
# Wind Effects News

## New Frontier of Education and Research in Wind Engineering

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Wind Engineering Research Center
Graduate School of Engineering
Tokyo Polytechnic University

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# Reports of APEC-WW2010, APEC-WW & IG-WRDRR Joint Workshop and Pre-conference event of 4AMCDRR

TPU Global COE Program has successfully organized series workshops on regional harmonization of wind loading and wind environmental specifications in Asia-Pacific economies (APEC-WW) from 2004 to 2009, and this year the sixth APEC-WW was held at Kwandong University, Gangneung, Korea during October 22-23, 2010 under the auspices of Prof. Young-Duk Kim. This series of workshop aims to 1) reach a common understanding of wind loading; 2) exchange information on the current status of wind loading standards/codes and to improve individual standards; 3) discuss bylaws/specifications for wind environmental assessment related to pedestrian level winds in an urban environment; and 4) discuss bylaws/specifications for air quality outside and inside buildings. 34 delegates attended the workshop and reported the results of Benchmark tests and their recent activities of wind engineering on both structural and environmental fields on behalf of 17 countries and economies. Resolutions for both groups are made individually after thorough face to face discussions on problems related to current wind standards/codes/bylaws/specifications. At the end of the workshop, it was decided to hold the next APEC-WW workshop in Vietnam in 2011.

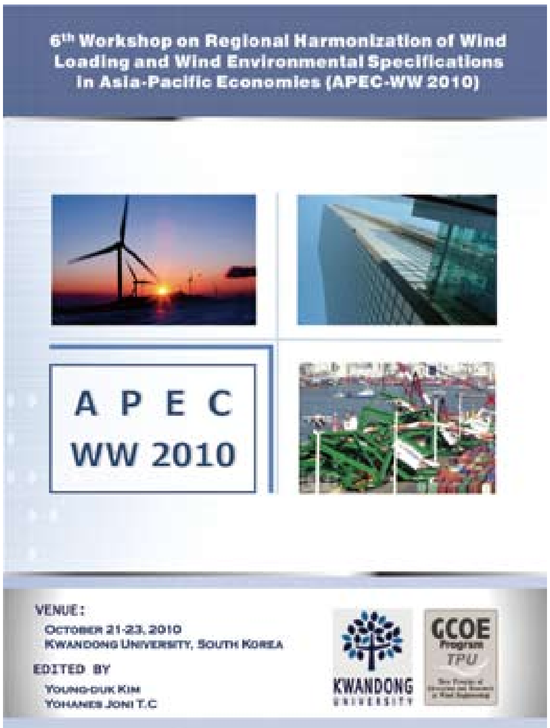



Figure 1 Proceedings of APEC-WW Workshop

A joint workshop on"Wind-Related Disaster Risk Reduction (WRDRR) Activities in Asia-Pacific Region and Cooperative Actions" was co-organized by TPU Global COE program and IG-WRDRR in Incheon, Korea on October 24, 2010. The International Group for Wind-Related Disaster Risk Reduction (IG-WRDRR) was formally launched under the framework of UN/ISDR, and it is responsible for establishing linkages and coordinating various communities to serve as inter-agency coordinators with a charter to work with international organizations involving agencies of the UN and involved NGOs, and to embolden their activities that help to serve as a bridge between policy makers and agencies responsible for actually carrying out the DRR at the local community level. Because extreme wind storms such as tropical cyclones are generally accompanied by high waves, storm surge, heavy rains, floods and landslides, TPU Global COE Program has paid great efforts to prompt the cooperative actions in WRDRR activities among various

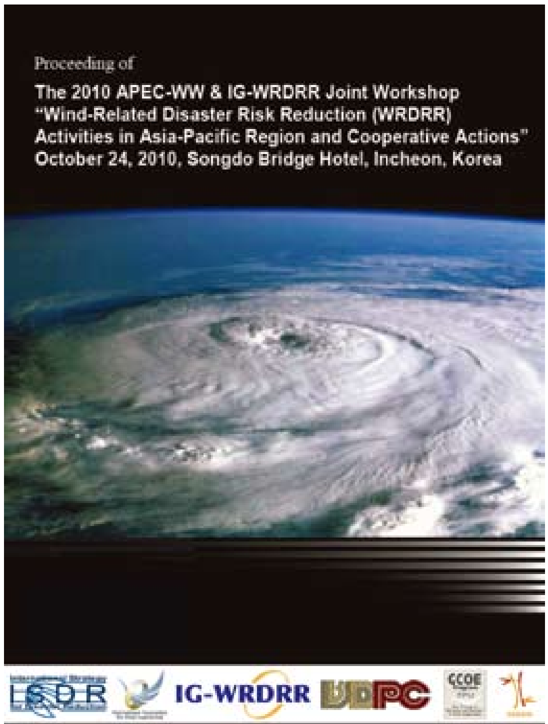



Figure 2 Proceedings of APEC-WW & IG-WRDRR Joint Workshop

professional organizations. One of the actions that TPU Global Program has taken was to include WRDRR as one theme of APEC-WW. At the joint workshop, about fifty people from more than 20 countries in the Asia-Pacific region participated and shared the current status and activities for WRDRR.

TPU Global COE Program co-organized a Pre-conference event of 4AMCDRR (The 4th Asian Ministerial Conference on Disaster Risk Reduction) on “Climate Change and Wind-Related Disaster Risk Reduction Activities in Asia-Pacific Region” on 25 October 2010. The risk of future disasters continues to escalate with population shifts towards urban centers located in the paths of typhoons/cyclones and the impending threat of their increased intensity and frequency as hypothesized by potential climate change. Urbanization has also led to the deterioration of regional and global environmental situations, which will have far reaching effects on social safety and public health. These tendencies are particularly significant in the Asian region. The Pre-conference event provided a platform for mutual exchange of information and knowledge between wind engineering experts, people working on DRR in various organizations, and policy makers. Representative persons from UN/ISDR, IG-WRDRR, IAWE, UNESCAP, WMO, ADRC, BDPC, SEEDS and APEC-WW presented current status and activities for WRDRR in Asia-Pacific region. Future collaborative action plans was intensively discussed and implemented. As one output of the Pre-conference event, the Chairman of IG-WRDRR, Prof. Yukio Tamura, submitted a message to the 4AMCDRR.

# 第２回 TPU-CARDC Wind Engineering Joint Workshop

2010年8月16日～18日に「中国空气动力研究与发展中心（China Aerodynamics Research & Development Center：CARDC」と「東京工芸大学グローバルCOEプログラム」の第2回ジョイントワークショップが中国四川省綿陽市のホテルで開催された。本ジョイントワークショップは，研究交流を通じて，相互理解を深化させ，研究協力協定書の締結を目的として企画されたものである。CARDCの参加者は10名，東京工芸大学の参加者は田村幸雄，大場正昭，義江龍一郎の3名である。

初日は，CARDCのSun Haisheng教授から参加者への歓迎の挨拶があり，その後，日本側から7件の発表と，CARDC側 3件の発表があった。二日目はCARDCの研究施設見学を行った。図1に施設建物を示す。残念ながら，軍関係の研究施設であるために風洞の撮影許可は得られなかったが，８m×６m風洞は測定断面４m×３mと８m×６mの２ヶ所の測定領域を有し，ファン動力は7800kWであった。その後，両研究機関で研究協定の細目について協議がなされ，最終日に研究協力協定書が締結された。共同研究はテキサステック大学が実施した実験建物の実測を，実スケールで風洞実験等を行うもので，自然風の再現，実測データとの比較検証など，幾つかの魅力的な研究課題に取り組むことになっている。

図１ 8m × 6 m風洞

図２　ワークショップ参加者の集合写真

# 第５回日韓風工学ジョイントセミナー(JaWEiK5)開催報告

第５回日韓風工学ジョイントミーティング (JaWEiK5) が 2010 年９月６日に韓国ソウル市 POSCO Center Art Hall にて開催された。本会議は，両国の風工学会および東京工芸大学グローバル COE プログラムによる共催で，2005 年に第１回が開催されてから毎年両国の持ち回りで開催されている。

会議は，まず韓国風工学会の Jong-Rak Kim 会長からの挨拶があり，今回は，"Bluff body aerodynamics and flow mechanics for large size structures" を主題として両国の最近の研究紹介，貴重な意見交換への期待が述べられた。

引き続き，第１セッションとして，京都大学 白土 博通 教授による Turbulence scale effect on spanwise correlation of gust force, Seoul National University Ho-Kyung Kim 教授による Aerodynamic stabilizing measures of a cable-stayed bridge in construction, Chungbuk National University Sungsu Lee 教授による Development of WindRisk(R); a tool for regional windstorm risk assessment, BOOLT simulation Seogcheol Kim 氏による CFD simulations of wind flows around buildings and terrains, DAEWOO Institute of Construction Technology Young-Min Kim 氏による Wind engineering on the Busan-Geoje fixed link bridges の講演が行われた。

第２セッションは主として日本側からの講演で，京都大学 河井 宏允 教授による Wake structure behind a 3D square prism in shallow boundary layer flow, 東北大学大学院 Choongmo Koo 氏による Discussion of design wind loads on cylindrical storage tanks, 京都大学 林 泰一 教授による Turbulent structure in high wind, 九州大学大学院 竹内 崇 氏による Unsteady wind forces on a body subjected to short-rising gust, 東京工芸大学 吉田 昭仁 准教授による Field measurement of Jeju World Cup Stadium roof and system identification, 同大学院 Wonsul Kim 氏による Interference effects on local peak pressures on two adjacent tall buildings, 同 松井 正宏 による Generation of time history of design wind speeds using typhoon model and empirical wind characteristics が発表された。

閉会に際して，2011 年度の担当である日本風工学会 河井宏允会長より，JaWEiK における技術情報交換の意義について述べられた。また，田村幸雄拠点リーダから，JaWEiK のこれまでの経緯と今後の展望などが述べられた。


図１ 集合写真


図２ JaWEiK の経緯について説明する田村幸雄拠点リーダ

# PALENC 2010 参加報告

## 開催日：2010 年 9 月 29 日 ( 日 ) – 10 月 1 日 ( 水 )
## 会　場：Rodos Palece Hotel, Rhodes Island, Greece

2010 年 9 月 29 日～ 10 月 1 日にギリシャ、ロードス島の Rodos Palece Hotel において、3rd International Conference on Passive and Low Energy Cooling for the Built Environment (PALENC 2010) が 5th European Conference on Energy Performance & Indoor Climate in Buildings (EPIC2010) と 1st Cool Roofs Conference と共同で開催された。

PALENC は，都市環境と建物デザインに関連した熱緩和技術とパッシブクーリング技術の研究と応用に関して議論をすることを主な目的として 2005 年から 2，3 年おきにギリシャで開催され、今回が第 3 回目であった。当会議は，400 名程度の参加があった。発表件数は，プレナリーセッションの Keynote Lectures が 14 件、Keynote Speech が 24 件、セッションでの研究発表が 200 件程度あった。以下に Keynote Lectures の講演者と講演タイトルを記す。

- ***F.Nicol:*** Where are we and where next thermal comfort?
- **B. Todorovich:** Planning improvements of energy performances of existing buildings at the level of the entire town. Predicted interventions and benefits. Example of Belgrade.
- ***H.Akbari:*** Cooling the globe: One roof and one pavement at a time.
- ***O.Seppaenen:*** Technical regulations to control energy efficiency of buildings in some EU Member States.
- ***A.Thiemann:*** Approaching future cities by sustainable energy performance in built environment.
- ***T.E. Kuhn:*** Active solar facades (PV and solar thermal).
- ***J.Stoops, R.Rooth:*** Measurement is critical to understanding.
- ***A.Battisti, F.Tucci, F.Cipriani:*** Eco-efficient and sustainable settlement experimentation in Mediterranean housing.
- ***R.Portsmouth:*** The cool roof market from an industry viewpoint.
- ***R.Giridharan, M.Kolokotroni:*** Micro scale geographical study of urban heat island within London.
- ***H.Akbari: Global cooling updates:*** Reflective roofs and pavements.
- ***Y.Wang, Y.Ng:*** Parametric study on microclimate effects of different greening strategies in high density city.
- ***N.Fintikakis:*** Energy Architecture and Quality of Life
- ***M.Santamouris:*** Cooling the Cities - The Absolute Priority

本会議は、分野別に分けられており興味深い発表が多かったが、一般講演は 4 部屋で同時に行われていたため、聞くことのできなかった講演もあり非常に残念であった。全体を通して活発な質疑応答がなされていて非常に有意義な国際会議であった。

# 2010 年 10 月に新潟県胎内市，秋田県潟上市で発生した被害調査速報

岡田玲，松井正宏，吉田昭仁，川名清三，田村幸雄
（東京工芸大学）

10 月 15 日 17 時過ぎに，新潟県胎内市村松浜および中村浜から塩沢にかけての地域で突風が発生し 3 名が負傷したほか，自動車が飛ばされたり住家が損壊したりするなどの被害が発生した。このため東京工芸大学風工学研究センタは，松井正宏教授，吉田昭仁准教授，岡田玲准教授，川名清三研究員ら（以下本グループ）による調査団を翌日 16 日に現地に派遣した。

新潟地方気象台の判断によれば当初，ひとつの竜巻による被害と見ていたが，その後の調査 [1] や，本村松浜付近に突風をもたらした竜巻が同地域で消滅したとの目撃証言や被害・痕跡などの新たな情報を収集した。気象研究所と本グループによるディスカッションなども経た結果，胎内市内で発生した突風（以下新潟竜巻）は，ほぼ同時刻に発生した 2 つの竜巻によるものと確認した。さらに新潟県の竜巻調査中である 17 日に秋田県潟上市においても突風（以下秋田竜巻）の発生が確認され，岡田のみが 18 日に現地に移動し調査を行った。

竜巻は特に発達した積乱雲の下で発生する強い上昇気流

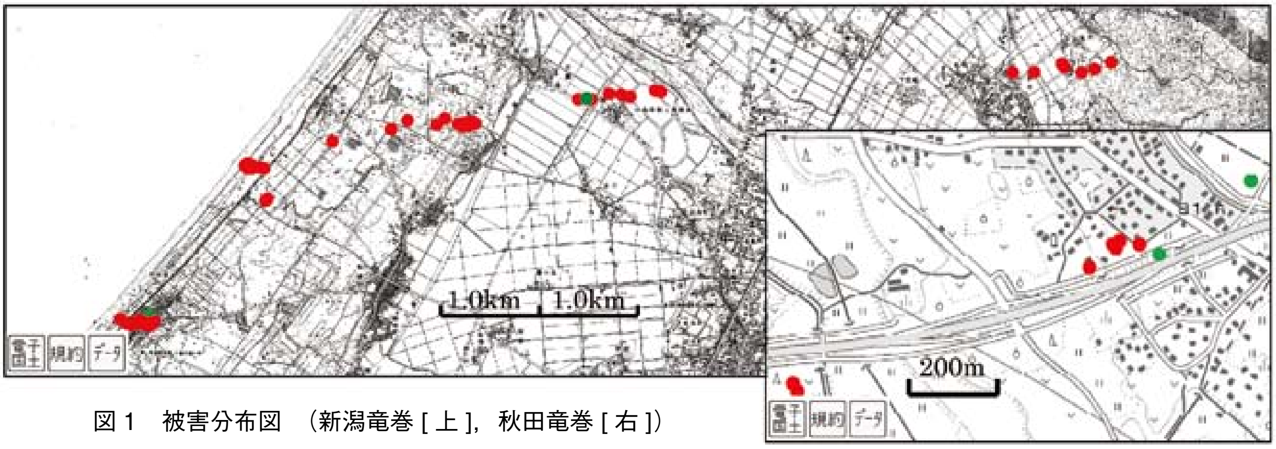



図１　被害分布図　（新潟竜巻［上］，秋田竜巻［右］）

などによって引き起こされる。気象庁によると，今回の竜巻とみられる突風は，北陸地方の上空には寒気を伴った気圧の谷が接近しており，大気の状態が不安定であった。胎内市で突風が発生した時間帯（15 日午後 5 時すぎ）には，活発な積乱雲が被害地付近を通過中であった。

一方，潟上市では，17 日昼前から夕方にかけて北日本を通過した。この気圧の谷の影響で大気の状態が不安定となり，秋田県では積乱雲が発達した。気象レーダー観測によると，13 時頃から 14 時頃にかけて活発な積乱雲が潟上市昭和大久保付近を通過しており，竜巻などの激しい突風が発生しやすい気象状況となっていたとのことである。

新潟竜巻，秋田竜巻の F スケールはそれぞれ F1，F0 とされた。詳細な被害調査報告を現在編集中である。本記事では，被害分布（図 1）と代表的な被害事例（図 2）を示す。

現地の被災者の証言などによると，竜巻は少なくとも二つ同時に存在しており，村松浜と中村浜から上陸し，西進したものと思われる。図 1 中で左下に被害が集中しているのが村松浜における被害の分布で，その後竜巻は西進せずに，消失したものと思われ，その見解は気象庁とも合致する。一方，それ以外の被害は一直線に分布しており，住宅，グリーンハウス，畑，雑木林などを中心として被害を受けた。なお今回の調査で数か所において竜巻の発生幅が確認できる事象があり，総合すると地面付近での竜巻の幅は 20 メートル程度と推察された。

同年 11 月 1 日にも千葉県の山武郡九十九里市，山武市，長生郡白子町などで突風が発生しており，なかでも九十九里市作田では昨年に引き続き被害を受けた倉庫もあった。これらも含め，今後被害の詳細について分析を進める。

今年は日本列島に接近する台風の数が例年に比べて少なく海水温が下がらなかったことも突風発生の一因と指摘されている。

謝辞:ご協力頂いた住民，市役所の方々に感謝いたします。

（左：外から，中央：中から，右：折れた幹）木が折れて住家の窓を突き破った（山田氏ご提供）（新潟竜巻）

持ち上がり落下したビニールハウス（新潟竜巻）

全壊した倉庫（秋田竜巻）
図２　代表的な被害の写真

参考文献

1）気象庁，竜巻等の突風データベース：http://www. data.jma.go.jp/obd/stats/data/bosai/tornado/index.html

# Interference effects on local peak pressures of two adjacent tall buildings

*Wonsul Kim, Yukio Tamura, Akihito Yoshida*

## 1 INTRODUCTION

Most wind load codes have been derived for isolated buildings. However, wind loads on tall buildings surrounded by other tall buildings in real environments may be quite different from those on isolated tall building. Surrounding tall buildings can either increase or decrease not only overall wind loads on a building but also local peak pressures acting on the building cladding. Unfortunately, few codes have referred to wind-induced interference effects on wind loads on buildings (AS/NZS 1170.2, 2002; AIJ, 2004). These codes only briefly accommodate wind load effects of neighboring tall buildings, mainly dealing with shielding effects, which is beneficial to the building structural system and claddings. Because there are a large number of variables involved, such as building size and shape, relative locations of interfering building(s), wind directions, upstream terrain conditions and so on, it is difficult to consider all parameters in codes.

The main aim of this study is to tackle the problem of interference for local peak pressures on a tall building in order to establish a generalized set of guidelines. Extensive wind tunnel experiments have been conducted to measure local peak pressures on a tall building with an interfering building for different height ratios and various wind directions for an urban exposure condition.

## 2 WIND-TUNNEL EXPERIMENTS

### 2.1 Pressure measurements

Wind tunnel experiments on a high-rise building model with various arrangements and height ratios of an adjacent building were carried out in a Boundary Layer Wind Tunnel located at Tokyo Polytechnic University, Japan as shown in Figure 1. For this study, the flow of the atmospheric boundary layer in the wind tunnel was interpreted as a geometrical scale of approximately 1:400. The approach flow represented an urban wind exposure using the spire-roughness technique with a power law exponent of 0.27.

Figure 1. Experimental models in wind tunnel

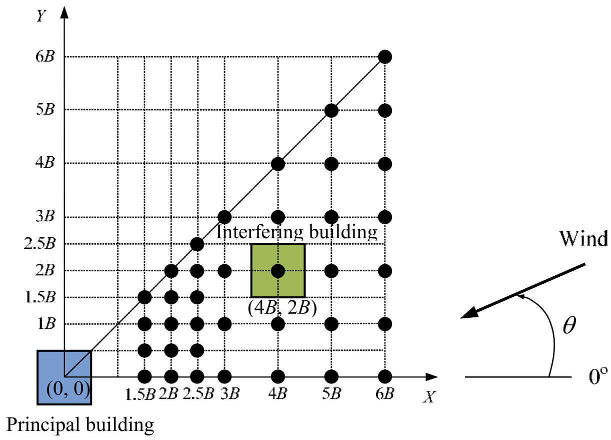



Figure 2. Coordinated system indicating different locations of interfering building and wind directions.

Table 1. Experimental models

| Experimental models | Dimensions (mm) ($B$×$D$×$H$) | Height ratios ($H_r$=$H_{ib}$/$H$) | Locations | Wind directions |
|---|---|---|---|---|
| Principal building | 70×70×280 | 1 | 1 | 0° – 355° (5° steps) |
| Interfering building | 70×70×140 | 0.5 | 37 | 0° – 355° (5° steps) |
| | 70×70×196 | 0.7 | 4 | |
| | 70×70×280 | 1 | 37 | |
| | 70×70×420 | 1.5 | 37 | |
| | 70×70×560 | 2 | 4 | |

* $H$ and $H_{ib}$ are height of principal building and interfering building, respectively

The wind speed and the turbulence intensity at the height of the model (principal building) were 8.2 m/s and 20%, respectively.

The considered experimental models comprised two buildings: the pressure model, referred to as the principal building, and the other model, referred to as the interfering building. Figure 2 shows the coordinated system indicating the different locations of the interfering building and wind directions. The center-to-center spacing between them was varied by Sx longitudinally and Sy laterally. Table 1 shows cases of the experimental models used in this study.

The fluctuating wind pressures on the building faces were simultaneously sampled every 0.00128 seconds and the sampling period was 7.5 seconds for each sample. The data were digitally low-pass filtered at 300 Hz. For each test case, 15 samples of 10-min length in full-scale conversion were analyzed. The tubing effects were numerically compensated by the gain and phase-shift characteristics of the pressure measuring system. The pressure data were filtered by means of a moving average filter corresponding to 0.2sec in full scale. Further, the maximum and minimum peak pressure coefficients were calculated by the Cook & Mayne method.

### 2.2 Simultaneous pressure measurement and flow visualization

To obtain further information and understanding on the interference mechanism for enhanced local peak pressures on the principal building with interfering building of $Hr$=1, flow fields around two buildings for worst wind directions in tandem and oblique arrangements have been investigated by simultaneous pressure measurements and flow visualization using dynamic particle image velocimetry (DPIV) in wind tunnel of Shimizu Institute of Technology, Japan. As shown in Figure 3, this system consisted of a high-speed digital video camera, a double pulse Nd: YAG laser and a particle generator. The fluctuating wind pressures and the image of particle were simultaneously sampled every 0.0001 seconds and the sampling periods were 7.5 seconds and 6 seconds for each sample, respectively. Tracer particles were discharged from downstream of the principal building and then circulated in the wind tunnel. The particles were illuminated by a pulsed laser light sheet. The image was captured in digital memory using a computerized data acquisition system for a field of view of 276mm×207mm.

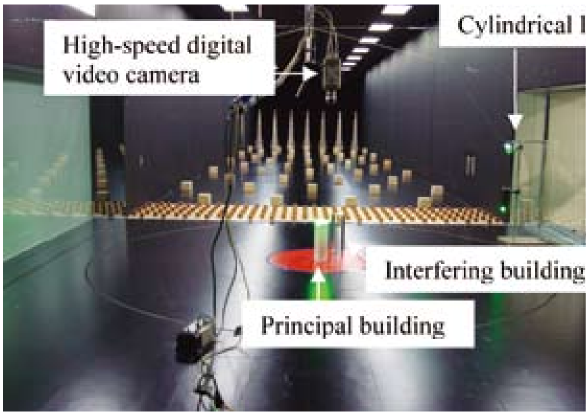



Figure 3. Simultaneous pressure measurement and flow visualization in wind tunnel.

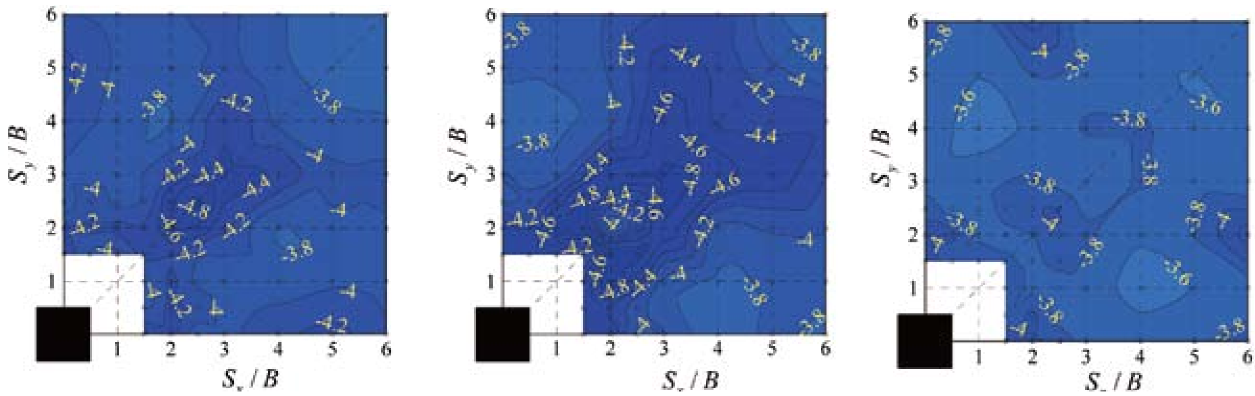
## 3 RESULTS AND DISCUSSIONS

### 3.1 Effects of building arrangement

The minimum negative peak pressure coefficient ($\check{C}_p$) for all measurement points on the principal building and all wind directions can be expressed by:

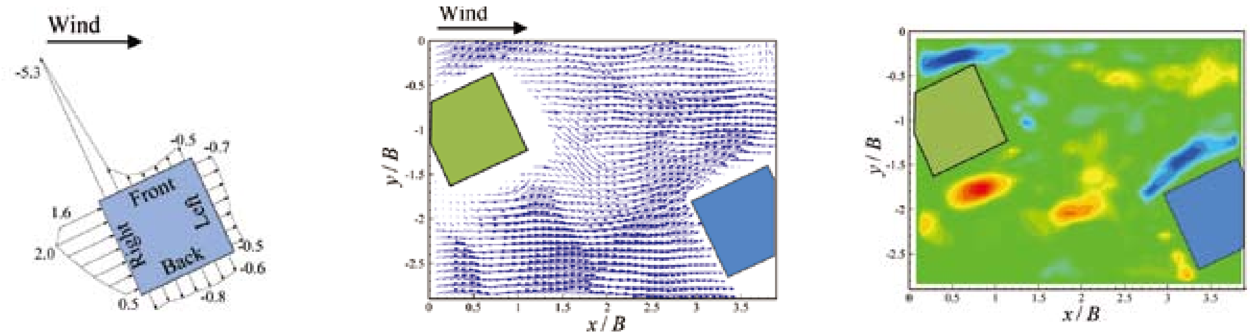
$$\check{C}_p = \min_{i,j,\theta}\left[\check{C}_p(i,j,\theta)\right] \quad (1)$$

Figure 4 shows the contour of $\check{C}_p$ on the principal building for interfering buildings of different height ratios and various




(a) Height ratio ($Hr$) = 0.5 (b) Height ratio ($Hr$) = 1 (c) Height ratio ($Hr$) = 1.5

Figure 4. Contour of $\check{C}_p$ on principal building for interfering building of various height ratios and locations ( $\check{C}_p$ (Isolated) = -3.7).




(a) Pressure coefficients (b) Velocity vector fiel (c) Vorticity field

Figure 5. Instantaneous pressure coefficients on principal building with interfering building of *H*r=1, velocity vector and vorticity fields for wind direction $\theta$=65$^{o}$ in oblique arrangement (Minimum vorticity and increment of vorticity contour are 100 and 100s-1, respectively).

locations, and $\check{C}_p$ on the isolated building was -3.7. From Figure 4, $\check{C}_p$ on the principal building was decreased and expanded with increase in height ratio of the interfering building.

Another interesting observation was that $\check{C}_p$ for *H*r=1 and 1.5 significantly decreased when the interfering building was located in oblique arrangement. However, it should be noted that the critical locations of the interfering building vary with increase in height ratio. Interference effects of $\check{C}_p$ on the principal building were also investigated in this study.

However, the results show that $\check{C}_p$ on the principal building for interfering building of different height ratios and various locations was similar to that an isolated building.

### 3.2 Flow pattern in oblique arrangement

Figure 5 shows the instantaneous pressure coefficients on the principal building with interfering building of *H*r=1, velocity vector and vorticity fields around two buildings in oblique arrangement with $(S_x, S_y)=(2.5B, 2.5B)$ for wind direction $\theta$=65$^{o}$ when the smallest minimum peak pressure coefficient on the principal building occurs. From Figure 5(b) and (c), the strong shear layer generated by the interfering building directly hit the principal building, leading to increased momentum at the upper face (front wall) of the principal building. This rose to a high pressure coefficient near the leading edge of the upper face of the principal building, as shown in Figure 5(a). Furthermore, it is inferred that some changes of wind directions ($55^{o} \leq \theta \leq 85^{o}$) could lead to an obvious decrease in minimum peak pressure coefficients acting on the principal building.

## 4 CONCLUSIONS

A detailed and comprehensive study of wind-induced interference effects on buildings has been carried out. Based on the results of these detailed experiments that consider various relevant parameters, general guidelines for limiting conditions have been formulated and critical interference effect situations identified.

## 5 REFERENCES

[1] AIJ-RLB (2004). “AIJ Recommendations for Loads on Buildings”, Architectural Institute of Japan.

[2] AS/NZS 1170.2 (2002). “Structural design actions, part 2: Wind actions”, Australian/New Zealand Standard.

# Experimental and numerical studies on convective heat transfer from urban canopy and its dependence on urban parameters.

*Sivaraja Subramania Pillai, Ryuchiro Yoshie, Chung Jaeong*

## INTRODUCTION

Weather Research Forecasting (WRF) model coupled with Urban Canopy Model (UCM) is an effective tool for the prediction of urban heat island phenomena. In this

UCM, local convective heat transfer from urban canopy and its dependence on urban parameters such as building coverage ratio and variations of building height is not explicitly modeled. The aim of this research is to clarify the local convective heat transfer coefficients, which depends on the urban parameters and to incorporate the results into the UCM with the help of experimental and numerical simulation results.

## SINGLE LAYER URBAN CANOPY MODEL

In the single layer Urban Canopy Model (Kusaka et al. 2001) in the WRF the heat flux from the canyon surfaces were modeled from equation 1 and 2.

$$H_W = C_W(T_W - T_S) \quad (1)$$

$$H_G = C_G(T_G - T_S) \quad (2)$$

$$\begin{aligned} C_W = C_G &= 7.51\, U_S^{0.78} & (U_S > 5\text{m s}^{-1}) \\ C_W = C_G &= 6.45 + 4.18\, U_S & (U_S \le 5\text{m s}^{-1}) \end{aligned} \quad (3)$$

Where HW, CW, TW are heat flux, heat transfer coefficient and temperature of the wall respectively. HG, CG, TG are heat flux, heat transfer coefficient and temperature of the ground respectively. US and TS are the velocity and temperature inside the canopy respectively. In this single layer UCM, the convective heat transfer coefficient from wall and ground depends only on the velocity inside the canopy as shown in equation (3). But this cannot be justified since other urban parameters also contribute to the heat transfer coefficient. Moreover this model can not distinguish the difference in convective heat transfer coefficients on different wall surfaces like windward, leeward and sidewall. Therefore to clarify this issue, wind tunnel experiments and CFD simulation with low-Re- k-ε model has been carried out. Based on the experiment and CFD results, the convective heat transfer coefficient and heat flux from the urban canopy will be modified with respect to the urban parameters like building coverage ratio and variations of building height, which will be incorporated in the UCM.

## WIND TUNNEL EXPERIMENT

The experimental setup consisted of an aluminum block array to model different cases of urban canopy. The building coverage ratios (hereafter referred to as BCR) were varied as 25.0%, 11.1% and 6.3% with both the uniform and the non-uniform height buildings. The inflow velocity and temperature of the air at the wind tunnel inlet were uniformly maintained at 1.9m/s and 7.8°C respectively throughout the cross section. The floor temperature was maintained at 53°C to simulate the unstable thermal environment. These conditions were adopted for all experimental cases. Figure 1 (left) and (right) shows the vertical profiles of mean wind velocity component U and mean temperature T at the measuring section for uniform and non uniform height case respectively. It has been observed that velocity decreases and temperature increases with increase in BCR in the roughness sub layer. The boundary layer is higher for the non-uniform height cases than for the uniform height cases.

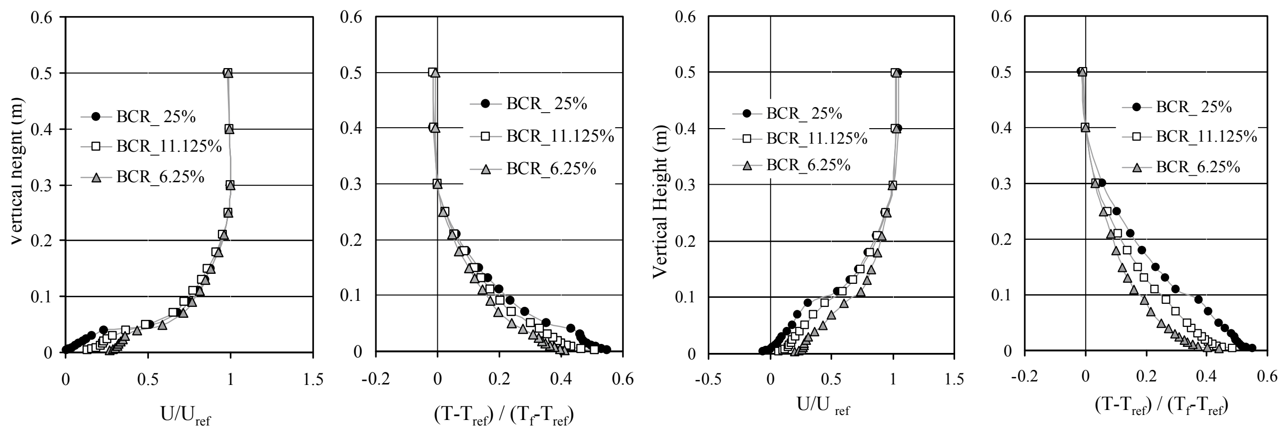



Figure1 (left): Mean velocity and temperature profiles for uniform height cases
Figure1 (right): Mean velocity and temperature profiles for non uniform height cases

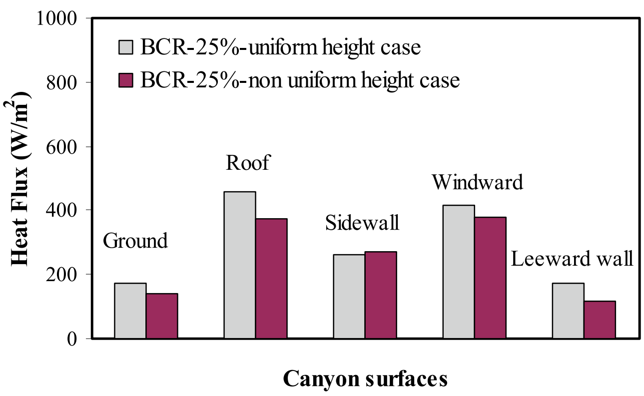
## CFD SIMULATION & RESULTS

CFD simulation was conducted with a low Reynolds number k-ε model (Abe, Nagano and Kondoh ,1994) because of its good prediction accuracy of turbulent heat transfer in a separating and reattaching flow. CFD results showed good agreement with the experimental results for all the cases.

Thus it has been considered that the CFD simulations were appropriate for further investigations regarding heat transfer from canyon surfaces.

The heat flux from various urban canyon surfaces like ground, roof, windward, leeward and sidewall varies with the change in the building coverage ratio and the variation of building height. Figure 2 (left) and (right) shows the heat flux from individual canyon surfaces for BCR 25% and 6.3% respectively. The heat flux from the canyon surfaces of 6.3% case is higher than that of 25% case. Heat flux from roof is higher than the windward wall in 25% case, which is reverse in 6.3% case. This is because of the change in flow pattern in the canopy. 6.3% case falls under the isolated roughness flow whereas 25% case exhibits skimming flow. More fresh air (which enhances the heat transfer) contact in all the canyon surfaces for isolated roughness flow than the skimming flow may be the reason for the above behavior.

From the simulation results it has been observed that the heat flux varies from the canyon surfaces viz. ground, roof, sidewall, windward wall, and leeward wall depends on the urban parameters like building coverage ratio and variations in building height of the urban canopy. Based on the CFD 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 in the Urban Canopy Model (UCM) of Weather Research Forecasting (WRF) model.



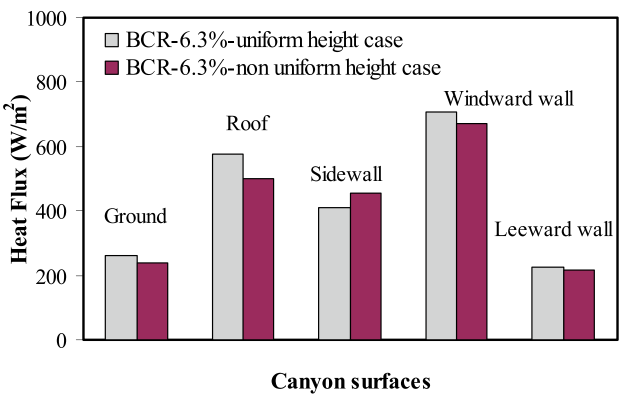




Figure 2. Left: Heat flux (W/m$^2$) for canyon surfaces –BCR 25% uniform & non uniform cases
Right: Heat flux (W/m$^2$) for canyon surfaces –BCR 6.3% uniform & non uniform cases

# お知らせ

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問い合わせ先：東京工芸大学工学研究科　グローバル COE プログラム　事務局
〒 243-0297　神奈川県厚木市飯山 1583
Email: gcoe_office@arch.t-kougei.ac.jp
Tel/Fax: 046-242-9658
URL: http://www.wind.arch.t-kougei.ac.jp/

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| | | | |
|---|---|---|---|
| 田村　幸雄 | 教授(拠点リーダー) | 教育研究拠点形成の統括 | yukio@arch.t-kougei.ac.jp |
| Ahsan Kareem | 教授 | EVO構築に関連する技術開発 | kareem@nd.edu |
| 大場　正昭 | 教授 | 通風･換気設計法の研究開発 | ohba@arch.t-kougei.ac.jp |
| 義江龍一郎 | 教授 | 市街地の熱･空気汚染予測･制御 | yoshie@arch.t-kougei.ac.jp |
| 水谷　国男 | 教授 | 自然通風･放射涼房システムの開発 | mizutani@arch.t-kougei.ac.jp |
| 松井　正宏 | 教授 | 工学的竜巻シミュレータの開発 | matsui@arch.t-kougei.ac.jp |
| 吉田　昭仁 | 准教授 | 風応答モニタリング･ネットワークの構築 | yoshida@arch.t-kougei.ac.jp |
| 森田　芳朗 | 准教授 | 各国の対風構工法の調査研究 | morita@arch.t-kougei.ac.jp |
| 大熊　武司 | 客員教授 | 耐風設計法の構築 | ohkuma@kanagawa-u.ac.jp |

東京工芸大学工学研究科　風工学研究センター

〒243-0297　神奈川県厚木市飯山1583

TEL & FAX : 046-242-9658 URL : http://www.wind.arch.t-kougei.ac.jp/




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