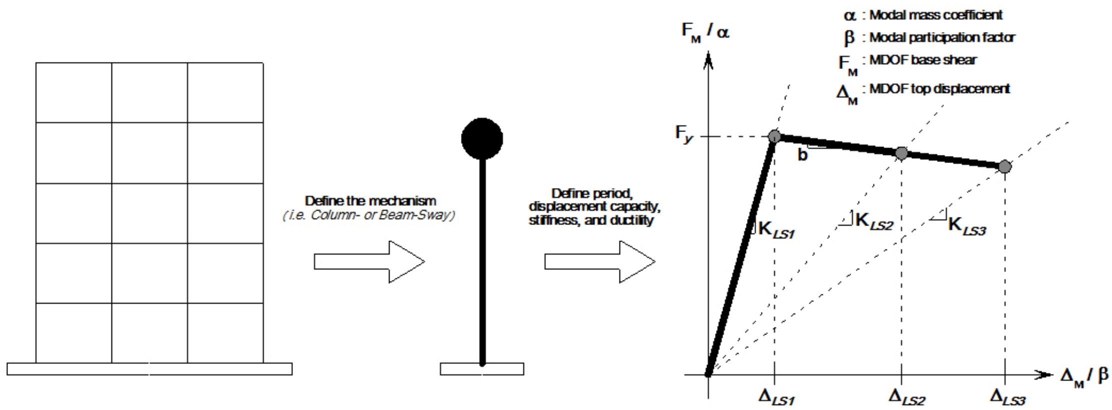

Figure 2. SDOF representation of the multi-storey structures (Bal, 2008)

$$\alpha = \frac{\left[\sum_{i=1}^{n}\left(w_i \Phi_{i,1}\right)/g\right]^2}{\left[\sum_{i=1}^{n} w_i/g\right]\left[\sum_{i=1}^{n}\left(w_i \Phi_{i,1}^2\right)/g\right]} \qquad (3a)$$

$$\beta = \frac{\left[\sum_{i=1}^{n}\left(w_i \Phi_{i,1}\right)/g\right]}{\left[\sum_{i=1}^{n}\left(w_i \Phi_{i,1}^2\right)/g\right]} \qquad (3b)$$

The ratio between the yield period, T_y, and Limit State Period, T_{LS}, can be directly related to the ratio of the yield stiffness, Ky and to the ratio of the limit state stiffness, K_{LS} (see Equation 4). This ratio would purely depend on the square-root of the Limit State ductility, μ_{LS}, in cases where the post-yield stiffness ratio is neglected (i.e. assumed as zero, see Equation 9). Otherwise a relationship can be derived as given below:

$$T_{LS} = T_y \sqrt{\frac{\mu_{LS}}{1 + \alpha\mu_{LS} - \alpha}} \qquad (4)$$

where T_{LS} is the limit state period, T_y is the yield period, K_{LS} is the limit state stiffness, K_y is the yield stiffness, Δ_{LS} is the limit state displacement at the effective height, Δ_y is the yield period at the effective height, and "b" is the post-yield stiffness ratio. The Equation 4 can be developed between Equations 5 and 8. The formula takes the form suggested by Crowley et al. (2008), if post-yield stiffness is neglected (see Equation 9).

$$T_{LS} = T_y \sqrt{\frac{K_y}{K_{LS}}} \qquad (5)$$

$$K_y = \frac{F_y}{\Delta_y} \qquad (6)$$

$$K_{LS} = \frac{F_{LS}}{\Delta_{LS}} = \frac{F_y + \alpha K_y\left(\Delta_{LS} - \Delta_y\right)}{\Delta_{LS}} \qquad (7)$$

$$K_{LS} / K_y = \frac{F_y / \Delta_{LS} + \alpha K_y\left(\Delta_{LS} - \Delta_y\right)/\Delta_{LS}}{F_y / \Delta_y} \qquad (8)$$

$$T_{LS} = T_y \sqrt{\mu_{LS}} \quad \text{(if b=0)} \qquad (9)$$

The DBELA methodology has been summarized above to underline the importance of yield period in the method and to facilitate the reader to have a better insight in the use of this parameter in a simplified displacement-based assessment methodology.

Building Classification

There are several building classes in the existing building stock, the number of which depending on the region. In the European-Mediterranean region, including Turkey, for example, Bal et al. (2008a) reports 8 different types of RC structures as:

a. Poor – Frame - Emergent Beam

b. Poor – Frame - Embedded Beam

c. Poor – Dual - Emergent Beam

d. Poor – Dual - Embedded Beam

e. Good – Frame - Emergent Beam

f. Good – Frame - Embedded Beam

g. Good – Dual - Emergent Beam

h. Good – Dual - Embedded Beam

The above classification may also be subdivided into cases of “bare”, “fully infilled” or “infilled with opening” cases to consider the effect of the masonry infills. Some other less significant building classes, such as “RC structures with flat slabs” may also be added into these classes depending on the building characteristics of the region considered. In the HAZUS classification, for example (Kircher et al., 1997; FEMA, 2003), it is possible to find timber or masonry buildings that differ in typology from the ones in Europe.

This study focuses on “Poor-Frame” groups defined by Bal et al. (2008a). Masonry buildings between 1 and 4 storeys, with flexible and rigid slabs, are also included in the building classes. Readers are referred to Bal et al. (2008b) for further information of application of DBELA on unreinforced masonry structures.

ECONOMICAL LOSSES EXPECTED AFTER AN EARTHQUAKE OF M_W=7.2

The model created for this part of the study covers the most populated 26 districts of total 39 districts in Istanbul. Due to the high computational demand, those geocells with very sparse settlements (essentially those containing greenery or water resources in the northern part of the city) have been eliminated from the calculations which halved the number of geocells for the entire city. It should be noted that this halving of the number of geocells removes less than 20% of the total number of buildings. In this exercise, Poor-Frame buildings that consist of two thirds of the stock have been used.

The scenario earthquake for this exercise is taken from recent studies by Crowley et al. (2005) and Crowley et al. (2008) and it has the magnitude of Mw 7.2 earthquake on fault segments S7 and S8 (see Figure 3). The failure segments are much closer to the European side of the city, thus, concentration of damage in that part, especially close to the coast, is expected.

The ground motion spectral displacements have been obtained by using the ground motion prediction equations by Akkar and Bommer (2007). In total, 12 building classes have been considered, varying between 1 and 7 storeys. Loss assessment calculations have been conducted by using the proposed DBELA method.

The main objective of this exercise is to obtain the level of economic losses depending on the level and spatial distribution of the physical damage. Consequently, physical damage has been transformed into Mean Damage (MD) value per each geocell (geocells are the closed rectangular areas with 0.005°x0.005° dimensions). The MD value has been calculated as:

$$MD=Nc,i\ DRc + Nh,i\ DRh + Nm,i\ DRm + Ns,i\ DRs \qquad (10)$$

where $N_{c,i}$, $N_{h,i}$, $N_{m,i}$ and $N_{s,i}$ are number of collapsed, heavily damaged, moderately damaged and slightly damaged buildings in geocell “i”, respectively. The DR values are expected damage ratios which are defined as the ratio of cost of recovering the building to the cost of reconstructing it. These values are 16%, 33%, and 105% for slightly, moderately, and heavily damaged buildings, and 104% for a totally collapsed building (see Bal et al., 2007 and Bal et al, 2008a for a comprehensive explanation of these values).

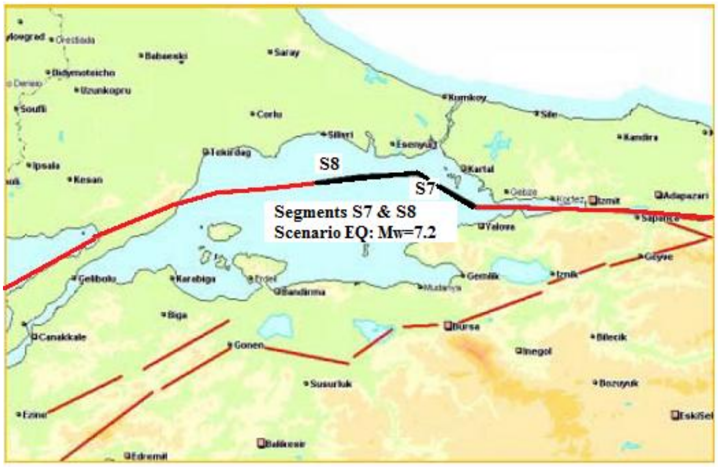

Figure 3. Considered scenario earthquake along the fault segments S7 & S8 in Marmara Sea

Based on the recent findings and suggestions by Crowley et al. (2008), spatial correlation has also been included in the calculation of expected ground motion fields. According to this, instead of assuming that the median values of the ground motion prediction equation apply for all the geocells at the same time, variation of the related uncertainty of the ground motion among several geocells is accounted for. In order to do that, 1000 random simulations where geocell-to-geocell variations (i.e. application of different uncertainty in the ground motion prediction equation for different geocells within the same simulation) have been represented are created. Consequently, loss assessment calculations have also been done 1000 different times for different simulations of the ground motion fields. Therefore, damage ratios for 1000 simulations for 12 building classes and for 4033 geocells builds up a large matrix of 12x1000x4033. This certainly increases drastically the analysis time, but on the other hand, the accuracy in prediction of the variability is worth spending this computational effort.

Resulting ground motion fields can be observed in Figure 4 at 0.2sec period and in Figure 5 at 1.0sec period. Spatial distribution of the ground motion field seems to be quite scattered if individual simulations are considered.

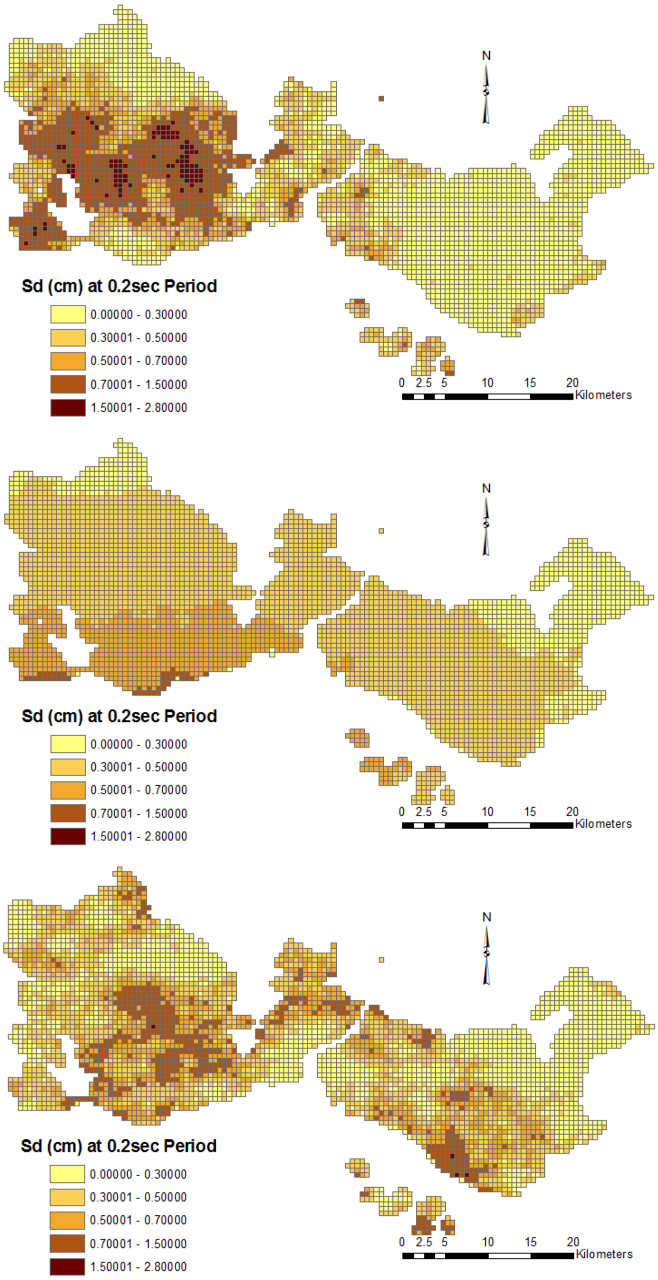

Figure 4. Spectral displacement at 0.2sec period (top) for Simulation # 1, (middle) for average of 1000 simulations, and (bottom) for Simulation # 1000

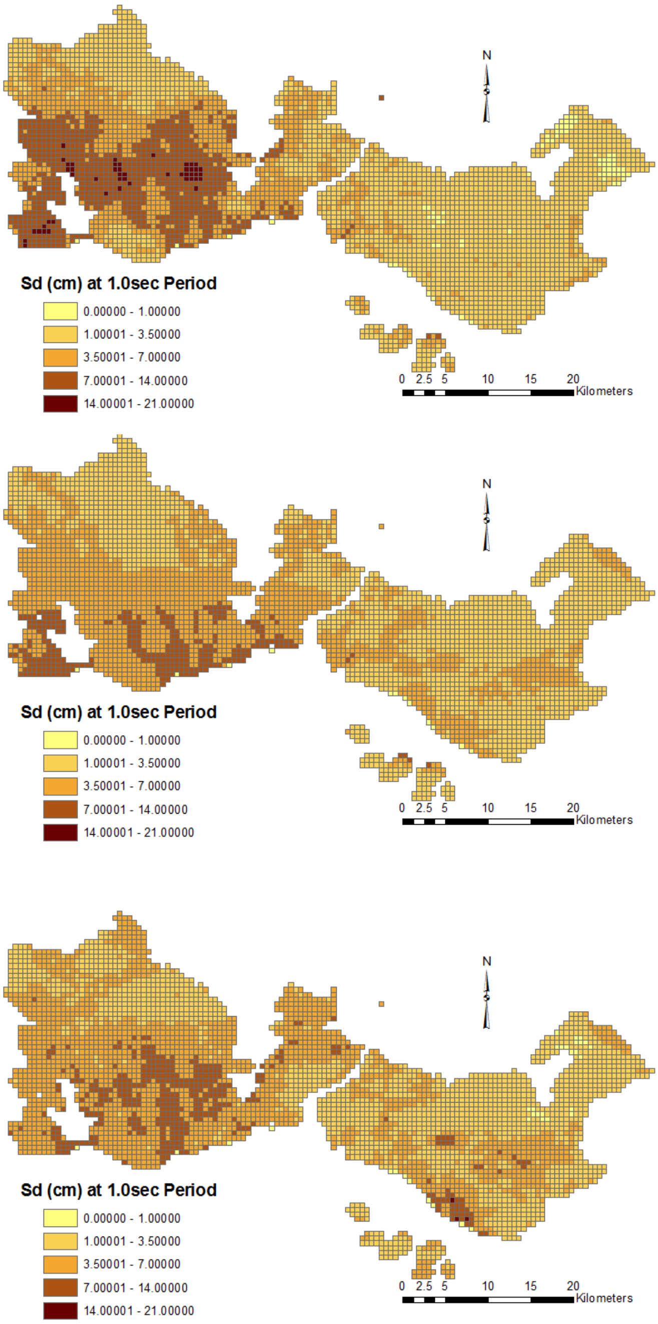

Figure 5. Spectral displacement at 1.0sec period (top) for Simulation # 1, (middle) for average of 1000 simulations, and (bottom) for Simulation # 1000

Following the extensive suite of analyses, mean damage values per geocell have been obtained. According to the recent findings by Bal et al. (2007 and 2008a), if average mid-rise residential, or residential & commercial RC buildings are concerned, replacement cost of an average building in Turkey varies between 150,000 € and 600,000 € (412,000 €, if average structural properties are concerned) per square-metre. Therefore, a cell with MD values of 400, for instance, would translate to direct monetary loss of 400x412,500 = 165 Million €. In other words, this would be the direct economic loss in a cell with approximately 400mx600m dimensions.

There are nearly 662,000 buildings in the considered area of application. The average Mean Damage Ratio (Mean Damage divided by the total number of buildings) for whole Istanbul is calculated as 18% with 21% coefficient of variation. Consequently, the total direct economic loss expected from the above-given scenario earthquake is calculated as 49 billion €. These values consist only of the loss originated from the damage/collapse of residential or residential/commercial mid-rise ordinary RC buildings that is two thirds of the stock and consist of the most vulnerable part of the building population in the region. This loss may drastically increase if a different scenario were to be considered where the onset of the damage also extending to the Asian side is accounted for.

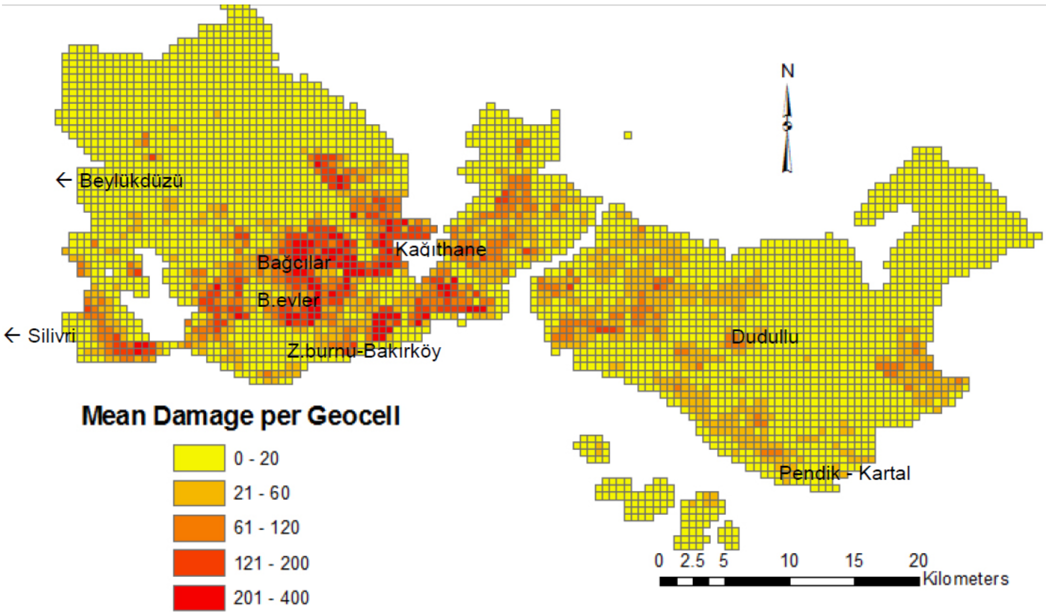

Figure 6. Spatial distribution of the expected mean damage

The above given calculations can also be conducted for multiple scenarios where annual probability of exceedance or annual rate of loss can be calculated, to be used in insurance premium estimations. This type of analyses would serve to insurance or re-insurance purposes. Additionally, it should be noted that the spatial distribution of the MD values does not represent the expected direct losses of industrial zones in Istanbul. These zones are mostly concentrated in North-West of Golden Horn *(in Ayazağa and along the river of Kağıthane)*, in the western edge of the city *(after Beylikdüzü, around Haraççı, Hadımköy, after Silivri, etc.)* or along the D100 Road in the Asian side *(Pendik, Kartal, Dudullu and around)*. Among these zones, according to the findings of the applied scenario earthquake, the industrial facilities along the Kağıthane River and through Ayazağa would be expected to face the highest level of damage. This issue however, is out of the scope of this study.

SOCIAL LOSSES EXPECTED AFTER AN EARTHQUAKE OF M_W=7.5

This section of the study presents damage distributions and social losses to the Istanbul Metropolitan Municipality as part of a testbed damage estimation exercise, as described in detail in Strasser et al. (2008). To simulate the conditions of a post-earthquake rapid-response situation, a scenario-based approach is adopted in which the spatial distribution of ground motions is provided by an external application, such as the ShakeMap package developed by the United States Geological Survey (e.g., Wald et al., 2006). The selected scenario is the deterministic scenario considered in the Red Cross study (BU-ARC, 2002). This scenario corresponds to a ‘‘credible worst case scenario’’ involving the rupture of the three main segments of the Main Marmara Fault closest to Istanbul in a Mw 7.5 earthquake (see Figure 7).

The ground-motion parameters provided by the testbed study are: macroseismic intensity (MSK), peak ground acceleration (PGA), and 5%-damped spectral accelerations and displacements at response periods of 0.2 and 1.0 s. The PGA values were derived by taking the average of the values predicted by the relations of Boore et al. (1997), Campbell (1997) and Sadigh et al. (1997). The spectral acceleration values at 0.2 and 1.0 s were derived by taking the average of the values predicted by the Boore et al. (1997) and Sadigh et al. (1997) relations at the NEHRP site class B/C boundary (VS,30 = 760 m/s), and then applying site-specific amplification factors following the NEHRP (1997) provisions. The study area covers 39 districts (ilçe) and 560 subdistricts (mahalle). In view of the large differences in size from one subdistrict to the next, the data have been resampled on a uniform grid of 0.005°x0.005° cells (approximately 400m x 600m). This results in a database of 8131 geocells.

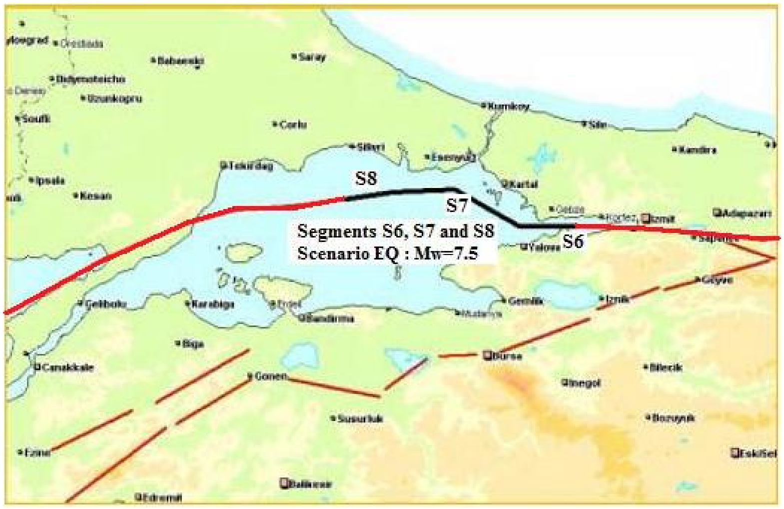

Figure 7. Considered scenario earthquake along the fault segments S6, S7 & S8 in Marmara Sea

The building stock inventory used is that derived in the Red Cross study based on the extensive data provided by the Turkish State Statistics Institute (SSI) and Istanbul Metropolitan Municipality (IBB). The building classification scheme considers 24 categories (B_{ijk}) based on construction type, building height, and construction year. Building stock data are available for 4,014 out of 8,131 geocells, the remaining 4,117 geocells corresponding to sparsely populated mountainous areas at the outskirts of Istanbul Metropolitan Municipality. The most common building type by far corresponds to reinforced concrete (RC) frame buildings, which represent 74% of the total number of buildings, with a predominance of low-rise (1–4 stories, 60% of the RC building stock) and mid-rise (5–8 stories, 34%) buildings. A large proportion of the RC building stock has been constructed in 1980 or later, following the introduction of earthquake-resistant design principles in the 1975 building code. Masonry buildings represent 25% of the total building stock, and are almost exclusively low rise. Two thirds of the masonry building stock has been built prior to 1979; a similar proportion of the RC building stock was built after 1980, reflecting the rapid expansion of the Istanbul Metropolitan Area in recent years. Prefabricated and shear wall buildings only contribute marginally to the building stock (<1% of the total number of buildings). Additional building classes are necessary for the DBELA methodology in order to allow a more detailed estimation of the vulnerability characteristics of the building stock. For reinforced concrete buildings, a total of 54 building classes have been identified for the whole RC building stock, as illustrated in Figure 8 where a type of logic tree approach has been used to represent characteristics of each building class. The proportion of buildings with a beam-sway mechanism or a column-sway mechanism has been defined using the geometrical characteristics of the aforementioned database. Finally, the proportion of buildings with each number of stories from 1 to 9 has been calculated using the 2000 Building Census data.

The proportion of buildings which fall into each branch of the logic tree have been estimated using both the 2000 Building Census data for the Istanbul region and the database of buildings given in Bal et al (2007 and 2008a). All pre-1979 RC buildings are assumed to have S220 type steel, following information which has been obtained on the manufacturing of this type of steel in Turkey. The proportion of buildings post-1980 with S220 and S420 steel have been estimated using available data on the production of each type of steel from 1980 until 2000. As described in Bal et al (2007 and 2008a), the S420 steel produced between 1978 and 1988 has been found to have different material characteristics to that produced between 1988 and 1998 and thus two separate groups have been defined for this steel type.

The masonry buildings have been divided into 24 building classes, one for each number of stories from 1 to 4 for both pre- and post-1980 and for the three masonry types: briquette, clay with a high percentage of voids and clay with a low percentage of voids. Buildings constructed before 1980 have been assumed to be of either briquette or clay with a low percentage of voids (harman tuğlası & blok tuğla), whilst masonry buildings constructed after 1980 are assumed to be constructed with clay with a high percentage of voids following the unsatisfactory, though frequent, practice of using infill material from RC buildings for the construction of masonry buildings.

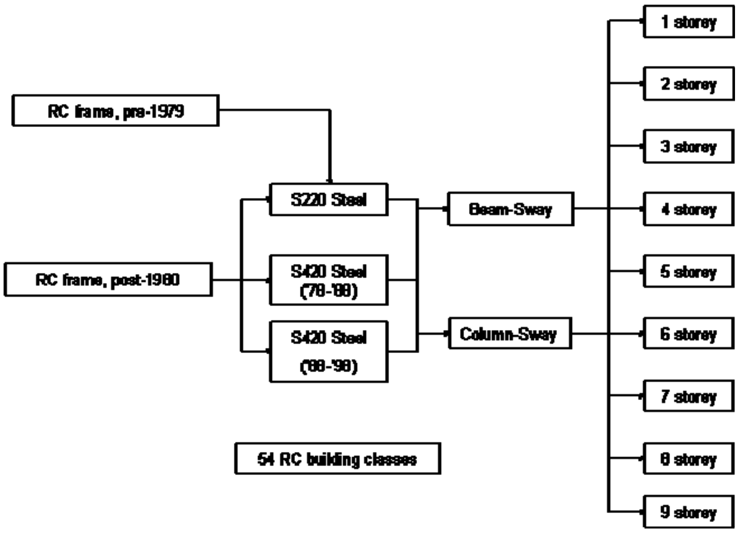

Figure 8. Diagram showing the different building classes which have been assumed for the RC building stock

Table 1 and Table 2 show the probabilistic distributions of the geometrical properties which have been obtained from the Turkish database of reinforced concrete and masonry buildings and which have been used to define the vulnerability of these buildings, as already described in Bal et al (2007 and 2008a).

Table 1. Geometrical characteristics of reinforced concrete buildings

Parameter	Mean Value	CoV	Probabilistic Distribution
Regular story height	2.84m	8%	Lognormal
Ground floor story height	3.23m	15%	Lognormal
Beam length	3.37m	38%	Lognormal
Beam depth	0.6	15%	Normal
Column depth at ground floor			
1-3 stories	0.45m	12%	Lognormal
4 stories	0.49m	30%	
5 stories	0.65m	30%	
≥ 6 stories	0.70m	28%	

Table 2. Geometrical characteristics of masonry buildings

Parameter	Mean Value	CoV	Probabilistic Distribution
Regular story height	2.62m	8%	Lognormal
Ground floor pier height	2.40m	15%	Normal

Social Losses

The results presented herein have been obtained using a Displacement-Based Earthquake Loss Assessment methodology (DBELA) presented in this study. Main focus in this section is given to the spatial distribution of the "collapsed" buildings and to the expected total social losses.

The proportion of each building class within each damage band (slight, moderate, extensive and complete) has been calculated using the ground motions provided as part of the testbed damage estimation exercise, as described in detail in Strasser et al. (2008). The damage data have been combined with the exposure data such that the number of damaged buildings within each of the 8131 geocells can be estimated. The damage distributions which have been obtained for the selected Mw 7.5 earthquake are presented in Figure 9. These damage distributions have allowed the social losses to be predicted in terms of the number of fatalities and injuries following the earthquake. The model recently proposed by Spence (2007) has been applied, as summarized in Table 3. A slight modification to the model by Spence (2007) has been included such that the proportion of critical injuries is added to the proportion of deaths so that the loss bands are comparable with other models used in the testbed study. The proportions presented in Table 3 are multiplied by the proportion of completely damaged buildings and the estimated number of people in the buildings. The latter data has been provided both during the day and during the night (Strasser et al., 2008). Population data have been provided by the aforementioned source in each geocell level as a single number, without subdivision to building groups. Expected injury ratios have been averaged by considering the building types and their distributions in a geocell. The number of homeless people has been estimated by summing all of the uninjured, slightly or moderately injured people in the collapsed buildings and all of the people in the moderately or extensively damaged buildings.

Table 3. Injury distributions for specific building types (Spence, 2007)

	Complete Damage State					
	U_I	**I_1**	**I_2**	**I_3**	**I_4**	**I_5**
Masonry (1F)	23.6%	50.0%	12.0%	8.0%	0.4%	6.0%
Masonry (2-3F)	16.5%	50.0%	15.0%	10.0%	0.5%	8.0%
Masonry (≥4F)	9.4%	50.0%	18.0%	12.0%	0.6%	10.0%
RC (1F)	32.9%	30.0%	19.0%	3.0%	0.2%	15.0%
RC (2-3F)	20.8%	30.0%	23.0%	4.0%	0.2%	22.0%
RC (≥4F)	9.7%	30.0%	27.0%	5.0%	0.3%	28.0%

U_I=uninjured; I_1=slight injuries;
I_2=moderate injuries; I_3=serious injuries;
I_4=critical injuries; I_5=deaths

The results of this scenario earthquake exercise indicate that about 47,000 buildings *(6.4% of the total building stock)* would collapse, 81,000 buildings would be extensively damaged *(i.e. beyond repair)*, 200,000 buildings would be moderately damaged and about 400,000 buildings would experience none to slight damage. Figure 9 shows the spatial distribution of the collapsed buildings in the 8,131 geocells used in this study. In terms of casualties, using the values presented in Table 3, these damage results would translate to 150,000 deaths and 364,000 serious injuries and around 4.5 million people rendered homeless, were the earthquake to occur at night.

The recent paper by Pyper Griffiths et al. (2007) has predicted that a quarter of a million buildings (40% of the building stock) would reach levels of extensive and complete damage for a similar scenario earthquake based on an extrapolation of the damage from the 1999 Kocaeli earthquake. The discussion of the aforementioned paper by Erdik (2007) argues that the losses would be about 2.5 times less than this, whilst Sözen (2006) suggests an optimistic best estimate of the loss would be that 10% of the building inventory would collapse and deaths would amount to 1% of the population. There is obviously a large scatter in the aforementioned results, but the predictions presented herein fall within this range; in all predictions the scale of damage is unacceptable and thus it is clear that mitigating measures are of utmost importance to identify and retrofit the most vulnerable building stock in Istanbul.

CONCLUSIONS

An application of the DBELA methodology has been done for pre-event calculations of the expected losses. A single scenario of Mw=7.2 has been used for the purpose of this application. The spatial correlation of the ground motion has been ignored in this stage. There are nearly 662,000 buildings in the considered area of application. The average Mean Damage Ratio (Mean Damage divided by the total number of buildings) for the whole of Istanbul is calculated as 18% with a 21% coefficient of variation. Consequently, the total direct economical loss expected from the above-given scenario earthquake is calculated as 49 billion €. These values consist only of the loss originated from the damage/collapse of residential or residential/commercial mid-rise ordinary RC and URM buildings. This loss may drastically increase if a different scenario were to be considered where the onset of the damage also extended to the Asian side.

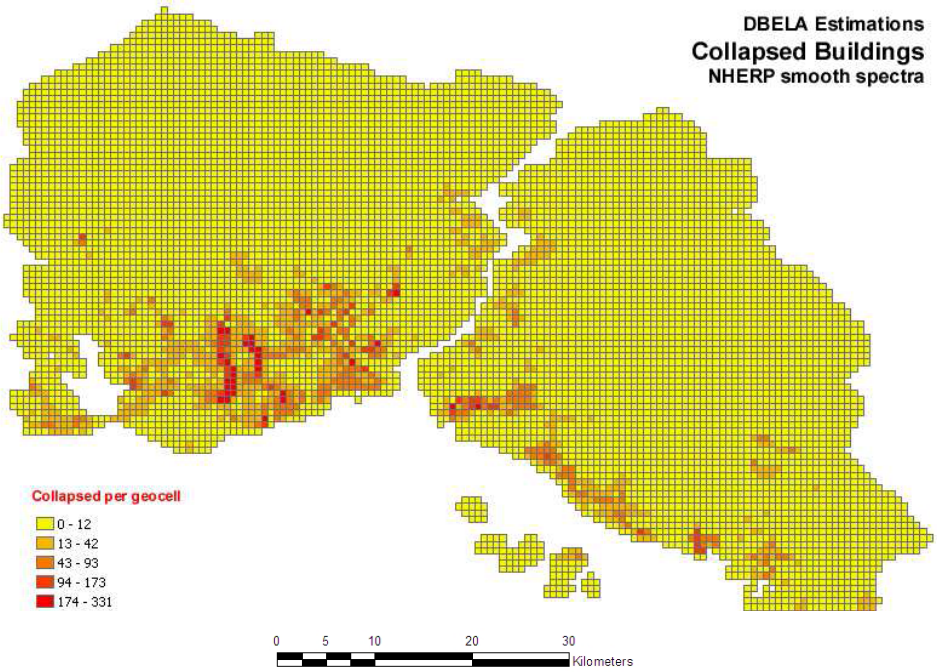

Figure 9. Spatial distribution of complete damage to all buildings in the Istanbul Metropolitan Municipality

A scenario earthquake of 7.5 has been used to estimate the possible post-event social losses and spatial distribution of the physical damage in Istanbul. The results are presented as part of a recent testbed study where several European loss estimation tools have been compared by using the same input related to a given scenario of an earthquake close to Istanbul. The results of this scenario earthquake exercise indicate that about 47,000 buildings (6.4% of the total building stock) would collapse, 81,000 buildings would be extensively damaged (i.e. beyond repair), 200,000 buildings would be moderately damaged and about 400,000 buildings would experience none to slight damage. In terms of casualties, damage results would translate to 150,000 deaths and 364,000 serious injuries and around 4.5 million people rendered homeless, were the earthquake to occur at night.

The above given calculations can also be conducted for multiple scenarios where the annual probability of exceedance or annual rate of loss can be calculated, to be used in insurance premium estimations. This type of analyses would serve for insurance or re-insurance purposes. Additionally, it should be noted that the spatial distribution of the MDR values does not represent the expected direct losses of industrial zones in Istanbul. These zones are mostly concentrated in North-West of Golden Horn (in Ayazağa and along the river of Kağıthane), in the western edge of the city (after Beylikdüzü, around Haraççı, Hadımköy, after Silivri, etc.) or along the D100 Road in the Asian side (Pendik, Kartal, Dudullu and around). Among these zones, according to the findings of the applied scenario earthquake, the industrial facilities along the Kağıthane River and through Ayazağa would be expected to face the highest level of damage. This issue however, is out of the scope of this study.

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REFERENCES

Akkar, S., and Bommer, J. J. (2007). “Prediction of elastic displacement response spectra in Europe and the Middle East”, Earthquake Engineering and Structural Dynamics 36, pp. 1275-1301.
ATC (2005). “Improvement of nonlinear static seismic analysis procedures”, FEMA-440, ATC, California, USA.
Bal, İ. E., Crowley, H., Pinho, R. and Gülay, G. (2007). “Structural characteristics of Turkish building stock in Northern Marmara Region for loss assessment applications”, ROSE Research Report 2007/03, IUSS Press, Pavia, Italy.
Bal, İ. E. (2008a). “Displacement-Based earthquake loss assessment: method development and application to Turkish building Stock,” PhD dissertation, Centre for post-Graduate Training and Research ine Earthquake Engineering and Engineering Seismology (ROSE School), University of Pavia, Italy.
Bal, İ. E., Crowley, H., and Pinho, R. (2008b). “Displacement-based earthquake loss assessment of Turkish masonry structures”, 14th WCEE, Beijing, China, paper no: 05-05-044.
Bal İ.E., Crowley, H., Pinho, R. and Gülay G. (2008). “Detailed assessment of structural characteristics of Turkish RC building stock for loss assessment models”, Soil Dynamics and Earthquake Engineering, 28(10-11), 914-932.
Boore, D. M., Joyner, W. B. and Fumal, T. E. (1997). ‘‘Equations for estimating horizontal response spectra and peak acceleration from Western North American earthquakes: a summary of recent work’’, Seismological Research Letters 68(1), 128–153.
BU-ARC (2002). ‘‘Earthquake Risk Assessment for Istanbul Metropolitan Area’,’ Project Report, Boğaziçi University and American Red Cross, Boğaziçi University Publications, Istanbul, Turkey.
Crowley, H., Pinho, R., and Bommer, J. J. (2004). ‘‘A probabilistic displacement-based vulnerability assessment procedure for earthquake loss estimation’’, Bulletin of Earthquake Engineering, (2), 173-219.
Crowley, H., Pinho, R., Bommer, J.J., and Bird, J.F. (2006). “Development of a Displacement-Based Method for Earthquake Loss Assessment”, IUSS Press, Pavia, Italy.
Crowley, H., Stafford, P. J. and Bommer, J. J. (2008). “Can earthquake loss models be validated using field observations?”, Journal of Earthquake Engineering, 12(7), 1078 -1104.
Erdik, M. (2007). “Discussion of: Istanbul at the threshold: an evaluation of the seismic risk in Istanbul’’, by Pyper Griffiths, J.H., Irfanoglu, A, and Pujol, S., Earthquake Spectra, 23(1), 63–75.
FEMA (2003). “HAZUS-MH Technical Manual”, Federal Emergency Management Agency, Washington D.C.
Glaister, S., and Pinho, R. (2003). “Development of a simplified deformation based method for seismic vulnerability assessment”, Journal of Earthquake Engineering, 7(S1), 107-140.
Kircher, C.A., Nassar, A.A., Kustu, O. and Holmes, W.T. (1997). “Development of building damage functions for earthquake loss estimation”, Earthquake Spectra, 13(4), 663-682.
NEHRP (1997) “Recommended provisions for seismic regulations for new buildings and other structures”, Report FEMA-303, Building Seismic Safety Council, Federal Emergency Management Agency, Washington DC.
Pinho, R., Bommer, J. J and Glaister, S. (2002). “A simplified approach to displacement-based earthquake loss estimation analysis", Proceedings of the 12th European Conference on Earthquake Engineering, London, UK, paper no. 738.
Priestley, M.J.N., Calvi, G.M. and Kowalsky, M.J. (2007). “Displacement-Based seismic design of structures”, IUSS Press, Pavia, Italy.
Priestley, M. J. N. (1997). “Displacement-Based seismic assessment of reinforced concrete buildings”, Journal of Earthquake Engineering; 1(1), 157–192.
Pyper Griffiths, J. H., Irfanoglu, A., and Pujol, S. (2007). ‘‘Istanbul at the threshold: an evaluation of the seismic risk in Istanbul’’, Earthquake Spectra 23(1), 63–75.
Sadigh, K., Chang, C.-Y., Egan, J. A., Makdisi, F., and Youngs, R. R. (1997). ‘‘Attenuation relationships for shallow crustal earthquakes based on California based on California strong motion data’’, Seismological Research Letters 68(1), 180–189.
Shibata, A., and Sözen, M. (1976). “Substitute structure method for seismic design in reinforced concrete”, ASCE Journal of Structural Engineering, 102(1), 1-8.

Spence, R. (ed.) (2007). "Earthquake disaster scenario prediction and loss modelling for urban areas", LessLoss Final Reports, IUSS Press, Pavia, Italy.

Strasser, F. O., Bommer, J. J., Sesetyan, K., Erdik, M., Cagnan, Z., Irizarry, J., Goula, X., Lucantoni, A., Sabetta, F., Bal, I. E., Crowley, H., and Lindholm, C. (2008). ''A comparative study of European earthquake loss estimation tools for an earthquake scenario in Istanbul'', Journal of Earthquake Engineering, 12(S2), pp.246–256.

Sözen, M. (2006) ''From Düzce to the city'', in Advances in Earthquake Engineering for Urban Risk Reduction, NATO Science Series, Springer.

Wald, D. J., Worden, B. C., Quitoriano, V., and Pankow, K. L. (2006). "ShakeMap Manual", Technical Manual, User's Guide and Software Guide, http://pubs.usgs.gov/tm/2005/12A01/.

TURKISH EXPERIENCE IN CONCRETE CONSTRUCTION INDUSTRY AND INFRASTRUCTURE

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ABSTRACT

Technical parameters used by the contractors for quality assessement during construction are discussed. The validity of using the compressive strength of concrete and the yield stress of steel as the only material design parameters is questioned. It is pointed out that performance characteristics of construction materials not only include mechanical strength properties but also long term durability characteristics and energy absorption capacity during fracture. Durability characteristics of materials, such as permeability of concrete, may not be directly related to the mechanical strength. The degradation of load bearing materials such as concrete and steel in time, may lead to early loss of servicability of structures or, loss of mechanical strength and rigidity, especially under dynamic earthquake loads, leading to sudden total collapse. It is pointed out that service life concept should be introduced into structural design and specifications. Only after this, it could be possible to introduce new quality control measures, such as permeability characteristics of concrete or corrosion properties of steel, on site, to be implemented by the contractors.

KEYWORDS
Quality control, Compressive strength, Durability, Service life, Corrosion.

INTRODUCTION

Quality of the materials, used in construction, is often described by their mechanical strength value. Generally, project design and specifications refer to the class of concrete by a characteristic strength, evaluated at the 28th day by testimg under compression, after curing in conditions described by the standards. As in the design and construction of new structures, condition assessment of existing structures also heavily depend on assessing the compressive strengh evaluated by cores, destructively taken from the structures. Although the compressive strength value of concrete is a major property to determine, since concrete is used as a load bearing material, it is the permeability property, which control the durability and long term servicability of the structures. Besides mechanical properties of concrete, any assessment related to the structural resistance against dynamic loads, such as earthquakes, should also take durability and degredation characteristics of the construction materials into account. For the safety of structures during their intended and designed service life, and seismic resistance, the load bearing structural members should be free of material damage, such as corrosion of steel bars and extensive cracking of concrete.

QUALITY DEFINED IN THE STANDARDS

Construction materials should be used according to the releavant standards to assure structural integrity and seismic safety. Many Turkish Standards, related to concrete, are superseded by European standards during the past years. Therefore, it is important to investigate the current standards on concrete and concrete making materials, and compare them with the construction methods and structures built with the previous Turkish standards.

According to standards, quality of concrete is composed of the quality of constituent materials such as aggregates (TS 706 EN 12620), cement (TS EN 197-1), water (TS EN 1008) and chemical admixtures (TS EN 934-2). Several other standards may be found for assessing the quality of other supplemantary additives such as blast furnace slag, silica fume or fly ash.

After choosing the materials with appropriate quality, performance properties of concrete has to be defined in both fresh and hardened states (TS EN 206-1). According to TS EN 206-1, not only strength class, but also workability (consistence) class, environmental exposure class, chloride content class, density class and maximum aggregate size class of the concrete have to be specified.

Workability class and maximum aggregate size class of the concrete are directly related to how concrete behaves in its freah state. The importance of specifying fresh concrete properties is important for insitu performance of concrete. Strength class is determined by sampling of fresh concrete prior to casting concrete in formworks. The samples, 150x150x150 mm cubes or 150 mm diameter, 300 mm long cylinders, are kept under humidity conditions at 20^oC for 28 days. Therefore the strength class is only related to strength potential of concrete, rather than quality of concrete insitu. The insitu quality of concrete can only be maintained by proper placing (for example, pumping), compaction (for example, vibration) and curing methods. Workability class and maximum aggregate size class ensure that concrete will exhibit the required consistence to fill the formwork, pass in between the reinforcing bars and concrete cover, and compact under vibration, without segregation or intense bleeding.

Environmental exposure class and chloride content class of concrete are related to expected durability properties of concrete. Several testing and/or experience is required to determine the long term conditions which the concrete structure will be subjected to. Strength class is only related to 28 day compressive strength, therefore is not adequate to represent the long term performance under environmental attack. The environmental exposure is classified into several categories such as, carbonation, chlorides, freeze-thaw and chemical attacks. These attacks are directly related to the permeability of concrete. Permeability of concrete is composed of two major properties, pore structure and microcracks in concrete. Strength property is related to total volume and maximum size of the pore structure, however permeability is related to the connectivity of the pore structure. A direct relationship may not exist between permeability and strength properties (Figue 1). Most of the microcracks form during hardening of concrete, when concrete did not develop considerable strength but prone to volume changes due to shrinkage phenomenon. Shrinkage is related to materials used in concrete, as well as curing methods and duration. Many mechanisms exist, such as chemical and thermal, promoting the volumetric change, leading to microcracking of concrete when tensile strain capacity is reached. Therefore, durability and permeability performance should be specified seperately from strength class.

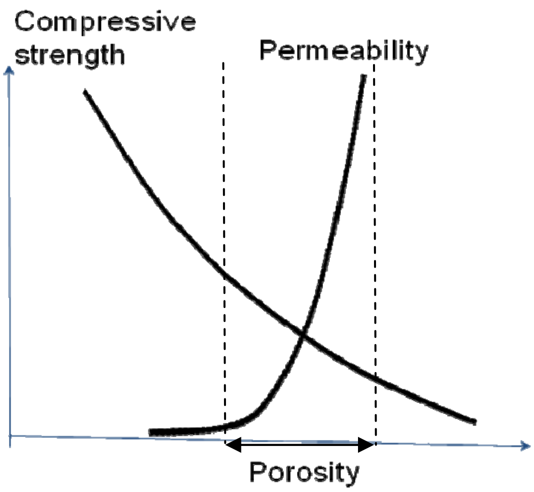

Figure 1. Relation between permeability and compressive strength of concrete with respect to increasing porosity.

Corrosion of steel can be prevented by many measures, most importantly by the quality and length of concrete cover. The permeability, connectivity of pore system, of the concrete cover plays an important role in the transportation of aggressive ions such as chlorides. The minumun thickness of concrete cover should be according to its designed value, so that the aggressive ions may not reach steel reinforcement and start corrsoion before the intended service life is reached. The corrosion of steel not only cause a decrease in the diameter and thus, strength of steel, but also decrease the ductility. Since the corrosion products are expansive, the volume increase cause an expansion of concrete, leading to cracking and spalling of the concrete cover. Therefore, the durability of concrete and the load transfer between steel and concrete will be affected adversely.

LABORATORY AND INSITU INVESTIGATIONS TO ASSESS QUALITY

The quality of materials used in construction of many decades of old buildings, of which concrete was produced on site, are investigated by taking cores and performing non destructive testing. It is observed that aggregates were used without washing and sieving (Figure 2) and no grain size distribution analysis was performed (Table 1).

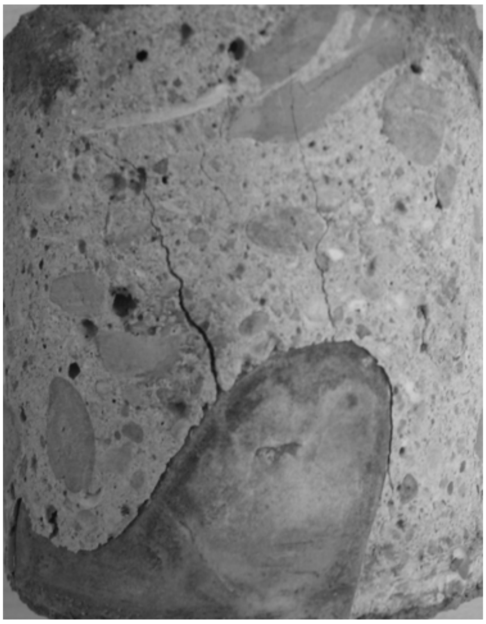

Figure 2. Size, type and shape of aggregates in a core, taken from a 30 years old building in Istanbul.

Table 1. Grain size distribution of aggregates used in concrete production.

	% passing			
Sieve size (mm)	31.5	16	8	4
	100	98	87	70
	100	97	91	83
	100	100	99	91
	100	80	59	51
	100	84	80	65

Microstructural analysis of concrete, made by fluoresence polarization microscope, revealed that the water-to-cement ratio was excessively high, the compaction was inadequate and highly carbonated (Figure 3). High amount of entrapped air voids was observed. Entrapped air voids indicate lack of vibration and poor workmanship during production of concrete.

Considerable variation was observed in the microstructure of concrete. Concrete was mixed manually, therefore large lumps of undispersed cement could be identified. This leads to high amount of water in local areas, which increase the capillary pore volume. Excessive amount of this type of connected porous zones can lead to carbonation of concrete and corrosion of steel reinforcement, and thus shorten the sevice life of structure.

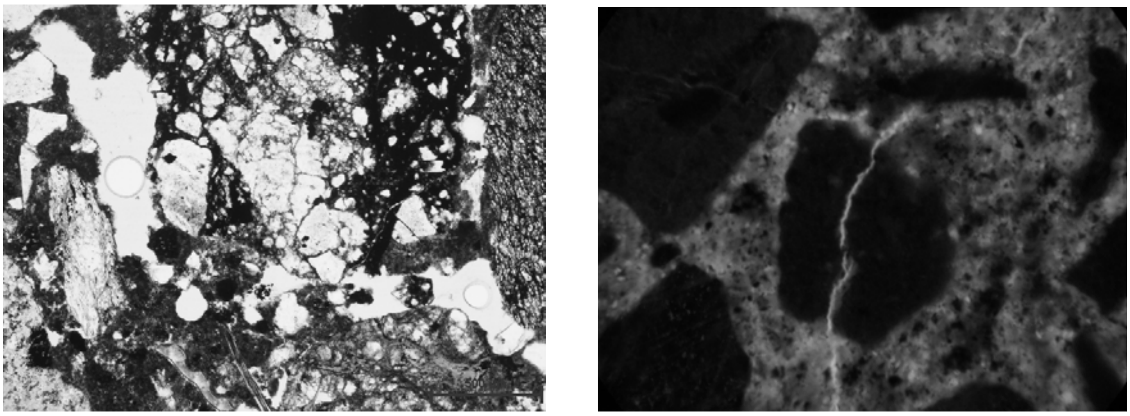

Figure 3. Microstructure pictures of concrete

Non-destructive tests, such as impact echo, revealed that the reinforcement exhibit corrosion and the bonding between concrete and steel was adversely affected. Impact echo method is based on sending elastic stress waves into concrete members, such as coloumns, and collecting back the signals received from the inhomogeneities inside the material. Reflection occur when the elastic wave hits an interface with an acoustically different material, such as air. Air interfaces in concrete can be cracks, pores or side boundaries of the strutural member. If the material is solid and free from major cracks and pores, no reflections from the discontinuities will occur. Thus the test result, amplitude-frequency spectrum, will contain only one sharp peak, the reflection from the boundary of the structural member.

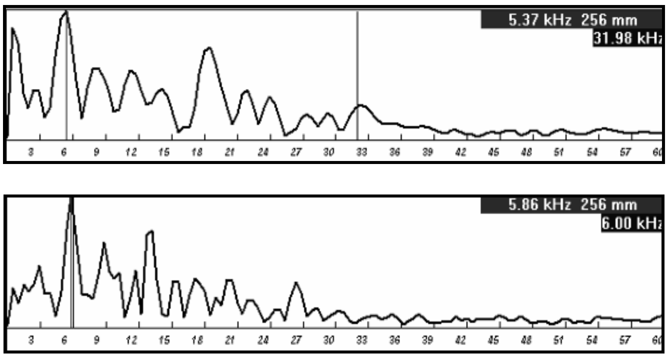

Figure 4. Impact echo test results on existing buildings, indicating multiple peaks and corrosion of the steel reinforcement (x-axis is frequency in kHz, y-axis is amplitude)

Several reinforced concrete structures were examined in Istanbul. Some test results indicating corrosion is presented in Figure 4. It can be observed that, there exist multiple frequencies around the location of steel. When steel corrodes, it creates an acoustically different interface, composed of rust and cracks.

Such non-destructive tests are useful in quick screeing of the existing structures. It is possible to identify structures with high risk of failure, before earthquake occurs.

The compressive strength classes, evaluated by cores, varied between C8 to C16, below the limits set by the standards, according to Environmental Exposure Classes.

Testing of concrete with close loop, displacement control compression machine proved that the ductility and energy absorption capacity of concrete decreases with increasing strength. Mechanisms such as aggregate debonding, aggregate bridging, crack deflection, crack branching and multiple cracking promote the comparaly higher ductility of low strength concrete. Aggregates fracture, rather than pull-out, in high strength concrete, and lead to brittle fracture. Thus, besides strength, toughness of concrete should also be taken into account, especially for prevention of sudden total collapse of structural members under earthquake forces (Figure 5).

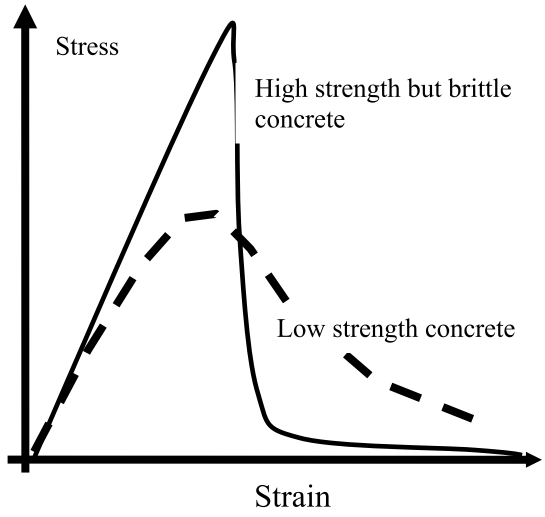

Figure 5. Strength-strain energy (ductility) relationship

The tensile test results of steel, performed at the construction materials laboratory of ITU Civil Engineering Department, has been analyzed and seen that the ratio of tensile strength to yield stress, an indication of steel ductility, exhibit a high variance (Figure 6). It can also be observed that some of the steel yield stress values can be above or below the standard limits.

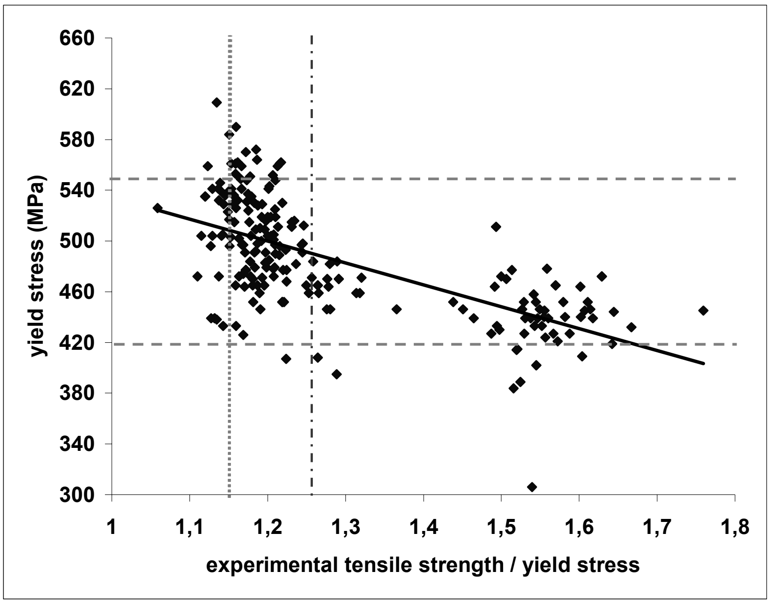

Figure 6. Experimental tensile test results of steel.

A comparion of concrete production control by statistical analysis of standards on concrete also revealed that care should be taken during proper sampling and testing since calculation of average strength can ignore low strength and concrete with unacceptable quality.

As a conclusion, quality of concrete is directly related to its microstructure and pore system. Strength, ductility and durability characteristics are affected differently by changes in concrete porosity. Selection of materials and quality assurance of concrete production are important steps in design of structures with seismic safety or strengthening of existing structures against earthquake.

CONCLUSIONS

After the evaluation of current standards and practice related to quality control measures of the construction industry, it can be concluded that the materials design, quality control during production and maintanance of the structures are important steps in construction. In order to build earthquake resistant structures, parameters besides structural design, which includes geotechnical studies according to location, selection of structural system and detailed analysis, are needed. These parameters should involve confirmity of materials, concrete mixture design, measures for workability and workmanship. Only then it will be possible to produce durable structures, conforming to their design service life, and will be resistant to degredation and thus, resist dynamic loads during earthquakes. Design codes and specifications should address this issue, define the neccesary criteria and address the relevant bodies with their responsibilities.

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REFERENCES

TS 706 EN 12620 Aggregates for concrete

TS EN 197-1 Cement- Part 1: Compositions and conformity criteria for common cements

TS EN 1008 Mixing water for concrete – Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete

TS EN 934-2 Admixtures for concrete, mortar and grout - Part 2: Concrete admixtures; Definitions, requirements, conformity, marking and labelling

TS EN 206-1 Concrete- Part 1: Specification, performance, production and conformity

REVIEW OF PROCEDURES USED FOR SEISMIC STRENGTHENING OF EXISTING PUBLIC SCHOOLS AND SOCIAL SERVICES BUILDINGS IN ISTANBUL, TURKEY

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ABSTRACT

In 2006, Istanbul Project Coordination Unit (IPCU) was established within the Istanbul Special Provincial Administration (ISPA) for the implementation and supervision of Istanbul Seismic Risk Mitigation and Emergency Preparedness (ISMEP) project in order to prepare Istanbul for a probable earthquake. One of the objectives of this project is retrofitting of priority public facilities, also including schools and social services buildings. In this paper, the seismic evaluation and strengthening design approaches developed for existing schools and social services buildings located in Istanbul are presented. The existing structure stock is consisted of both reinforced concrete and masonry buildings. Their structural conditions are reviewed and difficulties experienced during surveying are summarized. Relation between the concrete strength and the age of building stock is presented. Different analysis methods (both rapid and detailed) were performed during the seismic evaluation of the existing structure, and the retrofit schemes were developed accordingly. Many challenges were experienced during the implementation of the new 2007 Turkish Building Code, which had been revised and updated to incorporate aspects of performance based engineering design. The member evaluation methodologies described in the new Turkish Building Code, and ASCE 41 (reserve capacity vs. total capacity) is also compared based on the results of a simple (limited) study performed by the authors. Strengthening schemes meeting the required performance level per the code were developed considering the difficulties and problems to be faced at the construction site during implementation.

KEYWORDS
Retrofitting, existing structure, assessment, public buildings, masonry, earthquake, seismic strengthening

INTRODUCTION

A large portion of Turkey is subject to frequent earthquakes, generally from the North Anatolian Fault Zone, which is situated across the country and is responsible for many of Turkey's largest Earthquakes. Istanbul is one of the high seismic regions in Turkey and is located at the north of the North Anatolian Fault Zone in Western Turkey. The most recent major regional earthquake was the Izmit Earthquake that occurred on August 17, 1999. Densely populated region caused widespread damage and loss of life. If an event of the same magnitude was to occur near Istanbul the impacts on human suffering, social and economic losses would be much higher than that in the Izmit Earthquake event. It is critical to mitigate the seismic risk for public facilities to reduce casualties and ensure that impacts to those structures are minimized. Istanbul Project Coordination Unit (IPCU) was established within the Istanbul Special Provincial Administration for the implementation and supervision of Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP). The project aims to carry out seismic risk assessment of selected buildings and prepare retrofitting project designs. Seismic rehabilitation is the way to improve existing building's performance under seismic forces. Earthquake risk mitigation for buildings consists of three phases which are collecting existing building data, assessment/evaluation of existing structural performance, and developing/designing seismic strengthening schemes as required.

In this study, seismic assessment and retrofit design procedures used for Istanbul school buildings under scope of Istanbul Seismic Risk Mitigation and Emergency Preparedness Project are presented. The project consists of totally 216 school and social services buildings, of which most of them have reinforced concrete non-ductile moment resisting frames, and some of them have unreinforced masonry bearing walls. This paper focuses on the concrete frame buildings in the project.

The paper consists of four parts. The first part presents an introduction and definition of the project, short review of the existing building survey. Characteristic strength of building materials are compared also with their ages. Most of existing reinforced concrete schools and social services buildings in Istanbul, the existing concrete strength were tested to be quite low.

The second part covers the seismic performance evaluation of existing structures. Performance acceptance criteria are shortly defined and the assessment methodology is described. Most of those structures have inadequate lateral load resisting system, and they all suffer lack of ductility.

In the third part, retrofitting and rehabilitation phase of the project is briefly described. To reduce the deficiencies in the concrete frame buildings new shear walls were introduced in both normal axes of the building. Adding new shear walls reduced the expected lateral displacements of the structures during a major earthquake helping with the deformation compatibility deficiencies of many non-ductile structural elements within their existing gravity systems. For unreinforced masonry structures, shotcreting of selected existing masonry walls were the proposed solution.

The fourth part is devoted to the estimated costs for strengthened school buildings. The fundamentals of reducing strengthening costs in concrete buildings when introducing new shear walls are discussed.

EXISTING BUILDING INFORMATION AND SITE SURVEY

In order to assess the earthquake performance of existing buildings, information about structural system geometry, component cross-sections, characteristics of materials and soil conditions can be retrieved from available reports, in-situ tests and recent site surveys. With comprehensiveness of achieved as-built information, knowledge levels and corresponding safety factors are applied. Field observation of exposed conditions and analyzing construction documents must be performed in order to determine existing building characteristics pertinent to seismic performance. Material tests results, soil borings and test logs must also be determined in accordance with codes.

For this project, performed structural surveys consisted of measuring and documenting the structural characteristics and dimensions of the structural members, including overall conditions with respect to the corrosion, deterioration and other type of damage. 124 school campuses and 8 social services buildings consisted of 216 buildings in total were evaluated throughout the project. Figure 1 below shows the age distribution for the buildings evaluated in this project. Close to 60% of all inspected buildings have been 20 years or older.

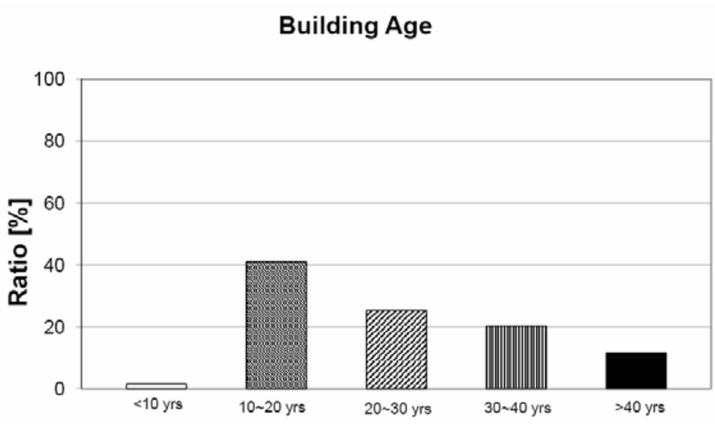

Figure 1. Building age distribution

Most of the buildings had no existing documentation; therefore, teams were sent to generate as-built documents, material testing and soil investigations were performed, and some foundation pot-holes were dug to explore existing foundation conditions. Material testing would not be required if material properties had been already available. Although material tests had been performed on several buildings in earlier times, the amount of core samples were not in compliance with the codes. Therefore, additional tests were performed in order to determine characteristic compression strengths of concrete.

As for ASCE41, when the design strength is unknown and test results are not available, a minimum of six cores shall be conducted for each floor level, 400 cubic yards of concrete or 10000 square feet of surface area, whichever requires the most frequent testing. Similarly, Turkish Building Code 2007 requires at least 3 cores per storey, one core at each 400 square meters, not less than 9 cores in total for normal knowledge level, whichever requires the most frequent testing.

As can be seen from Figure 2, more than 75% of the reinforced structures tested the existing concrete strength was less than 15 MPa, and approximately 40% all reinforced concrete buildings had less than 10 MPa concrete strength. A cut-off point of 7 MPa was determined for strengthening and any building having concrete strength less than this value was decided to be demolished.

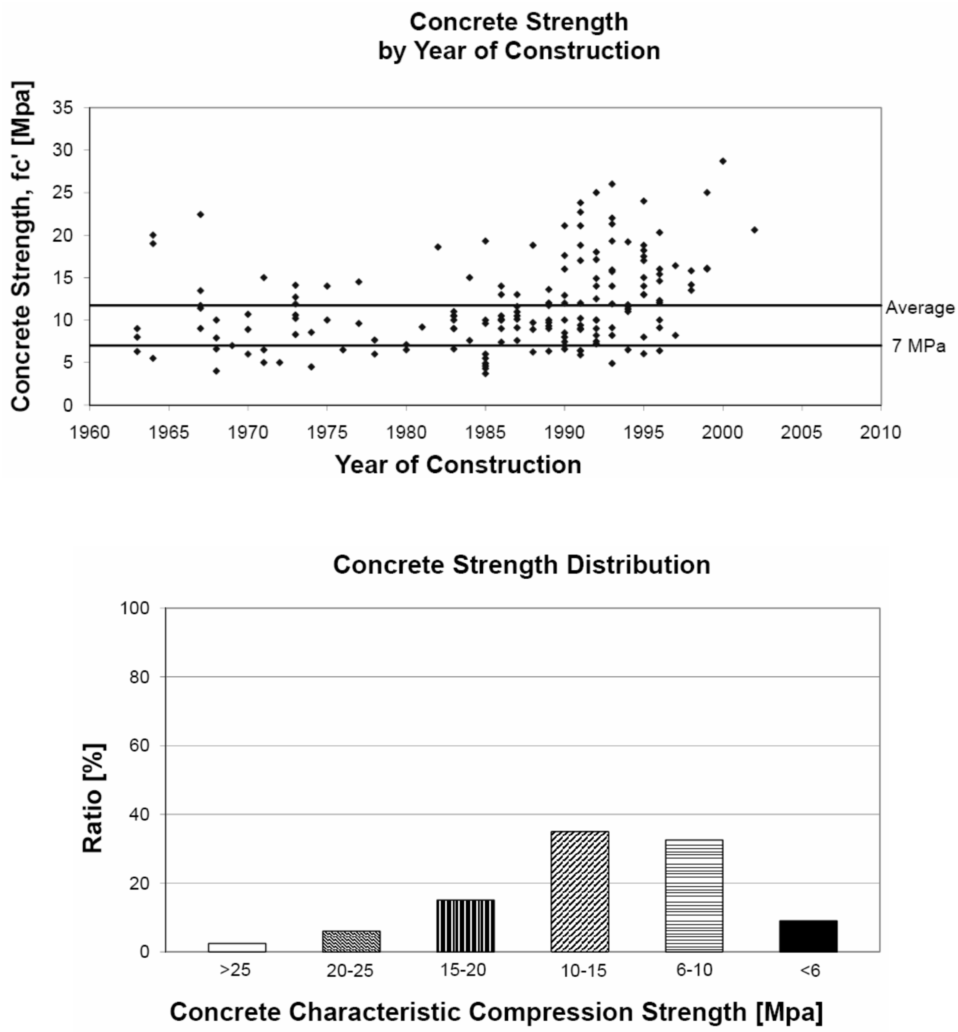

Figure 2. Existing concrete strengths

School and social services buildings in Istanbul usually have shallow spread or continuous footings. There were couple of cases where mat foundations were observed. Although the foundation information can be retrieved from the original design documents, the existing condition may not be the same as the design. Therefore, inspection pits, located on both the inner and outer side of several school buildings were used to assess the existing substructure condition. Additionally, the existing conditions of foundations were determined in detail during the strengthening construction, and the foundation strengthening designs were revised accordingly, as needed.

During site walk-through, one of the important deficiencies observed was the corrosion of reinforcement at the ground floors and/or basements (Figure 3). As a mitigation measure, they were cleaned, painted with protective coatings; heavily corroded rebars were replaced or spliced with new ones, and those columns were jacketed.

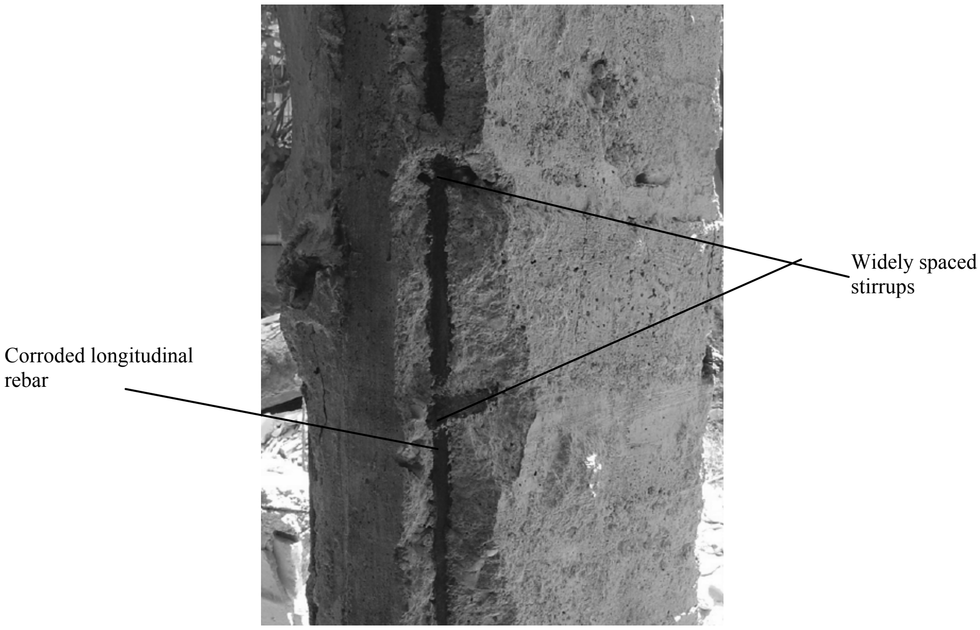

Figure 3. An existing column with corroded rebar

Another deficiency observation was lack of confinement in reinforced concrete structural elements. As you can see from Figure 3 above, most of the column stirrups were widely spaced, resulting in lack of ductility for those members.

ASSESSMENT

Structural assessment and design concept with the principle of performance criteria on the displacement and strain are specially developed for the realistic safety and rehabilitation of structures.

The assessment consisted of performing a Tier 1 analysis per ASCE 31-03 which involves checking the structure for common vulnerabilities present in concrete frame buildings; and performing an analysis of the average shear stress in the concrete columns, as well as checking the stress in existing shear walls.

Almost 60% of reinforced concrete school and social services buildings lateral system do not have any shear walls. The remaining 40% have shear walls in both directions, however, their material strengths were very low, and they were very lightly reinforced lacking the required ductility.

For masonry buildings, each existing masonry pier was checked for rocking, shear, and friction, to determine the existing overall capacity of the structure. In plane lateral shear of unreinforced masonry walls and wall piers in a line of resistance are considered as rocking-controlled if the expected lateral rocking strength of the corresponding wall or pier is less than the lower-bound lateral strength which is related with mortar and friction.

The results of assessment showed that almost all structures built earlier than year 2000 required structural strengthening.

DEVELOPING STRENGTHENING DESIGN CRITERIA *(Performance Criteria)*

Three structural performance levels are introduced with 2007 Turkish Building Code: Immediate Occupancy (IO), Life Safety (LS), and Collapse Prevention (CP). These performance levels relate to damage states for elements of lateral-force- resisting systems (Figure 4). Existing school buildings were retrofitted to meet both LS and IO occupancy requirements per Table 1.

The IO limit state implies that only limited structural damage has occurred. The basic vertical and lateral-force-resisting systems of the building retain nearly all their pre-earthquake strength and stiffness. The LS performance state implies that significant damage to the structure has occurred, but some margin against either partial or total structural collapse remains. The CP performance level implies that the post-earthquake damage state of the building is on the verge of partial or total collapse.

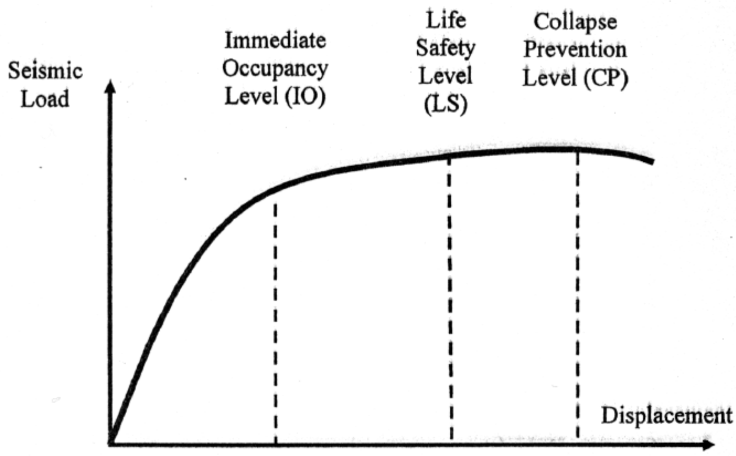

Figure 4. Performance levels (2007 Turkish Building Code).

Table 1. Building performance objectives

Purpose of Occupancy	**Earthquake probability of exceedence in 50 years**		
	50%	10%	2%
Buildings to be utilised immediately after the earthquake	-	IO	LS
Intensively and long-term occupied buildings and museums	-	IO	LS
Intensively but short-term occupied buildings	IO	LS	-
Buildings containing hazardous materials	-	IO	CP
Other buildings	-	LS	-

The ASCE-41 guideline, Seismic Rehabilitation of Existing Buildings, utilizes a similar approach to the 2007 Turkish Building Code. When using the linear procedure, unreduced building demands are used and individual members are assessed against member specific acceptance criteria which are dependent upon the member's gravity loading and ductile detailing.

Although similar in concept there is an important difference in the two approaches. The ASCE-41 linear procedure provides an "m" acceptance value which is compared to the demand to the capacity ratio of a member. The m-factors are used as acceptance criteria for deformation-controlled actions in linear procedures. The 2007 Turkish Code is similar in that it provides "r" acceptance value. However the "r" values are compared to the earthquake demand to reserve capacity ratio. Herein lays the major difference.

$M / (K \times C) < m_{limit}$ (ASCE 41)
$M_E / (K \times C_R) < r_{limit}$ (2007 Turkish Building Code)

M : Total demand (Gravity + Earthquake)
M_E : Earthquake demand
K : Knowledge factor
C : Member capacity
C_R : Reserve capacity (total capacity – gravity load demands)

A comparison of the total demand to total capacity using the ASCE 41 approach and the 2007 Turkish Building Code approach of comparing the earthquake demand to reserve capacity is presented in Figure 5 below. The earthquake demand is represented by the x-axis expressed as a percentage of the capacity. The y-axis represents the demand to capacity (D/C) ratio, where the D/C is as defined above.

The conclusion based on this study is that the Turkish code is more conservative when assessing beam and column elements. The conservatism could be quite significant. Therefore, the ASCE 41 methodology was selected for this project. However, in assessing non-ductile columns with high demand loads, the results obtained show good agreement between the two approaches. Assessing these crucial members can be performed by either method and find similar results as well.

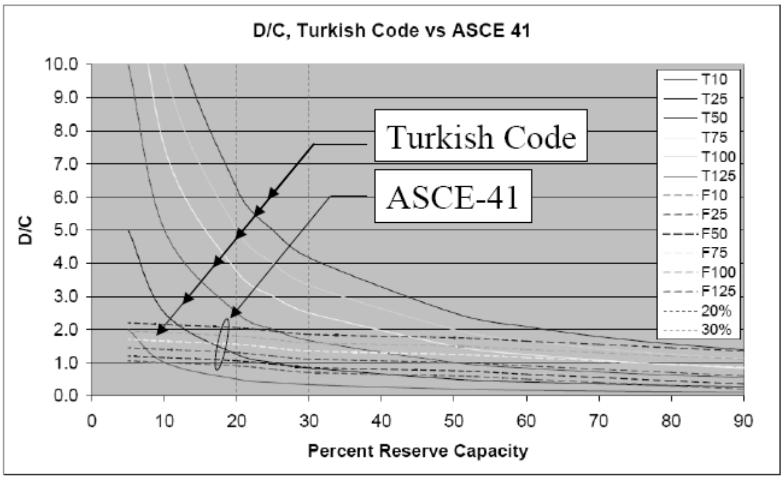

Figure 5. Comparison of demand to capacity (2007 Turkish Building Code vs. ASCE41)

A key assumption made by the design team was the original structural design of the building met the vertical gravity design requirements of the Turkish building code at the time of its design. The beams and column capacities were therefore assumed to have at least a capacity of 1.4DL + 1.6LL.

RETROFITTING DESIGN

The main objective of the retrofit design is to provide cost-effective upgrades that satisfy the performance targets with minimum impact to the building occupants and functionality. The common method of correcting the deficiencies in the concrete frame buildings was to introduce shearwalls in both normal axes of the building. The proposed shear walls were located at the exterior of the building where possible to minimize interior disruption during construction and construction cost (see Figure 6 and 7). Such a scheme also helped reducing the torsional effects on irregular structures.

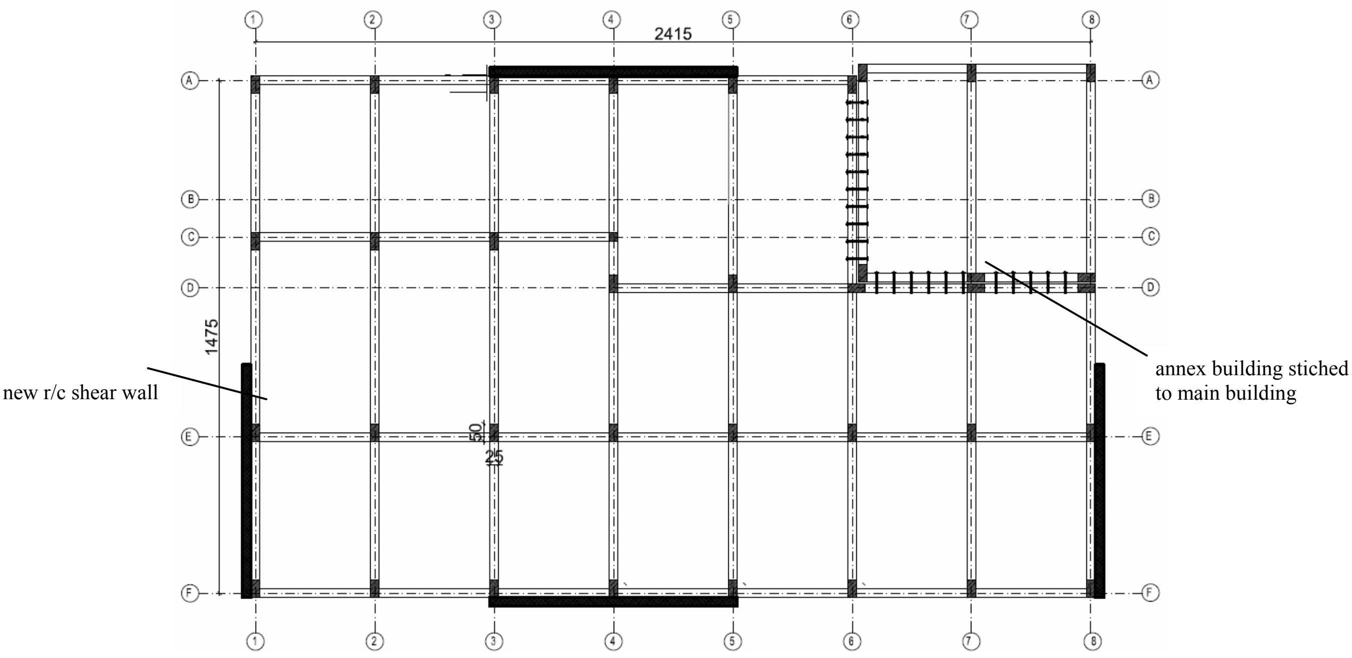

Figure 6. Exterior strengthening scheme example of a concrete moment frame building

Figure 7. New added shear wall from exterior

Generally, building additions (annexes) are not connected to the existing structure, but build against the existing structure by leaving a very small construction gap. As a result, the addition may have different structural response than the original structure during earthquakes, and they may easily collide with each other, causing severe structural damage. Several schools and services buildings in Istanbul within the scope of this project have annex buildings placed adjacent to the original existing building without any connections. A better approach will be to stitch the two building components rigidly together so they behave as a single mass, or have adequate seismic gap between them, and strengthened the annex by itself accordingly. The second approach is obviously more costly. Therefore, connecting the annex structures to the main structure was the preferred approach in this project. For those buildings, the two parts were stitched together to reduce the torsional effects; and appropriate details were developed as shown in Figure 8.

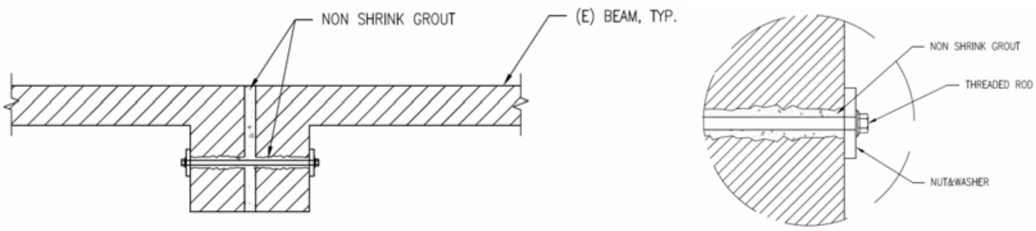

Figure 8. Typical connection detail

The common material used in unreinforced masonry buildings construction were solid brick, and/or stone. There were couple of buildings, where hollow clay tiles were used as bearing wall. In an unreinforced masonry structure the quality of the mortar and workmanship, and the pattern in which the units are assembled can significantly affect the overall capacity of the structure. Structural irregularities or overloading, dynamic vibrations, settlements, and in-plane and out-of-plane deformations can cause unreinforced masonry (URM) structures to fail. The non-ductile characteristics and brittle nature of those structures are the main reasons of their failure during major earthquakes. URM structures are vulnerable to significant damage in an earthquake simply because, most of the time the strength of the mortar is not adequate to take the story shears. Another deficiency is in the lack of load transfer from the diaphragms to the bearing walls. The connections between the bearing walls and the slabs are usually weak and cannot prevent out-of-plane failures. The lack of reinforcement, coupled with poor mortar and inadequate roof-to-wall and slab-to-wall ties can result in substantial damage to the building.

Severely cracked or leaning walls are some of the most common earthquake damages in unreinforced masonry structures. Moreover, separation between the slabs and the walls can jeopardize the vertical support of floor systems which could lead to the total collapse of the structure. In case of overstressing, inadequate connections to the roof, and slabs, and the brittle nature of the URM elements can threaten human lives.

For masonry structures, shotcreting of selected existing masonry walls were the proposed solution. Again, exterior masonry walls were preferred to be shotcreted (where possible) for minimum disruption and cost savings (Figure 9)

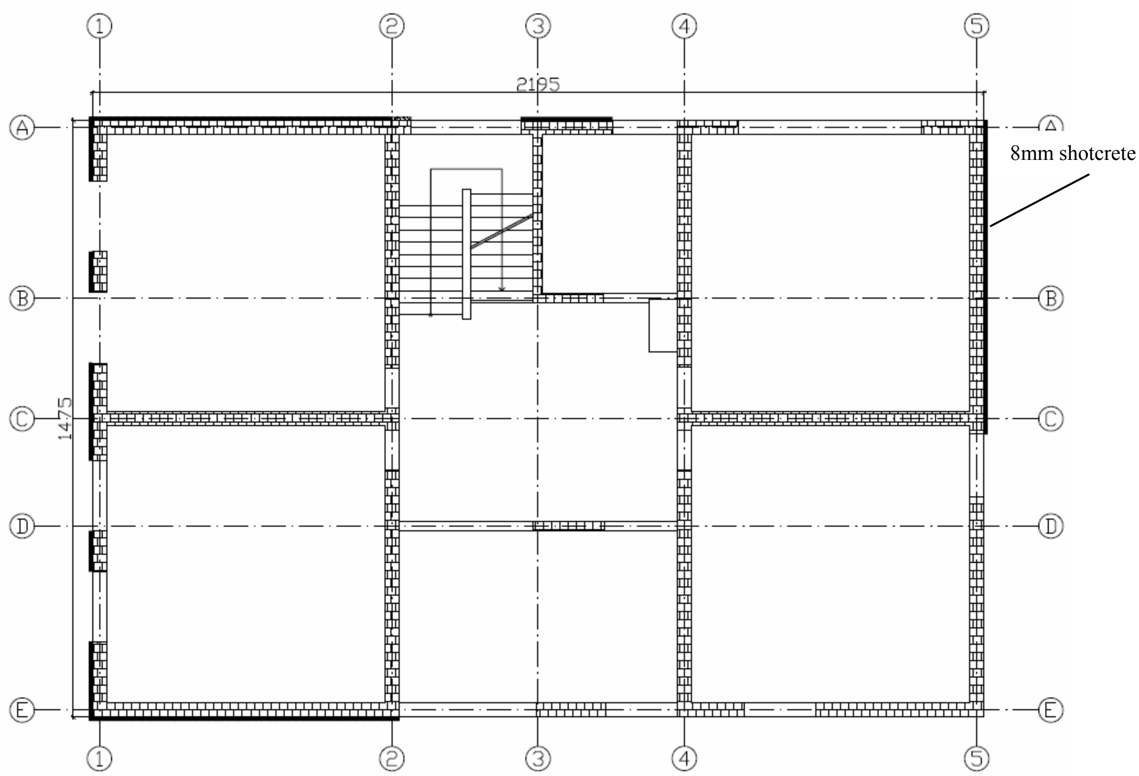

Figure 9. Exterior masonry pier shotcreting example scheme

ESIMATED STRENGTHENING COSTS

An estimate of the cost to implement the structural upgrade was developed. The estimate includes the related architectural, mechanical and electrical systems affected by the structural upgrade and the cost to repair major building deficiencies.

The approach of the estimate for school is promising because in many regions schools buildings are designed using similar building methods, with similar geometries. On the other hand, rehabilitation of a building is not the only alternative to assure safety during an earthquake; demolishing or replacing is another alternative. Therefore, a decision-making technique had to be developed essentially related with existing building strengthening to replacement cost ratio.

Figure 10 shows only structural strengthening cost, quantified in terms of percentage of the replacement cost. 90% of the structures have a structural strengthening cost between 10 to 25 percent of their replacement cost.

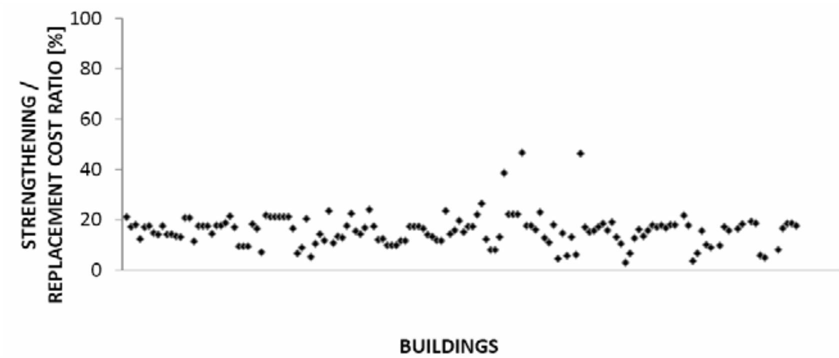

Figure 10. Strengthening vs. replacement cost ratio

CONCLUSIONS

Istanbul Project Coordination Unit (IPCU) is implementing and supervising the Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) which aims to carry out seismic risk assessment of selected buildings and prepare retrofitting project designs. In scope of this study project, 124 school campuses and 8 social services buildings consisted of 216 buildings in total were evaluated.

As-built documents, material testing and soil investigations were performed since most of the school buildings had no existing documentation. Almost half of the reinforced concrete school buildings have low quality concrete which has strength of less than 10 MPa.

Due to the existing building information, more than half of the school and social service buildings do not have any shear walls. Those moment-frame buildings' potential lateral displacements were minimized by introducing new shear walls. New shear walls were introduced to the exterior of the corresponding building where possible to minimize interior disruption during construction and construction cost.

Istanbul has 12 million people most of them living in, going to school, and working in non-ductile concrete buildings of poor design and construction quality. The best solution to retrofit typical Istanbul buildings is to limit the potential lateral displacement of the structures during ground shaking. This is most effectively done by introducing exterior concrete shear walls (where possible), transforming the lateral system away from a non-ductile concrete moment frame system. Retrofit designs should take advantage of non-linear behaviour where possible (foundations, column/beam acceptance criteria). When the retrofit construction is complete, this project will have resulted in a tremendous savings of lives of Istanbul students following the next large earthquake in the area.

REFERENCES

American Concrete Institute (2008) 1ACI 318-05 Building Codde Requirements for Reinforced Concrete and Commentary", Farmington Hills, MI.
American Society of Civil Engineers (2003). "Seismic Evaluation of Existing Buildings ASCE 31-03".
American Society of Civil Engineers (2007). "Seismic Rehabilitation of Existing Buildings ASCE 41-07".
American Society of Civil Engineers (2007). "Minimum Design Loads for Buildings and Other Structures ASCE 41-07", Reston, Virginia.
Alaluf, R., Cole C. (2009). "Improving the Seismic Performance of Existing Structures in Istanbul, Turkey", 2009 ATC & SEI Conference on Improving the Seismic Performance of Existing Buildings and Other Strcutures, San Francisco, CA
Chopra, A.K. (2000) "Dynamics of Structures, Theory and Applications to Earthquake Engineering", Prentice Hall, New Jersey.
Computers & Structures (2006). "SAP 2000 v10".
Erdik, M., Demircioglu, M., Sesetyan, K., Durukal, E. and Siyahi, B. (2004) "Assessment of Probabilistic Earthquake Hazard in the Marmara Region". Soil Dynamics and Earthquake Engineering, Vol: 24, 605-631.
Erdik, M., Seseytan, K., Durukal, E. and Endinciler, A (2008). "Assessment of Site Specific Earthquake Hazard at Specific Schools (ISMEP 1.2C)",Bogazici University, Kandilli Observatory and Earthquake Research Institute .
Ewing, R.D., Johnson, A.W., and Kariotis, .J.C. (1984) "Methodology fir Mitigation of Seismic Hzards in Existing Unreinforced Masonry Buildings: ABK Methodology" Pacific Earthquake Engineering Center, University of California, Berkeley.
Federal Emergency Management Agency (2003), "FEMA 450 NEHRP Recommended Provisions for New Buildings and Other Structures"
Institute of Turkish Standards (1997). "TS 498 Design Loads for Buildings", Ankara
Institute of Turkish Standards (2000). "TS 500 Requirement for Design and Construction of Reinforced Concrete Structures", Ankara
Institute of Turkish Standards (2003). "TS EN-12390-3 Testing Hardened Concrete – Part 3: Compressive Strength of Test Specimens", Ankara
International Code Council (2006), "International Building Code IBS"
Istanbul Project Coordination Unit (2008). "Guideline for Seismic Retrofit of School and Hospital Facilities in Istanbul", Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP).
Ministry of Public Works and Settlement, Government of Turkey (2007). "Specifications for Structures to be Built in Disaster Areas", Official Gazette.

REPAIR AND STRENGTHENING OF HISTORICAL BUILDINGS

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ABSTRACT

The investigation and structural analyses that are necessary basis for the repair and strengthening procedures are presented on a conceptual basis in relation to the restoration principles as they are stated on the Venice Charter. In recent years, significant developments have been achieved on repair, strengthening and retrofit of cultural heritage structures. There are innovative and traditional retrofitting techniques that could be carried out to improve the seismic behavior of historic buildings. This study mainly focuses on three conservation cases in Turkey which used one/both of this retrofitting technique. Analytical and survey works for repair and strengthening of three buildings are explained.

KEYWORDS
Historic masonry building, earthquake, restoration, repair, strengthening, ancient structures,

INTRODUCTION

The restoration of historical buildings differs from the ordinary ones. The aim of restoration according to the Venice Charter (1964) is to preserve and reveal the aesthetic and historical values of the monument or historical building. Particularly for structural restoration, the basic principles that should be taken into consideration may be listed as follows: The restoration in any case must be preceded and followed by archaeological and historical studies for the monument. Where traditional techniques prove inadequate, the consolidation of a monument can be achieved by the use of any modern technique for conservation and construction, the efficacy of which has been shown by scientific data and proved by experience. The valid contributions of all periods to the building of a monument must be respected, since unity of style is not the aim of a restoration. Replacement of missing parts must be integrated harmoniously with the whole, but at the same time must be distinguishable from the original. Additions cannot be allowed, except in so far as they do not detract from the interesting parts of the building, its traditional setting and its relation with its surroundings. Modern techniques and materials are admissible where adequate capacity cannot be ensured by traditional techniques. Measures are necessary to protect and safeguard fresco and mosaic decoration. This may exclude the use of some strengthening techniques that may cause damage. Before the repair and strengthening process more detailed assessments are made. Indications of the structural condition to which particular attention would be as follows: cracking of masonry (old or new cracks which indicate local stresses much in excess of average that is likely to be found), deformation of arches and vaults, tilts of walls, piers and columns, differential settlements as shown by changes in levels, slips or failures of tie members, the manner of construction of masonry and its general condition. In recent years, significant developments have been achieved on repair, strengthening, and retrofit of cultural heritage structures. There are innovative and traditional retrofitting techniques that could be carried out to improve the seismic behaviour of historic buildings. This study mainly focuses on some selected conservation cases which used several retrofitting techniques.

THE SULTAN ABDULAZIZ ROYAL HUNTING MANSION IN IZMIT

The Royal Hunting Mansion is one of the major cultural monument of Turkey and located in Izmit, Figure 1,2. The Royal Hunting Mansion ranks as a major architectural and historical landmark, partly an account of the fine early 19th frescoes on its interior walls and ceilings. After the 17 August 1999 Kocaeli Earthquake, the building was heavily damaged.

Figure 1: Entrance facade

Figure 2: Rear facade

Method of Repair and Strengthening

The bearing walls were not capable of resisting earthquake loads since they had more voids according to Turkish earthquake code (1998). In this respect, all the bearing walls were then strengthened by adding skins of RC shotcrete. The skins were 50mm thick with added to the inside faces of the internal walls only. During the shotcrete procedure, holes were drilled in the masonry, shear dowels (two per m2) were inserted in the holes by injecting resin, any remaining plaster and other loose material were removed from the surface. The surface was sand blasted and then saturated with water, the reinforcement was fixed and the shotcrete layer was sprayed. In order to improve the earthquake performance of the structure, a plane truss system functioning as a floor diaphragm had to be planned to built at the roof level using steel profiles. These new steel members were then anchored to the reinforced concrete lintels which were newly arranged on the top of the internal and external walls.

Modelling of the Building and Numerical Results

Numerical analyses were carried out to evaluate the state of the stresses and deformations in the masonry walls before and after the repair and strengthening process. Static and dynamic analyses have been carried out on the 3D model of the Mansion using FEM in ETABS. The masonry walls have been modelled by shell elements, while frame elements have been used to model the timber slab beams and steel truss elements. The results indicated that the strengthening scheme significantly (approximately 60%) reduced the story drift ratios.

THE AHI CELEBI MOSQUE

The 529 years old Ahi Celebi Mosque (Figure 3) is a building of great historical architectural significance and located at the shores of the Golden Horn in Istanbul. The Ahi Celebi mosque has a symmetrical plan shape with dimensions of 24.54mx16.90m..The roof system consists of six hemispherical, small diameter domes with a diameter of 4.00m and a main (central) dome with a diameter of 11.00m. The thickness of the main dome is 30cm at the top and 60cm at the support level. The wall thicknesses vary from 100cm to 150cm. Material used in the masonry walls consists of shallow solid bricks, equal thickness crushed tiles and lime mortar for joints.

Major structural problems of the Ahi Celebi Mosque originate from the tensile stresses (i.e. the masonry material in the system has low tensile strength) which occurred at different points of the building and are mostly concentrated at the lower zone of the main dome. Due to the circumferential tension, meridional cracks which might be produced by ground settlements and earthquake forces over the course of time, occurred.

Figure 3. Ahi Celebi M. under restoration

Figure 4. Applied steel ring detail

Method of Repair and Strengthening

The state of cracking patterns at the Mosque consists of two different types of cracks: the ones that pass through the masonry dome's entire height of the lower part, which are visible at the extrados; a second type of cracks, which are limited to the surface of the dome. Mortar injection is a typical example of passive type intervention for the second type cracks. The situation is beneficial to the stability of the dome, as the zones where sub-vertical compressive stresses are highest help to stiffen the entire dome with respect to tensile stresses arranged in the tangential direction. In this respect, two steel plate rings of 10mm thickness and 100mm wide are placed at the base level of the main dome, Figure 4.

Modelling of the Building and Numerical Results

In order to assess the seismic behaviour and effectiveness of external confinement of the dome, a dynamic analysis for the mosque was carried out with reference to the elastic time history analysis under the 17 August 1999 Kocaeli NS strong ground motion record (Yarimca). For support points of the main dome, principal stress histories before and after retrofitting are significantly reduced by up to 61%. Furthermore, a more uniform stress distribution over the dome is obtained after retrofitting.

THE FIRDEVS BEY ANTIQUE BAZAAR IN ISPARTA

The Firdevs Bey Antique Bazaar is a stone masonry building in Isparta, Figure 5. It is a rectangular plan shaped building. After detailed architectural and structural survey and site investigations, structural weaknesses of the building like cracking, material flaws, and inappropriate interventions over the course of time were determined. It was concluded that the major structural problems were the missing wooden tie bars, Figure 6, of the stone masonry vault and the excessive roof load resulting from irregular infill material.

Two retrofit strategies were developed, namely replacing the missing wooden tie bars with the new ones and removing excessive roof load from the building. The whole building was then modeled for the present case (i.e. without tie bars and with heavy roof load) and the retrofitted case (i.e. with wooden tie bars and with light roof load). Both gravity and seismic effects are taken into account using FEM analysis with SAP2000. The principal normal and shear stresses as well as the deformations in the vault before and after retrofitting process are compared. Numerical results show that these stresses are significantly reduced up to 57% for gravity loads and 60% for earthquake loads.

Figure 5. The Firdevs Bey Antique Bazaar

Figure 6. Inner view

REFERENCES

Sesigur H., Celik O.C., Cili, F. (2006) Repair and Strengthening of Ancient Structures in Seismic Areas. First European Conference on Earthquake Engineering and Seismology, Paper No. 1387, Geneve, Switzerland, September 3-8, 2006.

Cili, F., Celik O.C., Sesigur H. (2007) Restoration of Royal Hunting Mansion Damaged in 1999 Kocaeli Earthquake. 5th International Conference on Seismology and Earthquake Engineering, Tehran, Iran, May 13-16, 2007.

Celik O.C., Sesigur H., Cili, F., (2009) Importance of Wood and Iron Tension Members on Seismic Performance of Historic Masonry Buildings Three Case Studies from Turkey. ATC&SEI Conference on Improving the Seismic Performance of Existing Buildings and Other Structures, San Francisco, CA, USA, December 9-11, 2009 (to appear).

EFFORTS TOWARD SEISMIC RISK REDUCTION IN ROMANIA

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INTRODUCTION

The aim of the present paper is to describe the seismic risk reduction efforts in Romania. Seismic risk reduction in Romania can be achieved through several types of actions from which the major ones are (i) seismic vulnerability assessment, (ii) seismic rehabilitation of existing buildings and modern design for new buildings, (iii) increased number of recorded strong ground motions in conjunction with accurate soil characterization, and (iv) education and information of citizens.

Regarding the seismic rehabilitation, the Ministry of Regional Development and Housing in Romania (MDRL) is currently developing 3 main programs for seismic risk reduction in Romania:

- Program for the retrofitting of multi-storey residential buildings – Romanian Government is currently supporting from public funds the retrofitting of multi-storey seismic vulnerable residential buildings, irrespective of the ownership type.
- High emergency retrofitting program for public interest buildings – This program addresses to the high importance buildings, historical monuments, etc. The retrofitting of these structures is supported by MDRL.
- Program for risk mitigation and preparedness for natural disaster co financed by Word Bank and International Bank for Reconstruction and Development.

Based on the first program 15 buildings have been retrofitted, 6 are under retrofitting work and for 19 buildings the retrofitting work is being prepared to start. Moreover, design for seismic retrofitting is ready to start or undergoing for 23 buildings.

The World Bank program for seismic risk reduction worth of 73.7 mil USD (from which 56.9 mil USD are to be paid by International Bank for Reconstruction and Development and 16.8 by Romanian Government) and co-financed by the owners with 108 mil USD lead to the retrofitting of 8 public buildings of high importance. 17 buildings are under retrofitting and 18 buildings will follow. Moreover, MDRL is paying efforts towards issuing and revision of seismic design, evaluation and retrofitting codes and guidelines for quick inspection of damaged buildings after the earthquake. At central governmental level a comprehensive risk management program is under development. This comprises all kind of hazards: natural hazards, industrial hazards, pollution etc. MDRL is coordinating the cell of the Commission for Emergency Management handling the earthquake related hazards. MDRL is constantly supporting the management and development of the engineering seismic networks within it's specialized subordinated institutions.

While the public authorities are responsible for issuing modern regulations, implementing the effective construction quality control system and easy access of owners to the technical and legal tools, the research institutes and universities are called to play the major role in seismic risk mitigation by extensive research and education of practitioners and general public.

In this respect, a great support for Romanian efforts for seismic risk reduction came through a *Japan International Cooperation Agency* (*JICA)* project in Romania, implemented by the *National Centre for Seismic Risk Reduction (NCSRR)* in the period of 2002-2008. The Project and NCRSS's activities are described in the present paper.

One important component of the policy for seismic risk reduction is the retrofitting of the existing vulnerable buildings. In the last decade of the previous century a sustained activity for the seismic evaluation of existing buildings was undertaken by specialists under the coordination of MDRL and with the financial support of the local authorities. As a result of the seismic evaluation in Bucharest, 392 residential buildings were ranked as seismic risk class I and MDRL decided to retrofit them with high priority.

However, since modern or/and effective retrofitting strategies and techniques were not fully available to structural engineers, at the initiative of Technical University of Civil Engineering Bucharest (UTCB), the Romanian Government (Ministry of Regional Development and Housing, MDRL) requested in 1998 to the Japanese Government (Japan International Cooperation Agency, JICA) to begin a technical cooperation on the seismic risk reduction focused on the improvement of retrofitting techniques. Extensive negotiations started and several Japanese investigation teams visited Romania. Also, from 2000 a long-term Japanese expert was dispatched at UTCB for supporting the construction of the cooperation Project.

After four years of intensive efforts the *Project Design Matrix (PDM)* was defined and agreed, and on August 1, 2002, the *Record of Discussions (RD)* was signed between *MDRL* of Romania and *JICA*, and the *Project on the Reduction of Seismic Risk for Buildings and Structures* started from October 1, 2002 with a planned duration of 5 years.

NATIONAL CENTER FOR SEISMIC RISK REDUCTION

The implementing agency of the *Japan International Cooperation Agency (JICA) Technical Cooperation Project on the Reduction of Seismic Risk for Buildings and Structures* was the *National Centre for Seismic Risk Reduction (NCSRR)* as a public institution of national interest, a specialized legal entity, subordinated to the *Ministry of Regional Development and Housing (MDRL)* of Romania, created in 2002. The main activities of the NCSRR are as follows:

- Studying, evaluating, applying and disseminating new technologies for retrofitting the earthquake vulnerable buildings and structures;
- supporting the revision of codes and regulations for earthquake resistant design, seismic evaluation and retrofitting;
- seismic instrumentation (with focus on Bucharest) and soil testing;
- transfer of state-of-the-art knowledge in the domain of earthquake engineering to specialists through the organization of seminars, symposiums and conferences;
- issuing documentation regarding education of the population for preventing the seismic consequences;
- improvement of technical knowledge by training, studies and documentation, seminars, courses and lectures in Romania and abroad;
- promotion of the international cooperation in the domain of seismic risk management;
- publishing papers, studies and publications in the field of earthquake engineering;
- other activities pertaining the national and international projects implementation

The activities of *NCSRR* were carried out in partnership with *Technical University of Civil Engineering Bucharest (UTCB)* and *National Institute for Research and Development in Construction and Construction Economics (INCERC) Bucharest*. The main Japanese research institutions that supported JICA were the National Institute for Land and Infrastructure Management (NILIM) and the Building Research Institute (BRI). Figure 1 shows the position of *NCSRR* and the relationship between partner institutes and related organizations in the *JICA* Project.

The activities of the *NCSRR* are carried out in four divisions, namely:

- Division 1 - Building Retrofitting and Design Codes
- Division 2 - Seismic Observation Network
- Division 3 – Technical Experimentation for Soil and Structures
- Division 4 – Dissemination of Knowledge and Training of Engineers

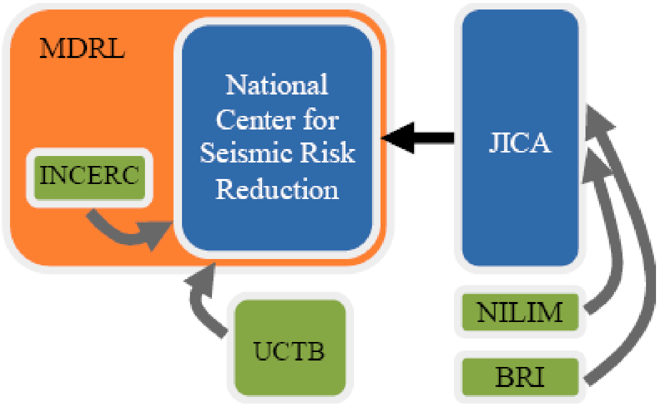

Figure 1. Relationship between NCSRR and other organizations

The JICA Project started on October 1st, 2002 with NCSRR as the implementing agency. The initial planned duration of the Project was five years, but after Romanian side request, an extra half year was accepted, and the Project ended on 31 March 2008.

According to the RD of the JICA Project the purpose was “Improving and dissemination of the technologies for reducing building collapse in case of devastating earthquakes are achieved”. The target of the Project were the Romanian citizens, in particular those in Bucharest.

According to the RD and PDM of the Project the planned activities were:

- First year – October 2002 – September 2003 - investigation of Romanian evaluation and retrofitting techniques; study of Japanese evaluation and retrofitting techniques; installation of equipments
- Second year - October 2003 – September 2004 - collection of existing data on strong Romanian earthquakes, soil properties and vulnerable buildings; installation of equipments
- Third year - October 2004 – September 2005 - performing structural and soil tests and investigations
- Forth year - October 2005 – September 2006 - draft of technical manuals on building retrofitting, on seismic motion evaluation and on soil conditions
- Fifth year - October 2006 – September 2007 - preparation of manuals on seismic evaluation and retrofit of buildings; preparation of documents for improving seismic evaluation and retrofitting design in Romania.

The JICA Project was extended for a six month period (October 2007-March 2008) with the purpose of knowledge transfer on quality management of retrofitting works. The following activities were carried out during the extension period:

- dissemination of information on quality management on retrofitting works to building engineers by model construction and seminar;
- preparation of manual explaining the quality management of retrofitting works.

All along the project was carried out a sustained activity of dissemination to the Romanian civil engineers of modern techniques and methodologies; and seminars for disaster prevention education were held for citizens.

During the *JICA* Project period, twenty nine (29) Romanian researchers/engineers were trained in Japan, seven (7) Japanese long-term experts and thirty seven (37) Japanese short-term experts were dispatched to Romania. Within the Project, equipments for seismic instrumentation, for soil investigation and soil testing, and for seismic testing of structural elements rising up approximately to 260 million yens (i.e. 2.2 million USD) were donated by *JICA* to Romania, through *NCSRR*. The total *JICA* financed Project cost was 7 million USD.

NCSRR EXPERIMENTAL RESEARCH ON STRUCTURAL ELEMENTS

Structural testing is a very efficient tool to understand better the behavior of the structural elements subjected to different types of loading. The analytical procedures used in common design practice cannot be calibrated without the information provided by the experimental research. On the other hand, the development of new, innovative, structural systems implies that structural testing to be used together with the analytical research to identify the structural behavior beyond the limits of the simplifications used in design practice. Therefore, it can be stated that the structural testing is a part of the structural design and evaluation system. According to the relation between the experimental and the analytical research, in the framework of the structural design system, the tests objectives can be classified as follows.

- *Checking of the design procedures*
  Structural testing can be used to check the equations and solutions presented in the design codes.
  These equations are generally developed based on simplifications of the real complex behavior of structures.
  The experimental research can reveal the behavior of the structural elements designed and detailed according to the codes.
- *Development of new numerical models and design equations*
  The experimental research is a must when trying to generate and develop new numerical models or design equations. Beside the analytical approach, the structural testing can result in important data related to the material, structural elements or structural systems behavior.
- *To clarify any problems where the analytical approach is complicated or unreliable.*

The main purpose of the structural testing conducted at the National Center for Seismic Risk Reduction was to try to identify the behavior of structural members designed according to the Romanian state of practice at different periods of time. This objective implies the identification of the failure pattern and the evaluation of the parameters that can describe in a favorable manner the member's behavior (e.g. for reinforced concrete members: yielding force and displacement, displacement ductility, ultimate bending force, ultimate shear capacity, etc.)

While some of these parameters can be reliable evaluated by analytical means, other can only be identified by experimental research. For example, the analytical procedures available for the evaluation of the shear capacity of reinforced concrete elements are calibrated to be used in the design of new structural system therefore these procedures offer conservative values of the capacity. These values cannot be used to reliable identify the capacity of the structural system although they are perfectly suited for the checking of the performance objectives criteria. Moreover, worldwide developed capacity assessment or design equations can be used only after a reliable confirmation by structural testing in a particular country. The suitability of each equation strongly depends on the state or practice in each country given not only the traditional construction materials and techniques but also quality of workmanship.

Therefore, structural testing is an essential tool in the process of issuing or revising design, evaluation and retrofitting codes. The experimental testing was developed as key component of the seismic risk reduction in Romania within the JICA technical cooperation project. The structural testing facility consists of a steel reaction frame, loading control device, data acquisition and processing systems. The reaction frame is similar to the one existing at Building Research Institute, Tsukuba, Japan. The maximum weight of tested specimens is 70kN and the maximum dimensions of the specimens are 2.5m by 3 m.

The following load combinations are possible with this provided equipment:

1) bending with shear force for beam testing,
2) bending with shear and axial force for column, shear wall and portal frame.
3) bending and shear tests for frame joints
4) shear test for slabs

This structural testing facility, worthy of approximately 1 million US$, was donated by JICA to the NCSRR and installed in March/April 2004 at the UTCB/NCSRR site, Bucharest (Figure 2 and Figure 3).

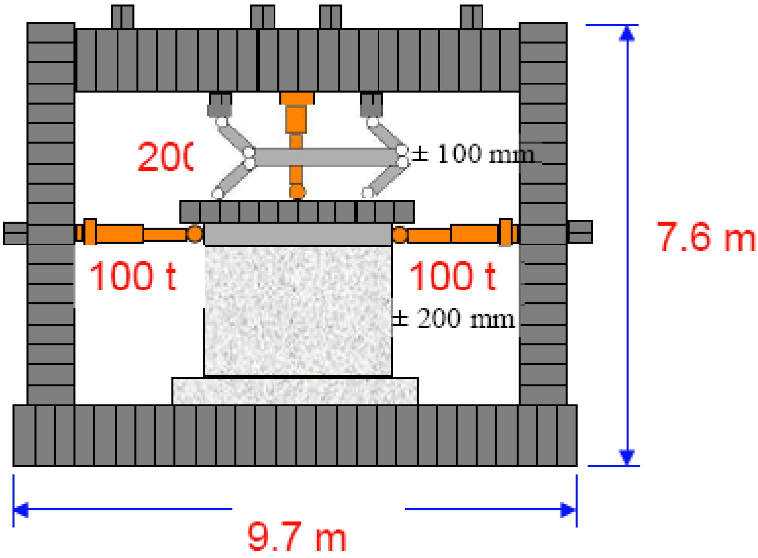

Figure 2. Overall dimensions, force and stroke capacities of loading system

Figure 3. Reaction frame and Column Specimen

The structural testing facility was used to support the seismic evaluation methods for structural systems with more reliable input data and develop cost-effective retrofitting methods. Data from the various structural experiments was fed back to the seismic rehabilitation of vulnerable buildings.

The testing programs were developed considering that the behavior of the structural elements is dependent on a large number of parameters which can influence to a certain degree the structural performance. It is desirable that the influence of these parameters to be evaluated by research (analytical and/or experimental) to allow the design solutions to meet the requirements of the intended performance objectives. On the other hand, the research activity (analytical or experimental) is a time consumption activity which requires important financial resources, not always available to the research community. An efficient structural testing program should consider the limitation of the number of variable parameters. A series of structural tests should focus on the influence of a relatively small number of parameters on the structural performance. If the variable parameters number is increased, the tests number has also to be majored. Only in this way the influence of each parameter on the structural behavior can be evaluated. The limitation of the parameters number can be done by using reliable analytical methods and results or by considering common, widely used values of some parameters.

The number of tested specimens since 2004 is listed in Table 1. At the beginning, the testing effort concentrated on vulnerable concrete elements designed and detailed according to the state of practice in Romania at the middle of the 20th century. Subsequently, masonry walls, RC slabs, and steel braces were tested. Figure 4 shows details on some tested columns and Figure 5 some results on the series of tested columns. Figure 6 and 7 show results of loading tests on various structural members.

Table 1. Current status of structural tests

Structural element	Number of tested specimens since 2004
RC columns	22
RC walls	5
Masonry walls	45
Steel braces	3
Energy dissipation device	1
RC slabs	14

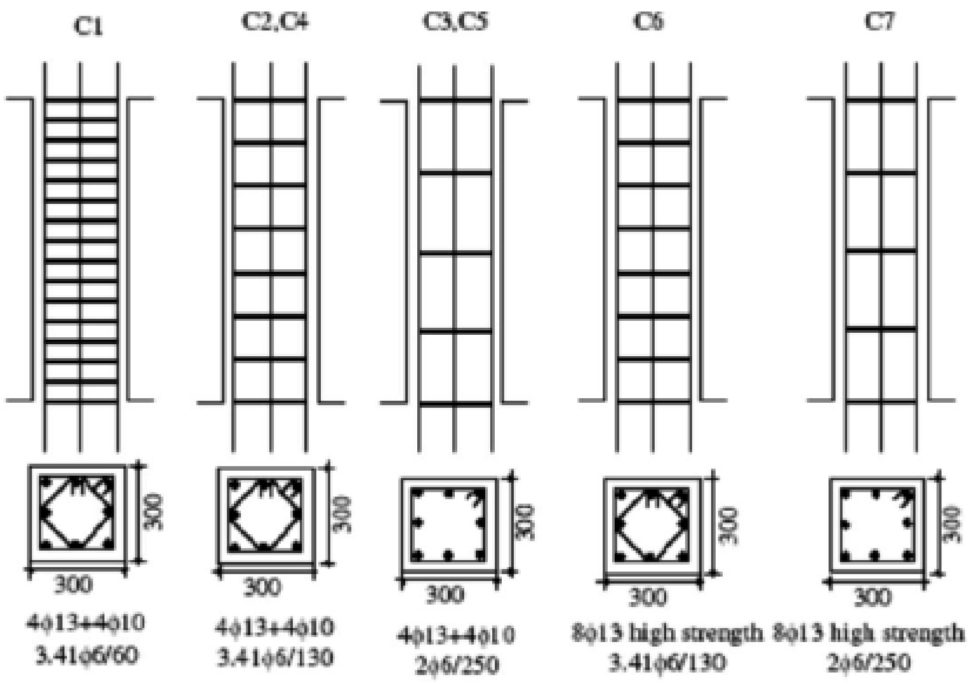

Figure 4. Details on some tested columns

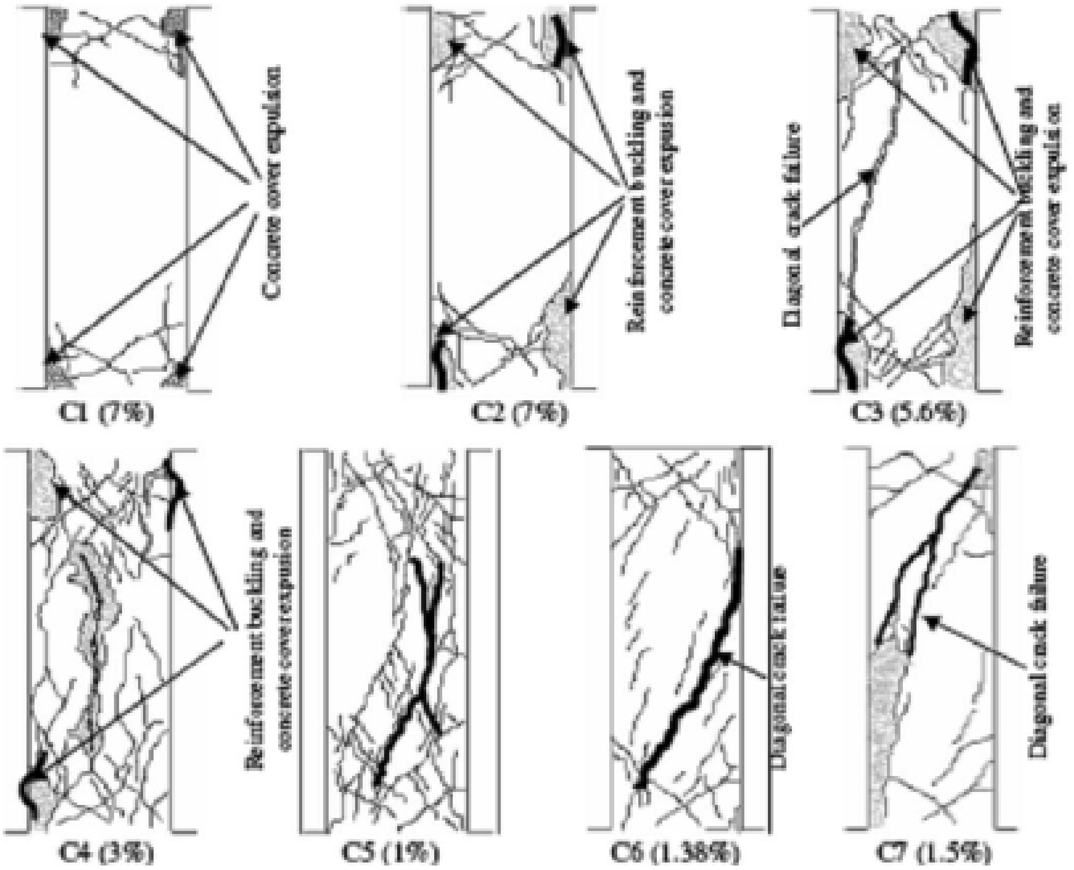

Figure 5. Some results on the series of tested columns

Figure 6. Test on RC columns (original specimen, retrofitted specimen with steel plate and with CF sheet)

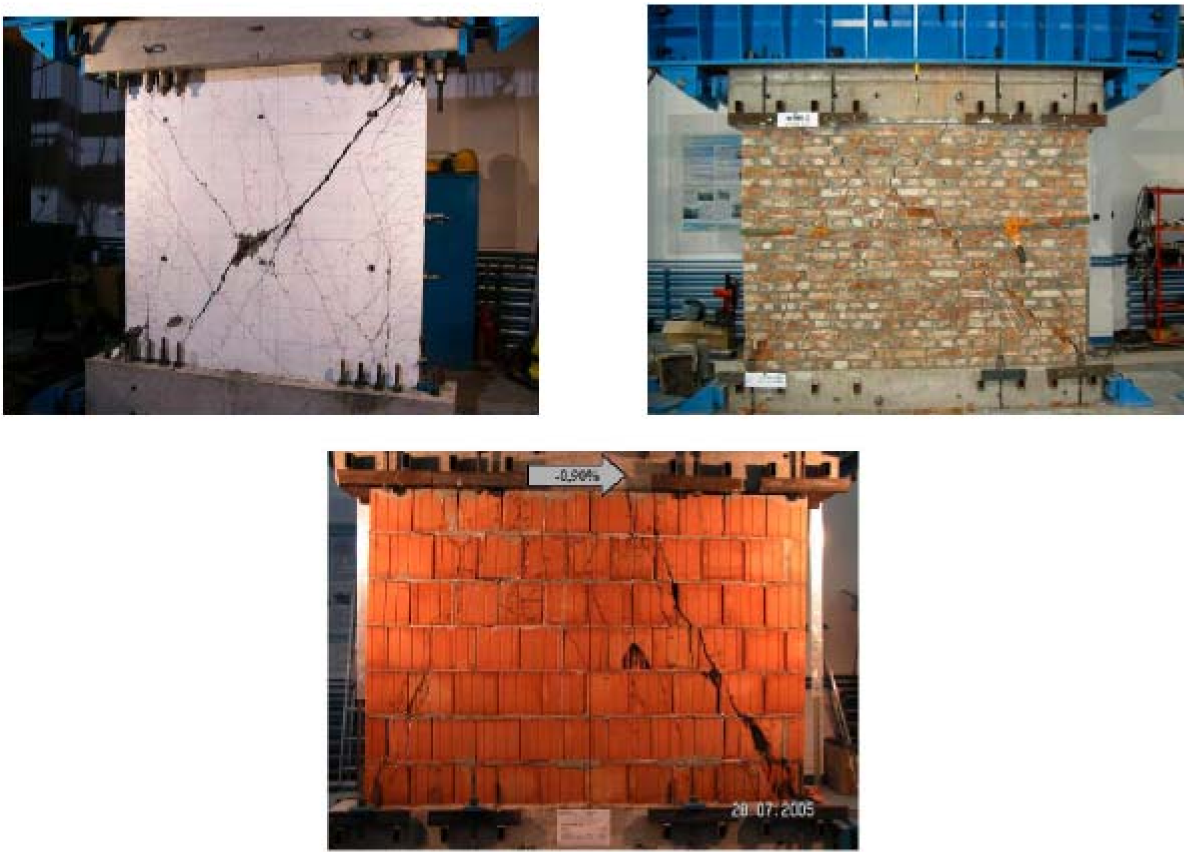

Figure 7. Test on walls (RC shear wall, masonry wall)

STRONG GROUND MOTION OBSERVATION AND SOIL INVESTIGATION

The main objectives of *NCSRR* activities for seismic strong motion observation and soil testing are:

- seismic strong ground motion data collection (in free field and boreholes);
- seismic strong motion data collection in buildings to study buildings behavior;
- revision of strong ground motion design parameters and developing new models for strong ground motion studies;
- ground condition characterization (especially at seismic station sites) through site investigation and laboratory soil testing

The equipment for strong ground motion observation, soil testing and investigation received by the *NCSRR* from *JICA* in 2003 were installed by the staff of *NCSRR* with technical support from Japanese experts and technicians from *OYO Seismic Instrumentation Corp.* dispatched in Romania especially for this purpose. Starting from 2005 *NCSRR* network was enlarged with Romanian investment (within the budget ensured by *MDRL*), other sites and buildings being instrumented with *Geosig* equipments and technical support. Nowadays NCSRR digital network consists of 40 accelerometers (6 ETNA, 11 K2, 10 IA-1, 3 GSR), 34 under exploitation and 6 under installation.

Free-field seismic stations for ground motion attenuation analysis

Six Kinemetrics ETNA stations were installed in 2003 on the SW direction starting from Vrancea epicentral area toward Bucharest, for ground motion attenuation analysis. All of them are in buildings with 1 or 2 storeys, which can be considered as a free field condition. Ground conditions are under investigation. One Geosig IA-1 accelerometer was installed in 2007, on a perpendicular axis to the SW, direction that will be further instrumented. Details about the free-field stations are given in Table 2, and their distribution is in Figure 8.

Table 2. NCSRR Seismic Network - Free field stations in Romania

No.	Site	Sensor location	Type of instrument
1	Focsani	2 storey building	*ETNA*
2	Ramnicu Sarat	1 storey building	*ETNA*
3	Buzau	1 storey building	*ETNA*
4	Ploiesti	3 storey building	*ETNA*
5	Giurgiu	2 storey building	*ETNA*
6	Urziceni	1 storey building	*ETNA*
7	Brasov	free-field	*IA-1*

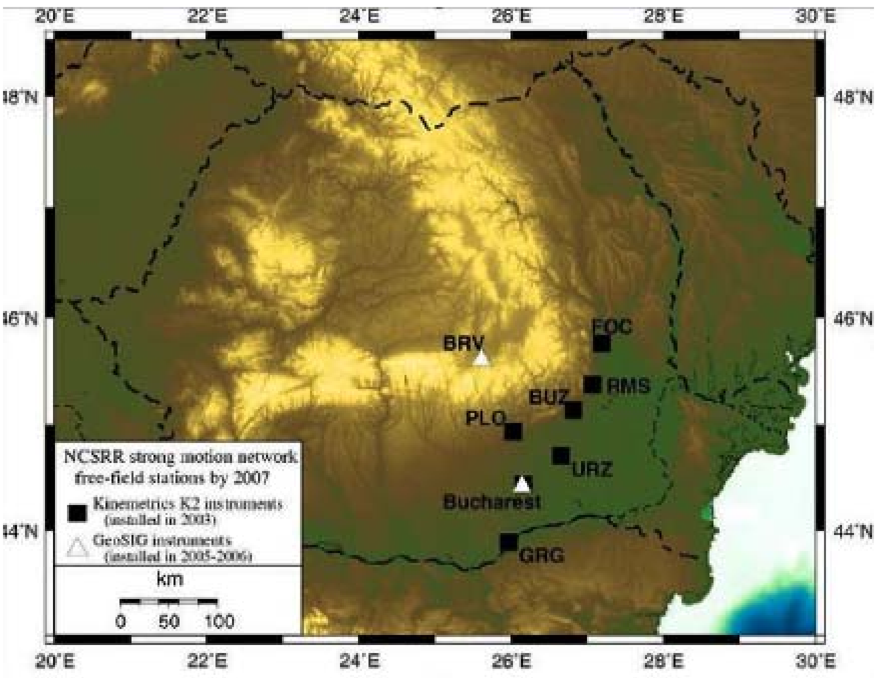

Figure 8. NCSRR free field seismic instrumentation (outside Bucharest)

Seismic stations for site effects assessment in Bucharest

Table 3. NCSRR Seismic Network – free field and borehole instrumentation in Bucharest

No.	Site	Surface sensors location	Shallow borehole depth	Deep borehole depth	Type of instruments
1	*UTCB* Tei/*NCSRR*	free field	-28	-78	*K2/FBA-23DH*
2	*UTCB* Pache	1 storey building	-28	-66	*K2/FBA-23DH*
3	*INCERC/NCSRR*	1 storey building	-24	-153	*K2/FBA-23DH*
4	Civil Protection Hdq.	1 storey building	-28	-68	*K2/FBA-23DH*
5	Piata Victoriei / Filantropia Hospital	free field	-28	-151	*K2/FBA-23DH*
6	City Hall	free field	-28	-52	*K2/FBA-23DH*
7	Municipal Hospital	free field	-30	-70	*K2/FBA-23DH*
8	*UTCB* Plevnei	free field	-30	-	*GSR24/ AC23-DH*

NCSRR installed in 2003 in Bucharest seven (7) Kinemetrics K2 stations with sensors at ground surface (close to free-field conditions) and in boreholes at two levels of depth: the first level at about 30m depth and the second level between 52m and 153m depth. In 2005 another site in Bucharest was instrumented with Geosig equipments (free-field and a 30m depth borehole). In 2010 a borehole station will be installed in the city of Iasi (NE from Bucharest). At all the stations the soil profile of the boreholes is known, and NCSRR and Tokyo Soil Corp. (Japan) performed down-hole tests. A brief description of the borehole instrumentation is given in Table 3 and their location within Bucharest in Figure 9.

Seismic stations for structural monitoring

Two residential buildings and two public buildings were instrumented in 2003 with Kinemetrics instruments. In 2006 the *Technical University of Civil Engineering Bucharest UTCB* main building and in 2008-2009 the *Faculty of Civil Engineering Brasov* were instrumented with *Geosig* instruments. All sensors are tri-axial acceleration sensors, their orientation follows the transversal and longitudinal directions of the buildings. In the case of Kinemetrics instrumentation, all sensors are connected to one K2 acquisitions station that laso has an internal sensor. In case of Geosig instrumentation are used two acquisition stations with internal sensors. The building instrumentation is described in Table 4.

Table 4*.* NCSRR Seismic Network - Building instrumentation

No.	Site	Station(s) location	Sensor 1	Sensor 2	Sensor 3	Type of instruments
1	Stefan cel Mare 1	10th floor (base)	10th floor (top)	4th floor	basement	*K2/Episensor ES-T*
2	Stefan cel Mare 2	basement	7th floor (top)	Free field	-	*K2/Episensor ES-T*
3	*TVR* Tower	13th floor (base)	13th floor (top)	basement	-	*K2/Episensor ES-T*
4	*BRD-GSG* Tower	19th floor	3rd basement	-	-	*K2/Episensor ES-T*
5	Faculty of Civil Engineering, Bucharest	3rd floor (top) & basement	-	-	-	*IA-1*
6	Faculty of Civil Engineering, Brasov	8th floor top & basement	-	-	-	*IA-1*

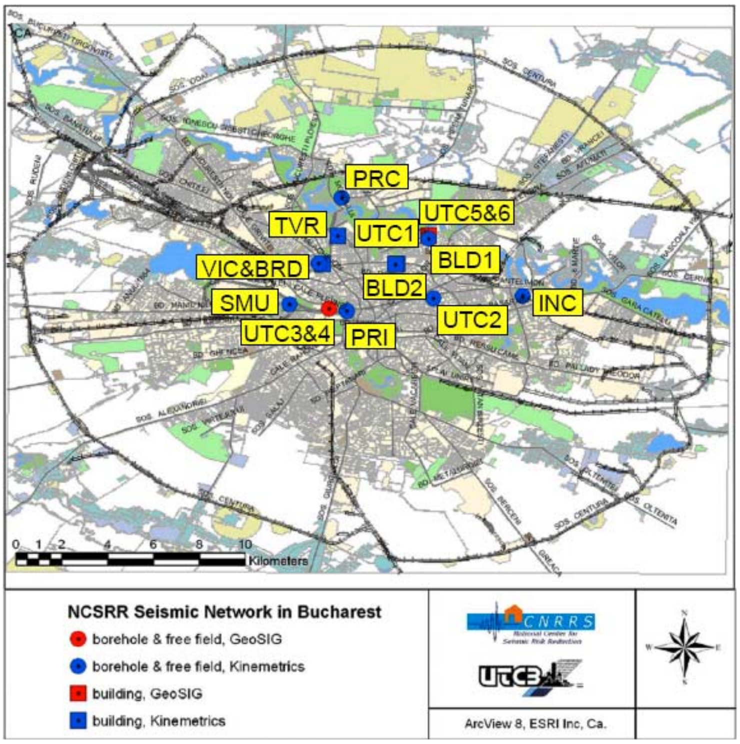

Figure 9*.* NCSRR seismic instrumentation in Bucharest

In Figure 9 is presented the location of the *NCSRR* seismic stations in Bucharest.

In Figure 10 and Figure 11 are presented photos from the borehole and building instrumentation works. The instrumented buildings are presented in the following photos:

- Stefan cel Mare street - residential building 1 – high-rise RC frame structure, Figure 12,
- Stefan cel Mare street - residential building 2 – mid-rise RC soft story structure, Figure 13,
- National Television Tower Building – high-rise RC frame structure, Figure 14,
- *BRD-GSG* Tower Building – high-rise RC inner core and perimeter frames, Figure 15,
- Faculty of Civil Engineering: Brasov – Figure 16 and Bucharest – Figure 17 (RC frame structures).

Figure 10. Seismic instrumentation of a borehole

Figure 11. Seismic instrumentation of a building

Figure 12. Building 1 - Stefan cel Mare street

Figure 13. Building 2 - Stefan cel Mare street

Figure 14. TVR Tower Building

Figure 15. BRD-GSG Tower Building

Figure 16 *Faculty of Civil Engineering Brasov*

Figure 17. Faculty of Civil Engineering Bucharest

Since its installation in 2003, the *NCSRR* network recorded almost 200 seismic motions from over 30 earthquakes (from Vrancea subcrustal and crustal seismic sources, and also from Bulgaria and North Dobrogea shallow sources) with moment magnitudes ranging from MW=3.2 to 6.0. The October 27, 2004 Vrancea earthquake (Mw=6.0, focal depth 98.6km) is the strongest recorded until now by the *NCSRR* seismic network and is the strongest event since 1990. The earthquake was felt on large areas but produced almost no damage (as reported by news agencies). In Figure 18 are presented examples of ground motions recorded during the October 27, 2004 earthquake.

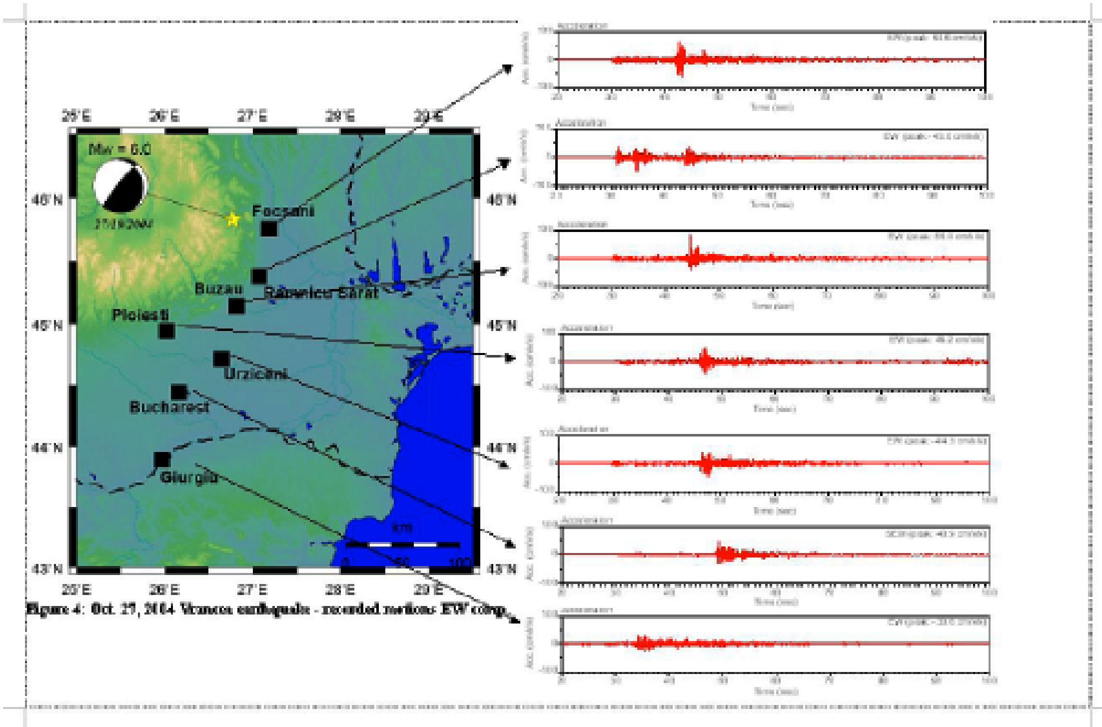

Figure 18. Seismic records obtained in NCSRR free-field network during Vrancea earthquake of October 27, 2004

Microtremor observation is another activity developed within the Project by Division 2. Portable acquisition stations and sensors were also donated by JICA. Microtremors were measured on buildings and on ground (single-station of array measurements) for the identification of building dynamic characteristics, for the evaluation of site response characteristics and for identification of seismic velocity profiles. Until today the following measurements were performed:

- Single station measurements of ground ambient vibrations – 19 locations
- Array measurements of ground ambient vibrations – 5 locations
- Measurements of building ambient vibrations – 7 buildings.

A joint activity of Divisions 2 and 3 is the borehole geophysical investigation (PS-logging tests) for identification of seismic velocities at different sites. The equipments were also donated by JICA. Until today almost 30 PS logging tests were performed. In Figures 19 and 20 is presented the equipments for PS-logging.

Figure 19*. Borehole sensor for PS logging*

Figure 20*. Portable acquisition station*

The equipments for soil testing and investigation consist of drilling equipment and cyclic triaxial testing equipment (presented in Figure 21 and in Figure 22) were donated by JICA in 2003-2004.

Figure 21. Drilling equipment on truck

Figure 22. Triaxial testing apparatus

Using the equipments donated within the Project, Division 3 performed the following activities:

- Drilling boreholes – 17
- CPT tests – 5
- SPT tests – 7
- Surface wave tests – 6
- Dynamic triaxial tests – 23
- Static triaxial tests – 45
- Tests for geotechnical characteristics of soil – 50
- Bender element tests – 15.

NCSRR ACTIVITIES FOR DISSEMINATION AND EDUCATION OF CITIZENS AND ENGINEERS

Seminars for engineers, inhabitants of vulnerable residential buildings and students were organized by *NCSRR* in cooperation with *MTCT* and Bucharest City Office. The total number of seminars amounted at 32, out of which 4 were for citizens, 7 for students and 21 for engineers. The importance of preparedness for the next big earthquakes such as adequate behavior in the earthquake and seismic evaluation and retrofitting of the vulnerable buildings were emphasized in these seminars.

Seminars for engineers are organized by *NCSRR* in cooperation with *UTCB* and *INCERC*. Lecturers in these seminars are Japanese experts and the staff of *NCSRR* as shown in Figure 24. The Project contributed in the preparation of a series of educational leaflets to instruct disaster preparedness for school children as shown in Figure 25.

Figure 23. Seminars for citizens

***Figure 24**.* Seminar for engineers at UTCB and Iasi Technical University

Figure 25. Manuals on disaster preparedness for school children

For efficient information of the students and engineers regarding the implementation of retrofitting works a full scale model one story frame was constructed. Using this frame, various retrofitting techniques were applied: concrete infill wall, steel brace, steel jacketing, fiber carbon jacketing for columns and beams.

Figure 26. Model frame with retrofitting solutions

PROJECT OUTPUT

Development of technical documents

Within the Project NCSRR contributed to the development of the following technical documents:

・ NCSRR staff actively participated at the elaboration of the following codes: P100-1/2006 Seismic Design Code for Buildings, P100-3/2008 Vol.1 Seismic Evaluation Code for Buildings, P100-3/2008 Vol.2 Seismic Retrofitting Codes for Buildings.

・ Seismic evaluation manual for existing RC buildings (based on P100-3/Vol. 1 – Code for seismic evaluation and retrofit of existing building – Volume 1: Seismic evaluation)

・ Seismic retrofitting manual for existing RC buildings (based on P100-3/Vol. 2 – Seismic Retrofitting code for buildings)

・ Manuals and the Codes previously mentioned gathered information from Japanese Guidelines and Technical Manual for Seismic Retrofitting (permission granted within JICA Project by Japan Building Disaster Prevention Association); structural testing results feed the preparation of the Manual.

・ Textbook on Design Input Earthquake Ground Motion; the first draft was issued in December 2005, the second draft was proposed in March 2007 and the final version is under publication.

・ Quick inspection manual for damaged buildings; the manual was developed under the cooperation of NCSRR with INCERC, UTCB and IPCT and was enforced by MDRL as Guideline in December 2006.

・ Manual for quality management of retrofitting works was completed in March 2008.

Design of retrofitting of two existing vulnerable buildings

The Project selected two existing vulnerable buildings in Bucharest, classified in seismic risk class 1, and carried out the retrofitting design of them using the methods and techniques introduced in the project. One is a residential building with soft and weak ground floor built in 1960's and located at 90-96 Mihai Bravu Boulevard. The project adopted a retrofitting solution with fluid viscous dampers and steel jacketing in the ground floor and steel plate jackets in upper stories walls after detailed investigation and discussion (Figure 27). The other is also a residential building without proper seismic design built prior to 1940's and located at 20 Stirbei Voda Street. The retrofitting solution is to add new RC walls and steel jacketing of RC columns, of which most of the works will be done from the exterior (Figure 28). Both projects are developed in partnership with Proiect Bucuresti.

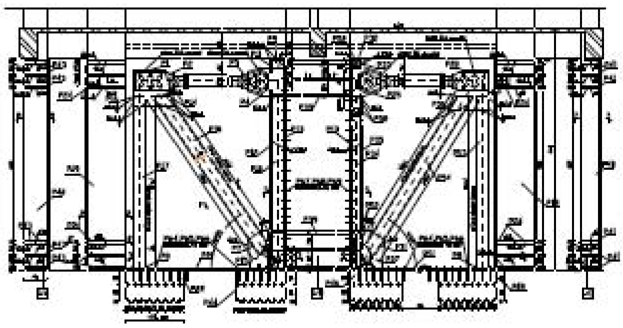

Figure 27. Soft and weak groundfloor RC building built in 1960's and retrofitting solution

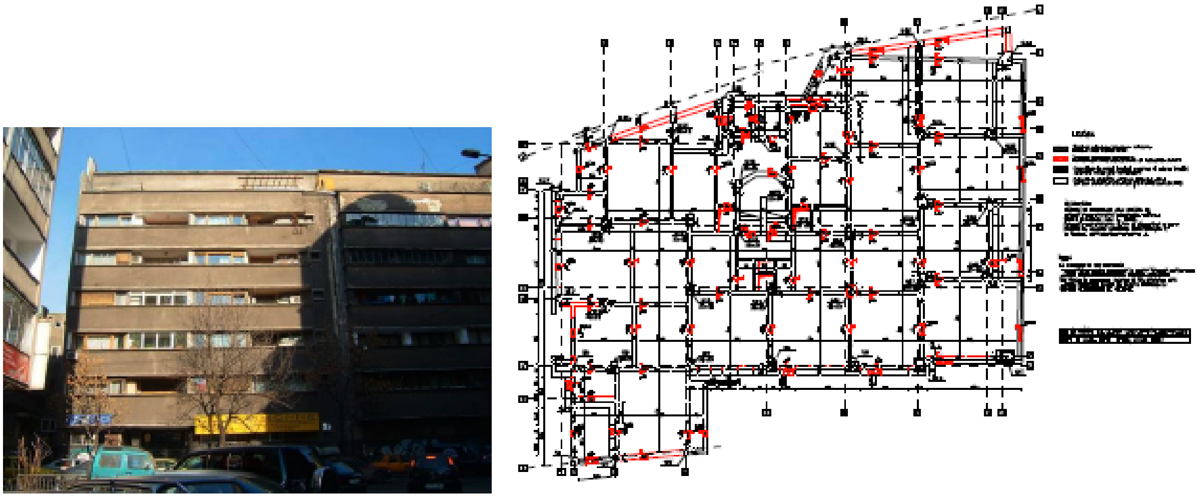

Figure 28. RC building built prior to 1940's and retrofitting solution

Earthquake engineering international conferences in Romania with JICA support

In 2000 was organized at UTCB the International JICA Seminar "*Earthquake hazard and Countermeasures for Existing Fragile Buildings*". The event was attended by …and was entirely supported by JICA. In 2002 was organized at Romanian Academy the International Conference ELERR "*Earthquake Loss Estimation and Risk Reduction*". The event was attended by , and was jointly supported by *JICA* and by two other international research projects (*SFB 461* and *RISK-UE*). In 2007 was organized at Romanian Academy the ISSRR2007 "International Symposium on Seismic Risk Reduction. The JICA Technical Cooperation Project in Romania". The event was entirely supported by JICA and sponsors, and was attended by 188 from 13 countries.

On the occasion of these events, the following publications were issued:

- Earthquake hazard and Countermeasures for Existing Fragile Buildings, 2001. Contributions from JICA International Seminar, Bucharest, Romania, November 23-24, 2000, Lungu, D., Saito, T. (Ed.), Independent Film, Bucharest, 315 p.
- Proceedings of the International Conference "Earthquake Loss Estimation and Risk Reduction", Lungu, D., Wenzel, F., Mouroux, P., Tojo, I., (Ed.), 366p + 421p
- Proceedings of the International Symposium on Seismic Risk Reduction. The JICA Technical Cooperation Project in Romania, Ed. Orizonturi Universitare, Timisoara, 753p.

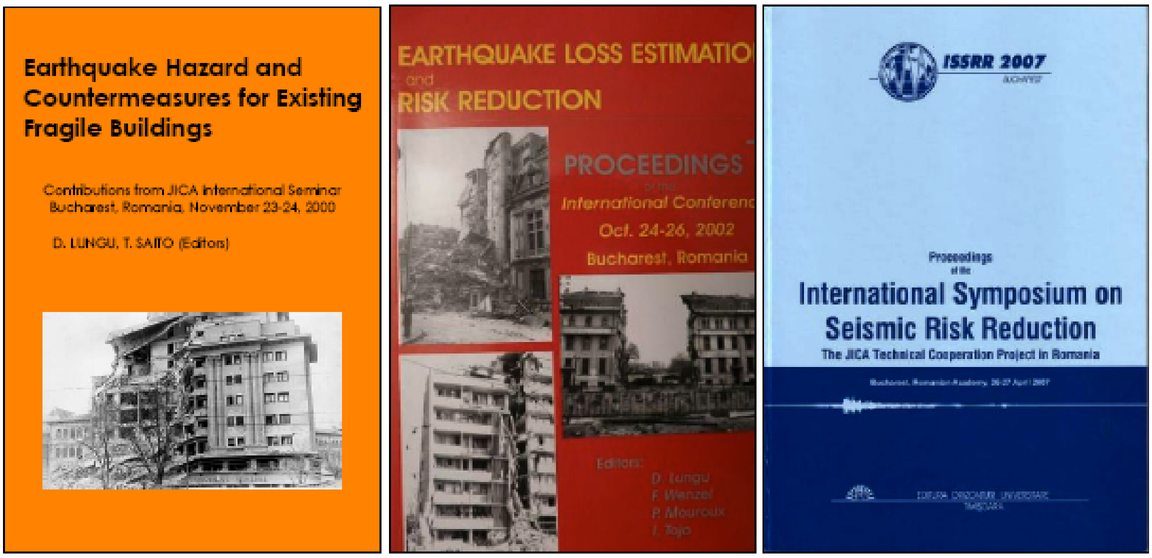

Figure 28. Proceedings of JICA supported conferences

Within the JICA Technical Cooperation Project for Seismic Risk Reduction, NCSRR and JICA organized in the period July 25 – July 27, 2007 the Training Program on Seismic Risk Reduction. Ten engineers from universities and design offices participated in the program. The topics of the lectures covered the fields of seismic evaluation and retrofitting and geotechnical earthquake engineering. Attendance certificates were handled to the participants.

Conclusions of the final evaluation for the project

According to the evaluation report prepared by the Joint Evaluation Team, the Project has been implemented timely and properly according to the Record of Discussions towards the achievement of the Project Purpose. The Project Purpose and Overall Goal are valid and in line with the policy of MDRL as well as with the principle of Japanese cooperation to Romania.

In the Project, the followings are the most highly rated achievements.
- The first retrofitting design using modern techniques was completed for a soft-story building in Bucharest.
- As a result of the cooperation between JICA experts in the Center and INCERC, manuals of earthquake education for school students were issued.
- Seminars and meetings with the residents in vulnerable buildings, students and engineers were held frequently, which improved their understanding on the earthquake effects and countermeasures.
- State of the art equipments were provided and are operated properly by well-trained Romanian counterparts.

ACKNOWLEDGEMENT

NCSRR deeply acknowledge the generous, continuous and long-lasting financial support of JICA during the implementation of the Project. The technical support of Building Research Institute (BRI), Tsukuba and National Institute for Land and Infrastructure Management (NILIM), Tsukuba, Japan provided to NCSRR staff is gratefully acknowledged. The partnership between NCSRR, UTCB and INCERC for the implementation of the JICA Project is valuated. The continuous support of MDRL Romania for NCRSS is gratefully acknowledged.

REFERENCES

Aldea, A., N. Poiata, Kashima, T., Albota, E., Demetriu, S., 2007. NCSRR digital seismic network in Romania, Proc.of ISSRR2007 International Symposium on Seismic Risk Reduction. The JICA Technical Cooperation Project in Romania, p.43-156

Aldea, A., Kashima, T., Poiata, N., Kajiwara, T., 2006. "A New Digital Seismic Network in Romania with Dense Instrumentation in Bucharest", 1st ECEES First European Conference on Earthquake Engineering and Seismology, Geneva, Switzerland, 3-8 September 2006, Paper Number: 515, 10p., CD-ROM

D. Cotofana, V. Popa, 2007. Ductility Upgrade Retrofitting Solutions for Reinforced Concrete Columns. Experimental Study. International Symposium on Seismic Risk Reduction, The JICA Technical Cooperation Project in Romania

Lungu, D., Arion, C., Aldea, A., Cornea, T. 2001, City of Bucharest seismic profile: from hazard estimation to risk mitigation, JICA International Seminar "Earthquake Hazard and Countermeasures for Existing Fragile Buildings", November, 23-24, 2000, UTCB, D. Lungu and T. Saito, Editors, Bucharest, Romania

M. Seki, R. Vacareanu, T. Saito, D. Cotofana, E. Lozinca, V. Popa, A. B. Chesca, 2008, Cyclic shear tests on plan and FRP retrofitted masonry, Conferinta internationala "14th Word Conference on Earthquake Engineering", October 12-17, 2008, Beijing, China

Nagata, K., Vacareanu, R. 2007 – Joint Terminal Evaluation Report on the Project on Reduction of Seismic Risk for Buildings and Structures, 20p.

Popa Viorel , Dragos Cotofana, Basarab Chesca , Radu Vacareanu , Eugen Lozinca, 2007, Structural testing program for masonry elements, Structural Testing Report

Vacareanu, R., Aldea, A., Arion, C., Lungu, D., Aug. 2003. "Toward the seismic microzonation of Bucarest-city, Romania: The National Center for Seismic Risk Reduction and the JICA Project", Research Reports on Earthquake Engineering, No. 87, Tokyo Institute of Technology, Japan, pag. 29-33

http://www.sharaku.nuac.nagoya-u.ac.jp/laboFT/bururu/index.htm,
http://www.oyosi.co.jp/kbururu.pdf
http://cnrrs.utcb.ro/cnrrs_en/ncsrr.html

SAFE STRUCTURE PRODUCTION, ENGINEERING SERVICES AND BUILDING INSPECTION

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ABSTRACT

After 1980s, shanty housing process became mostly unearned income. The nature of illegal housing changed and single floor buildings turned into multi-storey ones, illegal housing became widespread in every sector from commercial and industrial buildings to agricultural and touristic buildings. Various reports prepared after 1999 Gölcük and Düzce earthquakes indicate that the housing problem in our country is mostly about quality rather than quantity. Illegal building stock which was legalized especially through zoning remissions, constitute big risk areas in our cities in terms of natural disaster and earthquake. An understanding of regulation and collaboration to promote technical concern against political, commercial, clan and religious concern contributes to emergence of a correct building inspection process and the production of a healthy environment and safe buildings to a great degree.

KEYWORDS
Building inspection, building stock, earthquake, illegal, Zoning Law, professional competency

INTRODUCTION

The situation of the building stock in our country stands before us as a great problem in the means of life and property safety. The bitter facts we have encountered with the earthquakes we have experienced in the near past are the basic reasons of this hypothesis.

Mainly done for sheltering in metropolitans until 1980s, but being illegal, shanty housing process became mostly "**unearned income**" oriented after 1980. Left to private property owners, build-and-sell builders, micro entrepreneurs and shanty house owners until then, urban unearned incomes came into the focus of capital owners and land mafia in the following period. In this period the nature of illegal housing changed and single floor buildings (shanty houses) turned into multi-storey ones, illegal housing became widespread in every sector from commercial and industrial buildings to agricultural and touristic buildings. In this context, public land surrounding the city and near the coastline was plundered, water basins were occupied together with agricultural and forest land, illegal urban settlements consisting of multi-storey buildings came into existence.

The rate of shanty houses for rent in this period reached up to 50% when compared to the total number of houses for rent. Illegal settlement became an unearned and illicit income for the ones who plundered and sold public land. Owners of more than one shanty house held a prospective investment and a significant unearned income area. **Today, 60% of the urban areas of our metropolitan cities** consist of settlements which don't conform to the zoning legislation. Besides, on one hand, with the continued zoning remissions, the existing shanty houses obtained a legal identity, on the other hand buildings constructed on lots and plots with regular building authorizations (permit) tended to extend widthwise, lengthwise and upwards (illegally).

In the result of such an attitude, according to a research conducted by Prime Ministry Undersecretaries of Housing in 2002, taking year 2000 as basis; 62% of the domiciles had building permit and 33% had occupancy permit. The rate of unauthorized buildings with no habitation permit is higher in Istanbul. The rate of buildings which are produced illegally without acquiring any engineering service is at the rate of 70%, the rate of buildings with occupancy permit is 10%.

FACTS REVEALED AFTER 1999 EARTHQUAKE

Various reports prepared after 1999 Gölcük and Düzce earthquakes indicate that the housing problem in our country is mostly about quality rather than quantity. It is a commonly known fact that illegal building stock, which was legalized especially through zoning **remissions,** constitutes big risk areas in our cities in terms of natural disaster and earthquake. Moreover, luxurious settlement areas built on forest lands, university campuses, industrial facilities built on agricultural lands, tourism facilities built on coastal areas which are not permitted for settlement, illegal trade centers built in city centers, skyscrapers and similar illegal buildings which are built on areas with deed registries bearing the provision that "**not permitted for construction**", but of which construction was completed through a series of scandals in terms of zoning law and of which destruction became definite legally, contributed to a great degree to depravation in the society in terms of construction culture.

This situation not only prevents safe building production, but it was also put on the agenda as one of the important reasons preventing correct use of engineering climate by the users and producers.

In this context, 1999 Gölcük and Düzce earthquakes were recorded in the history not only as an earthquake, as a result of which illegal buildings and buildings that do not conform to the permit were damaged, but also many buildings with authorization and occupancy permit were damaged to a great degree.

BUILDING INSPECTION FROM THE PAST TO PRESENT

It was attempted to inspect housing with regulations, such as "Municipality Law" Nbr.1580 and "Public Health Law" which came into force in 1930, "Municipality Buildings and Roads Law" which entered into effect in 1933, "Law on the Measures to be Taken Before and After Earthquakes" which came into force in 1944, "Building Construction Incentive Law" which entered into effect in 1948.

However, in addition to the rapid migrations experienced in our country after 1950, unplanned industrialization trends led to an increase in illegal buildings and urban sprawl. In 1956, for the purpose of dealing with settlement and housing in the borders of Municipality and contiguous areas within planning integrity, "**Zoning Law**" Nbr.6785 came into effect. For the purpose of directing and inspecting the dwelling, settlement, industrialization and housing processes of our country more effectively, **Ministry of Public Works and Settlement** was founded in 1958, but rapid urban sprawl and non-inspected and illegal settlement increased rapidly.

In 1972, the scope of Law Nbr.1605 and Law Nbr.6785 on zoning was broadened in a manner to include concepts of Metropolitan cities, regional and sub-regional plans. However, in this process, rapid urban sprawl, non-inspected and illegal settlement continued to exist. In the period following 1980, with the understanding that physical planning processes may not be developed within the framework of central administration's directions, "**Zoning planning authority**" was granted to the local administrations.

SETTLEMENT REMISSIONS AND LACK OF INSPECTION

Zoning remissions have always been an indispensable part of zoning practices. The fact that laws on zoning were ignored in the period after 1950, has been an important reason for the increase in illegal settlement. In order to legalize such illegal buildings the concept of "**zoning remission**" was introduced. It was ensured that illegal buildings were remitted through "**zoning remissions**" and were legalized. Settlement remissions, to a great extent, contributed to the transfer of unearned incomes occurred in the city to certain people unjustly and emergence of an illegal and unlawful construction culture.

Zoning remissions contributed to the emergence of a non-inspected building stock which did not receive engineering service and was produced unsafely in urban areas with or without zoning permit, with or without permit during construction process. Besides constructing projects with building right, forming an inspected building production through receiving engineering service was ignored to a great extent.

In 1985, zoning Law Nbr.3194 was enacted and it was seen that practices under the scope of improvement and zoning plans were significantly realized and became effective in the shaping of cities through "**zoning remission**" Law Nbr.2981, which was enacted one year later. Again, between years 1986-1988, in addition to broadening of remission scope through Law Nbrs.3290, 3366 and 3414, it was facilitated for this kind of buildings to benefit from infrastructure services as well.

RECENT BUILDING INSPECTION PRACTICES

Zoning Law Nbr.3194 has been drawn up to provide the development of the settlement area and housing in those areas to be according to the plan, project, science, health and environmental conditions

In Zoning Law Nbr.3194, project inspection, which constitutes the first aspect of building inspection was appointed to local administrations (governorship, municipality and administrations which are competent to give authorization), in the second stage, during execution of building inspection, it was appointed to free-lance engineers and architects which are identified as technically accountable. This law is being applied in 62 provinces of Turkey, except for the ones which are excluded as per Law Nbr.4708.

Holding a diploma was the only requirement for engineers and architects who have participated in the building inspection under Law Nbr.3194. There were no stipulated requirements on registration, supervision of profession members who took part in that process and whether they have professional competence or not. **Responsibilities and authorizations not being cleared and paid by building owners, these people used their signature for obtaining the permit to fulfill the formality.** Besides, since engineers and architects do not take part in many local administrations and even if they take part, they don't have the sufficient professional competence, an effective structure inspection could not be realized.

Today, inspection services under TUS system as per zoning Law Nbr.3194 are being held in 62 cities.

Nevertheless, building owners do not have sufficient knowledge and awareness and this prevents the creation of demand and pressure about building safety. As a result, neither structure projects nor the structure building process (structures) were inspected sufficiently. Unfortunately, this attitude still continues today in a great scale.

If we consider that public buildings were heavily damaged and collapsed in the earthquakes we have experienced, this shows that there is a serious inspection problem in these buildings.

LAW ON STRUCTURE INSPECTION NUMBER 4708

Life and property losses in the earthquakes of 1999 made it necessary to establish a new and effective structure inspection system. Structure inspection by Law Nbr.595, which was enacted for this purpose and brought into force, was unfortunately repealed after a short while. Besides, by law of "**competence in engineering and architecture**" Nbr.601, which was enacted for seeking **professional competence** in engineers and architects and provide the certification of this competence by **professional chambers** was also repealed.

Structure inspection Law Nbr.4708 which was enacted in July 2001, was brought into force in 19 pilot provinces, being a lot more disadvantaged law than structure inspection by Law Nbr.595.

"The purpose of this law is to provide project and structure inspection and to regulate the procedures and terms regarding structure inspection for the production of high quality structures, conforming to the zoning plan, technical, artistic, sanitary rules and standards in order to provide safety of life and property. "

This law covers the inspection of structures specified under article 26 of Zoning Law Nbr.3194 and structures to be built inside and outside the borders of municipality and contiguous areas that are not included among structures which are not subject to permit as specified under article 27. Besides, detached two-storey structures except for basement floor which are settled on a single lot and not over 200 m^2 are not taken under cover of the Law Nbr.4708.

As per Law Nbr.4708, engineers and architects who have completed 12 years in their profession may obtain "**inspector**" certificate by applying to Ministry of Public Works and Settlement. Ministry completes the required analysis on the submitted file and **does not require any documentation**

regarding professional competence and professional ethics. Any engineer or architect who has completed 12 years in any organization can obtain "**project inspector certificate**". These certificates are valid for five years.

I shall emphasize that a comprehensive building inspection is always needed for providing both security of life and property, and producing a modern habitable environment and buildings. Unfortunately, Law Nbr.4708 was enacted together with lots of deficiencies. However, without having the luxury of excluding one another, it should be perceived as a must, that all public institutions, the ministries and the Parliament being the prominent ones, should collaborate closely, cooperate and take account of each other's opinions.

As we have mentioned in the stages of enacting this law, "**signature affixing attitude**" in the permit issuing stage of Law Nbr.3194 can also be mentioned for Law Nbr.4708. Inspection work is held by several structure inspection organizations with discounts between 50%-70% for the inspection service cost which consists in 3% of the structure cost. Therefore, since the service cost is significantly reduced, effective structure inspection is prevented and unfair competition occurs. Many structure inspection organizations which attempt to execute their duties duly become aggrieved as a result of this unfair competition.

I shall also express that absence of a construction supervisor in structure production process is a significant deficiency. While it was thought that this deficiency was rectified with a regulation enacted on February 5, 2008, with the circular note issued by Ministry of Public Works and Settlement, this task became impossible to achieve again, to say the least. It is understood that, known as the school of building production and inspection, Ministry of Public Works and Settlement forgot who "**Construction Supervisor**" is and what he/she shall do!

Again, some of the municipalities do not require project registration status certificate from engineers and architects; thus some engineers and architects who carry on signature affixing tasks in order to attempt "**unfair competition**" rather than executing their profession properly were brought to the attention. At least, documentation shall be required indicating whether the engineer or architect, who has drawn up the project or who attempts to be a Construction Supervisor is banned from his/her profession or not. This documentation shall indeed by made by **Professional Chambers.**

CONDITION OF THE BUILDING STOCK IN ISTANBUL

- Most of the buildings in Istanbul are illegal and constructed with no inspection.
- Coastal lines, landfill areas, water courses and surroundings are facing a significant risk.
- There is a serious lack of inspection in fuel stations and places where inflammable, poisonous and contaminating substances are processed, stored or distributed. These activities are commonly held in settlement areas.
- Majority of the existing building stock was not built taking earthquake regulations into consideration. Briefly, buildings were either produced with no or inadequate level of engineering service.
- There is a lack of sufficient and corporate-scale information regarding building reinforcement.
- Schools, hospitals, fire departments, bridges and some of the other public buildings have an extremely low earthquake safety. These structures pose a great risk.
- Together with the buildings located on the historic peninsula, historical and cultural structures located in other places are facing a great risk.
- There is a great demand for establishing a risk management to minimize losses in contrary to the attitude of **save the day** at the time of earthquake and afterwards.
- Industrial and commercial structures, industrial plants, workplaces where people work collectively are under a significant earthquake risk.

CONCLUSION

Ensuring life and property safety in structures may only be realized through effective inspection. Both realizing location selection decisions and project inspection within the correct framework and professionals with competency and obeying code of conduct for inspection of the practice are required to a great degree. In this context, only holding the diploma must not be sufficient. Since new information is too rapidly put on the agenda and becomes old-fashioned in the same pace, "**continuous on-the-job training**" is required at a great scale. Mainly arranged by Chamber of Civil

Engineers, on-the-job training arranged continuously by professional chambers shall be emphasized. Only engineers and architects who have received this training may realize the correct service production and adopt an attitude conforming to the professional ethics.

It is very upsetting that the local administrative authorities put the modern structure inspection understanding aside and consider service production only in terms of diploma. Life and property losses resulting from collapsing buildings naturally or due to earthquakes are in strong connection with the lack of an effective structure inspection system.

Enacted in 1938, Law on Engineers and Architects Nbr.3458 requires an engineering service, which is solely based on diploma. We face this as a mechanism only for completing the formality that is commonly embraced by executing authorities and engineers. It does not consider a non-stop learning, so-called continuous education after school. Additionally, this law promotes a system which does not consider certification and **professional competency.**

It is therefore not sufficient that only engineers and architects are **competent.** It must always be on the agenda that everyone involved in construction process has to have certification, with education and has to obey a specific code of conduct.

Although today, it is a correct practice that engineers and architects who obtained "**Building Inspector Certificate**" are made to attend the course by their own professional chambers, it is not sufficient for a good building inspection. Additionally, it is very difficult to obtain the desired result from the law on building inspection, which does not take **professional competency** as a basis and which does not make **professional responsibility insurance an obligation.**

In addition to the well-informed owners and users, it must be made an obligation for building contractors, masters, foremen and regular workers to have training and certification.

It must be emphasized once again that an understanding of regulation and collaboration to promote technical concern against political, commercial, clan and religious concern does not only contribute to emergence of a correct building inspection process, but also contributes to the production of a healthy environment and safe buildings to a great degree, and it leads to a raising consciousness.

In conclusion

- Renewing zoning and building inspection system in a manner to cover risk management, **organizational structuring, legislation arrangements** required for damage minimization, raising awareness among public on **disaster hazard and risk.**
- An effective collaboration between public bodies and several professional groups,
- In scope of a modern disaster management system, requirement of planning from national and metropolitan level to building level.
- Revision of the current legislation in integrity with an understanding to foresee preparation for earthquake and decreasing the risks, to include the concepts of "**hazard**" and "**risk**",
- In addition to microzoning, urban risk sectors, conservation plan and new zoning tools, the zoning law shall include the following,
    - **Building Inspection Law** taking Professional Competency as the basis,
    - Professional responsibility insurance,
    - Building Law,
- Providing an arrangement which will renew Istanbul instead of erecting new towers on anywhere possible.
- It is required to reinforce or rebuild schools, hospitals, other public building, workplaces in which people work collectively, industrial facilities, dwellings and other buildings which do not have earthquake safety.
- Providing new lands and opening new settlement areas in our cities and in Istanbul cannot solve the problems of the city, rather it appears as an investment without return,
- Not considering urban transformation practices as a zoning right, and providing the return of new benefits realized by those practices back to the public,
- Administrative authorities of Istanbul shall establish the resource issues, tools of renewal and transformation, method and strategies properly; and it must be definitely given up the works conducted through projects instead of an integrative planning.

- Urban transformation practices are the parts of a whole, and shall rely on reconciliation as a result of urban renewal, and shall not be used as a way and trend of transferring unearned income to certain people.
- All following are required: risk minimization through ensuring that the buildings are produced with earthquake safety; risk elimination through ensuring that the existing buildings are reinforced safe against earthquake; establishing arrangements and practices which ensure risk transfer through strengthening of the insurance system.

CONTRIBUTIONS TO THE EVALUATION AND MITIGATION OF SEISMIC RISK IN MEXICO

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ABSTRACT

Some examples of recent actions and experiences are presented concerning early warning, prevention and mitigation of seismic risk in urban areas and also in areas where the construction practices are non-specialized. The use of microtremors to evaluate site effect is described, taking as a basis the experience obtained in Mexico City, a place where the phenomenon is characteristic. A summary is presented to describe the evolution of building codes together with a description of the characteristic building types in urban areas. Also a financial tool, designed to promote applied research and preventive measures, is briefly described mentioning its basic operational scheme.

KEYWORDS
Seismic risk, early warning, emergency response, microzonation, building codes, building types, preventive measures.

INTRODUCTION

An overview is presented about the main activities and current results of projects undertaken in order to derive preventive measures and mitigate seismic risk. All of these activities are considered in a general scheme set by the National System for Civil Protection (SINAPROC), created after the 1985 earthquakes in Mexico.

Taking into account the high potential for one or several great magnitude earthquakes that could occur in the near future due to the subduction process along the western coast of Mexico, an early warning system has been put in operation in order to provide a signal for Mexico City, about 300 km away from the seismogenic zone. The system is intended to give up to 60 seconds in advance for the inhabitants of the biggest city in the country to take safety measures.

The first building code in Mexico was released in 1920, but it was until 1942 when the seismic design coefficient factor was explicitly included. The efforts were put in Mexico City due to its fast development especially including high rise buildings. Since then updating has been subject to advances in the knowledge of seismogenic zones behavior, seismicity, seismic microzoning and contributions about the behavior of different type of structural systems under inertial lateral and vertical seismic loads; specifically in design parameters like ductility, energy dissipation capability, lateral stiffness and lateral resistance.

The efforts are sustained to encourage states and municipalities to develop their own building codes. It has been found that a common and unsuitable practice in those environments has been to adopt the building code developed for Mexico City, mainly due to its frequent updating.

In the case on Mexico, A, B and C buildings types are considered, corresponding to the importance factor, which is taken as a basis to determine the design loads as well as the acceptable limits in the structural system parameters related to its behavior, e.g. maximum lateral displacement and the occurrence of yielding in the component materials. Estimation is that after 1985 earthquakes, theoretically 40% of buildings in urban area do not comply with a seismic code.

The preventive measures also have been supported using financial instruments, designed and operated by the Federal Government. The Mexican National System for Civil Protection (SINAPROC) has a main unit called FONDEN (Natural Disasters Fund) dedicated to support states, municipalities and other public units to attend an emergency and to recover from the effects produced by a natural phenomenon. Part of the activities of FONDEN is to promote and support economically those projects that may produce technical information, measures and cultural elements that will be useful to identify and evaluate natural hazards and risks, develop preventive measures taking into account the highly desirable transit from the reactive scheme to a preventive one.

SEISMIC POTENTIAL IN GUERRERO COAST

A high seismic potential area has been identified along the western coast, particularly along the coast of the state of Guerrero, which is characterized by a subduction process between Northamerican and Cocos plates. Large magnitude earthquakes have occured in an episode that included events in 1899 (M 7.9), 1907 (M 7.6), 1908 (M 7.5, 7.0), 1909 (M 7.2) and 1911 (M 7.5). After that sequence no earthquakes with magnitude equal or greater than 7 have been observed in that segment along the coast. Because of that the segment has been named as Guerrero Seismic Gap.

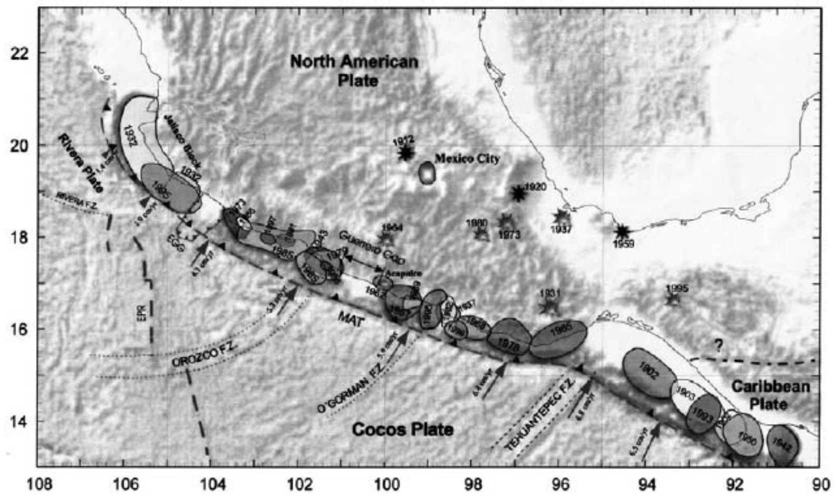

Figure 1. Rupture areas of great large magnitude earthquakes during 20th century in Mexico. Guerrero gap, a high seismic potential area, is shown *(National Seismological Service, Institute of Geophysics, UNAM).*

A seismic gap is that in which a subduction zone or strike slip fault system has not produced a large magnitude event within a period greater than 50 years. In Figure 1 rupture areas of earthquakes occurred during the last century are shown. Those located along the coast are interplate earthquakes while the ones located inland are due to and intraplate process.

It has been evaluated that the maximum magnitude for a future event produced in the seismic gap could reach 8.3. However, it is possible that the accumulated seismic energy could be released in two or more events, in a similar way to that observed at the beginning of the 20th century.

Nowadays, since Mexico have both a larger population and number of buildings, the level of seismic risk has increased significantly along the coast areas as well as in Mexico City. This situation has moved the civil protection authorities to permanently review and update those procedures for emergency response. Particularly, new seismic research and instrumentation projects have been supported in order to evaluate and mitigation seismic risk.

SEISMIC ALERT SYSTEM

Due to the high seismic potential identified in the Guerrero gap, an early warning system has been developed in order to provide a timely signal for the inhabitants of the biggest city in the country.

The CIRES (Seismic Instrumentation and Recording Center), an institution patronized by the Mexico City government authorities since 1987, has a system with 12 seismic sensing stations in operation in Guerrero coast which value the forecast of the local seismic activity magnitude and send it by radio to the central station in Mexico City. The seismic alert system (SAS) operates in a continuous way since

August of 1991 and its objective is to give seismic anticipated warning to Mexico city, in case of an earthquake occurs in the region that is covered with sensor stations in Guerrero.

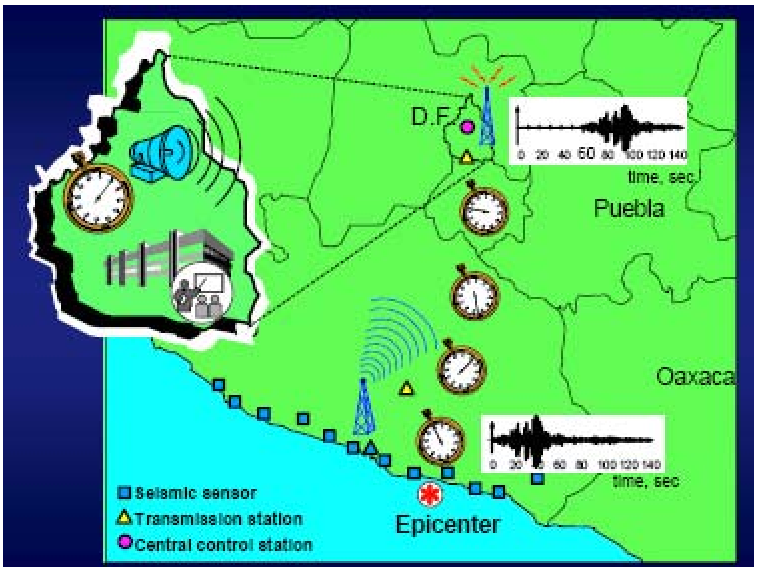

Figure 2. Seismic Alert System designed to provide an early warning signal to Mexico City in case of a great magnitude earthquake occurrence in Guerrero gap

Since the distance between the coast and Mexico City is around 320 km, and taking into account that radio signal is faster than seismic waves, the population can be warned approximately 60 seconds before the strong phase of the earthquake arrives. The system is designed to make a public warning when the estimated magnitude is equal or greater than 6. It is necessary to point out that, although the system is able to detect earthquakes from, neighbor areas, it works only for events originated along the Guerrero coast.

Presently, the seismic alert signal is broadcasted through commercial radio stations, through TV channels 11 and 22 and is used in the subway and schools, among others.

EXPERIENCES IN SEISMIC MICROZONATION

During the decade of 60's the site effect was identified for Mexico City, laying on an ancient lake bed. At that time the lack of enough seismic recording instruments made not possible to quantitatively estimate the phenomenon.

During the decade of 70's the first sesimic regionalization map was produced, classifying the mexican territory on the basis of exposure to seismic hazard, representing at that time one of the most important advances in the risk mitigation field. A to D zones were defined, indicating growing hazard levels, respectively (CFE, 1993). It was recognized that although this map has been useful it does not show those places (particularly alluvial valleys) where ground motion amplification should be expected.

Because of this, and particularly after the 1985 earthquakes, microzonation studies were made, mainly on the most populated cities. Nowadays there are about 50 seismic microzonation studies in the country (Lermo y Vega, 2001), for 35 cities based mainly on strong motion data, ground velocity data, microtremors, geotechnical parameters and surface geology.

It has been noticed that one of the mostly used techniques is the spectral quotients determination, using horizontal and vertical components, respectively (Nakamura's technique), which produces an acceptable estimation of ground dominant frequencies but not of the relative amplification, being generally underestimated. However, this technique provides better results in comparison with the use of microtremors through the same procedure.

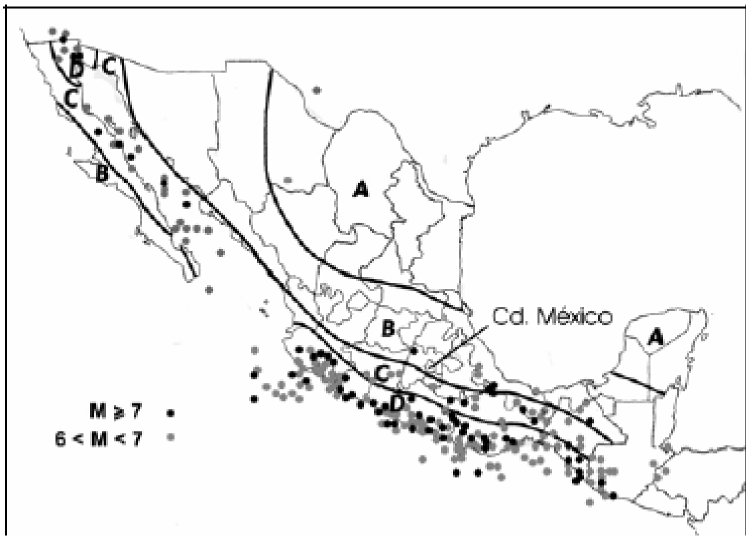

Figure 3. Seismic regionalization of Mexico.
Epicenters of earthquakes with M > 6 during 20th century are shown

Presently, the best results have been obtained with spectral quotients based on strong motion data. Such quotients are obtained taking as a reference the strong motion data from a station located on hard soil in order to estimate both dominant periods and amplification factor in every soft soil site where acceleration or velocity data are available. A better definition of site effect is achieved depending on the availability of a large number of accelerograms, corresponding to events with a wide range of depth, magnitude and azimuthal distribution. The fact that in some regions a hard soil site is not available to be used as a reference station has encouraged the application of procedures that do not require it (e.g. Nakamura´s technique).

Figure 4. The soil response of about 35 cities has been evaluated during the last 20 years using microzonation techniques.

In Mexico a stationarity test has been widely applied if microtremors are to be used; it consists on the verification of spectral amplitude and dominant period variations through time. This aspect becomes relevant if it is considered that microtremors depend on vehicle transit, industrial activity, etc.

Microtremors became very popular in several countries because of its very short time of application and low cost. In the case of Mexico City the clear correlation between the dominant periods defined with microtremors and strong motion recordings lead to think, al least during the first years, a high efficiency of the method, practically at any place.

GENERAL PROCEDURE TO DESIGN AND CONSTRUCT A NEW BUILDING

In order to solve a specific necessity an executive project is made taking into account the owner requirements and following the minima requirements established in the applicable code. Space distribution and structural characteristics are defined under safety criteria and, at the same time, the more suitable materials are selected.

On the basis of the building code the future loads for the structure are determined for its useful life; the procedure for analysis and structural design is developed using the building code and technical and complementary norms that complement it for the loads determination, analysis and design procedures for both the different structural elements and most common materials.

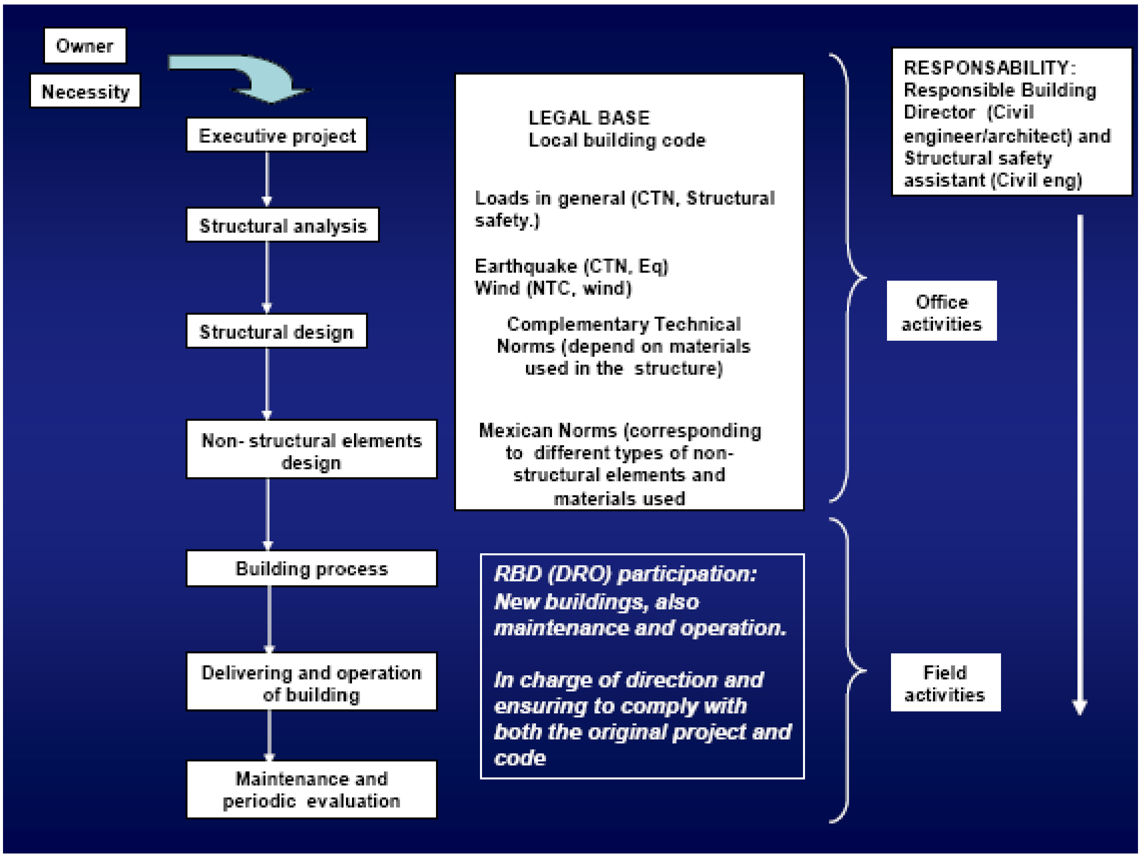

Figure 5. Ordinary sequences followed to design and construct a new building

Once the analysis and design process is finished the results take form in the building and supervision blueprints which, together with the calculus memory book, are provided to both the owner and the builder. The construction process is supervised by the owner and the engineer responsible for the whole project, known as the Responsible Building Director (DRO), who must be a professional architect or civil engineer.

When the building is finished the DRO will deliver it in full working condition, presenting an operation and maintenance manual.

MEXICAN BUILDING CODES DEVELOPMENT

The building code establishes the general requirements and the norms that complement it. In Mexico they are revised and updated depending on the most advanced knowledge available, regularly every ten years, unless an extraordinary seismic event occurs. Following, a summary of the evolution of building codes in Mexico is presented, showing its main characteristic at the time.

1920. The building code was based on rules adopted from other countries. Established minima dimensions and allowed stresses for materials.

1942. Code based on allowed stresses. Maximum accepted height for buildings is 35 m.

1957. Emergency code after M 7.8 earthquake in Guerrero coast. The use of design spectra is adopted, including probabilistic concepts for seismic resistance design.

1966. Design spectra take into account new concepts as recurrence periods. Resistance factor design included. Classification of buildings depending on its importance factor formally established.

1976. Updated version based on experiences from the last 10 years. Ultimate resistance design is included considering uncertainty in loads and resistance. A main body of the building code and its Complementary Technical Norms are maintained. New concepts are included (e.g. ductility)

1985. Emergency building code after M 8.1 earthquake in Michoacán coast. Significant change on demand level, Spectral design acceleration increases 75% average.

1987. Most of the changes from the emergency code are maintained. The Responsible Building Director (DRO) figure is included.

2000 – 2004. New criteria included. Tendency to change design based on ultimate resistance to design by capacity and performance. 5 to 10 years frequency to update norms.

CHARACTERISTIC CONSTRUCTIONS IN MEXICO

The National Constitution establishes that every state and municipality has the right to make its own building code and complementary norms. In most of the cases municipalities make their building codes taking as a basis the code from a developed city, e.g. Mexico City, Guadalajara, Monterrey, or the codes from a neighbour state close to the border with the United States (e.g. California). However, for the Technical Norms that complement a building code, generally are taken those from Mexico City, with the exception of localities at the north border where concrete, steel and/or timber structure codes from American institutes are used. It is necessary to set clear that only in few cases small changes are made according to the locality conditions.

Figure 6. Non-engineered house, generally by self construction used by a single family. Construction average cost is 100 USD/m2

Well confined masonry dwelling, built by the owners with traditional procedures (Figure 6). This kind of dwelling has in general an average surface of 40 m2, with an approximate cost of 4000-5000 USD. It will have a good performance in the presence of wind and earthquake due to the right amount, correct location and distribution of reinforced concrete confining elements. Furthermore, the foundation is characterized by good rigidity and resistance which together with the reinforced concrete slab allows us to expect a good behavior of the house.

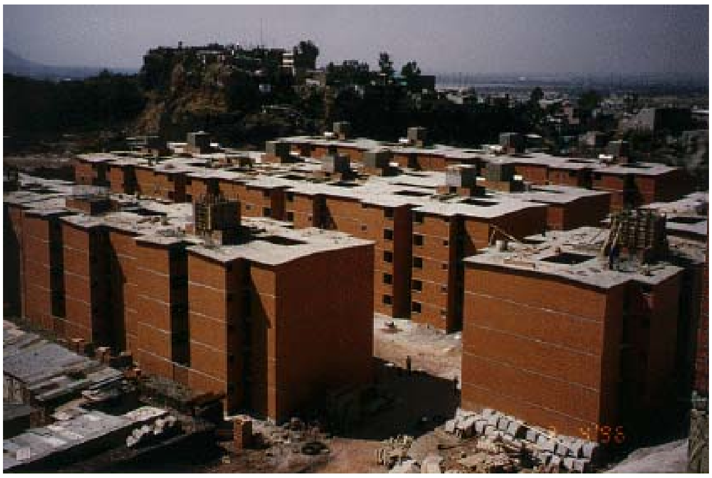

Figure 7. Engineered multifamily dwelling, very common in urban areas.
Built with masonry walls and concrete slabs. Cost range 135- 270 USD/m2

Confined masonry multifamily reinforced building commonly used to solve popular dwelling necessities in urban zones (Figure 7). Rigid body behaviour with high shear resistance is achieved due to the use of a reasonable quantity of walls together with concrete slabs as floor system, obtaining a safe response in case of earthquake. This kind of constructions are made by the big house-building enterprises using systematic procedures and prefabricated elements, for example industrialized ceramic block which allows to provide affordable housing for low income population together with an appropriate safety level.

Figure 8. Engineered multifamily urban dwelling, based on prefabricated slabs, concrete beams and columns. Cost range 200 - 330 USD/m2

Apartment building based on reinforced concrete frames, commonly with less than five stories to avoid inclusion of elevators, as set by the building code (Figure 8). The floor systems are made with partial prefabricated elements to shorten building time and to reduce building costs. In most of the cases the builder is the owner, supported by a professional. This type of solutions is applied in urban areas.

Apartment and/or offices building, based on reinforced concrete frames, sometimes with walls of the same material, built with prefabricated or partially prefabricated elements (mainly for the floor systems) in order to reduce mass and therefore inertial forces generated by an earthquake (Figures 9 and 10).

Figure 9. Engineered dwelling, middle-high economical level, built with partially prefabricated floor.
Cost range 550 - 800 USD/m2

Figure 10. Engineered dwelling, high economical level, reinforced concrete.
Cost range 700 -1400 USD/m2

Due to its dimensions this kind of buildings requires special installations and equipment, e.g. elevators, water storage and distribution systems, which increases the cost. These buildings are commonly made by experienced enterprises although recently the big real estate developers are participating.

The department stores and malls are commonly built using prefabricated elements, made with reinforced concrete or structural steel (Figure 11). In some cases, when the reinforced concrete solutions are audacious, the evaluation of the proposed joint systems for the structural elements is made by specialized laboratories through destructive tests, simulating the effects of earthquakes. This kind of solutions, although less labour work on site is needed, requires a high level supervision, aspect in which special attention must be put in the case of Mexico.

Figure 11. Commercial centers, totally prefabricated, Cost range 500 - 700 USD /m2

SIMPLE PROCEDURES TO RETROFIT AND REINFORCE LOW COST DWELLING

Figure 12. Poster used to disseminate retrofitting and reinforcement procedures in areas where rural self-construction dwelling predominates. This kind of dissemination material is widely used in Mexico in order to provide simple procedures to people with low income in the countryside.

To diminish losses in self-construction dwelling, in which the lack of technical supervision and the use of low quality materials are predominant, a poster like the one shown in figure 12 has been widely distributed throughout the country, particularly in those areas located near the important seismogenic zones. Simple procedures to retrofit and reinforce the dwelling exposed to strong seismic and/or wind effects are explained, together with recipes to apply wire mesh, prepare mortar, etc. The application of this kind of measures has been useful to diminish in a significant way the physical vulnerability.

Figure 13. Illustrated booklet that provides simple procedures to reinforce rural dwelling for earthquake and wind actions; works as a complement to the poster shown in Figure 12.

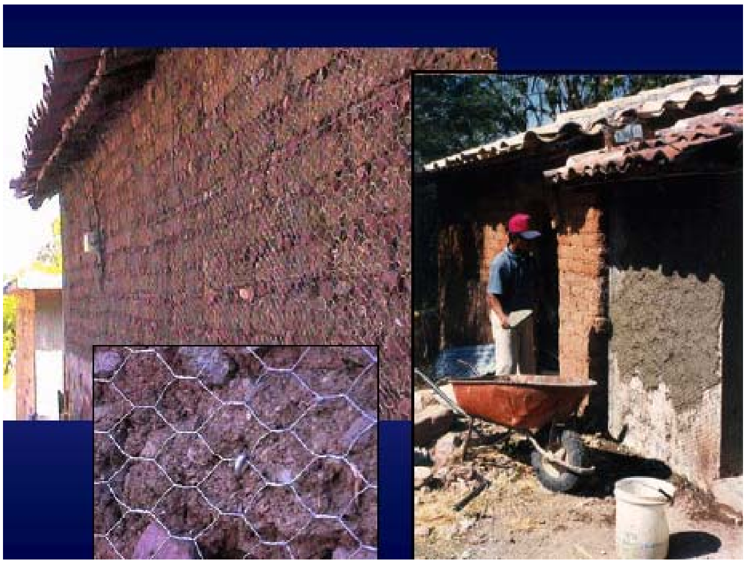

Figure 14. Example of application of *chicken wire* and plastered mortar for reinforcement of a rural dwelling

Strengthening low cost construction, using simple procedures like the ones presented on figures 12 and 13, is simple and easy to prepare by the user (Figure 14). This kind of solutions, not necessarily with structural meshes and using low quality plastered mortar, employed in traditional masonry buildings (adobe and red brick) allows to increase 50-100% the resistance of a dwelling exposed to lateral forces generated by earthquakes or wind. In these cases it is underscored that the reinforcement must cover the entire periphery of the construction, in order to have a continuous element to guarantee a monolithic behavior of the four walls that commonly form this kind of construction.

FINANCIAL INSTRUMENTS FOR DISASTER PREVENTION AND ATTENTION

The National System for Civil Protection (SINAPROC), created after the 1985 earthquakes, has three main branches:

The General Direction of Civil Protection (DGPC) contributes to the prevention and mitigation of disasters, providing guidance, advice and support and promoting civil protection culture. Also provides the necessary support to the population in case of contingencies, seeking the return to normality as quickly as possible.

The National Center for Disaster Prevention (CENAPRED) prevents and warns to mitigate the population risk to natural and manmade phenomena that may threaten their lives, property and environment, through research, monitoring, training and dissemination activities.

Finally, the Natural Disaster Fund (FONDEN) is the financial instrument of SINAPROC that supports the states in Mexico, and units of the Federal Government to attend an emergency and to recover from the effects produced by a natural phenomenon.

As an important part of this mechanism there is a special fund to promote and support preventive activities in order to reduce the risks, and to avoid or reduce the effects of the destructive impact derived from natural phenomena, known as the Natural Disasters Preventive Fund (FOPREDEN). This fund operates for the municipal, state and levels and units of the Federal Government that may apply every year, through a simple format. The actions supported by this fund must be oriented to the identification and evaluation of hazards, vulnerabilities or risks; to reduce risks and to mitigate losses and damages derived from the impact of natural phenomena, and to strengthen preventive capabilities and self-protection of the population.

It was created by the Federal Government in 2003 and has been supporting projects since 2004. It has been used as an efficient tool to promote actions with the central purpose to timely attend the causes of disasters, taking into account their social component, and to focus the institutional efforts and resources to improve preventive schemes and gradually dedicated less money to remediate/reactive measures. One of the main arguments in this mechanism is that economically preventive measures cost in general 1/5 of those to remediate the impact of phenomena.

The number of applications for this financial instrument has grown every year, reflecting a major interest from the states and municipalities. In 2009 the authorized amount for FOPREDEN projects is 22.2 million USD.

CONCLUSIONS

After the experience of the 1985 earthquakes significant changes occurred in Mexico. At the federal government level a National System for Civil Protection was created, as an organic unit to protect and prepare the society against hazards, and to help it to recover its normal condition in the case of disasters. Within this frame, several efforts have been made to prevent and diminish the seismic risk in urban and rural areas, through different procedures and practices.

Since 1991 an early warning system has been working for Mexico City; although several technical details have been corrected and that it is focused to one segment of the major seismogenic zone, its usefulness has been acknowledged by specialists, authorities and the society.

The microzonation studies is order to evaluate seismic response of alluvial valleys has been encouraged from several institutions, putting it as a priority to determine the site effect and to provide parameters useful to improve design practices. Although the use of microtremors sometimes provide quick results, special care has to be taken to assure the quality of the obtained information (e.g. amplification factor, dominant period), specially in those cases where strong motion data is available.

About the building codes a significant improvement has been observed, particularly in the case of Mexico City. However, a major effort is being made to encourage the states and municipalities to develop and update its own building code in order to attend a particular scenario depending on the distribution of the seismogenic zones, and also to improve the technical supervision, an aspect difficult to control.

Concerning the rural dwelling in earthquake prone areas, dissemination material with simple procedures to reinforce and retrofit has been useful to diminish the vulnerability. However, a continuous effort is still needed, in coordination with local authorities, to show the benefits derived from the application of those techniques.

From an integral perspective of risk management, a financial mechanism has been put to practice since 2004 using federal funds, to promote and support projects that produce scientific and technical knowledge, as well as preventive measures and procedures, taking into account the aspects mentioned above, among others. The utility of this financial mechanism has been acknowledged and has been useful to align results and products obtained at different stages and fields related with risk management.

REFERENCES

Centro de Instrumentación y Registro Sísmico, A.C CIRES. Seismic Alert System for Mexico City http://www.cires.org.mx

Comisión Federal de Electricidad (1993) Manual de Diseño de Obras Civiles. Sección C, Tomo I, Tema 1, Capítulo 3 Diseño por Sismo.

FONDEN –Sistema Nacional de Protección Civil http://www.proteccioncivil.gob.mx/

Lermo, J. y Vega, D. (2001). Peligrosidad y Prevención en algunas zonas urbanas de México. Publicación del Centro Peruano Japonés de Investigaciones Sísmicas y Mitigación de Desastres

Reglamento de construcción D.F. http://cgservicios.df.gob.mx/prontuario/vigente/385.htm

Servicio Sismológico Nacional, Instituto de Geofísica, UNAM. http://www.ssn.unam.mx

Singh, S.K., J. M. Espíndola, J. Yamamoto and J. Havskov. Seismic potential of Acapulco-San Marcos region along the Mexican subduction zone. Geophys. Res. Lett., 9, 633-636, 1982.

KAZAKHSTAN'S EFFORTS TO PREVENT COLLAPSE OF THE EXISTING BUILDINGS BY EARTHQUAKES

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ABSTRACT

The state of art in the field of earthquake study in Kazakhstan is shown. The methodology of earthquake aftermath prediction is given for the Republic as a whole and some data about damage in the city of Almaty in the case of strong earthquake occurrence are presented. Peculiarities of Building Cods of Kazakhstan that have been toughened in comparison with similar building cods of other FSU countries are considered. The data on ensuring of seismic resistance for existing building and constructions in the Republic of Kazakhstan are presented.

KEYWORDS
Seismology, damage prediction, building, chimney, hydrotechnical system, earthquake, destruction, secondary factors.

ON SEISMIC DANGER OF KAZAKHSTAN

One third of the territory of Kazakhstan is dangerous from the seismic point of view. These are the southern and south-eastern regions of the republic. Here lives approximately half of the whole population of the republic, 40% of the industrial potential is concentrated, more than 400 towns and settlements are situated, including the southern capital of the republic - Almaty. In the course of the last hundred years in this region more than ten heavy earthquakes took place, two of which (the Chilik earthquake in 1889 with m=8,3 and the Keminsk earthquake in 1911 with m=8,2) with a magnitude above eight, are ranked as ones of the world-wide seismic catastrophes. The city of Almaty in the course of its comparatively short existence experienced two earthquakes with an intensity of 9-10, and was destroyed completely.

The problem of prediction and reduction of damage from earthquakes and their induced secondary factors is a vital problem for the residents of earthquake prone regions. Not only prediction of damage from probable earthquakes but even the assessment of losses from the occurred ones presents considerable difficulties. Sometimes damage counts made by different authors for the same earthquake gives different values. it is caused by inability of different authors to take account of certain types of damage in full measure because of absence of a unified assessment technique for damage. it should be noted that certain types of damage are difficult to count and some types of social losses just defy to estimating neither in degrees nor in money terms. earthquakes are followed not only by destruction of buildings and constructions, failure of engineering services but by the ecological disruption of geological environment as well seismically induced landslides, creeps, mudflows, avalanches etc., which considerably affect national economy.

Thus the study of social-ecological, technical and economical aftermath of strong earthquakes and their secondary factors is of important research and national-economic importance. Besides a sharp necessity arise to go from passive waiting of a disaster to a purposeful study and managing system development long before the disaster occurrence.

In this respect the main effort mast be aimed at the development of prediction techniques for social and economical damage and disruption of geological environment ecology caused by earthquakes as well as at the creation of an information system and the recommendations on organization and engineering-technical measures for reduction of losses, victims and traumatism. The methodological scheme of earthquake damage prediction is given in figure 1.

In case of destructive earthquake with the magnitude of 9 points in Almaty surroundings, the number of victims may raise to the amount of 150 thousand people, of the wounded - 400.000 people, ruined habitations will amount to 60%, the number of the homeless - about 600.000, the summary economical losses may be about us $ 6,5-7,0 bln. This is why, according to the laws of the republic of Kazakhstan, «on emergency)) and «on the national security)), the seismic safety of the population and of the national economy is equated to the national security.

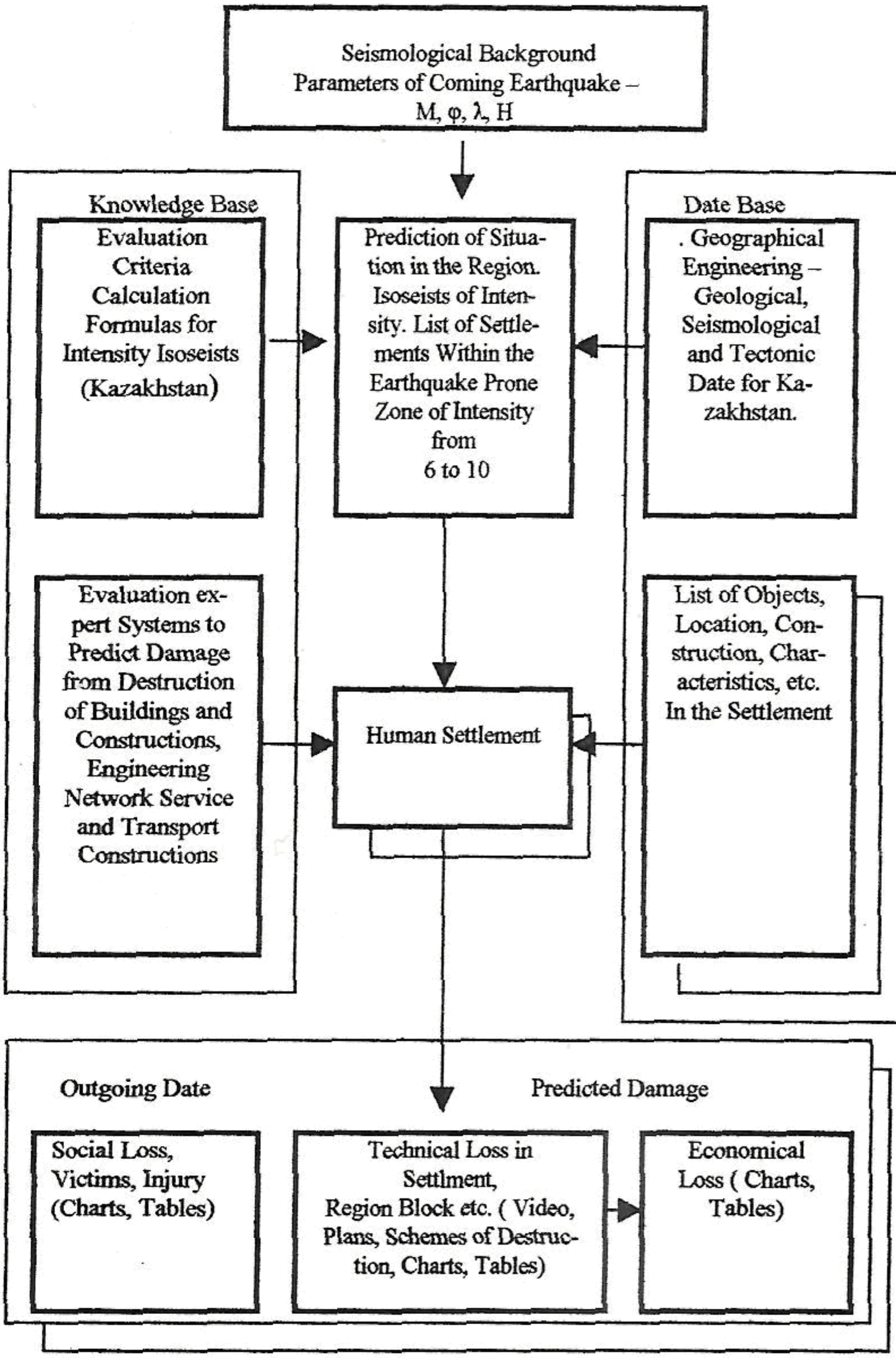


Figure 1. Methodical Scheme of Earthquake Damage Prediction

THE MAIN DIRECTIONS OF WORKS AND RESEARCHES ON SEISMIC SAFETY ENSURING

In the USSR "Building Codes and Regulations, Design Codes" were issued last time in 1982. Building codes and regulations of the Republic of Kazakhstan "Building in Earthquake Prone Areas. Design Codes" (Snip Rk 2.03-30-2006) were issued in 2006.

The building cods of the Republic of Kazakhstan are characterized by the very strict requirements. In comparison with all the other building cods of the FSU countries they lay 20% higher demands to designed seismic loads for the same designed intensities according to the MSK scale. Additionally the building cods of Kazakhstan take into account a number of basic aspects such as peculiarities of steel construction design and seismic stability of the existing buildings.

Seismic stability of buildings and constructions in the territory of Kazakhstan is represented by the objects ranging from seismically stable to seismically resistant.

In view of the current building cods of the republic of Kazakhstan we have developed the technique of seismic stability evaluation of present buildings, constructions and engineering network services.

Various methods of building retrofitting depending on its structural layout, chosen construction material and the level of seismic reinforcement are proposed basing on the results of the mentioned works.

At that economic indexes are taken into account. It is not recommended to retrofit the buildings when wear-out of their main bearing constructions is more than 60%. Losses (percentage wise of its Balance sheet value) versus extend of object damage during earthquakes are shown in figure 2. The exception is historical buildings.

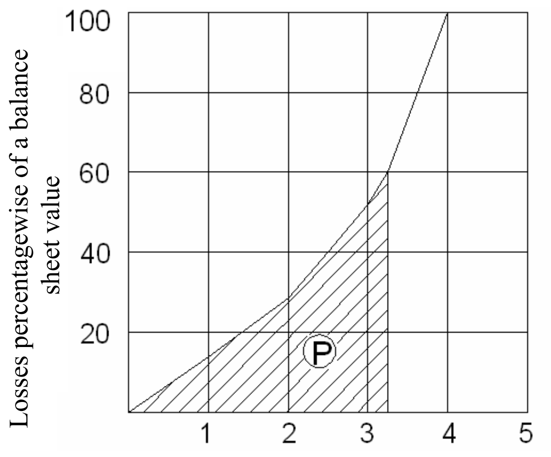


Figure 2. Dependence of damage (percentage wise of balance sheet value) on average extent of construction damage during earthquakes P – area of damage where a construction remains rehabilitable

The situation with school and hospital buildings is different. In Almaty 84 of 238 educational institutions liable to reinforcement are reinforced until now that is 30%. For the whole Republic of Kazakhstan this figure is lover and equals about 20%.

45 of 55 seismically dangerous buildings of health protection are reinforced in Almaty that is 72%. All over the Republic about 55% of health protection objects are reinforced.

After collapse of the Soviet Union active building of mosques, churches and other religious construction started. Even looking beautiful in architectural aspect the major of them are not seismically resistant, especially mosques. The reason is the practice to put them into operation without inspection of specialists. When we make comments and recommend seismic reinforcement

mullahs and ministers of religion blame us for prejudication and apostating. They have managed to debar specialists in earthquake engineering that makes us anxious.
Seismic reliability of the strategic engineering objects such as hydrological and power stations, objects of oil and gas industry and metallurgy industry, chimneys and bridges is under our stringent control. Complex study of the structures of special destination (chimneys, bridges) has been carried out. The study included:

– analysis of design materials;
– natural inspection of all main structures of the hydrotechnical system;
– analysis of the technical decision in situ;
– test of objects in situ with determination of dynamic characteristics of the objects and
– physical and mechanical characteristics of the construction material;
– test of a small-scale model of the objects with use of shaking table;
– design and parametric analysis;
– development of recommendations for further exploitation.

Figures 3 and 4 represent the data on tests and seismic reinforcement of the Kapchagai hydrotechnical system. Figure 5 demonstrates the data on natural period determination of chimney in situ in the thermal power station No2 in Almaty city.

The examples of the existing types of buildings in the city of Almaty are shown in figure 6.

According to technical and economical reasons the way of building of new modern and seismically resistant objects is selected at present in the Republic of Kazakhstan.

In previous time 10 different structural types of buildings were constructing in Kazakhstan while now their number is twice reduced. It permits to use the most seismically stable objects like the following:

– monolithic RC framed and framed-bounded types of buildings;
– framed and framed-bounded in metal frame with RC inclusions;
– bricked with monolithic RC inclusions;
– monolithic RC buildings with rigid structural layout;

Since 2003 every building in the earthquake prone regions of the Republic of Kazakhstan irrespective of a proprietor (governmental, private or individual) is severely inspected by the special controlling departments of city authorities. In the case of inadequacy to the seismic regulations they should be removed of brought in correspondence in a short term. Besides nobody has right to build anything even in his private territory without permitting documents and special projects.

(a)

(b)

Figure 3. The study of operating and seismic reliability of the upstream deck of the Kapshagaiskaya hydroelectric power station: General view (a),Study of the dam on the model (b)

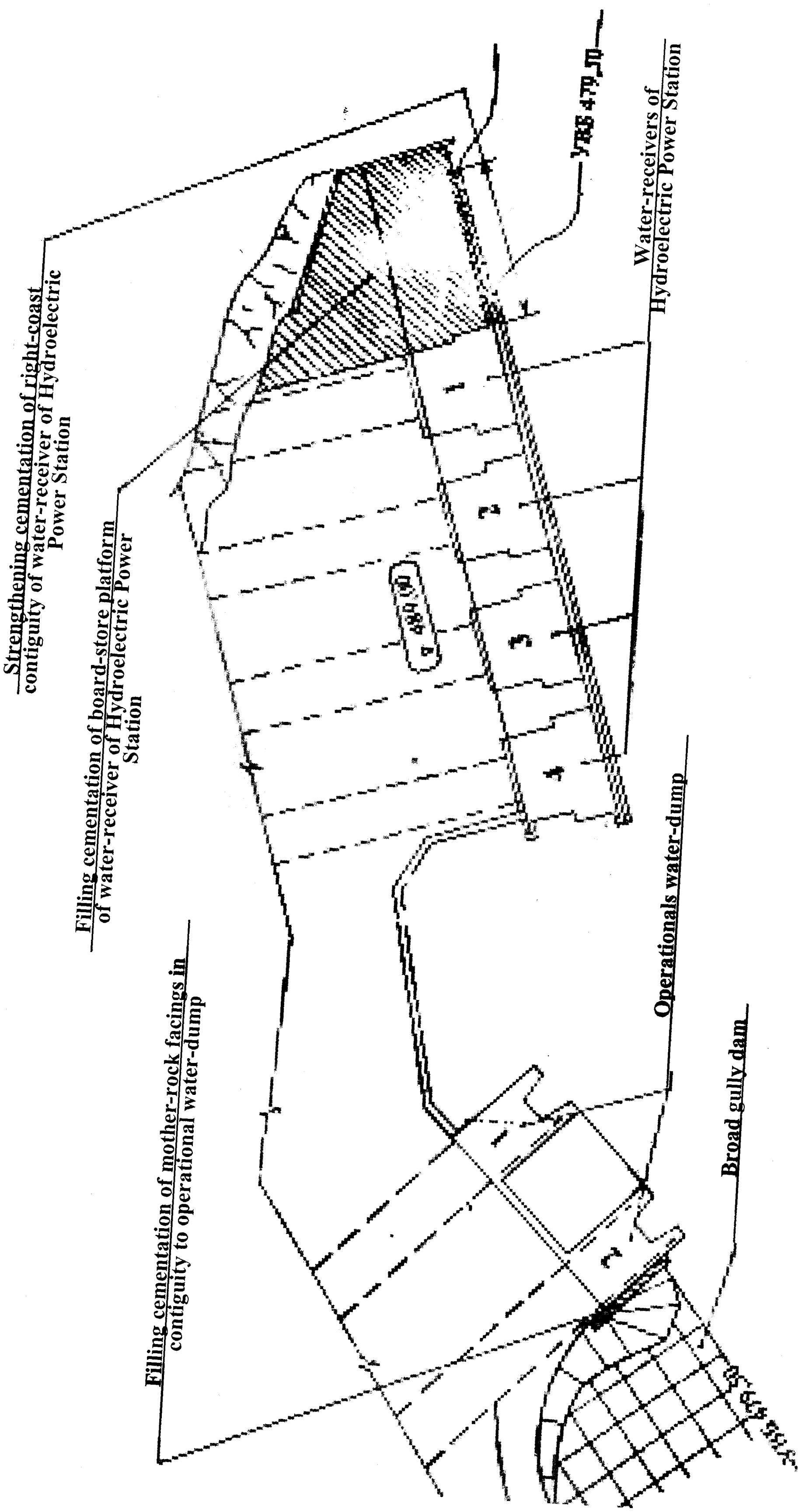
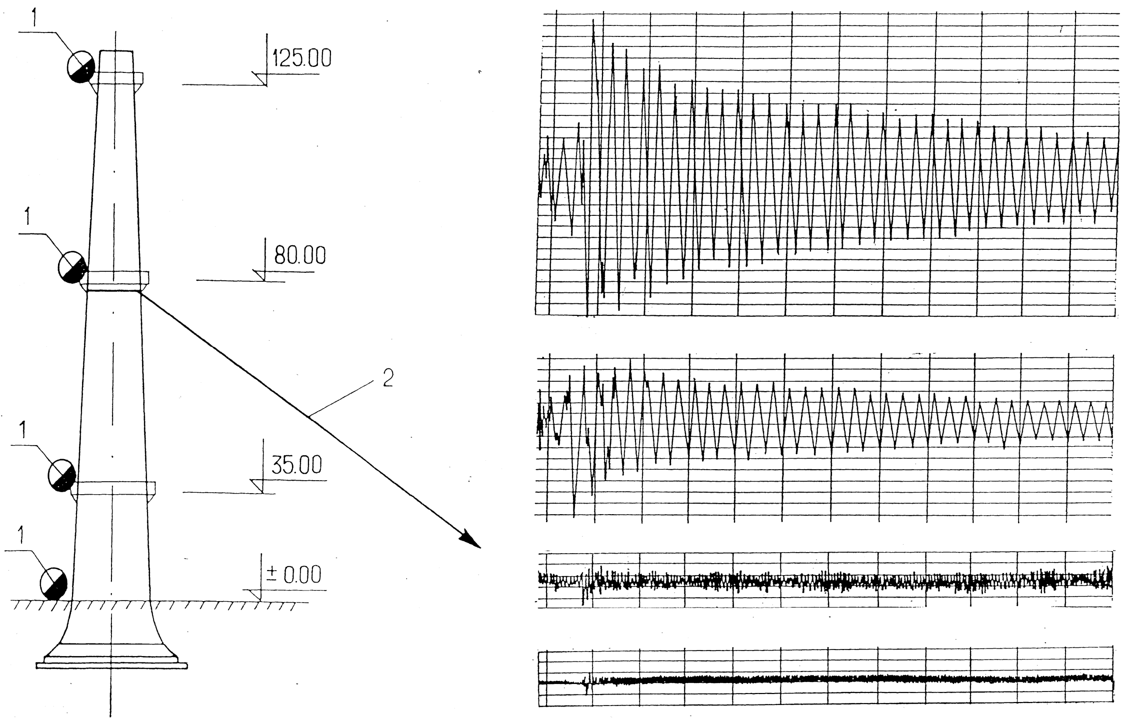


Figure 4. Strengthening of Kapchagai Hydrosystem



(a) (b)

Figure 5. Testing of constructions by the method of a back stroke.
Scheme of the chimney (a): 1 – Acselerografs, 2 – Cord. Results of the testing (b)

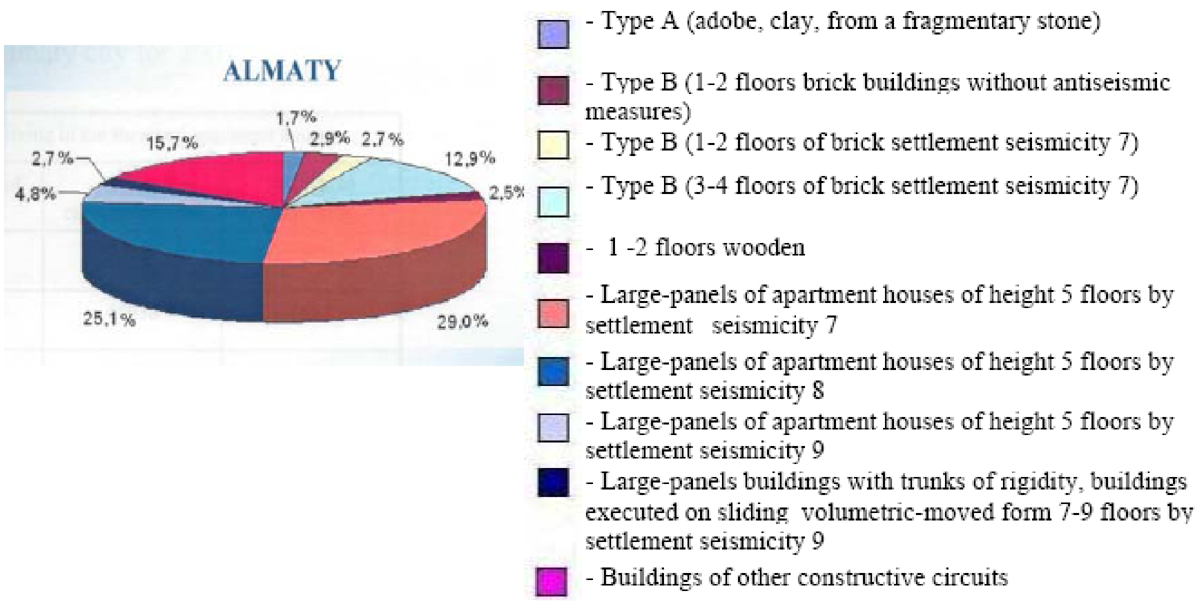


Figure 6. Distribution of buildings as designs

CONCLUSIONS

Big projects and vast scientific and applied works for preparedness to strong earthquakes are carried out in Kazakhstan at present. This activity includes the problems of normative documents development for earthquake engineering, design and building of up-to-date earthquake resistant buildings and constructions as well as reinforcement of the existing buildings. However these works are not as fast and purposeful as the circumstances demand. That is according to our data the probability of strong earthquakes during the following 5-7 years is rather high in the territory of Southeastern Kazakhstan.

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PRESENT STATUS OF EARTHQUAKE PREPAREDNESS ACTIVITIES IN CHILE

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ABSTRACT

The present situation and status of the different activities related to Earthquake Preparedness activities in Chile are described. The activities are divided in three groups: Codes and Standards, Structural and Seismic Review procedures, and Building Permits procedures. In Chile, the codes related to earthquake engineering practice are divided into two major groups: the first defining the loads and actions, and the other dealing with materials behavior, strength, and detailing requirements. The overall characteristics of these codes are discussed. Special emphasis is given to the seismic design code provisions that define the expected level of earthquake action, depending on building characteristics and site soil conditions. A seismic zoning map (based on a given level of probability of exceeding maximum ground acceleration) is included in the codes. Two different analysis procedures are allowed: an equivalent lateral forces procedure where torsion is considered through an amplification of the static torsion in the building; and the standard response spectrum analysis method with a three degree of freedom per story model of the building. The maximum responses of the different modes are combined using the CQC combination rule. Additional restrictions are imposed to torsion effects, and to overall building deformations. Some ideas being discussed for the revision of the code are presented. A brief description of the main changes that the codes have undergone in the last 25 years is described and how these changes were prompted by significant earthquakes is briefly described. Starting in 2003 and implemented in a gradual manner the local authorities required, with the support of the Chilean Association of Structural Engineers, that for all buildings the structural and earthquake engineering projects of the buildings shall be reviewed by an independent reviewer, from a rooster of authorized professionals kept under the authority of the Ministry of Housing. This review has become a well established process and all projects need now to undergo the review before the actual construction permits can be issued. A brief description of the process that is required to obtain building permits is provided. Before construction can start, the project drawings (architectural and structural) and a set of construction specifications need to be submitted for approval to the local Municipality. This process is required for all buildings, but for public utility buildings (schools, hospitals, police stations, Fire fighting stations, communication centers, etc.) and for office and residential buildings of more than 5 stories the project has to include also the approval by an independent reviewer. The estimated number of existing buildings which do not conforming to the current building code and their characteristics is briefly discussed, in particular for: schools, hospitals, public facilities, residential and office buildings and non-engineered buildings.

KEYWORDS
Codes and Standards, Structural and Seismic Review, Building Permits Procedures, Code Compliance.

INTRODUCTION

Chile is a country with a long history of earthquake occurrences. Since the early days of the nation as an independent country and before that during the time of the "Conquistadores" the history of the country has been shaped by the very large earthquakes affecting the territory. Based on the traditions of the people indigenous to the region, even further back in history the effects of very large earthquakes have shaped not only the geography but also the way of living of the people in the region. In order to addres the issue of the present situation and status of the different activities related to Earthquake Preparedness activities in Chile three different aspects of the situation will be considered and described: Codes and Standards, Structural and Seismic Review procedures, and Building Permits procedures. The most important aspects are going to be discussed interms of present conditions and expected develpments in the future.

CODES AND STANDARDS

General

The different codes related to the practice of earthquake engineering in Chile can be grouped into three major groups:

- Definition of Loads or Actions
- Material Behavior, Design, and Detailing
- Earthquake Codes

The actual names, numbers, the date since their last revision, and their present status are shown in the following table.

Table 1. Codes related to Earthquake Engineering / Structural Design in Chile.

	Number	Name	Date	Status
Actions	NCh431	Snow Loading	1977	Applicable
	NCh432	Wind Loading	1971	Applicable (*)
	NCh1537	Dead / Live Loads Specification	1986	Applicable (*)
Materials / Design	NCh427	Design of Steel	1977	Under review
	NCh430	Design of Reinforced Concrete (ACI 318)	2008	Applicable
	NCh1198	Design of Wood	2006	Applicable
	NCh1928	Design of Reinforced Masonry	2003	Applicable
	NCh2123	Design of Confined Masonry	2003	Applicable
Earthquake	NCh433	Earthquake resisting design of buildings	1996	Applicable (*)
	NCh2369	Earthquake resisting design of industrial structures and facilities	2003	Applicable
	NCh2745	Earthquake resisting design of base isolated buildings	2003	Applicable

(*) Modifications are being studied and are going to be proposed in the near future.

Codes and Regulations are the key to adequate Earthquake Engineering and Construction practices. If they are properly done and adequately followed they should allow to provide a uniform level of safety and quality to different buildings.

If the codes and regulations are strictly enforced there is an implicit warranty that the behavior of the buildings under the action of the loads that can occur during their service life will be that expected from them when the codes and regulations were made and put into effect.
But this is only an ideal scenario. In real life, it is almost impossible to predict what the behavior of a building will be under the action of loading of different types; especially under the action of seismic loading.

A schematic description of the Chilean official codes approval procedure is presented in Figure 1 (Cruz, 1989). In this figure the flow of the information and the manner in which the different stages of the code document elaboration, review, and approval procedures are managed is shown.

The code committees are joined by members coming from all the areas related to any given code, and normally include persons from the scientific and research community, from related industry companies, from private consulting offices, and from the government agencies. On the web site for Chilean National Institute of Standards, www.inn.cl, the official versions of the codes can be obtained. They are in general, written only Spanish, but pdf files can be obtained at a relatively modest price.

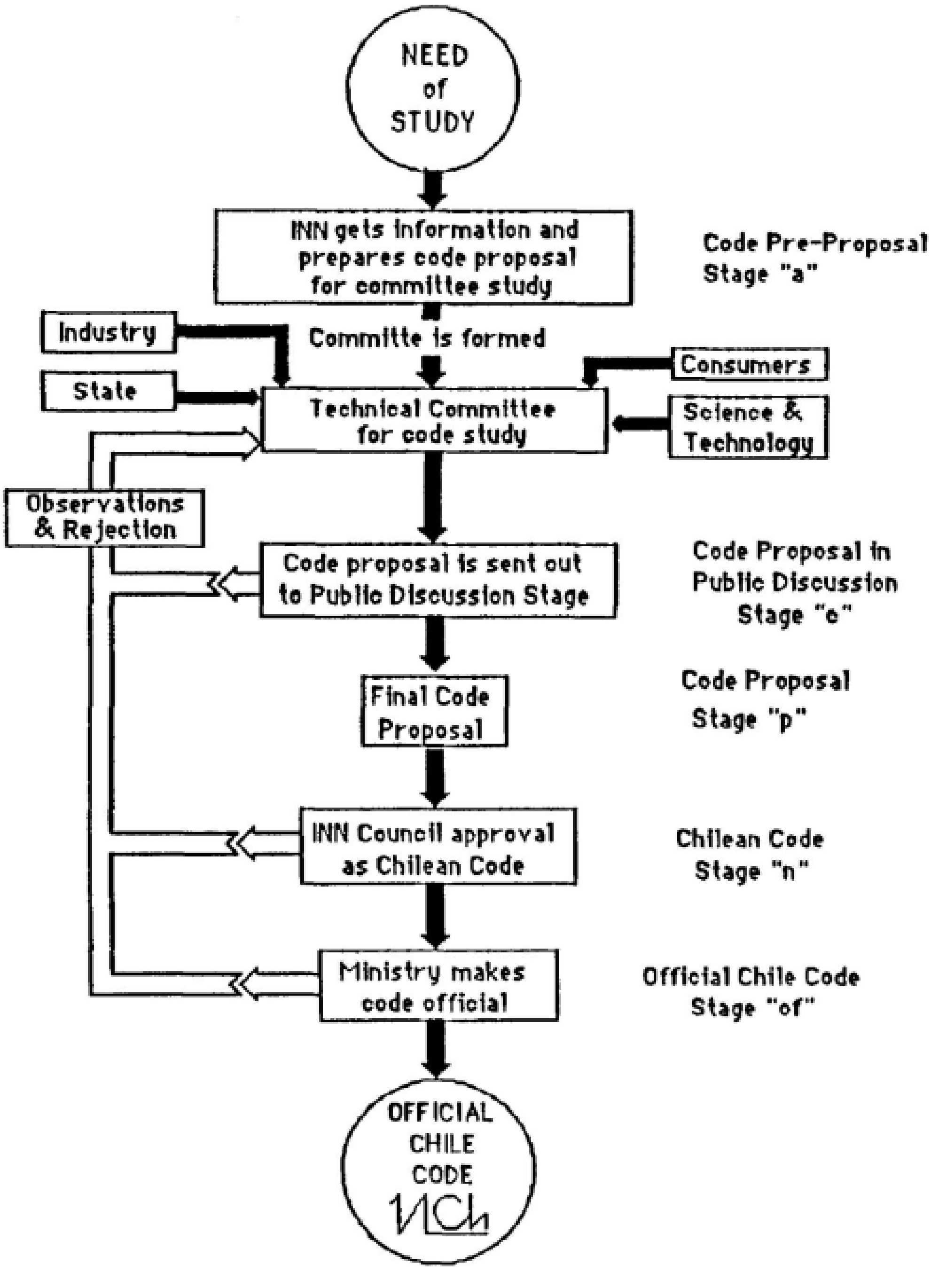

Figure 1. Schematic description of the Chilean official codes approval procedure (Cruz, 1989)

Periodic updating and revision of codes is a requirement; to keep up with improvements in construction technology, to include new developments in analysis and design techniques, and to take advantage of the always-increasing knowledge on material properties and structural behavior.

The exchange of information between different countries related through a common situation like the occurrence of earthquakes should be improved. The benefits of such an effort start by recognizing that others to improve their own analysis, design, and construction practices can readily use the experience of one country in the field of earthquake engineering.

The benefits come not only from avoiding duplication of research efforts but also, and most importantly, from taking advantage of the real size laboratory experiments that the occurrence of large earthquakes generate.

In-depth study of earthquake effects in real buildings provides valuable information for the appraisal of the adequacy of codes and regulations. Through the analysis of earthquake induced damage and in-depth knowledge of building characteristics, of material properties, and of earthquake ground motion (actual records) the important factors in building response can be identified and improvements to codes can be proposed.

Earthquake Codes

The expected level of earthquake action, is determined depending on the structure characteristics (R, z) and the site soil conditions (Soil type 1, 2, 3, 4). A seismic zoning map for the complete country, based on a given level of maximum ground acceleration that has a set value of the probability of being exceeded (10% in 50 years) is defined in the codes. The resolution of the map is at the Municipality level and the steps in the zoning coefficients is rather large (0.2, 0.3, and 0.4) therefore this creates some difficulties at the regional boundaries.

In Figure 2, the basic design spectrum for Industrial facilities is shown for the largest value of seismic zone coefficient A0 = 0.40, damping ratio of z = 5% and a response modification factor of R = 5.

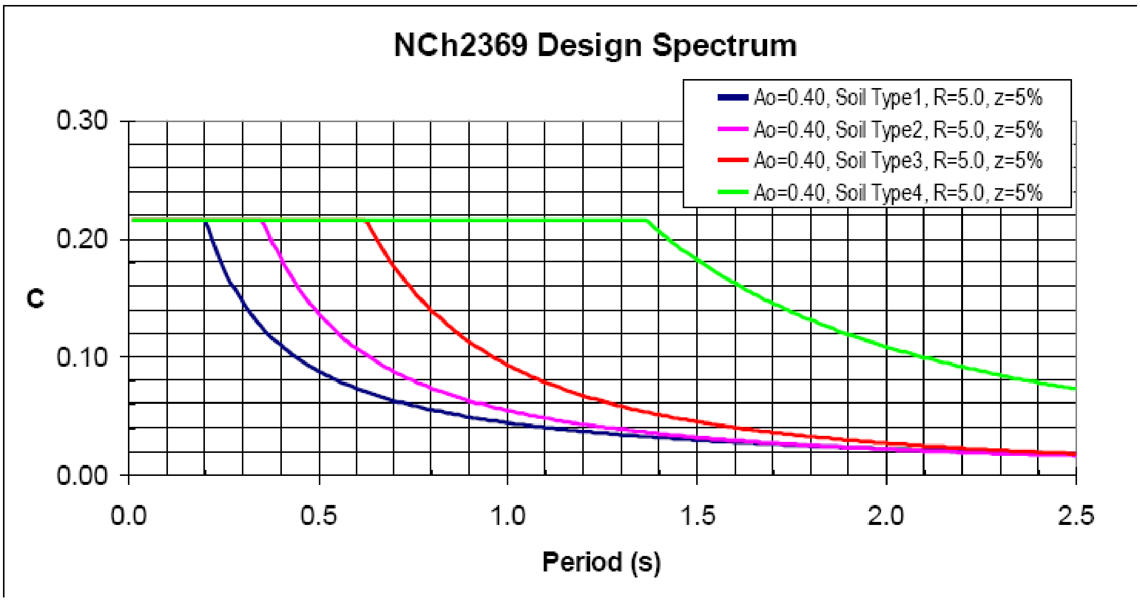

Figure 2: Design Spectra for different Soil conditions from the Chile Code NCh2369.

The design spectrum for the case of residential and office buildings although based in the same concepts has a different shape. In this case, the value of the response modification coefficient is dependent on the fundamental period of the building in the corresponding direction of analysis. Figure 3 illustrates the shape of the seismic coefficient “a” (left hand side scale) normalized to a value of 1.0 at zero period; and of the response modification factor “R” (right hand side scale) as a function of the fundamental period of the building for the four different soil types defined in the code.

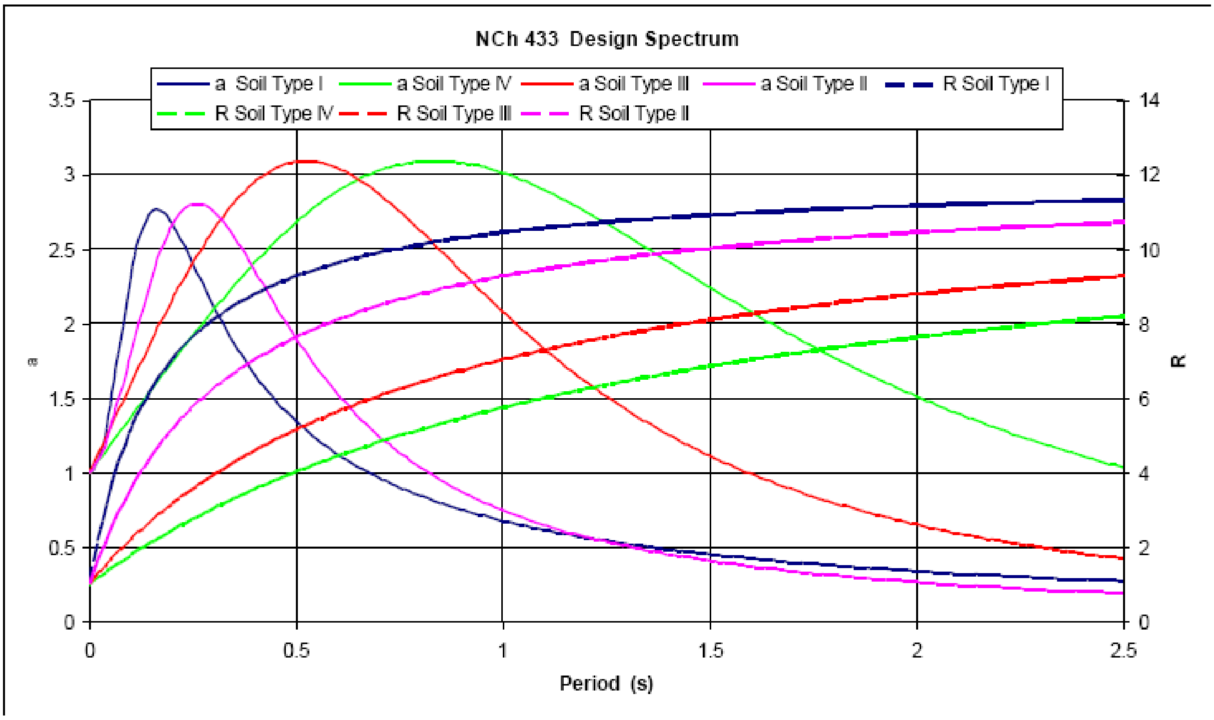

Figure 3: Shape of the Design Spectra for different Soil conditions from the Chile Code NCh433.

In the different codes for earthquake engineering there are some specific prescriptions regarding analysis procedures. In general, two different analysis procedures are allowed "Equivalent Static analysis" and "Response Spectrum analysis", but more sophisticated analysis procedures can be used in special cases:

- An equivalent static lateral forces procedure where in plan torsion is considered through an amplification of the static torsion in the building.

- The standard response spectrum analysis method considering a three dimensional model of the building with at least 3 degrees of freedom per story. The maximum responses of the different modes are combined using the CQC combination rule.

In office and residential buildings restrictions are imposed to torsion effects, and to overall building lateral displacements and inter-story drifts.

For industrial buildings several specific requirements based on performance of typical design and detailing solutions observed in previous earthquakes are given. These special requirements are related to anchoring systems details, bracing configurations, the need for over strength in "non-ductile" elements, etc.

The M = 7.8 earthquake in Central Chile in 1985, that affected two of the most densely populated areas (Santiago and Valparaiso) and the most important region of the country in terms of economic output prompted the revision of the building code; the previous version dated from 1972. A set of figures including photographic evidence of the type of damages to buildings and infrastructure observed in this earthquake are included in Appendix A.

The main changes that the codes have undergone in the last 25 years are:

- Seismic Zoning (A0 = 0.4, 0.3, 0.2)
- Response Modification Factors (R depends on material and configuration)
- In dynamic analysis, the modal maxima combination rule was changed (before it was based on the average between the sum of absolute values and the square root of the sum of the squares of the individual modal maxima (RMS).

- The restrictions to lateral displacements and story drifts were updated

Some ideas presently being discussed for the next revision of the codes, that are expected to be completed within the following two years, are:

- Load Combinations adjusted for new material codes (ASCE-7 type)
- Updating of Seismic Zoning maps and effect of site soil conditions
- Updating of detailing and special requirements on Industrial buildings code

STRUCTURAL AND SEISMIC REVIEW

Starting in 2003, but implemented in a gradual manner, the national building authorities require, with the full support of the Chilean Association of Structural Engineers, that the project of all the buildings shall be reviewed by an independent reviewer, from structural and earthquake engineering standpoints. The reviewer for any given project must be selected from a rooster of authorized earthquake / structural engineering professionals and shall be completely independent from the professional team or engineering office that carried out the project design.

The structural / seismic reviewer rooster is maintained under the authority of the Ministry of Housing, through a Committee that has members appointed by the Ministry from the academic and the professional communities. In the rooster, one of three different levels can be assigned to the reviewers depending on the individual qualifications. The level of the reviewer required for a given project depends on the complexity and importance of the building being considered.

This review procedure has become a well established process and all projects need now to undergo the review before the actual construction permits can be issued. Building owners awareness with respect of the benefits of this process is increasing, therefore, requirements for a more comprehensive review are starting to appear directly from the owners or even from the banks and financial institutions providing credit and or insurance to these properties.

BUILDING PERMIT PROCEDURES

For all buildings, regardless of their size or occupancy, before construction can start, the project drawings (architectural and structural) and a set of construction specifications need to be submitted for approval to the building department of the Municipality (township) where the site for the project is located.

For public buildings (schools, hospitals, police stations, fire fighting stations, communication centers, etc.) and for office and residential buildings of more than five stories in height the project has to include also the certificate of the approval by an independent structural / seismic reviewer.

This procedure is well defined and has been included since many years in the General Construction Ordinance (a law of the country) and therefore all the involved parties (owner, builder, construction company) and the administrative authorities must follow it. Failure to comply will result both in Civil and Penal sanctions imposed by the judiciary system.

CONCLUSION

The number of new buildings, which are not conforming to the current building codes, can be estimated to be less than 2 or 3%, and in general correspond to informal or very low cost housing (dwellings) in rural areas. The large majority of these structures must be considered as non-engineered buildings, and uses traditional construction methods with rather poor quality of material and workmanship.

Regardless of their location throughout the country, for schools, hospitals, public facilities, and residential and office buildings the cases where building are non-conforming with the code requirements is essentially zero, as strict enforcement of building permit procedures exist.

Nevertheless, it important to realize that there is a significant stock of older buildings including not only housing but also public buildings that were built according to the provisions of previous versions of the seismic codes. As a consequence, these buildings have larger vulnerability when compared to the newer buildings. Perhaps 25% of total building stock falls in this category.

On the other hand, given the frequency of occurrence of large earthquakes in Chile, most of the older buildings have already undergone one or more significant earthquake, with magnitude larger than 7 and with epicenter located within say 150 km of the building site. Clearly, these buildings have been already "experimentally tested." Performance has been in general acceptable, and damage has been limited to mostly non-engineered buildings.

ACKNOWLEDGMENTS

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REFERENCES

Cruz, E.F., (1989). "Present State of Seismic Design and Analysis Regulations in Chile," Earthquake Spectra, 5 No. 4,661-674.
INN (1971). NCh432, Cargas de Viento, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (1977). NCh 431, Cargas de Nieve, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (1977). NCh427, Diseno en Acero, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (1986). NCh1537, Sobrecargas de Uso, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (1996). NCh433, Diseno Sismico de Edificios, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (2003). NCh433, Diseno Sismico de Estructuras Industriales, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (2003). NCh1928, Diseno de Albanileria Reforzada, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (2003). NCh2123, Diseno de Albanileria Confinada, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (2003). NCh2745, Diseno Sismico de Edificios con Aislacion de Base, Instituto Nacional de Normaliza-cion, Santiago, Chile.
INN (2006). NCh1198, Diseno en Madera, Instituto Nacional de Normalizacion, Santiago, Chile.
INN (2008). NCh430, Diseno en Hormigon (ACI 318), Instituto Nacional de Normalizacion, Santiago, Chile.

APPENDIX A
EFFECTS OF THE M=7.8 EARTHQUAKE OF 1985-03-03 IN CENTRAL CHILE

Figure A1. Settlement of embankment at the entrance of the Llo-lleo-Santo Domingo Bridge.

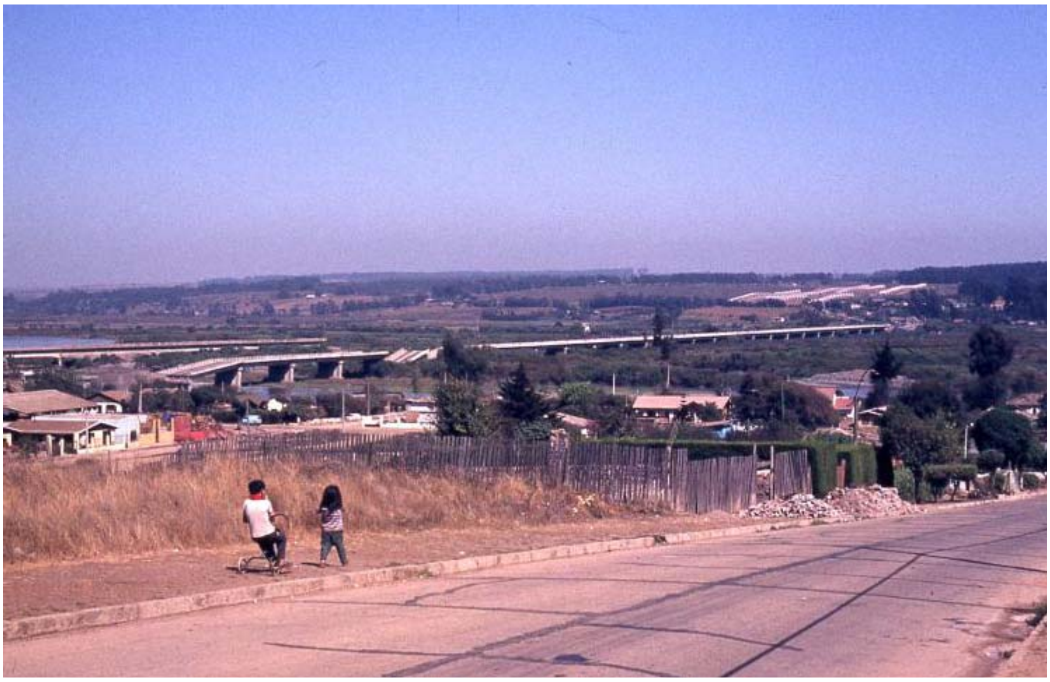

Figure A2. Llo-lleo-Santo Domingo Bridge. Several spans collapsed due to ground failure under the piers.

Figure A3. Acapulco Building in Viña del Mar. General View and Detail of Damage in Coupling beams. Building was erected in the mid 1960s and had already suffered some damage with a smaller earthquake in 1971.

Figure A4. Acapulco Building in Viña del Mar. Detail of Damage in main Shear walls. Note the plain reinforcement bars.

Figure A5. Villa Olimpica Buildings in Santiago. Twin buildings one of them partially collapsed. Note the initiation of the same type of failure at the top of the far column of the ground floor in the left side picture.

Figure A6. El Faro Building in Vina del Mar (Renaca). Shear wall failure at Ground floor due to significant torsion effects. Building was significantly inclined and was demolished soon after the earthquake.

Figure A7. Don Jose Building in Vina del Mar. Reinforced concrete, shear walls and coupling beams. Damage to coupling beams (left) and to interior partitions (heavy and brittle). Note the large and heavy pieces of partition material damaging furniture.

Figure A8. Fundacion Chile Building in Santiago. Damage to columns in a two story reinforced concrete frame building. "Short column effect" due to infill walls not properly separated.

Figure A9. Reinforced / Confined Masonry building in Melipilla. Damage to unconfined masonry walls in the Ground floor Upper floors have little or no damage.

Figure A10. Confined Masonry / Reinforced Concrete building in Vina del Mar. Damage to unconfined masonry walls and to the shear walls in the Ground floor. Buildings are located on a hill side. Topographic effect is significant, as same buildings in a flat area did not have damage.

INDONESIAN EFFORTS TO PREVENT THE COLLAPSE OF EXISTING BUILDINGS HIT BY EARTHQUAKES

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ABSTRACT

Since Indonesia lays in a very active earthquake region, any efforts to prevent collapse of exixting building is valuable for the people as well as for the country. Rules and standards have been developed for reducing collapse when earthquake hit the region but the implementation such as building control system necessary to be improved. Based on the monitoring and evaluation on the implemetation of standard conducted by Research Institute for Human Settlements (RIHS), current building standard code, SNI 03-1726-2002 which accomodated the seismic hazard zoning map and designing principles ofearthquake resistant building structure has to be revised. The new earthquake hazard map is produced based upon updated available seismotectonic data, implementing new fault models, and incorporating new ground-motion prediction equations as Next Generation Attenuation (NGA) . Performance base design concept with references i.e. FEMA (2009), ASCE (2005) and IBC (2009) are used in the revision of sub structure and upper structure of the building.

KEYWORDS
Indonesia, earthquake, collapse, building

INTRODUCTION

Indonesian archipelago lays in a very active earthquake circumstances region which been affected by four major lithospharic plates, i.e. India-Australia plate, Pacific plate, Philippine plate and Euro-Asia plate. The world tectonic map and position of Indonesian archipelago as shown in Fig. 1.

The Year of 2004 is justifiable as the year of earthquakes in Indonesia due to the big earthquakes happened in Nabire, Papua on February 6th and November 26th, in Alor Nusa Tenggara on November 12 th and Andaman's earthquake which was resulting big tsunami in Nanggroe Aceh Darussalam (NAD) Province on December 26 th. After the year 2004, in every year large earthquakes happened and resulted big damages on infrastructures as well as human victims i.e. big earthquake happened in Nias on March 28 th 2005, in Yogyakarta on May 27 th 2006 in South Java sea shores which resulted tsunami in Pangandaran on July 17th 2006, and in West Sumatera on March 6 th 2007 . The series of earthquake disasters especially the big earthquakes realized the people and Government that better preparedness in disaster mitigation concept necessary to be implemented to keep away from the big damages in human life as well as in infrastructures.

The data showed that the big damage after earthquake disaster mostly happened in non-engineered buildings such as housings, schools, mosques, churches etc. Such phenomena were affected by the common situation that building permit for non-engineered buildings has not been arranged and implemented well compare to those for engineered buildings such as multi storey offices, housings other buildings. A relative new phenomenon was found after big earthquake hit Padang Pariaman on September 30, 2009. Many local goverment offices and other public buildings collapsed and some peoples even some students were burried by the collapsed building. Such condition evoked the importance of evaluation on the content of rules and standards as well as the implementation of those in building permit processes, building construction processes and building control system.

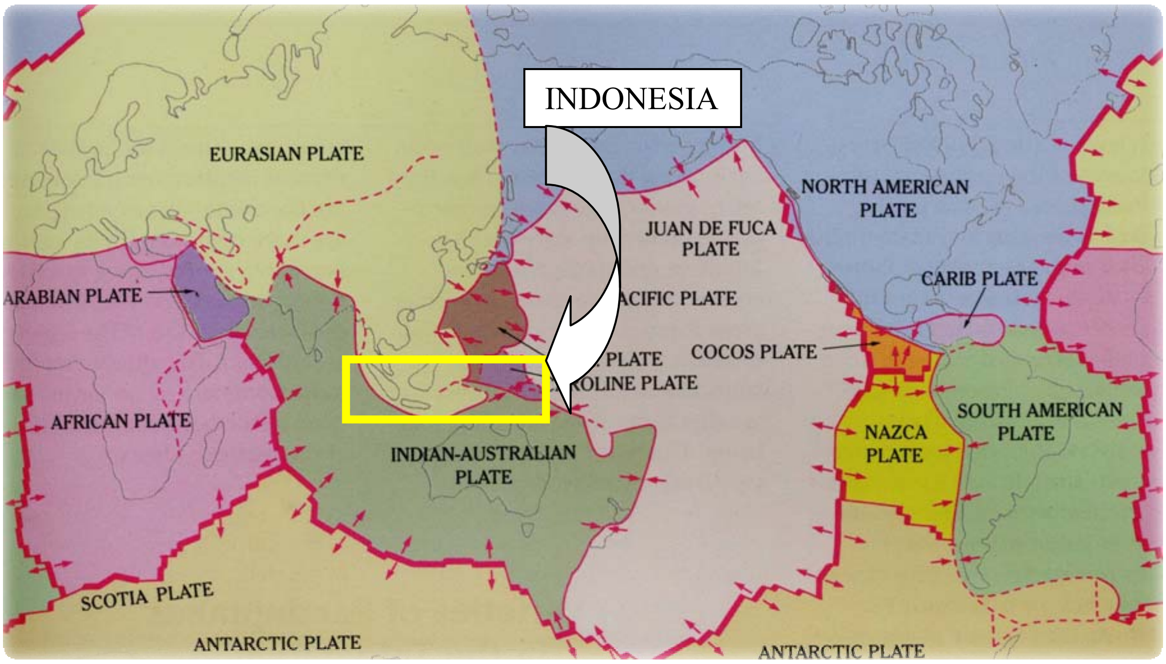


Figure 1. The World tectonic map and position of Indonesia

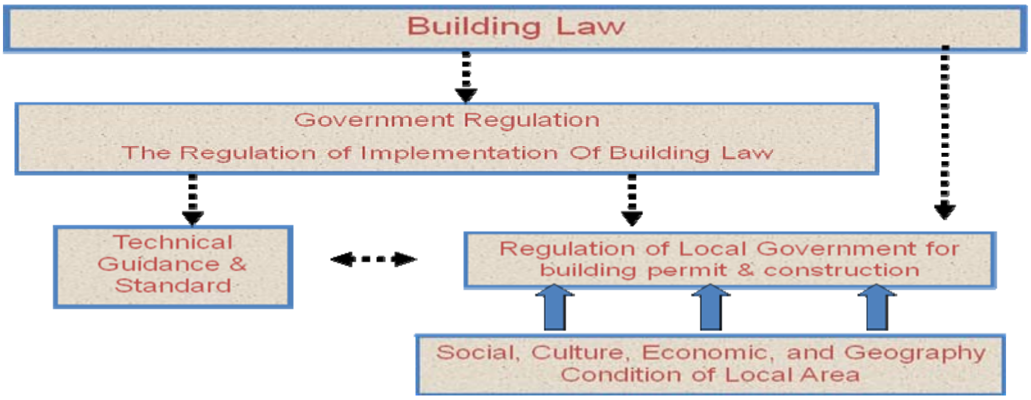
RULES AND STANDARDS IMPLEMENTED IN BUILDING CONSTRUCTION

Indonesian building law (UUBG No 28) was established in 2002 which followed by the establishment of Goverment Decree on Technical Guidelines of Building Construction (PP 36, 2005). In such law and regulation, the construction of a building should be based on the use principle, safety, and in harmony with its environs. The aim of the establishment of building law is to establish orderly building construction which ensure reliability of the building in terms of safety, health, comfort and mobility. The law regulates building technical requirements related to its function, design and construction, operation and maintenance as well as community involvement and technical guidance and administrative requirements which consists of building permit, land status and land ownership.

Since the establishment of such law and regulation, building control system has been upgrading with the policy to ensure the construction of a building is conducted in order and in conformity with the enforced codes and standards, to ensure safety and efficiency in the use of sources either human, energy and cost, and to ensure that the building constructed is functionally feasible in terms of habitability and reliability as well as being in harmony with its environ. The institution's involvement and task force are:

1. Ministry of Public Works issues regulations, reference codes and standards as well as technical guidance, manuals, etc;
2. Local government institutions carry-out field implementation through :
   - *Building control division;*
   - *City planning division*;
3. Other related institutions involved are testing bodies, insurance, registered consultants etc.

The control points consist of planning permit (land status, conformity of location with the master plan), building permit (conformance to building code/standards in terms of structure, architecture, mechanical and electrical), occupancy permit, certificate of conformity and rehabilitation permit. By the implementation of decentralization policy in 2002, building permit under the authorizatiion of local goverment.. Based on the experiences of Nangroe Aceh Darussalam (NAD) 2004 and Yogyakarta 2006 earthquake disaster, JICA and Ministry of Public Works assist the local goverments which located in earthquake hazard zones in the implementation of building permit system from the acceptance of application documents, inspection and issuance of building permit certification or rejection. The strata of building law, regulation of local goverment and technical guidance and standard is shown in Fig. 2. Concistency in the implementation of law, goverment regulations related to building is the key to success of the implementation of building standards in the construction activities. One example on such applications is the Jakarta Governor's decree on building permit process and the establishment of Evaluation Team on Purposed Building Construction System accelerated the implementation of related standards in the building construction process.



Source : Directorate General of Human Settlements (MPW-RI).

Figure 2. The strata of building law, regulation of the central goverment, regulation of local government and technical guidance.

CURRENT CODE ON EARTHQUAKE RESISTANT DESIGN FOR BUILDING

In the year 2002, current earthaquake resistant design for building and construction SNI 03-1726-2002 was established as a substitute for the previous SNI 03-1726-1989. The references used in the revised were:

1. National Earthquake Hazards Reduction Program (NEHRP) : "NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures", Part 1 & 2, Federal Emergency Management Agency (FEMA), 1997 Edition.
2. Uniform Building Code (UBC) Volume 2 : "Structural Engineering Design Provisions", International Conference of Building Officials, 1997 Edition.

The general provision in SNI 03-1726-2002 mentioned that effect of designed earthquake should be considered in building structure design as well as all other parts of the building.Basic approach in the earthquake resistant building design is:

1. The existance of earthquake is in probabilistic event that in designing need to consider the maximum probability. It mentioned in the code that the probability number is 10 %.
2. Predicted service life time of the designed ordinary building to be 50 years.
3. Designing the earthquake resistant buildings using Peak ground acceleration (PGA) of each zone with the return period of the earthquke in about 500 years.

Importance Factor

In many building categories, the effect of earthquake load in building design should consider the Importance Factor (I) for probality of the earthquake event during the service life-time of the building and designed return period of the earthquake. In such standard, the importance factor of designed buildings based on the categories are presented in Table 1. Buildings with occupancy permit before the establishment of the standard, the Importance Factor, I, should be multiplied 0.8.

Seismic Zoning Map

One important part in the current earthquake design standard is the availability of seismic zoning map which produced from the concensus of experts, scientists, and practicians in related fields and most of them represented famous universities, associations and research institutes in Indonesia as shown in Figure 3. From the concensus was also agrred to introduced six seismic zones in Indonesia with the Peak Ground Acceleration (PGA) of each zone determined as shown in Table 2 below.

Soil type and Peak Ground Acceleration

The PGA in each zone on the map mentioned above is the propagation of seismic waves from the bedrock to the ground surface in the areas concerned The wave acceleration in the ground surface of an area is based on the character of the soil between the base rock and the ground surface. The type of soil which lie between bedrock and ground surface are classified into three categories as the hard soil, the medium soil, and the soft soil, based on the weight average value of soil parameters, namely shear wave velocity (Vsi), standard penetration test value (N) and un-drained shear strength (Su).

Table 1. Importance factor for each category of building

Building Category	Building Service Life-time (year)	Probability of the design earthquake (%)	Return period of the design earthquake (year)	Importance Factor I
Normal Buildings : Housing, commercial, office	50	10	500	1.0
Post earhquake important buildings : hospital, relief center, radio/TV facilities	50	< 10	750	1.4
Post earhquake dangerous buildings : storage of poisonous material (gasses, acids, poisons)	50	<10	1000	1.6
Historic buildings : monumental building, monuments, memorial building	200	< 10	2000	1.8 *)
Simple building : multistory reidential building, old building (renovation, strengthening)	20	10	200	0.8 *)

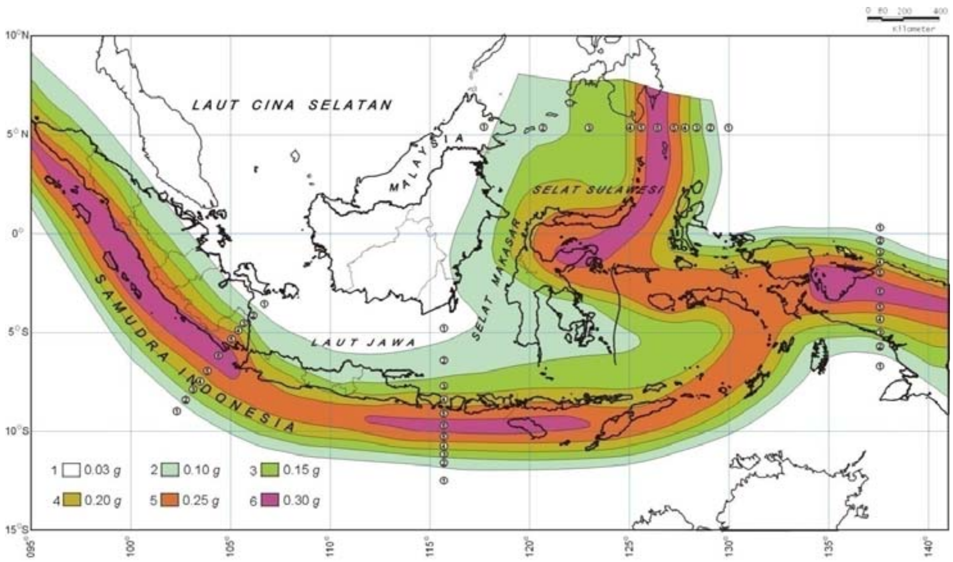


Figure 3. Seismic zoning map of Indonesian area as in SNI 03-1726-2002

In practice, the effect of seismic load design in the building structure on the ground surface for each soil category has been expressed in the factor of seimic response spectra (C) as shown in Fig. 4.

The factor of seismic response spectra, C, determined in the acceleration of gravity, and based on the relationship between the natural period of the building (T) with the soil's parameter that has been given in the form of curves for each zone. When T = 0, the seismic response spectra factor equal to the maximum acceleration on the ground surface, A_o (shown in Table 2).

Table 2. Peak Ground Acceleration in each category of soil

Seismic Zone	Peak base Rock Accelaration (‘g)	Peak ground Acceleration , Ao (‘g’)			
		Hard Soil	Medium soil	Soft Soil	Special soil
1	0,03	0,04	0,05	0,08	A special investigation is required for each condition location
2	0,01	0,12	0,15	0,20	
3	0,15	0,18	0,23	0,30	
4	0,20	0,24	0,28	0,34	
5	0,25	0,28	0,32	0,36	
6	0,30	0,33	0,36	0,38	

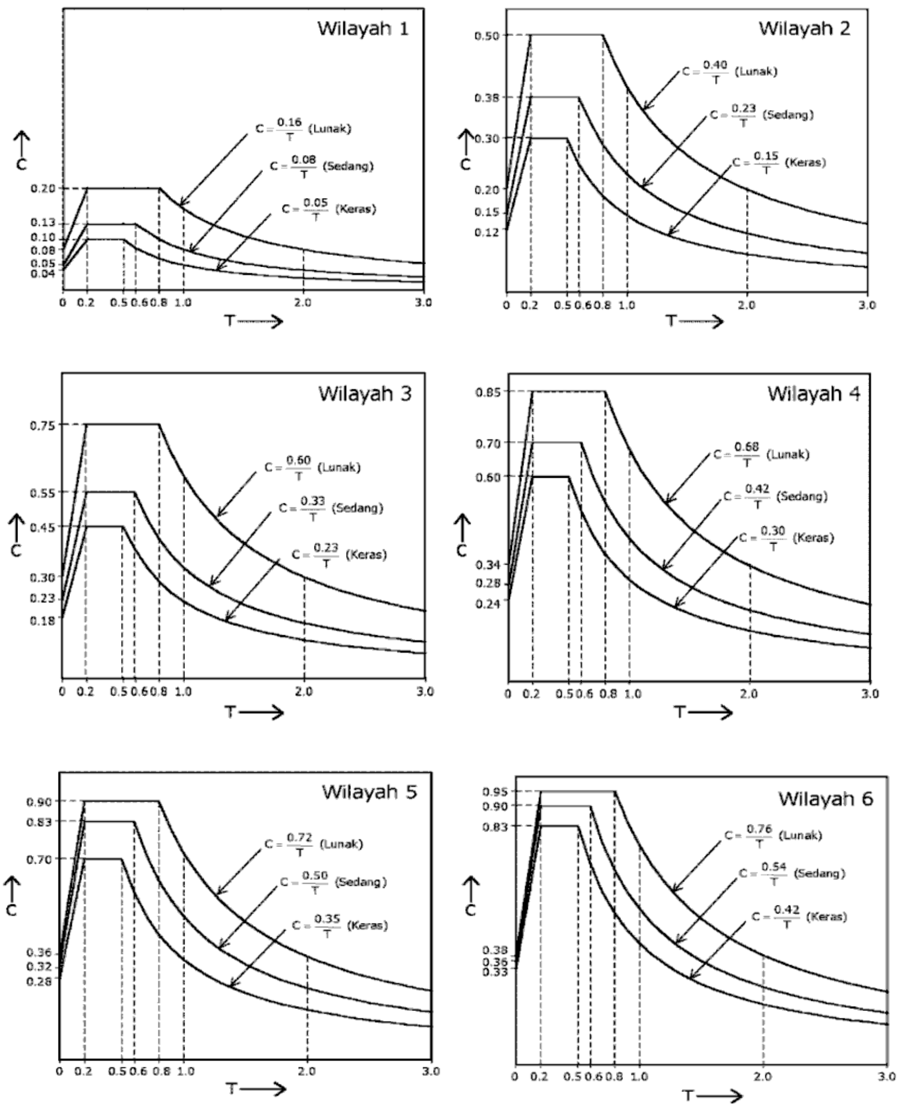


Figure 4. Earthquake response spectra in each zoning and soil category

Ductility, over-strength factor, and seismic effect on building structure

The load-deflection (V-δ) diagram as shown in Fig. 5 is based on the equal maximum deflection concept, δm, at the point of near collapse, the first yield point depends on the ductility factor μ with the equation of :

$$1 \leq \mu = \frac{\delta max}{\delta y} \leq \mu m$$

Where :
δy : deflection due to V_y at first yielding
μ = 1 : structure in elastic condition (δy = δm)
μ = μm : structure at maximum ductility
μm = 5.3 for fully ductility frame and μm= 3.3 for partially ductile shear wall

In the SNI 03-1726-2002, it is mentioned that :

1. μ can be selected by designer / owner, but not exceeding μm
2. The over strength factor related to the safety factor againt overload and under strength : f1 = 1.60
3. The over strength factor related to degree of redundacy of the ductile structure before collapse : f2 = 0.83 + 0.17 μ
4. Seismic reduction factor to obtain the nominal seismic load on a ductile structure : R = μ f1 = 1.6 μ
5. Total over strength factor to obtain the maximum seismic load on a ductile structure befor collapse : f = f1 f2 = 1.6 f2

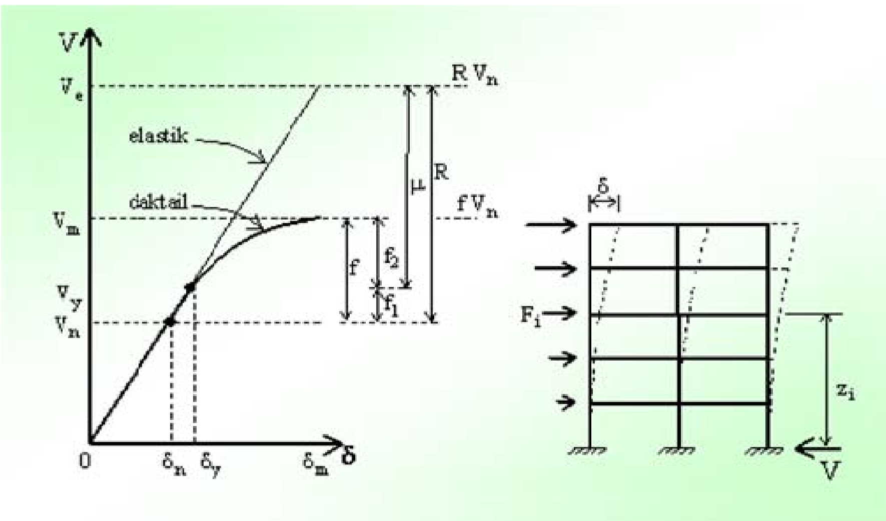


Figure 5. The load-deflection diagram of building structure

6. Nominal seismic load for design of a ductile structure = $V_n = 1 + \frac{V_y}{f1} = \frac{V_e}{R}$
7. Maximum possible seismic load on a ductile structure before collpase : V_m = f V_n
8. Maximum nominal seismic load for design of portion of a ductile structure that must remain elastic, the maximum possible seismic load on a ductile structure:
9. If δn is deflection due to the nominal seismic load Vn then:
   - deflection at first yielding : $\delta_y = f_1 \ \delta_n$
   - deflection at near collapse : $\delta_m = R \ \delta_n$
10. The ductility parameters of building structures are presented in Table 3 .

Table 3. The ductility parameters of building structures

Structural Condition	Parameters			
	μ	R	f2	f
Fully Elastic	1.0	1.6	1.00	1.6
	1.5	2.4	1.09	1.7
	2.0	3.2	1.17	1.9
	2.5	4.0	1.26	2.0
Partially Ductile	3.0	4.8	1.35	2.2
	3.5	5.6	1.44	2.3
	4.0	6.4	1.51	2.4
	4.5	7.2	1.61	2.6
	5.0	8.0	1.70	2.7
Fully Ductile	5.2	8.5	1.75	2.8

Designing with 3-D (dimension) structures

In designing the earthquaake resistaant building with 3-D structure analysis, SNI 03-1726-2002 gave some notes:

1. For building structure higher than 10 stories or 40m, P-delta effect must be considered
2. Design of eccentricity between the center of mass and the center of rotation on every floor must be considered to stimulate :
   a. The effect of rotational component of the ground motion
   b. The possible change of the center of mass due to change of gravity loads
   c. The possible change of the center of rotational due to the effect of post elastic plastification
3. The value of foundamental natural vibration period (T1) should be limited as $T_1 < \zeta n$, when n is the number of building stories and ζ is a coefficient for limitation of foundamental natural shaking period of building structure as described in Table 4.

Table 4. Coefficient for limitation of of foundamental natural shaking period of building structure

Seismic Zone	ζ
1	0,20
2	0,19
3	0,18
4	0,17
5	0,16
6	0,15

Designing regular and irregular building structures

A building is categorized has regular structure if it fulfill the following conditions:

1. The height of building measured from the level of its lateral restraint is not exceeding 10 stories or 40 m.

2. Building structure plan is rectangular without any partial extensions. If there is, the length must not be more than 25% of the maximum structure plan dimension in that direction
3. The building structure plan does not have any corner omissions. If there is such a omissions its side dimension must not be more than 15% of the maximum structure plan dimension in that direction
4. The building structural system is composed of two perpendicular lateral load resisting sub systems, each parallel with the principal axes of the overall building structural plan
5. The building structural system does not have setbacks. If there is a setbacks the dimensions of the smaller upper part must not be less than 75% of the maximum structural plan dimension of its lower part in that direction. A penthouse need not be considered as a setback if it is not more than 2 story high.
6. The building structure system has a regular lateral stiffness distribution without any soft stories. A soft storey is defined as one storey that has a lateral stiffness less than 70 % of that of the upper story, or less than 80% of average lateral stiffness of the 3 stories above it. In this case, the lateral stiffness of a story is defined as the story shear producing a unit inter story drift.
7. The weight of each stories is not more than 150% of the weight of the story above or below it. The weight of a penthouse need not meet this requirement.
8. The building structural system has lateral load resisting sub system consisting of continuous vertical element, with no offsets more than half of the dimension of the element
9. The building structural system has continuous floors, without opening with an area of more than 50% of the area of that floor. If there are floors containing such openings, their number must not exceed 20% of the total number of stories.

Other building that could not fulfill such mentioned conditions is categorized having irregular building structure. For the regular building structure, the analysis of effect of designed seismic load is considered as equvalent static while for the irregular building structure is dynamic.

ON-GOING REVISION OF THE STANDARD FOR SEISMIC RESISTANT BUILDING CODE

The develoment of new seismic zoning map

Some big earthaqukake hit Nanggroe Aceh Darusalam, Nias, Yogyakarta, Nabire, Bengkulu generated the strong need of the revision of the seismic zoning map that had been used in the SNI 03-1726-2002. A probabilistic hazard model for estimation of seismic hazard in Indonesia has been developed based upon updated available seismotectonic data, implementing new fault models, and incorporating new ground-motion prediction equations as Next Generation Attenuation (NGA). Seismic sources were divided into fault, subduction, and background zones and by considering truncated exponential, pure characteristic model or both models. Hazard from background zone was calculated using different values of M_{max} and by using gridded seismicity from Frankel, et al. (1995).

Hazard maps of PGA with M_{max} 6.5 and 7.0 for shallow background source are shown in Figs. 6 and 7 respectively. Hazard maps for 0.2 and 1-second spectral accelerations for shallow background source with M_{max} 6.5 are presented in Figs. 8 and 9 Specifically for Jakarta, the value of PGA corresponds to return periods of 500 years for shallow background source with M_{max} 6.5 and M_{max} 7.0 are 0.225 g and 0.245g, respectively. In general, the results of PGA from this study are significantly higher than that of current Indonesian Seismic Hazard Map in Indonesian Seismic Building Code SNI 03-1726-2002. The increase of PGA values is affected by the increase of maximum magnitudes and other input parameters and by utilizing 3-D earthquake source model. Similar results have also been reported by other previous studies. The spectral hazard map developed in this study will then be proposed as a revision for the current seismic hazard map.

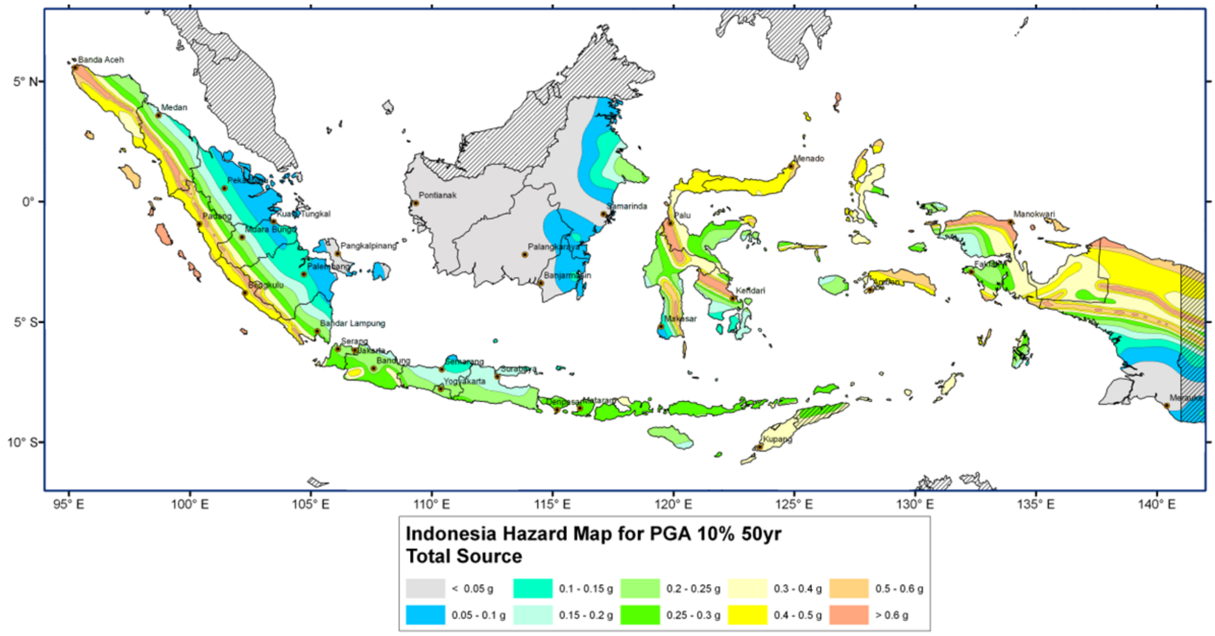


Figure 6. Map of PGA use shallow background sources with M_{max} 6.5 for 10% probability of exceedance in 50 years (500 years return period of earthquake).

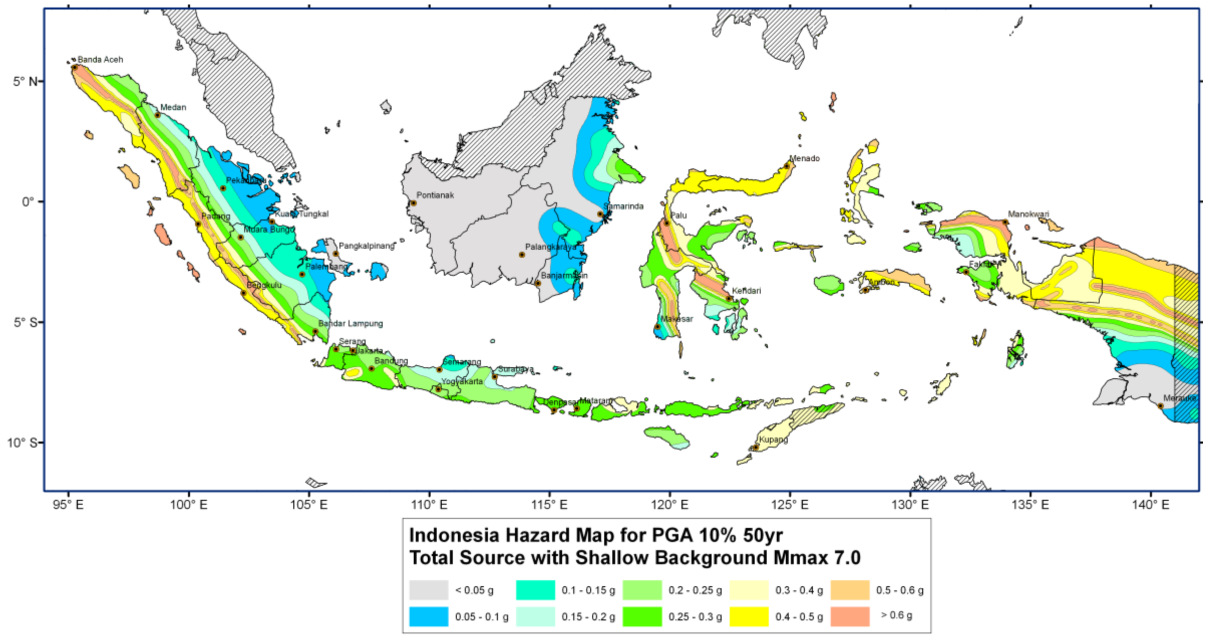


Figure 7. Map of PGA use shallow background sources with M_{max} 7.0 for 10% probability of exceedance in 50 years (500 years return period of earthquake).

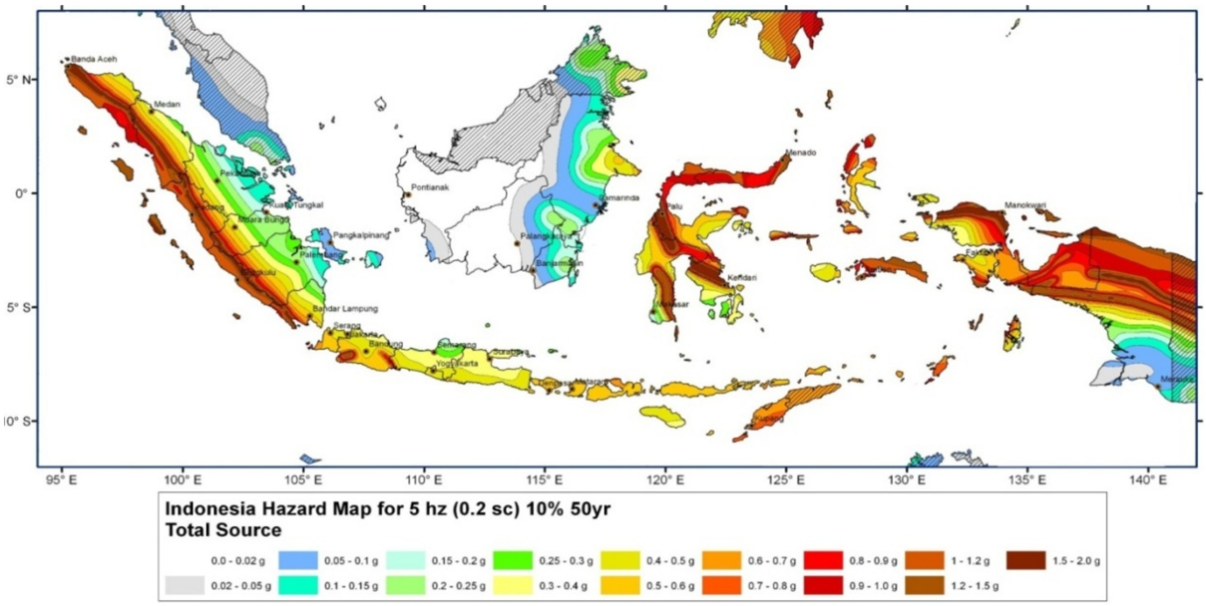


Figure 8. Map of 0.2 sec spectral acceleration use shallow background sources with M_{max} 6.5 for 10% probability of exceedance in 50 years (500 years return period of earthquake).

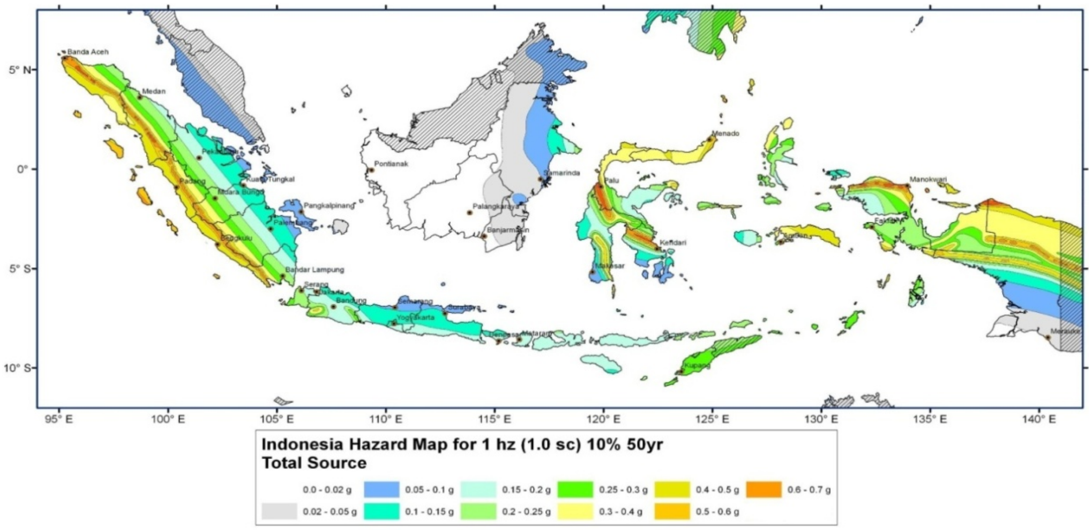


Figure 9. Map of 1.0 sec spectral acceleration use shallow background sources with M_{max} 6.5 for 10% probability of exceedance in 50 years (500 years return period of earthquake).

Revision on the designing principles of sub-structure and upper structure of building.

For revision of the upper and sub structures of building, the team agreed to use ASCE 7-05 as a reference in the preparation of SNI 03-1726-2010. However, the adoption is not identically, but adaptation with reference to the conditionof the development of construction technology in Indonesia in order to avoid gaps between the standard and implementation. Such condition is expected to address any levels of Indonesian construction expertese and the standard could be understood by many stake holders in building construction.

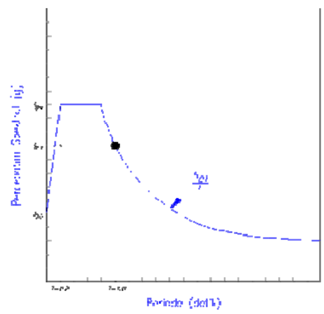
The revised parts of the standard in term of building structure focus on two major groups namely the sub-structure and upper-structure. The sub-structure part regulates soil conditions between the bedrock and the ground surface, and the interaction of soil with the building foundation. The upper-structure part regulates the structure of the building. There are several differences on basic concept of SNI 03-1726-2002 and the new SNI 03-1726-2010. Some items that have not been accommodated in SNI 03-1726-2002 but necessary will be added in the new SNI.

Some requirements on sub-structure parts that had been discussed by the experts and be considered to be discussed in SNI 03-1726-2010 are:

1. Foundation under seismic loading
   Based on ATC-40 (1996) item numbert 4.4.3 foundation acceptability criteria are:
   a. For the life safety and structural stability performance objectives, individual geotechnical components are acceptable regardless of their maximum displacements
   b. For performance objectives beyond life safety for damage control, the effects of permanent displacements of geotechnical components warrant consideration.
   c. FEMA 356 (2000): 10.6 Response Limits & Acceptable Criteria;
      1) Fixed base assumption:
         a) If the base of the structure is assumed to be completely rigid, the geotechnical components shall be classified as deformation-controlled
         b) If the alternative overturning method is used, the geotechnical components shall be classified as force-controlled.
      2) Flexible base assumption:
         The geotechnical components shall be classified as deformation-controlled, but soil strength need not be evaluated.

2. Load Resistant Factor Design (LRFD) Method
   SNI 03-1726-2002 have a perspective to LRFD (Ultimate Limit State design), however, to achieve the implementation of good LRFD design methods for building foundations it is necessary to understand the foundation engineering system followed by the development of Indonesian manual for specific LRFD foundations for the implementation. Such condition is expected can reduce the problems arise of the application of LRFD design method for building foundation in SNI 03-1726-2010.

3. Site specific spectra analysis wave propagation
   In determining an accurate design spectra some considerations has to be focused namely : a synthetic input motions required correctly, determination of bedrock elevation and options of the software in accordance with the frequency content of the earthquake for avoiding numerical distortion. Some parameters and results of spectra analysis can be a designed with reference to SNI 03-1726-2010 as could be seen in Fig 10, the site amplification value for short period in Table 5 and the site amplification value for long period in Table 6.



$S_{DS} = A_a \times S_S$
$S_{D1} = A_v \times S_1$
A_a : Amplification factor for T=0.2 sec
A_v : Amplification factor for T=1.0 sec
(For 10% PE in 50 years) = S_{D1}/S_{DS}.

Figure 10. Response Spectra for SNI 03-1726-2010

4. Liquefaction
   a. Liquefaction analysis must be done for the building foundation, which located in the upper layer of saturated sand (Special Soil / F)
   b. Metode analisis liquefaction dan lateral spread tidak perlu dimasukkan ke dalam SNI 03 1726 2010 (pending ASCE 7 10).
   c. Need to put up a requirement of NSPT boundary where liquefaction analysis is not necessary

Design capacity problems and basement structures in terms of seismic load and soil structure interaction is being deeply studied by some experts in order to get appropriate model for Indonesia situation with reference to ASCE 7-05, ASCE 7-10, FEMA 440, NEHRP 2009, ASSHTO 2005 and some commentary and scientific paper.

Table 5. Site amplification coefficient value for short period (Fa)

	Zone T=0.2 second				
	Ss ≤ 0.25	**Ss = 0.5**	**Ss= 0.75**	**Ss = 1.0**	**Ss ≥ 1.25**
Rocks (SB)	1.0	1.0	1.0	1.0	1.0
Hard Soil (SC)	1.2	1.2	1.1	1.0	1.0
Medium Soil (SD)	1.6	1.4	1.2	1.1	1.1
Soft Soil (SE)	2.7	1.7	1.2	0.9	0.9
Special Soil (SF)	SS	SS	SS	SS	SS

Notes:
SS= Spectral acceleration value at short period (T=0.2 second)
For value in between, linear interpolation necessary
SS: need site-specific analysis

Table 6. Site amplification coefficient value for short period (Fa)

Classifications Site	**Zone T=1.0 second**				
	S1 ≤ 0.1	**S1 = 0.2**	**S1= 0.3**	**S1 =0.4**	**S1 ≥ 0.5**
Rocks (SB)	1.0	1.0	1.0	1.0	1.0
Hard Soil (SC)	1.7	1.6	1.5	1.4	1.3
Medium Soil (SD)	2.4	2.0	1.8	1.6	1.5
Soft Soil (SE)	3.5	3.2	2.8	2.4	2.4
Special Soil (SF)	SS	SS	SS	SS	SS

Notes:
SS= Spectral acceleration value at short period (T=1.0 second)
For value in between, linear interpolation necessary
SS: need site-specific analysis

The basic concept applied in upper-structures parts, for some reasons, consider to use SNI 03-1726-2002, however, some modifications and additions made with reference to ASCE 7-05 as the dominant reference of SNI 03-1726-2010. Some items that have been discussed among the experts are:

1. Some rules in SNI 03-1726-2002 can still be used with a realistic adjustment
2. Seismic Design Criteria:
   a. Occupancy Catagory
   b. Ground Acceleration (2500 years)
   c. Seismic Design Category
3. Seismic Design Requirements for Building Structures
4. Seismic Design Requirements for Nonstructural Component
5. Seismic Design Requirements for Nonbuilding Structures

6. IBC 2009 and ASCE 07-05 determine the strong earthquake that is suitable for design based on the risk of 2% and t = 50 years or T = 2475 years (2500 years) with state-of-the-art theory (attenuation function with 0.2 and a spectral response, 0 seconds)
7. In California and most areas of the USA instead of near fault area, the structure was designed with earthquakes in 2500 years but the detailing with the way T = 500 years (old theory) with good detailing has a margin of safety for strength = 1.50
8. To design the structure, MCE earthquake planned reduction factor 1 / 1, 5 = 2 / 3
9. In contrast, in the New Madrid Fault Area region, MCE can have the force of 4 to 5 times compared with T = 500 years
10. For areas like this must be multiplied by 1.2 sd MCE 3.5 or specially designed taking into account the fault area. The average amplification values ranging between (1.5 x1, 2) = 1.8 sd (1,5 x3, 5) = 5.3

The seismic design concept is considered to be changed in accordance with international trends on the implementation of performance-based design to obtain efficiency and efectiveness in building construction and enlarge earthquake performance level on the condition of near-collapes with the earthquake design level on 2475-year return period as shown in Fig. 11.

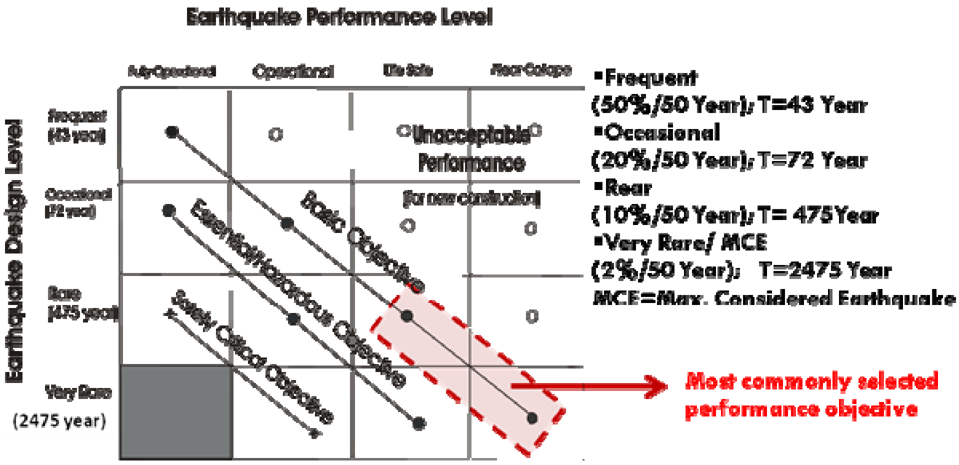


Figure 11. Earthquake Performance Level SEAOC Vision 2000 Committee

The comparisson between the current SNI 03-1726-2002 and new version SNI 03-1726-2010 is presented in Table 7. The differences in both standards could be more since the discussion among experts and practicians are accomodated by the end of August 2010.

Table 7. Some differences between SNI 03-1726-2002 and SNI 03-1726-2010

No.	SNI 03-1726-2002	SNI 03-1726-2010
1.	Earthquake hazard map with a return period of 500 years	Earthquake hazard map with a return period of 500, 1000 and 2500 years
2.	Seismic hazard map at T = 0 second in bedrock	Seismic hazard maps at T = 0, 0.2 and 1 second in the bedrock
3.	Peak Ground Acceleration values shown in the six zones	Peak Ground Acceleration values shown by using contour
4.	Response Spectra is shown in the six diagrams of C vs T	Response spectra are displayed using the software, so that the diagram C vs T can be obtained at any coordinate necessary
5.	Foundation design leads to the LRFD method	Not using LRFD
6.	Not recommended for liquefaction analysis	Accomodate liquefaction analysis for the foundations located in the upper layer of saturated sand
7.	Structural design concept refers to the equal displacement	Structural design concepts based on factors that represent the building occupancy (performance-based design)

CONCLUDING REMARKS

Efforts to prevent collapse on building hit by earthquake has to be sustainably developed to assure the people could stay safely in the buildings because Indonesia laays in the severe earthquake hazard area. Indonesian building law (UUBG No 28) was established in 2002 which followed by the establishment of Goverment Decree on Technical Guidelines of Building Construction (PP 36, 2005).. In such law and regulation, the construction of a building should be based on the use principle, safety, and in harmony with its environs. Standard building code that inline with the provison of the law is necessary to be develped to guarantee less lost in term of materiaals and human life. New earthquake hazard map that giving more precise prediction of the earthquake occurance has been intrioduced base upon updated available seismotectonic data, implementing new fault models, and incorporating new ground-motion prediction equations as Next Generation Attenuation (NGA). Performaance based design concept is implemented in the revision of SNI 03-1726-2002 based on new references to get efficiency in building construction that appropriate and guarantee safetiness to the occupants.

ACKNOWLEDGEMENTS

Most of the content of this paper was presented in IPRED Meeting 2 in Istanbul, Turkey in 2009 which sponsored by UNESCO. The writers would like to convey sincere thanks to IPRED comission in UNESCO for the support and cooperation. Special thanks also be adsdressed to the Agency for Research and Development, Ministry of Public Works for the support especially to the team members of revision of SNI 03-1726-2002.

REFERENCES

American Society for Civil Engineering (2005). Minimum design loads for buildings and other structures (ASCE 07-05).

Building Code Council (2009). International building code.

FEMA (2009). National earthquake hazard reduction program (NERPH) recommended seismic provisions for new buildings and other structures, 2009 edition. FEMA P-750.

Government of the Republic of Indonesia (2002). Building law no 28 Year 2002.

Irsyam, M. Asurifak, M. et.al. (2010). Development of spectral hazard maps for a proposed revision of the Indonesian Seismic Building Code. Geomechanics and Geoengineering . Publisher Taylor and Francis.

National Standard Board (2002) . Code of practise for designing earthquake resistant building. SNI 03-1726-2002

REVISION OF IAEE GUIDELINES FOR EARTHQUAKE RESISTANT NON-ENGINEERED CONSTRUCTION

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Professor Emeritus, Hokkaido University, Japan
President, NewsT Research Lab.
Email: to-yuji@nifty.com

ABSTRACT

A large majority of houses and buildings in the world can be classified as non-engineered construction. Some of them are (1) un-reinforced masonry (stone, brick or concrete block masonry), (2) wooden construction, (3) earthen construction (adobe or tapial), (4) confined masonry, etc. And most of the loss of life in past earthquakes has occurred due to the collapse of these houses and buildings. Because of the continued use of such construction in the world, it is essential to introduce earthquake resistant features in their construction. The International Association for Earthquake Engineering (IAEE) published the “Guidelines for Earthquake Resistant Non-Engineered Construction” in 1986. More than twenty years have passed since the publication and also the guidelines are still used in many parts in the world, the possible revision of the guidelines was discussed among three of the committee members for the 1986 edition. The revision is on the way with the supports of UNESCO and the International Institute of Seismology and Earthquake Engineering (IISEE), JAPAN.

KEYWORDS
non-engineered construction, un-reinforced masonry, wooden construction, earthen construction, earthquake.

INTRODUCTION

A large majority of houses and buildings in the world can be classified as non-engineered construction. And most of the loss of life in past earthquakes has occurred due to the collapse of these houses and buildings. Because of the continued use of such construction in the world, the International Association for Earthquake Engineering (IAEE) published the “Guidelines for Earthquake Resistant Non-Engineered Construction” in 1986. More than twenty years have passed since the publication of 1986 edition and also the guidelines are still used in many parts in the world, the revision of the guidelines will be helpful to minimize the damage caused by earthquakes.

NON-ENGINNERED CONSTRUCTION

Many buildings are spontaneously and informally constructed in various countries in the traditional manner without any or little intervention by qualified architects and/or engineers. Some types of the non-engineered construction are (1) un-reinforced masonry (stone, brick or concrete block masonry), (2) wooden construction, (3) earthen construction (adobe or tapial, i.e. rammed earth), (4) confined masonry, etc.

IAEE GUIDELINES IN 1986

The “Guidelines for Earthquake Resistant Non-Engineered Construction” was published by the International Association for Earthquake Engineering (IAEE) in 1986. It is a revised and amplified version of “Basic Concepts of Seismic Codes, Vol.1, Part II, Non-Engineered Construction”, published also by IAEE in 1980. The revision resulted from the work of an ad-hoc Committee, integrated by Anand S. Arya, Chairman (India), Teddy Boen (Indonesia), Yuji Ishiyama (Japan), A. I. Martemianov (USSR), Roberto Meli (Mexico), Charles Scawthorn (USA), Julio N. Vargas (Peru) and Ye Yaoxian (China). These efforts were guided by the objectives of IAEE, related to the promotion of international cooperation among scientists, engineers and other professionals in the field of earthquake engineering through the exchange of knowledge, ideas and the results of research and practical experience.

The guidelines start with the presentation of the basic concepts that determine the performance of constructions when subjected to high intensity earthquakes, as well as with the sensitivity of that performance to the basic geometrical and mechanical properties of the systems affected. This information is later applied to the formulation of simplified design rules and to the presentation of practical construction procedures, both intended to prevent system collapse and to control the level of damage produced by seismic excitations. Emphasis is placed on basic principles and simple solutions that can be applied to different types of structural systems, representative of those ordinarily used in low-cost housing construction in different regions and countries in the world.

The guidelines consist of nine chapters, i.e. 1) The Problem, Objective and Scope, 2) Structural Performance during Earthquakes, 3) General Concept of Earthquake Resistant Design, 4) Buildings in Fired-Brick and Other Masonry Units, 5) Stone Buildings, 6) Wooden Buildings, 7) Earthen Buildings, 8) Non-Engineered Reinforced Concrete Buildings, 9) Repair, Restoration and Strengthening of Buildings, and Appendix. An electronic version of the guidelines has been available at the website (http://www.nicee.org/IAEE_English.php) of NICEE at the Indian Institute of Technology Kanpur (IITK), since shortly after the 2001 Gujarat Earthquake.

REVISION OF THE GUIDELINES

Three members of the committee for the 1986 edition, i.e. Dr. Anand S. Arya, Ir. Teddy Boen and Dr. Yuji Ishiyama met in Tokyo, Japan during “The International Symposium 2008 on Earthquake Safe Housing”, which was held on November 28 and 29 in 2008. Since more than twenty years have passed after the publication and also the guidelines are still used in many parts in the world, they discussed the possible revision of the guidelines and agreed to make a working group in IAEE including the original members who are willing to participate in it and some new members who are also willing to join it. Since there is no special fund allocated to the working group in IAEE, the revision is mainly done through e-mail communications. Now the revision is on the way with the supports of UNESCO and the International Institute of Seismology and Earthquake Engineering (IISEE), JAPAN. The revision will be hopefully finished by the end of 2010 and will be reported at the next World Conference on Earthquake Engineering (WCEE) in Portugal in 2012.

Basic principle of the revision is as follows.
(1) Total number of pages should be kept minimum as the 1986 edition.
(2) A few pages to explain the minimum requirements for safer housing and buildings will be included.
(3) All should be easy to understand and be applicable at the construction site.

CONCLUDING REMARKS

The revision of the IAEE Guidelines for Earthquake Resistant Non-Engineered Construction has started. It is encouraged the participation of younger generation as well as the experienced generation. Those who have interests in the revision are recommended to send their comments on the guidelines to the three members of the committee for the 1986 edition, i.e.

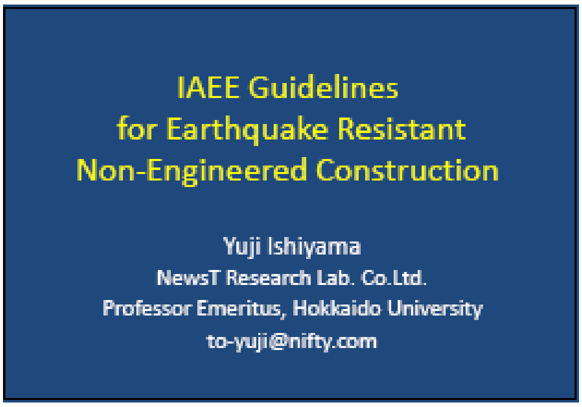
Anand S. Arya (India): anandsarya@gmail.com
Teddy Boen (Indonesia): tedboen@cbn.net.id
Yuji Ishiyama (Japan): to-yuji@nifty.com

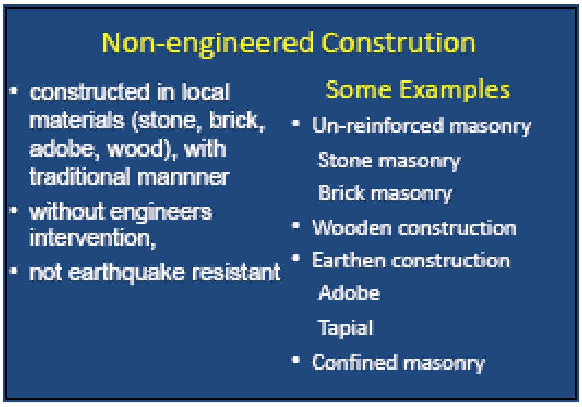
ACKNOWLEDGMENTS

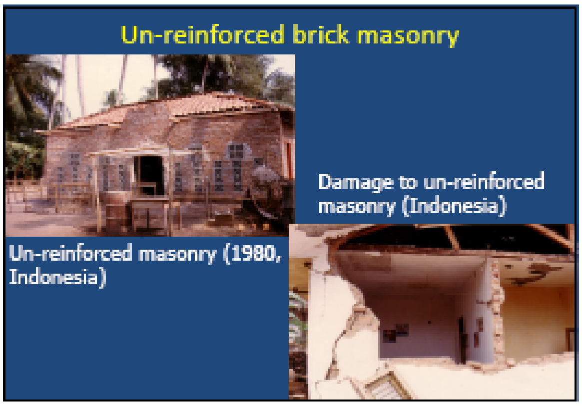
The meetings and activities for the revision of the guidelines will be supported in parts by UNESCO, IISEE (International Institute of Seismology and Earthquake Engineering) in Japan, other organizations and institutions. Their assistance is gratefully acknowledged.

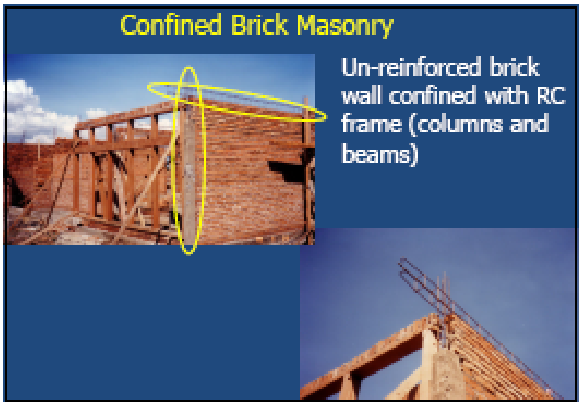
REFERENCES

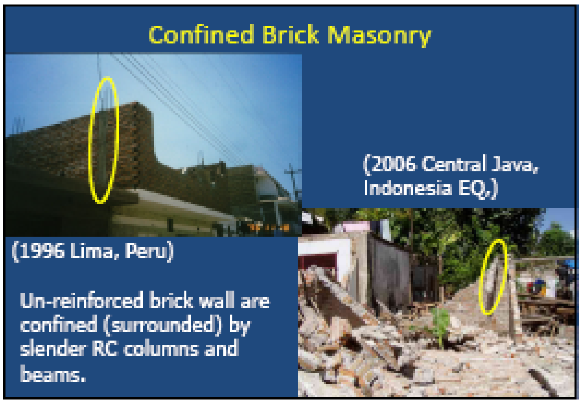
Arya, A.S, Boen, T., Ishiyama, Y., et.al. (1986). “Guidelines for earthquake resistant non-engineered construction”, The International Association for Earthquake Engineering, 1-158.

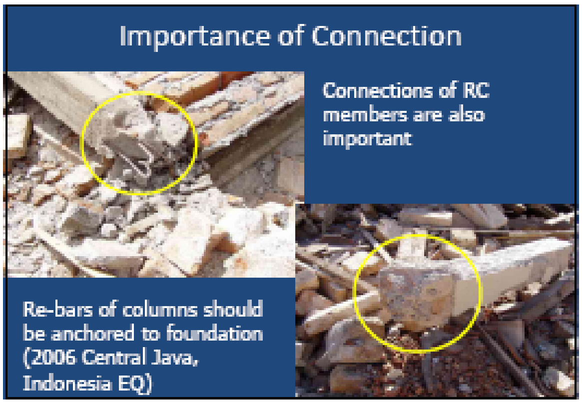

IAEE Guidelines
for Earthquake Resistant
Non-Engineered Construction
Yuji Ishiyama
NewsT Research Lab. Co.Ltd.
Professor Emeritus, Hokkaido University
to-yuji@nifty.com

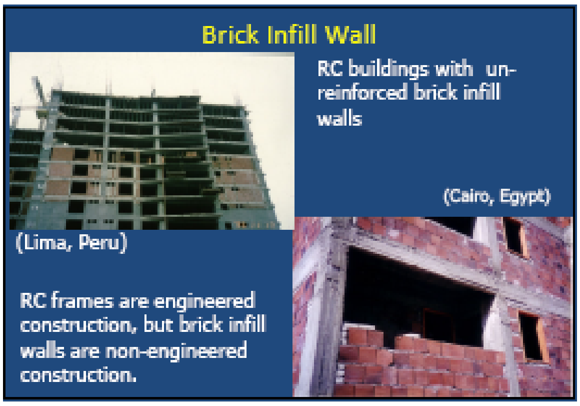

Non-engineered Constrution
• constructed in local materials (stone, brick, adobe, wood), with traditional mannner
• without engineers intervention,
• not earthquake resistant
Some Examples
• Un-reinforced masonry
Stone masonry
Brick masonry
• Wooden construction
• Earthen construction
Adobe
Tapial
• Confined masonry


Un-reinforced brick masonry
Damage to un-reinforced masonry (Indonesia)
Un-reinforced masonry (1980, Indonesia)


Confined Brick Masonry
Un-reinforced brick wall confined with RC frame (columns and beams)

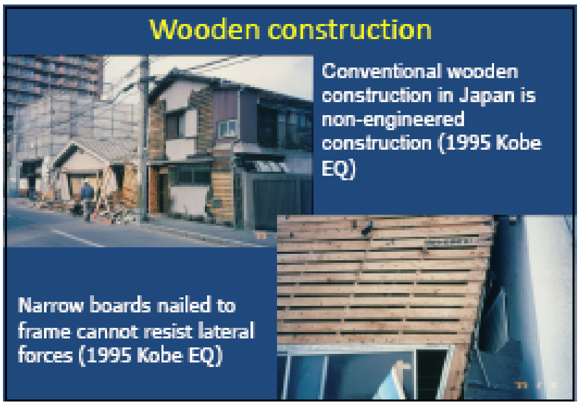

Confined Brick Masonry
(2006 Central Java, Indonesia EQ.)
(1996 Lima, Peru)
Un-reinforced brick wall are confined (surrounded) by slender RC columns and beams.

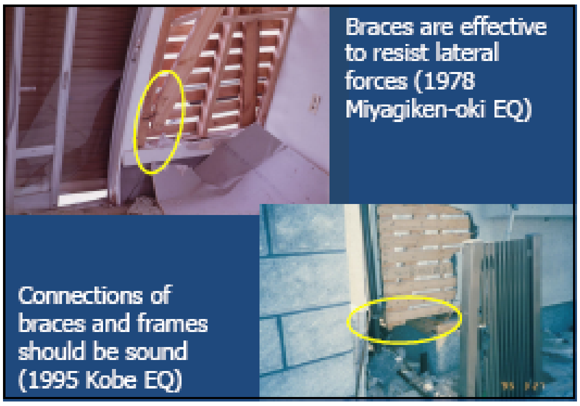

Importance of Connection
Connections of RC members are also important
Re-bars of columns should be anchored to foundation (2006 Central Java, Indonesia EQ)


Brick Infill Wall
RC buildings with un-reinforced brick infill walls
(Cairo, Egypt)
(Lima, Peru)
RC frames are engineered construction, but brick infill walls are non-engineered construction.


Adobe (sun-dried mud block construction)
Damage to Adobe (1996 Nazca, Peru EQ)
Damage to Adobe (2001 Atico, Peru EQ)

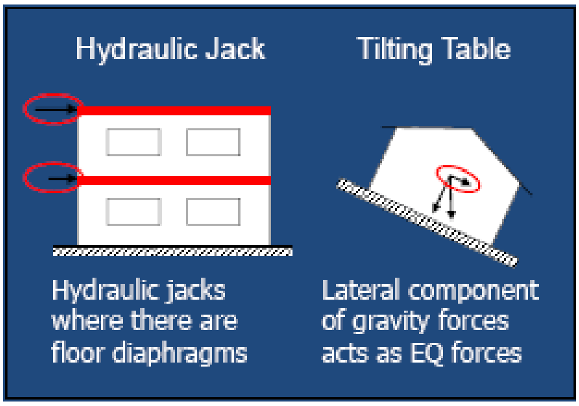

Tapial (cast-in-place mud construction)
Damage to Tpial (1990 Rioja, Peru EQ)
Tpial under construction (1990 Peru)


Wooden construction
Conventional wooden construction in Japan is non-engineered construction (1995 Kobe EQ)
Narrow boards nailed to frame cannot resist lateral forces (1995 Kobe EQ)

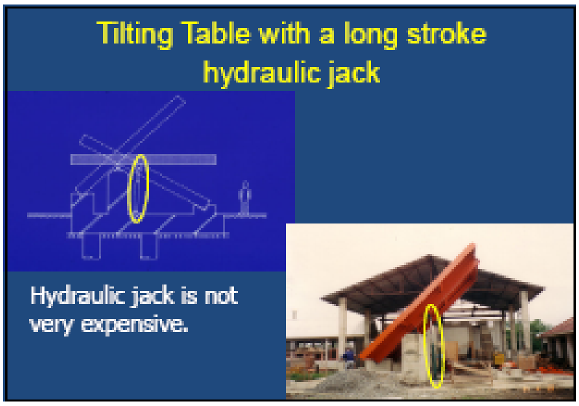

Braces are effective to resist lateral forces (1978 Miyagiken-oki EQ)
Connections of braces and frames should be sound (1995 Kobe EQ)


Experiments to Verify Seismic Performance
• Application of lateral forces
• Tilting table
• Shaking table


Application of Lateral Forces
Experiments to apply horizontal forces simulating earthquake forces
Bandung, Indonesia
Lima, Peru
Lateral forces are applied as concentrated forces, in case there are rigid horizontal beams or floor diaphragms.


Hydraulic Jack
Tilting Table
Hydraulic jacks where there are floor diaphragms
Lateral component of gravity forces acts as EQ forces


Tilting Table in Cuzco, Peru


Tilting Table with a long stroke hydraulic jack
Hydraulic jack is not very expensive.


Tilting table test of confined masonry
(Bandung, Indonesia)
Steel Roof
Bamboo Roof
Lateral forces are applied as a component of gravitational forces


Research Center for Human Settlement (RCHS, Indonesia)
Tilting table moved to a new laboratory

Shaking Table

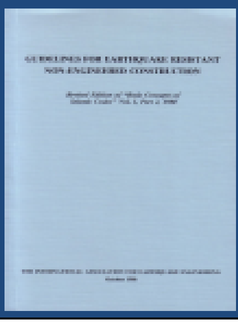
Shaking table tests are very useful and effective,

but expensive.

Experiment of un-reinforced brick masonry construction using shaking table (Dec. 2007, Tsukuba, Japan)

- The knowledge, that can be obtained through shaking table tests, will be utilized to understand the data obtained by other structural tests, e.g. component or element tests.
- The shaking table test results also contribute improving analytical methods of structures of non-engineered construction.

Guidelines for Earthquake Resistant Non-Engineered Construction



Revised Edition (1986)

International Association for Earthquake Engineering (IAEE)

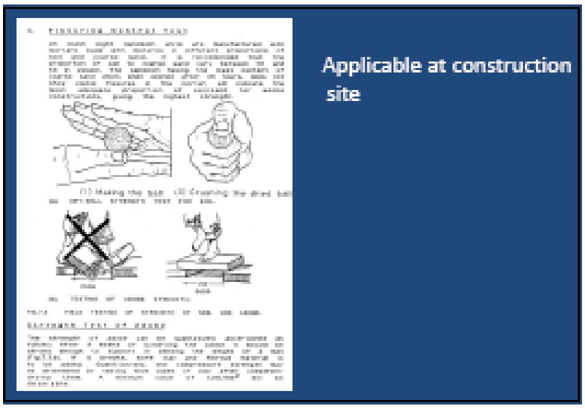
- Anand S. Arya (India)
- Teddy Boen (Indonesia)
- Yuji Ishiyama (Japan)
- A. I. Martemianov (USSR)
- Roberto Meli (Mexico)
- Charles Scawthorn (USA)
- Vargas Julio N. (Peru)
- Ye Xaoxian (China)

Table of Contents (158pp)

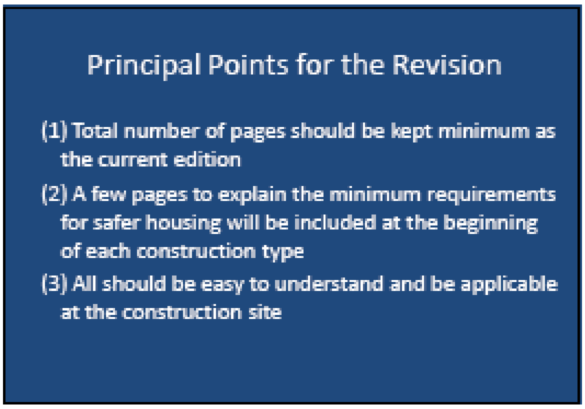
Down Load

http://www.nicee.org/IAEE_English.php

Easy to understand with many illustrations


Applicable at construction site


Key Requirements for Safer Housing
1. Quality of Materials
2. Structural Section of Main Members
3. Connection of Structural Members
KEY REQUIREMENTS FOR SAFER HOUSING


Principal Points for the Revision
(1) Total number of pages should be kept minimum as the current edition
(2) A few pages to explain the minimum requirements for safer housing will be included at the beginning of each construction type
(3) All should be easy to understand and be applicable at the construction site


If you have interest, please contact
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Teddy Boen : tedboen@cbn.net.id
Yuji Ishiyama : to-yuji@nifty.com
Thank you

MLIT'S EFFORTS TO PREVENT THE COLLAPSE OF EXISTING BUILDINGS BY EARTHQUAKES

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Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan.
Email: katsumi-y2ym@mlit.go.jp

INTRODUCTION

In Japan, we have the Building Standard Law for new constructions and some measures for promoting seismic retrofits of existing buildings.

CONTENTS

1. Japan's Building Standard Law (BSL)

The purpose of the BSL is to safeguard the life, health, and property of people by providing minimum standards concerning the site, construction, equipment, and use of buildings. The BSL applies to all buildings throughout Japan. The BSL has both building codes and planning codes other than general provisions and is applied continuously from the time of its construction to the time of its destruction.

A building should be structurally safe enough to resist its dead load, live load, snow load, wind pressure, earth pressure and seismic force. What is important here is that Japanese seismic code has two-tier target for structural design. First, the building should not be damaged by earthquakes of a medium scale which means intensity 5 on the Japanese scale that can infrequently happen. Second, the building should not collapse or fall by earthquakes of a large scale which means intensity 6 to7 on the Japanese scale that can very rarely happen. Simply put, it's "No damage by medium load, no collapse by large load."

Building confirmations, interim inspections and final inspections are conducted by building officials or "designated confirmation and inspection bodies". Building confirmations and inspections used to be conducted exclusively by building officials, who work for prefectural or municipal governments. However, the BSL was amended in 1998 to allow private sector to conduct building confirmations and inspections and private bodies started building confirmation and inspection services in 1999. As of April 1, 2008, there were about 1,800 building officials in 431 local authorities, while there were about 1,400 private building inspectors in 126 organizations.

In Japan, we have a licensing system for building designers. We call it "Kenchikushi" and it plays the dual role as an architect and a building engineer. It is stipulated in the Kenchikushi law. Both "practice" and "title" are protected by the Kenchikushi Law. "Kenchikushi" has mainly 3 categories; 1st-class, 2nd-class, and Mokuzo, which means Wooden structure, Kenchikushi. 1st-class Kenchikushi shall be able to design and superintend the construction works of buildings of all constructions, sizes and uses.

Since the BSL was enacted in 1950, we have had several major earthquakes and suffered severe damages. We learned from the experiences, and repeatedly revised the seismic requirements in the BSL. For example, after Tokachi Offshore Earthquake in 1968, the RC standards were strengthened and the minimum stirrup space was reduced to improve ductility of RC columns in 1971. After Miyagi Offshore Earthquake in 1978, "New Earthquake-Resistance Standard", which is the current design principle, was introduced in 1981. After Great Hanshin -Awaji Earthquake in 1995, a separate law for seismic retrofit was enacted, and interim inspection scheme was introduced to the BSL.

The key consideration of "New Earthquake-Resistance Standards "(introduced in 1981) are to directly confirm that buildings will not collapse even in the event of major earthquakes by structural calculations. The key consideration of previous earthquake resistance standard before 1981 had been that buildings will not suffer damage from medium-size earthquake. People had considered buildings would withstand even large earthquakes thanks to high ductility.

2. Retrofits of existing buildings

Japan has suffered from many earthquakes. Unfortunately, we cannot say that we are fully prepared for earthquakes. In 2003, among 47 million housing units, 25% had insufficient earthquake resistance. Among 3.4 million non-residential buildings, 35% had insufficient earthquake resistance. MLIT developed basic principles in promotion seismic performance evaluation and seismic retrofit of buildings in 2006 and set up the target to raise the percentage of housing and specified buildings with sufficient earthquake resistance to 90% by 2015 from the current about 75%.

Since current seismic code is stricter than before, it is certain that the percentage of housings with insufficient earthquake resistance will decrease as the housings are reconstructed. In addition to that, Japanese government has been trying to accelerate the process by implementing promotional measures. First, we enacted the Act for Promoting Seismic Retrofit of Buildings. Second, we offer assistance through subsidies, financing and tax breaks. Third, we promote technical development for seismic retrofit. Fourth, we offer consultation services and provide useful information about retrofit cost and contractors to building owners.

Under the Act for Promoting Seismic Retrofit of Buildings, owners of buildings used by large number of people, such as hospitals, theaters and department stores are required to direct efforts toward seismic capacity evaluation and seismic retrofit. In principle, when you implement a major repair, you have to comply with the current building codes. However, when you get certification by a local authority regarding a seismic retrofit work, the provisions of the current building codes other than those related to earthquake resistance are not applied retroactively. The number of certifications issued had amounted to about 5,500 by 2008.

In addition to the Act for Promoting Seismic Retrofit of Buildings, There are subsidies for both seismic capacity evaluation and seismic retrofit. As for seismic capacity evaluation, the owner needs to pay only 1/3, and the rest is paid by national and local government. As for seismic retrofit, about 23% is paid by national and local government. There is also lending programs to supply low interest loans for the cost of seismic retrofit. And tax breaks are also available. Through these measures, seismic capacity evaluation were conducted for about 545,000 housing units, and seismic retrofit were conducted for about 31,000 housing units by March 2009.

MLIT's Efforts to Prevent the Collapse of Existing Buildings by Earthquakes

Great Hanshin-Awaji Earthquake (1995)

Yasuo Katsumi
Ministry of Land, Infrastructure, Transport and Tourism

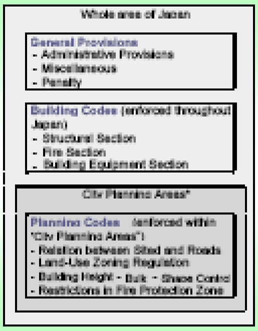
Contents

1. Japan's Building Standard Law

Purpose of the Building Standard Law

Article 1. The purpose of this Law is to safeguard the life, health, and property of people by providing minimum standards concerning the site, construction, equipment, and use of buildings, and thereby to contribute to the furtherance of the public welfare.

Composition of the BSL



*City Planning Areas; 99,873 km², 26% of total land (as of March 2007)

Principle of Structural Regulation

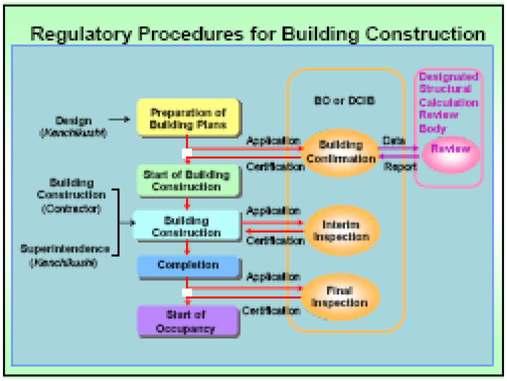
Principle: A building should be structurally safe enough to resist its dead load, live load, snow load, wind pressure, earth pressure and seismic force.

To be specific, technical standards have been put in place based on the following principle:

(1) The building should not be damaged by snowfall, storm or earthquakes (Intensity 5) of a medium scale that can infrequently happen.

(2) The building should not collapse or fall by snowfall, storm or earthquakes (Intensity 6 to 7) of a large scale that can very rarely happen.

(3) The building should be structurally strong enough to support its dead weight and applied loads and ensure its usability regardless of any extreme deformation or vibration it might receive.



Building Regulatory Authorities

Opened to private sector since 1999.

Building officials		Designated confirmation and inspection bodies
Prefectural or municipal officials Prefectures and specific cities with populations of over 250,000	Attributes	Private (either profit or non-profit)
About 1,800 building officials in 431 local authorities (as of April 1, 2008)	Staff (organiza-tions)	About 1,400 private building inspectors in 126 organizations (as of April 1, 2008)
About 200,000	No. of confirma-tions / year	About 430,000

Licensed Building Designer (1)

Kenchiku-shi (Architect/Building Engineer)

- Stipulated in *Kenchiku-shi* Law
- Practice is protected
- Title is protected
- Dual role: Architect and/or Engineer

Licensed Building Designer (2)

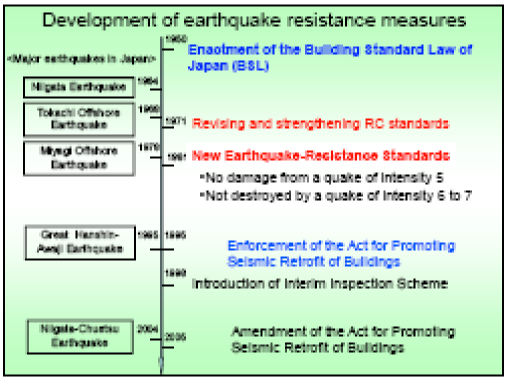
Kenchiku-shi (Architect/Building Engineer)

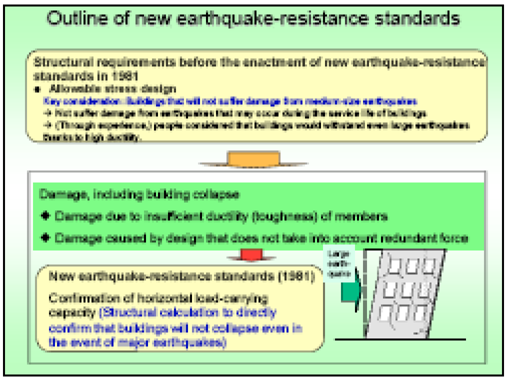
– 1st class *Kenchiku-shi* can design buildings and superintend construction work for all buildings.

– 2nd class *Kenchiku-shi* can design and superintend construction work mainly for small buildings.

– *Mokuzo (wooden structure) Kenchiku-shi* can design and superintend construction work of only small wooden buildings.

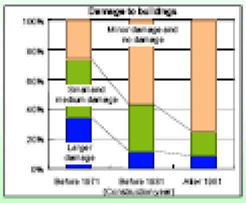
*In addition to these categories, new classifications, "Structural design 1st-class *Kenchiku-shi*" and "Equipment design 1st class *Kenchku-shi*" were created in November 2008.





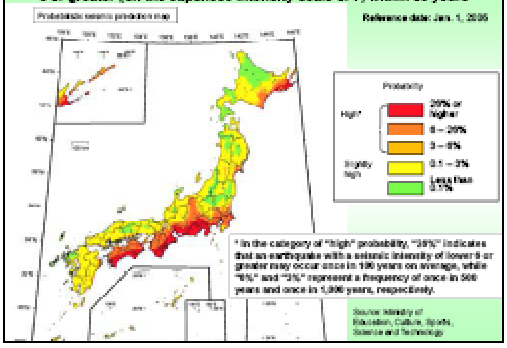
Damage caused by the Great Hanshin-Awaji Earthquake (1995)

	Number of fatalities
Persons seemed to have been crushed to death under collapsed buildings, furniture or others	4,831 (88%)
Persons seemed to have been burnt to death	550 (10%)
Persons killed by other causes	121 (2%)
Total	5,502 (100%)



2. Retrofit of existing buildings

Probability of occurrence of earthquakes with a seismic intensity of lower 6 or greater (on the Japanese intensity scale of 7) within 30 years



* In the category of "high" probability, "30%" indicates that an earthquake with a seismic intensity of lower 6 or greater may occur once in 100 years on average, while "6%" and "3%" represent a frequency of once in 500 years and once in 1,000 years, respectively.

Source: Ministry of Education, Culture, Sports, Science and Technology

Existing buildings with insufficient earthquake resistance

	Total stock	Stock with insufficient earthquake resistance
Housing	47 million units	11.5 million units (25%)
Non-residential buildings	3.4 million buildings	1.2 million buildings (35%)

* Estimated by the MLIT based on the 2003 Housing and Land Survey

* Estimated by the MLIT based on the Survey of New Construction, questionnaires for each prefecture, etc. (2003)

Measures for earthquake-resistant houses and buildings

- Enforcement of the Act for Promoting Seismic Retrofit of Buildings
- Assistance through subsidies, financing and tax breaks
- Promotion of technical development for seismic retrofit
- Consultation services, provision of information regarding cost and contractors

The Act for Promoting Seismic Retrofit of Buildings

(enacted in 1995)

- Based on the lessons learned from the Great Hanshin-Awaji Earthquake
  - Obligations of the owners of buildings used by large number of people to direct efforts toward seismic performance evaluation and seismic retrofit
  - Concerning certified seismic retrofit work, provisions of the current law other than those related to earthquake resistance are not applied retroactively
  - Guidance, advice, instructions, etc. from local authorities
- Certification under the Act for Promoting Seismic Retrofit of Buildings

(1995 to 2008)

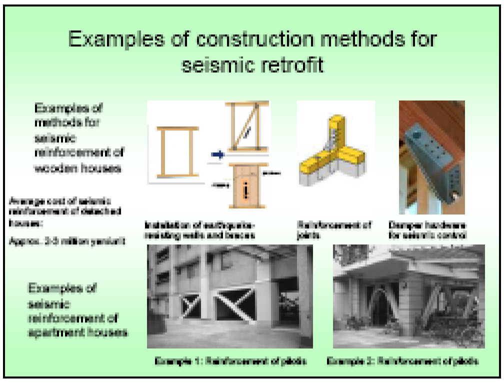
	Public Buildings	Private Buildings	Total
Number of certifications	4,857	684	5,541

Support scheme for seismic performance evaluation and seismic retrofit

- Subsidies
  - Seismic performance evaluation
    Natl Govt 1/3 + local govt 1/3 + owner 1/3
  - Seismic retrofit
    Natl Govt 11.5% + local govt 11.5%
- Lending programs
  - Low interest loan for the cost of seismic retrofit
- Reduced taxation
  - 10% of the cost of seismic retrofit (max 200,000 yen) deducted from income tax

Total number of cases which obtained support for seismic performance evaluation and seismic retrofit

- Seismic performance evaluation (total as of March 2009)
  - Houses: about 545,000 units
  - Specified buildings*: about 62,000
    * buildings used by large number of people
- Seismic retrofit (total as of March 2009)
  - Houses: about 31,000 units
  - Specified buildings: about 15,000



IISEE's Efforts to Train Experts in Evaluating and Retrofitting Existing Buildings, Including the Newly Established China Project

N. Hurukawa
International Institute of Seismology and Earthquake Engineering (IISEE),
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Email: hurukawa@kenken.go.jp

Introduction

International Institute of Seismology and Earthquake Engineering (IISEE) is carrying out international training in seismology and earthquake engineering since 1960. A total of 1,380 participants from 96 countries and regions have completed our training courses. We have 1) one-year training courses, which are approved as a Master Degree program, 2) a short-term training course, and 3) an individual training course.

Earthquake Engineering Course

The earthquake engineering course is one of the one-year training courses which had started in 1960. Capacity is about 10 trainees. A total of 483 participants from 54 countries have completed this training course as of July 2009. The course begins with structural analysis and structural dynamics and moves systematically onto seismic resistant structures such as reinforced concrete and steel construction, state-of art technologies of seismic isolation, and earthquake resistant limit state design. After 8 months lectures in class, each participant studies a specific subject under the instruction of an IISEE staff member or lecturer and finally makes a Master paper.

Seismic Evaluation and Retrofitting

"Seismic Evaluation and Seismic Rehabilitation" is a 5-days lecture, which was started in the 1991-1992 course, and is one of important lectures in the course. Seismic capacity evaluation and seismic rehabilitation (retrofit) of existing buildings and bridges are introduced with emphasis on our practice after the 1995 Hyogoken-Nanbu (Kobe) earthquake. Inspection and evaluation of earthquake damage to buildings and bridges, and post-earthquake countermeasures for damaged buildings are also introduced in the lecture. We also have a visit to a retrofit construction site during the course. A couple of participants have selected topics on "Seismic Evaluation and Seismic Rehabilitation" in their individual studies since the 1995-1996 course. For example, a participant from CISMID, Peru is now studying "Development and analytical model for pushover analysis on masonry walls retrofitted with disposable fiber mats."

Newly Established China Project

A magnitude 8.0 earthquake occurred in sichuan, china in may 12, 2008, and caused severe damage. More than 87,000 persons were died or missing and 5 million houses were collapsed.

In order to nurture Chinese structural engineers, the IISEE has started a new JICA (Japan International Cooperation Agency) technical cooperation project in cooperation with the Ministry of Land, Infrastructure, Transportation, and Tourism in Japan. The IISEE will establish a new training course on "seismic design, evaluation, and retrofitting" October 2009, in which the IISEE accepts 20 Chinese participants every year. This course will continue 3 years. After their coming back to China, they will become instructors and train thousands of Chinese structural engineers.

IISEE's Efforts to Train Experts in Evaluating and Retrofitting Existing Buildings, Including the Newly Established China Project

N.Hurukawa

International Institute of Seismology and Earthquake Engineering (IISEE), Building Research Institute, Tsukuba, Japan

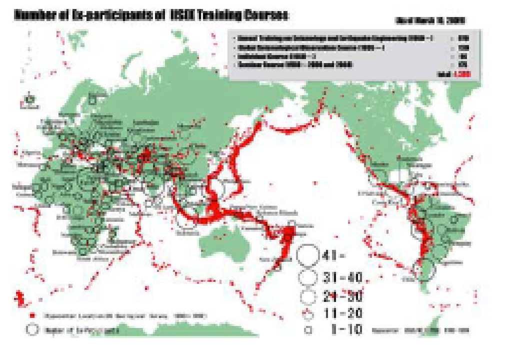
UNESCO-IPRED Workshop in Istanbul on 2009.7.5-7

International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

International Institute of Seismology and Earthquake Engineering (IISEE)

- The IISEE is carrying out international training on seismology and earthquake engineering since 1960.
- A total of 1,380 participants from 96 countries and regions have completed our training courses.
- We have
  1) one-year training courses, which are approved as a Master Degree program,
  2) a short-term training course, and
  3) an individual training course.

International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN



International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Earthquake Engineering Course

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International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

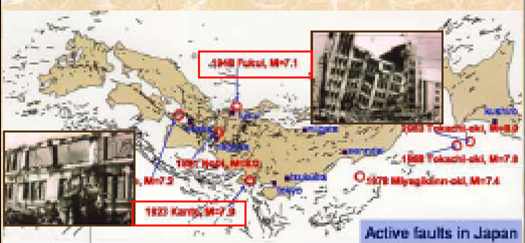
Subjects, 2008-2009

1. Orientation
2. Structural Analysis
3. Structural Dynamics
4. Seismic Design
5. Seismic Evaluation and Retrofitting
6. Earthquake Hazard Assessment
7. Earthquake Risk Assessment
8. Disaster Mitigation Policy
9. Disaster Risk Management
10. Disaster Mitigation and Development Assistance
11. Practice for Earthquake Disaster Mitigation Policy
    Observation Visit
    Colloquium
12. Individual Study → Master Paper
13. Others

International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Lecture of Seismic Damage and Design Code

- History of earthquake damage and seismic design code of Japan
- Code comparison among Japan, China and other areas



International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Japan consists of the following four plates:

1. North American Plate
2. Eurasian Plate
3. Philippine Sea Plate
4. Pacific Plate

M>=7 EQs

Japan: 101 EQs in last 100 years

World: 20 EQs/year

Nine EQs in last 100 years caused more than 1,000 deaths in Japan

International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Seismic Evaluation and Retrofitting

- "Seismic Evaluation and Seismic Rehabilitation" is a 5-days lecture, which was started in the 1991-1992 course, and is one of important lectures in the course.
- Seismic capacity evaluation and seismic rehabilitation (retrofit) of existing buildings and bridges are introduced with emphasis on our practice after the 1995 Hyogoken-Nanbu (Kobe) earthquake. Inspection and evaluation of earthquake damage to buildings and bridges, and post-earthquake countermeasures for damaged buildings are also introduced in the lecture.
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International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Individual Studies on Seismic Evaluation and Retrofitting

2003-04: Seismic Evaluation and Rehabilitation of Reinforced Concrete Building In Dominican Republic (Dominican Republic)

203-04: Evaluation of Seismic Capacity and Retrofitting of a Typical 12 Stories RC Frame Structure in Buchazest, Romania (Romania)

2004-05: Evaluation and Retrofit of RC Frame Buildings –A Japanese Approach (Bhutan)

2004-05: Seismic Retrofitting of Reinforced Concrete Building (Peru)

2005-06: Energy-Based Seismic Retrofit of Reinforced Concrete Buildings (Philippine)

2006-07: Post Earthquake Quick Damage Inspection of Buildings in Nepal (Nepal)

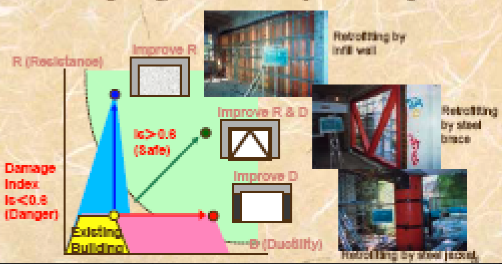
2006-07: Improvement of Masonry Structures against Seismic Force (Pakistan)

2008-09 : Development and analytical model for pushover analysis on masonry walls retrofitted with disposable fiber mats (Peru)

International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Lecture of Seismic Evaluation and Retrofitting

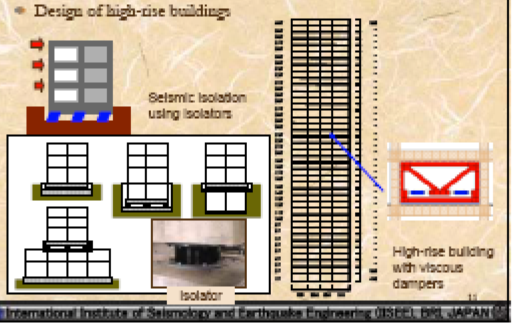
- Japanese screening method using damage Index, Is, for seismic evaluation
- Retrofitting strategy and retrofit techniques for buildings



International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Lecture of New Technology in Seismic Design

- Response control and seismic isolation techniques
- Design of high-rise buildings



International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Questionnaires on Curriculum

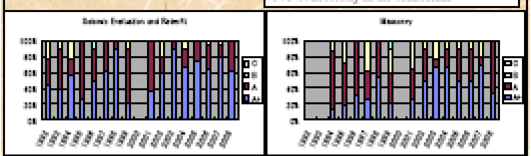
1. Through your experiences, please choose and mark one of A+, A, B, or C for every item below and mark.

A+ : Very important, should be increased more

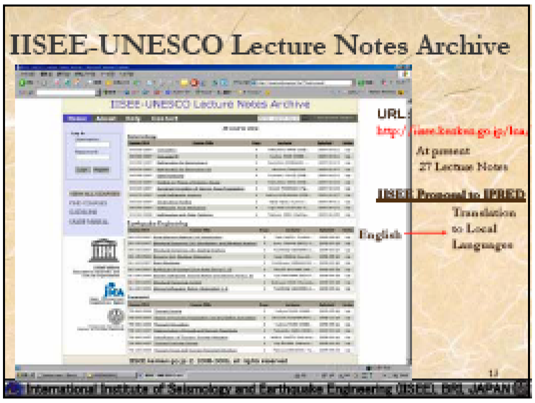
A : Important

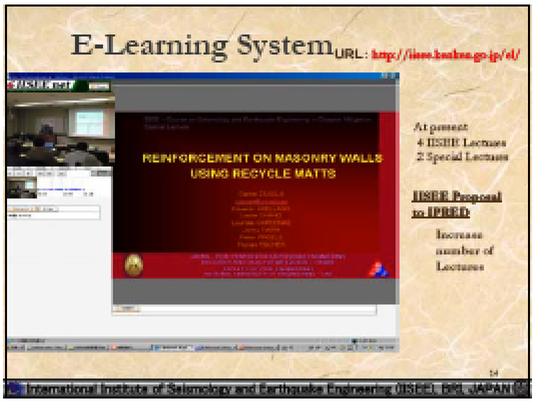
B: Fair, necessary in the curriculum

C : Not necessary in the curriculum



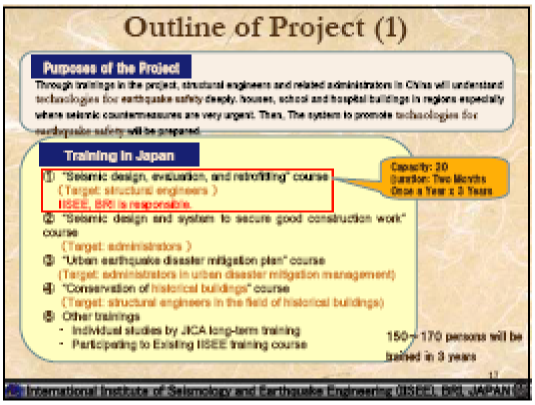
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

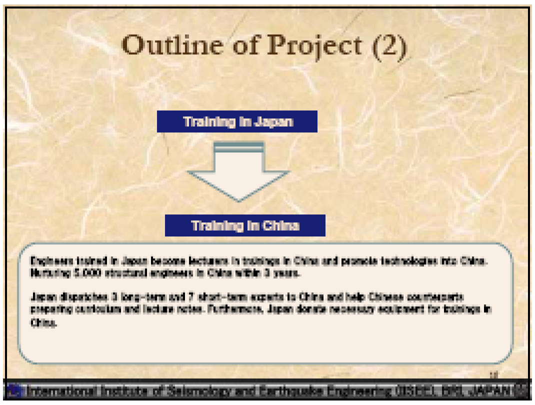

IISEE-UNESCO Lecture Notes Archive
URL: http://iisee.kenken.go.jp/lna/
At present
27 Lecture Notes
IISEE Proposal to IPRED
English
Translation to Local Languages
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


E-Learning System
URL: http://iisee.kenken.go.jp/el/
REINFORCEMENT ON MASONRY WALLS USING RECYCLE MATTS
At present
4 IISEE Lectures
2 Special Lectures
IISEE Proposal to IPRED
Increase number of Lectures
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Newly Established China Project
Sichuan Earthquake in China (May 12, 2008)
Photo 1. School dormitory: Ground floor was collapsed.
Photo 2. Failure of a brick building.
A magnitude 8.0 earthquake occurred in Sichuan and caused severe damage. More than 87,000 persons were died or missing and 5 million houses were collapsed (Photos 1, 2).
The Building Research Institute (BRI) carried out investigation on site to study cause of damage and supports for recovery.
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Sichuan Earthquake in China (May 12, 2008)
One Year Later
中日建筑抗震技术人员培训项目
新闻发布会
Photo 3. Press release after project R/D sign.
On May 12, 2009, one year anniversary of the earthquake, a new JICA technical project on nurturing structural engineers had started in Beijing, China.
The director of the IISEE, Dr. Hurukawa, had attended the ceremony (Photo 3).
In order to nurture Chinese structural engineers, the IISEE has started a new JICA (Japan International Cooperation Agency) technical cooperation project in cooperation with the Ministry of Land, Infrastructure, Transportation, and Tourism in Japan.
The IISEE will establish a new training course on "seismic design, evaluation, and retrofitting" this October.
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Outline of Project (1)
Purposes of the Project
Through trainings in the project, structural engineers and related administrators in China will understand technologies for earthquake safety deeply. houses, school and hospital buildings in regions especially where seismic countermeasures are very urgent. Then, The system to promote technologies for earthquake safety will be prepared.
Training in Japan
① "Seismic design, evaluation, and retrofitting" course
(Target: structural engineers)
IISEE, BRI is responsible.
Capacity: 20
Duration: Two Months
Once a Year x 3 Years
② "Seismic design and system to secure good construction work" course
(Target: administrators)
③ "Urban earthquake disaster mitigation plan" course
(Target: administrators in urban disaster mitigation management)
④ "Conservation of historical buildings" course
(Target: structural engineers in the field of historical buildings)
⑤ Other trainings
・ Individual studies by JICA long-term training
・ Participating to Existing IISEE training course
150～170 persons will be trained in 3 years
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Outline of Project (2)
Training in Japan
Training in China
Engineers trained in Japan become lecturers in trainings in China and promote technologies into China. Nurturing 5,000 structural engineers in China within 3 years.
Japan dispatches 3 long-term and 7 short-term experts to China and help Chinese counterparts preparing curriculum and lecture notes. Furthermore, Japan donate necessary equipment for trainings in China.
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

BRI'S EFFORTS TO PREVENT THE COLLAPSE OF EXISTING BUILDINGS BY EARTHQUAKES

S. Koyama
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BRI (Building Research Institute), Tsukuba, Japan.
Email: skoyama@kenken.go.jp

INTRODUCTION

Building Research Institute (BRI) was founded in 1946 as the only national research organization of the Government of Japan, whose concerns were concentrated upon housing, planning, and the building sciences to meet growing national needs for safe and comfortable human settlements in Japan. BRI had been conducting leading researches that were essential to accomplish administrative policy, making an effort to contribute to national development and maintaining international standards. The research works were for (1) The Prevention of Disasters, (2) The Improvement of the Living Environment, (3) The Rational Organization of Building production and the Development of New Building Techniques, (4) The Effective Use of Energy and Resources, and (5) The Promotion of International Cooperation (Building Research Institute, Ministry of Construction, 1996).

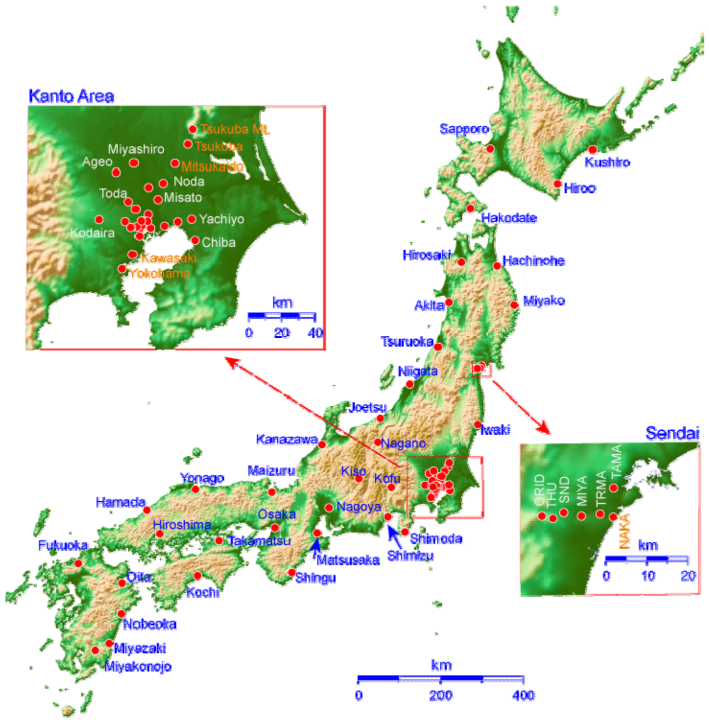

Figure 1. BRI strong motion network (BRI Strong Motion Observation web site, 2009)

RESEARCH ACTIVITIES FOR SEISMIC SAFETY

Research themes in BRI have been set according to the above five and the governmental policy at that time. The ways of “the effort to prevent the collapse of existing buildings by earthquakes” belong to the first one. For instance, building standard law of Japan was promulgated in 1950 and drastically revised in 1981 as “New seismic design method”. This revision was based on the result of five years research theme named “Development of New Seismic Design Method” which was started in 1972 and consisted of 6 subjects and 20 themes.

OTHER ACTIVITIES

In order to accumulate basic information for research themes, several relating activities are also simultaneously conducted. The one is “Investigation of Disaster”. When the large disaster occurs either in the world or in Japan, a committee for disaster investigation is to be set up in BRI and dispatches investigation team. Strong motion observation started in 1957 is also one of the important and relating activities. The aim is to record the earthquake ground motions and the behaviours of buildings during earthquakes in order to contribute to studies concerned with earthquake-proof design methods. 74 observation stations are placed in important cities throughout Japan and accumulating precious records (BRI Strong Motion Observation web site, 2009).

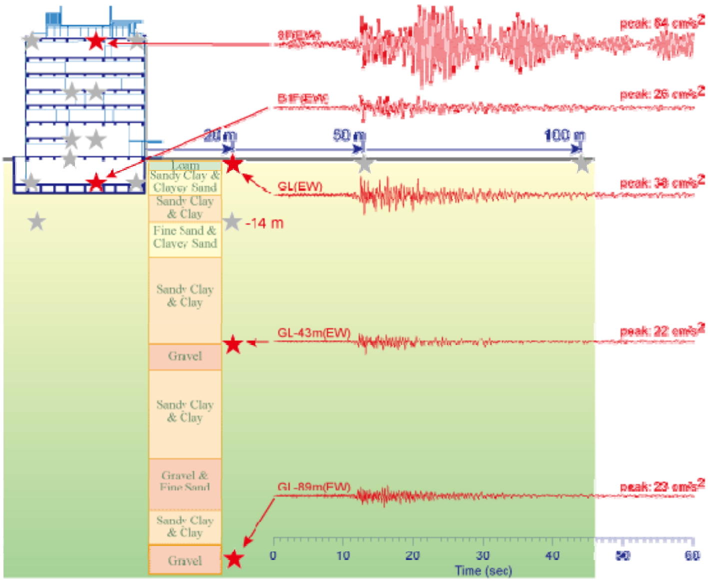

Figure 2. Dense instrumentation at BRI (BRI Strong Motion Observation web site, 2009)

Figure 3. Example of seismic retrofitting experiment using UFC (Ultra High Strength Fiber Reinforced Concrete). The thickness of wall is half and the shear strength of wall is 1.5 than usual wall. (Fukuyama H., et al., 2009)

NEW BRI

On April 1, 2001, BRI reorganizes its structure from a national research institute to one of Incorporated Administrative Agency by Japanese law. In this new century, new BRI is requested to search moderate "sustainability" rather than "development" as ever (BRI web site, 2008). In this point of view, how to advance effective use of existing buildings could be the key of the research themes on seismic safety. For instance, the research theme "Research and Development on General Seismic-Retrofitting-Technologies for Increasing Ratio of Seismically Safety Buildings" was conducted in order to support the suggestion proposed by the Promoting Council for Seismic Disaster Prevention (Fukuyama H., et al., 2009). The suggestion is "The ratio of the seismically safety buildings should be increased to 90% by 2015 to reduce casualties and amount of damage due to future earthquakes by half (Earthquake disaster prevention strategy of Tokai earthquake and Tonankai and Nankai earthquake (idea), 2005)."

CONCLUSION

BRI was founded as the only national research organization and reorganized to one of Incorporated Administrative Agency. Even if the base of establishment has changed, the work of BRI for the safety of life is constant. We continue make efforts to prevent the collapse of existing buildings depending on the demand of the times.

REFERENCES

BRI Strong Motion Observation web site (2009) http://smo.kenken.go.jp/
BRI web site (2008) http://www.kenken.go.jp/english/index.html
Building Research Institute, Ministry of Construction (1996) BRI 50 Years - Profile -, 18.
Earthquake disaster prevention strategy of Tokai earthquake and Tonankai and Nankai earthquake (idea) (2005) http://www.bousai.go.jp/chubou/12/setumei-siryo1.pdf (in Japanese)
Fukuyama H., et al. (2009) Research and Development on General Seismic-Retrofitting-Technologies for Increasing Ratio of Seismically Safety Buildings, The BRI Annual Report, No.43 (in Japanese, in press).


BRI's efforts to prevent the collapse of existing buildings by earthquakes
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(Building Research Institute, http://www.kenken.go.jp),
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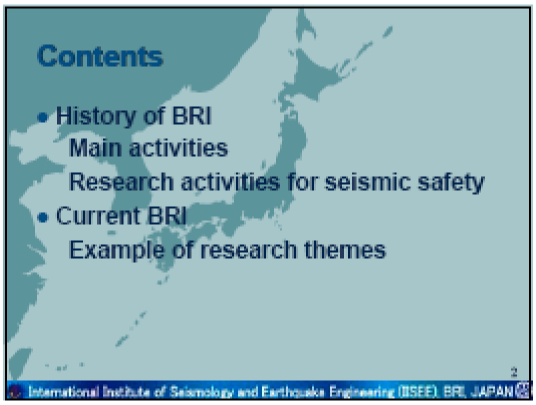
Contents
• History of BRI
Main activities
Research activities for seismic safety
• Current BRI
Example of research themes
2
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


History of BRI
• Building Research Institute (BRI) was founded in 1946
• The only national research organization of the Government of Japan
• BRI's concerns were concentrated on housing, planning, and the building sciences
• In order to meet growing national needs for safe and comfortable human settlements in Japan.
3
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Organization (as of 1996)
Code & Evaluation Research Center
Administration Department
Research Planning & Information Department
Housing & Building Economy Department
Material Department
Structural Engineering Department
Production Department
Environment, Design & Fire Department
Urban Planning Department
IISEE (established in 1962)
Administration Div./ Research Div.
4
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Main Activities
(1) The Prevention of Disasters
(2) The Improvement of the Living Environment
(3) The Rational Organization of Building production and the Development of New Building Techniques
(4) The Effective Use of Energy and Resources
(5) The Promotion of International Cooperation
5
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Research Activities for seismic safety
• Research themes in BRI have been set according to the above five & the governmental policy at that time
• The ways of "the effort to prevent the collapse of existing buildings by earthquakes" belong to "The Prevention of Disasters"
• The activities of "The Prevention of Disasters" are closely related with actual disasters
6
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Pair of research themes and relating codes or guidelines

- 1946 /Resistance of Building against Extraordinary Loads
  - 1950 /Promulgated Building Standard Law
- 1962-1963 / Study on Earthquake Resistant Design of Tall Building
  - 1963 / Amendment of Building Standard Law (Removed limit of building height set as 31m)

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International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Pair of research themes and relating codes or guidelines(cont.)

- 1972-1976 / Development of New Seismic Design Method
  - 1980 /Amendment of Building Standard Law Enforcement Ordinance (Introduced New Aseismic Structural Design)
- 1995-1999 / New System of Building Structure
  - 2000 /Amendment of Building Standard Law Enforcement Ordinance (Performance base building code was supplemented)

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International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Pair of research themes and relating codes or guidelines(cont.)

- 1981-1985 / Development of Repair Technology for Buildings and Infrastructure Damaged by Earthquake
  - the quick inspection of damaged buildings ➔

http://www.kenchiku-bosai.or.jp/Jimukyoku/Oukyu/data/epand/epanfall.PDF

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International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Other Activities

In order to accumulate basic information for research themes, several relating activities are also simultaneously conducted.

- Reconnaissance Investigation of Disaster
- Strong motion observation
- International Cooperation

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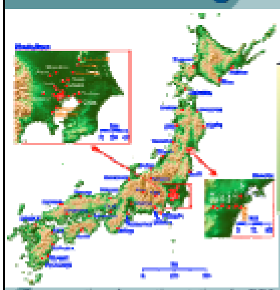
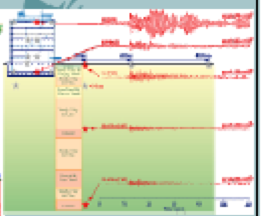
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

BRI strong motion network



Strong motion observation stations by BRI (BRI Strong Motion Observation web site, 2009)



Dense strong motion observation array in BRI (BRI Strong Motion Observation web site, 2009)

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International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

Current BRI

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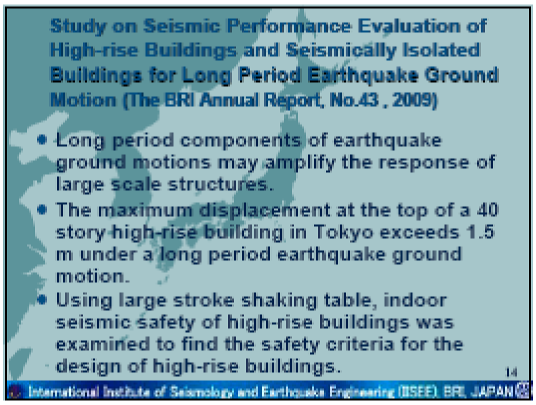
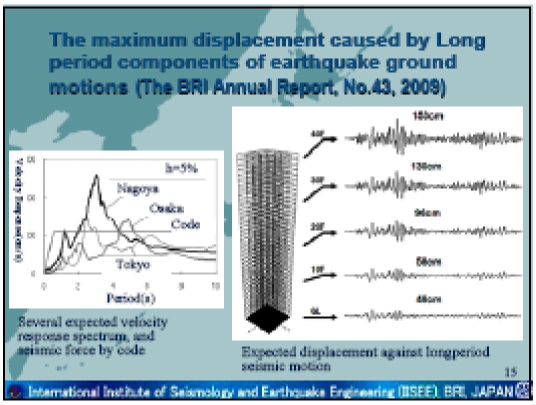
12

International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Research themes relating to seismic safety
(The BRI Annual Report, No.43, 2009)
• Research and Development on General Seismic-Retrofitting-Technologies for Increasing Ratio of Seismically Safety Buildings
• Development of Reduction Technology of Damage to Non-Structural Members Cleared by Seismic or High Wind Damage, Structural Safety of Large Suspended Ceiling and Steel Roof
• Study on Seismic Performance Evaluation of High-rise Buildings and Seismically Isolated Buildings for Long Period Earthquake Ground Motion
13
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


Study on Seismic Performance Evaluation of High-rise Buildings and Seismically Isolated Buildings for Long Period Earthquake Ground Motion (The BRI Annual Report, No.43 , 2009)
• Long period components of earthquake ground motions may amplify the response of large scale structures.
• The maximum displacement at the top of a 40 story high-rise building in Tokyo exceeds 1.5 m under a long period earthquake ground motion.
• Using large stroke shaking table, indoor seismic safety of high-rise buildings was examined to find the safety criteria for the design of high-rise buildings.
14
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN


The maximum displacement caused by Long period components of earthquake ground motions (The BRI Annual Report, No.43, 2009)
h=5%
Nagoya
Osaka
Code
Tokyo
Period(s)
Several expected velocity response spectrum, and seismic force by code
Expected displacement against longperiod seismic motion
15
International Institute of Seismology and Earthquake Engineering (IISEE), BRI, JAPAN

PERU'S EFFORTS TO PREVENT THE COLLAPSE OF EXISTING BUILDINGS BY EARTHQUAKES

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INTRODUCTION

Recent quakes in Peru showed how weak are traditional materials without reinforce under quake demands. Different kinds of damage were reported on non engineering houses built with two materials: adobe and brick clay masonry. The collapse of this kind of structures killed many people due to their weakness out of plane and also their poor resistant against forces and in addition the sites conditions of soil.

COLLAPSE ON ADOBE AND MASONRY BUILDINGS

The houses built on soft soils experienced collapse due to the big displacements, the increment of the soil demand due to site conditions, and due to non reinforcement on walls that were used on non engineering constructions. Non engineering house don't use any cane, wood, confine elements on the ends of the walls, therefore, opening of the corners, lost of alignment of walls and overturning on walls (See Figures 1 to 4), are likely damages. As a result of the big displacements, after the damage of walls and the opening of corners appear, the roof collapse and structural system became unstable and total collapse may occur.

Figure 1. Overturning of walls

Figure 2. Collapse

Figure 3. Collapse of roof

Figure 4. Collapse roof

A characteristic of the collapse of walls starts with diagonal cracks on the surrounding area of windows then the area of the wall between the opening and the door is small and very weak, therefore the collapse of the walls occurs. Other characteristic of the adobe walls is lintel beam without enough penetration of the wall, just because this beams don't have enough support on the walls, then horizontal cracks appears and collapse of surrounding adobe blocks. If there are not collar beam, strong vertical cracks appears on the corners of walls between walls then the collapse and overturning of walls and collapse of roof occurs.

Masonry buildings with severe damage or collapse usually are mix structures with first floor of adobe and second floor of masonry (it happens on 15/8/2007 Pisco quake). Non regulated constructions and its condition of non engineering structure give a nature of weakness. When non belt beam is on the building, damage or collapse is possible (Figure 5). Irregularity in stiffness and mass, will be the origin of stability failure like the case of soft story (Figure 7), and also the case of low stiffness combine with unbalance, will produce collapse of the building (Figure 6). A special case are the historical valuable buildings (Figure 8) without reinforce in locations with soft soil, where collapse or heavy damage is evident.

Figure 5.Non belt beam

Figure 6. Irregularity

Figure 7. Soft story

Figure 8. Non reinforce

EFFORT TO PREVENT COLLAPSE ON NON STRUCTURAL HOUSING

Proposal for reinforce Adobe walls

The use of a fiber disposable plastic bag or rice bag can be use as an economic alternative to reinforce an adobe wall and avoid the collapse. This technique could be applied increasing the section of the walls totally or increasing the corner section as confinement. Figure 9 presents the sequence of the reinforcement increasing the corner section.

Figure 9. Four stages of reinforcement an adobe wall

Proposal for reinforce Masonry walls with disposable mats

The use or disposable mats bounding with adhesive could save lives to avoid the collapse of the walls. Due to economic factor is quite important for emerge economies where people don't have enough money for retrofit their own house. Two alternatives has been studied: one with an X configuration and total wrap disposable mat, became a good alternative for save lives of a non reinforced masonry house. Mats cover the cracks with an adhesive used as a paint. Pull out test confirm that not failure may occur on the mat during an extreme load, and will works as an envelope to the wall, for avoid the collapse. The test results also shows that non increase on stiffness can be reached, however the will not collapse because the mat is acting as a big bag to provide support to the wall.

Figure 10. Disposable mat X configuration

Figure 11.Complete wrapped with mat

Proposal for reinforce Masonry walls with steel wire mesh

After the recent quakes a likely used method to reinforce masonry walls was the used of partial reinforce and complete reinforce with using steel wire mesh with the addition of a mortar has been used as an alternative for retrofit walls. The procedure starts with retirement of the finishing of the wall, paint and mortar. Then over the brick walls the wire mesh is fixed with nails each 30 to 40 cm. in both directions. Finally a mortar 1:4 (cement, sand) is used to cover the wire mesh reinforcement in a thickness between 2.5 to 3 cm.

Figure 12. Partial Reinforce

Figure 13. Finish of Partial

Figure 14. Complete reinforce

The partial reinforce is an economic alternative of reinforce a wall with a good behaviour even better than the complete wire mesh reinforce, due to the advantage of the orientation of the mesh in the direction of the diagonal shear, usually the failure mode of the wall. In both cases increment of the stiffness is reached specially in the partial reinforce case.

FINAL COMMENTS

From the structural point of view, wall reinforce using recycle mats are an alternative to maintain the walls without collapse and avoid the lost of lives and injure during quakes. However this method will not increase the resistant of a damage wall after retrofit, will only avoid the collapse. By the other hand, partial and complete reinforce with steel wire mesh will recover the strength of a damage wall, and also increase the stiffness. The behaviour of these kind of alternative of reinforce shows better performance than the wall without retrofit. It means will behave better during the next quake and will avoid collapse and save lives.

One of the key issues in the retrofit non structural housing in Peru is the search of these kind of economic and easy to use alternatives of reinforce, because the economic factor is quite important on a population. Manual of retrofit with mats (Figure 15) has been prepared to spread the knowledge among the constructors and avoid lost of lives on next quakes.

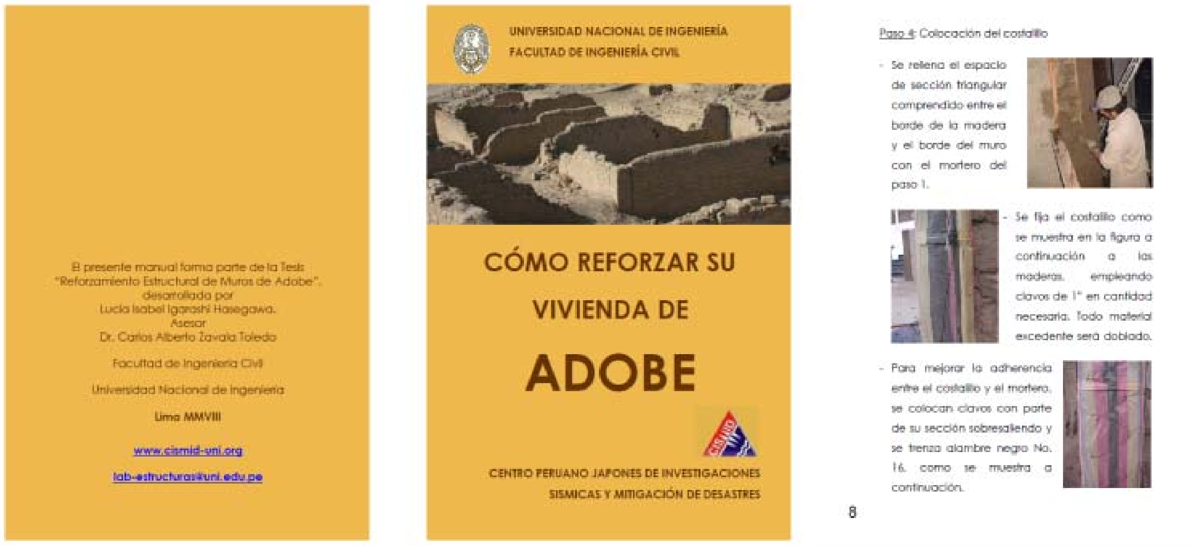

Figure 15. Retrofit manual for adobes

REFERENCES

Igarashi L. (2008) A proposal method for reinforce adobe walls. National University of Engineering, Faculty of Civil Engineering. Thesis dissertation, Lima Peru. (in Spanish)

Zavala C., Estrada M., Chang L. Cardenas L. (2008) Behaviour of non-engineered houses during Pisco earthquake 15/8/2007. Proceedings of the 14 WCEE - S18031 Beijing China.

EGYPT'S EFFORT TO PREVENT THE COLLAPSE OF EXISTING BUILDINGS BY EARTHQUAKES

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INTRODUCTION

It has been estimated that, during historical time more than 50 million people have lost their lives in earthquakes during ground shaking, such as soil amplification and/or liquefaction, landslides and tsunamis or its immediate after effects, as fires. The distribution of population takes generally no account of earthquake risk, at least on a large scale. An earthquake may be large but not destructive; on the other hand, an earthquake may be destructive but not large. The absence of correlation is due to the fact that, great number of other factors entering into consideration: first of all, the location of the earthquake in relation to populated areas, also soil conditions and building constructions. Soil liquefaction has been identified as the underlying phenomenon for many ground failures, settlements and lateral spreads, which are a major cause of damage to soil structures and building foundations in many events. Egypt is suffered a numerous of destructive earthquakes as well as Kalabsha earthquake (1981, Mag 5.4) near Aswan city and the High dam, Dahshour earthquake (1992, Mag 5.9) near Cairo city and Aqaba earthquake (1995, Mag 7.2). As the category of earthquake damage includes all the phenomena related to the direct and indirect damages, the Egyptian authorities do a great effort to mitigate the earthquake disasters. The seismicity especially at the zones of high activity is investigated in details in order to obtain the active source zones not only by the Egyptian National Seismic Network (ENSN) but also by the local seismic networks at, Aswan, Hurghada, Aqaba, Abu Dabbab and Dabbaa. On the other hand the soil condition, soil amplification, soil structure interaction, liquefaction and seismic hazard are carried out in particular the urbanized areas and the region near the source zones. All these parameters are integrated to obtain the Egyptian building code which is valid to construct buildings resist damages and consequently mitigate the earthquake disasters.

HUMANITARIAN RESPONSE AND COORDINATION IN EARTHQUAKE DISASTERS

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INTRODUCTION

The emergency environment in a natural disaster is different than a conflict-related complex emergency environment. There are usually sudden and overwhelming needs in the affected country at a natural disaster. The entities and officials entitled to respond to the disaster might be amongst the casualties. The damaged infrastructure and communications system would make it more difficult to coordinate the responders. Depending on the scale of the disaster, both national and international media may closely follow the situation and this can cause some pressure on the affected country's government. And if there are also international responders on site, it might increase the workload of the affected country to coordinate numerous responders at the same time. The above described facts create the need for special responding tools at the natural disasters.

The Office for the Coordination of Humanitarian Affairs (OCHA) has the responsibility of the coordination in a disaster or emergency. For the implementation of this responsibility, the United Nations General Assembly mandated the Emergency Relief Coordinator (ERC) at the level of Under-Secretary General for Humanitarian Affairs by the General Assembly Resolution 46/182 of December 1991. This mandate includes coordinating, facilitating and mobilizing the humanitarian assistance of the United Nations system.

To achieve this challenging goal, OCHA developed various response tools. These tools are mobilized in support of the affected government on request. Some of these response tools that are utilized at the field level are United Nations Disaster Assessment and Coordination (UNDAC) system, International Search and Rescue Advisory Group (INSARAG), On-Site Operations Coordination Centre (OSOCC) and support modules from International Humanitarian Partnership (IHP), Asia-Pacific Humanitarian Partnership (APHP) and Americas. This paper describes the response tools, in particular UNDAC, INSARAG, OSOCC, IHP/APHP, of OCHA.

REFERENCES

Erdogan, N. (2008) Field Coordination at Internationally Responded Earthquakes. First Edition August 2008, Istanbul. (ISBN 978-605-60166-0-8)
Katoch, A. (2006) The Responders' Cauldron: The Uniqueness of International Disaster Response. Journal of International Affairs Spring/Summer 2006, vol.59, no.2, 153-172.
United Nations General Assembly Resolution, A/RES/46/182. 19 December 1991.
The Office for the Coordination of Humanitarian Affairs, UNDAC. (2006) UNDAC Handbook, Fifth Edition.

JICA'S APPROACH IN EARTHQUAKE DISASTER REDUCTION – TURKEY'S CASE

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INTRODUCTION

Japan International Cooperation Agency (JICA) is the comprehensive implementing organization of the Government of Japan's Official Development Aid (ODA) by providing technical cooperation, concessionary loans, and grant-aid to meet the needs of people living in developing countries. In order to achieve JICA's Vision "Inclusive and Dynamic Development", 4 missions have been adopted, which are; (1) addressing the global agenda, including climate change, water security and food supplies, and infectious diseases; (2) reducing poverty through equitable growth; (3) improving governance, such as through reform of the policies and systems of developing country governments; and (4) achieving human security.

JICA has a network of 96 overseas offices and has undertaken projects in around 150 countries. The operation volume is estimated around $10.3 billion dollars, which is handled by approximately 1,600 staffs.

According to the ODA Charter of the Government of Japan, "disaster" is defined as a global issue which is the prioritized as an important area for assistance. In this context, JICA is actively extending cooperation to those disaster prone countries to support them build-up capacity to manage disasters in a more efficient and effective way. At this moment, more than 30 Projects related to disaster is on-going throughout the world.

JICA established strategic goals for each disaster management cycle stage, according to the Hyogo Framework of Action adopted in the World Conference on Disaster Reduction in January, 2005. Developing disaster resilient communities and societies is the strategic goal in the Preparedness/Mitigation phase, quick and effective delivery of emergency assistance to victims is the strategic goal in the Emergency Response/Relief phase, and smooth transition to and implementation of recovery and reconstruction is the aimed in the Recovery/Reconstruction phase. It can be said that JICA is a unique donor organization that has both technical and financial tools to reach out to the victims and people in every stage of a disaster. JICA is managing its disaster cooperation according to these strategic goals set.

As a bilateral donor organization of Japan, JICA have continuously supported the Republic of Turkey in the earthquake field, based on its common characteristics as being earthquake prone. It is worthy to note that JICA have seamlessly extended its support to every stage of the disaster management cycle starting from 1993, 6 years before the 1999 Marmara Earthquake.

As a result of this continuous support, Turkey has significantly gained its capacity in managing disasters, especially in the mitigation / preparedness phase, which in the past was more focused to react after an impact.

JICA is now implementing a Project to strengthen the research capacity of Istanbul Technical University and Middle East Technical University, which are the 2 core research centers for earthquake research. Also, in this year of 10th anniversary of the Marmara Earthquake, JICA is currently working to formulate "Disaster Education Project" and "Strengthening of Seismic Observation Capacity Project" which is expected to commence within this fiscal year.

Based on the experience of Japan, JICA will always be the driving force to promote disaster cooperation to achieve a disaster resilient and a sustainable Turkey and the world.

SEISMICITY AND SEISMIC HAZARD IN THE VICINITY OF ISTANBUL

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INTRODUCTION

The North Anatolian Fault (NAF) formed approximately 13 to 11 Ma ago in the east Anatolia and propagated westward. It reached the Sea of Marmara no earlier than 200 ka ago, although shear-related deformation in a broad zone there had already commenced in the late Miocene (Şengör et al. 2005). Tectonics in this region is characterized by the splitting of the NAFZ into at least two major branches running more or less in an E-W direction. Debates focus on the continuation and segmentation of NAFZ in the Marmara Sea problem in the earth science community. Several models have been proposed for the position and character of the NAFZ in the Marmara Sea region both on land and at sea. None of these models refuses the probabilities of high seismic hazard in the sea of Marmara region in this century.

The last 2000 years data on earthquake history of Marmara proves that the tectonic activity caused disastrous earthquakes in Marmara Region. The epicenter locations of historical (prior 1900) and recent (post 1900) earthquakes (Figure 1) correlate well with the known fault zones. Strong earthquakes of historical and instrumental periods, pattern of seismic activity mechanism solutions of active faults and stress tensor analysis (Figure 2) imply the continuation of NAF in the northern part of the Sea of Marmara and a high level of seismic hazard in the Marmara region.

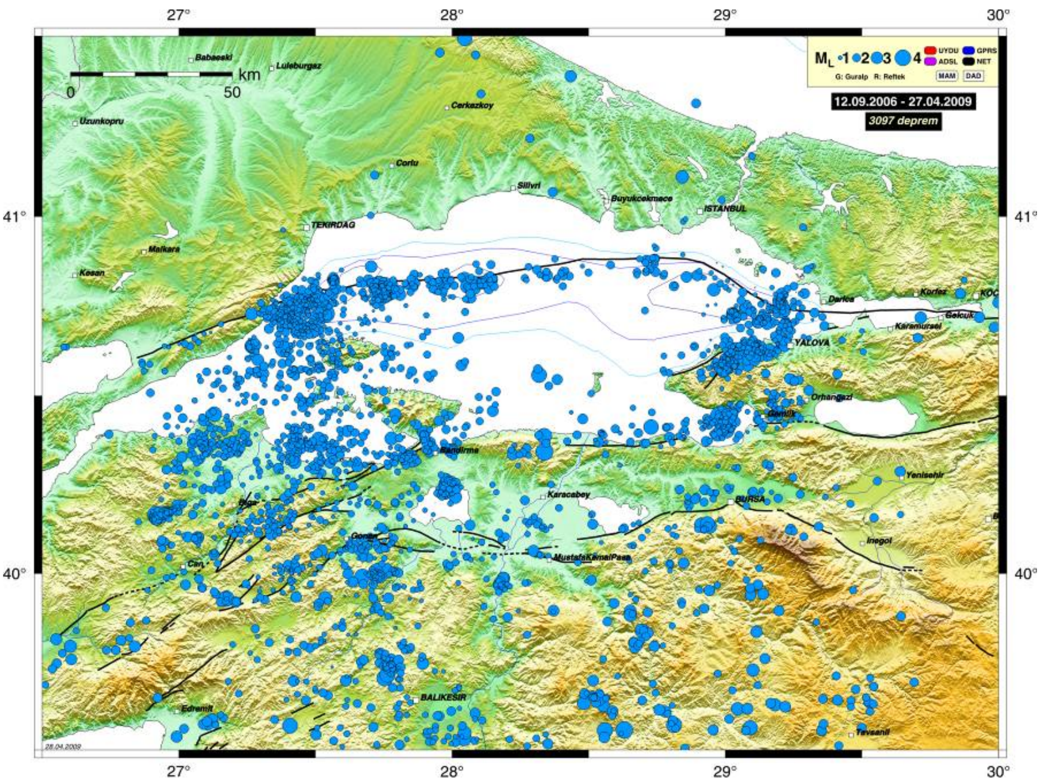

Figure 1. The epicentral map of earthquake activity determined during TÜRDEP Project study (İnan et al. 2007). The number of relocated seismic events is 3097 that occurred in the time period between 12.04.2006 and 27.04.2009. Earthquake epicenters are scaled to their magnitudes. Note the consistency of earthquake cluster at the north of Marmara Sea with the western extension of NAF.

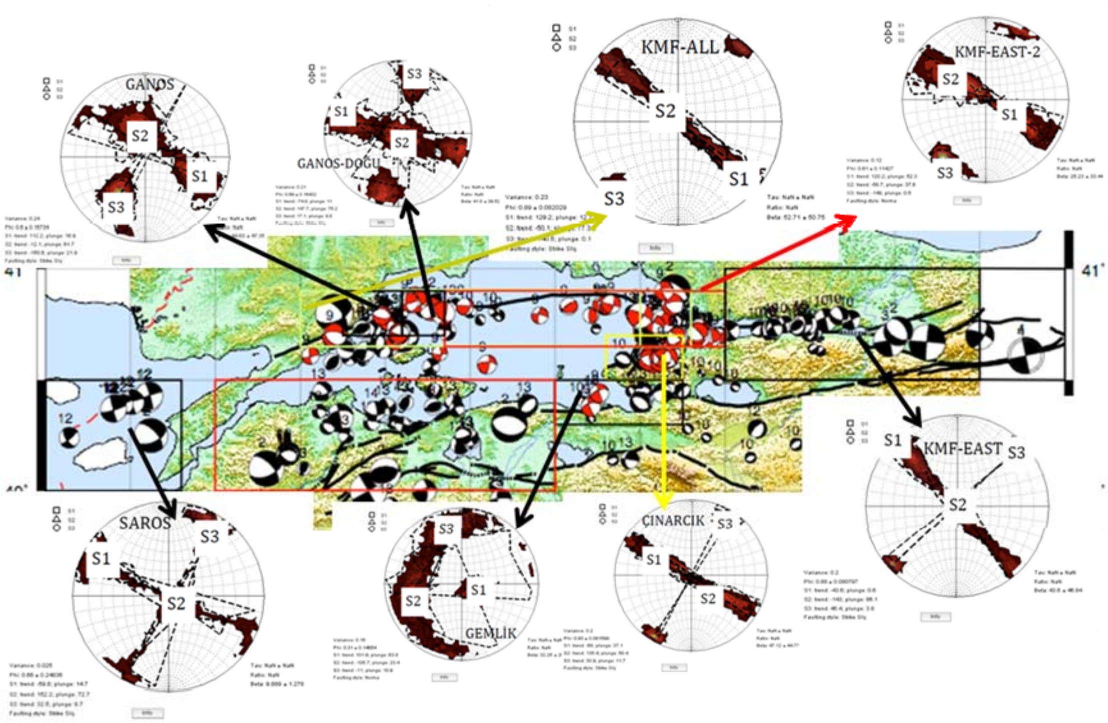

Figure 2. The stress tensor analysis of the Marmara earthquakes that occurred in the time period between 1912 and 2009 May. 300 earthquakes with magnitudes ranging between 3.0 and 7.4 have been used for stress tensor inversion. The lower hemisphere projection system was used for the mechanism solutions.

Until today, many qualified reports and studies directed to understanding the seismicity characteristic and earthquake hazard of İstanbul City and its vicinity have been published (Table 1).

Table 1. List of the seismic hazard models (probabilistic and deterministic) for Marmara and İstanbul City that are produced by different institutions and researchers.

MRPW (1998): 1 Probabilistic Model (Turkey)
JICA-IMM (2003): 4 Deterministic Models (Marmara).
BÜ-KOERI (2003): 1 Deterministic, 1 Probabilistic Model (Marmara).
Atakan, K (2002): 3 Probabilistic Models * 4 Attenuation Equations = 12 Probabilistic Models (Marmara).
Parsons (2000, 2004): 1 Hybrid Model (Marmara).
Cisternas et al. (2004): 1 Statistical Model (Hurst analysis).
Sesame (IUGS-UNESCO IGCP-382): Probabilistic Model, 2001-2003 (EU & Eastern Mediterranean).
Bayrak et al. (2005): Deterministic Model (Turkey).
General Directory of Railway, Harbour & Port of Turkey (2007): Probabilistic Model (Turkey).
Ulusay et al. (2004): Deterministic Model (Turkey).
İstanbul Metropolitan Planning Office (2006): Probabilistic Model (Istanbul).

Population is around 15 million in İstanbul City. Many industrial and urban complexes are located in the vicinity of İstanbul and Marmara region. Almost 40% of NGP is obtained from this region. A major earthquake may cause wide-spread and immense damage and loss (Erdik and Durukal, 2008). The expected economic loss may exceed the %10 of NGP of country. It is obvious that the seismotectonic and seismic hazard models and loss estimation studies for Marmara and İstanbul become vital.

The probability of occurrence of earthquake with magnitude Mw≥7.0 in the Sea of Marmara ranges between % 35 and % 70 in the next 30 years, depending on the method of calculations (Parsons, 2004). The Hurst analysis of the overall behavior of the 2000 years seismicity in the Marmara region gives a high probability (Hurst exponent: H = 0.82) implying that the maximum earthquake magnitude in the region could be larger than Mw = 7.5 (Cisternas et al., 2004).

CONCLUSION

- The NAF displays the right-lateral strike-slip character in the north Marmara Sea.
- Some localities close to Çınarcık and Central Marmara Basins display normal fault activity.
- The characteristics of seismic source zones, methodology and attenuation very much affect the hazard values. ‘Consensus’ is needed on these arguments and production of unique seismic hazard map that will satisfy the engineering needs
- Based on recent geological and seismological studies, Scientific Community agreed that the stress field along the western extension of North Anatolian Fault in Marmara Sea (namely North Marmara Fault), south of İstanbul metropolitan area will cause a large earthquake (M≥7) and may create Tsunami.
- The expected rate of maximum acceleration (PGA) along the southern coast of İstanbul ranges between 0.25 g and 0.6 g.

REFERENCES

Cisternas, A., Polat, O. and Rivera, L. (2004) The Marmara Sea region: Seismic behaviour in time and the likelihood of another large earthquake near Istanbul (Turkey). Journal of Seismology, 8: 427–437.

Erdik, M. and Durukal, E. (2008) Earthquake risk and its mitigation in İstanbul. Natural Hazard, 44:181-197.

İnan, S., Ergintav, S., Saatçılar, R., Tüzel, B. and İravul, Y. (2007) Turkey makes major investment in earthquake research. EOS 88:(34) 333.

Parsons, T. (2004) Recalculated probability of M > 7 earthquakes beneath the Sea of Marmara, Turkey, J. Geophys. Res., 109, B05304, doi:10.1029/2003JB002667.

Şengör, A.M.C, Tüysüz, O., İmren, C., Sakınç, M., Eyidoğan, H., Görür, N., Le Pichon, X., and Rangin, C. (2005) The North Anatolian Fault: A New Look. Annu. Rev. Earth Planet. Sci., 33: 37-112.

ISTANBUL SEISMIC RISK MITIGATION AND EMERGENCY PREPAREDNESS (ISMEP) PROJECT

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INTRODUCTION

Istanbul is most vulnerable city because of its seismic-prone location nearby the North Anatolian Fault, and its high population and commercial/industrial densities. Taking into consideration that the probability of a major potential earthquake will bring mass destruction in physical environment and economic sector with a high risk of life loss to Turkey, there is an urgent need to shift existing faith-oriented, reactive and recovery based policies into proactive, mitigative and preventive approaches.

Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) is a significant attempt to implement essential principles of comprehensive disaster management financed by the World Bank and the European Investment Bank. The main objectives are to improve the city of Istanbul's preparedness for a potential earthquake through enhancing the institutional and technical capacity for disaster management and emergency response, strengthening critical public facilities for earthquake resistance, and supporting measures for better enforcement of building codes and land use plans. Accordingly, ISMEP Project consists of three (3) components which are implemented through Istanbul Special Provincial Administration, Istanbul Project Coordination Unit.

DESCRIPTION OF THE PROJECT

The Project consists of the following components:

Component A Enhancing Emergency Preparedness

The objective of this component is to enhance the effectiveness and capacity of the institutions related with disasters and emergency management in Istanbul to prepare for, respond to and recover from significant emergencies, especially those arising from earthquakes. Specifically, the component will support:

- Improvement of emergency communications system,
- Establishment of an emergency management information system,
- Strengthening the institutional capacity of the İstanbul Disaster Management Center, Upgrading the emergency response capacity in the Istanbul metropolitan region,
- Public Awareness and Training.

Component B Seismic Risk Mitigation for Priority Public Facilities

The studies carried out under this component is relevant with the priority public buildings, support to the national disaster studies, cultural and historical heritage buildings. The main activities within the scope these components are shown below:

- Retrofitting or reconstruction of priority public facilities, including hospitals, clinics, schools, administrative buildings, student dormitories, social service facilities.
- Support National Disaster Activities.
- Development of an inventory of cultural heritage buildings in Istanbul and carrying out of
- seismic risk assessment of selected cultural heritage buildings.

Analyzing the current land management policies and instruments for identification of the different models and methods required for mitigating earthquake risks on public buildings with improved management and generation of new financial resources.

Component C Enforcement of Building Code

Includes the enhancement of the institutional and technical capacity for the enforcement of the building codes and various training activities.

Conducting a public awareness campaign for the importance of compliance with building code and land use plans.

Supporting ongoing and additional studies and activities to enhance guidelines and regulations for better enforcement of building code and land use plans.

Supporting the voluntary accreditation/training of engineering professionals in accordance with international and European standards.

Supporting selected municipalities to streamline issuance of building permits and introduce transparent measures in enforcement of building code and land use plans.

Social Aspects and Contributions

ISMEP Project including all components give crucial importance to accomplish social dimensions of ongoing technical and institutional works and to increase public awareness on disaster mitigation activities.

Under the scope of Component A, it is aimed to spread a disaster volunteering system throughout Istanbul, and to develop a conceptual, administrative and practical model for its integration with "Provincial Disaster Management Organization.

The activities for "Design and Implementation/Dissemination of Public Awareness Campaign and Materials for Disaster Preparedness and Building Code Enforcement" under Component A and C are aimed to increase public awareness on disaster prepardeness and importance of planning and building code enforcement for disaster mitigation by designing training modules, public awareness campaigns and materials for different target groups.

Under Component B, a study on the social aspects of retrofitting has been initiated in order to reduce the problems arising from the retrofitting works and to inform the beneficiaries. In that, it was aimed to increase the awareness of the administrative staff, teachers, students and their parents about retrofitting activities.

Summary of Project Implementation

The feasibility assessments completed to date cover 675 schools which include 985 buildings. 230 schools, which include 282 buildings, have been strengthened (retrofitted) and strengthening of another 90 schools (115 buildings) is in progress and expected to be completed by the end of January 2010. Another 12 schools have been rebuilt (reconstructed). Feasibility studies for 49 hospitals and polyclinics (consisting of 227 buildings) were carried out and 2 hospitals and one polyclinic were strengthened. One additional polyclinic is being reconstructed, and one pediatric hospital and two other healthcare centers are under design. Currently, 7 hospitals and polyclinics (18 buildings) are under construction for strengthening and procurement notice for the strengthening of another 2 hospitals/1 polyclinic will be published in the coming weeks. The strengthening and renovation of one administrative facility (2 buildings) and three dormitories (10 buildings) have been completed; 1 more dormitory and 5 social service facilities (17 buildings) are being retrofitted and 1 dormitory will be reconstructed following the preparation of the reconstruction design.

Progress was also made in the implementation of component A - Enhancing Emergency Preparedness. The back-up Governorship Disaster Management Center (DMC) has been further equipped with information and communication technologies and its staff have been extended. Several types of emergency response equipment delivered to the relevant institutions. Within the scope of component C (Enforcement of Building Codes), based on the needs assessment for pilot municipalities (Bağcilar and Pendik), the procurement of part of IT systems for better land use planning and building permit issuance has been completed and the rest is ongoing. The pilot trainings have been provided to the municipal decision makers, technical staff, muhtars and communities at the pilot municipalities.

CONCLUSION

ISMEP Project conveyed a pro-active approach for risk mitigation and prevention for a potential of earthquake in Istanbul. The activities of ISMEP Project have crucial importance in terms of the prevention of potential loss of lives and mitigation of social, economic and financial impacts. Besides, ISMEP Project will be an outstanding model for the design and implementation of other projects and activities in the field of disaster management.

REDUCING RISK OF EARTHQUAKE DISASTER BY EDUCATION

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INTRODUCTION

The August 17, 1999 Marmara Earthquakes impacted Turkey's industrial heartland at a critical economic time. We live, therefore, in a different world than we did before 1999. We are now more aware of our vulnerabilities and more understanding that we have a personal responsibility for the safety of our families, our neighbours and our nation. Pre-disaster measures such as mitigation and preparedness, therefore, came on to the agenda of the government and country, together with the 1999 Marmara earthquakes. The 1999 earthquakes therefore provoked major changes in policies and notable fundamental changes in attitudes to disasters, prompted by the scale of human and physical destruction in 1999 and the realization of probability that Istanbul could be struck by a major earthquake in the next 30 years. Disasters may strike quickly and without warning, similar to the Marmara Earthquakes of 1999.

The recent disasters question behaviour regarding our own safety, the safety of our family and community, and moral issues of right and wrong. Local officials and relief workers will be on the scene after a disaster, but they cannot reach everyone right away. Therefore, the best way to make your family and your community safe is to be prepared by education before disaster strikes.

Actions recently taken by ITU Disaster Management Research and Implementation Center to eliminate or reduce the long-term risk to human life and property, from the impact of future hazards, and some of the recent activities that involves achieving readiness status among communities, individuals, government and businesses to effectively respond to and recover from a disaster in Turkey are categorized and summarized below.

The Center of Excellence for Disaster Management was established in 2001 at the Istanbul Technical University under a memorandum of understanding with the United States Federal Emergency Agency (FEMA). ITU and FEMA carried out project ACHIEVE (A Cooperative Hazard Impact reduction Effort via Education); a Disaster Management Education Project implemented according to an agreement signed in 2000 between the Prime Ministry of the Republic of Turkey and FEMA. 31 Faculty members from ITU were certified by FEMA on February 28, 2001 to carry out education and training programs in Turkey.

The aim of the Center of Excellence for Disaster Management is to train local and organizational officials for disaster management, who are employed as public or private officials required to work at disaster sites, officials working in local authorities, and emergency operations centers and architects, engineers, teachers and students. All new techniques and knowledge regarding disaster management is conveyed by seminars and courses to the target groups. The long and short-term goals of the center are to train officials for disaster prevention and mitigation. Priority is given to emergency managers of relevant institutions and local authorities and secondly, public training programs are considered. The most important outcome of the project is the training of local disaster management officials in order to prepare the country and its people for a possible future disaster, minimize any possible losses, and accelerate the recovery stage following a disaster. Along with this national training project, work has been done to prepare a national disaster preparedness plan which had the first round of approval on June 1, 2009 in the Turkish parliament. The center has published books and proceedings, organized education seminars on national and international levels and coordinated research projects. Among them, the educational activities may be grouped as follows:

National Activities: Some research projects that have been realized by ITU -CEDM for the Turkish Ministry of Interior:

- Cooperation with Ministry of Internal Affairs
- National Emergency Management, Education and Exercise Implementation Program
- Development of National Emergency Management Model
- The Restructuring of the Turkish Fire Bridges
- The Development a National Database Using GIS & Remote Sensing Systems (RSS) and the Standards For a Disaster Management Decision Support System

ITU -CEDM has been enabled institutions and organizations to improve their integrated disaster management point of view. The center assisted the Erdemir-Ereğli Steel Company Disaster Management Planning Consultancy with the improvement of their disaster management Systems and planning.

ITU CEDM has Cooperation agreements with:

1. Ministry of Interior, Republic of Turkey
2. Ministry of Public Works & Settlement, Republic of Turkey
3. The Governor's Office of Istanbul
4. İstanbul Municipality
5. Turkish Red Crescent Society
6. AKUT (Search & Rescue Association)
7. FEMA
8. JICA

Faculty members involved in the ITU CEDM initiated a Master of Science degree program in Disaster Management. The mission of the program is to educate professionals, who are in charge with emergency and/or disaster management systems, equipped with contemporary knowledge and abilities to establish and coordinate effective disaster manager capacities and system with an ultimate goal of saving live and property.

General Topics:

- Incident Command Systems
- Mitigation Strategies
- Emergency Drills and Exercises
- Disaster Resilient Community
- Community Training for Disasters
- Disaster Management for Earthquakes
- Donation Management
- Mass Care and Shelter
- Resource Management
- Volunteer Resources
- Emergency Response Teams
- Vulnerability and Risk Assessment
- Hazard Mapping
- Business Continuity

Specific Topics:

- Communication Technologies
- Terrorism
- Technological Disasters
- Emergency Management in Schools
- Building Security and Safety
- Emergency Management in Industrial Facilities
- Emergency Management in Transportation
- Emergency Management in Airports
- GIS Based Data for Disasters
- Debris Management
- Fire Management

- Public Education and Awareness
- Standard Operating Procedures

The center has published more than 20 books in related with disaster management subjects to meet the needs of documents and source book in Turkish. For example:

1. The Restructuring of the Turkish Fire Brigades under the Light of International Experiences, ITU Press, 2001.
2. A Model for Restructuring the Turkish Fire Brigade (in Turkish), ITU Press, 2002.
3. A National Emergency Management Model Study (in Turkish), ITU Press, 2002.
4. Proceedings, FEMA-ITU Higher Education Conference in Turkey, 2003.
5. Disaster Management Planning for Schools, ITU Press, 2004.
6. The Disaster Management Reconnaissance Report for the Nov.15 and Nov. 20 Terrorist Attacks in Istanbul, ITU Press, 2004.

As a summary framework for our center in disaster reduction can be listed as follow:

- Generate New Knowledge
- Transfer Knowledge
- Advocacy
- Community Service
- Setting Positive Example

Future work includes the dissemination of knowledge and experiences of ITU-CEDM in the field of disaster management to Turkey and the region in order to mitigate vulnerability of disaster as a whole.

REFERENCES

Blanchard, B.W., (2003), The Role of Colleges and Universities in Disaster Reduction. Kocaeli '99 Emergency Management Conference Istanbul Technical University, Istanbul Turkey. 16-17 January 2003.

TURKISH CATASTROPHE INSURANCE POOL (TCIP)

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INTRODUCTION

ABOUT TCIP

By reason of geologic and topographic structure and climate attributes of our country, it is frequently confronted with natural disasters that lead to immense losses of life and property. Natural disasters that affect our country can be put in order according to their severity; earthquakes, land slides, water floods, rock sliding, fires, avalanches, storms and underground water movements. Within the past 60 years, when we take into consideration the statistics of the structural damage caused by the natural disasters in our country, it is observed that 2/3 of these damages occur due to earthquake. As a result, in our country when we mention natural disasters, the first thing that comes to peoples mind is earthquakes. When basing the seismic zones map that is in effect at the present time, 96% of the territories of our country are inside the seismic zones that possess various ratios of risk, and that 98% of our inhabitants are located in these areas. These ratios dramatically reveal the fact that our country is an earthquake country.

The effects of the earthquakes in our country not only felt in the disaster originated regions but whole country, and therefore all of the residents living in the country are affected by the consequences of an obvious and considerable extent. Compensating the material damages, getting back to regular life in seismic zones, alleviating the needs of those who require emergency assistance, and so on incurred expenditures brings an immense financial burden to the national economy and the state. 17th of August 1999 Marmara Earthquake is the most recent example for this and deemed as the disaster of the latest century, which caused a huge devastation for our country in economic and social aspects.

Subsequent to the Marmara earthquake which took place on 17th of August 1999 and caused loss of thousands lives and properties, great numbers of precautions were taken in order to minimize the damages of earthquakes by the public authority. On of the most significant precautions is the execution of the Turkish Compulsory Insurance Pool (TCIP).

Within the Marmara Earthquake Emergency Reconstruction Project, World Bank assisted Turkey in designing insurance program to be able to manage its own national catastrophic exposure. The project consisted of two main objectives; one was technical assistance to the General Directorate of Insurance in establishing TCIP and ensuring sound management of the pool for the first five year of establishment. The second was to provide initial capital through contingent loan facility. The project was the first World Bank project to have components of financial risk management, disaster mitigation and emergency preparedness.

Immediately after the devastating earthquake, on 27.08.1999 Law No.4452 "Measures to be taken Against Natural Disasters and Authorization in Regards to Arrangements to be done in Overcoming the Damages Caused by Natural Disasters Law" was enacted giving three months of provisional authority to the Council of Ministers to organise and establish legal framework against natural disasters. With this power of authority Decree Law No.587 "Decree Law Relating to Compulsory Earthquake Insurance" entered into force by being published on 27.12.1999 that has given birth to TCIP. The tariffs and regulations were published on 8th of September 2000 and as of 27th of September 2000, TCIP began offering cover after 9 months of formation process following decree law. Following year on 27th of March 2001, earthquake insurance has become compulsory for the dwellings those subject to compulsory earthquake insurance as described in the decree law. Currently 28 accredited insurance companies and their agents are providing Compulsory Earthquake Insurance in the name and on behalf of TCIP. This newly formed system produced a victorious performance at a short time and proposed as a model solution for many countries by the international organizations.

THE PURPOSE OF TCIP

Compulsory Earthquake Insurance is a new insurance system which is created to ensure the compensation of the material damages on dwellings caused by earthquakes. Following a comprehensive research, this system is created with the cooperation of the World Bank, Turkish Government and the insurance sector and its fundamental purposes are as follows:

- In order to give insurance protection against the earthquake for all the residences, subject to compulsory earthquake insurance, in return for a affordable premium, to provide risk sharing mechanism within the country, at the same time transferring financial burden caused by the earthquake damages to the international reinsurance and capital markets through insurance system.
- Reducing the state's financial burden caused by the earthquakes
- To use the insurance system as an instrument in increasing the quality of construction of houses.
- Ensuring long term fund accumulation for compensation of earthquake damages
- To contribute to the development of insurance awareness in the society.

With the application of the Compulsory Earthquake Insurance, without relying to the budgetary means of the government, a concrete protection is provided by immediately compensating the material losses in residences. At the same time, by way of public relation activities and affordable cost of insurance increased public awareness on earthquake insurance. Until sufficient internal sources are accumulated, a significant portion of the risk is transferred to the international markets through reinsurance schemes. Because the financial burden incurred on national budget as a result of earthquakes is reduced, potential additional taxes are prevented.

STRUCTURE OF TCIP

Pool Management Company

The government decided to outsource all operational tasks to private insurers. The decision necessitated engagement of a manager to handle all technical tasks in the TCIP's daily operations. The government appointed MIli Re as the Pool Management Company for five years until 2005. As from 2005, these tasks have been put forward by the Garanti Insurance Company in the capacity of Manager of Pool until year 2010.

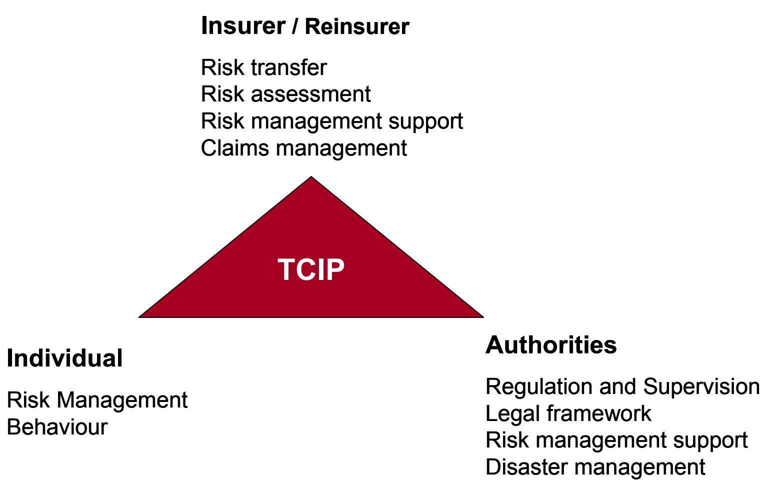

Figure 1. Public / Private Partnership

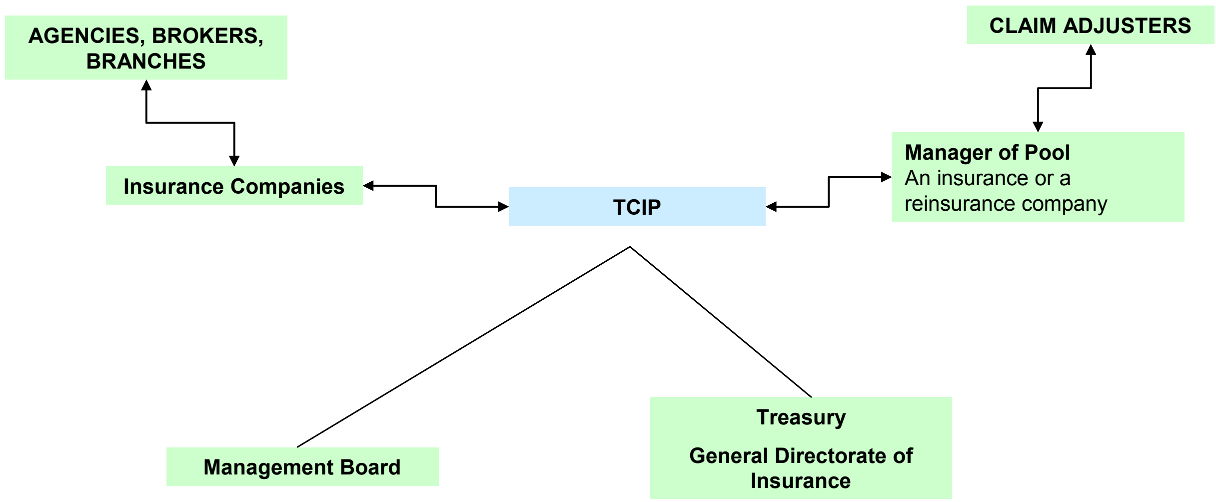

Figure 2. Operational Structure

DETAILS OF COMPULSORY EARTHQUAKE INSURANCE

Insurable Property

Compulsory Earthquake Insurance constitutes a system of insurance that is in general meaning, intended for dwellings that remain inside the boundaries of the municipality. Buildings and dwellings subject to compulsory earthquake insurance are as follows:

- Building constructed as dwellings on lands subject to private ownership and has registered title deed,
- Independent sections within the context of the Condominium Law No: 634,
- Independent sections situated inside residential buildings but used as small business establishment, bureau and similar purposes,
- By reason of natural disasters, properties built by the government or built by housing credit,

Un-Insurable Property

The properties that fall outside the Compulsory Earthquake Insurance are as follows:

- The dwellings belonging to public body and institutions
- The dwellings built in residential areas of a villages
- The dwellings entirely used for commercial and industrial purposes (Block of offices, business center, administrative service buildings, training center buildings etc.)
- The dwellings that are still under construction
- Independent units and dwellings that were built after 27th of December 1999, without any construction permit granted within the framework of the legislation

Compulsory insurance for the dwellings built in residential areas of villages is not anticipated for the reasons such as there are no municipal inspections and building inspection system and because who live in these areas anticipated to have a low level of income. However, for the homeowners those reside in these areas, if wishes so, may obtain earthquake insurance from insurance companies in the market. Owners of commercial and public buildings are not required to buy earthquake insurance, but they can voluntarily purchase it from private insurance companies.

Scope of Cover

With the Compulsory Earthquake Insurance;

- Earthquakes
- Fires as a result of earthquakes
- Explosions as a result of earthquakes
- Landslides as a result of earthquakes

causing material damages to the insured buildings are covered up to the sum insured by TCIP including foundations, main walls, common walls separating independent sections, ceilings and bases, stairs, platforms, halls, roofs, and chimneys.

Maximum Sum Insured

The intent of the Compulsory Earthquake Insurance is to have a standard cover with a minimal premium. Consequently, TCIP grants cover in specified maximum sum insured determined by using unit cost of building construction. As of 01nd of January 2009 maximum sum insured amount granted by TCIP policies in all structure types is determined as 140.000 Turkish Lira.

The sum insured is determined according to the magnitude and structure type however not exceeding the maximum sum insured amount of the dwellings. If the value of the dwelling exceeds the sum insured amount given by TCIP, the insured optionally can get additional cover for the exceeding amount from the insurance companies.

Tariff Rates and Premiums

The TCIP's premium tariff is determined by the Treasury Under secretariat and 3 factors determine the insurance premium amount:

- Location of the building according to earthquake risk zones
- Construction type of the building
- Gross square area of the dwelling

Descriptions of the structure styles that are indicated in the tariff are as follows:

A. Steel, Reinforced Concrete Frame Structures: These structures are made up of steel or reinforced concrete bearing frames.
B. Masonry Stone Structures: These are structures that do not have frames, bearing walls made by rubble stones, hewn stone, brick or filled, unfilled concrete briquette, and floorings, stairs and ceilings made up of concrete or reinforced concrete.
C. Other Structures: Structures that do not enter into the above mentioned groups.

Policy sum insured is obtained by multiplying the unit square meter costs with the gross square meter area of the dwelling.

As of 1st of January 2009, the unit square meter costs which are settled according to the structure type and used in calculation of the insurance compensation are as follows:

A. Steel, Reinforced Concrete Frame Structures: 550 TL
B. Masonry Stone Structures: 395 TL
C. Other Structures: 205 TL
(Maximum sum insured for all construction type is determined as 140 thousand TL.)

The above indicated gross square meter values which are used as base in calculation of the insurance compensation, determined annually according to changes in the ratios of the "Building Construction Cost Index" statements made by the State Institute of Statistics and announced in the Official Gazette.

Base policy premium is obtained by multiplying the sum insured with the tariff rate.

Premium Amounts According to the Risk Zones and Construction Types (for Istanbul)

FOR ISTANBUL PREMIUM AMOUNT FOR 100 SQUARE METER RESIDENCE (TL)				
		RISK ZONES AND PREMIUM (TL)		
CONSTRUCTION TYPE	**SUM INSURED**	**I**	**II**	**III**
Steel, R Concrt	(100 s.meter x 550 TL.) 55.000	136.00	100.30	60.70
Masonary Stn	(100 s.meter x 395 TL.) 39.500	167.10	123.60	71.50
Others	(100 s.meter x 205 TL.) 20.500	127.80	87.40	51.10

Premium Amounts According to the Risk Zones and Construction Types (Outside of Istanbul)

OTHER CITIES PREMIUM AMOUNT FOR 100 SQUARE METER RESIDENCE (TL)						
		RISK ZONES AND PREMIUM (TL)				
CONSTRUCTION TYPE	**SUM INSURED**	**I**	**II**	**III**	**IV**	**V**
Steel, R Concrt	(100 s.meter x 550 TL.) 55.000	131.00	95.30	55.70	40.30	34.20
Masonary Stn	(100 s.meter x 395 TL.) 39.500	162.10	118.60	66.50	33.70	29.80
Others	(100 s.meter x 205 TL.) 20.500	122.80	82.40	46.10	26.00	25.00

In the apartment buildings and housing complexes within the context of regulation, group insurances took out by the administrator which has minimum eight independent sections are subject to 10% discount from the above mentioned tariffs. Minimum premium on TCIP policy is 25 TL

Essential Information and Documents for Insurance Policy

Essential information is as follows:

- Name, address, telephone number and mobile phone number of the insured
- Tax ID number and Turkish Republic ID number of the insured
- Full address of the residence that is to be insured
- Title deed information (block, plot, parcel, page number) (dwelling title deed or land title deed)
- Construction year of the building (1975 and before, between 1976 – 1996, between 1997 – 1999, 2000 and after)
- The construction type of the building (Steel, Reinforced Concrete Frame Structures, Masonry Stone Structures, others)
- Total number of floors in the building
- The damage condition of the building (free of damage, slightly damaged, moderately damaged)
- Gross square meter (m2) of the dwelling (apartment)
- Type of usage of the dwelling (apartment) (residential home, business establishment, office and others)

Distribution Channels

Compulsory Earthquake Insurance policies are arranged through the accredited insurance companies and agents belonging to these companies in the name and on behalf of TCIP. Currently 28 accredited insurance companies and their agents are providing Compulsory Earthquake Insurance in the name and on behalf of TCIP.

TCIP has contractual agreement with the insurance companies. Insurance companies are obliged to pay sum of monthly premium production to TCIP at the beginning of the following month.

Basic Figures about the Portfolio of TCIP

Total No. of Policies	3.299.778
Total Sum Insured	86.000.000.000 €
Total Annual Premium	145.000.000 €
Avg. Sum Insured	24.000 €
Avg. Premium	44€
Growth by number of policies (%)	20.4
Total number of Paid Claim Files	10.471
Total Claims Paid (from 2000)	9.163.000 €

GENERATION OF CODE COMPATIBLE ARTIFICIAL EARTHQUAKES

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INTRODUCTION

Most of the current world-wide earthquake resistant design codes permit the usage of artificial strong ground motions, either during the design stage or for the performance analysis of existing structures. According to the latest version of Turkish Earthquake Resistant Design Code of 2007 (TERDC-2007), at least three generated acceleration records in accordance with certain properties should be used for seismic analysis to be performed by linear or nonlinear time history analysis, and the most unfavourable response quantities should be considered in the design. Alternatively a set of 7 artificial strong motions should be employed; henceforth mean values of the structural response values are taken into account. Herein this study, an iterative methodology based on structural dynamics theory is proposed to obtain the design spectrum compatible artificial acceleration time series.

THEORETICAL BACKGROUND

TERCD-2007 permits the employment of artificial ground motions during linear or non-linear time history analysis. According to the code regulations, these motions have to satisfy the following conditions:

- The duration of strong motion part of the acceleration record shall neither be less than 5 times the first natural vibration period of the building nor less than 15 seconds.
- Mean value of spectral acceleration for each recorded or simulated acceleration record with 5% damping ratio at zero period (T=0) shall not be less than the spectral acceleration A0×g where A0 is the effective ground acceleration coefficient specified according to the seismic zone and g is the acceleration of gravity.
- Mean of the spectral acceleration values computed for each recorded or simulated acceleration record with 5% damping ratio within a period range of 0.2T1~2T1, where T1 is the dominant vibration period of the structure, shall not be less than 90% of the elastic spectral acceleration Sae(T).

Synthetic motions are mostly generated by stochastic methods that take into account the local site effects and seismicity of the region, (Taşkın and Hasgür, 2006). Alternatively, as in this paper, a deterministic method based on attaining the design spectrum iteratively by using Fourier Transform Pairs, is introduced. The first simulation step is realized by filtering, therefore changing the frequency content of any strong motion record and later approaching the target design spectrum ordinates by inverse Fourier transformation. Finally, simulated time histories are obtained by applying FFT.

Iteration Procedure

The iterative procedure for the generation of an artificial earthquake initiates with the selection of the code defined elastic design spectrum Sae(T), adequate with the local site conditions and seismic zone. Later any recorded acceleration time history a(t) and the duration of the artificial earthquake td is selected to be used for the simulation.

Simulation starts with the calculation of the absolute acceleration response spectrum Sai(T) of the selected earthquake record. As well known, spectral values are computed by the solution of the dynamic equation of motion (Eq.1) of a SDOF system having a mass of M; damping C and stiffness K.

$$M\ddot{u}(t) + C\dot{u}(t) + Ku(t) = -M\ddot{u}_g(t) \quad \Rightarrow \quad u(t) = -\frac{1}{\omega_{Di}} \int_0^t \ddot{u}_g(\tau) \exp\left[-\xi\omega_i (t-\tau)\right] \sin \omega_{Di} (t-\tau) d\tau \qquad (1)$$

Here $\ddot{u}_g(t)$ is the ground acceleration; u(t), $\dot{u}(t)$ and $\ddot{u}(t)$ are the relative displacement, velocity and acceleration of the SDOF system subjected to $\ddot{u}_g(t)$. ω_i is the angular frequency; ξ is the damping ratio and $\omega_{Di} = \omega_i\sqrt{1-\xi^2}$ is the angular frequency of the damped system.

The spectral ratio defined in Eq.2 is computed by the division of Sai(f), which is the absolute acceleration response spectrum for specific values of frequency, by the elastic design spectrum with ordinates converted to frequency, Sae(f).

$$K(f_j) = \frac{S_{ae}(f_j)}{S_{ai}(f_j)} \qquad f_j = \frac{\omega_j}{2\pi} \qquad \text{j=1,2,…,N} \qquad (2)$$

By applying Fourier Transformation to the selected record by Eq.3, Fourier Spectrum FS(j) is calculated. Depending on the value of the K(fj) ratio converging to 90%, reverse Fourier Transformation is applied to obtain the new time histories as in Eq.4.

$$FS(\varpi) = \left|\int_0^{t_d} \ddot{u}_g(t) e^{-i\varpi t} dt\right| \quad [FS(\varpi)]^2 = \left[\int_0^{t_d} \ddot{u}_g(\tau)\cos(\varpi\tau)d t\right]^2 + \left[\int_0^{t_d} \ddot{u}_g(\tau)\sin(\varpi\tau)dt\right]^2 \qquad (3)$$

$$\bar{a}(t) = \int G(f) e^{ift} df \qquad \Rightarrow \qquad G(f_j) = FS(f_j)\cdot K(f_j) \qquad (4)$$

The first obtained simulated motion has to be multiplied by high-and low pass filtering functions $H_1(i\varpi)$ and $H_2(i\varpi)$ and later by envelope Z(t) so that both the frequency content in the strong motion portion and the peak velocity and displacement values are captured.

Below Fig.1 exhibits the flowchart of the procedure for generating an artificial earthquake.

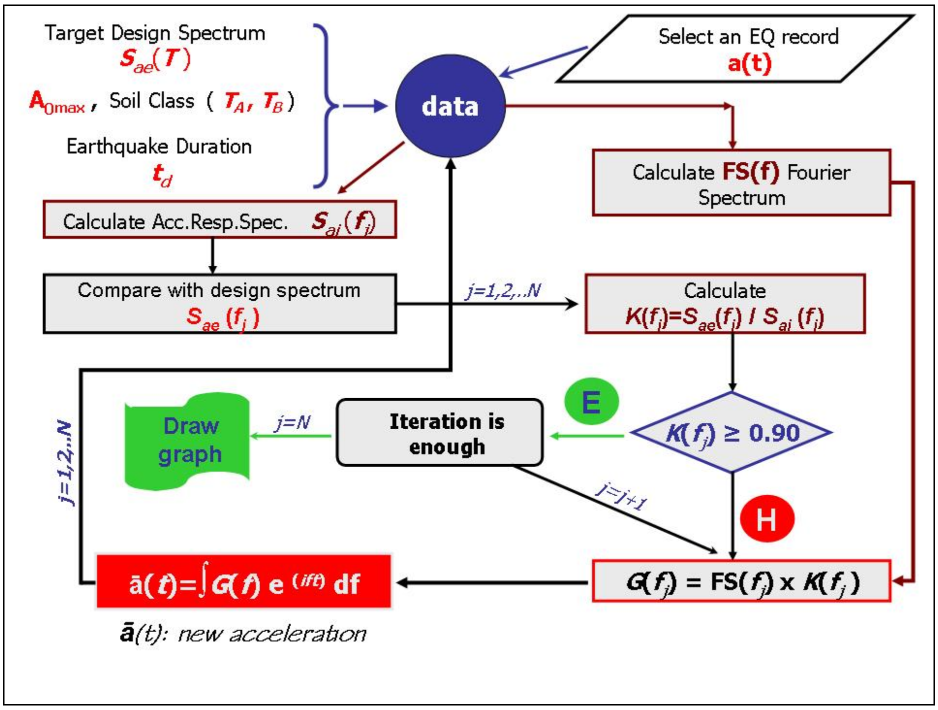


Figure 1. Flowchart of the iterative procedure.

GENERATION OF AN EXAMPLE ARTIFICIAL STRONG MOTION

As an example case to illustrate the success of the iterative procedure in frequency domain, an artificial earthquake motion is generated for seismic zone-1 (A0=0.40) with a duration of td=40s considering a soil class of Z2 with characteristic spectral periods T_A=0.15s and T_B=0.40s. Bolu-EW component of November 12, 1999 Düzce Earthquake is selected as the initial record. Following Fig. 2, shows the original time history compared with the artificial motion generated right after the first simulation step. The $H_1(i\varpi)$ filtering parameters are applied as ω_1=15.6 rad/s and ξ_1=0.60 as advised by Kanai and Tajimi (1960); $H_2(i\varpi)$ filtering parameters are used as ω_2=0.897 rad/s ve ξ_2=0.715 as in Murakami and Penzien (1975). Housner-Jennings B type envelope function Z(t) is also employed during the first iteration step.

Taking the first period as T(1)=0.025s (f=0.40Hz) with an increment of ΔT=0.002s to T(5)=0.033s and afterwards selecting the ΔT=0.05s up to T=5.1s, a number of 89 discrete periods are used during the simulation.

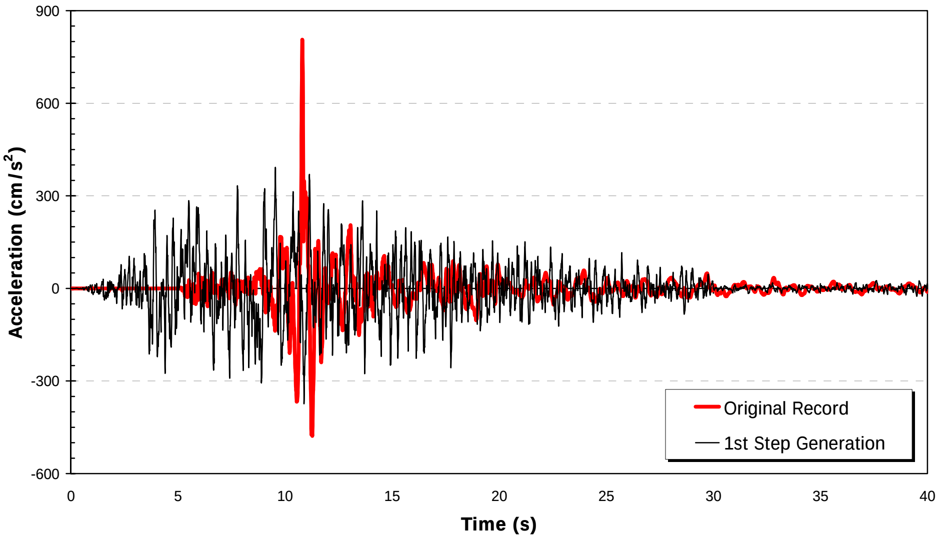


Figure 2. Comparison of the acceleration-time histories after the first simulation step.

Figures 3 and 4 exhibit the number of iterations realized for each period and the final acceleration response spectrum compared with the elastic design spectrum in TERDC-2007.

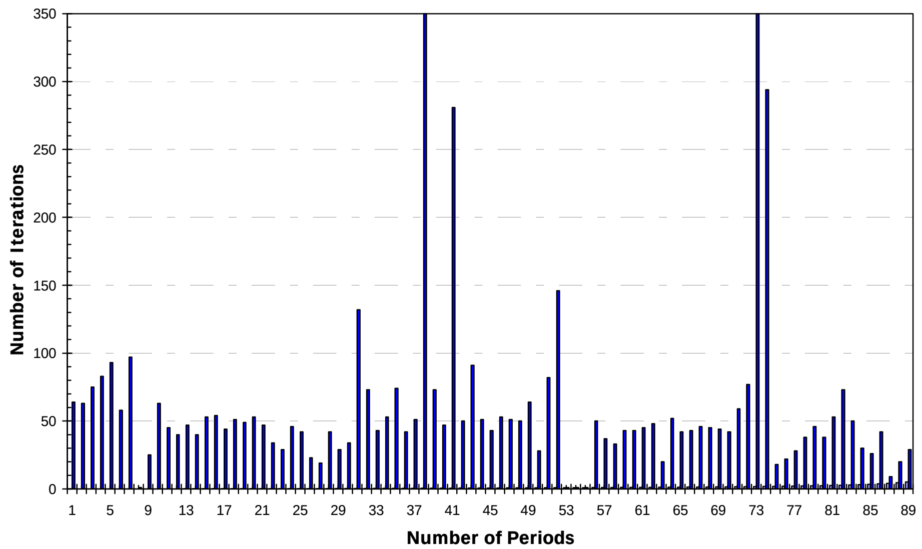
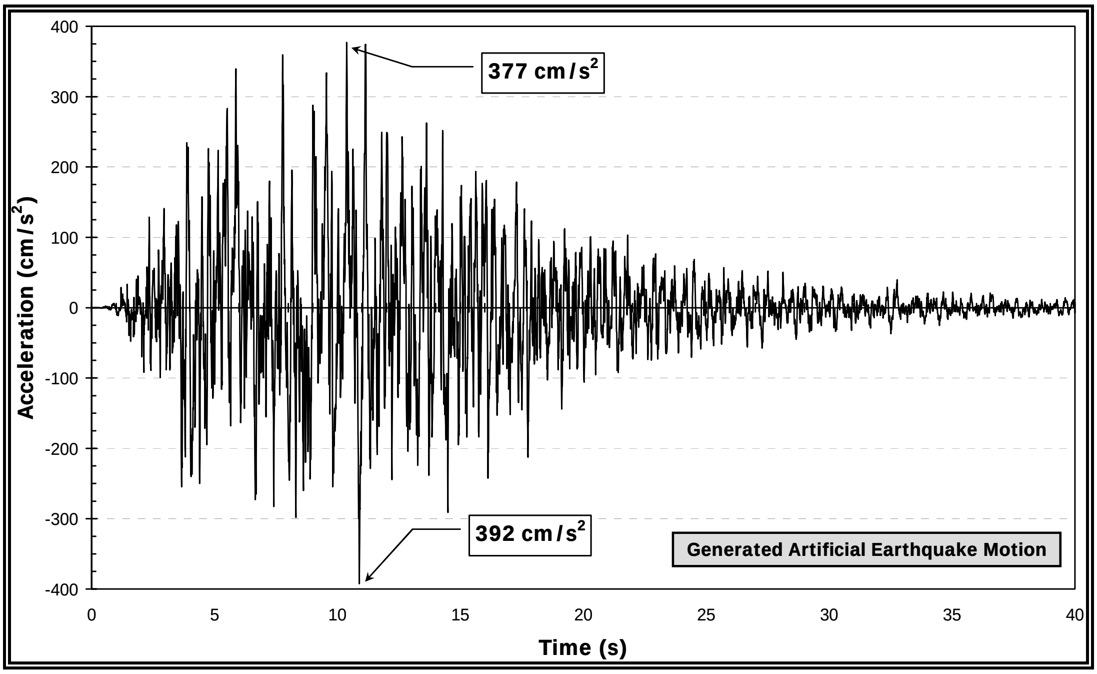


Figure 3. Distribution of number of iterations.



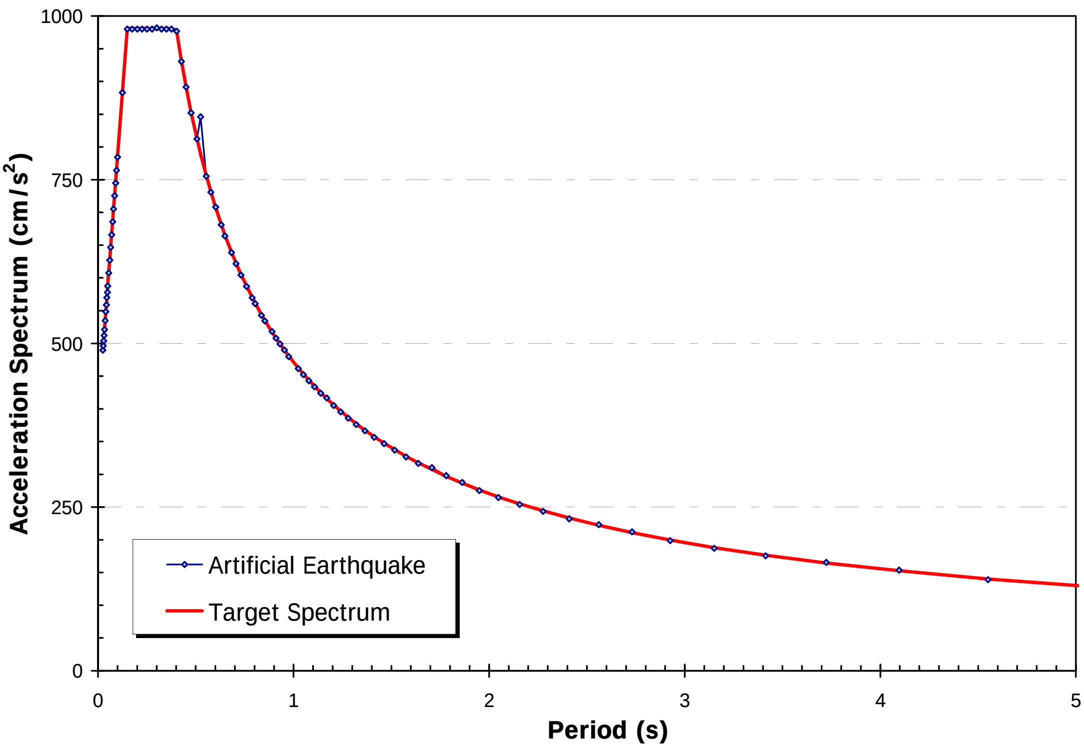


Figure 4. Comparison of the spectra for artificial earthquake and target spectrum.

REFERENCES

Ministry of Publicworks & Settlement (2007) Turkish Earthquake Resistant Design Code, Ankara, Turkey.

Taskin B., Hasgür Z. (2006) Monte Carlo analysis of earthquake resistant R-C 3D shear wall-frame structures, Structural Engineering & Mechanics 22(3), 371-399.

Murakami M., Penzien J. (1975) Nonlinear response spectra for probabilistic seismic design and damage assessment of reinforced concrete structures, University of California, Berkeley, EERC:75-38.

Tajimi H. (1960) Semi-empirical formula for the seismic characteristics of the ground, Proceedings of the 2nd WCEE, Tokyo and Kyoto, 781-798.

HISTORICAL BUILDINGS-RENOVATION WORKS-EARTHQUAKE RISK

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INTRODUCTION

“Preservation of historical buildings”, which belongs to all humankind, has become the most important issue of our century. Especially in countries which are placed in seismic zones like our country is, many precautions have been taken against seismic risk. We have been witnessing to considerable development in the field of earthquake engineering. Earthquakes which occur not only in our country, but also in other countries became a good reason for developing new rehabilitation techniques.

Besides, especially while strengthening of our historical buildings against seismic risk, important progress has been obtained in civil engineering, architecture, history of art and restoration.

Unfortunately, it has been observed that sometimes negative effects arise while strengthening of historical buildings.

Many of the historical buildings have been under seismic risk because of intervention on their structural systems. For example, in masonry buildings, holes have been opened in lateral load bearing masonry walls. Unfortunately, the unconsciously done changes in structural systems have caused a lot of uncertainties in these important historical buildings.

INTERNATIONAL PLATFORM FOR REDUCING EARTHQUAKE DISASTERS (IPRED)

United Nations
Educational, Scientific and
Cultural Organization

Japan International
Cooperation Agency

ISTANBUL TECHNICAL UNIVERSITY
1773