Wind Effects

New Frontier of Education and Research in Wind Engineering

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INDEX

TPU Global COE Program "New Frontier of Education and Research in Wind Engineering"

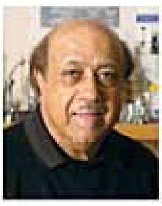
Yukio Tamura

The Global Center of Excellence (COE) Program "New Frontier of Education and Research in Wind Engineering" was proposed by the Wind Engineering Research Center (WERC) of the Graduate School of Engineering, Tokyo Polytechnic University, and approved by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in 2008. This Global COE program has been collaborating with the University of Notre Dame, USA. It is a five-year program on research and education and will be completed at the end of March, 2013. It covers three main wind related projects: Project 1 for wind resistant design; Project 2 for natural cross-ventilation; and Project 3 for wind environment and air pollution. The Wind Hazard Mitigation Center (WHMC) and the Wind Engineering Information Center (WEIC) facilitate the advance of the Global COE program.

Our program evolved from the 21st Century COE Program to the Global COE Program, and with the collaboration of the University of Notre Dame, we had been pioneering some new trials including construction of the EVO. With respect to the basic policy that provides the motivation for studies on prevention of wind disaster, natural ventilation, air pollution and the wind environment, based on "affection for human beings", "affection for global resources", and "affection for atmospheric environment", respectively, we would like to pursue our targets "New Frontier of Education and Research in Wind Engineering". The final goals are to promote global level advances in the quality of wind engineering education and research, and to create safe and secure societies all over the world. WERC, as the core of COE, is equipped with seven wind tunnels and is currently staffed by five professors, two guest professors, and two associate professors: Y. Tamura (Director of Global COE Program, Leader of Project 1), A. Kareem (Leader of University of Notre Dame, Project 1), T. Ohkuma (Project 1), M. Ohba (Leader of Project 2), R. Yoshie (Leader of Project 3), M. Matsui (Project 1), K. Mizutani (Project 2), A. Yoshida (Project 1), and Y. Morita (Project 1).

The overarching vision of GLOBAL COE is to build a sustainable urban environment that is resilient to extreme wind events and is in harmony with regional local climates. Its focus will be on developing an integrated education and research program that spans over a wide spectrum of problems to address wind-related challenges


Y.Tamura
Professor
(Director)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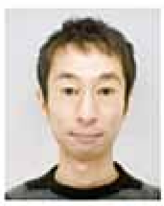

Y.Morita*2
Assoiate Professor
(Construction)

Fig.1 Global COE Members (*1: till 2009FY, *2: from 2010FY) of the next frontiers in urban regions of Asia and beyond.

During the Global COE term from 2008FY to 2012FY, TPU WERC played important roles in promoting education and research in the wind engineering community. The main output includes the following:

-Inauguration of School of Architecture and Wind Engineering (2010)
-Bridges and challenges to the future by development of research center with prospect for future study system on global center-to-center basis, through organization of international workshops/symposiums and educational programs
-Establishment of EVO VORTEX-Winds by cooperation with the University of Notre Dame, having participation of 14 world leading universities and institutes
-Launch of IG-WRDRR (2009) under the umbrella of UN ISDR, and community level wind-related disaster risk reduction activities
-Emphasis on training and education of young engineers and researchers, particularly in Asia Pacific region, through Short-term fellowship, International PhD Students Internship, Open Seminars by leading researchers, International Advanced School and Intensive Course for PhD students by 25 Guest Professors
-First-rate achievements on research in three research fields: Wind resistant design; Natural/cross ventilation; and Wind environment and air pollution.
-Harmonization of wind load codes and standards in Asia Pacific region, through APEC Wind Engineering Network and APEC-WWs since 2004
-Dissemination and disclosure of the latest research results, various databases, and state-of-the-art information/knowledge, through WEIC website
-Evaluation of achievements from international and global viewpoint, through Global COE Advisory Board composed of six world eminent researchers

Current activities should be continued after the Global COE program is finished, and several attempts have been made to get funding. Continuous organizations of several excellent events such as International Advanced School on Wind Engineering (IAS), Workshops on "Regional Harmonization of Wind Loading and Wind Environmental Specifications in Asia-Pacific Economies" (APEC-WW) are strongly desired by the wind engineering community. As is well known, database-assisted design/research/education is one of the future trends in the wind engineering field. ASCE 7 Minimum Design Loads for Buildings and Other Structures is going to authorize the TPU aerodynamic database as a sophisticated and quality-assured database. In the same direction, the established EVO VORTEX-Winds should be maintained to realize higher level education, research and design in the wind engineering filed. TPU databases have a strong connection with EVO VORTEX-Winds, ASCE and other activities, and maintenance of TPU databases is a duty of the TPU wind engineering group.

TPU WERC and wind engineering group members have already applied for some grants for research promotion and a research core initiative supported by the Japanese Government, including the Joint Usage/Research Center Program of MEXT. Considering past integrated contributions to the society and established unique wind engineering research facilities, I believe and strongly hope that this Joint Usage/Research Center Program will be awarded to our wind engi-neering group. Then, all our facilities and databases belonging to WERC, WHMC, and WEIC will be efficiently used by researches from other universities and institutes.

The Jules Verne Climate Wind Tunnel of CSTB in France, Full-scale Test Facility of IBHS in USA, and WindEEE Dome in Canada are recent trends to directly evaluate wind resistant performance of building frames, cladding, components and others under full-scale extremely strong winds or tornado-like wind conditions, reproducing combined conditions with rain, hail, wild fire, and so on.

In order to create efficient and comfortable environments, and due to people's basic demand to create iconic symbols in cities, buildings are becoming taller and slenderer, and bridges and roof structures are becoming longer and lighter, thus becoming more vulnerable to winds. The importance of wind engineering is significantly increasing, and day by day improvements and challenges to the future are required to be at the forefront of research and education to provide cutting edge research results.

ACKNOWLEDGEMENT

Recent activities of the TPU wind engineering group have been supported by the Ministry of Education, Culture, Sports, Science and Technology, Japan, through the Global Center of Excellence Program, 2008FY-2012FY.

On behalf of Global COE members and TPU WERC, I would like to express our sincere gratitude to the members of the Advisory Board of the TPU Global COE Program: Prof. Hiroshi Akiyama; Prof. Kishor Mehta; Prof. Robert Meroney; Prof. Shuzo Murakami; Prof. Dr. Giovanni Solari; and Prof. Haifan Xiang, for their kind and useful advice and encouragement. The late Professor Kenichi Honda and the former TPU President, Professor Nobuyuki Kobayashi, should be also particularly acknowledged for their kind and continuous support and encouragement.

I would also like to express my sincere gratitude to all past and current Global COE members, guest professors, post-doctoral fellows and researchers, PhD candidates, short-term fellows, TPU staff, and COE Support Office members for their great efforts to achieve our Global COE objec-tives in education and research in wind engineering.

Report of Global COE Research Projects

Project 1: Wind Hazard Mitigation

The mission of Project 1 is to mitigate the effects of wind induced disasters and to propose effective wind resistant design for structures. Through the G-COE program, the following items were investigated.

- characteristics of gusts such as those produced by tornadoes and thunderstorms
- monitoring of response of buildings and structures with GPS
- development of experimental system for determining cladding performance under wind pressures
- wind damage recognition using satellite and aerial images
- aerodynamics for various structures and groups of buildings
- development of engineering virtual organization, EVO, in the cyber-infrastructures
- any other issues related to wind engineering in the structural engineering field

As shown in previous reports, see the back numbers of this bulletin, the project items were carried out as planned. More researches were also carried out.

Some activities in the 2012 fiscal year were as follows.

1) Proposal of design tornado for important facilities

Based on the damage data for historical tornadoes and statistical modeling and analysis for exceeding probabilities of tornado wind speeds, design tornadoes were proposed. The properties of the design tornado were estimated for very rare events whose annual probability is around 10^{-7}. Through the estimation, investigation results for the Tsukuba tornado, F3, May 6th, 2012, were taken into account, and some comparisons among tornadoes in the US and Japan were also considered.

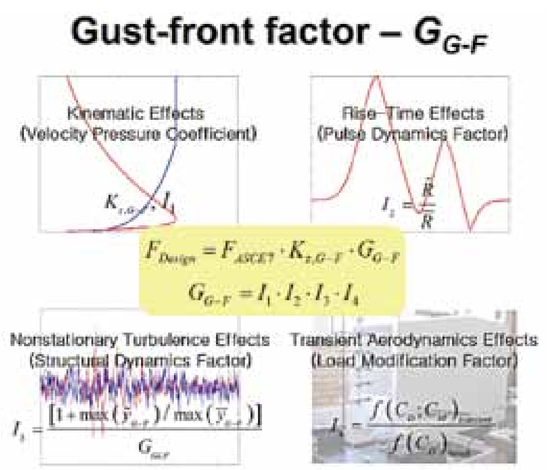
(by Y. Tamura, M. Matsui)

2) Investigating Impact of Extreme Wind Events on Structures

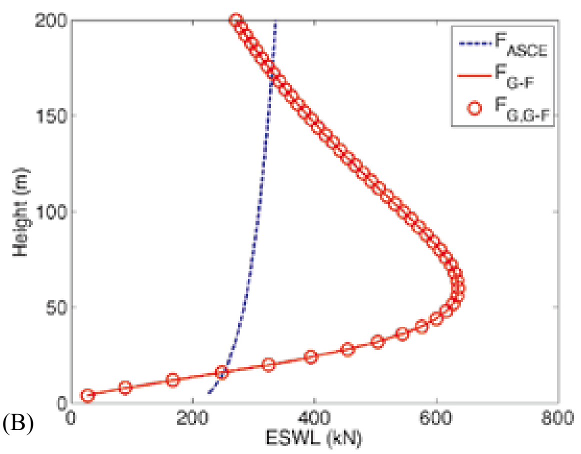
This multi-faceted research endeavor examined the impact of extreme wind events (i.e., thunderstorms, gust fronts and hurricanes) on structures. In order to realistically capture the characteristics of gust-front winds and their attendant load effects, a gust-front factor framework was proposed, which expresses a generalized description of the genesis of the overall wind load effects on structures under both gust-front and boundary layer winds. A schematic diagram that portrays the genesis of the design wind loads in gust-fronts is given in Figure

1(a). It is further extended to a generalized version for application in international codes and standards. As shown in Figure 1(b), gust-front winds may produce a higher local equivalent static wind loads distribution that results in an approximate doubling of base forces compared to those in boundary layer winds. This underscores the role of enhancement of kinematic effects by variation in wind profiles between boundary layer and gust-front winds on the overall design load. In addition, a new gust-front factor formulation based on a coupled blade/tower model is derived through a synthesis of recently derived methodologies for gust-front loadings on buildings and ongoing work that seeks to construct a framework for the assessment of gust-front effects on wind turbine assemblies (Figure 1c). For better understanding of the characteristics of non-stationary winds, fixed averaging interval (FAI) and variable averaging interval (VAI) approaches were assessed for hurricane and downburst data (Figure 1d).

(by A. Kareem, D.K. Kwon, M. McCullough, Y. Tamura; S. Cao)



(A)



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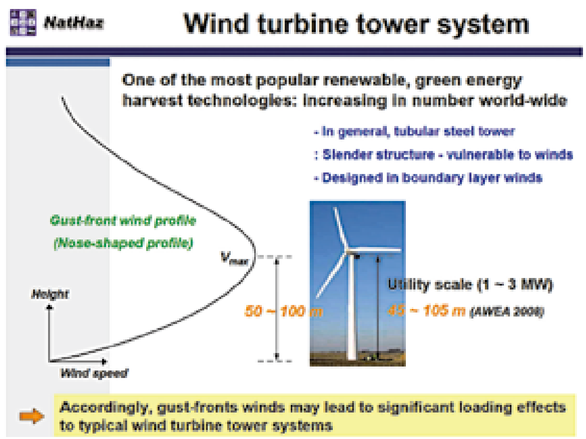

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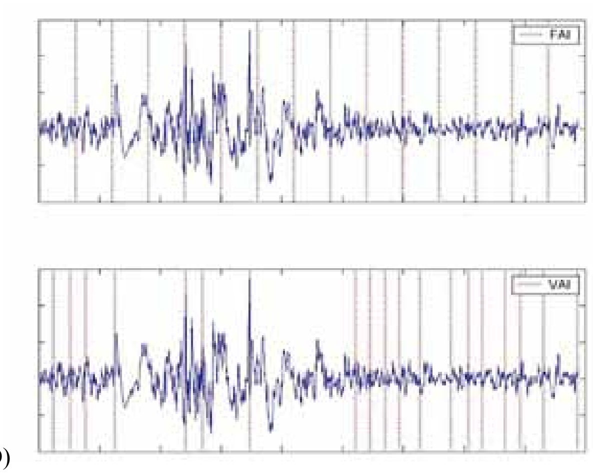


(D)

Figure 1 Schematic diagrams and results from extreme wind analysis programs

3) Development of wind induced structural response monitoring network and analysis and modeling of data

Even though the height and complexity of tall buildings continues to expand, their design process still relies on methodologies that have yet to be systematically validated in full-scale. Thus, the only way to determine the accuracy of this process, particularly as these designs push the envelope, is through comprehensive monitoring programs based on observations of these structures after they are constructed, under dynamic loads such as strong winds and earthquakes. The PI and his colleagues have been engaged in such efforts through the Full-Scale Monitoring Program since 2002, which has been constantly upgraded to ensure long-term data from these signature buildings (Figure 2A). As the height of these structures increases, the traditional hub-and-spoke wired acquisition systems normally used in these measurement systems are no longer practical, necessitating a new framework that is free from the losses common in alternate architectures like wireless systems. To overcome these limitations, the PIs have developed a next generation of modular system named *SmartSync,* which utilizes the building's existing Internet backbone as a system of "virtual" instrumentation cables for multiple sensor types at variable sampling rates including Global Positioning Systems (GPS), accelerometers, and meteorological stations etc. (Figure 2B). The software modules in SmartSync in terms of web-based on-line approach deliver high-quality response and meteorological monitoring with a range of data mining/dissemination/ management, processing and system identification capabilities available through a combination of real-time and on-demand services (Figure 2C). Figure 2D shows the resonant component of the GPS displacements during an earthquake event as a proof-of-concept of SmartSync (by A. Kareem, T. Kijewski, K. Kwon, R. Bashor; McCullough, Y. Guo, S. Bobby, Y. Tamura)

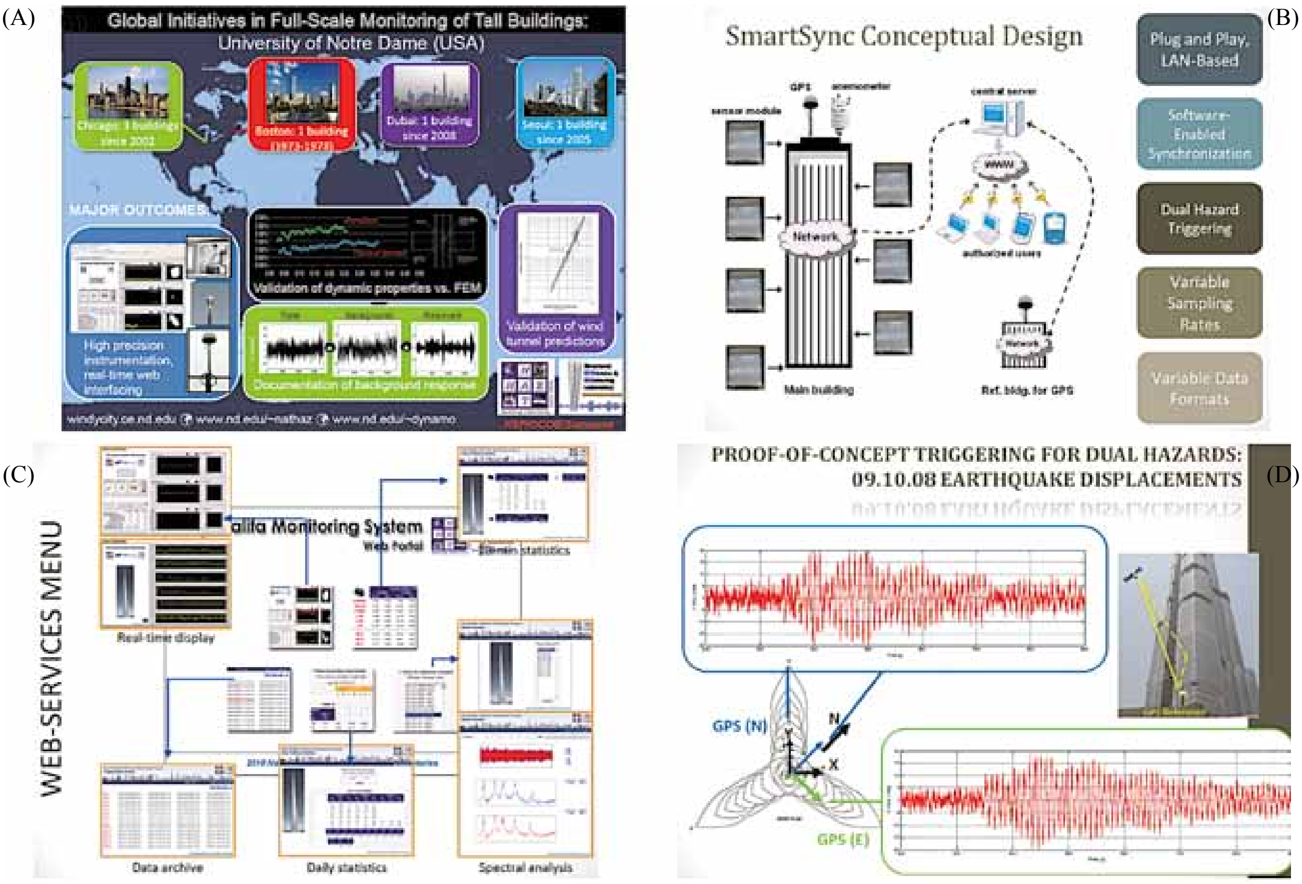


Figure 2 Wind induced structural response monitoring network

4) Development of experimental system for simulating behaviors of ceiling system and photovoltaic system exposed to severe differential pressure due to strong winds

In the past, most damage due to the strong winds such as tornadoes, typhoons and down bursts has been to low rise buildings, especially to cladding, roof panels and ceiling boards.

Recently, the peak pressure coefficients have been estimated under various types of conditions (using wind tunnel tests, numerical simulations, and field measurements) for cladding design, and effective design criteria have been derived. However, as shown in these pictures, there are many kinds of ceiling boards, claddings, solar panel systems, etc. Thus, it is important to establish testing systems to clarify the strength of cladding against severe suctions under static and dynamic conditions. An experimental system for simulating the behavior of cladding [called pressure chamber] was set up in our Wind Engineering Research Center. A cladding specimen was set on the top face of the pressure chamber and the pressure inside the chamber (chamber pressure) was varied from -10kPa to 10kPa.

Figure 3 shows a conceptual drawing of the experimental system. The experimental system consists of 3 parts: Pressure Generating Section, Pressure Adjusting Section, and Test Section. It is controlled by a personal computer, as shown in Figure 3. In the pressure generating section, there are 2 fans (11 kW). One of them is for positive pressure supply and another one is for negative pressure supply. In the Pressure Adjusting Section, there is an interlock valve for adjusting the pressure inside the pressure chamber.

This system was used to conduct tests on ceiling panels and solar panel systems. An example of a specimen is shown in Figure 4.

(by Rei Okada, Akihito Yoshida, Masahiro Matsui, Yukio Tamura)

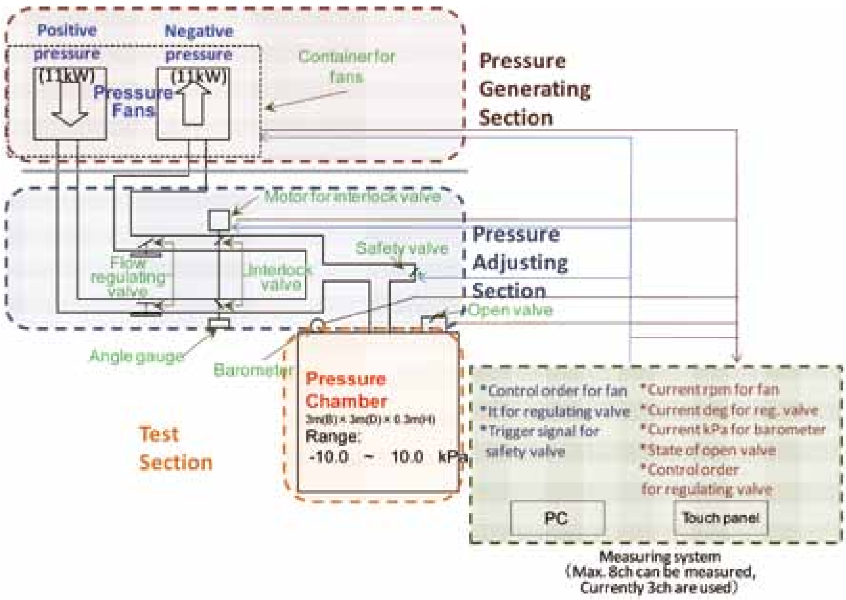


Figure 3 Conceptual Drawing of experimental system

Figure 4 Example of specimen
(after loading extraordinary pressure)

5) Towards a Robust Damage Assessment from Remote Sensing Imagery

Development of algorithms capable of correcting photometric and geometric differences between before and after image-pairs was the key research focus in this work. As a part of this study, a fast robust feature matching and random sampling algorithm is proposed. For feature extraction, we adopted a scale- and rotation-invariant interest point detector and descriptor termed SURF (Speeded Up Robust Feature). An approximate k-Nearest Neighbor algorithm was used for feature matching. A speed-up of 10x was achieved without compromising robustness through randomized kd-trees and a constrained RANSAC algorithm.

In our work we also addressed color balancing for the purpose of change detection. For multitemporal images, an ideal color correction approach should be effective in transferring the color palette of the source image to the target image for the unchanged areas while being able to transfer the global color characteristics for the changed area without creating visual artifacts. To achieve this goal, we proposed a new local color balancing approach that uses adaptive windowing. We evaluated the proposed method against other state-of-the-art ones using a database consisting of aerial image pairs. Our proposed approach outperformed other state-of-the-art algorithms. To validate results of building segmentation and damage classification, ground truth datasets was prepared and is hoped to make it publicly available to researchers.

(by J. Thomas, A. Kareem, K. W. Bowyer)

Figure 5 Source images (left). Target images (middle). New target image transformed using the proposed adaptive windowing based local color transfer (right).

6) Pressure and flow field investigation of interference effects on external pressures between high-rise buildings

Interference effects between two high-rise buildings with different shapes and different arrangements were studied by conducting pressure measurements and PIV measurements.

PIV experiments were performed to check the flow patterns of several cases that cause high and low interference factors. The layout of the experiment is as shown in Figure 6. The results show that where large negative pressure appears at the upper corner of the principal building, the principal building is usually downstream of the interfering building and it is attacked by the shear layer flow separated from the upstream interfering building. The mean wind speeds near that target corner are relatively low. But the strong turbulence of the attacking wind caused by the upstream interfering building can increase the fluctuating pressure coefficient. When high negative peak pressure appears at the lower corner of the leading edge of the principal building, the flow pattern results indicate that the high mean negative pressure at the leading edge of the principal building is mainly due to the high wind speed parallel to the target face. The high mean wind velocity occurs because the configuration of the two buildings can speed up the wind by inducing it to pass through the channel between them.

For both the upper corner cases and the lower corner cases, data of the extreme instantaneous flow field are also investigated. A high-speed shear layer wind from the upstream building and the strong interaction of the flow fields of the two buildings near the leading edge of the target face of the principal building might be the reason for large minimum peak pressure.

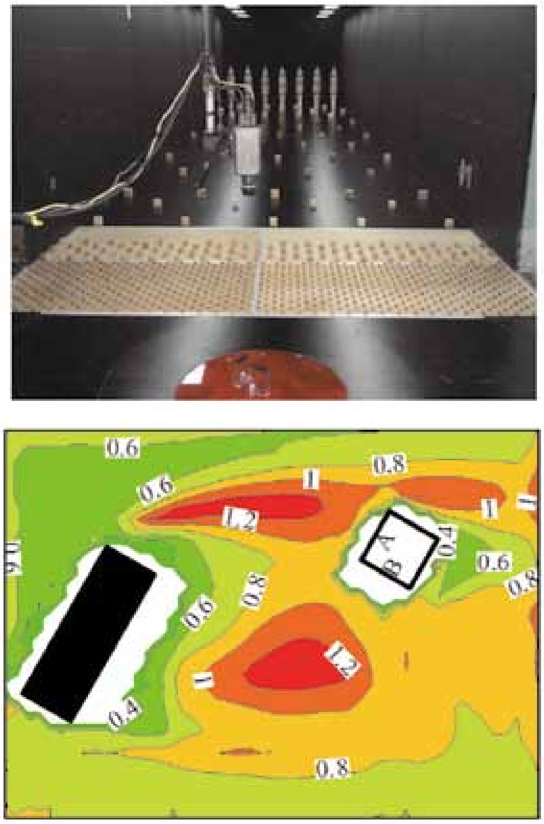


Figure 6 Standard deviation of along wind speed

(by Y. Hui, A. Yoshida, Y. Tamura)

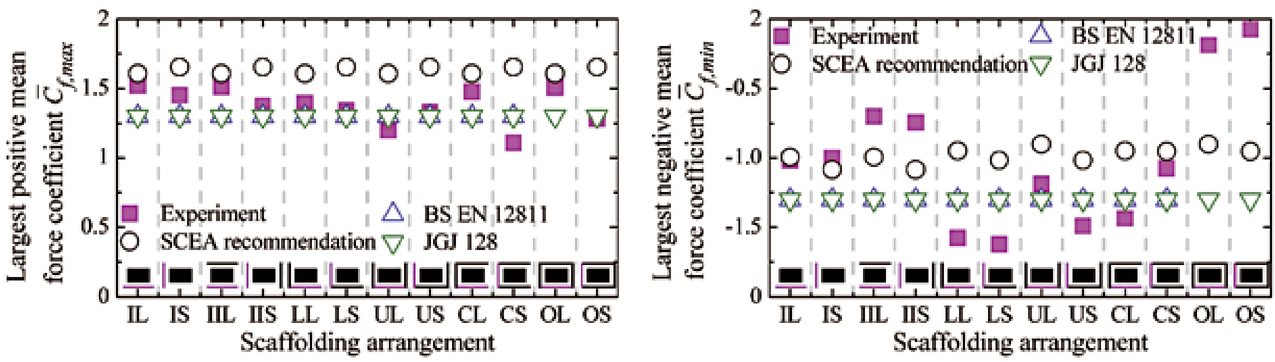
7) Wind loads on clad scaffolding with different arrangements and building opening ratios

Cladding increases the wind loads on clad scaffolding, and nonporous cladding increases them the most. Wind tunnel experiments were carried out based on a prototype of nonporous sheet-clad scaffolding. Twelve scaffolding arrangements and four building opening ratios were tested. Mean force coefficients for entire scaffolding for different scaffolding arrangements and building opening ratios were determined.

For most scaffolding arrangements, positive mean force coefficients tend to become smaller and negative mean force coefficients tend to become larger when building opening ratios increase. For positive mean force coefficients, the values for different arrangements are not very different. Furthermore, the wind directions that result in the largest positive mean force coefficients are almost the same: perpendicular to the outer surface of the scaffolding. The magnitudes of the largest negative mean force coefficients vary widely for different arrangements, which due to the influence of the scaffolding models on other sides of the building. BS EN 12811 and JGJ 128 underestimate the mean force coefficients of scaffolding for some scaffolding arrangements. SCEA recommends appropriate positive mean force coefficients, but still underestimates the negative mean force coefficients for some arrangements, as shown in Figure 7.

The interference effects of neighboring buildings on mean force coefficients of clad scaffolding were also studied. A neighboring building with the same dimensions as the principal building at different locations was tested in the wind tunnel. When the neighboring building was on the same side as the scaffolding, the shielding effects on positive mean force coefficients were significant, and the effects became weaker as the distance to the neighboring building increased. When the neighboring building was on the left or right side of the scaffolding, the positive mean force coefficients were larger than for the corresponding isolated cases, and the values tended to be smaller as the distance between the two buildings increased.

(by F. Wang, Y. Tamura, A. Yoshida)



(a) Largest positive mean force coefficient (b) Largest negative mean force coefficient

Figure 7 Comparison of the largest mean force coefficients with current design recommendations

8) Fetch effects of surrounding buildings on wind pressures and forces acting on low-rise building

The objective was to investigate the fetch effects of surrounding buildings on wind pressures and wind forces applied to a low-rise building. The wind pressure coefficients were defined in two different ways: normalized by velocity pressure of the incident flow and the normalized by the velocity pressure at each measurement point. Based on the interference effect approach, a method of evaluating the wind loads was proposed. The results show that (zoning) interference factors can be expressed as an exponential function of area density C_A only.

Shielding effects on wind force correlation and quasi-static wind load combinations were examined using peak normal stresses in columns. Combination factors were evaluated and they increased with increasing area density, and a shielding factor of combination factors was proposed using an exponential function of area density.

The effects of incident flows on wind loads and their combination effects were also investigated. The effect of boundary-layer flows on interference factors, zoning interference factors, and interference factor of combination factor were found to be small.

(by Y. C. Kim, A. Yoshida, Y. Tamura)

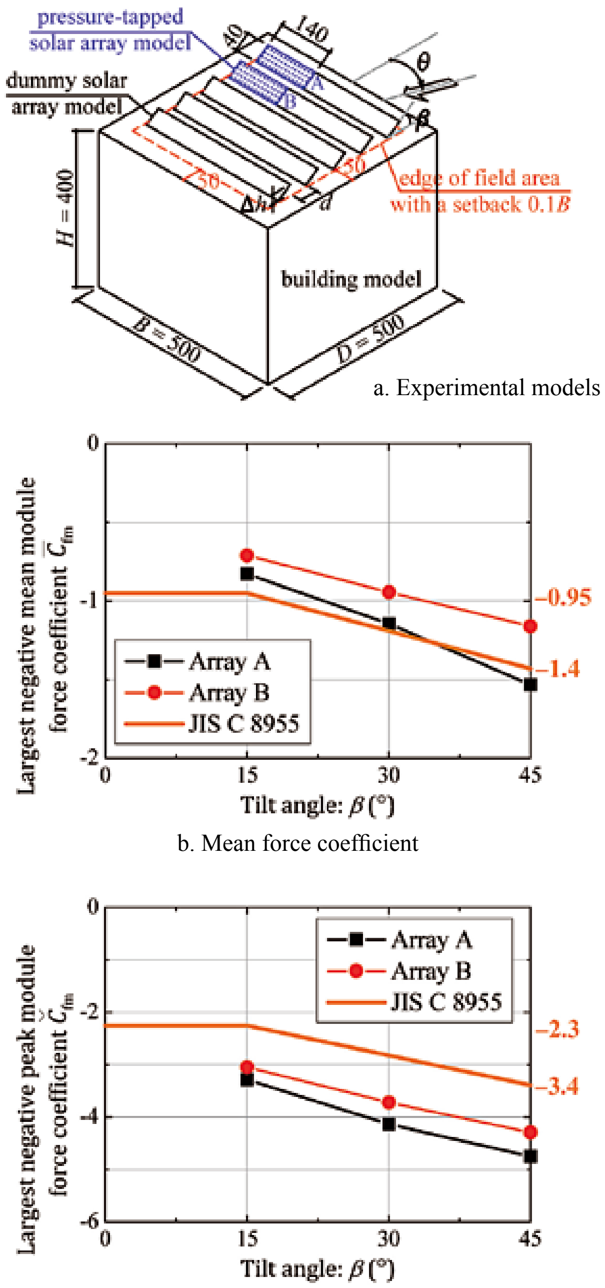
9) Wind loading characteristics on solar collectors

A series of wind tunnel experiments were performed to evaluate wind loads on solar panels on flat roofs, mainly focusing on module forces calculated from area-averaged net pressures on solar modules of a standard size. In order to investigate the module force characteristics at different locations on the roof, solar array models with pressure taps installed as densely as possible were moved from place to place. Design parameters including tilt angle and distance between arrays, and building parameters including building depth and parapet height, were also considered. The results show that unfavorable negative module force coefficients for single-array cases are much larger than those for multi-array cases; tilt angle and distance between arrays increase negative module forces; effects of building depth and parapet height on negative module forces are not obvious; and recommendation values in JIS C 8955 Standard correctly estimate negative mean module force coefficients but not peak values.

(by J. Cao, A. Yoshida, P. K. Saha, Y. Tamura)

10) Development of an EVO: VORTEX-Winds

A Virtual Organization for Reducing the Toll of EXtreme Winds (VORTEX-Winds) is being developed to achieve improved understanding and modeling of wind effects on structures through shared access to geographically dispersed resources and global collaborations in real-time for more effective research and education http://www.vortex-winds.org. The collection of the field's leading universities, organizations, firms and government agencies to form this prototype collaboratory and to secure their commitments to contribute their resources has been accomplished. The EVO comprises two major sections: e-design and analysis modules and knowledge base. The e-design and analysis system involves stitching of geographically dispersed modules encompassing *Database-Enabled Design, Full-Scale Data, Stochastic Tools, Tele-Experimentation, Uncertainty Modeling, Damage Assessment,* and *Computational*



a. Experimental models

b. Mean force coefficient

c. Peak force coefficient

Figure 8 Effect of tilt angle on largest negative mean and peak module force coefficients

Platforms. The database-assisted design section has been fully functional and evolved with the inclusion of a newly developed database-enabled design module for low-rise buildings (DEDM-LR) and for high-rise buildings (DEDM-HR). The latter has been further extended to accommodate international codes and standards. Other modules are at various levels of completion. A sample of screenshots of the DEDM-LR and -HR is given below for quick reference. VORTEX-Winds promises to enhance the capability of its members and end users beyond their current resources through a synergistic, integrative approach to understanding and modeling the complex wind-structure interactions. The result will be creation of a community as a whole better positioned to address the next frontiers in the field.

(by A. Kareem, T. Kijewski-Correa, G. Madey, D.K. Kwon, D. Kumar, L. Carassale, Z. Zhai, N. Regola, Daniele Wei, Y. Tamura, S. Cao)

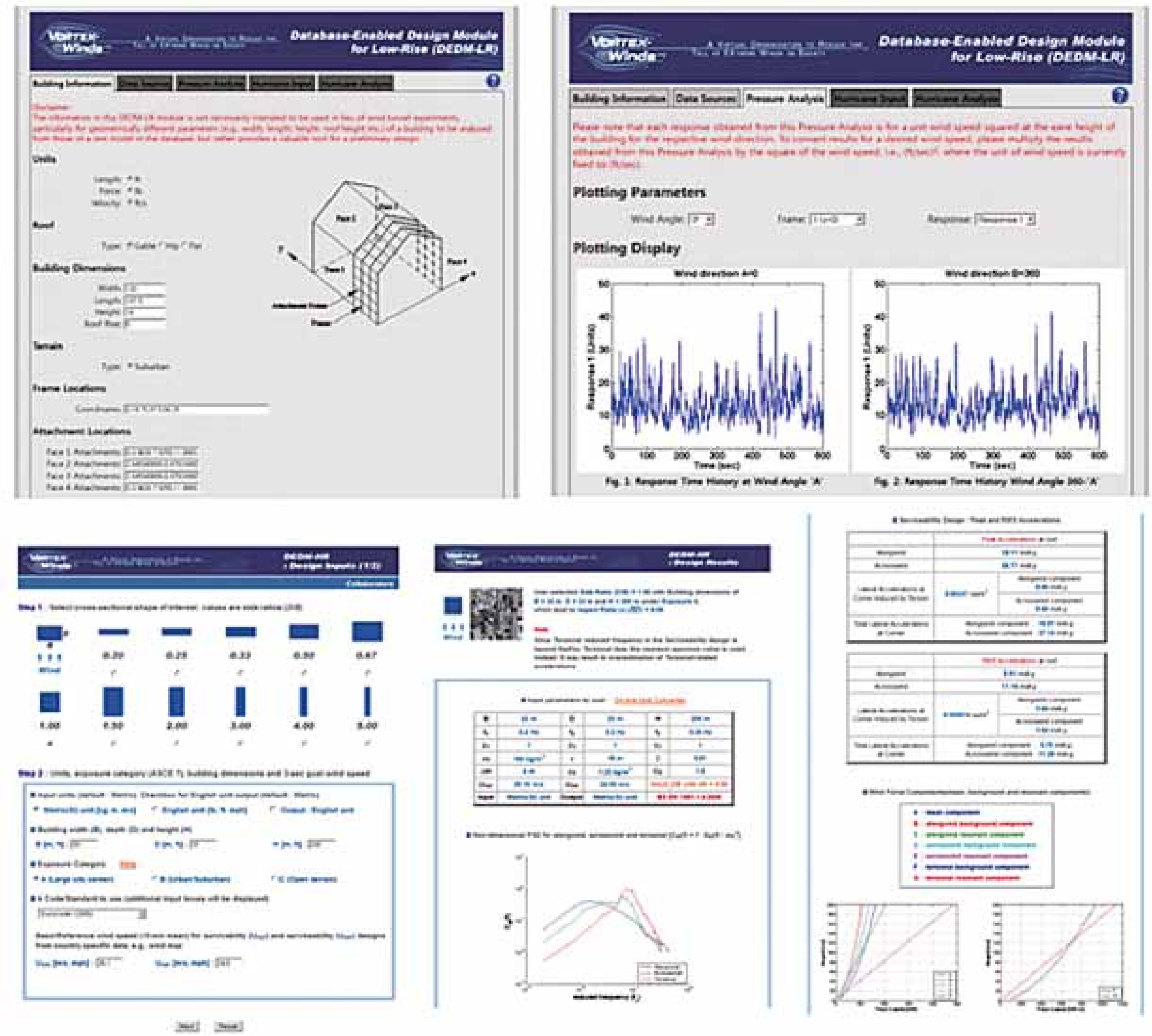


Figure 9 Sample of screenshots of the DEDM-LR and -HR

Project 2: Natural/Cross ventilation

This project is aimed at developing a method of designing natural/cross ventilation for sustainable buildings utilizing natural wind, and also to establish a hybrid system for dehumidifying and cooling with natural draft and radiating heat compatible with the weather conditions of Asia-Pacific countries. The former research theme was performed by Prof. Masaaki Ohba with Dr. Kenji Tsukamoto and Dr. Isaac Lun as GCOE researchers. They focused on physiological and psychological research on human subjects in a cross-ventilated environment using a climate controllable wind tunnel. The latter research theme was performed by Prof. Kunio Mizutani with Dr. Haeyoung Kim as GCOE researcher. The main results obtained after five years of research are reported as follows.

1) Physiological characteristics of human body in cross-ventilated environment

To clarify the influence of frequency of fluctuating airflow on mean skin temperature and sweat rate, which indicate the body's physiological response, human subject experiments were conducted in a climate controllable wind tunnel. Sinusoidal and uniform wind flows were produced inside the test room by adjusting the frequency of the sinusoid wave while keeping air temperature at 32ºC, humidity at 70% and air velocity at 0.4 m/s.

Figure 1 shows the power spectrum of sweat rates on the forehead/chest and wind velocity. The sampling frequency of sweat rate was 1Hz so that Nyquist frequency was 0.5Hz. It was found that the spectra of sweat rates comprised several sweating waves. In particular, the spectral peak frequency of sweat rate showed a high power component at the sinusoidal frequency of the produced wind velocity. Figure 2 shows the power spectrum of skin temperature on the chest and wind velocity. The spectral peak frequency of skin temperature corresponded closely with the spectral peak frequency of the sinusoidal wave flow.

From the results of the subject experiments, the spectral peak frequency of skin surface temperature and sweat rate corresponded closely with the spectral peak frequency of the sinusoidal wind flow in the range between 0.02Hz and 0.2Hz. The sweat evaporation rate was higher in the low-frequency range than in the high-frequency range, showing that the cross-ventilated airflow had physiological influences on the human body.

2) Modification of physiological thermoregulation model for cross-ventilated environment

The first two-node model was proposed by Gagge et al (1971). The model subdivided the human body into two layers: skin and core. Energy balance equations of these compartments were derived to evaluate thermal sensation of the body. The two-node thermal sensation transient model was employed in thermal comfort standards of ASHRAE and ISO7730.

In a thermally stagnant environment, by using the climate controllable wind tunnel, it was confirmed that mean skin temperature in thermal-transient conditions of a stagnant environment could be predicted by modifying the human thermoregulation coefficients of sweat rate and evaporative heat loss of diffusion of the 2-node model.

In a cross-ventilated environment produced by step-wise changing of wind velocity, the accuracy of skin temperature prediction by the 2-node model deteriorated,

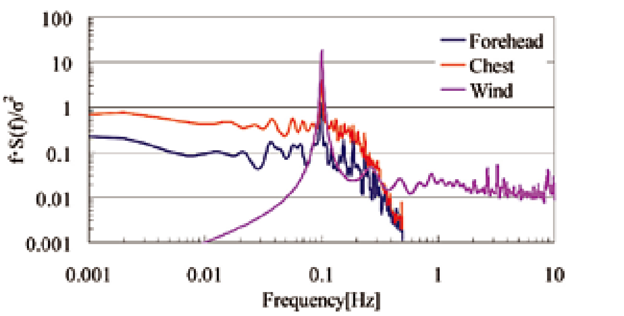


Figure 1 Power spectra of sweat rate on chest/forehead and wind velocity

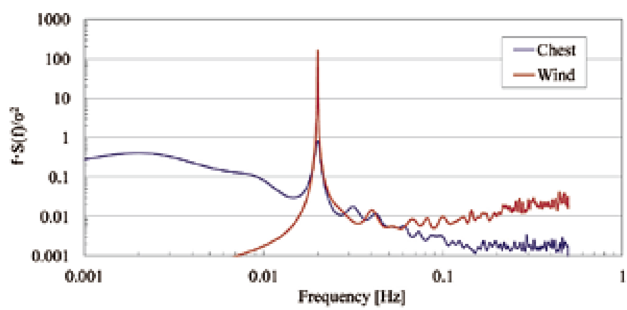


Figure 2 Power spectra of skin temperature on chest and wind velocity

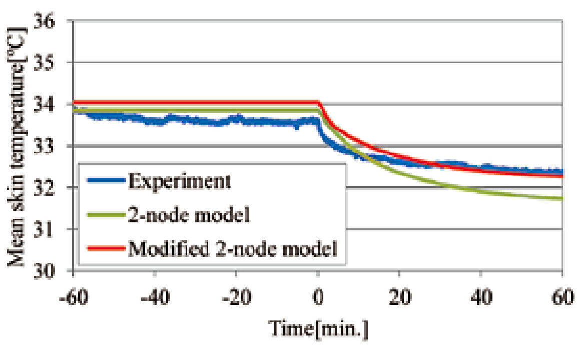


Figure 3 Comparison of measured and predicted skin temperatures in cross-ventilated environment

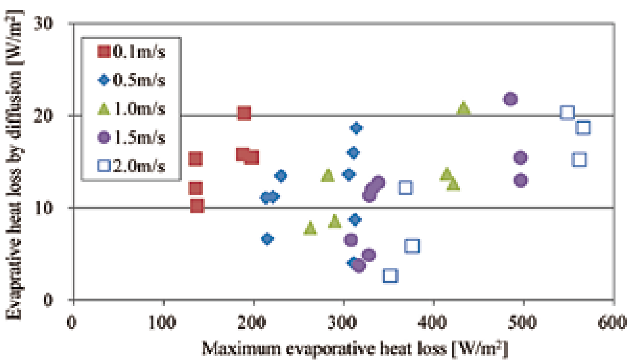


Figure 4 Relationship between maximum evaporative potential and evaporative loss by diffusion through skin from subject experiments

as shown in Figure 3. Figure 4 shows the relationship between maximum evaporative potential and evaporative loss by diffusion through the skin from subject experiments. Regardless of wind velocity, evaporative heat loss by diffusion was kept constant. However, the two-node model showed that the evaporative heat loss by diffusion was 6% of the maximum evaporative heat loss, which is a function of wind velocity. We modified the sweat rate and evaporative heat loss by diffusion of the 2-node model. As shown in Figure 3, the time history of mean skin temperature in thermal-transient conditions in a cross ventilated situation could be predicted with high accuracy.

CFD simulation was done using the 65-node model developed by Tanabe (2002). This model, based on the Stolwijk (1971) multi-node model, is a physical model based on heat balance equations for individual body parts. Its inputs include age, sex, basal metabolic rate, and fat rate. It considers thermal conductance between tissues, the detailed vascular system, and the thermoregulatory system consisting of perspiration, vasomotion, shivering heat production, arterio-venous anatomies, etc.

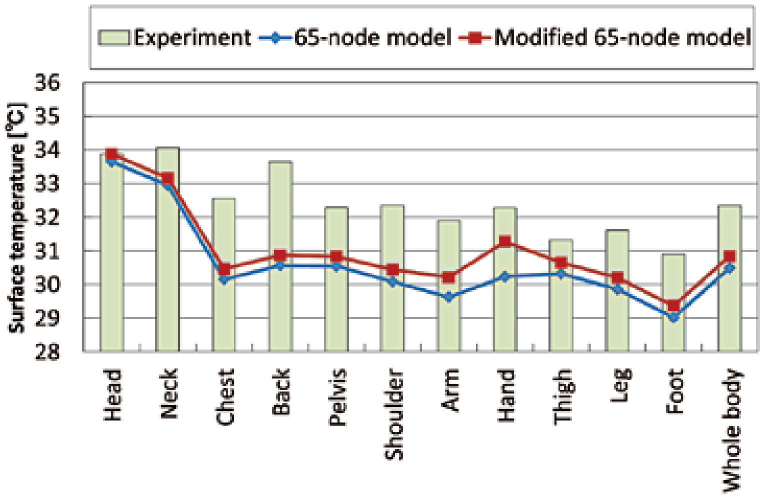


Figure 5 Prediction accuracy of body skin temperatures at 32°C in early summer environment by modified 65-node model

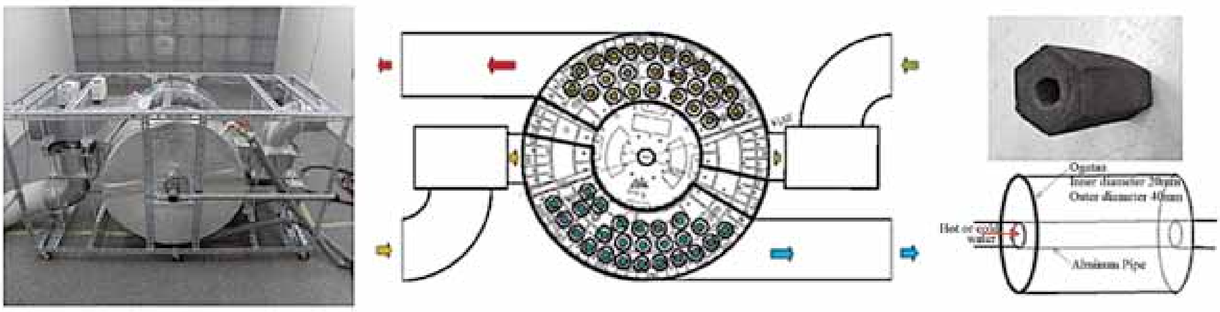


Figure 6 Absorption and desorption of moisture unit and experimental device

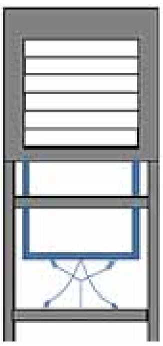


Figure 7 Natural ventilation system

Figure 8 Wing-jet ventilation system

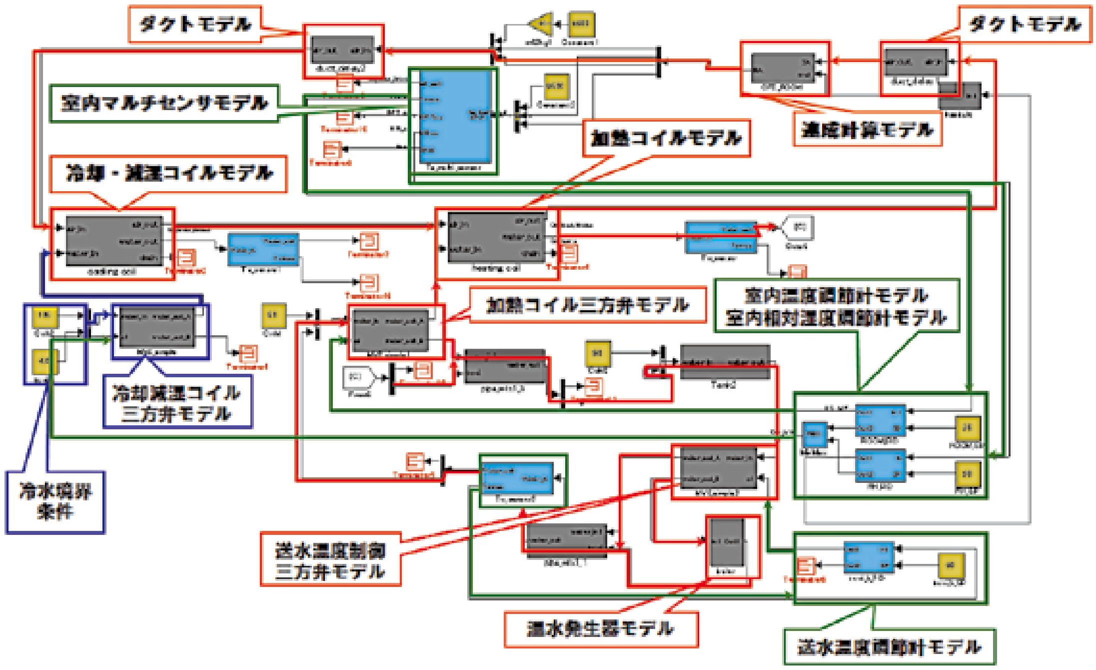
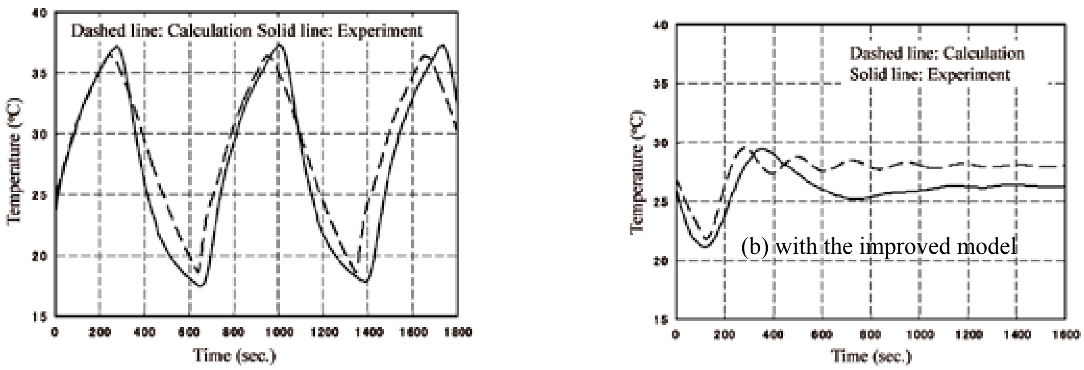


Figure 9 Coupled dynamic system model



(a) without improved model

(b) with improved model

Figure 10 Comparison between blow temperature of and experiment

The Launder-Kato-modified linear low-Reynolds-number k-ε turbulence model was used in this study. The QUICK scheme was applied to deal with the convection term of the equations and the SIMPLEC algorithm was used to control the pressure-velocity coupling. The first cell was 0.2 mm from the surface and the y+ value was equal to 1. In this fine grid region, five layers were set with a change of thickness ratio of 1.1.

In order to verify the skin temperature and skin wettedness predicted by the modified 65-node model, the subject experiment was carried out 10 times in the climate controllable wind tunnel. The subjects were in a standing posture and wore trunks with 0.03 clo. In these 10 tests, only young male persons were investigated. The air temperatures of the room were set at 32°C. The wind speed was kept at 1.0 m/s and blew from the front of the subjects.

Figure 5 shows the results of CFD analysis. The 65-node model predicted that the surface temperatures at chest and back were around 2.5 to 3°C lower than the subject experimental results. This is because the evaporative heat loss by diffusion was over-predicted in the cross-ventilated environment. We modified the evaporative heat loss by diffusion using the regression equation obtained from the subject experiment. The modified 65-node model increased the accuracy of skin temperature prediction.

(by M. Ohba, K. Tsukamoto, I. Lun)

3) Research on characteristics of absorption and desorption of moisture in direct cooling and heating desiccant devices comprising absorbent tube-shaped charcoal

A prototypical direct cooling and heating desiccant system was used as an absorbent material comprising absorbent tube-shaped charcoal. The experiment showed that dehumidification was possible at cooling temperatures over 15°C, and an absorbent material could also reproduce at heating temperatures of 40°C. Moreover, when cooling and heating of moisture absorption material were repeated every hour, the amount of dehumidification of each cycle was not changed.

4) Development of Natural Ventilation System with Constant Air Volume

The newly developed natural ventilation system is shown in Figure 7. The angle of the wings changes when the hybrid spring system is pulled below by winds. By adjusting the angles of the wings with the spring system, an almost uniform downstream wind velocity of approximately 2~3 m/s under natural wind fluctuations could be obtained.

The characteristic of the wing-jet ventilation system was also investigated in the wind tunnel, as shown in Figure 8. The wing rotates depending on the wind direction. The upper part of the wing-jet receives positive pressure when natural wind blows, so the bottom part receives negative pressure. This system can be installed on the outside of the roof floor. By using this negative pressure, indoor air can be taken to the outside naturally.

5) Research on simulation of coupled dynamic model of air conditioning system

In this study, we examined the dynamic simulation model of an air conditioning system consisting of heat source equipment, heat exchanger, transport equipment and a room. The efficiency of the air conditioning system could be increased by optimum operation control using the dynamic model. In this study, the current chilled water coil model was examined. We developed a linked simulation that performs simultaneously between coupled of dynamic system model as shown Figure 9, and CFD of air conditioning system contained improved model We verified the accuracy of the simulation calculations in an artificial climate room, whose temperature could be controlled stably by using a linked simulation, as shown in Figure 10.

(by K. Mizutami, H. Kim)

Project 3: Outdoor Wind/Thermal Environment and Air Pollution

In the Global COE program of Tokyo Polytechnic University, Project 3 covers research and education in the fields of outdoor wind environment and air pollution. The ultimate purpose of the project is proposal of guidelines for urban development. Fig.1 shows framework of the entire research of Project 3. Many research items direct toward this ultimate goal with some of them closely related to each other. In this article, achievement in some of the important study areas, namely: Just three items because of page limitation. Reproduction of occurrence frequencies and vertical profiles of wind velocity and temperature by meso-scale simulation, Generalization of convective heat transfer from urban canopy surfaces, effect of atmospheric stability on urban pollutant concentration and its generalization are outlined and presented.

1) Reproduction of occurrence frequencies and vertical profiles of wind velocity and temperature by meso-scale simulation

We aimed to use the WRF (The Weather Research and Forecasting Model), a meso-scale simulation model, in order to prepare standard wind data at high-altitude for the assessment of the pedestrian wind environment and air pollution. We also aim to use WRF for research on urban heat island phenomena, which is becoming serious in large cities in Japan. One of the effective countermeasures against heat island phenomena is to lead cool air of sea breeze into urban canopies. This strategy strongly depends on the vertical profile of wind velocity and the temperature of the sea breeze. Before doing these investigations using WRF, it is necessary to confirm how WRF can correctly reproduce the occurrence frequencies and vertical profiles of wind velocities. For this validation, observation data measured by Doppler-Sodar in the Minami Senju district in Tokyo (Miyashita et al. 2002) were used. In order to well regenerate the vertical profile of wind velocity by WRF, it is considered

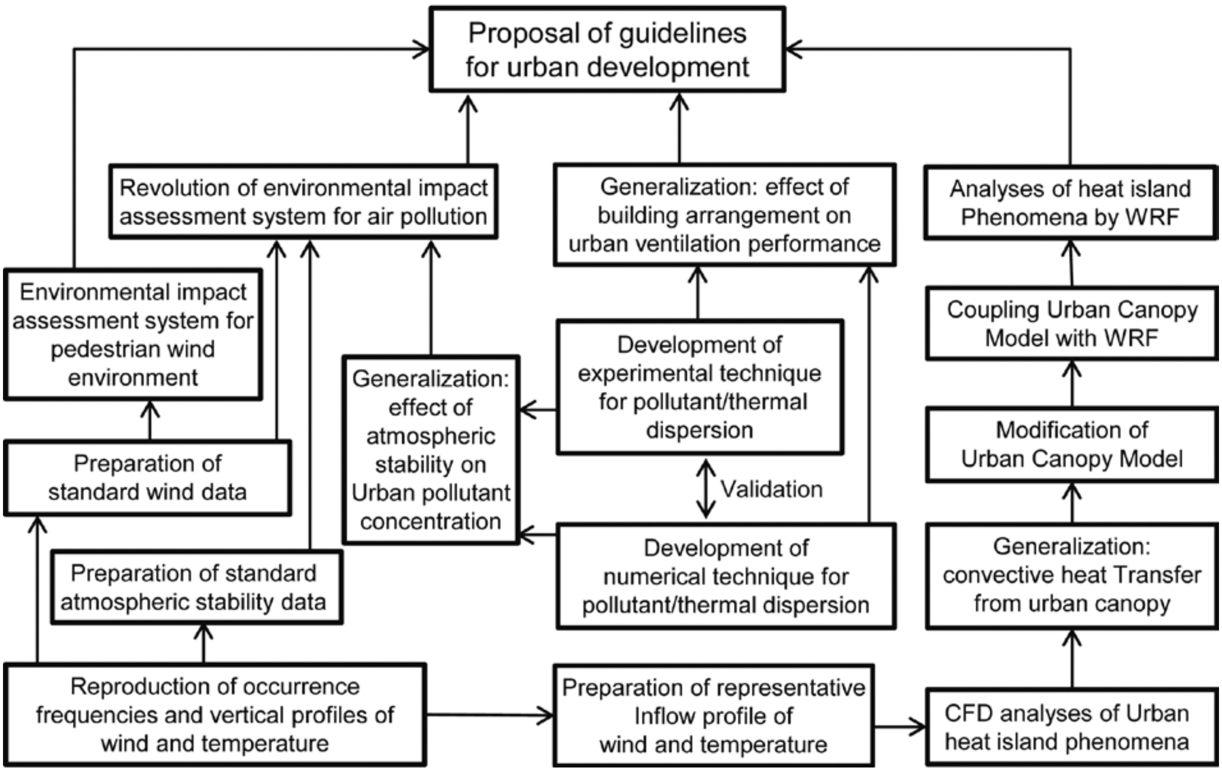


Figure 1 Framework of the entire research of Project 3

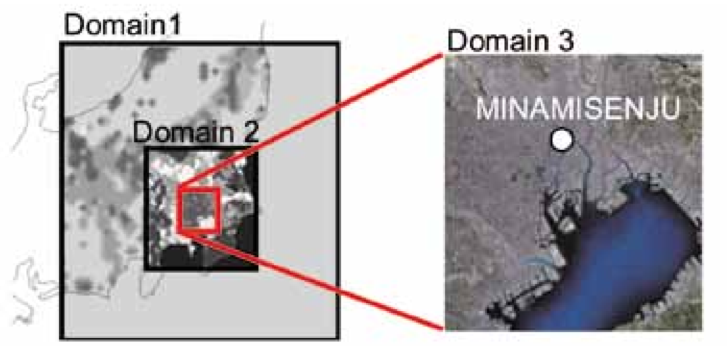


Figure 2 Computational Domain

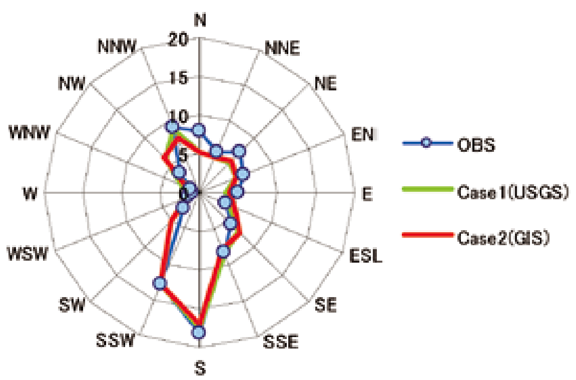


Figure 3 Wind rose

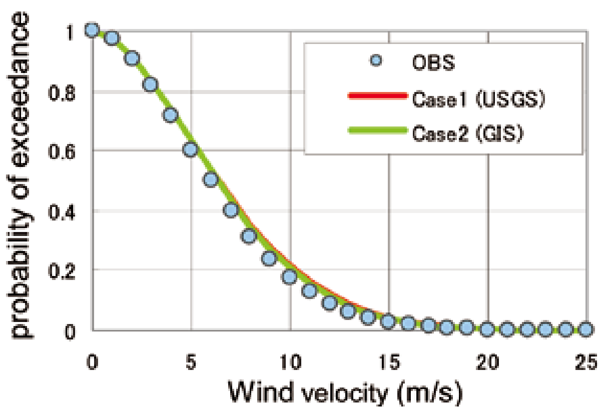


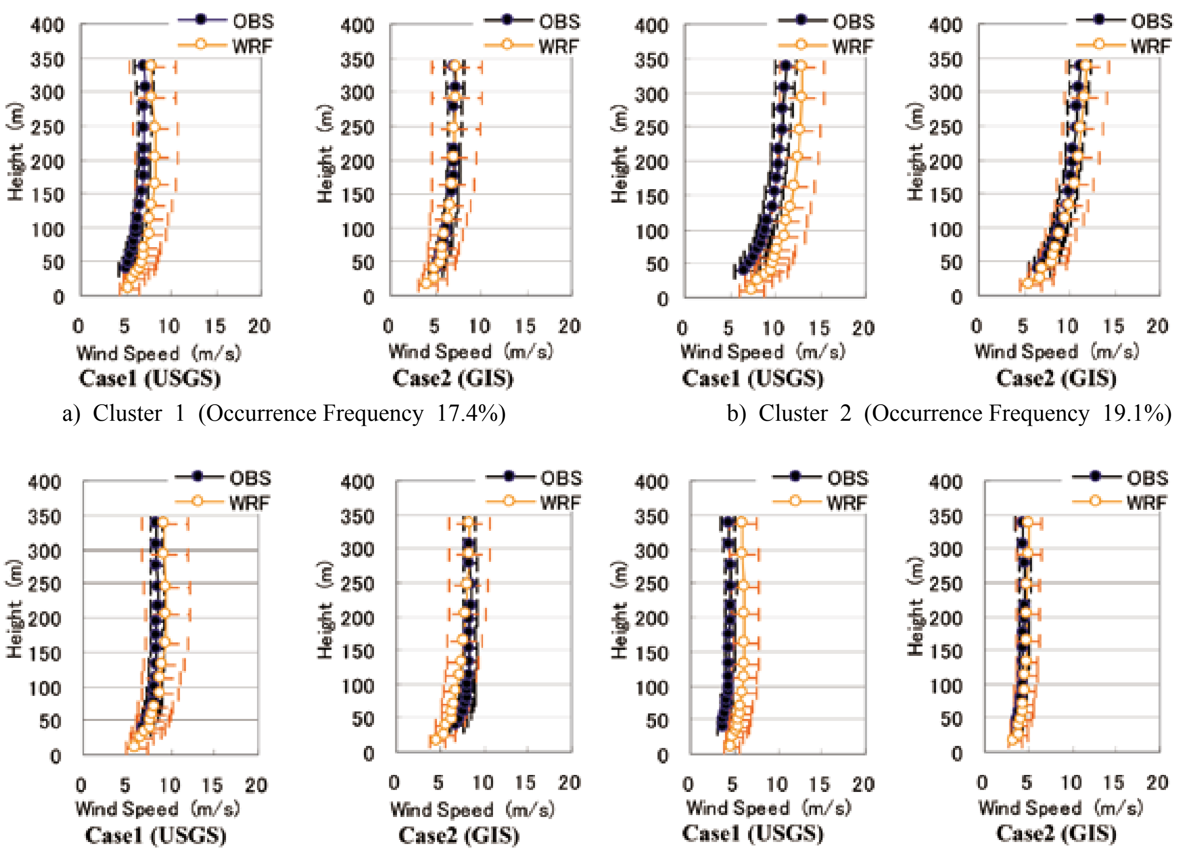
Figure 4 Probability of Exceedance for Mean Wind Speed

that an appropriate surface roughness should be given to the WRF calculation. Thus, we used GIS (Geographic Information System) data to appropriately classify urban land-use categories and to give roughness lengths to the WRF calculation. The calculations were conducted using three-stage, two-way nesting grids. The calculation domains is shown in Fig. 2. The Minami Senju district, used for the comparison, is included in Domain 3.

We carried out two kinds of calculations: one using the default setting of WRF with USGS (Case 1), and the other using the land-use categories and surface parameters based on GIS data. Fig. 3 and Fig. 4 compare wind rose and probabilities of exceedance of mean wind velocity (10 minutes averaging 300m high) between the results of WRF and observation data, respectively. Calculated wind roses by Case1 and Case2 agreed well with the observation data. The probability of exceedance of wind velocity calculated by Case 2 agreed very well with the observation data. The probability of exceedance calculated by Case 1 was higher than that of Case 2. However, the difference was not so large at this high altitude.

For the comparison of vertical profiles for mean wind velocity, we firstly extracted southerly wind (wind direction=180°±33°at 200m high) for both observation and calculation. Then the vertical profiles of wind velocity of the observation data were classified into eight clusters by cluster analysis. Corresponding clusters of calculated results were made so that each cluster at the same time of the observation data became the same cluster. Fig. 5 shows vertical profiles of wind velocities in representative four clusters. Averaged values ±1σ(standard deviation) at each height in each cluster are plotted in the figures. The percentage shown in the caption for each cluster is the occurrence frequency for that cluster. There is a pretty good match between observation and calculated results. In particular, Case 2 using GIS is remarkably close to the observation values. Case 1, using the default setting of USGS, generally show higher values than the observation data.

As mentioned above, it becomes clear that the WRF can well reproduce the wind rose and occurrence



a) Cluster 1 (Occurrence Frequency 17.4%)

b) Cluster 2 (Occurrence Frequency 19.1%)

c) Cluster 3 (Occurrence Frequency 13.5%)

d) Cluster 4 (Occurrence Frequency 11.4%)

Figure 5 Vertical Profile of Mean Wind Speed frequencies and vertical profiles of wind velocity if the roughness length is appropriately given. Although description about temperature was omitted in this manuscript, occurrence frequencies and vertical profiles of the temperature were also investigated. It was found that occurrence frequencies and vertical profiles of temperature calculated by the WRF agreed very well with the observation data except at lower altitude. Prediction accuracy of the temperature at lower altitude was improved by coupling an Urban Canopy Model with the WRF. Thus, we obtained a prospect that the WRF can be used for our purpose, i.e. preparation of standard high-altitudes wind data, extraction of representative vertical profiles of wind velocity and temperature, and analysis of urban heat island phenomena.

2) Generalization of convective heat transfer from urban canopy surfaces

The WRF coupled with an Urban Canopy Model is considered as an effective tool for the prediction of urban heat island phenomena. The Urban Canopy Model is responsible for predicting the heat transfer from the urban canopy to the overlaying atmosphere. In the Urban Canopy Model (Kusaka et al., 2001) adopted by the WRF, the local convective heat transfer from the urban canopy surfaces and its dependence on urban parameters such as building coverage ratio and building height variations are not explicitly modeled. In the model, the Convective Heat Transfer Coefficient (CHTC) from canopy surfaces is evaluated from Jurge's formula (1924). In this formula, the local convective heat transfer coefficient from building walls and ground depends only on the velocity inside the canopy. However, this cannot be justified since other urban parameters also contribute to the heat transfer coefficient. Moreover, this model cannot distinguish the difference between convective heat transfer coefficients on different wall surfaces, i.e., windward, leeward, side wall of the building and the ground, instead it expresses the CHTC generally as wall. Thus, we need to generalize the CHTC of the building canopy surfaces (ground, windward wall, leeward wall and side wall) more explicitly with respect to the urban parameters that affecting the CHTC of urban canopy surfaces.

For this purpose, wind tunnel experiments were firstly carried out to roughly grasp the dependence of urban parameters on bulk heat transfer from an urban canopy in a thermally stratified wind tunnel as shown in Fig. 6. Six experimental cases were carried out for different configurations of urban canopy (three cases with uniformheight and the other three cases with non-uniform-height). The building coverage ratios (hereafter referred to as BCR) were varied as 6%, 11% and 25% for both the uniform- and the non-uniform-height cases.

However, it is not an easy task in wind tunnel

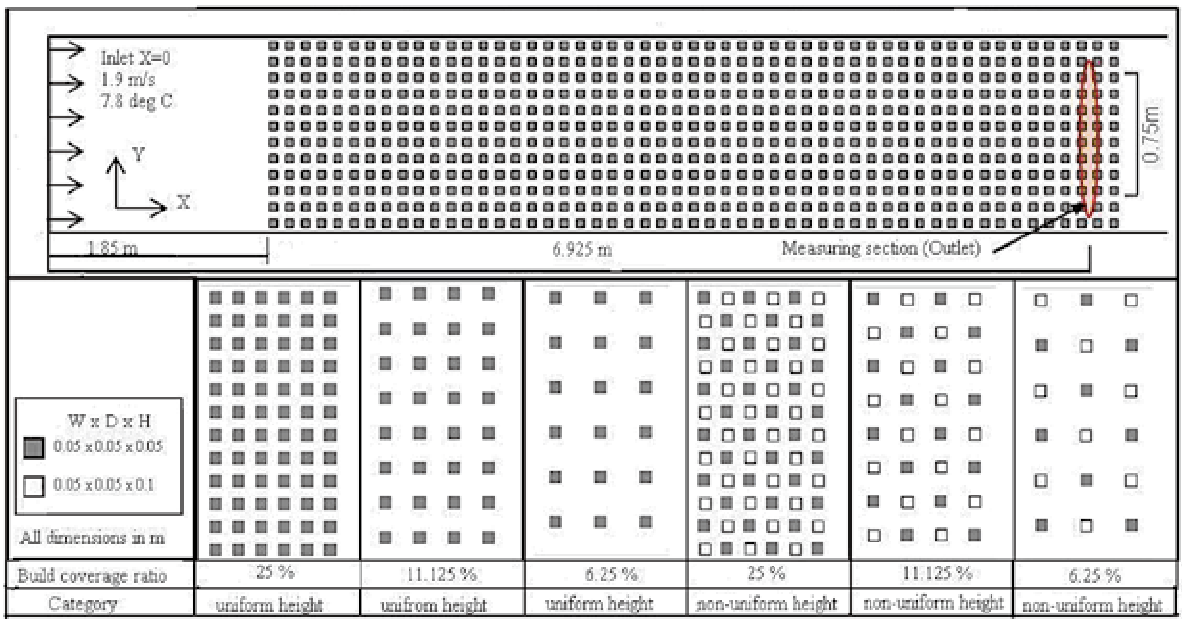


Figure 6 Experimental setup and List of experimental cases

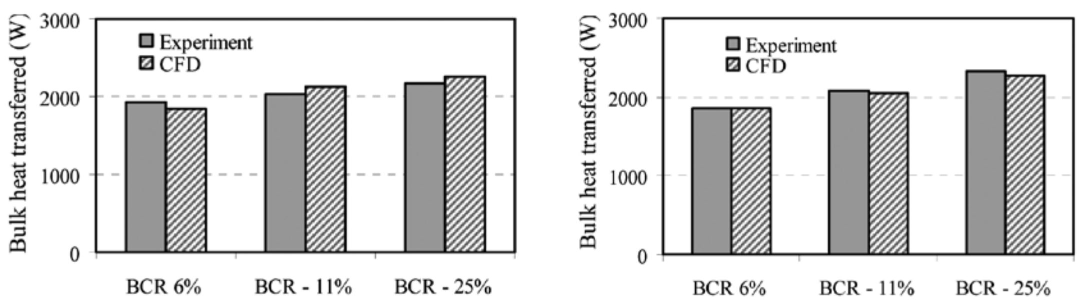
experiments to evaluate local CHTC, which vary on individual surfaces of building roof, wall and ground. Hence CFD simulation with a low-Reynolds-number model was conducted to predict the convective heat transfer on these surfaces. Figure 7(a) and (b) compares the bulk heat transferred from the urban canopy by the experiments and the CFD simulations for uniform- and non-uniform-height cases, respectively. The CFD results showed good agreement with the experimental results.

After this validation, the local CHTC for a particular wall surface was investigated from the CFD results. Fig. 8 (for example) shows the local CHTC of canyon surfaces with horizontal distance in the flow direction for roof, windward wall, leeward wall and ground.

Parametric CFD simulations more than 30 cases changing urban configuration parameters were conducted in order to generalize the CHTC from the urban canopy surfaces to the atmosphere. Tentative equations for evaluating local CHTC from urban parameters and atmospheric parameters were proposed based on the results of the parametric CFD simulation. Fig. 9 compares the local Nusselt number (Nux) obtained from the proposed equation and CFD simulations. The proposed equation well expresses the Nux obtained from the CFD simulations. But we need more parametric studies to increase generality. The generalized equations will be incorporated into the Urban Canopy Model in WRF which can be used for urban planning for mitigating urban heat island phenomena.

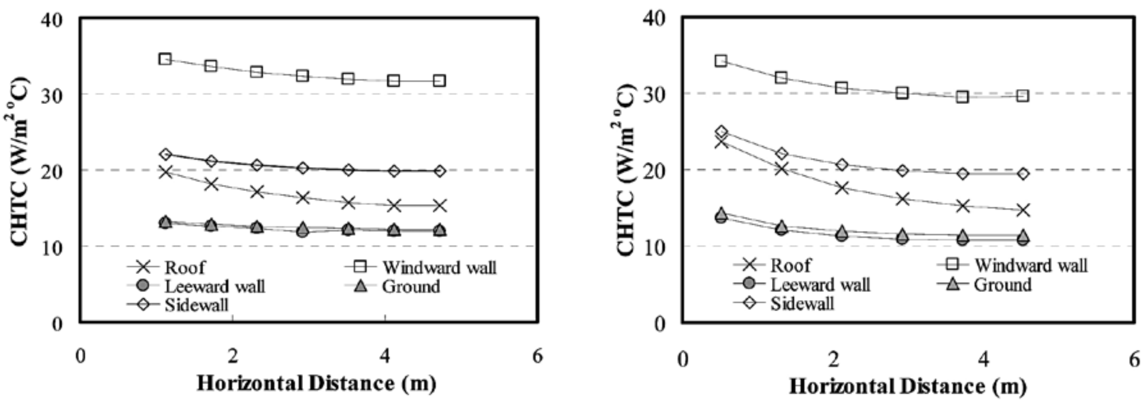
3) Effect of atmospheric stability on urban pollutant concentration and its generalization

For environmental impact assessment of air pollution, a Gaussian plume model is usually used in Japan. This model is applicable for pollutant dispersion from a high chimney, but it is obvious not appropriate for pollutant dispersion within an urban area. Even so, it is used for this situation. One of the reasons why wind tunnel experiments (WT) or CFD simulations are not commonly used for environmental impact assessment for air pollution is that too many cases of wind tunnel experiments or CFD simulations would be required because various classes of



(a) Uniform-height case (b) Non-uniform-height case

Figure 7 Comparison between experiment and CFD simulations: Bulk heat transferred from urban canopy for various BCR



(a) Uniform height case (b) Non-uniform height case

Figure 8 CHTC profile in horizontal distance in the flow direction for individual canopy surfaces for 6% BCR

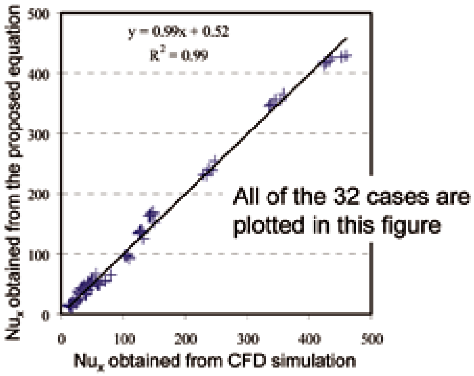


Figure 9 Comparison between local Nusselt number obtained from CFD simulation and proposed equation

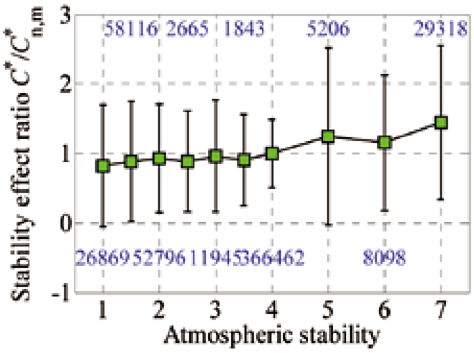


Figure 10 Stability effect ratio

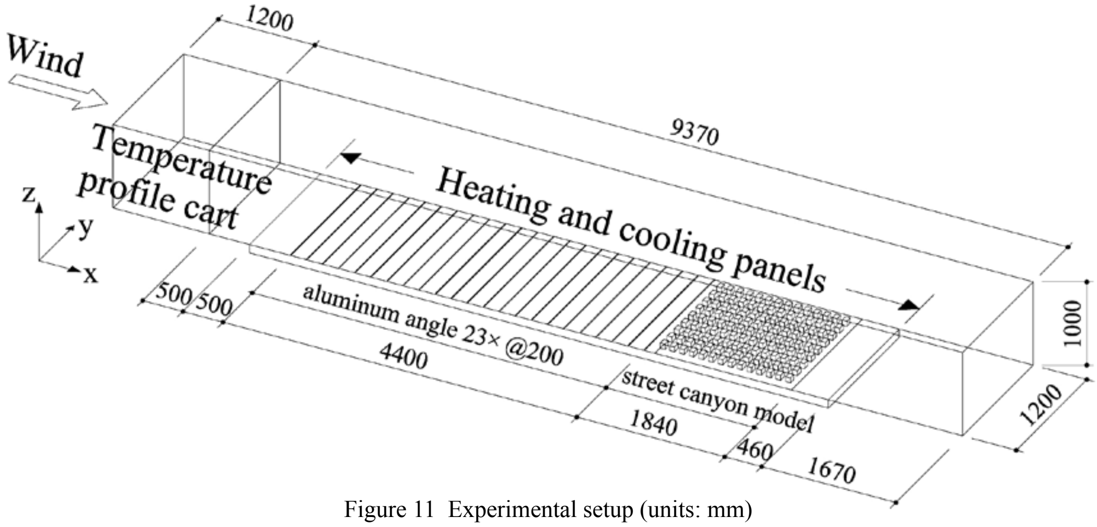


Figure 11 Experimental setup (units: mm)

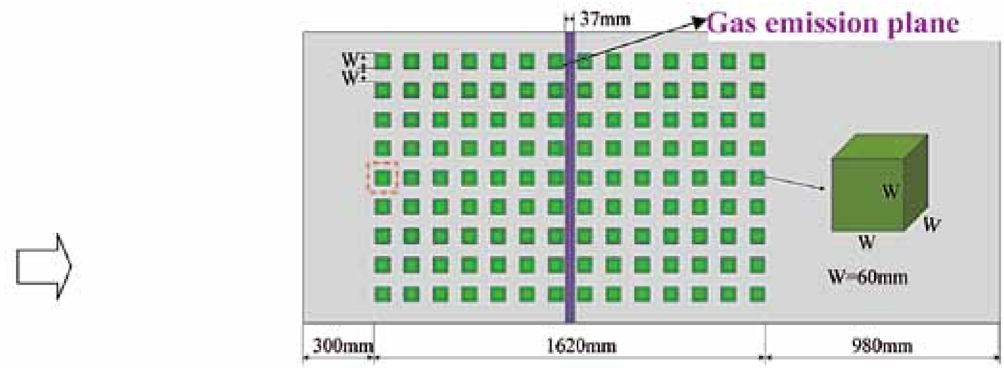
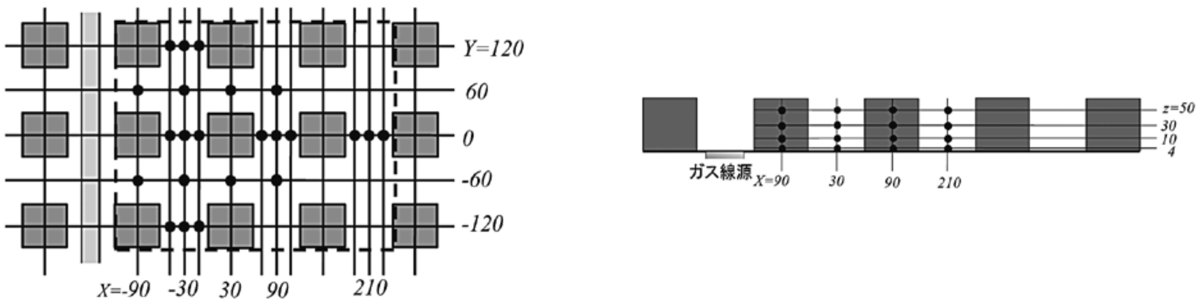


Figure 12 Arrangement of building blocks



(a) top view

(b) side view

Figure 13 Measuring points

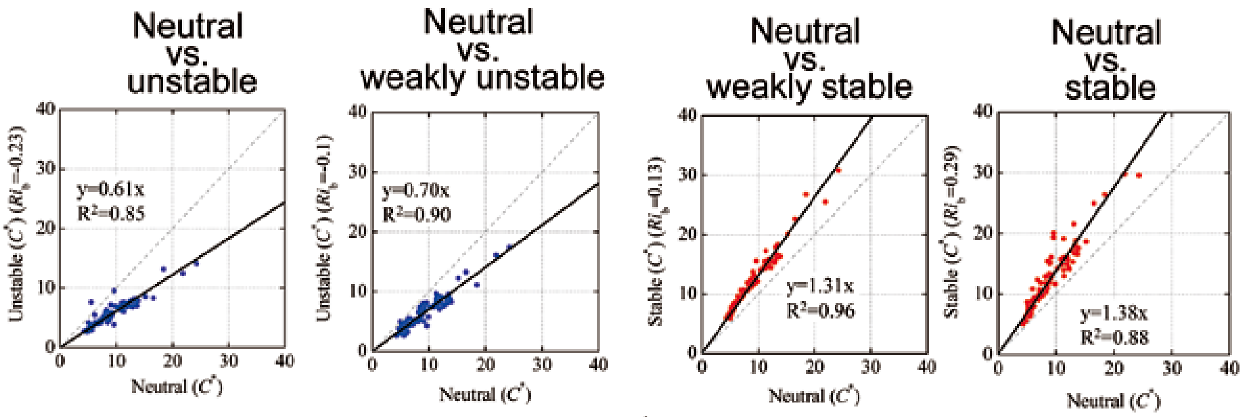
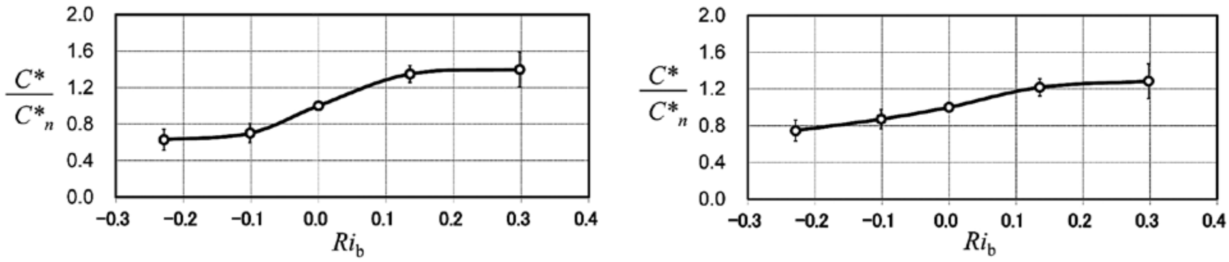


Figure 14 Correlations of C* (Neutral-Un-neutral)



(a) From experimental results

(b) From CFD results

Figure 15 Stability Effect Ratio (SER) = Ratio between C* under un-neutral condition and C*n under neutral condition

atmospheric stability would have to be considered. (Eg. 16 wind directions ×10 stability classes = 160 cases). Another reason is that few institutes have a thermally stratified wind tunnel. If a general function independent of wind direction, urban shape, and location expressing the effect of atmospheric stability on pollutant concentration could be proposed, it would become possible to conduct WT/CFD for only neutral conditions and convert the results (pollutant concentrations under neutral condition) into those in other atmospheric stability conditions by using the proposed general function.

We firstly attempted to find the general function from observation data at air pollution monitoring stations of the Tokyo Metropolitan Government (TMG). The index “Stability Effect Ratio (SER)” was proposed for this purpose. It is the ratio between C* (non-dimensional concentration under non-neutral condition) and C*n,ave (non-dimensional concentration under neutral condition). All averaged values of the “Stability Effect Ratio ± 1σ” are plotted against stability classes in Fig. 10. The numbers in horizontal axis express the atmospheric stability classes. It can be seen a tendency that the SER increases with the increase of the atmospheric stability. All of the 26 monitoring stations had the similar tendency. Thus, there is a possibility that the “Stability Effect Ratio” is independent of urban shape and location. But standard deviations are very large probably due to variability or uncertainty of the atmospheric condition and gas emission rate.

In order to reduce the uncertainty, wind tunnel experiments were conducted under non-neutral (weakly unstable, unstable, weakly stable and stable) and neural conditions. The experiments were conducted in a thermally stratified wind tunnel at Tokyo Polytechnic University (TPU). Fig. 11 shows the experimental setup.

A street canyon model (Fig. 12) was put in a downstream of the turbulent boundary layer. Fig. 13 shows measuring points. The locations of the measuring points were selected so that various flow patterns (reverse flow, upward flow, downward flow in the street canyons and flow on the roads) were included.

The correlations for normalized non-dimensional concentration C* between neutral condition and non-neutral conditions were investigated and shown in Fig.

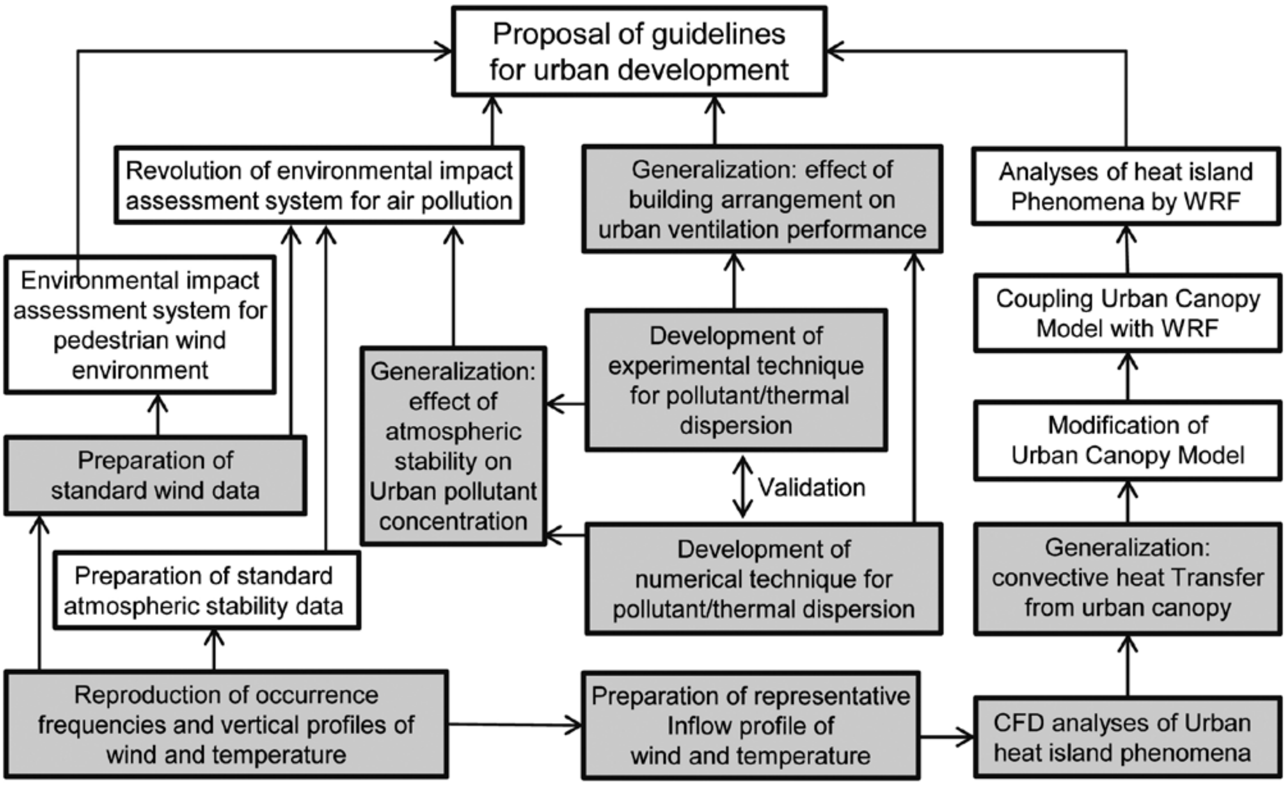


Figure 16 Framework of the entire research of Project 3

14. As shown in the figures, data were plotted almost on a single straight line. Thus the ratio between C* under non-neutral conditions and neutral condition were independent of the measurement locations (the flow filed around the measuring positions). The slope becomes steeper with the increase of the Bulk Richardson Number.

Fig. 15a shows the ratio between C* under un-neutral condition and C*n under neutral condition obtained from experiment. We also conducted CFD simulations, and the result is shown in Fig. 15b. The curve is Stability Effect Ratio (SER) on pollutant concentration (SER= C*/ C*n). Averaged SER ± σ (the standard deviation) of all the measuring points are plotted in the figures. As shown in the figures, with the increase of Rib, the SER increases. Since the standard deviation is relatively small, the SER is almost independent of the locations or flow fields. But we need further case studies to confirm the generality of the SER. If the function of the SER is universal one, we can predict pollutant concentration under un-neutral condition from experimental or CFD results under neutral condition by using the function. It will bring about a drastic change in the environmental impact assessment of air pollution in Japan.

Concluding remarks and future prospects

In this manuscript, some of the research results obtained by the Project 3 : wind environment and air pollution group were introduced. Three of the most important study areas, namely: Reproduction of occurrence frequencies and vertical profiles of wind velocity and temperature by meso-scale simulation, Generalization of Heat transfer from urban canopy surfaces, Effect of atmospheric stability on urban pollutant concentration and its generalization were outlined and presented. These study areas are taking very important role in the framework of the entire research of Project 3 as shown in the Fig 16. Unfortunately, we have not achieved the final goal, even second goals yet. But fortunately the goal and the strategy are quite clear, and the research progresses that move toward the final goal have been steadily built. The research items that we made remarkable progress are shaded in the Fig. 16. We will continue our efforts to achieve the final goal.

(by R. Yoshie)

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A Tribute to Jack E Cermak "the Father of Wind Engineering"

Like many from my part of the world, I came to the United States to study structural engineering, for example, concrete or steel structures. During my studies, I was introduced to wobbly tall buildings by Professor Hansen at MIT following an article in the Wall Street Journal on "Dizzying Heights". This piqued my curiosity and motivated me to learn more about wind and how it interacts with structures. A quick literature survey led to Jack Cermak and Alan Davenport. Both men very enthusiastically responded to my request for papers and the possibility of a fellowship for pursuing my PhD. My master's advisor said that since I am more interested in structures I should go to Canada as Jack's group was more focused on fluid dynamics. My final decision was made by the snow in Canada and I landed in Colorado from Massachusetts. In retrospect, this was a great decision as in Jack's group I added another dimension to my portfolio, fluids.

I remember vividly my first visit with Jack. Upon arrival his secretary ushered me into his small office located in the main campus of CSU with stacks of files reaching to the ceiling. I could not see Jack and after a little peeking through the little openings I noted a very distinguished person sitting in his chair writing something on a note pad. He did not notice me as we could barely see each other. I looked around and noticed that there was no open space on the walls due to a huge number of certificates of honor. The secretary then returned and told Jack I was there. He then stood up and we had a very cordial conversation. I was impressed by the files and the variety of books, but most importantly the collection of certificates. During the conversation he pointed at the certificate of his recent induction into the National Academy of Engineering, of which he was very proud. Later, fellow students told me he was, at that time, the only one from the state of Colorado!

I soon learned why he was the only Coloradan to do so. He was the first to develop scaling laws to model atmospheric boundary layer winds in a wind tunnel. This led to the modeling of structures in wind tunnels to study wind effects. The World Trade Center Towers in late sixties were the first application of this technology conducted under Jack's direction at CSU. Today this technology is invariably used around the world to study wind load effects on most structures. Jack accomplishments are due in part to his very strong fundamentals in mechanics his work habits and his eye for applications. This is an ideal combination for making such a pioneering contribution. He always discussed the overall goals of a project to his associates and students and then left them alone to innovate and come up with good solutions with minimal interference from his side.

This put a lot of pressure on us, which taught us how to innovate and develop self confidence. As a result, following Jack's footsteps, a large number of his students and colleagues have made in their own careers major contributions to the field.

He was easy to work with, letting you do things your way with minimal interference provided you had results to show! As students, we had a hard time going to his classes, which were often scheduled at 7 am in Colorado's winter. On Friday afternoon, most grad students would be heading to FAC in local bars. Often, as we made our way out of ERC, his huge light blue Oldsmobile would emerge from the sloping Taft Hill Street causing us to quickly turn around, often slipping and sliding due to sudden maneuvers on icy roads, in an attempt to make it back to ERC before him and turn all the instrumentation back on.

Upon graduation, I left for Houston, where the training I got under Jack quickly helped me to start working in offshore structures. I often called Jack for counsel and had long chats with him at structures congresses. He was always a good listener and offered great advice.

It was very sad to hear about his eye problem and after that I spoke occasionally with him on the phone to cheer him up. I also had a chance to visit with him in the early fall of 2008. We had a few good laughs as I reminded him of some old stories.

In February 2009, I heard of my election to the National Academy of Engineering. The first person I wanted to share the news with was Jack. I called him and Gloria said that he is snoozing, but that I should convey the news myself. Gloria placed the phone near his ear and I told him the news! Gloria tells me that he jumped up and his face was glowing with happiness she had not seen for months. This is great news for a mentor about his student in our discipline. As I proudly walk in my office every day looking at the same certificate Jack showed me during our first meeting, I see his face looking at me.

I also recall clearly, Jack and I attended the inaugural CWE Conference in Tokyo organized by Prof. Murakami, then at the University of Tokyo. We both stayed in the Maranuchi Hotel near the Tokyo Station and took subway every day of the conference to Hangu Campus where the conference was being held. Sometimes other invitees joined us, for example late Prof. Ferziger from Stanford, on our way to the conference venue and discussions regarding pros and cons of CWE were the topic of conversation. Jack was among other luminaries in fluid mechanics, CFD and wind engineering in attendance and made remarks at the conference as to the future of CWE and its implications on wind tunnel experiments.

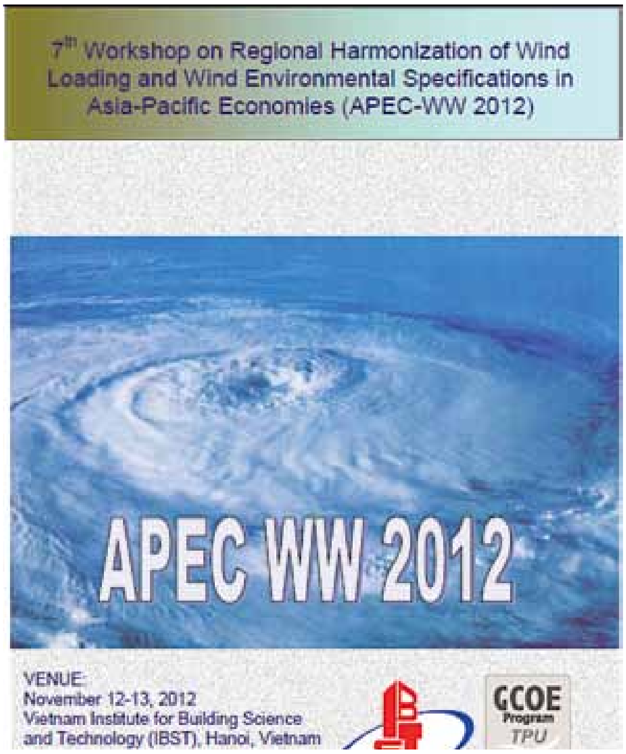
I am proud to say that Jack, who had a legendary career, now has many generations of students (great great grand students) in academia both at home and abroad who are carrying on his legacy. He will be remembered in the hallways of academia and design offices not only for his seminal contributions, but for being a true gentleman and scholar. Jack we will miss you, may you rest in peace!

Ahsan Kareem
PhD Class of '78

Report of the 7th Workshop on Regional Harmonization of Wind Loading and Wind Environmental Specifications in Asia-Pacific Economies (APEC-WW2012)

Date: November 12-13, 2012
Venue: POSTECH International Convention Center, Pohang, Gyungbuk, Korea

The TPU Global COE Program successfully organized a series workshops on regional harmonization of wind loading and wind environmental specifications in Asia-Pacific economies (APEC-WW) from 2004 to 2010, and this year the sixth APEC-WW was held at the Vietnam Institute for Building Science and Technology (IBST), Hanoi, Vietnam from November 12-13, 2012 under the auspices of Dr. Nguyen Dai Minh. This series of workshop aims to 1) reach a common understanding of wind loading; 2) exchange information on the current status of wind loading standards/codes and improve individual standards; 3) discuss bylaws/specifications for wind environmental assessment related to pedestrian level winds in an urban environment; and 4) discuss bylaws/specifications for air quality outside and inside buildings. 29 delegates attended the workshop and reported their recent activities on wind engineering in both structural and environmental fields on behalf of 16 countries and economies. Resolutions for both groups were made individually after thorough face to face discussions on problems related to wind map data, low rise building model, combination effect in codes, return period of frame and cladding, debris impact, design against tornado, outdoor air pollutants, indoor air quality criteria, current assessment criteria and statutory requirements in APEC countries for the pedestrian level wind environment, benchmark test results on pedestrian wind, benchmark test results on pollutant dispersion and urban ventilation, and the use of wind tunnel tests or CFD simulations as tools for environmental impact assessment for air pollution and pedestrian wind environment within urban areas. Future collaborative action plans were intensively discussed and implemented.



Report of mission to Bangladesh to reduce tornado disaster risks in Bangladesh
International Group for Wind-Related Disaster Risk Reduction (IG-WDRR)

Date: January 13-15, 2013
Venue: Tangail and Dhaka, Bangladesh

Summary

The International Group for Wind-Related Disaster Risk Reduction (IG-WDRR) dispatched a mission to Bangladesh from 13-15 January 2013 to promote efforts to reduce tornado disaster risks. Participating experts included Dr. Yukio Tamura, Chairman of the IG-WDRR (Tokyo Polytechnic University), Dr. Yuichi Ono, Vice-chairman of the IG-WDRR (Tohoku University), Dr. Taiichi Hayashi (Kyoto University), Dr. Elizabeth English (Waterloo University), Dr. David Prevatt (University of Florida), Dr. Kalyan Kumar Das (Assam Engineering College), Dr. Yoshinori Shoji (Meteorological Research Institute of Japan), and Ms. Mitsuko Shikada (SEEDS Asia, Myanmar).

The purposes of the mission were to review tornado shelters, communicate with users and villagers, raise public awareness of tornado risks, provide information to reduce the risks, organize a technical workshop, and propose follow-up activities. Mr. Muhammad Saidur Rahman, Director of Bangladesh Disaster Preparedness

Center, provided support in making local arrangement. Ms. Arjumand Habib, Director of Bangladesh Meteorological Department, hosted a workshop.

January 13

The expert team visited Rampur Village, Tangail District, to check tornado shelters (Mini Shelter Room) constructed based on the design and building materials suggested during the previous visit of the team in January 2012. The two MSRs comprised concrete sides and bottom with concrete steps. They were approximately 1.5 meters high and could accommodate 4-6 adults. They were constructed beneath the bedroom so that residents could take immediate action to seek shelter during an emergency without leaving the house. One of the MSRs was actually used during a severe weather event in 2012, according to the owner. No storm affected the house but the owners felt secure in the MSR. The owner seemed happy to have it and they had many visitors. The owner kept some winter clothes in the room during the rainy season, but they all got wet due to high humidity. The lid of the other one had a slightly different structure. Instead of metal, the owner used pieces of wood with small holes (5 cm diameter). This was not the type of lid suggested by the expert team last year because it took longer to open. Also, the owner reported that some mice and insects got into the room. The owner had the same wet clothes problem during the rainy season. The team suggested replacing the lid with one piece of wood or metal for easy operation during an emergency.

After the inspection of the MSR, the team interacted with 100 villagers in their open-roof community meeting space. Most villagers showed a strong interest in installing an MSR, but some mentioned a budgetary problem. The team explained what tornadoes are and introduced measures to save lives. The team witnessed many public awareness posters to reduce tornado risks in the village.

January 14

The expert team paid a visit to the Union Disaster Management Committee of Balla Bazar Union, located in Tangail District. The committee members all felt that the project of building MSRs was a good effort to reduce tornado risks. Then, the team organized a public awareness meeting at Balla High School with approximately 1,000 participants. The expert team explained tornado risk and how to survive a deadly wind storm.

January 15

The Workshop on Tornado Disaster Risk Reduction was organized by the International Group for Wind-Related Disaster Risk Reduction (IG-WDRR) and hosted by the Bangladesh Meteorological Department in Dhaka, Bangladesh, 15 January 2013. The workshop was co-organized by the Tokyo Polytechnic University Global COE Program, supported by the Ministry of Education, Culture, Sports, Science and Technology of Japan, the Bangladesh Disaster Preparedness Center, the International Association for Wind Engineering, and SEEDS Asia. The workshop was chaired by Dr. Yukio Tamura and Mr. Muhammad Saidur Rahman, and facilitated by Dr. Yuichi Ono. The workshop participants comprised experts and representatives of the Bangladesh Government, the United Nations, NGOs, and academia. The workshop reviewed the activities of the IG-WDRR, shared recent state-of-the-art research findings related to tornado disaster risk reduction, and proposed priorities for action. The launch of the Tornado Preparedness Program was suggested by the workshop and encouraged by Mr. Mohammad Abdul Wazed, Director-General of the Department of Disaster Management of Bangladesh. It was suggested to make efforts to install more shelters in tornado prone areas.

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