ICUS Newsletter

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International Center for Urban Safety Engineering
Institute of Industrial Science, The University of Tokyo

Nankai Trough earthquake: latest damage estimation

By
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The Japanese Cabinet Office Central Disaster Prevention Council's working group for promotion of disaster countermeasures of the Nankai Trough gigantic earthquake released a notable report on August 29, 2012. It is a detailed damage estimation in case of future possible Nankai Trough earthquake, based on the "Great East Japan Earthquake and Tsunami Disaster" due to the "off the Pacific coast of Tohoku Earthquake" on March 11, 2011. This preliminary report outlines expected damages if a series of five quakes should happen continuously and simultaneously in Tokai, Tonankai, Nankai, Eastern Kyushu Island, and the tip of the crustal plate.

Recent figures in hazard assessments tend to be raised ever since seismologists and experts failed to predict the Tohoku earthquake with moment magnitude (Mw) 9.0. However, even before this earthquake on March 11, 2011, Japan had already entered a seismically active period, facing danger of massive earthquakes occurring within the coming three to five decades. As for this area off the Pacific coast of Tohoku, experts had pointed out the possible threat

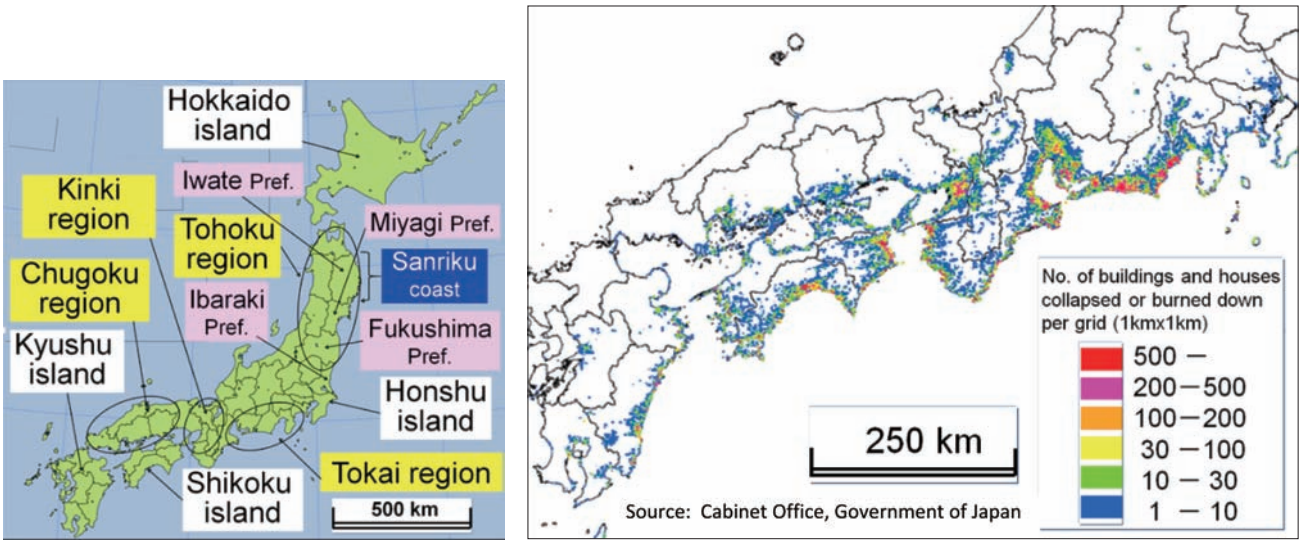


Figure 1 Distribution of structural damage due to M9 class Nankai Trough Earthquake: No. of buildings and houses collapsed or burned down

of "offshore Miyagi Prefecture Earthquake", about M7.5, centered under the Pacific coast of Miyagi Prefecture, with 85% probability in the next two decades, and even 99% in the next three decades. Although, the quake that actually hit offshore Miyagi Prefecture and its surrounding areas in 2011 was greater than expected -- as massive as M9 --, there had always been common awareness about its high probability: 90% for M7.1 to 7.7 class earthquake in the region of Northern off Sanriku in the next three decades, 70-80% for M7.7 quake near the southern trench off the Sanriku coast in the next two decades, and 90% for M7-class event offshore Ibaraki Prefecture in the next three decades. Obviously, Tohoku coastal region had been waiting to be hit by huge earthquakes anytime.

The "Great East Japan Earthquake and Tsunami Disaster", brought on by strong ground motions and killer tsunami, still continues to impact the entire nation, both deeply and extensively. The tragic disaster has taught us the real fear of a devastating earthquake, and warned us of the importance of preparation for proper disaster countermeasures.

Where large-scale earthquakes have historically occurred

Yet, we must keep in mind that another region in Japan is in danger of a similar or even larger earthquake disaster: a zone along the Nankai Trough, an oceanic trench that stretches off the coast of the island of Honshu. The Nankai Trough marks a plate boundary that is caused by the slip of the Philippine Sea Plate beneath the Eurasian Plate, on top of which the regions of Kinki, Shikoku and Kyushu are located.

In the past centuries, quakes have frequently occurred in this zone. Past well known events include: Keicho (1605, about M8), Hoei (1707, M8.7), Ansei Tokai (1854, M8.4) and Tonankai (1854, M8.4), Showa Tonankai (1944, M7.9) and Nankai (1946, M8.0) earthquakeearthquakes.

Some experts say that the 2011 M9-class event has made crusts around Japan increasingly unstable. In any case, we have to admit that a huge earthquake is likely to occur along the Nankai Trough in the near future. Here I show the overview of damage estimations and the effects of disaster countermeasures.

Latest Predictions

The maximum earthquake that may happen along the Nankai Trough is expected to be Mw 9.1. Several fault models have been considered to simulate different types of damage, due to ground motion or due to tsunami. Also, by changing the location of asperities that generate strong ground motions and large slip areas that induce large tsunami, four different cases of damage, in which the extent of disaster largely differ by region (Tokai, Kinki, Shikoku and Kyushu), have been estimated.

When these predictions come true, very strong ground motions

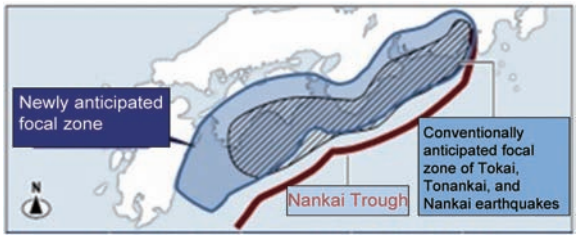
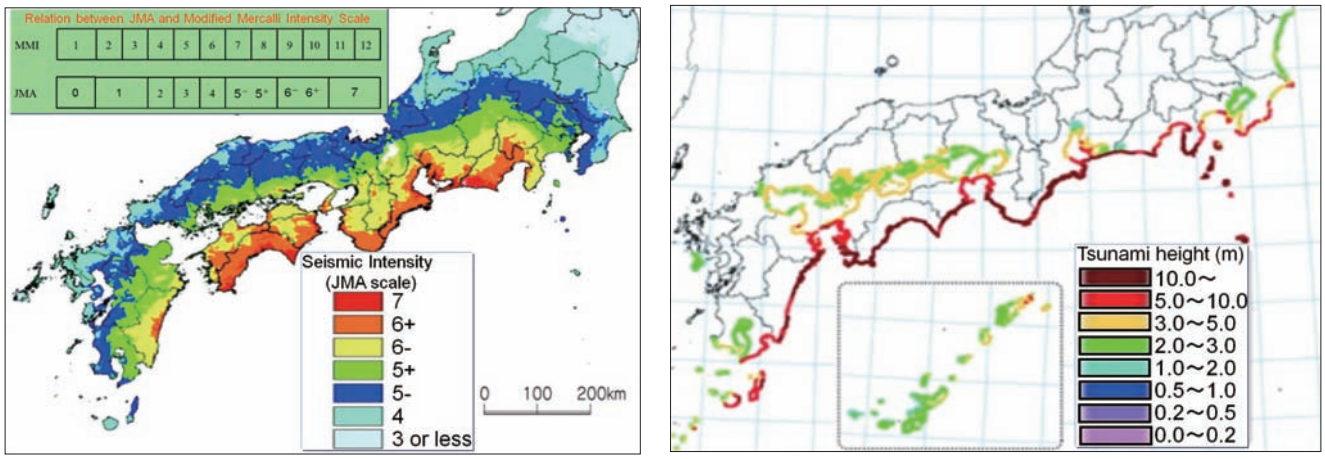


Figure 2 Newly anticipated Nankai Trough earthquake fault

Table 1 Estimated damage due to M9 class earthquake predicted along Nankai Trough

	Case 1 (Damage in Kyushu becomes severer)	Case 2 (Damage in Shikoku becomes severer)	Case 3 (Damage in Kinki becomes severer)	Case 4 (Damage in Tokai becomes severer)
No. of death toll in all affected areas (x1000)	229	226	275	323
No. of injured persons in all affected areas (x1000)	610	612	615	623
No. of buildings and houses collapsed or burned down (x1000)	2,386	2,364	2,371	2,382



Source: Cabinet Office, Government of Japan

Figure 3 Estimated seismic intensity (left) and tsunami height (right) due to possible M9 class Nankai Trough earthquake

measured 7 in Japan Metrological Agency (JMA) seismic intensity scale -- the highest out of 10 JMA levels -- will strike ten prefectures and 151 cities, towns, and villages, in addition to intensity 6+ in 21 prefectures and 239 cities, towns, and villages. Very huge tsunami waves are also expected to reach above 20 meters in 8 prefectures as shown in Figure 3. Some parts of the three major metropolitan areas, Tokyo, Nagoya and Osaka, will be damaged while critical distribution route between east and west of Japan may be cut.

Consequently, the total number of buildings and houses that might be collapsed or burned down is estimated to be between 2.364 and 2.386 million. Figure 1 represents one example of damage distributions. The estimation of deaths are between 226 and 323 thousand, and injured between 610 and 623 thousand respectively as Table 1 shows. Tables 2 and 3 indicate that these latest estimations represent larger figures when compared to the actual damage by the 2011 East Japan Earthquake and Tsunami Disaster and the 2003 estimation on Nankai Trough (covering Tokai, Tonankai and Nankai earthquakes) by the Japanese government.

The recent preliminary report refers to only human casualties and damage to buildings and houses. Estimation of other damage, i.e. lifeline utilities, traffic facilities, daily living difficulties, disaster waste, economy and other aspects are to be released at some other stage.

Table 2 Comparison of damage by newly anticipated Nankai Trough worst-case scenario earthquake and the "2011 East Japan Earthquake and Tsunami Disaster"

	Magnitude※1	Inundation area	Population in inundation area	Dead / missing	Buildings collapsed or burned down
2011 East Japan	9	561km^2	About 620,000	About 18,800※2	About 130,400※2
Newly anticipated Nankai Trough	9.0 (9.1)	1,015 km^2 ※3	About 1,630,000※3	About 323,000※4	About 2,386,000※5
Comparison rate		1.8	2.6	17	18

Table 3 Comparison of damage by newly anticipated Nankai Trough worst-case scenario earthquake and 2003 damage estimation of Tokai, Tonankai and Nankai earthquakes

	Magnitude※1	Inundation area	Population in inundation area	Dead / missing	Buildings collapsed or burned down
2003 estimation of Tokai, Tonankai, Nankai quakes	8.7 (8.8)	–	–	About 24,700※6	About 940,200※7
Newly anticipated Nankai Trough	9.0 (9.1)	1,015 km^2 ※3	About 1,630,000※3	About 323,000※4	About 2,386,000※5
Comparison rate		–	–	13	2.5

Source: Cabinet Office, Central Disaster Management Council, Committees for technical investigation on countermeasures for the Tonankai and Nankai Earthquakes (Sept. 17, 2003)

※1: Figures in parenthesis show tsunami scale Mw (moment magnitude)
※2: Based on announcement by the headquarters for emergency disaster control on June 26, 2012.
※3: Projected inundation areas are based on that all levees and water-gates are functional in case of quakes.
※4: Disaster estimation on the following conditions: Damage in Tokai region becomes severer, midnight in winter season, with wind speeds of 8m/s.
※5: Disaster estimation on the following conditions: Damage in Kyushu region becomes severe, evening in winter season, with wind speeds of 8m/s.
※6: Disaster estimation at 5 am. ※7: Disaster estimation at 18:00 pm.

Table 4 Damage estimation before and after countermeasures

Weather condition: winter season with wind speeds of 8m/s		Total collapse of residences		Death toll	
		Estimated damage	Estimated damage with countermeasures	Estimation	Estimation with counter-measures
Basic scenario	midnight	970,000	310,000	266,000	60,000
	evening	1,210,000	437,000	226,000	32,000
quake happening in landward scenario	midnight	2,380,000	800,000	323,000	105,000
	evening	1,820,000	520,000	278,000	59,000

Source: Cabinet Office, Government of Japan

Issues and countermeasures

The largest crisis is when tsunami attacks shortly after strong ground motions -- people in many areas cannot move and have no time to evacuate. Nevertheless, experts point out that the possibility of such huge earthquake and tsunami is very low, suggesting that appropriate evacuation and countermeasures would help to greatly reduce the death toll as shown in Table 4.

It is extremely important to maintain a correct sense of crisis, and to take accurate measures. Table 4 shows that we must further improve *"implementation of disaster resilient built environment"*. That is to say, we must further increase quake-proofing of houses and buildings, flame-resistant products, emergency evacuation areas, people's consciousness to evacuate, total evacuation framework, and many other issues. By drawing out maximum effect, damage can drastically be reduced: building damage down to one third of the estimated figure, and human casualties down between one seventh and even one third.

Yet, we must keep in mind all damage cannot be prevented. The scenario of more than 30 thousand deaths and 300 thousand totally collapsed buildings still remains. We should remember that the latest estimations exceed the damages due to the 1995 Kobe or the 2011 East Japan earthquakes by far. We need to establish a total disaster management system, and start making preparations for recovery ahead of disaster.

5th Joint Student Seminar on Civil Infrastructure: Bangkok, Thailand

By Y. Takano, master student, Nagai Laboratory

The 5th Joint Student Seminar was held in Bangkok, Thailand, on Aug. 20-21, 2012. The seminar was composed of two parts: presentation session and field trip.

On the first day, presentation session was held at Chulalongkorn University, where 2 keynote speakers and 16 students delivered talks on their research in different fields: disaster information collection, numerical simulation, transportation, geotechnology, concrete, and reconstruction from the Tohoku Earthquake. These presenters belong to universities in Thailand, Korea and Japan, representing countries such as Thailand, Korea, Indonesia, Ethiopia, and Japan. The inspiring discussions further broadened my interest and knowledge on civil and urban engineering.

Participants spent two productive days in Bangkok

The next day, we enjoyed the tour to King's Palace and Chao Phraya River. At the Palace, we learned about the history of Thailand. Along the river, we could still see the scars left from the serious flood last year, but also witnessed some signs of recovery. I hope the seminar next year will be just as successful and worthwhile.

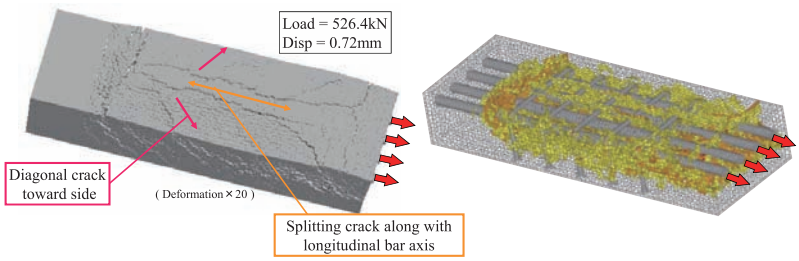
Analytical investigation of RC anchorage failure: confined by 3D RBSM transverse bar

By Y. Takano, master student, Nagai Laboratory

Nowadays in Japan, seismic design code is becoming more stringent. To fulfill strict requirements, larger reinforcement must be applied, leading to the increase of reinforcement congestion. Therefore, the bond performance of the congestion part needs to be clarified.

Simulations were carried out to study relationship of bond performance with failure mechanism of reinforcement and concrete around the anchorage zone of structural elements. To analyze anchorage failure, "3D Rigid Body Spring Model (RBSM)" was used. The objective was to confirm the effects of transverse reinforcement in enhancing anchorage.

Reinforcement congestion at beam-column joint



Result of analysis (cracks on surface and inside)

The simulation has confirmed the effect of transverse bar, which showed a good match with the experiment data in terms of anchorage capacity, crack patterns and failure modes. Internal crack propagation was also simulated.

For this research work, Yoshiyuki Takano received the Best Presenter Award at the 5th Joint Student Seminar.

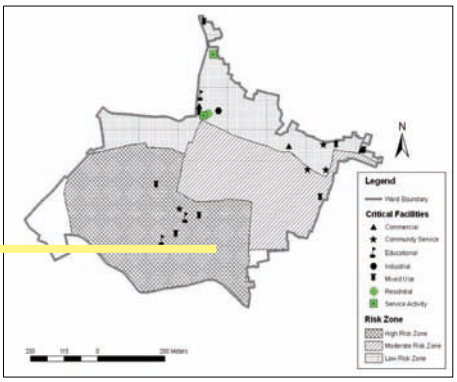
BNUS: earthquake and fire hazard assessment Ward 65, Dhaka

By Prof. M. A. Ansary, BNUS

Ward 65, or so-called 'Puran Dhaka', is situated in the old part of Dhaka City in Bangladesh. This area is unique in its land use pattern. Mixed-type land use, along with high population density, has made this area vulnerable to earthquake and fire hazard. Bangladesh Network Office for Urban Safety (BNUS) has conducted a number of surveys to assess vulnerability of the important facilities in this area

There is a total of twenty two essential facilities in Ward 65, including mosques, schools, a college, community centers and clubs. Among these, eleven facilities have recently been surveyed by BNUS. Several non-destructive testing (NDT) techniques have been carried out to assess the earthquake vulnerability of the buildings. Microtremor and Ferro scanners have been used as the tool for NDT. Fire hazard vulnerability has also been assessed, using the Community Vulnerability Assessment Tool (CVAT).

Hazi Abdul Latif Mosque



Location of important facilities

Assessment activities

15th WCEE: exhibit and presentation

By M. Numada

The 15th WCEE (World Conference of Earthquake Engineering) was held in Lisbon, Portugal, on September 24-28, 2012.

ICUS exhibited a booth, showcasing its main activities. A number of visitors, including researchers, engineers, and business people, came to share our ideas and information.

ICUS exhibition booth

Many took keen interest in the introduction and overview of ICUS, particularly in our basic policy and approach in sustainable management in urban environment and risk reduction.

We showed a video of the 2011 Tohoku disaster, filmed by ICUS members, monitoring the recovery and reconstruction progress over time. This footage, along with our briefing, helped to deepen visitors' understanding of the situation in the damaged areas.

Also on display was the PP-band retrofitting technology for non-engineered masonry structure. The availability and the applicability of this technique captured participants' attention. Not only visitors from Iran, India, Pakistan, Indonesia or other countries where a large number of masonry houses stand, but also those from the technologically developed nations, such as the US or the EU countries, expressed positive interest in this research.

Each member of ICUS gave a presentation on their own research theme in oral, e-poster, and poster style. We are delighted and proud of the good performance at both WCEE.

WCEE is held every four years. The venue of the next conference in 2016 is Santiago de Chile.

Explanation about PP-band technology activities

24th ICUS open lecture: sharing present challenges of Fukushima

By T. Kato

The 24th ICUS open lecture was held July 28 at the IIS Convention Hall, the University of Tokyo. The theme was "Sharing Present Challenges of Fukushima", organized jointly with the Japan Society of Urban and Regional Planners (JSURP).

Fukushima is stepping towards recovery, yet moves are still small and slow. The entire country must come together to overcome the crisis. People from different standpoints gathered to share a common understanding on the ongoing problems.

Kicking off the discussion, Mr. Mutsuo Anzai, Policy Administrator, Revitalization Bureau for the Evacuation Areas Fukushima Prefectural Government, chronologically reviewed the actions of national/local governments.

Mr. Akira Tamagawa, working at Namie Town Office, Fukushima, reported on victims' current reality.

Ms. Miharu Takamura from Minami Soma looked back on her painful experiences of evacuation and refuge, raising questions on the support system.

Dr. Kyoji Hoshino (Professor Emeritus, Fukushima Universy; Director, Fukushima NPO Network Center) spoke about the social significance of NPOs, public administrations and welfare councils.

The closing speaker was Dr. Hiroshi Suzuki (Professor Emeritus, Fukushima University; Chairman, Fukushima Prefecture Reconstruction Committee) who focused on temporary relocation of municipalities away from disaster-hit regions.

Participants rediscovered the hardships in Fukushima, particularly in the Futaba hazard area, and also re-realized the continuous need for support.

The lectures were held as the third of the series of "Sharing Experiences" symposia, organized jointly with JSURP. The first (May 20) and the third (July 28) was held at ICUS, while the second (June 16) was in Tokyo and the fourth (Sept 29) in Kobe.

Panelists in heated discussion

Samanthi Hewage, Kuwano Lab master student, receives Furuichi Award

By R. Kuwano

Ms. Samanthi Renuka Indiketiya Hewage, a graduate student of the Civil Engineering Department, the University of Tokyo, received the Furuichi Award 2011 for her outstanding master thesis study. The prize is awarded to the excellent master thesis of the year in the Civil Engineering Dept. At the graduation ceremony on September 27, the prize was handed to her by Professor Junichi Koseki.

Ms. Hewage conducted her master research under the supervision of Dr. Kuwano. She performed a series of experiments to evaluate the loosening of soil around underground cavities.

Samanthi Hewage congratulated by Prof. Koseki

Currently available techniques to detect subsurface cavities still face many limitations -- they only identify air-filled voids separated from soil. Also, the maximum of accurately detected depth is limited to only a few meters; in the case of clayey and high moist soils, it is further limited to around 1 meter. That is why detecting cavities in deeper grounds is extremely difficult. But if a cavity continues to upsize towards the surface, ground subsidence is inevitable.

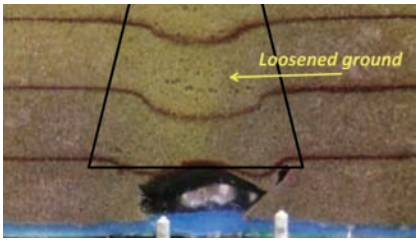
Since air-filled cavities in general are associated with the loosening process of the surrounding grounds, it is easier to find loosened soil first and then look for nearby cavities. Thus, even cavities hidden deeper can now be detected by capturing signs of loosened areas on the subsurface. This way, accuracy and efficiency of the current methods will improve at a reasonable cost.

The first objective of this study was to figure out the extents of loosening in relation to the cavity size, and also

to identify the parameters which affect scale and rate of loosening.

Artificially loosened soil was produced in the laboratory. Through two-dimensional model tests, cavity was expanded by water infiltration and drainage. Effects of cavity size, density, ground compaction and rate of drainage on soil loosening and cavity expansion was observed.

As the second objective, quantitative study on mechanical features of loosened soil was conducted. Evaluationwas made by triaxial tests, while the influence of condition change was experimented: density, cavity size and location.



Loosening above artificially created cavity in soil

Furthermore, the extent of loosening was studied by X-ray CT scan, so as to compare the difference of behavior in two- and three-dimensional responses. Results obtained from the two dimensional model tests show that the height of the loosened area extends up to five times that of the cavity height while radial expansion is limited when compared to vertical expansion.

As a conclusion, it was found that subsurface cavities are more vulnerable to cave-ins, and that loosening expands to at least twice the height of cavity. Overall stiffness of the ground may decrease significantly even by a very small void.

Hidden ground cavities may lead to large and dangerous ground cave-ins. The outcome of this study will serve as an important clue in developing a novel technique to detect cavities and thereby prevent ground sinking.

Farewell to Dr. Takahiro Endo

By K. Meguro

Research Associate Dr. Takahiro Endo retired from ICUS in Oct. 2012 to join the GOSAT-2 (G2) Project Preparation Team, National Institute for Environmental Studies.

Having joined ICUS in Apr. 2003, Dr. Endo was committed to the development of LiDAR simulation system for forests, and served in the "carbon dynamics of Amazonian forest (CADAF)" project, a JST-JICA program.

Dr. T. Endo

ICUS thanks Dr. Endo for his contributions and wishes him all the best with his new position.

ICUS Activities July – September

- Professor Haruo Sawada and Dr. Takahiro Endo attended *Carbon Dynamics of Amazonian Forest in Brazil* Aug. 4–26. Dr. Endo also attended the *XXII Congress of the International Society for Photogrammetry and Remote Sensing* in Melbourne, Australia, Aug. 27–Sep. 3.
- Dr. Takaaki Kato visited Nanjing, China, Jul. 11–20 to attend *Japan-China Joint Meeting on Comprehensive Disaster Prevention Planning and Standards for Disaster Prevention Design.*
- Dr. Akiyuki Kawasaki was at AIT in Bangkok, Thailand, July 31–Sep. 14, and again from Sep. 30–Oct. 7. He also visited Yangon Union of Myanmar Sep. 6–8 on a collaborative research with Yangon Technological Univ., the Japanese Embassy and JICA.
- Dr. Muneyoshi Numada visited Jakarta and Banda Aceh, Indonesia, Jul. 21–26, to lecture on PP-band retrofitting technology.
- Professor Kimiro Meguro, Dr. A. Kawasaki, Dr. M. Numada and Dr. Shinya Kondo traveled to Lisbon, Portugal, for the 15th WCEE from Sep. 22–29.

Awards and Honors

- Professor Mikio Koshihara received the World Monuments Fund/Knoll Modernism Prize in Sept. 2012, awarded by World Monuments Fund.
- Ms. Samanthi Hewage won the Furuichi Award for her master research summarized on pages 6 and 7.

Editor's note...

Since the Fukushima nuclear power plant accident broke out in March 2011, we have become more conscious of electricity usage. Particularly during the summer season, we at IIS had to make every effort in minimizing peak power load and reducing total consumption. Air conditioners were kept fixed at 28 degrees centigrade. Room lights were mostly turned off in daytime. Some old refrigerators in offices were replaced by latest energy-efficient models. By accumulating these small efforts, IIS has managed to achieve satisfactory level of electricity savings. It seems that we have somehow accustomed to the new life style of using minimum electricity.

On the other hand, we know that people in general do not like to sacrifice comfort or economic growth. Also, as pointed out in the main article, we must hasten to prepare for the possible giant earthquake which may strike in the near future. Many difficult tasks still lie ahead. We can only overcome such challenges by social strategy development and engineering technology innovation. We, the ICUS members, need to continue making efforts by working together with colleagues around the globe, thereby contributing to the safety of urban system.

By R. Kuwano

USMCA 2013: Oct 9-11 in Hanoi, Vietnam

The 12th International Symposium on New Technologies for Urban Safety of Mega Cities in Asia (USMCA 2013) will be held in Hanoi, Vietnam on October 9-11, 2013. Check out the ICUS website for latest information. **http://icus.iis.u-tokyo.ac.jp/en/**

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The International Center for Urban Safety Engineering (ICUS) is a research center located at the Institute of Industrial Science, The University of Tokyo.

The purpose of ICUS is to identify, investigate, and resolve issues towards the realization of sustainable urban systems for the prosperity and safety of society considering challenging socio-economic problems.