(3) Lectures "Protecting Lives: Lessons learned and Future prospects"

1) Views for Post-2015: Achievements and Challenges in the Field of Disaster Risk Reduction

Mr. Sálvano Briceño, Chair of the Science Committee, Integrated Research on Disaster Risk and Former Director of UN International Strategy for Disaster Reduction reiterated that the trend of increasing natural disasters is not due to the increase in natural phenomena and hazards but due to the increase in vulnerability of society. Traditionally, societies have been focused on preparing for response to disaster. However, there is an urgent need to focus on risk reduction, i.e. addressing the vulnerabilities that are the main causes of disaster. These vulnerabilities include poorly constructed and located buildings, ecosystem and natural resource depletion, lack of risk awareness and risk governance institutions and accountability. Then, universities are still training professionals of different disciplines in a fragmented manner rather than with integrated and holistic approaches. These problems led to the creation of the topic of "disaster risk reduction" (DRR) and the launch in 2000 of the United Nationals International Strategy for Disaster Reduction (ISDR). ISDR is a conceptual framework aimed at building disaster-resilient communities by increasing awareness of disaster reduction's importance as an integral component of sustainable development, with the goal of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters.

ISDR was launched as a successor to the International Decade on Natural Disaster Reduction (IDNDR) from 1990 to 1999. In 2005 the Hyogo Framework for Action (HFA) was adopted by 168 Member States of the United Nations at the World Disaster Reduction Conference. The HFA is a 10-year plan to make the world safer from natural hazards. ISDR is now preparing for the third World Disaster Reduction Conference in 2015 where a post-Hyogo regime will be adopted. The HFA set up the basis for risk-governance mechanisms; however, governments are still in the early stages of developing them and there is a need to strengthen them as a policy priority. That governance needs to include accountability, transparency and participatory approaches. DRR also needs to be recognized not only in the climate change adaptation process but also as the first step before adaptation can take place in all other sectors. DRR is also an essential requirement in the next phase of the Millennium Development Goals (MDG). Environmental policies need to include formal recognition of DRR as an essential ecosystem service. There is also a need for greater awareness of the importance of safety in all buildings, which can only be achieved through greater high-level leadership.

Because the academic world is at the origin of the problem through the fragmentation of education of professional disciplines, the Integrated Research on Disaster Risk program was launched aiming to have the scientific community develop more integrated approaches to understanding risk in research and in education.

2) Long-Period Ground Motion as a New Urban Threat

Mr. Kazuki Koketsu, Professor at the Earthquake Research Institute of the University of Tokyo explained that long-period ground motion (LPGM) has become an important issue due to the recent rapid increase in number of large-scale structures, and it can also affect base-isolated buildings. Large subduction-zone earthquakes and moderate to large crustal earthquakes can generate far-source LPGM in distant sedimentary basins through path effects, while near-fault LPGM is mostly generated through the source effects of rupture directivity. Far-source LPGM consists primarily of surface waves with a longer duration than that of near-fault LPGM. Unlike short-period ground motion, LPGM can only be predicted through numerical simulation.

The Japanese government's Headquarters for Earthquake Research Promotion (HERP) set up the Section for Subsurface Velocity Structures (SSVS). Numerous institutions constructed velocity structure models across Japan, and SVSS has begun a three-year project to update those models for LPGM hazard maps. These maps are being created through numerical simulation. The updated models will be combined into a Japan integrated velocity structure model. Velocity structure models control the accuracy of LPGM hazard maps more than source models. A velocity structure consists of three parts, called the "surface soil layers," the "deep sedimentary layers" and "crustal structure deeper than the seismic basement." Surface soil layers do not affect LPGM as much as the other two parts, so the focus is on the two parts that are lower than the engineering bedrock. The use of accretionary wedges has been shown to be very important in developing a velocity structure model for LPGM. For the final difference algorithm, numerical simulation requires the velocity structure topography to be flattened, and the "squashing" method—pushing topographical features from above sea level to below sea level—has been shown to be superior to "bulldozing" or removing those features.

To date, three wide-area 1st grade models have been developed. The performance of the model for Tokai and Tonankai earthquakes was tested by comparing simulations against data recorded for the 1944 Tonankai earthquake, and showed a good agreement. The results have been published and have been incorporated into the third edition of a television program *MegaQuake* by NHK.

3) Structural Design Requirement on the Tsunami Evacuation Buildings

Mr. Hiroshi Fukuyama, Director of the Department of Structural Engineering at BRI explained that his lecture would first cover the categorization of damage to buildings caused by tsunami, and would then consider structural design requirements for tsunami evacuation buildings. In the Great East Japan Earthquake and Tsunami of 2011, the city of Rikuzentakata was hit by tsunami waves 15 meters high. Most of the wooden structures were washed away, while most reinforced concrete (RC) buildings remained structurally intact. That said, several RC buildings suffered severe damage. The first example is the total collapse of a two-story structure when the tsunami load exceeded the horizontal resistance capacity of the building. Second, the first story of a two-story structure collapsed when tsunami pressure on the second story propagated to the first story. Third, a building overturned due to a high buoyancy and insufficient building weight. In cases such as this, pile foundations can be used to increase resistance to overturning; however, even some buildings with pile foundations overturned. Accumulated air pockets under floor slabs increase buoyancy, which should be considered in structural design. The fourth example is the deformation of walls through failure of shear walls and columns to resist aftershocks and secondary tsunami. Fifth is tilting due to scouring at the corner of a building by strong whirling streams of the tsunami. Sixth is sliding, which can be avoided by utilizing pile foundations. Seventh is impact by debris causing shear wall failures and debris entering buildings.

Turning to damage to steel buildings, failure of exposed column bases and column top connections was quite frequent, resulting in upper structures being washed away. In other cases, although the exterior finishing survived almost intact, tsunami load and buoyancy caused overturning. Most steel buildings entirely lost the exterior and interior finishing, with only the skeleton remaining. However there was a large residual deflection.

Based on these examples, BRI's Department of Structural Engineering reviewed 2005 structural design requirements for tsunami evacuation buildings. Where no high ground is available for tsunami evacuation, tsunami evacuation buildings should be constructed on the highest ground for quick evacuation, particularly in coastal areas. The study reviewed the influence on resistance of building height, defense, and distance from the sea. The targets for the structural design of tsunami evacuation buildings are to not collapse, overturn or slide. Structural design to meet those targets is based on calculations incorporating tsunami pressure and load, story shear force and buoyancy. BRI strongly hopes that the proposed structural design method will accelerate the construction of tsunami evacuation buildings for protecting lives from tsunami disasters.

4) The Importance of Collaboration for Complementary Research in the Field of Earthquake Engineering-An Example SAFECAST Project in Europe

Mr. Faruk Karadoğan, Professor and former Rector of Istanbul Technical University (ITU) told participants that he would provide some background information in order to then be able to pose a question.

Collaboration and complimentary research is important in structural engineering and research topics. Turkey has engaged in three successive collaborative projects in Europe. The first two, ECOLEADER and PRECAST EC8 aimed to quantify the ductility capacity of precast concrete structures compared to cast-in-situ concrete structures. The outcome confirmed that precast frames and buildings can exhibit ductile behavior comparable to cast-in-situ structures. However, it was clear from the findings that the deformability of the floor system, and in particular the actual design of the connections between the floor/deck system and the vertical columns, was not fully understood and therefore difficult to model correctly for the numerical studies used in design of precast buildings structures.

The SAFECAST project emerged from these two projects, as a consortium of RTD providers and SME associations from Italy, Spain, Portugal, Turkey and Greece. The project aimed to fill the gap in knowledge of seismic behavior of precast pre-stressed structures, with specific reference to connections, deformability and interaction between precast and cast-in-situ elements. Further, the project aimed to develop reliable numerical tools, and to codify new criteria for the design of precast structures in seismic regions exploiting the properties of connection devices. A series of monotonic, cyclic and shaking-table tests were carried out on connection devices, joints and subassemblies. Large-scale pseudo-dynamic testing was carried out on single-story and multi-story frames. Numerical simulation was employed to verify adequate numerical models.

SAFECAST was completed in March 2012 with the publication of the *Design Guidelines for Connections of Precast Structures under Seismic Actions*. In conclusion, the outcome demonstrates the importance of regional cooperation, as well as the need for increased budgets for cooperative projects. Local administrative bodies and peoples should be engaged to satisfy the local needs.

Five years previously, at the UNESCO kick-off meeting, it had been said that there are sufficient laboratories, training centers and trained students around the world, and it was time to increase the cooperation of these institutions by linking local and individual efforts together. Mr. Karadoğan concluded by asking whether IPRED can be improved to be an organization that can coordinate predefined collaborative projects.

5) Question and Answer Session

Question for Mr. Fukuyama: In your study, why did you determine that a distance of 500 meters from the coastline is considered safe? When determining inundation depth and pressure, is it not necessary to also take into account the topographical shape and height of the ground? In cases of very low ground, what building height should be considered safe for refuge in case of tsunami?

Mr. Fukuyama: Topographical conditions were outside of the scope of our study. Based on limited data we considered 500 meters from the coastline to be a safe distance; however, we do not have definitive data. Going forward we will continue to improve our design methods. We recommend a building height of at least two stories above the inundated stories, and those stories must have flooring.