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

Wind Effects

New Frontier of Education and Research in Wind Engineering

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INDEX

Annual report of Global COE research projects

Project 1: Wind resistant design

1) Experimental investigation of external and internal pressures acting on building models in tornado-like flow

The main objective of the work was to clarify the effects of gust events such as tornadoes on structures. Scaled building models were subjected to a stationary vortex created using a tornado simulator.

The influence of factors such as building location relative to vortex centre, swirl ratio, and terrain roughness on the external and internal pressures on a building model under tornado-like flow was evaluated. Building faces perpendicular to the tangential flow experienced suction pressures less than those on the other faces near the core boundary. Lower swirl ratios produced higher suction pressures on a roof than on building walls, whereas higher swirl ratios produced suction on roofs comparable with pressures on a leading edge wall. Higher negative minimum peak internal pressure coefficients were experienced with a 3.9% opening ratio within a vortex core than with a 0.1% opening ratio. The lowest minimum net peak roof force coefficients could increase four-fold, for the same building location but different building orientation.

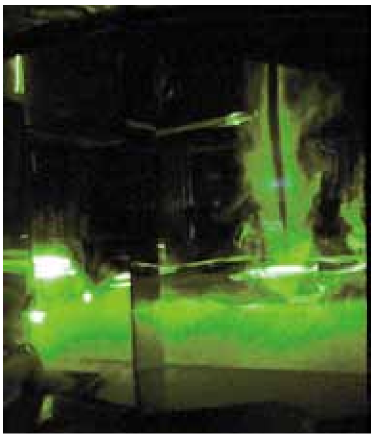


Figure 1. Generated tornado vortex core on simulator floor

2) Automatic Wind Damage Detection from Remote Sensing Image Signals using Wavelet-based Pattern Recognition

Rapid, accurate and automated identification of damage location as well as damaged buildings will aid conventional field investigations after a strong wind disaster. In the present investigation, damage location was identified automatically from low-resolution aerial/satellite imagery by using novel texture-wavelet analysis of wind-borne debris deposits for a quick survey. Software was designed for this purpose. Damage location was then mapped by high resolution imagery. Buildings were then segmented by using color invariance properties and edge detection. Damaged buildings were classified using wavelet feature extraction along with pattern recognition techniques. These methods were applied on pre- and post-storm imageries and on post-storm imageries alone. Even using post-storm imageries alone, an accurate and economic identification was achieved. The percentage area of roof damage was quantified using texture-wavelet analysis of building roofs. Application in real time situations such as that of the Tuscaloosa, (US) tornado and the Tokunoshima (Japan) tornado and in other types of natural disasters such as a Thailand flood, were also investigated.

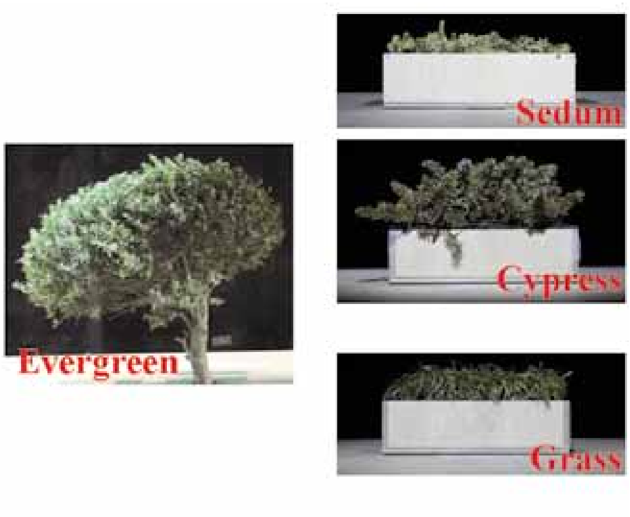
Figure 2. (a) Wind damage path detection from debris deposits (b) Wind damaged building detection at the damaged

3) Experimental evaluation of wind resistant performance of green roofing systems

Aerodynamic characteristics of three real trees (a) and commercial green roof modules with three different vegetations (b) were investigated under turbulent uniform flows. Wind forces under different wind speeds and wind-speed-variant projected areas were measured. The effect of solidity ratio, view angle and turbulence intensity were considered. The results showed that even considering area reduction due to increasing wind speeds, mean drag coefficients decreased with increase in wind speed for deciduous and coniferous trees (c), while the values for green roof modules were wind speed - independent regardless of the vegetation type (d).

A scaled 1:67 pressure-tapped model (including both building and module model) was designed to determine wind force characteristics of rooftop modules. Roof shape, module position, wind direction and parapet height were varied. Compared with module force characteristics under uniform flows, the total uplift and horizontal forces were mainly decided by the complex rooftop wind conditions.

(a) trees



(b) green roof modules

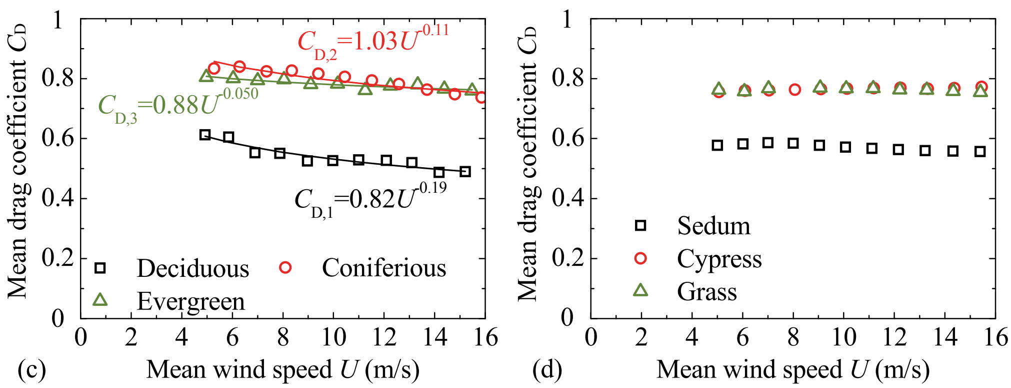


Figure 3. Variations of mean drag coefficient of trees (c) and green roof modules (d) due to mean wind speed

4) Development of experimental system for simulating behaviors of cladding exposed to severe differential pressures due to strong winds

In the past, most damage due to the strong winds has been to low-rise buildings, particularly to roof panels and ceiling boards.

Recently, peak pressure coefficients have been estimated under various conditions for cladding design and effective materials have been developed. However, as shown in these pictures, there are many kinds of details for ceiling boards, claddings, eaves, etc., so it is important to establish a testing system to clarify the strength of claddings against severe suctions under static and dynamic conditions.

To establish the experimental method and to solve problems of testing using a pressure chamber, a ceiling specimen was set up and its strength was measured. The main reasons for the collapse of this ceiling system were 2 types of screw failures, as shown in Figures 4 and 5.

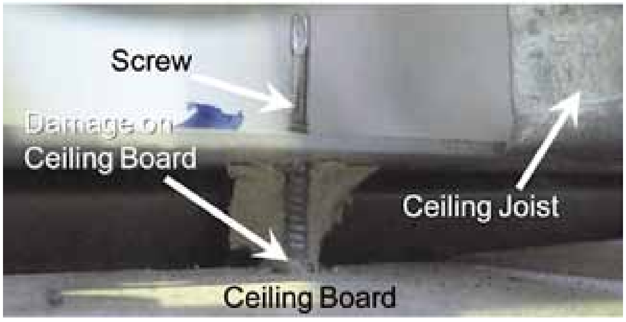


Figure 4. Damage to Ceiling board

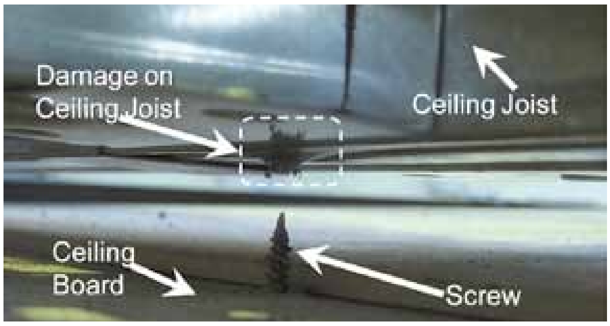


Figure 5. Damage to Ceiling joist

5) Damage Investigations of Recent Tornadoes in Japan and Their Publication on Internet Database

To mitigate damage due to strong wind disasters, it is important to share all sources about them with everybody in the world. Many organizations have accumulated a lot of information about disasters at home and abroad. However, this information has been recorded by many kinds of media such as newspapers, specialized agencies, and articles on the World Wide Web, using modes of expression, description and language that vary from organization to organization. A database of wind hazard information with a common platform needs to be established.

EVO (Engineering Virtual Organization [https://www.vortex-winds.org/]) has been jointly-developed with the University of Notre Dame, and this could meet this need as a damage database is one of its main contents. Our GCOE group carried out field investigations for 3 tornadoes and 1 downburst.

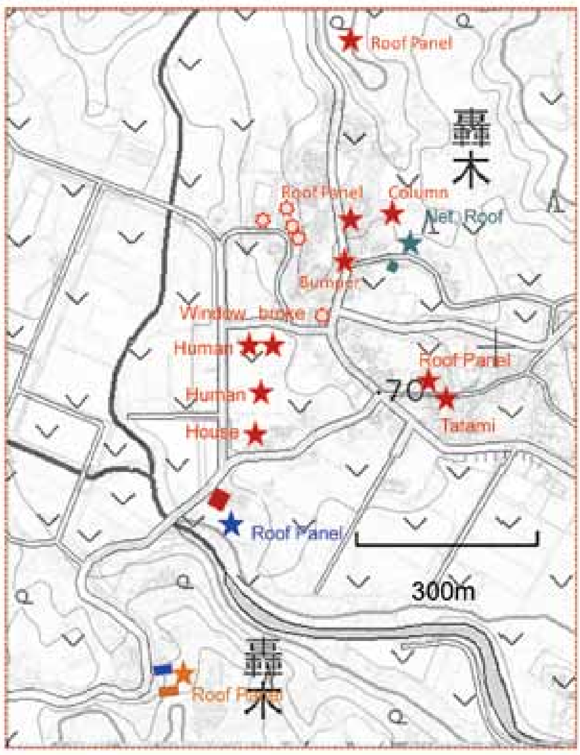


Figure 6. Damage foot prints

6) Interference Effect on Local Peak Pressure between High-Rise Buildings

This research focused on wind induced interference effects on local peak pressure distribution between tall buildings. Its purpose was to clarify interference effect phenomena and to codify them appropriately for design of high rise buildings. Interference effects were thus investigated through wind tunnel experiments. Through comparison of different cases with the isolated case, we obtained results showing the influence of an interfering building on the extreme pressure coefficients of a target building. Based on our experimental data, we estimated the maximum and minimum peak pressure distributions and checked the influence of the interfering building on the peak pressure coefficients of the target building. Figure 7 shows contours of interference effect.

7) Estimation of Wind Load on Solar Collectors

The use of solar energy has extensively increased around the globe. It is therefore necessary to improve understanding of wind loading on solar collectors to ensure proper installation and to avoid damage by strong wind. To get detailed information about wind loading, wind tunnel experiments have been conducted on a ground-mounted solar panel model placed at different inclination angles. The full size of the solar panel was taken as 1m*2m and at a 1/3.33 model scale the tested model was 300mm*600mm. A total of 144 equally

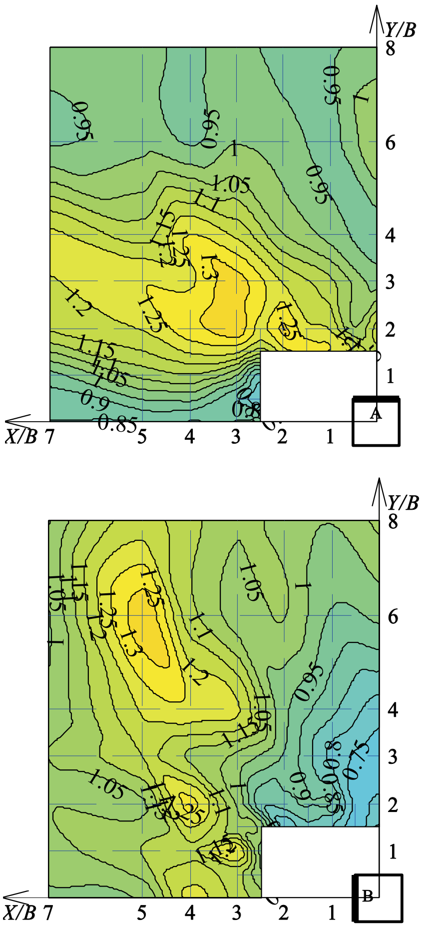


Figure 7. Interference factor with interfering building located in various positions

distributed pressure taps were placed on its upper and lower surfaces. A turbulent flow exposure area was simulated and the sampling period was 630 seconds for each sample, corresponding to 10 minutes in full scale. Mean wind force coefficients on a solar panel placed at 0º, 5º, 10º, 15º, 30º and 45º inclination angles for 0~180º wind directions are shown in Figure 8.

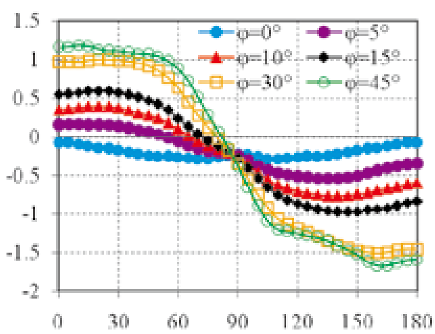


Figure 8. Mean wind force coefficient at different inclination angles

8) Aerodynamic characteristics of triangular cross section tall buildings with different helical angles

The main objective of this study was to investigate and analyze the aerodynamic behavior of a number of models with the same volume and triangular cross sections and to identify the most reliable one based on pressure distributions, force & moment calculations, power spectral densities and response analysis.

Wind forces and moments were calculated by integrating pressures obtained from wind tunnel experiments on all the models. Power spectral densities for across wind, along wind and torsional directions were calculated for all the models. Responses were calculated from generalized wind forces. New experiments were conducted on two pressure models with corner and surface modifications. Power spectral densities for across wind direction and overturning moment coefficients for various models are shown in Figure 9.

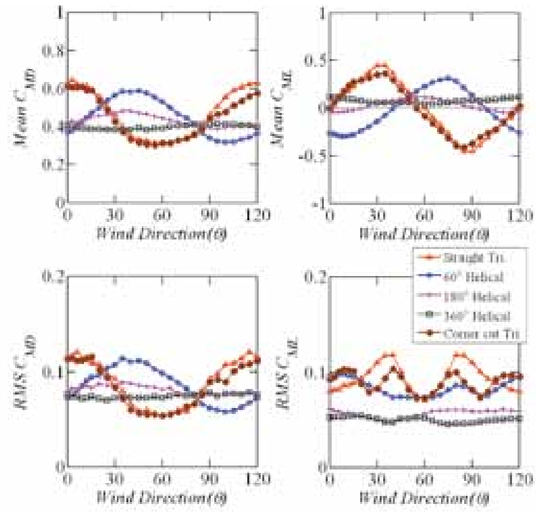


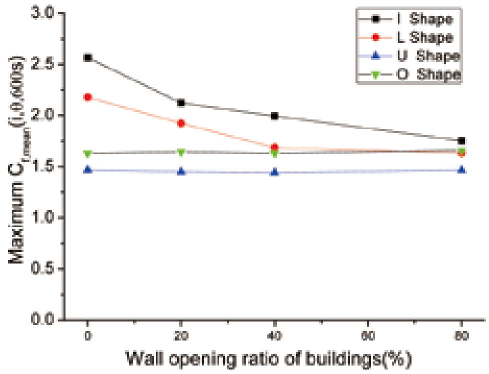
Figure 9. Overturning moment coefficients

9) Wind Force Characteristics of Scaffoldings with sheets

Wind loading is very critical to the stability of scaffolding, especially when it is covered with sheets of 0% porosity, which significantly changes the wind forces acting on it.

In this study, wind tunnel experiments were carried out based on a prototype of scaffolding attached to a medium-height building, and covered with sheets of 0% porosity. Wind force characteristics were studied for scaffoldings with sheets for different building openings, scaffolding arrangements and interference effects on local wind forces on scaffoldings with sheets of two adjacent buildings.

As shown in Figure 10 when the building wall opening ratio increases, local wind force coefficient decreases, and the local wind force coefficient is larger when the scaffolding arrangement is I-shaped and L-shaped.



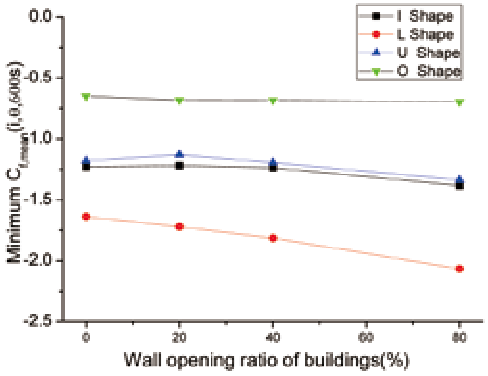


Figure 10. Effect of building opening ratio on mean local wind force coefficient of scaffolding

10) Fetch Effects of Surrounding Buildings on Wind Pressure and Forces acting on Low-rise Building

The objective was to investigate the fetch effects of surrounding buildings on wind pressures and wind forces acting on a low-rise building. A series of pressure measurements were performed with a target model moved to the downstream side for area densities of 6%, 11%, 16%, 25%, and 44%.

The wind pressure coefficients were defined in two different ways: with the coefficients normalized by the velocity pressure of the incident flow and with the coefficients normalized by the velocity pressure at each measurement point. After a detailed investigation of the characteristics of peak wind pressures and wind forces, a method of evaluating wind loads based on an interference effect approach implementing (zoning) interference factor was examined. The results are shown in Table 1. The results show that (zoning) interference factors can be expressed as an exponential function of area density CA only.

11) Influence of Structural and Non-Structural Components on Dynamic Properties of Buildings

This research focused on the influence of structural and nonstructural components on the dynamic properties and stiffness of experimental and full-scale buildings during construction. Two three-storey buildings and a one-storey experimental building model were built during many construction stages for investigation. Various vibration tests were implemented including ambient vibration, sinusoidal and sweep vibration, free vibration, white noise vibration and seismic base excitations. Excitation amplitudes were set from relatively small, medium to large amplitude levels. Influence of structural and nonstructural components such as Autoclaved Light Concrete (ALC) walls, mortar joints and sealing joints, interior cover plates, separation walls, and windows on the dynamic properties and stiffness of buildings were investigated. Furthermore, finite element models of buildings during construction stages were also developed to build up more accurate finite element models as well as for updating and verification. Some recent system

Table 1. Effect of building opening ratio on mean local wind force coefficient of scaffolding

Interference factor for drag force, IF_D	Interference factor for lift force, IF_L	
$0.77e^{-3.18C_A}$	C_A<0.06	0.7
	C_A>0.06	0.4

	Wall surface		Roof surface	
	max IF	min IF	max IF	min IF
zone I	$1.15e^{-1.46C_A}$	$0.87e^{-2.55C_A}$	-	$0.89e^{-3.3C_A}$
zone II	$1.12e^{-2.41C_A}$	$0.81e^{-2.46C_A}$	-	$1.09e^{-3.21C_A}$
zone III	-	-	-	$0.61e^{-2.52C_A}$

identification techniques were coded for estimation of dynamic properties from different vibration tests.

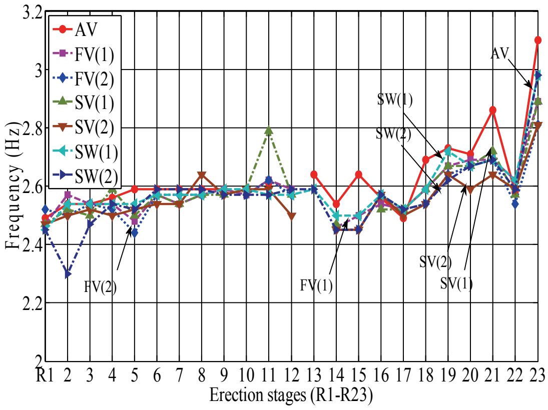
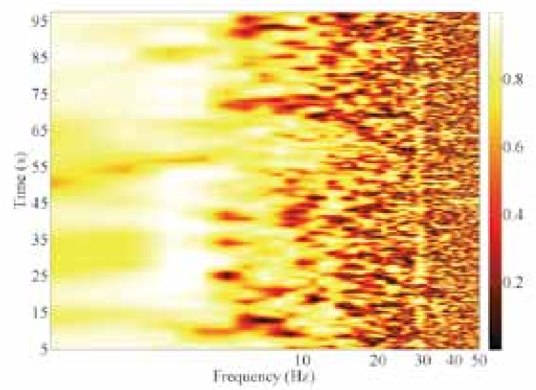


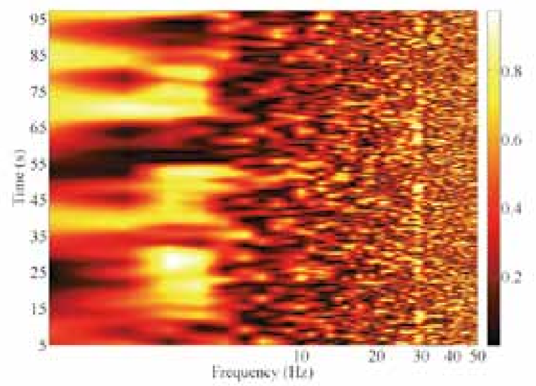
Figure 11. Natural frequencies estimation

12) Wavelet Coherence Structure of Surface Pressure on Prism

This research investigated spanwise and chordwise coherence structures of wind turbulence and pressures on typical prisms B/D=1, B/D=1 with a splitter plate and B/D=5 using the new approach of wavelet transform. Wind turbulence and surface pressures on the prisms were measured in wind tunnel tests. The conventional approach using Fourier coherence revealed information on the coherence structure in the frequency domain, but wavelet coherence identified the coherence structure in a simultaneous time-frequency plane. Moreover, intermittency and high coherence events of the coherence structure in the time-frequency plane were investigated by wavelet coherence. The influences of bluff body flows and physical phenomena on prism surfaces, chordwise pressure coherence, time-frequency resolution and wavelet function parameters on wavelet coherence of wind turbulence and pressure were investigated and discussed.



a.Spanwise separation y=25mm



b. Spanwise separation y=125mm

Figure 12. Wavelet coherence maps of pressure (B/D=1)

13) Effects of overall local behaviors of structure on internal stresses in members under wind load

Conventional wind load standards are not necessarily enough to determine design wind load for structural members where loading effects depend on both overall and local behaviors, such as the exterior walls of thin-walled cylindrical shells and cladding-supporting members of long-span roofs. The project investigated

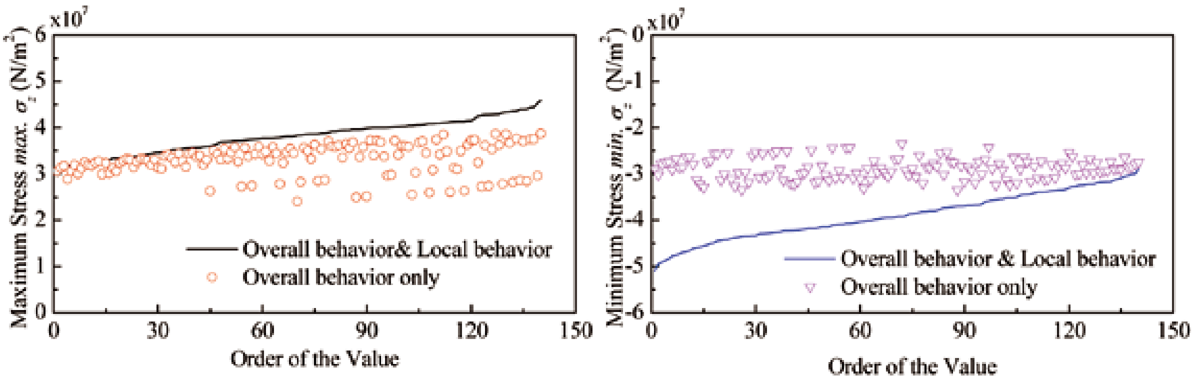


Figure 13. Contributions to largest loading effects due to overall behaviors for thin-walled cylindrical shells

the contributions to the largest loading effects from the overall and local behaviors of structures under wind load.

Considering the overall behavior only will underestimate the loading effects on structure members, especially circumferential stresses which are predominantly due to the local behavior of the thin-walled shell, as shown in Figure 13. However, for the supporting frames of roof claddings, internal stresses due to local wind pressure can be calculated in a quasi-static manner, considering the distributions of local wind pressures and the influence functions for certain loading effects.

14) Estimation of Rain-Wind Induced Cable Vibration

The main objective of this research was to estimate cable vibration due to the combined effects of wind and rain. Cable vibration is dependent on factors such as rain, wind speed, wind yaw angle as well as cable inclination angle. Thus, the experiment was set up to enable these parameters to be varied. A picture and drawing of the experimental setup are shown in Figure 14. Wind speed stability was checked at the wind tunnel exit, where the model was placed. The approaching wind was checked at different positions. The experiment was started at the beginning of 2012FY.

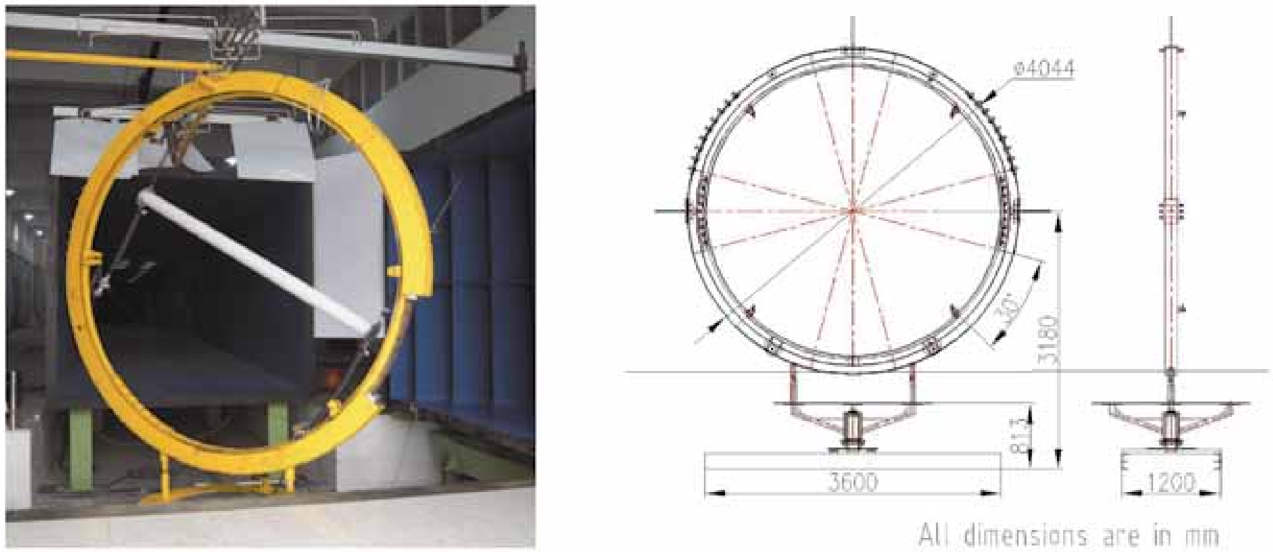


Figure 14. Experimental set up

Project 2: Natural/Cross ventilation

1) Development of thermal sensation index under thermal-transient conditions in cross-ventilated environment

A transient environment was reconstructed by making stepwise changes in air temperature, humidity and wind velocity in a climate chamber. Human thermoregulation coefficients of a 2-node model as a human heat balance model were modified to subject experimental data in stagnant environmental conditions. Higher prediction accuracy of transient mean skin temperature was achieved. However, universal human thermoregulatory coefficients of the model in ventilated environmental conditions could not be modified.

Psychological subject experiments were also conducted under thermal-transient conditions using a climate chamber. Figure 1 shows the transient thermal sensation indexes in regard to skin temperature, thermal comfort and pleasant sensations. When the human heat

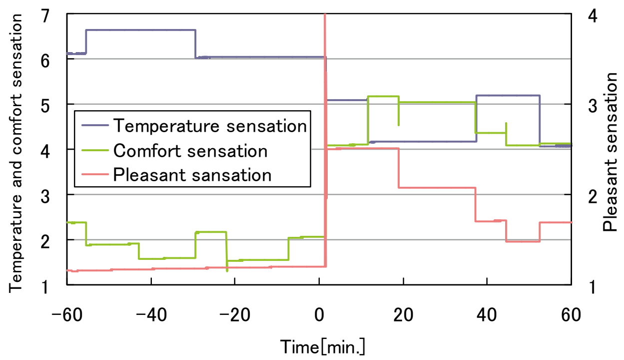


Figure 1. Transient thermal sensations under transient thermal condition in cross-ventilated environment.

balance changed to the negative side by making stepwise changes in cross-ventilated environments, the thermal pleasant sensation became "very pleasant". However, the duration of the pleasant sensation was shorter than that in stagnant environmental conditions.

2) Study on prediction accuracy of skin surface temperatures and sensible heat losses in stagnant environment using numerical thermal manikin

The purpose in this study was to clarify the prediction accuracy of a numerical thermal manikin by comparing the prediction results of skin surface temperatures and sensible heat loss obtained from an experimental thermal manikin in a stagnant environment.

The test room was created in the climate controllable wind tunnel at Tokyo Polytechnic University. The thermal manikin in a standing posture and unclothed condition was set near the center of the test room. Three tests were carried out with air temperatures set at 20, 25 and 30 °C.

The prediction accuracy of skin surface temperatures by the numerical thermal manikin for the three cases was verified. The skin surface temperatures obtained from

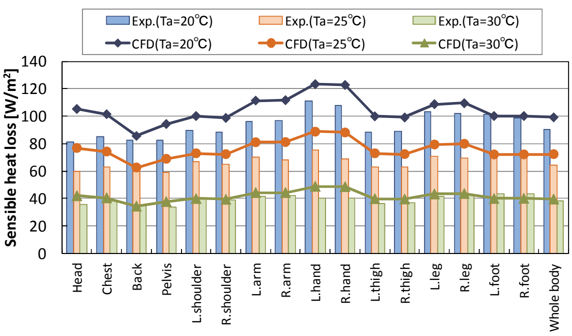


Figure 2. Prediction accuracy of sensible heat losses in thermal manikin.

experiment and CFD showed a similar trend. Figure 2 shows the prediction accuracy of sensible heat loss by the thermal manikin. For all three cases, the CFD results were slightly higher than in the experiment. However, the predicted values generally corresponded well with the experiment.

3) Development of Environment Responsive Façade Engineering to Enhance Liveability, Sustainability and Energy Conservation in Optimized Design of Low-rise and Mid-rise Residential Buildings

This project aimed to develop an environmental responsive façade in order to enhance liveability, sustainability and energy conservation in optimised design of low-rise and mid-rise (below 13-storey) residential buildings in Japan. Emphasis was put on low-cost green features that would remain effective over the widest possible range of weather conditions and would require little or no operational energy input and the minimum degree of maintenance. The objectives of the present project were: (1) to determine façade design features that have the potential to substantially enhance liveability, sustainability and energy conservation in optimised design of low-rise and mid-rise residential buildings in Japan using Computational Fluid Dynamics (CFD) techniques and wind tunnel tests, cf. Figure 3; (2) to assess the technical feasibility and economic and environmental viability of various features for application to new residential buildings (low-rise and mid-rise) designs and to retrofit existing residential buildings in Japan; and (3) to demonstrate the applicability of simulation tools for evaluating the benefits of various unconventional/innovative design features.

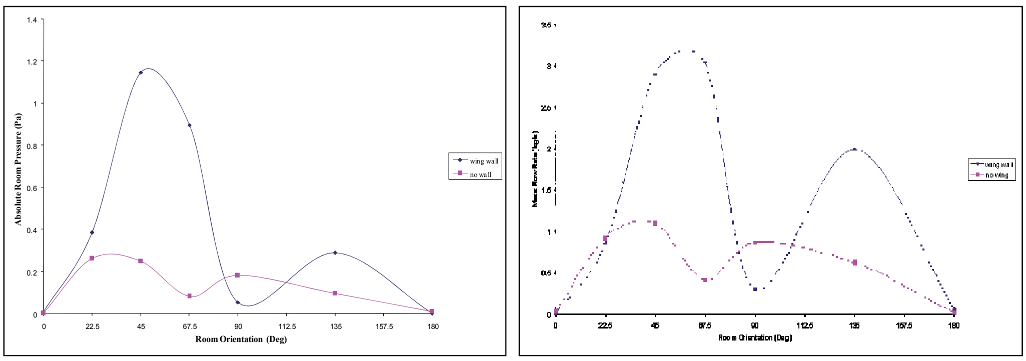


Figure 3. (left) room pressure for two room configurations, (right) mass flow rate in room.

4) Development of Natural Ventilation System with Constant Air Volume

Rooms need ventilation as long as they are occupied and that requires use of energy. However, air-conditioning equipment can substantially increase building running costs to maintain the indoor environment. Thus, a natural ventilation system that runs cheaply has become an increasingly attractive option. In this research, a natural ventilation system with constant air volume was developed. This system and its mechanism are shown in Figure 4. When the angle of wings is fixed, the downstream wind velocities are proportional to the upstream wind velocities, and it is verified that the wind force on the wing is proportional to the square of the upstream wind velocity. By using these relations, a spring system was designed to obtain a constant air volume regardless of wind conditions. 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.

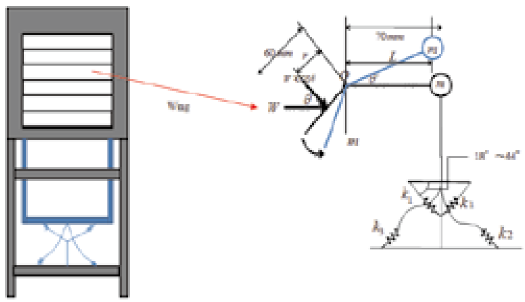


Figure 4. Natural ventilation system and its mechanism

5) 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 used as an absorbent material comprising absorbent tube-shaped charcoal from wood briquettes was made. Experiments showed that dehumidification was possible at cooling temperatures above 15°C, and an absorbent material could also reproduce in the heating temperature at 40°C. Moreover, when cooling and heating of moisture absorption material were repeated every hour, the amount of dehumidification of each time was not changed. Therefore, the system can continuously dehumidify if heating and cooling are done alternately using these two units.

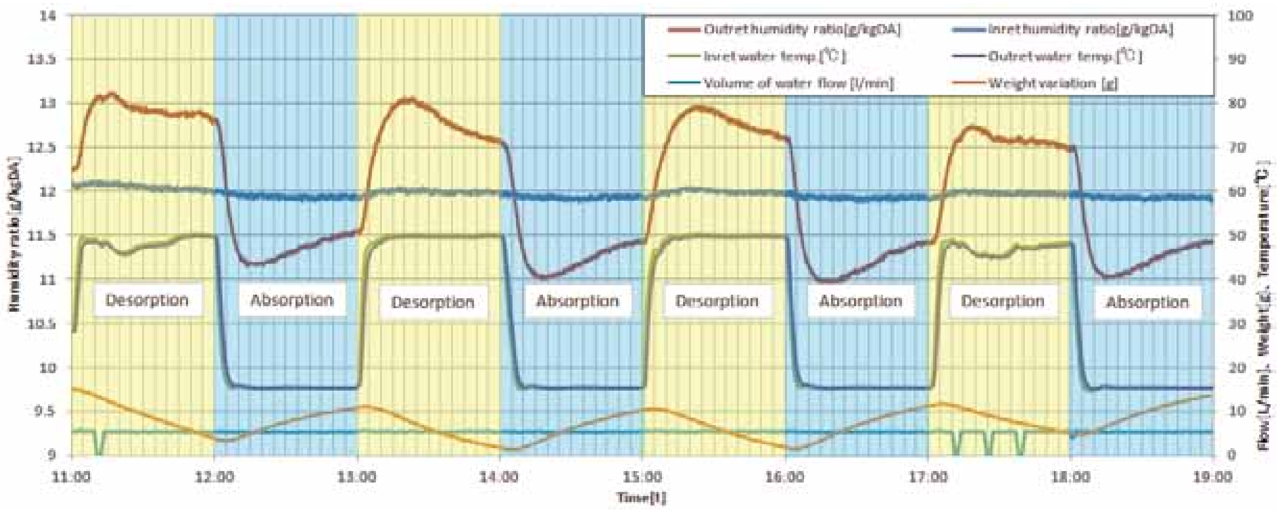


Figure 5. Experimental results of absorption and desorption by cooling and directly heating charcoal from wood briquettes (heating temperature:50°C, cooling temperature:15°C)

Project 3: Outdoor Wind Environment

1) Experimental, computational studies on heat transfer from urban canopy and its dependence on urban parameters to develop a modified urban canopy model.

The Weather Research Forecasting (WRF) model coupled with the Urban Canopy Model (UCM) are effective tools for prediction of urban heat island phenomena. In UCM, local convective heat transfer from the urban canopy and its dependence on urban parameters such as building coverage ratio and building

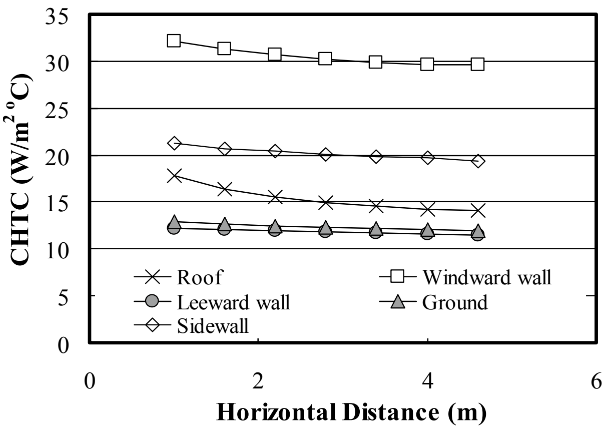


Figure 1. CHTC profile of horizontal distance in flow direction for individual canopy surfaces for 11% BCR

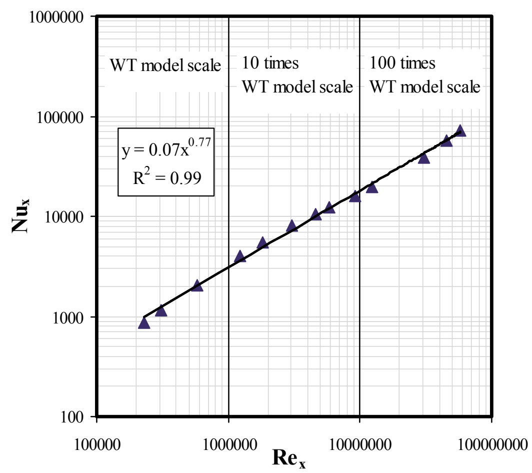


Figure 2. Generalization of CHTC by Nu_x and Re_x relationship

height variations are not explicitly modeled. In the single layer Urban Canopy Model (Kusaka et al. 2001) in WRF, the heat transfer coefficients from canyon surfaces are evaluated from Jurges formula. In this formula, the local convective heat transfer coefficients from building walls and ground depend 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 between convective heat transfer coefficients on different wall surfaces, i.e., windward, leeward and side walls. Therefore, wind tunnel experiments and CFD simulations were carried out to clarify this issue.

Wind tunnel experiments were conducted to roughly grasp the dependence of urban parameters on bulk heat transfer from the urban canopy in a thermally stratified wind tunnel. However, it is not an easy task in wind tunnel experiments to evaluate local convective heat transfer coefficients, which vary on individual canyon surfaces such as building roofs, walls and ground. Thus, CFD simulation with a low Reynolds number k-ε model was conducted to evaluate the convective heat transfer on these surfaces. Calculated CFD results showed good agreement with experimental results. After this validation, the effects of urban canopy parameters on local convective heat transfer on individual surfaces were investigated by CFD simulation. Based on these results, the convective heat transfer coefficient and heat flux from the urban canopy will be modified with respect to the urban parameters, which will be incorporated into the UCM.

2) Reproduction of vertical profiles and occurrence frequency of wind velocity by WRF

To assess the pedestrian wind environment around tall buildings based on occurrence frequencies of wind velocities we need reliable statistical wind observation data from near their construction sites. However, wind observatories are not always located near construction sites. Even if they do, the observation height is sometimes not high enough and the wind data are affected by surrounding buildings. Meso-scale simulation can be an alternative to direct observation. The authors intended to use the WRF (The Weather Research and Forecasting Model), a meso-scale simulation model, to prepare standard wind data at high altitude for the assessment of the pedestrian wind environment. We also plan to use WRF for research on urban heat island phenomena, which is becoming serious in large cities in Japan. One effective countermeasure 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 regenerate 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) and those by Doppler Rider near the “Tokyo Sky Tree” (Ootsuka et al. 2011) were used. In order to well regenerate the vertical profile of wind velocity by WRF, it is considered that an appropriate surface roughness should be given to the WRF calculation. However, the default setting of WRF based on USGS (United States Geological Survey) expresses urban areas as only one category and gives a uniform roughness length regardless of building densities and heights. Thus, we used GIS (Geographic Information System) data to appropriately classify urban land-use categories and to give roughness lengths to the WRF calculation. We checked two cases of WRF calculations, using a default setting (Case 1) and using GIS data (Case 2), and compared the results with observation data. The calculated probabilities of exceedance of wind velocity at high altitude (especially Case 2) corresponded very well with that of the observation. In addition, it was apparent that calculated vertical profiles of mean wind velocity of Case 2 were very close to those of the observation.

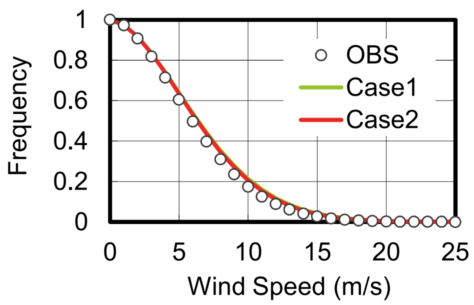


Figure 3. Probability of Exceedance for Mean Wind Speed (300m high, Minami-Senju)

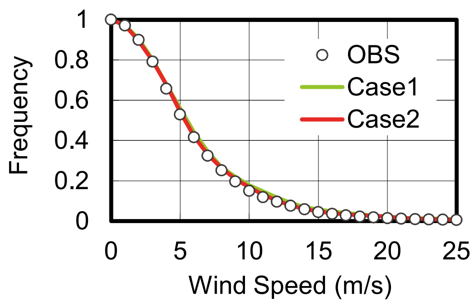


Figure 4. Probability of Exceedance for Mean Wind Speed (700m high, "Tokyo Sky Tree")

3) Investigations on urban ventilation performance considering building and stratification parameters

In China, urban ventilation efficiency is becoming an important concern because of urban heat island phenomena and serious air pollution.

One purpose of this study was to systematically evaluate the planning of new areas by investigating effects of urban building configurations on ventilation performance. The urban ventilation performances of various building arrangements were evaluated by spatial average of wind speed ratio (VRw), spatial average of normalized concentration (C*) and visitation frequency (VF). A new urban design parameter (PR) for urban ventilation was proposed. Relationships among three indices were investigated. Another purpose of this study was to obtain a general function between atmospheric stability and concentration from observation data at air pollution monitoring stations in Tokyo.

Figure 5 shows the relationship between PR and C*. Figure 6 shows monthly averaged NO_x concentration and atmospheric stability probability distribution (classified by Pasquill–Gifford Method).

4) Inflow turbulence generation for LES in Non-isothermal Boundary Layer

When simulating turbulent atmospheric boundary

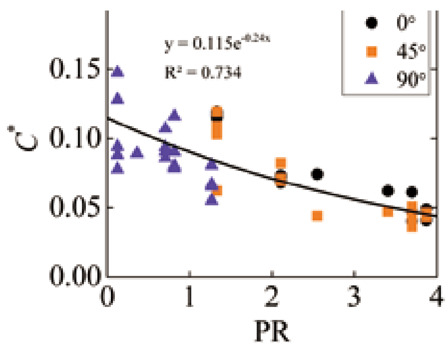


Figure 5. Relationship between PR and C*

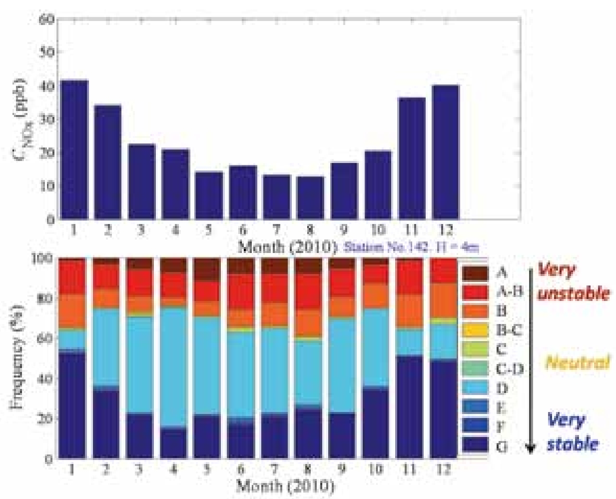
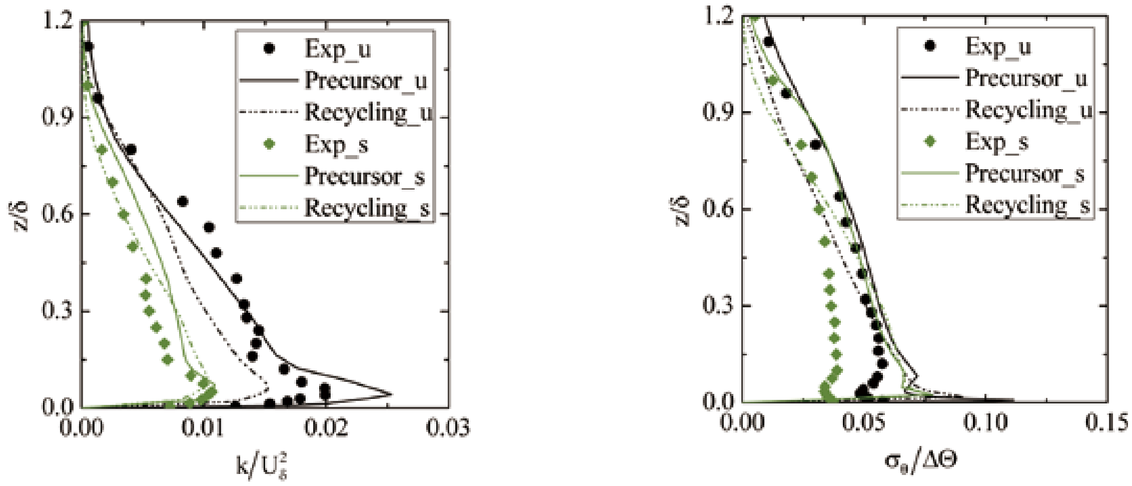


Figure 6. Monthly averaged NO_x concentration and atmospheric stability probability distribution

layers using Large Eddy Simulation, a crucial issue is how to impose physically correct fluctuating inflow data. In a non-isothermal field, not only inflow velocity fluctuation but also temperature fluctuation is necessary. In this research, two inflow turbulence generation techniques (precursor method and recycling procedure) were investigated for both unstable and stable conditions. Figure 7 shows the inflow characteristics generated by both the precursor method and the recycling method. The generated turbulent kinetic energy and the r.m.s. value of temperature fluctuation agreed relatively well with those of the wind tunnel experiment for both unstable and stable conditions, and both methods can be used to generate turbulent inflow data for LES in a non-isothermal boundary.

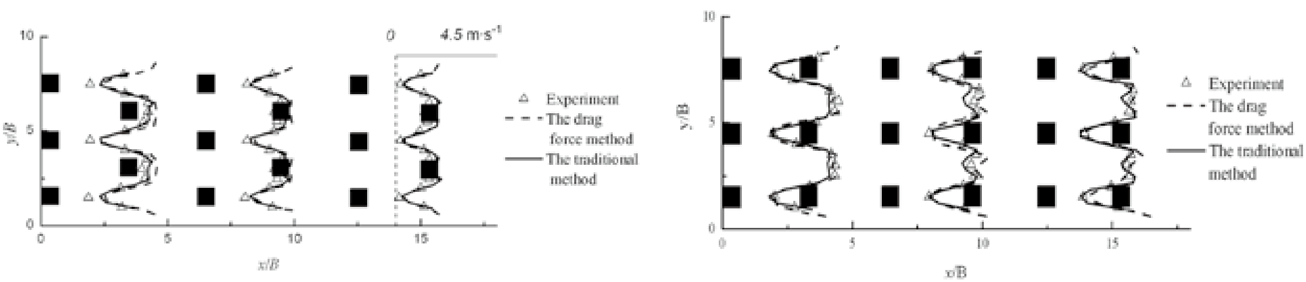
5) Large-eddy simulation of flow around obstacle arrays using drag force method of gas-solid two-phase flow

The traditional method (body-fitted method) is mostly used for simulating an urban environment. However, with increasing numbers of simulated buildings, huge numbers of grids are needed and generating body-fitted grids requires a great deal of time and labor. In order to solve this problem, a drag force method of gas-solid two-phase flow was proposed. This method doesn't need body-fitted grids and enables easier grid generation than the traditional method. Figure 8 shows that the results of the traditional method and the drag force method were almost in agreement with experimental data. The drag force method simulates the obstacle arrays more simply than the traditional method.



(a) Turbulent kinetic energy (b) r.m.s. value of temperature

Figure 7. Generated inflow characteristics by precursor and recycling methods.



Lateral profiles of streamwise mean velocity at z = H/2 along the x-axis of the staggered obstacle array

Lateral profiles of streamwise mean velocity at z = H/2 along the x-axis of the aligned obstacle array

Figure 8. Lateral profiles of streamwise mean velocity

Report on ”The 8th international Advanced School on Wind Engineering” (IAS8)

(Course A: Structural Wind Engineering)
Date: November 14-16, 2011
Venue: Hong Kong Polytechnic University, Hong Kong, China

(Course B: Environmental Wind Engineering)
Date: November 16-18, 2011
Venue: Hong Kong University of Science & Technology, Hong Kong, China

The international Advanced School (IAS) on Wind Engineering is one of the educational activities of Global Center of Excellence (GCOE) Program at Tokyo Polytechnic University (TPU), entitled “New Frontier of Education and Research in Wind Engineering”, to provide advanced professional training in the field of wind engineering. The 8th IAS was successfully held in Hong Kong, China, from 14th to 18th November 2011. It was co-hosted by GCOE of Tokyo Polytechnic University, The Hong Kong Polytechnic University (HKPU) and The Hong Kong University of Science & Technology (HKUST) with Prof. Yukio Tamura (TPU), Prof. You-Lin Xu (HKPU), and Prof. Tim Tse (HKUST) as coordinators. The 8th IAS was inaugurated by Prof. Yukio Tamura, President of International Association for Wind Engineering and Professor of TPU, Japan. Prof. Alex P.K. Wai, Vice President of HKPU and Dr. C.M. Koon, Assistant Director of the Hong Kong Building Department are honorable officiating guests and gave opening speeches in the opening ceremony.

The 5 days’ IAS8 was divided into two courses with different themes: Structural Wind Engineering and Environmental Wind Engineering. In between the two courses, two technical visits to 1) The Hong Kong Airport Core Programme Exhibition Centre and Hong Kong Bridge Structural Health Monitoring Centre and 2) The CLP Wind/Wave Tunnel Facility (WWTF), HKUST, were organized to further strengthen the courses and to provide relevant demonstrations. 11 worldwide prominent wind experts from 9 different countries all over the world were invited to give excellent lectures. The details of the lectures were as follows:

Structural Wind Engineering

Prof. You-Lin Xu (The Hong Kong Polytechnic University, Hong Kong)

1. Numerical models for simulating typhoon wind fields in boundary layer.
2. Directional typhoon wind speeds and profiles in Hong Kong.
3. Simulation of directional typhoon wind speeds and profiles over complex terrain

Prof. Richard Flay (The University of Auckland, New Zealand)

1. Bluff body aerodynamics 1.
2. Bluff body aerodynamics 2.
3. Gust factor approach to determine the along-wind dynamic response to turbulence.

Prof. Yukio Tamura (Tokyo Polytechnic University, Japan)

1. East Japan Earthquake and Tsunami Disaster on March 11 2011
2. Damping devices to suppress wind-induced response.
3. Monitoring techniques in wind engineering.

Prof. Chris Baker (University of Birmingham, United Kingdom)

1. Thunderstorms and tornados.
2. Wind effects on trees and crops.
3. Wind effects on vehicles.

Prof. Kenny Kwok (University of Western Sydney, Australia)

1. Wind-induced vibration of structures-with special reference to tall building aerodynamics.
2. Human perception of tall building motions in strong

wind environments.

Prof. Ted Stathopoulos (Concordia University, Canada)

1. Understanding wind codes and standards: Fundamentals behind their provisions I.
2. Understanding wind codes and standards: Fundamentals behind their provisions II.
3. Understanding wind codes and standards: Fundamentals behind their provisions III.

Environmental Wind Engineering

Prof. Chris Baker (University of Birmingham, United Kingdom)

1. Wind effects on people.

Prof. Kenny Kwok (University of Western Sydney, Australia)

1. The role of wind engineering in air ventilation assessment (AVA) for building developments.

Prof Michael Schatzmann (University of Hamburg, Germany)

1. Properties of urban boundary layers.
2. Experiments in field and wind tunnel boundary layers.
3. Emergency response tool for accidental releases.

Prof Qingyan Chen (Purdue University, USA)

1. Wind in building environment design.
2. Models for predicting ventilation performance in buildings.
3. Predictions of room air distribution: Solved and unsolved problems.

Prof Shinsuke Kato (University of Tokyo, Japan)

1. Control of airflow and particle dispersion in hospital rooms by CFD and ventilation effectiveness analysis.
2. Wind induced cross ventilation with single-sided opening.
3. Preferable urban wind related with indoor environment.

Prof Matthew Santamouris (University of Athens, Greece)

1. Passive Cooling of Buildings I.
2. Passive Cooling of Buildings II.
3. Passive Cooling of Buildings III.

Prof Ryuichiro Yoshie (Tokyo Polytechnic University, Japan)

1. Energy conservation effects of hybrid ventilation in high- rise office buildings.
2. Influence of form of building groups on urban ventilation.

3.Technique for simultaneously measuring fluctuating velocity, temperature and concentration in non isothermal flow.

The 8th IAS received excellent responses from students, engineers, designers, researchers, scientists and consultants working in the fields of structural and environmental wind engineering. It attracted more than 85 participants, who came from universities, consultant firms, government agents, and other private sectors, such as the Hong Kong Polytechnic University, The Chinese University of Hong Kong, City University of Hong Kong, The University of Hong Kong, Planning Department, Buildings Department, Highways Department, Environmental Protection Department, etc. They are benefited from the two courses via the rigorous discussions between the students and speakers during and after each lecture. The IAS8 was evidently appreciated by the participants, who expressed that more international activities of this kind should be organized to facilitate collaborations and acknowledge exchanges.

Finally the closing ceremony was held on 18th November 2011, for which Prof. Yukio Tamura of TPU, Japan, gave a heart-stirring close speech. The success of the IAS8 was a collective effort of GCOE of TPU, HKPU and HKUST.

Report of The 6th Korea-Japan Joint Workshop on Wind Engineering (JaWEiK6)

Date: October 31st, 2011
Venue: Disaster Prevention Research Institute, Kyoto University

The 6th Korea-Japan Joint Workshop on Wind Engineering (JaWEiK6) was held in the Disaster Prevention Research Institute of Kyoto University, Kyoto, Japan on October 31, 2011. This workshop was co-organized by the Japan Association of Wind Engineering and the Wind Engineering Institute of Korea. There were

20 presentations (7 from the Japanese side, 8 from the Korean side and 5 from the Chinese side). The name of this workshop will be changed from JaWEiK to CJK Workshop on Wind Engineering from next year. The 1st CJK Workshop will be held in Korea in June, 2012. The titles of the presentations were:

Gi-Nam Kim (Hyundai Eng. & Const. Co., Ltd), Wind-Resistant Design of ULSAN Bridge

Haesung Lee (Seoul National University), Restoration of causality condition for the convolution integral of aerodynamic force

Ho-Kyung Kim (Seoul National University), Estimation of wake galloping of unparallel cylinders

Hyun-Goo Kim (Korea Institute of Energy Research), Wind Resource Assessment of Building Integrated Wind Turbine by RS, NWP and CFD

Wan-Ho Jeon (CEDIC Co.), Development of Automatic Wind Resource Analysis System by using CFD

Hongjin Kim (Kyungpook National University), Assessment of typhoon behavior and performance of TMD by system identification

Ji Young Kim (Daewoo Institute of Construction Technology), Field measurements of architectural structures and their comparisons with structural analysis

Jongdae Kim (Samsung C&T), CFD estimation of flutter derivatives for plate girder bridge

Yaojun Ge (Tongji University), Wind Engineering Group in China

Shuyang CAO (Tongji University) Wind Engineering Study in Tongji University

Haili Liao (Southwest Jiaotong University), Wind Engineering Study in SWJTU

Chen Kai (China Academy of Building Research), A new approach for the calculation of wind-induced response: Generalized Coordinate Synthesis method

Qing-Shan Yang (Beijing Jiaotong University), Wind-induced Responses of Long Span Roofs

Tomomi Yagi (Kyoto University), Generation factors of dry-state galloping of stay-cables in consideration of surface conditions

Susumu Fukunaga (Honshu-Shikoku Bridge Expressway

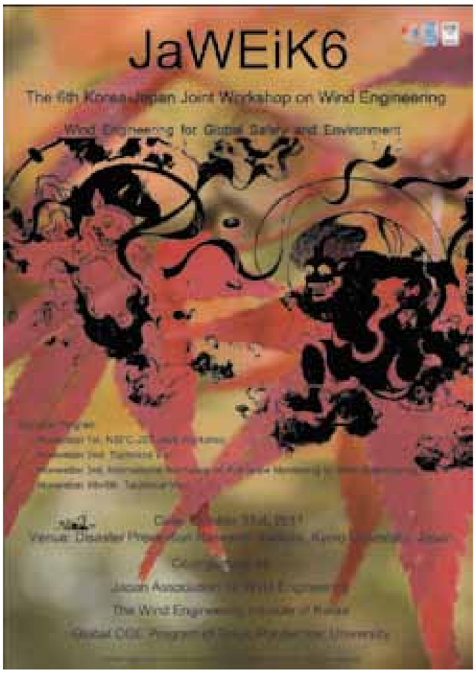


Figure 1. Poster of JaWEiK6

Figure 2. Group photo

Company Limited), Results of field observation for vibration of cables on Tatara Bridge

Yasuo Okuda (Building Research Institute), Damage to buildings in inundation area induced by tsunami -great east Japan earthquake

Masahiro Matsui (Tokyo Polytechnic University), Design tornado for assessing important structures in Japan

Tetsuya Takemi (Kyoto University), High-resolution meteorological modeling of wind extremes associated with weather disturbances

Hiroaki Nishimura (General Building Research Corporation of Japan), Wind damage to metal roof coverings due to typhoons in 2011

Hiromasa Kawai (Kyoto University), Structure of a pair of conical vortices and pressure on a flat roof in smooth and turbulent flows

Report of The 4th International Workshop on Equivalent Static Wind Loading (NSFC-JST Joint Workshop)

Date: November 1, 2011
Venue: Disaster Prevention Research Institute, Kyoto University

The 4th International Workshop on Equivalent Static Wind Loading (NSFC-JST Joint Workshop) was held in the Disaster Prevention Research Institute of Kyoto University, Kyoto, Japan on November 1, 2011. This workshop is one of the activities of a cooperative research project named “New Strategies for Wind Disaster Risk Reduction of Wind Sensitive Infrastructures” funded by the National Science Foundation of China (NSFC) and the Japan Science and Technology Agency (JST). This cooperative research project was organized by Tongji University, Beijing Jiaotong University and Tokyo Polytechnic University and this workshop is held twice a year. The 1st workshop was held in Tongji University, Shanghai, China, the 2nd was held in Tokyo Polytechnic University, Atsugi, Japan and the 3rd was held in Beijing Jiaotong University. There were 13 presentations (4 from the Japanese side and 9 from the Chinese side) related to research progress of this cooperative research project. As the technical tour of this workshop, all participants visited E-defense (biggest shaking table in the world) and the Akashi-Kaikyo Bridge. The next workshop will be held after the CJK Wind Workshop at the same place in Korea.

Figure 1. Photo of workshop venue

Figure 2. Group photo at Akashi-Kaikyo Bridge

Report of Research Symposium on Full-scale Monitoring for Wind Disaster Mitigation

Date:November 3rd, 2011
Venue: Disaster Prevention Research Institute, Kyoto University

This symposium was held in Kihada Hall, Disaster Prevention Research Institute of Kyoto University, Kyoto, Japan on November 3, 2011. Its objects were to exchange knowledge of research results on full-scale monitoring in many research fields such as wind engineering, meteorology, civil engineering, railways, electricity and so on for prevention or mitigation of the wind-related disasters and clarification of the mechanism of strong wind.

There were 19 presentations, including three invited lectures: by Prof. Ahsan Kareem (University of Nortre Dame), Prof. Yao-jun Ge (Tonji University) and Y. L. Xu (The Hong Kong Polytechnic University). The titles of the invited lectures were:

Ahsan Kareem (University of Nortre Dame)
Performance of buildings in urban areas under winds

Yao-jun Ge (Tonji University)
Full measurement of dynamic and aerodynamic performance of a long-span suspension bridge

You Lin Xu (The Hong Kong Polytechnic University)
Wind and structural health monitoring of landmark structures

Figure 1. Prof. Tamura explained the contribution of Prof. Ishizaki

Figure 2. Photo of dinner party

Public defense on doctoral dissertation

Final defense of a doctoral dissertation was held at the Atsugi campus of TPU on February 4, 2012. Mrs. Sudha Radhika presented her doctoral dissertation draft as shown in Figure 1.

PhD students, researchers and engineering designers in the wind engineering field participated in the public hearings. There was active and fruitful discussion

Figure 1. Presentation by Mrs. Sudha Radhika.

between audience and presenter. Figure 2 shows the public hearings. After the public hearings, the final assessments on the doctoral dissertation were carried out by five examiners including one external examiner to ensure the quality of the dissertation. TPU awarded a PhD degree to Mrs. Sudha Radhika in March, 2012.

Figure 2. Audience and presenter in public hearings.

Automatic wind damage detection from remote sensing image signals using wavelet based pattern recognition

Sudha Radhika, Yukio Tamura, Masahiro Matsui

1 INTRODUCTION

In this era of climatic changes, heavy wind damage to buildings and structures has become a major issue. Impacts of such disasters can be reduced by a rapid but accurate identifica-tion of damage locations and faster reconstruction. Researches were conducted on tornado track identification from pre- and post-storm satellite imageries by Soe et al 2008 and Thomas et al 2002. In past works, cyclone damage to buildings was estimated from pre- and post-storm satellite imageries, e.g., Womble et al 2007. Many researches were also done on damage caused by other types of natural disasters such as earthquakes, from aerial imageries, e.g., Hasegawa et al (2000) and Matsuoka (2000).

In the present investigation, wind damage locations were initially identified automatical-ly from low resolution remote sensing imagery, by using newly introduced texture-wavelet analysis of wind borne debris deposits, for a quick survey and for emergency aid. The dam-age locations were then mapped on high resolution imagery. Buildings were thus segmented by using color invariance properties and edge detection. Damaged buildings were automati-cally identified using wavelet based feature extraction along with pattern recognition tech-niques such as Artificial Neural Network, (ANN) and Support Vector Machine (SVM). These methods were applied separately on pre- and post-storm imageries and on post-storm imageries alone. It was observed that even using post-storm imageries alone, accurate and economic damaged building identification could be achieved. The percentage roof damage area was also quantified using texture-wavelet analysis of damaged building roofs, which showed good positive correlation with manually obtained percentage area of damage. New user-friendly software was designed for rapid and easy damage detection from debris deposits. The current research was also applied in real time situations such as the Tuscaloosa tornado (US) and the Tokunoshima tornado (Japan) and in other types of natural disasters such as in a Thailand flood where water covered areas were also detected. Application in determining F-scale of a tornado from the debris deposit path width and a generalization of automatic building damage detection is also determined in this research.

2 METHODOLOGY

2.1. Data Acquisition

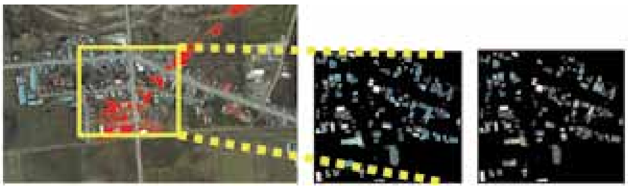
Pre- and post-storm aerial and satellite imageries of both low and high resolutions ac-quired before and just after wind damage were utilized in this research. Field survey data were also collected to validate the final obtained result.

2.2. Image Enhancement

For rapid investigation of damaged areas, to reduce the time taken to scan the damage in the entire imagery, the wind damage path is initially identified from wind borne debris de-posits in the post-storm imageries and the image is cropped in that particular damage area for further investigation (Radhika et al., 2011). Texture-wavelet analysis on the post-storm imageries alone is performed to identify the pattern of the sharp broken edges in the debris deposit. Thus, the path is identified as shown in Fig. 1 (a) and both the pre- and post-storm images are cropped in the exact damage location.

As the pre- and the post-storm images are collected at different instances, the images as such have apparent misalignment as well as varied illumination. Proper image enhancement, such as illumination normalization for the two cropped images as well as image registration is done using geometric transformation to adjust the image alignment.

From the cropped, enhanced and registered pre- and post-storm imageries buildings are segmented by utilizing the colour invariance property and the edge detection method (Radhika et al., 2011) as shown in Fig. 1(b) and (c).



1(a) 1(b) 1(c)

Fig. 1(a) Tornado path detected 1(b) Building roof structures segmented from pre-storm image and 1(c) post-storm image.

2.3. Change Detection

Fig.2 (a) and (b) shows pre- and post-storm roof-top aerial images and Fig.2 (e) shows the ground survey image of a sample building. The non-damaged roof portion, which is common for both imageries, is marked in red outline in Fig. 2 (b). If this common area for both pre- and post-storm imageries is removed, the remaining portion represents the change that occurred to the building after strong wind damage (Womble et al., 2007). This is at-tained by the change detection method by common portion deletion.

Fig. 2(c) shows a building sample after common portion deletion in RGB format. Addi-tionally, hue, saturation, vision and intensity information, shown in 2(d) of the image, are also obtained.

2.4. Feature Extraction

Here the conventional feature extraction approach as well as the latest wavelet extraction approach are used on change-detected roof tops as well as directly on post-storm rooftop imageries.

Wavelet Transform Feature Extraction

In the current work, as the data is a two-dimensional imagery, two-dimensional discrete wavelets are used. Discrete wavelets used in the present case include Daubechies, Coiflets, Symlets, discrete Meyer and biorthogonal wavelets. Experiments were done and biorthogo-nal 3.7 was identified as the best wavelet which has a minimum absolute percentage error of 0.24% in identifying the pattern of broken building structures and scattered debris. Wavelet decomposition is performed and the low-frequency information, which gives information on smooth regions, is filtered out and the image is reconstructed from high-frequency information alone, i.e. the three detailed coefficients, which gives information mainly on broken edges. Statistical features are extracted from the reconstructed building image samples.

Texture-Wavelet Analysis

Image histogram features are extracted by using texture analysis on the wavelet recon-structed building roof images, thus texture-wavelet analysis, on change detected as well as directly on post-storm imageries. The texture is identified by measuring the distribution on the wavelet reconstructed image, Fig 2(g). The damaged area with maximum distribution intensity is segmented from the rest of the roof portions using Otsu's segmentation method, where the objects (damaged area) to be segmented are separated from the background (re-maining) (Otsu, 1979), Fig. 2(h). The damaged portions thus obtained are normalized with the roof area in order to obtain the percentage area of damage.

$$\%P_D = (\frac{A_D}{A_T}) \times 100 \text{ --- (1)}$$

where PD is the percentage area of roof damage, AD is the damaged roof area and AT is the total roof area. The validation procedure is done by manual inspection of the damaged area. Fig. 2(i) shows the damaged area by

2(a) 2(b) 2(c) 2(d) 2(e) 2(f) 2(g) 2(h) 2(i)

Fig. 2(a) Pre-storm, 2(b) Post-storm, common area marked in red outline, 2(c) After change detection 2(d) In-tensity information 2(e) Ground truth data of the same building 2(f) Broken Edges detected by Canny edge detection 2(g) Intensity of distribution of broken edges detected using texture-wavelet analysis, 2(h) Damaged area segmented automatically, and 2(i) Manually inspected damage area manual inspection.

The conventional edge detection method is Canny edge detection (Canny, 1986). Fig. 2(f) shows the broken edges detected by Canny edge detection for the same building sam-ple.

2.5. Automatic Damaged Building Identification

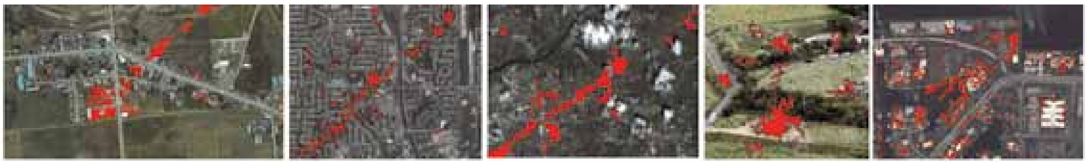
The best features that contribute to accurate classification are selected using a decision tree method that is capable of selecting the best features that can correctly classify the buildings into damaged or non-damaged category based on J48 algorithm (Radhika et al 2009). Classification is performed on all the samples extracted by both ordinary feature extraction and wavelet based feature extraction, and the damaged buildings are identified using both the artificial neural network (ANN) method as well as the modern computational statistical learning concept, Support Vector Machine (SVM), and the results are as shown in Fig.3.

3 RESULTS, OBSERVATIONS AND DISCUSSIONS

In addition to the Saroma, Japan, tornado, 2006, the automatic tornado damage path tracking system for the wind borne debris deposits was performed for Moore, Oklahoma, US tornado damage, 1999 and Punta Gorda, US Hurricane damage, 2004 and also in real time situations such as that of Tuscaloosa, Alabama, US tornado April 27, 2011, and To-kunoshima tornado in Kagoshima, Japan, November 19 2011. Results are shown in Fig. 3.

Automatic roof-damaged building identification from pre-storm and post-storm as well as using post-storm alone with ANN and SVM were performed. Results are shown in Fig 4. It is observed that an efficient classification of 90% is obtained with SVM, even using post-storm images alone, with the aid of wavelet based feature extraction when compared with the conventional methods. Percentage area of roof damage with 0.75 correlation factor with the manually obtained percentage area of roof damage obtained using texture-wavelet anal-ysis directly on post-storm building rooftops alone, evaluates the accuracy of the method used, see Fig 5.

In short, accurate and fast wind damage identification from a remote sensing perspective is successfully achieved through this research. Accurate and fast damage



3(a) 3(b) 3(c) 3(d) 3(e)

Fig. 3 Damage path tracked for Post-storm 3(a) Aerial image of Saroma Tornado, Japan 2006, 3(b) Satellite image of Moore, Oklahoma, Uunoshima tornado in KagS tornado, 1999, 3(c) Satellite image of Tuscaloosa, Alabama, US tornado, 2011, 3(d) Oblique aerial imagery of Tokoshima, Japan Nov 19 2011, 3(e) Satellite image of Punta Gorda after Hurricane Charley, 2004

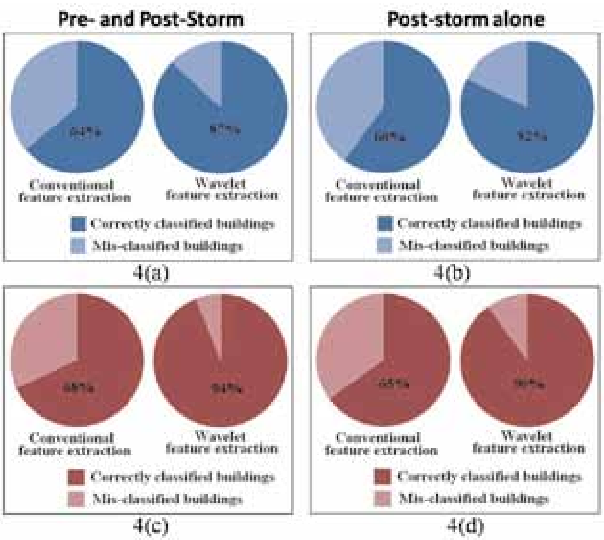


Fig. 4 Damaged building identification 4(a) and (b) using ANN 4(c) and 4(d) using SVM

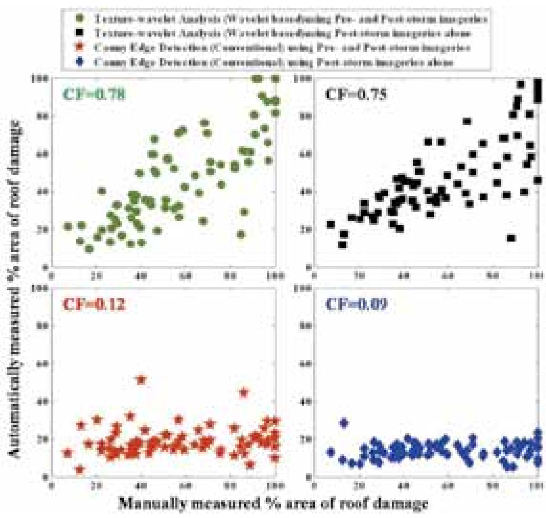


Fig. 5. Comparison between correlation factors of automatically and manually obtained percentage area of roof damage under four different conditions

identification will save more lives and enable faster restoration of building structures.

Real time application of texture wavelet analysis to other natural disasters, such as the re-cent Thailand flood, was also performed. Debris width determined from an eagle's eye per-spective was used to find the F-scale of the tornado damage and the results are validated by field investigation data. A generalization of automatic building damage detection with an efficiency of 85% is performed with training building samples provided from Saroma tornado aerial images and testing samples from satellite images of Punta Gorda.

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Experimental investigation of external and internal pressures acting on building models in tornado-like flow

G.R.Sabareesh, Masahiro Matsui, Yukio Tamura

1 INTRODUCTION

Recent statistical investigations by Tamura (2011) show that the numbers of tornadoes occurring per year in Japan are as high as 35~40. Such gust events involve very complex in-teractions between wind and building structures. These local weather disturbances are char-acterized by their unpredictability, short life and danger, making real time investigations difficult. Past studies (Chang (1971), Jischke and Light (1983), Mishra et al. (2008b), Haan et al. (2010), Yang et al. (2011)) have contributed to the simulation of tornado-like flow re-gimes for building models using vortex simulators. Some of these studies considered mean components of pressures only. They also failed to analyze the effect of building internal pressures.

This paper investigates the effects of a series of factors such as building location with re-spect to vortex, terrain roughness, and swirl ratio effects on building surface pressures, as well as the effects of opening ratio and opening orientation on internal pressures and result-ing roof wind forces on buildings under such extreme wind events.

2 FLOW FIELD

Scaled building models were subjected to a stationary vortex created using the experimental tornado simulator developed at the Wind Engineering Research Centre, Tokyo Polytechnic University. The first task was to verify the viability of this simulator for pressure measurements on building models under a tornado-like flow regime.

Parameters that govern a tornado-like flow such as swirl ratio and aspect ratio were found to agree with those that are achievable in a laboratory vortex, as reported by previous researchers.

The scalar components of wind speed were measured at various points across the tornado simulator floor and at various heights. The effect of updraft wind speed, swirl ratio and terrain roughness on scalar components of wind speed were investigated. It was found that, at a high updraft wind speed, a clear vortex core appeared; with increase in swirl, the turbulence in the region close to the centre of vortex increased; and with increase in terrain roughness, the maximum values of mean velocities shifted to greater heights. The pressure on the floor was distributed cylindrically and the curve best fitted with Rankine-type showed its core to be of the same size as one from the wind speed distributions.

3 RESULTS AND DISCUSSION

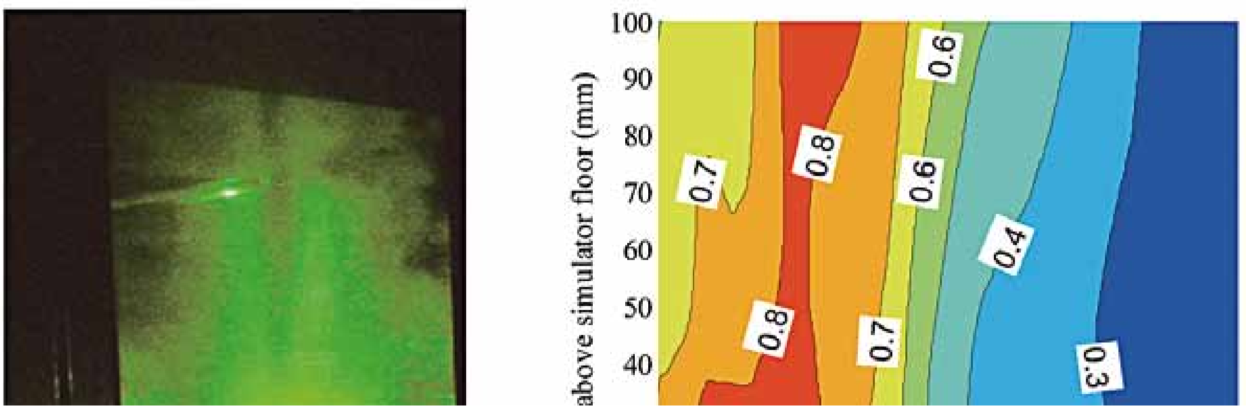
The surface and internal pressures on the building model are presented in the form of pres-sure coefficients normalized using a reference pressure based on velocity at roof height. The reference static pressure was measured outside the simulator frame. Surface pressures on the cube model of the building exposed to tornado like flow was determined at different radial locations from the tornado vortex. For this, the building model was moved such that face B was facing away from the vortex. It was observed that the different building walls (shown as A, B, C and D in the exploded face of cube) experienced similar pressure magni-tudes at the centre of the simulator, see figure 2(a), whereas the roof experienced higher suction pressures. Building walls perpendicular to the tangential flow (A & C) experienced lesser suction pressures compared to the other walls when the building was located near the core boundary. At locations very far from the vortex centre, the wall facing away from vor-tex (B) experienced least suction pressures.

The terrain roughness, see Figure 2(b), enhanced suction pressures on roofs of the building models due to the increase in core updraft accompanying the introduction of the roughness. The shift in maximum value of mean velocity to a higher elevation on the ground reduced the tangential velocity acting on the cube model. Thus, the separation points were shifted to the roof edges, resulting in less negative pressures on the side walls (A, B, C &D) compared to the case of the building near smooth ground. The roughness heights are non-dimensionalised with respect to the building height.

When analyzing the behavior of the cube for different swirl ratios, it was found that the leading edges of the cube experienced clockwise flow, which showed pressure coefficients more negative than the central pressure deficit, and the trailing edges showed pressure coef-ficients more negative than the central pressure coefficients on the floor at all swirl ratios. The roof centre also experienced greater negative pressure coefficients of the order of 1.25~1.75 times the central pressure deficit.

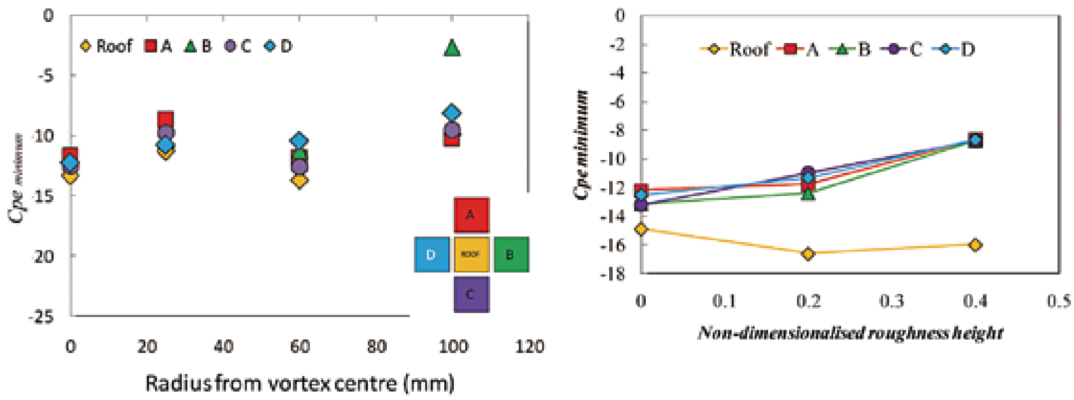
Some analogous situations were tested, where the flow direction was inclined to the cube surface in boundary layer flow, and the nature and distribution of pressure coefficients were entirely different, although the local flow situation appeared similar for the selected cases of the cube in tornado-like flow. This clarifies and demands the need for separate analysis of net wind loads acting on building models in tornado-like flow regimes taking into consideration the swirling effects of flow.

The internal volume was scaled as shown in Figure



(a) (b) (c)

Figure 1. (a) Vortex core generated in simulator (b) Contour plot showing non-dimensionalised velocity at dif-ferent radial locations above simulator floor (c) Cube model of building immersed in vortex flow



(a) (b)

Figure 2. (a) Minimum peak external pressure coefficients at different building locations S=1.3(a) Minimum peak external pressure coefficients at different terrain roughness S=0.87

(a) (b)

Figure 3. (a) Scaled volume chamber beneath the simulator floor (a) Low-rise building model used for internal pressure studies

3 for investigations of internal pres-sures to avoid internal volume distortion at model scale and to maintain similarity in dy-namic response of volume between full scale and model scale.

Many factors such as the effect of building model location with respect to vortex, swirl ratio, opening porosity and terrain roughness can impact on internal pressures developed under a tornado-like flow regime and result in changes in net roof wind force. The effect of each of these factors separately is discussed. Two opening configurations with opening rati-os 3.9% and 0.1% (distributed leakage) were considered. Internal pressures under these opening configurations behave differently in forced and free vortex regions. Higher nega-tive minimum peak internal pressure coefficients occur with a single central opening within the vortex core than with multiple holes. This behavior reverses outside the vortex core, see Figure 4 (a).

The building roof engulfed in the stationary vortex experienced higher net roof suction force when there were multiple openings with a total opening ratio of 0.1% through the building walls, whereas when the building model was located away from the vortex, a roof with a 3.9% opening ratio experienced higher suction.

With increase in swirl ratio, the difference between the minimum peak internal pressure coefficients of the two opening configurations investigated became predominant. The fluc-tuating component of internal pressure in the multiple opening case showed a dramatic re-duction compared to the case of a single central opening.

The internal pressure coefficients decreased in magnitude with the introduction of roughness. When analyzing the Helmholtz resonance frequency, it was observed that the in-troduction of roughness shifted the peak of Helmholtz resonance to the higher frequency side.

A numerical model based on acoustic theory (Holmes 1979) that predicted the fluctuat-ing pressures effectively for flow through openings was also found to be viable for predict-ing internal pressures in tornado-like flow.

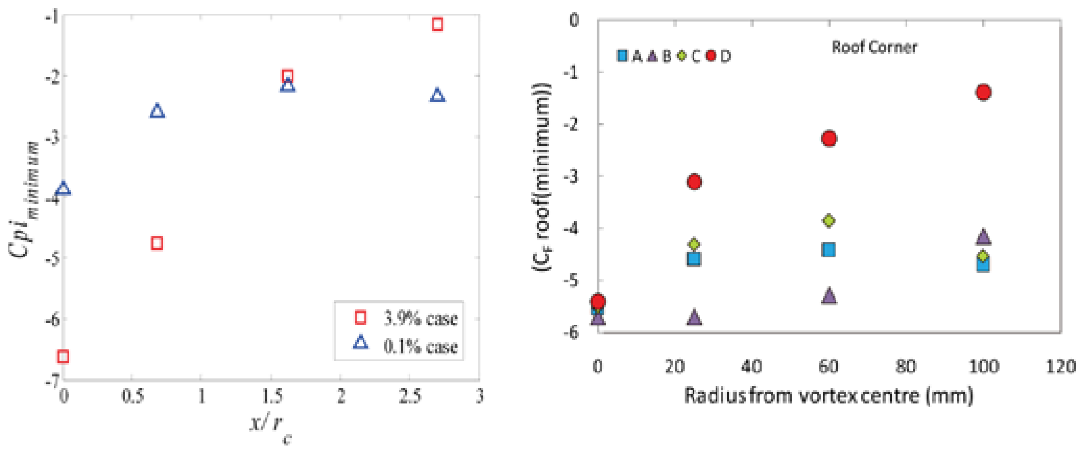


Figure 4. (a) Minimum peak internal pressure coefficients (b) Lowest minimum peak roof force coefficient

Using this numerical model, the internal pres-sures and resulting wind loads on a roof were predicted for a single central opening located on other side walls of a building, for different building locations from the simulator centre. Thus, the effect of opening orientation on internal pressures and resulting roof wind force were analyzed. It was found that the lowest minimum net peak roof force coefficient could increase four fold for the same building location, see Figure 4(b).

Based on these findings from the experimental investigations, the design pressures and net wall forces experienced by a strategically important building such as a nuclear power plant exposed to an extreme natural disturbance such as a tornado were evaluated, which could serve a broader purpose of tornado-resistant building design.

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(Hardcover, ISBN 978-3-7091-0952-6 (pages 358)).

The book presents a state-of-the-art in environmental aerodynamics and the structural design of wind energy support structures, particularly from a modern computational perspective. Examples include real-life applications dealing with pollutant dispersion in the building environment, pedestrian-level winds, comfort levels, relevant legislation and remedial measures. Design methodologies for wind energy structures include reliability assessment and code frameworks.

Contents:T. Stathopoulos:Introduction to environmental aerodynamics.-T.Stathopoulos:Applications of environmental aerodynamics.-B.Blocken: Computational wind engineering. Theory and applications.-A. Zasso, P. Schito: Aero-servo-elastic design of wind turbines: numerical and wind tunnel modeling contribution.- P. Schaumann et al.: Support structures of wind energy converters.- C.C.Baniotopoulos et al.:Topics of the design of tubular steel wind turbine towers.-C. Borri, P. Biagnini, E. Marion: Large wind turbines in earthquake areas: structural analyses, design/construction and in-situ testing.

Global COE Intensive Course

Celebrated researchers are invited as guest professors in the field of wind engineering to give the lectures with current and fascinating topics. The lectures in FY2011 are as follows.

- Date: Oct. 27 and 29, 2011
- Venue: Atsugi Campus, Tokyo Polytechnic University

- Lecturer: Professor Yaojun Ge (Tongji Unviersity)
- Title: Fundamental Aerodynamics of Bluff Body / Computational Models for Aerodynamic Flutter / Long-Span Bridge Aerodynamics / Wind and Rain Induced Effects on Structures / Compative Study of Wind Loading Codification

- Date: January 11-13, 2012
- Venue: Seminar room, 2F, APEC Centre, Tokyo Polytechnic University

- Lecturer: Professor Richard de Dear (The University of Sydney)
- Title: Building, Climate, Energy and Comfort/ Physiological Principles of comfort / Indoor Thermal Environmental Measurements and Standards / The Adaptive Comfort Approach / Outdoor Thermal Comfort

- Date: February 2-3, 2012
- Venue: Room 021, Main building, Tokyo Polytechnic University

- Lecturer: Professor Akashi Mochida (Tohoku University)
- Title: Technology and Policy for Urban Heat Island Mitigation -Japanese Experiences- / Prediction of microclimate in urban area-Current status and remaining issues- / Analysis of microclimate to guide urban planning and building design (Part 1) / Analysis of microclimate to guide urban planning and building design (Part 2) / Analysis of key mechanisms causing urban warming and snow disasters

- Date: February 14-16, 2012
- Venue: Room 011, Main building, Tokyo Polytecnic University

- Lecturer: Professor Partha Sarkar (Iowa State University)
- Title: Wind Effects on Long-Span Bridges I: Aerodynamic Load Models and Parameter Identification/ Wind Effects on Long-Span Bridges II: Response Prediction and Stay Cable Vibration/ Tornado-Induced Loads and Structural Damage/ Interference Wind Effects of Civil Structures/ Aerodynamics of Wind Turbines

■ Date: February 21-24, 2012
■ Venue: Room 011, Honkan (Main building), Atsugi Campus, Tokyo Polytechnic University

■ Lecturer: Professor Lingmi Zhang(Nanjing University of Aeronautics & Astronautics)
■ Title: Direct and Inverse Problems of Structural Dynamics / Time Domain Modal Parameter Identification of Engineering Structures / Frequency-Domain Modal Parameter Identification of Engineering Structures / Physical Parameter Identification based on Model Updating & Validation / Applications of Structural System Identification in Wind Engineering

■ Date: February 21-24, 2012
■ Venue: Room 011, Honkan (Main building), Atsugi Campus, Tokyo Polytechnic University

■ Lecturer: Professor Alan Jeary (University of Western Sydney)
■ Title: Dynamic response of structures / The approach of different countries to codification for wind action / Damping. It's measurement and applications. / Structural Damage caused by meteorological effects / Recent experience of wind excitation of various types of structure

■ Date: March 7-9, 2012
■ Venue: Room 011, Main building, Tokyo Polytecnic University

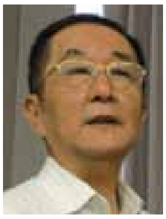
■ Lecturer: Professor Cao Shuyang (Tongji Univeristy)
■ Title: Turbulent structures of boundary layers / Actively controlled with tunnel / FDM fundmentals / CFD applications to wind engineering / Wind characteristics of strong typhoons

Global COE Open Seminar

Aim of the Global COE open seminars is to provide students a chance to be informed of current and fascinating research activities by inviting a researcher or engineer to lecture who is playing an active role in the field of wind engineering around the world, as well as Japan. Global COE open seminar in FY2011 is as follows.

The 36th Global COE Open Seminar
Date: June 8th, 2011 15:00 - 17:00
Venue: Main Conference Room, 6th Floor, Main building (Honkan), Atsugi Campus, Tokyo Polytechnic University

■ Invited Speakers: Professor Xueyi Fu (China Construction Design International)
■ Title: Design of super-tall buildings and long-span structures



■ Invited Speakers: Professor Qiusheng Li (City University of Hong Kong)
■ Title: Wind effects on buildings: field measurement, wind tunnel testing and numerical simulation

The 37th Global COE Open Seminar
Date: January 28th, 2012 13:30 - 15:00
Venue: Room 011, Main building (Honkan), Atsugi Campus, Tokyo Polytechnic University

■ Invited Speakers: Dr. Katsutoshi Ohdo (National Institute of Occupational Safety and Health)
■ Title: Wind load acting on scaffolds and safety measures against the load

The 38th Global COE Open Seminar
Date: January 28th, 2012 15:00 - 16:30
Venue: Room 011, Main building (Honkan), Atsugi Campus, Tokyo Polytechnic University

■ Invited Speakers: Assistant Professor Tomohiro Kobayashi (Ritsumeikan University)
■ Title: Measurement of Flow Quantities and Accuracy of CFD for Cross-Ventilated Flow Field.

The 39th Global COE Open Seminar
Date: February 18th, 2012 15:00 - 17:00
Venue: Room 011, Main building (Honkan), Atsugi Campus, Tokyo Polytechnic University

- Invited Speakers: Professor Ivan S.K. Au (City University of Hong Kong)
- Title: Bayesian ambient modal identification: from theory to practice

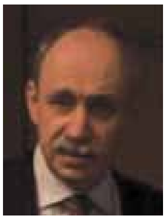
The 40th Global COE Special Open Seminar
Date: February 27th, 2012 15:00 - 17:00
Venue: Room 012, Honkan, Atsugi Campus, Tokyo Polytechnic University

- Invited Speakers: Prof. Bernd Leitl (Meteorological Institute, University of Hamburg)
- Title: ETWL – Environmental Wind Tunnel Laboratory

The 41st Global COE Special Open Seminar
Date: March 6th, 2012 10:00 - 12:00
Venue: Hotel Sunroute Plaza Shinjuku

- Invited Speakers: Professor Kishor Mehta (Texas Tech University)
- Title: Interdisciplinary Research for Wind disaster Resiliency

- Invited Speakers: Professor Giovannni Solari (Genova University)
- Title: Wind models for safety and management of anthropogenic systems



The 42nd Global COE Open Seminar
Date: March 10th, 2012 14:00 - 16:00
Venue: Room 011, Main building (Honkan), Atsugi Campus, Tokyo Polytechnic University

- Invited Speakers: Professor Kenji Okazaki (National Graduate Institute for Policy Studies)
- Title: Motivation for Earthquake Disaster Reduction

Announcement

CJK (China, Japan and Korea) International Wind Engineering

Date: June 1, 2012

Venue: POSTECH International Convention Center, Pohang, Gyungbuk, Korea

NSFC-JST Cooperative Research Meeting

Date: June 2-3, 2012

Venue: POSTECH International Convention Center, Pohang, Gyungbuk, Korea

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