# ICUS/INCEDE NEWSLETTER

*International Center for Urban Safety Engineering*

**Institute of Industrial Science**
**The University of Tokyo**

*VOLUME 3 NUMBER 2*
*JULY -SEPTEMBER 2003*


# ISSUES RAISED BY THE RCENT SUBWAY FIRE IN SOUTH KOREA


***By***

***Makoto TSUJIMOTO****


A train was set on fire with two liters of gasoline at the Jungangno Subway Station in Daegu, South Korea at about 9:53 a.m. on February 18, 2003. This incident killed 192 people, which without doubt accounts for the largest number of deaths resulting from a fire in a subway train. It was reminiscent of another recent accident involving a mountain train in Salzburg, Austria (November 11, 2000). In both cases, the passengers died because their escape routes were cut off by flames and smoke, with the trains burning over an extended period of time. However, the case in Korea was an incendiary fire caused by setting fire to gasoline, and ultimately the issue presented here is how to make disaster prevention plans for these kinds of intentionally-caused and rapidly-spreading fires. The table in the following page shows the items of disaster prevention equipment on each floor of the station and the figure shows the general conditions surrounding the incident at the Jungangno Station.

## Floor plan of the station

The stairways that serve as escape routes at the Jungangno Station are very well planned, both in location and width. Another small station from which the author boarded a train has a single

*Front of the train No.79 , where the fire started (Photo by Atsushi Okajima)*

stairway from the platform to the concourse positioned in the central area; however, Jungangno Station, the location of this fire, has wide stairways at both ends of the platform, from which a smooth escape seems to have actually been made. Many were found dead at the ticket gates that provide exits from the central stairway from platform B3 to concourse B2.

The concourses on floors B2 and B1 are large, although their extensive size could disorient people when filled with smoke, and are all provided with stairways at either end connecting to adjacent floors and there are no basic layout problems (they do not, for example, narrow down immediately before coming aboveground as seen in subway stations in Japan).

Also, according to the data provided by Mr. JAE Jim-Joo (at 06:00 a.m. of February 28, 2003, Fire Fighting Situation Daily Report, Central Emergency Rescue Headquarters Situation Office), concourses are required to have smoke barriers at each 40 m diameter boundary; for this reason, concourses B2 and B1 are divided into three sections with 50-meter high hanging walls, which ironically worked to effectively concentrate the heat of the fire in the central section.

However, there are problems with the passageway to the underground shopping area on floor B1. The underground shopping area runs perpendicular to concourse B1, and has a floor level approximately two meters higher than the floor of the concourse, which does not provide easy access either, although the reasons behind this are not clear. In addition, a fire shutter doubling as an access control point is installed across the entire width of the opening where the stairway from the concourse reaches the shopping area. Smoke detectors are installed on both sides of the shutter, and these were activated to close the shutter during the fire (the author saw the shutter close on a TV news show at approximately 10:00 a.m. of March 3, 2003 at Pusan Airport; details unknown). A structurally very complex access door is installed at door 1; it is unknown whether it was used during the escape. Also, many people seem to have died at the shutter because their escape route was cut off when the shutter closed suddenly. On the other hand, the shopping area seems to have sustained no damage and was able to continue operation because the shutter closed early on, and this demonstrates that the shutter served its primary purpose. However, the sudden loss of an escape route when the shutter closed remains a problem.

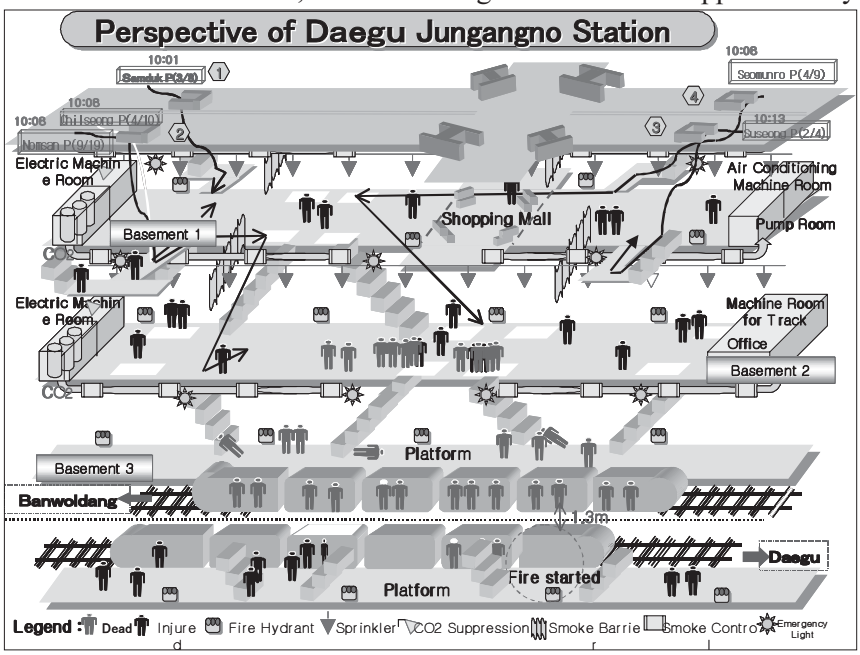
*Area and apparatuses of different floors of Jungangno Station*

| Floor | | Total floor area ($m^2$) | Apparatuses against fire |
|---|---|---|---|
| Basement 1 | Concourse Office Room | 3,847 | CO2 suppression systems, portable fire extinguishers, sprinklers, automatic fire detectors, smoke control installations, fire hydrants, direction lights, emergency lights, fire alarms |
| Basement 2 | Concourse | 4,586 | |
| Basement 3 (fire floor) | Platform | 2,004 | Automatic fire detectors (by smoke), fire hydrants, fire alarms, emergency lights, direction lights |

## Disaster prevention equipment in the station building

As shown in the table, the basic specifications for disaster prevention equipment in the station building are roughly equal to or exceed those in Japan. Unfortunately the fire was started in a train; however, such extensive damage would not have been sustained if the fire had been started in concourses B1 or B2 because the sprinklers would have been activated. No-one at the site commented on the smoke control system because it may constitute an issue in court. However, the concourses are divided into approximately 35-meter sections to satisfy the requirement to extract smoke at a rate of 40,000 cubic meters per hour in each section.

There is no knowing under the present conditions whether the smoke control system worked or had any effect; however, the airflow volume according to regulations must be approximately




*Perspective of Daegue Jungangno Station*

10 times the ventilation frequency, which is considered manageable by diverting the general air-conditioning equipment. It is necessary to wait for the results of the investigation on how the equipment operated during the fire, including how it was related to the supply/exhaust openings in the sidewalks aboveground.

### Subway cars

The most significant issue may be the combustibility of interior materials in the subway cars.

Japanese technical standards (Ministerial Ordinance Interpretation Criteria III-19 defining technical standards for railways) require: 1) the use of noncombustible materials; and 2) the use of noncombustible surface coatings for ceilings, outer panels and linings. Noncombustible materials in this case must satisfy incombustibility standards for railway vehicles stipulated by the Ministry of Transport (now the Ministry of Land, Infrastructure and Transport), in which a 182 mm x 257 mm sample may be passed as noncombustible if it meets criteria such as not igniting over an ethanol flame as small as 0.5 cc, and carbonization or deformation of less than 100 mm. Though referred to as noncombustible, these materials are quite different from the noncombustible materials specified by building codes (included in the specifications are concrete, glass, rock wool, etc.; testing methods used are the corn alcohol calorimeter test, etc.), and it may be more accurate to describe them as not easily igniting with a match or lighter.

There is no knowing at this point whether the interior materials in the Daegu subway cars came up to the level of performance required by Japanese standards for trains; however, it is not possible to say that the high level of heat generated by two liters of gasoline in a Japanese subway train would not ignite the interior materials and develop into an extensive fire.

*Front of the train No.80, most far from the fire (Photo by Atsushi Okajima)*

Furthermore, devices to manually open platform access doors in emergency (hereinafter referred to as emergency handles) are marked with red borders to indicate their locations; emergency handles are located in pairs on the seat side cover at each access door in Daegu, while they are provided in the cars but not indicated in Japan, because Article 74 of the ministerial ordinance stipulates an exception for cars traveling in the third rail line section, etc., which allows them to be inaccessible to passengers other than those who are well-informed.

In the case of a subway train, it is difficult to walk between the train and the tunnel (a gap of 50 cm) after exiting from an access door when the train stops between stations. Thus the Japanese measure does not necessarily pose a danger; however, it will reduce the possibility for passengers to escape from danger on their own if a train stops at a station as in this incident.

### Other Issues

The six cars of the train No. 79, where the fire started, and the train No. 80, that is12 cars altogether, burned uniformly and almost completely.

Judging from the conditions of the melted plastic in concourses B2 and B1, the temperature was high in the central area, and the severest scorching occurred to the tunnel ceiling slab above the center portion of train No. 80, exposing two layers of steel reinforcing bars, although the fire started in No. 1 car of train No. 79. These points remain big questions. Fire damage seemed to be fairly distributed as a result of the firefighting efforts which continued over an extended period of three hours starting from the tunnel side considering that the fire was controlled in stages from the outside inwards; however, thermal contamination was also the severest in the central area on floors B2 and B1 as mentioned before, although the fire started at the end of the station. The fire spread extremely fast in the early stages, and may have reached the rearmost car of the train by the time the oncoming train had drawn into the platform. It is therefore important to examine carefully what effect the draught generated by the train played in spreading the fire.

***Professor, Department of Environmental Studies, Nagoya University, Japan***

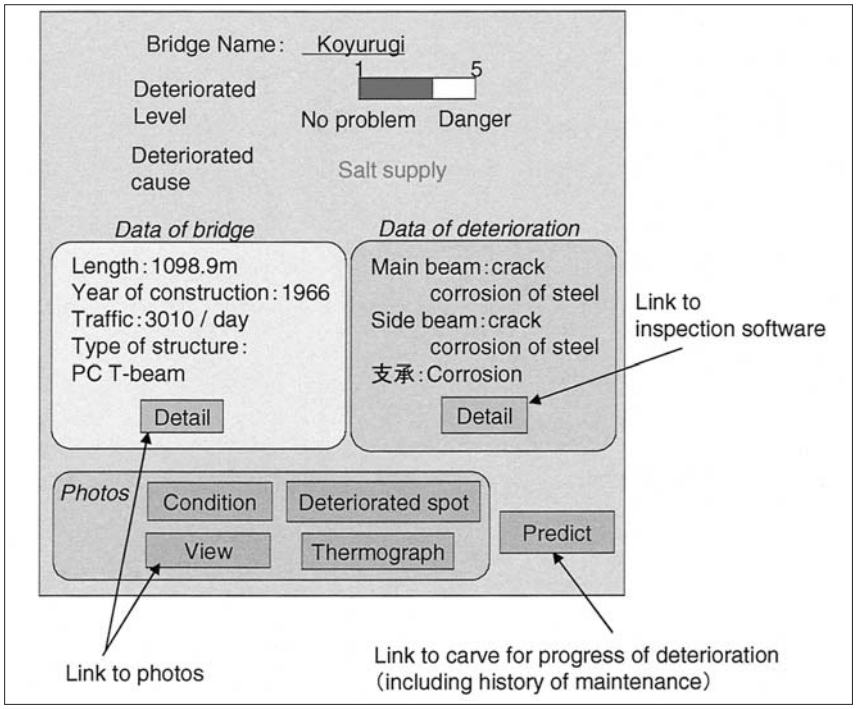
# Study of Making a Database for Deteriorated Concrete Bridges

*by*

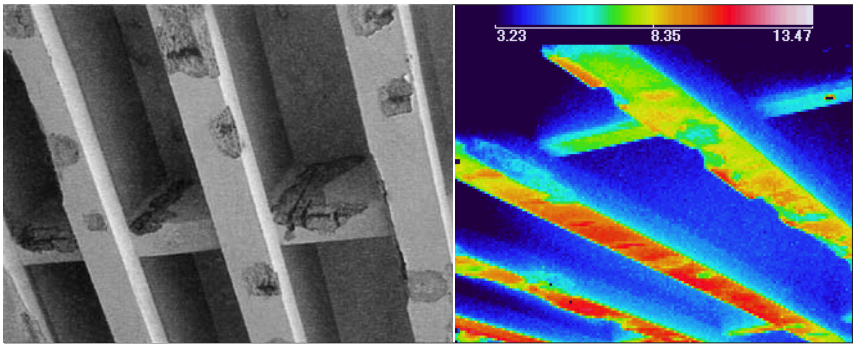
***Yoshitaka Kato and Somnuk Tangtermsirikul***

In most of the Asian regions, the fragility of a structure, which is based on the defects from design criteria, inadequate construction management and maintenance management, etc., is high and therefore, poses a major threat to safety. As most of these structures were built almost at the same time during the Asian 'bubble' economic growth, there is almost clear and certain possibility that, these structures would cause huge and fatal structural problems at the same time in near future causing extensive damage to the society and the economy as a whole. Thus an amicable solution to the same is a demand of time and needed to effectively guard against this hidden disaster. In order to deal with the problem, ICUS has been focusing on related research activities equipped with advanced technology and tools, such as, numerical models, remote sensing (RS), GIS, GPS, etc. for devising appropriate methodologies in order to manage and maintain the urban buildings and infrastructure, and working actively towards mitigation of urban disasters and environmental problems for sustainable development of Asian cities with adequate safety and security.

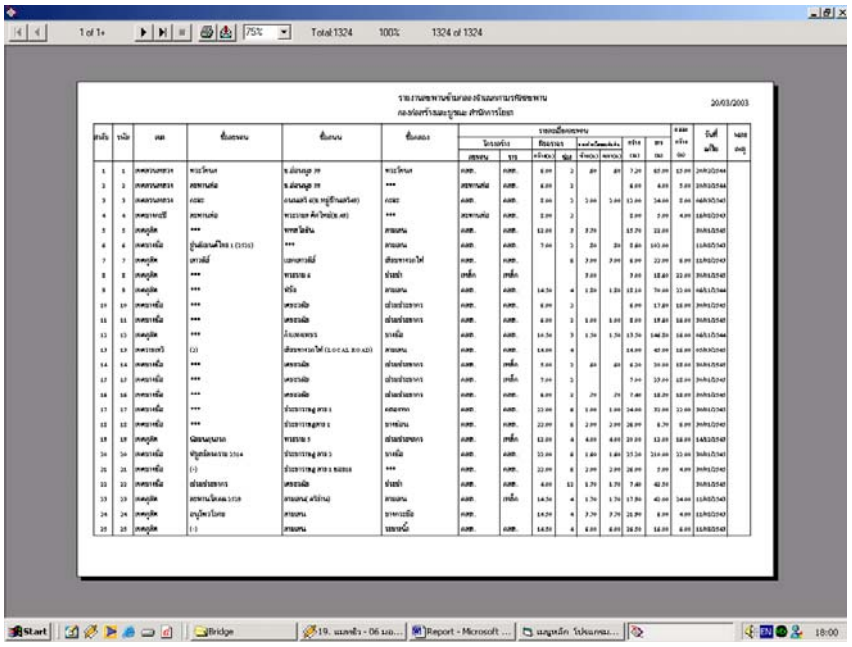
ICUS along with the School of Civil Engineering of the Asian Institute of Technology (AIT) established a Regional Network Office for Urban Safety (RNUS) last October at AIT in order to meet and deliver its above-mentioned objective more effectively and efficiently. Recently, RNUS has successfully initiated two joint projects on 1) Study on Making a Database for Deteriorated Concrete Bridges and 2) Urban Flood Risk Mapping using GIS, RS and Mathematical Model in Bangkok.




*A schematic diagram of the database*



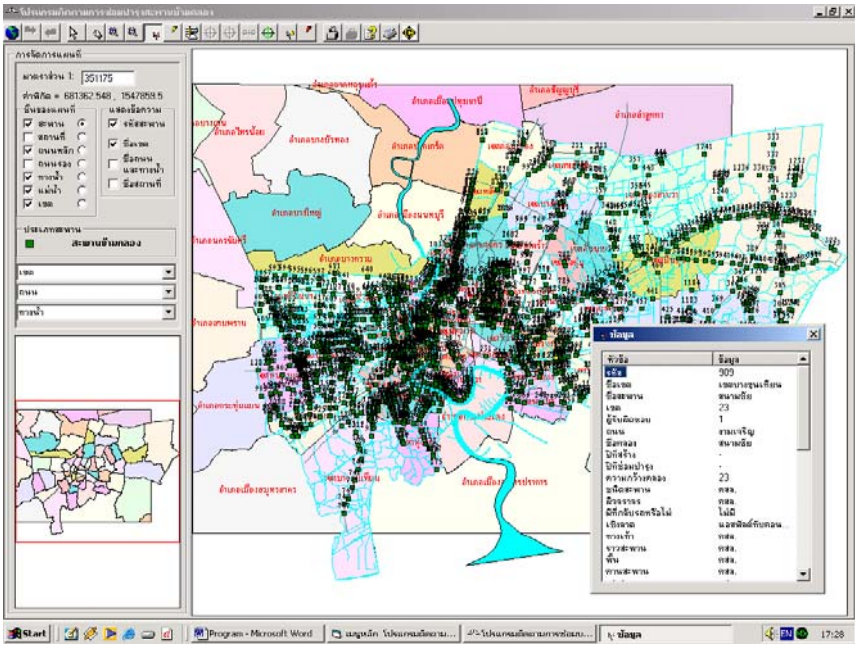

*Example of detailed data (digital still camera & thermograph)*



*Example of the tabulated information of the bridges*

This article presents a brief overview the activities of the Project 1.

A total of 9 concrete bridges from Bangkok metropolitan area were selected as targets for investigating and making a database in this research. The structural data for each bridge were collected from the organization responsible for maintenance of the same. A specialist in diagnosis of concrete structures investigated these bridges by visual inspection in order to understand the deterioration levels. At the same time, the photos of the deteriorated spots on the concrete bridges were taken by digital still camera and thermograph for the database under development. The schematic diagram of database in this research is shown in the previous page. It not only provides the location of structures, but also causes and levels of deterioration. Each column links with the corresponding data.



*GIS based information of bridges in Bangkok*

*Example of data of digital still camera*

In 2003, a total of 1953 bridges are under the responsibility of the Bangkok Metropolitan Administrative Office (BMA). These include a total of 31 flyovers, 598 pedestrian bridges, and 1324 canal bridges. The designed GIS based information system shows the location of the selected bridge on the map of Bangkok. All the mentioned 1953 bridges have been put into the system. An example of the GIS information for the canal bridges and an example of the tabulated information of the canal bridges are shown on the right side of this page and lower part of the previous page. The tabulated information of the bridges indicates location of bridges on the map, name of the bridges, types and size of pier, beam, girder, slab, year of construction, and information about repair and maintenance work. The two photos in the right side show an example of the visual data collected with digital still camera.

Readers may also refer to an extended version of this article available at ICUS homepage (http://icus.iis.u-tokyo.ac.jp).

## News from ICUS Regional Network Office, RNUS, in Bangkok

*After joining of Dr. Dutta of ICUS as the Coordinator of the ICUS Regional Network Office for Urban Safety (RNUS) in June, 2003, the activities of the Network Office have been expanding. A homepage of RNUS has been prepared, which includes its activities (http://www.sce.ait.ac.th/rnus/). The two mini-projects of RNUS initiated last year are in progress. A brief report of Project 1 is presented in the previous article. Two near future events of RNUS are 1) a seminar on "Water Resources in the 21st Century under Climate Change Scenarios" to be held on November 14, 2003 and 2) International Workshop of WSSI on "Seismic Risk Management for Countries of the Asia Pacific Region" to held during December 7-8, 2003 in Bangkok. RNUS is the local organizer of this workshop.*

*Dr. Dutta gave the following two invited talks in Bangkok:*

- *on "Hydrological forecasting of flood and inundation damage" at the International Seminar on Innovation Model for Sustainable Water Resource Management, Kasetsart University, Bangkok, Aug. 20, 2003 and*
- *on "Flood Risk Management: Role of Hydrologist and need of integration of MetSAT and Hydrologic Model" at the UNESCAP Eight Meeting of the Regional Working Group on Meteorological Satellite Applications and Natural Hazards Monitoring, Sep. 8-10, 2003.*

# 5th ICUS Open Lecture Focused on Urban Fire Disaster

The 5th ICUS Open Lecture was held with the theme of "Urban Fire and Its Safety Counter-measures: Lessons Learnt from Urban Fire and Countermeasures against It".

The pattern of fire occurring in cities has been diversified along with the advancement of urban landscapes and its increased complexity. Still fresh in our memory, the fatal subway fire in the city of Daegu, South Korea on February 18, costing 192 human lives was one of the worst disasters ever happened in the world. An urban fire in today's world may cause the damage far beyond our imagination by destroying costly urban infrastructure and paralyzing information infrastructure for a long time.

In the Open Lecture, each presenter delivered a lecture discussing on the countermeasures to be taken in the future in context of (1) the present situation of complicated recent urban fire, (2) fire in the tunnel on urban highways and (3) subway fires based on the lessons learnt from the Daegu subway fire. A fourth important point of discussion was on (4) safe and efficient ways of evacuation, in case of any of the above fire occurrences.

The Open Lecture was held on July 3, 2003 at the Auditorium of the Research Center for Advanced Science and Technology (RCAST) of the University of Tokyo. Despite the sweltering heat on that day, about 150 audiences attended the meeting and interacted with the presenters.

Prof. Taketo Uomoto, Director of ICUS, gave an opening address and then introduced the outcomes of research activities carried on by ICUS during the last one year. The following four lectures followed thereafter.

*A snapshot from the meeting hall during the Open Lecture*

The first speaker was Mr. Toshiaki Kitazato, who is the Representative Chief of the Local Development and Disaster Prevention Association Former Deputy General Manager of Fire and Defense management Agency, Former Councilor of Cabinet Office. Mr. Kitazato presented his lecture on "Present situation of urban fire in our country and the countermeasures". He began with describing the history and the present situation of urban fire, and then reported on the countermeasures for urban fire implemented so far from the viewpoints of urban planning, Fire Defense Act and reinforcement of fire defense force. Moreover, he talked on the necessity to revise the Fire Defense Act, referring to the reinforcement of risk management system in Japan after the Kobe earthquake and past building fires occurred in Japan. Lastly, he touched upon the countermeasures for fire defense and disaster prevention.

Mr. Toshiaki Tachimori, Director of Metropolitan Expressway Public Corporation, was the second speaker at the Open Lecuter. He gave a lecture on "Counter-measures for the prevention of tunnel disasters on Metropolitan Highway." He introduced many examples of tunnel fires occurred in the metropolitan highway in the past and countermeasures taken against them. He reported that, if the scale of a tunnel fire is large, the tunnel is often destroyed by the fire and it takes longer time for the restoration in many cases. He also stated that, the first 10-minutes from the onset of the fire is important for the fire fighting and evacuation, and it is important to study how and what activities can be done during this time. Therefore, the tunnels on metropolitan highways are equipped with the system to automatically detect the occurrence of an accident by image processing using CCTV installed at the interval of 100 m, Mr. Tachimori informed.

The third speaker was Professor Makoto Tsujimoto, Department of Environmental Research Major of Urban Environmental Science, Graduate School of Nagoya University. Prof. Tsujimoto spoke on "Issues in the Daegu City subway fire in South Korea." He

explained the transition of phenomena from the onset of Daegu City subway fire, and reported that the fire accident was recorded by 16 sets of TV camera, and the transition of phenomena during the fire can be grasped by analyzing these records. He said that the "Guideline for the utilization of extra deep underground" has been decided by the Cabinet Meeting in Japan, in which the actions to be taken for 7 risks (fire, earthquake, active fault, inundation, etc.) have been indicated. According to him, a study will be made in the future on the counteractions to be taken at the time of accident like the one that happened in Daegu City.

*Prof. Tachimori during his talk in the Open Lecture*

The fourth and final speaker of the Open Lecture was Prof. Kimiro Meguro, Associate Professor of ICUS. Prof. Meguro gave his lecture on "Urban fire and countermeasure for evacuation." He showed some cases such as, the expansion of damages by earthquake or fire, and analysis of human behavior during evacuation by mathematical simulation and GIS. He reported that many precious lives were lost just after the onset of the accident at the time of Kobe earthquake, and stated the importance of prior arrangements to restrain the damage as a countermeasure against the earthquake. He also stated that it is important to train the ability of imagination of people to recognize what will happen at the time of accident, in addition to hardware countermeasures adopted to physically restrain the damages.

Finally, Prof. Yoshifumi Yasuoka of ICUS made the concluding remarks of this Open Lecture, and expressed gratitude to the participants; and the 5th ICUS Open Lecture was adjourned.

***(by Masahiro Setojima)***

## Visitors to ICUS

*During the period of July-September, 2003, ICUS received the following visitors.*

- *Dr. Phisan Santitamnont, Assistant Professor, Survey Engineering Department, Chulalongkorn University, Thailand (Aug. 4).*
- *Prof. Ioan Olariu, Structural Mechanics Department, Technical University of Cluj-Napoca, Romania (Sept. 3).*

## 3rd International Workshop of WSSI in Bangkok during December 7-8, 2003

The World Seismic Safety Initiative (WSSI), an undertaking of International Association of Earthquake Engineering (IAEE), is organizing the 3rd International Workshop on "Seismic Risk Management for Countries of the Asia Pacific Region" in Bangkok, Thailand during December 7-8, 2003. Since its inception in 1992, WSSI has worked with many countries around the world in general and in Asia Pacific Region in particular. WSSI and its programs during those ten plus years had some remarkable successes in some countries and in others; they have not been able to make an impact in terms of implementation of risk mitigation strategies. WSSI in 2003 has more experience of what works and what does not work. WSSI understands the limits of what it can achieve with the resources it has. To take stock in its own programs and to learn from its past experience and the experience of countries WSSI has worked with, it is decided to hold the this Workshop. The main purposes of this Workshop are to:

1. Learn from countries where WSSI programs have made some positive difference in terms of risk mitigation and management.
2. Learn from countries where WSSI programs have not made any major impact in terms of risk mitigation efforts.
3. Develop a plan in consultation with all the attending countries about what WSSI should do for the next five years and where they should focus their human and financial resources.

The local organizing activities of this workshop are being carried out by the ICUS Regional Network Office in Bangkok, RNUS, as the Local Organizer.

## Awards received by students of Sustainable Engineering Divsion of ICUS

Two graduate students, Mr. Hisashi Kanada and Mr. Misuzu Yoshikuni, of Prof. Uomoto's Laboratory of the Sustainable Engineering Division of ICUS received the Incentive Awards for their papers and presentations at the Annual Conference of the Japan Concrete Institute held on July 28, 2003. The title of the paper of Mr. Kanada was "Application of multi-spectral method to inspection of salt damaged concrete structures". Mr. Yoshikuni presented the paper on "Elucidation of the fundamental theory of concrete conveyance system using DEM". ICUS Staff congratulate both the students.

***Editor's Note***

*This afternoon (October 15, 2003) we had a quite big earthquake in the Kanto area. The seismic intensity around Tokyo was reported as the rank of 3 to 4. When it occurred, I was in my office on the 5th floor in the Institute of Industrial Science building. The vibration was the biggest that I have ever felt in my office. Frankly speaking, at that instance, it was not easy for us to recall what we should do. In particular for students and staffs from foreign countries it seemed difficult to understand how to behave.*

*This issue of the ICUS Newsletter features the fire in urban areas, where the main article is on the serious fire at a subway station in Taegu, Korea. Fire is one of the most serious damages induces from the earthquake. Today's earthquake has evoked me the importance of the first behavior, that is, stopping all fire sources, even in shaking. Attention !!! In Japan we may have big earthquakes anytime in these years!!!*

***(Y. Yasuoka)***

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