GCOE Program TPU
New Frontier of Education and Research in Wind Engineering

Wind Effects

New Frontier of Education and Research in Wind Engineering

Bulletin

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Wind Engineering Research Center
Graduate School of Engineering
Tokyo Polytechnic University

INDEX

Annual Report of Global COE Research Projects

Project 1:Wind Hazard Mitigation

1) Development of tornado-like-flow simulator and measurement preparation for wind speeds and pressures

Actual tornado damage is very complex, making it very difficult to interpret how accidents have occurred and to evaluate applied wind forces. The objectives of this research were to investigate the flow fields and pressure fields of tornado-like swirling flow and the behaviors of low-rise buildings under tornado-like flow, and to establish a design-based tornado model to evaluate wind effects on wind-sensitive structures. To this end we set up experimental systems for measuring wind velocities and pressures using a tornado simulator, investigated basic pressures on a cube, modified a moving tornado simulator to create stable swirl flows and developed a large tornado simulator for measuring wind speed distributions.

2) Surface pressure and characteristics of wind load on prisms immersed in a transient gust front flow field

Thunderstorm-generated gust fronts are responsible for various degrees of structural damage in many areas of the world. However, the resulting impact of gust-front winds is not understood well enough to accurately quantify their flow kinematics, dynamics and impact on structures. Gust-front winds are transient in nature and have a flow profile that differs significantly from that of a typical boundary layer flow field. This study focused on the effects of this flow profile and its transient nature on the aerodynamics of bluff, prismatic bodies. A gust-front-type flow field was generated using a multiple-fan wind tunnel and the resulting surface pressures were captured on a suite of prismatic models, which varied in size in relationship to the oncoming wind profile. The temporal variations in surface pressures were analyzed using traditional time, frequency and time-frequency domain schemes. Results indicate the changing nature of the surface pressure field with time, highlighting both qualitative and quantitative differences between local and area-averaged pressures under a host of flow profiles.

3) Wind disaster detection from satellite images

The main focus of this research was to identify buildings damaged by strong winds, such as tropical cyclones, tornados etc. initially by comparing the characteristics of satellite and aerial images of pre- and post-storm conditions and later from post-storm conditions alone, automatically. This research introduced wavelet, a novel technique for pattern recognition of high-resolution satellite images, to identify damaged buildings. More accurate and faster damage identification will save more lives and enable more building structures to be restored faster. This research also planned to prioritize damaged buildings based on the intensity of damage, into different damage scale so that immediate aid could be provided. Automatic identification from post-storm damage alone reduces the cost and also increases the speed of restoration. Detection of hurricane-prone building damage from satellite images of the shores of Punta Gorda, United States before and after Hurricane 'Charley' 2004, were completed in FY2009. Results were obtained for accurate identification using Wavelet Feature Extraction, thereby making wind disaster mitigation quicker and more efficient. Study is under way on Tornado disaster detection from aerial pre- and post-images of Saroma-Cho Tornado 2006.

4) Real-time-monitoring system for wind-resistant performance of buildings in sustainable urban area -Establishment of infrastructure technique-

The purpose of this study was to establish a real-time-monitoring system to estimate the wind-resistant performance of buildings by measuring their response displacements. Accelerometers are insufficient for this purpose because of their mean component, so the RTK-GPS technique was employed. Based on measured data, FEM analysis was used to calculate and monitor the base shear, end moments and stress distributions through the internet. This information will become important for verifying the conditions of buildings. We have installed GPS antennas at 3 measuring sites so far and started to measure the responses.

5) Investigation of fetch effect on wind pressures on low-rise building

The objective of this research was to investigate the fetch effect on wind pressures applied to low-rise buildings. Here, the term fetch means the areas/dimensions of low-rise buildings surrounding a target low-rise building. A low-rise building of 15m×15m×15m (B×D×H) was chosen, and the dimensions of surrounding buildings were the same. A series of wind pressure measurements were performed for various area densities and fetches. The area densities considered were 6.25%, 11.1%, 16%, 25%, and 44.4% with dummy models arranged normally (normal arrangement). For the area density of 25%, which is a typical area density in Japan, the dummy models were arranged in both staggered and normal configurations. To identify the effects of approaching flow, pressure measurements were made on a smooth surface when area density was 44%.

A total of 62 tests were carried out, and the effect of wind direction and roof shape were not considered.

6) Study on wind loading on porous cover roof sheets for a low-rise building

Thermal reduction is always a problem for building roofing systems, especially profiled steel sheet systems, and roofing systems with cover sheets have been applied to overcome it. This was a new study on wind loadings on porous roof cover sheets. This research focused on determining wind loading on porous roof cover sheets on a low-rise building under the effects of parapet, porosity, underneath volume, terrain category, and roof style. A numerical method based on the unsteady form of the Bernoulli equation was applied to predict lower pressures from known upper pressures and the computational results were compared with experimental results. Moreover, field measurements and an investigation will be carried out using CFD (Computational Fluid Dynamics). Results of this study will be useful for practical design.

7) VORTEX-Winds: Virtual Organization to Reduce the Toll of Extreme Winds on Society

The objectives of the research were to establish VORTEX-Winds (Virtual Organization to Reduce the Toll of Extreme Winds on Society). VORTEX-Winds coordinates geographically dispersed e-analysis and design modules and a knowledge base to enable automated, integrated analysis and design of structures, and facilitates education and training of the future work force; to establish and sustain a community contributing to and employing the resources integrated by cyber-infrastructure technologies; to enhance analysis and design capabilities concerning the effects of extreme winds on civil infrastructure; and to facilitate education and training of the future work force in the field. We established an initial membership of a virtual collaboration that included participation from global members; established an organizational structure for the collaboration; developed a basic architecture for e-analysis, design modules and knowledge base; established a Drupal-based secure web portal to serve as the collaboration cyber-interface; established a preliminary framework for the development of a database-assisted design module by integrating databases at Notre Dame and Tamkang Universities (members of the collaboration); and initiated a population of a knowledge base, e.g., windwiki, crowd sourcing of the analysis of glass damage during Hurricane Ike.

8) Study on relation between modern roof construction methods and meteorological conditions

In planning cladding construction methods, it is important to consider wind and rainfall conditions. In the practical design of curtain walls, for example, detailed design conditions are established based on the joint probability of wind and rainfall. In studying traditional cladding construction methods in East Asia, the latest meteorological database was used to determine wind and rainfall conditions and to estimate their joint probability. A method was proposed in which similarities were evaluated by applying principal coordinate analysis of the joint probability of wind and rainfall. As a result, the first principal coordinate showed a high probability of simultaneous occurrence of wind and rainfall. The highest score was seen in the Muroto Promontory data and the second principal coordinate showed high probability irrespective of wind speeds. The highest score was seen in the Jakarta data.

Project 2: Natural/Cross ventilation

This project was aimed at developing a method

for designing natural/cross ventilation for sustainable buildings utilizing natural wind, and also at establishing a hybrid system for dehumidifying and cooling with natural draft and radiating heat compatible with the weather conditions of Asia-Pacific countries. The main research results obtained in the 2009 FY are reported as follows.

1) Human-subject experiments on evaporative cooling by fluctuating flow

Predicted Mean Vote (PMV) indicates thermal comfort level. However, it targets a steady stagnant environment and does not consider the cooling breeze effect of fluctuating wind on perspiration evaporation. Through an experiment using human subjects in an actual housing space, it was found that natural ventilation fluctuated in direction and velocity with lower frequency than that generated by an electric fan or an air conditioner. The cooling effect by wind turbulence and sweat evaporation is very important for evaluating thermal comfort in a naturally ventilated environment. In 2009FY the effects of turbulence, temperature and humidity of the wind stream on skin wettedness were investigated using a climate controllable wind tunnel

The fluctuating flow was produced by the airflow generator equipment of a climate controllable wind tunnel by adjusting the frequency and amplitude of the sinusoidal wave while keeping air temperature at 32 ºC, humidity at 70% and air velocity at 0.4 m/s.

Figure 1 shows the relationship between skin wettedness and sinusoidal flow. When the frequency of the sinusoidal flow decreased, it is found that skin wettedness tended to decrease. The sweating wave was composed of several waves from 0.05 Hz to 0.5 Hz. The spectral peak frequency on the forehead and chest occurred at 0.05 Hz, as shown in Figure 2. This corresponded to the spectral peak frequency of fluctuating flow. Figure 3 compares the measured skin wettednesses with those predicted by the ASHRAE SET* calculation program. The prediction accuracy at fluctuating flow decreased in comparison with the results for uniform flow. This is because the ASHRAE calculation program does not consider airflow turbulence on skin wettedness.

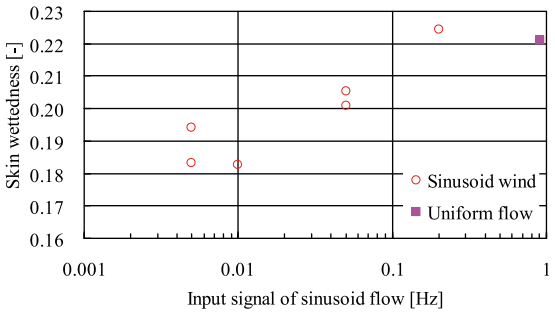


Figure.1 Relationship between skin wettedness and sinusoidal flow

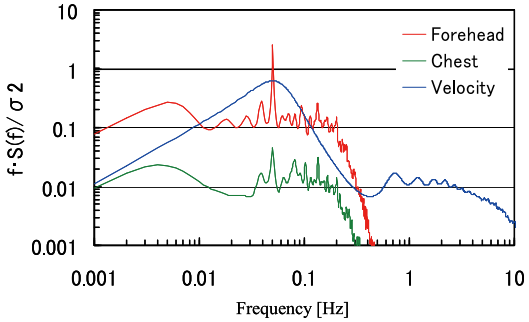
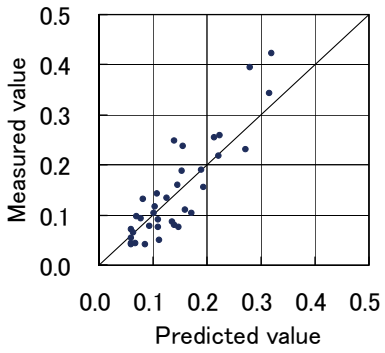
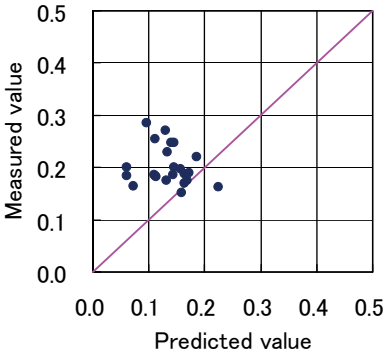


Figure.2 Power spectrums of sweating and wind velocity



(1) Uniform flow



(2) Fluctuated flow

Figure.3 Comparison of measured (experiment) and predicted (ASHRAE SET* calculation program) skin wettedness

2) Desiccant module in natural ventilation path incorporated in external wall

We studied an active type and a passive type

dehumidification system.

The active type dehumidification system was a Heat-Pump Desiccant-Based Air-Conditioning and Ventilation System (Fig.4). We tested the operating characteristics of the system.

In addition, we developed a numerical analysis method for heat and moisture transfer in a desiccant module for a passive type dehumidification system (Fig.5). Using this numerical analysis technique, we will develop a desiccant module in a natural ventilation path incorporated in an external wall (Fig.6) in the future.

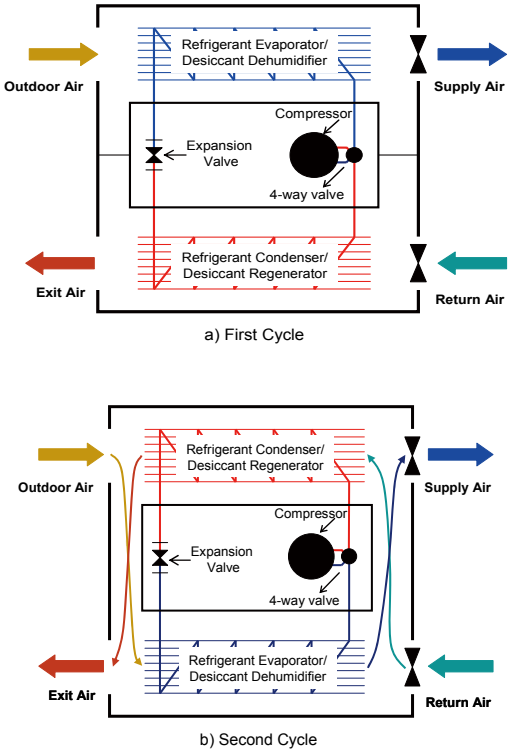
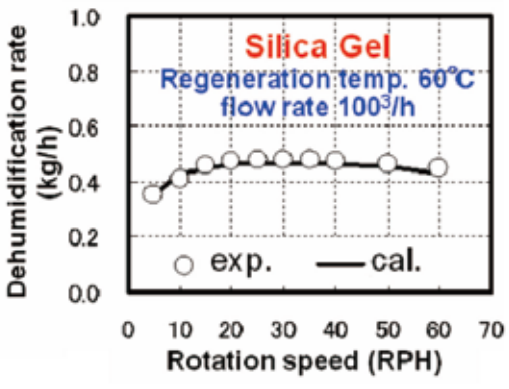


Figure.4 Heat-Pump Desiccant-Based Air-Conditioning and Ventilation System



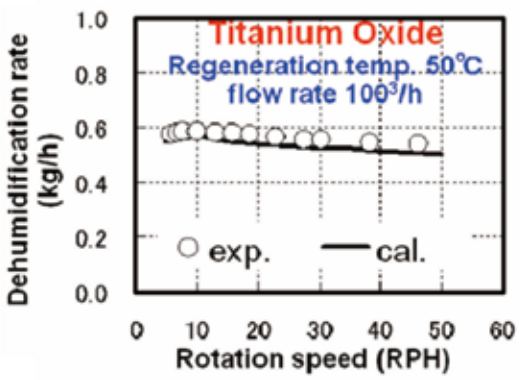
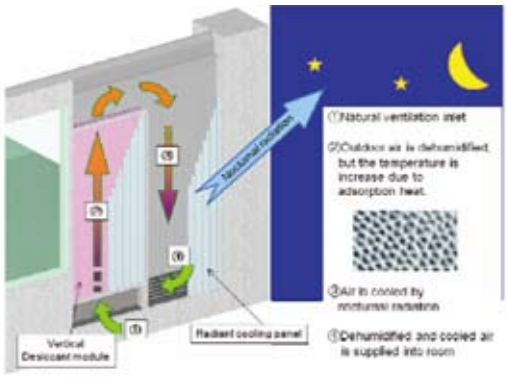
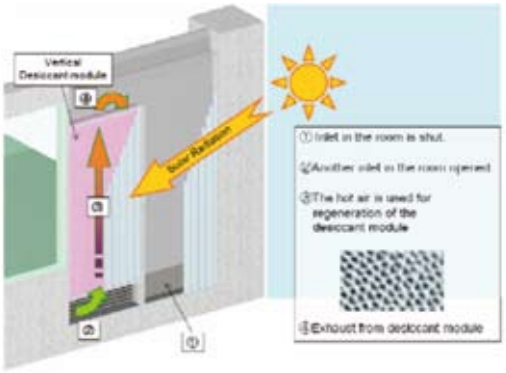


Figure.5 Validation of Numerical Analysis



a) Air flow during night purge (Dehumidification)



b) Air flow in the day time (Regeneration)

Figure.6 Desiccant module in natural ventilation path incorporated in external wall

Project 3:Wind environment/Air pollution

1) Classification of vertical profiles of wind velocity and temperature in summer obtained from meso-scale simulation using cluster analysis

Urban heat island effects have been observed in many cities located near the Japanese coast. Many researchers have reported various countermeasures for mitigating heat island phenomena. One strategy is to

utilize sea breeze by leading cool air into urban canopies. However, the effectiveness of this strategy depends on the characteristics of the sea breeze, particularly the vertical profiles of wind velocity and temperature. Many field observation researches have shown that the vertical profile of mean wind speed under strong wind conditions follows a power law relationship. However, the vertical distribution of wind velocity and temperature during weak summer winds, which produce particularly serious heat island effects, has yet to be made clear. Recently, CFD simulations have been applied to real urban cities in order to examine the effects of various countermeasures to heat island phenomena. However, such simulations require appropriate vertical profiles at the inflow boundary, which is another reason to investigate the vertical profiles of wind velocity and temperature. In this study, meso-scale simulation was conducted in the Tokyo area for the summers of 2006 and 2007 in order to obtain spatial distributions of velocity and temperature data under sea breeze conditions. Based on the obtained data, the vertical patterns of sea breeze were classified using cluster analysis and the occurrence frequencies of the patterns and their relationships with weather conditions were examined.

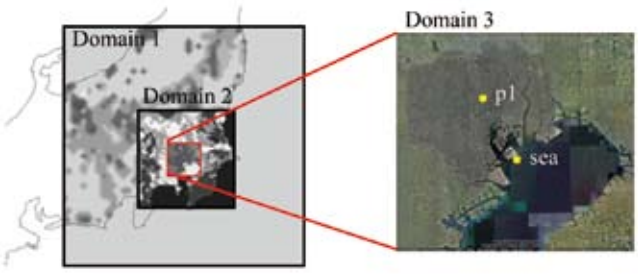


Figure.1 Calculation Region of WRF and Locations Chosen for Analysis

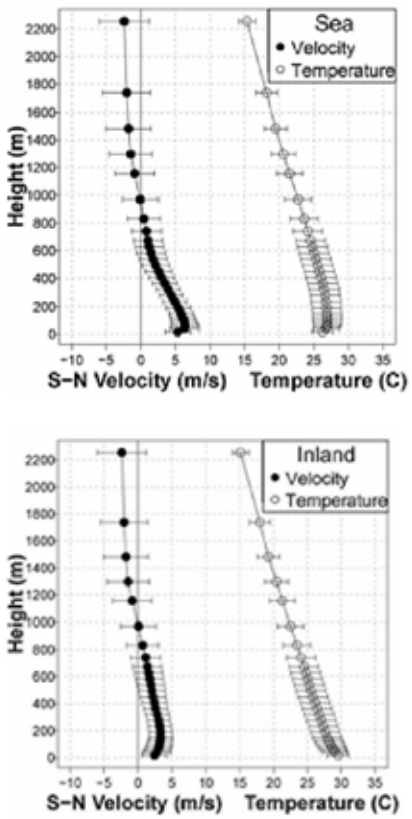


Figure.2 Vertical Distribution of Wind Velocity and Temperature Obtained by Cluster Analysis

2) Wind tunnel experiments on convective heat transfer from an urban surface to the atmosphere and CFD analysis with a low Reynolds number model

We investigated the ventilation performance of various configurations of urban areas by wind tunnel experiments. It was found that non-uniformity of building heights greatly improves ventilation performance and reduces air temperature in urban canopies due to the “vertical ventilation path”, i.e., the effect of vertical advection and vertical turbulent diffusion. However, if the cooling energy of sea breeze is consumed in an upwind city, the benefits to downwind cities might be reduced, but if there is abundant cooling energy, this may not be a problem. One promising way to clarify this point is mesoscale numerical simulation with an Urban Canopy Model (UCM). Consumption of cooling energy by urban canopies can be expressed by other words such as “convective heat transfer from the surfaces of urban canopy”. In most UCMs, convective heat transfer from the urban canopy to the atmosphere is evaluated in accordance with the Monin–Obukhov similarity theory, and the dependence of urban parameters such as building coverage ratio, volume ratio and variations to building height on convective heat transfer is not explicitly modeled. The final goal of this research is to clarify the local convective heat transfer coefficients, which depend on urban parameters, and to incorporate the results into the UCM. As the first step of this research, wind tunnel experiments were carried out to roughly grasp the dependence of urban parameters on bulk heat transfer from urban canopy. However, wind tunnel experiments have limitations in investigating the local convective heat transfer coefficients (CHTC).

Furthermore, the CHTCs obtained from the experiments cannot be converted to CHTCs in real scale. Thus, CFD simulation with a low Reynolds number k-ε model was conducted, which can accurately predict the convective heat transfer on surfaces. After validation of the CFD simulation by comparison with experimental results, the effects of urban canopy parameters on local CHTC were investigated by CFD simulation. The results were generalized by the relationship between Rex (Reynolds number) and Nux (Local Nusselt number) for different cases of urban parameters.

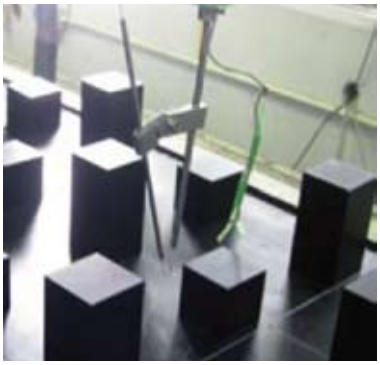
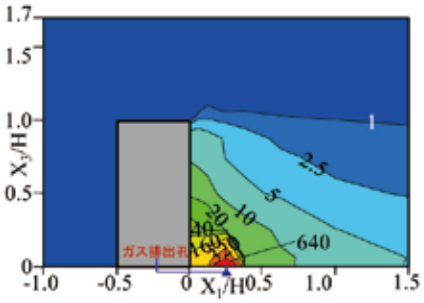


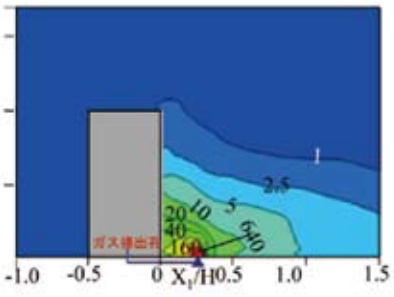
Figure.3 Wind Tunnel Experiment on Convective Heat Transfer from an Urban Surface to the Atmosphere

3) CFD simulations of gas dispersion around high-rise building in non-isothermal boundary layer

Urban heat island phenomena and air pollution become serious problems in weak wind regions such as behind buildings and within street canyons, where buoyancy effect can not be neglected. In order to apply CFD techniques to estimation of ventilation and thermal and pollutant dispersion in urban areas, it is important to assess the performance of turbulence models adopted to simulate these phenomena. Thus, we carried out wind tunnel experiments and CFD simulations of gas and thermal dispersion behind a high-rise building in an unstable non-isothermal turbulent flow. The standard k-ε model and a two-equation heat-transfer model as RANS models, and LES, were used for the CFD simulation. An important purpose of this study was to clarify the effect of inflow turbulence (both velocity and temperature) on flow field and gas/thermal dispersion for the LES calculation. Thus, LES calculations with/without inflow turbulence were conducted. The inflow turbulence was generated through a separate pre-simulation with LES, in which all the wind tunnel and roughness elements were reproduced. The characteristics of the generated flow (mean wind velocity, mean temperature, rms values of velocity and temperature fluctuation, Reynolds stresses, turbulent heat fluxes) agreed well with those of the wind tunnel experiment. The generated turbulent flow data was used as the inflow boundary condition for the main LES computational domain in which the flow and dispersion around a high-rise building were calculated. The calculated results showed that both RANS models overestimated the size of the recirculation region behind the building and underestimated the lateral dispersion of the gas. Turbulent flow structures of LES with and without inflow turbulence were completely different. The LES result with inflow turbulence achieved better agreement with the experiment.



Experiment



LES

Figure.4 Gas concentration behind a building

Distribution of "Preparedness for wind-related hazards in Haiti"

The magnitude 7.0 earthquake that occurred in the Republic of Haiti on January 12, 2010 caused serious damage, including a death toll of over 220,000. It is being reported that even at present, six months after the Haiti Earthquake, there are as many as 1.6 million earthquake victims, who have lost their homes and are living in tents. Since Haiti will soon enter the hurricane season and is likely to be struck by a hurricane, there is an urgent need to build temporary housing to provide these victims with protection from flying objects. However, although restoration is in progress, it is very difficult to provide the required temporary housing before the hurricane season. Therefore, in order to promote understanding of what preparations need to be made and what measures need to be taken by earthquake victims and government officials for the upcoming hurricane season, we created a booklet entitled "Preparedness for wind-related hazards in Haiti" and distributed it to related organizations. The booklet is published in English and French, the official language of Haiti, with many illustrated explanations so that ordinary citizens who do not have expert knowledge can easily understand the information inside. The booklet is available on the UN/ISDR's PreventionWeb website.

http://www.preventionweb.net/english/professional/publications/v.php?id=13864

Figure.1 Front Page Design

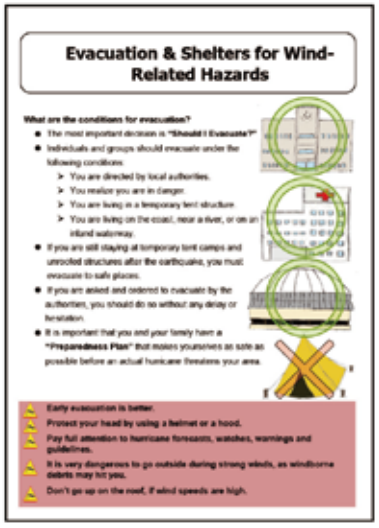


Figure.2 Explanation of the Evacuation Sites

Figure.3 Explanation of Reinforcement of Houses

Figure.4 Removal of Potential Flying Objects

Figure.5 Illustration on the Danger of Flying Objects

A Proposal for Tornado Risk Reduction in Bangladesh

Based on the conclusions of the Tornado Risk Reduction Forum (see Newsletter, Vol. 24 for details) held in Bangladesh in December 2009, IG-WRDRR (Chairman: Yukio Tamura, IAWE President/TPU Global COE Director), an international group established in June 2009 with the aim of reducing the risk of serious wind-related hazards (storm hazards plus flood hazards) that have been rapidly increasing in frequency in recent years, submitted a proposal to the Bangladesh government and supporting countries and organizations, including Japan, as part of its activities. The proposal was released to the press in both English and Bengali. The following is the proposal as released to the press.

"The International Forum on Tornado Disaster Risk Reduction for Bangladesh - To Cope With Neglected Severe Disasters" was held in Bangladesh on 13-14 December, 2009 at the Hotel Sheraton. Over one hundred seventy people including large number of international experts from USA, Japan, Switzerland, Thailand and China attended the forum. While Dr. Muhammad Abdur Razzaque, the Honorable Minister of Ministry of Food and Disaster Management was the Chief Guest, Mr. Tamotsu Shinotsuka, Ambassador of Japan in Bangladesh, Prof. Dr. M.S. Akbar MP, Chairman of Bangladesh Red Crescent Society, Mr. BMM Mozharul Huq, Advisor, Humanitarian Response Team, UNDP were present as Special Guests. Chaired by Prof. Yukio Tamura, IAWE President/TPU Global COE Director, the forum was addressed by Mr Salvano Briceno, Director of UNISDR and Mr. Tokiyoshi Toya, Director of WMO as guest of honors. Mr. Muhammad Saidur Rahman, Director, BDPC presented the address of welcome and Mr. Farhad Uddin, DG DMB proposed the vote of thanks from the local organizers. The event was co-organized by Tokyo Polytechnic University Global COE Program TPU/GCOE, Government of Bangladesh (Disaster Management Bureau, Ministry of Food and Disaster Management, Meteorological Department, Ministry Of Defence), Bangladesh Disaster Preparedness Centre (BDPC) and International Association for Wind Engineering (IAWE). Through a number of sessions addressed by key international and local experts, the forum capture severe local storm disaster risks in Bangladesh, raise awareness of the risks at local, national, and international levels, and develop a strategy to reduce the risks through active interactions among renowned international experts, national and local experts, and local practitioners and decision makers. The strategy includes components of early warning system, risk and vulnerability assessment, research in meteorology, climatology, and engineering, household and community shelter, public awareness and education, finance and community planning, and governance and policy making. The outcomes of this forum will help the Government of Bangladesh to adopt policies and development planning to reduce risks from severe local storms. The outcomes will stimulate donor agencies and NGOs to implement specific projects to reduce the disaster risks. Overall, the forum will contribute to the implementation of the Hyogo Framework for Action.

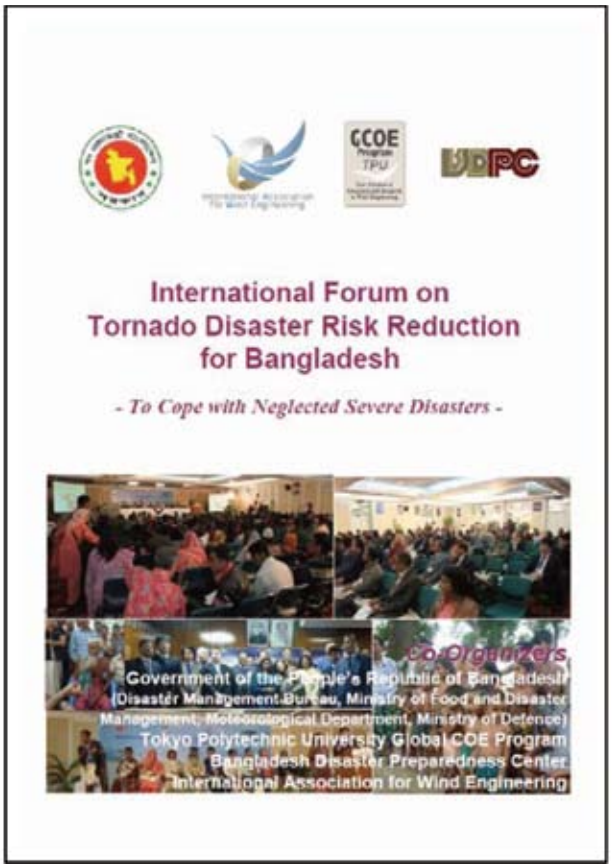


Figure.1 Front Page of the Report

TPU-CARDC Wind Engineering Joint Workshop and Technical tour

Date : May 11, 2010
Venue : Tokyo Polytechnic University, Atsugi, Japan

On May 11, the joint wind engineering workshop was held by the 'Global COE program, Wind Engineering Research Center: WERC, Tokyo Polytechnic University: TPU' and the 'China Aerodynamics Research & Development Center: CARDC' (13:00-18:00). Before and after the workshop, a technical tour of WERC facilities for the participants from CARDC was also conducted. CARDC is the biggest aerodynamic research, test and development organization in China and has the most powerful and comprehensive capabilities. It is an aerodynamic research and test community and has a complete set of facilities providing a range of sizes from small, medium to large-scale, and a range of speeds from low and high-speed to hypervelocity. It is also equipped with facilities for three research means of wind tunnel testing, numerical simulation and model free flight testing, as well as a wide research coverage of aerodynamics, aerothermodynamics, aero-physics and aero-optics. It has over 3,000 staff. This Joint Workshop is planned with the aims of information exchanges with regard to cutting-edge research and the exchange of opinions for collaborations between TPU and CARDC. From CARDC, 5 researchers joined the workshop including the director and senior researchers. At the beginning of the workshop, Prof. Yukio Tamura (Director of Global COE program, TPU) outlined our program. After that, 8 topics from TPU and 4 topics from CARDC were reported. In addition, a technical tour of experimental facilities in WERC was conducted. On this tour, 4 wind tunnel test facilities, a tornado-like flow simulator, and an experimental solar panel system were introduced. Through these academic events, active exchanges of opinions and information were accomplished. The following are the titles and speakers of the research topics in the joint workshop.

•Low Speed Aerodynamics Researches at CARDC, *Dr. M. Li, CARDC*

•The Research and Development on High-Speed Train Aerodynamics, *Dr. M. Li, CARDC*

•Control of Outdoor Wind and Thermal Environment and Air Pollution -The vertical profiles of wind velocity and temperature in sea breeze was classified by cluster analysis-, *Dr. J. Chung, TPU*

•Experimental and Computational Studies on Heat

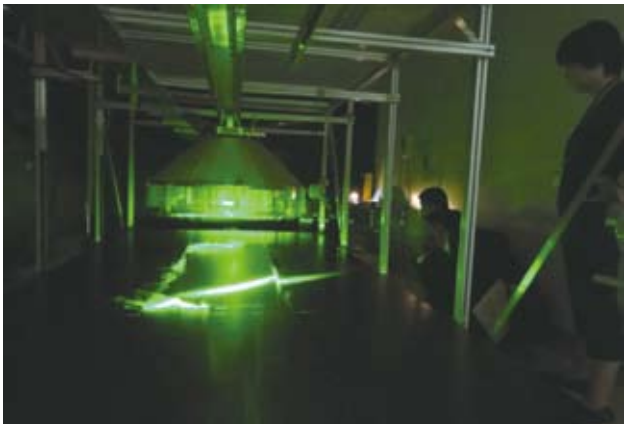


Photo 1 Technical Tour

Photo 2 Joint Workshop

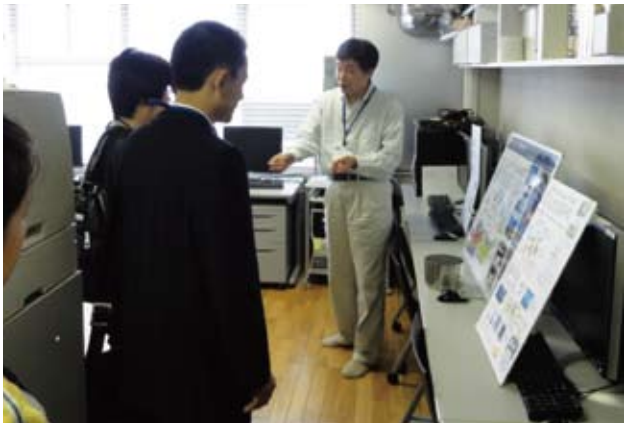


Photo 3 Technical Tour

Transfer from Urban Canopy and Its Dependence on Urban Parameters, *Mr. S. Sivaraja, TPU*

•The Measurement of Wind-induced Response of Buildings Using GPS Technology and System Identification of Structures, *Prof. A. Yoshida, TPU*

•Ambient Vibration Analysis using Mode Indicator Based Method, *Dr. J. Ku, TPU*

•Investigation of Fetch Effect on Wind Pressures Applied to Low-Rise Building, *Dr. Y. Kim, TPU*

•Interference Effects on Local Peak Pressure between Two Buildings, *Mr. W. Kim, TPU*

•Velocity Measurements in Tornado Like Flow, *Mr. G. Sabareesh, TPU*

•The Aerodynamic Characteristic Research on the Torch Tower of the Beijing Olympic Game, *Mr. L. Chen, CARDC*

•Wind-Tunnel Test and Research of Ultra-High Voltage Transmission Tower-line Coupling System, *Mr. L. Chen, CARDC*

•Introduction of Research Study on Natural/Cross Ventilation in Global COE Program, *Prof. Y. Ohba, TPU*

Photo 4 Group Photo

Report on the Fifth International Symposium on Computational Wind Engineering (CWE2010)

Date : May 23-27, 2010
Venue : Friday Center, USA

The Fifth International Symposium on Computational Wind Engineering (CWE2010) was held from May 23 to 27 at the Friday Center in Chapel Hill, North Carolina, U.S.A.

As shown below, a different theme was selected for each day, with keynote addresses, guest addresses and panel discussions given to examine these themes, thereby adding new dimensions to the program and making the symposium very productive. Yukio Tamura and Ryuichiro Yoshie, from Tokyo Polytechnic University, participated in the panel discussions held on the first and third days, respectively, as panelists.

•First day: Applying Computational Wind Engineering to Practice: Perspectives from the Political, Academic, Corporate and Public Sector Communities

•Second day: Trends in High Performance Computing for Wind Engineering

•Third day: Development, Validation, and Application of Atmospheric Boundary Layer Models and Turbulence Models for CWE

Fourth day: Coupling Computational Wind Engineering and Mesoscale Meteorological Models

Another feature of this symposium was that many researchers from the meteorological field attended. In particular, during the discussion sessions on the third and fourth days, researchers in wind engineering and meteorology engaged in an active exchange of views. The number of papers presented at the symposium was 263, including keynote addresses, and the total number of participants was about 350, which was the largest

ever. Thanks to the efforts of Professor Alan Huber, the Symposium Chairman, who had frequent discussions with those in charge of the sessions in advance to make a detailed plan, the symposium achieved success not only in terms of size, but also in terms of content.

The following papers were presented by the members of the Tokyo Polytechnic University Global COE Program

- •Sivaraja Subramania Pillai, Ryuchiro Yoshie, J. Y. Chung: Experimental and computational studies of heat transfer from urban canopy and its dependency on urban parameters
- •Ryuichiro Yoshie, Jiang Guoyi, Taich Shirasawa, Jaeyong Chung: CFD simulations of gas dispersion around high-rise building in non-isothermal boundary layer
- •Sabareesh Geetha Rajasekharan, Yukio Tamura, Masahiro Matsui, Akihito Yoshida: Numerical evaluation of fluctuating internal pressures for various opening configurations in buildings
- •Sudha Radhika, Yukio Tamura, Masahiro Matsui: Using wavelets as an effective alternative tool for wind disaster detection from satellite images
- •Vu Thanh Trung, Yukio Tamura, Akihito Yoshida: Numerical computation for lower surface pressures on a porous sunshade roof cover sheet
- •Shuyang Cao, Yaojun Ge,Yukio Tamura: Mechanisms of the lift force on the circular and rectangular cylinders in shear flows
- •Thai-Hoa Le, Yukio Tamura, Masaru Matsumoto: Spanwise pressure coherence on prisms based on spectral POD and wavelet transform based tools

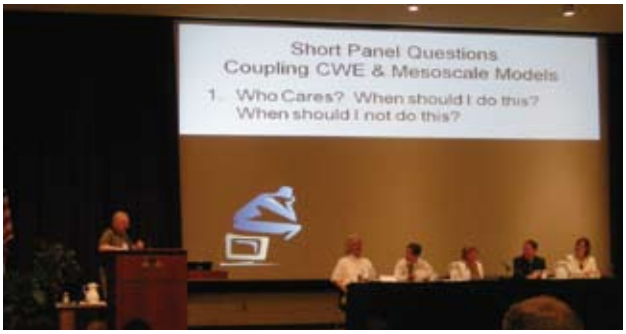


Photo 1 Panel Discussions

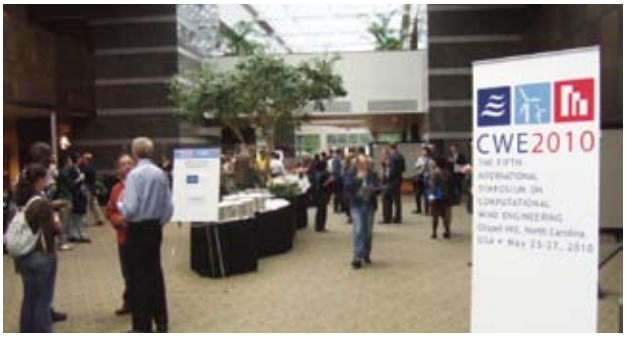


Photo 2 Friday Center

Announcement

Future events are scheduled as follows.

The 7th COE International Advanced School on Wind Engineering

Date: December 6-8, 2010
Venue: CSIR Science Centre, India

The 5th International Symposium on Wind Effects on Buildings and Urban Environment (ISWE5) "Wind Hazard Resilient Cities: New Challenges"

Date: March 7-8, 2011
Venue: Hotel Sunroute Plaza Shinjuku, Japan

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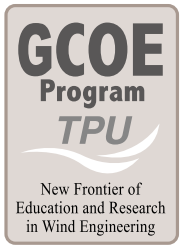

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New Frontier of Education and Research in Wind Engineering

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