Wind Effects News

Wind Effects on Buildings and Urban Environment

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Wind Engineering Research Center
Graduate School of Engineering
Tokyo Polytechnic University

INDEX

COE International Advanced School on "Wind Resistant Design of Buildings and Structures"（COE-IAS3）開催報告

開催日：2007 年 11 月 21 日 (水) -23 日 (金)
会　場：中国同済大学橋梁学科講演ホール

2007 年 11 月 21 日～ 23 日の 3 日間にわたり，中国同済大学橋梁学科講演ホールで COE International Advanced School on "Wind Resistant Design of Buildings and Structures" が「東京工芸大学 21 世紀 COE プログラム」と「中国同済大学橋梁学科」の共催で開催された。

第 1 回 の COE International Advanced School は 2006 年 7 月に厚木市で開催され，"Computational Wind Engineering" に関する内容で講義が行われた。続いて，2007 年 3 月に東京国際フォーラムで開催された第 2 回は，構造系分野の Course A と環境系分野の Course B から構成され，風災害，風荷重，自然換気，室内環境，都市環境などの各分野の概要から最新のトピックにいたる幅広い内容で講義が行われた。今回，初の海外開催となる第 3 回は，中国の上海で行われ，" 建築物と構造物の耐風設計 " について下記の講師陣による興味深い内容の講義が行われた。

Yaojun Ge – Tongji University, China
John D. Holmes – JDH Consulting, Australia
Ahsan Kareem – University of Notre Dame, USA
Michael Kasperski – Ruhr University, Germany
Kenny C.S. Kwok – Hong Kong University of Science and Technology, Hong Kong
Giovanni Solari – University of Genova, Italy
Yukio Tamura – Tokyo Polytechnic University, Japan

講師：左より，Ge，Holmes，Kareem，Kasperski，Kwok，Solari，Tamura （敬称略）

COE-IAS3 の開会に先立って，東京工芸大学，田村幸雄教授より参加者へお礼の挨拶がなされた。全世界の自然災害による経済的損失の 85%が風に関連する災害であることなどの説明がなされ，高層建築物や大型構造物の建設が盛んな中国における風工学分野の研究の重要性および本 International Advanced School の意義について説明があった。

今回来場した聴講者は，学生や技術者，研究者など合計 92 名であり，中国国内は南の広州から北のハルビンまで広い範囲から集まり，中国大陸以外からの受講者も 6 名を数えた。講義は 3 日間，AM 8：30 から PM 5：00 まで行われ，各講義後の受講者達の質問は大変熱心なものであった。中には 20 個以上の質問を用意した受講者もおり，その真剣さに講師の方々も大変驚かされていた。

閉会時には，再び田村幸雄教授より参加者へのお礼の挨拶がなされた。このように多くの聴講者と講師，そしてスタッフの協力を得て，本 COE International Advanced School は盛大に終了した。

(曹 曙陽)

講師と受講者の懇親会

国際ワークショップ“4th Workshop on Regional Harmonization of Wind Loading and Wind Environmental Specifications in Asia-Pacific Economies (APEC-WW2007)”開催報告

開催日：2007 年 11 月 19 日，20 日
会　場：同済大学 YiFu ビル

2007 年 11 月 19 日～ 20 日，「中国同済大学土木工程防災国家重点センター」，「中国土木学会風工学グループ)」及び「東京工芸大学 21 世紀 COE」の共催で，国際ワークショップ "4th workshop on Regional Harmonization of Wind Loading and Wind Environmental Specifications in Asia-Pacific Economies (APEC-WW2007)" が中国・上海の同済大学にて開催された。第 1 回の APEC-WW は 2004 年 11 月に東京工芸大学，第 2 回目は 2005 年 12 月に香港科技大学，第 3 回目はインド・ニューデリーのインド国際センターで開催され，今回はこれに次ぐ第 4 回目のワークショップである。APEC-WW の目的は，各国における風荷重に関する基準や風環境に関する条例などについて情報を交換し，これを発展させ調和を図ることである。今回は 13 ヵ国 26 名が参加し，日本からの参加者は東京工芸大学の田村，大場，義江，曹の4名である。

11 月 19 日には，まず組織委員会の Ge 教授と名誉委員長の Xiang 教授から参加者への歓迎の挨拶があった。その後，本ワークショップのコンセプトに基づき，参加 13 ヵ国における現状について，各国の代表者からカントリーレポートがなされた。11 月 20 日には，参加者が風荷重と風環境の二つのセッションに別れ，より詳細な議論を行った。風荷重に関するセッションでは，前回に引き続き，3つの例題（①鉄骨造倉庫，②中層オフィスビル，③高層ビル）に対し，各国の基準に基づく風荷重を相互比較した。風環境のセッションでは，①大気汚染の各国基準の比較　②室内空気汚染の各国基準及び測定方法の比較　③風環境評価方法に関する議論が幅広く行われた。この2日間のワークショップの結果，風荷重と風環境に関して，それぞれレゾリューションがまとめられた。また将来の活動計画も付記された。次回は 2009 年に台湾・台北市で開催される APECWE-VII 国際会議と同時開催の予定である。

（大場正昭，曹 曙陽）

参加者の集合写真


会場となった中国同済大学

The 2nd WERC International Symposium on Architectural Wind Engineering　開催報告

開催日：2007 年 11 月 5 日，6 日
会　場：東京工芸大学，厚木キャンパス

2007 年 11 月 5 日，6 日に東京工芸大学本館において，The 2nd WERC International Symposium on Architectural Wind Engineering が開催された。本シンポジウムは初日に構造系，2 日目に環境系の講演が行われ，若手を中心に招待した海外からの講演者 8 名の他，風工学研究センターに関係する 12 名の講演者が，最新の風工学に関する研究成果，学術フロンティアプロジェクトにおける研究成果等を発表した。以下に講演者とその講演内容を紹介する。また，参加者は 60 名以上を数え，活発な討議が行われた。

招待講演者

Q.S. Li (City University of Hong Kong, H.K., China)
"Wind Effects on Super-Tall Buildings"

Jenmu Wang (Tamkang University, Taiwan)
"Charting a course toward e-Wind: Essential information and Web technologies"

Yuanqi Li (Tonji University)
"Application of Wind-induced Envelope Responses on Wind-resistant Design of Spatial Structures"

Kangpyo Cho (Wonkwang University)
"Interference effects on wind pressures of high-rise apartment building complex"

Edward Ng (The Chinese University of Hong Kong, China)
"Some Issues Regarding Wind (tunnel) Engineering for Urban Climatic Studies of High Density Cities with Complex Topographical Features"

Taeyeon Kim (Yonsei University, Korea)
"Ventilation System of Kitchen to Prevent Odor Spread in High-rise Residential Building"

Borong Lin (Tsinghua University)
"Numerical study on the effective landscape pattern in Chinese residential district for better outdoor microclimate"

David Etheridge (University of Nottingham, UK)
"Wind tunnel investigation of unsteady flow in a natural ventilation stack"

その他の講演者

Shuyang Cao (TPU, Japan)
"Wind characteristics of a strong typhoon"

Akira Katsumura (Wind Engineering Institute, Japan)
"Study on universal equivalent static wind load on large span cantilevered truss roof"

Hirotoshi Kikuchi (Shimizu Corporation, Japan)
"Wind pressures on cylindrical models with serrated roughness and flow field"

Hajime Okada (Izumisohken Engineering, Japan)
"Study on behavior of roof tiles in strong wind"
Jun Kanda (The University of Tokyo, Japan)
"Dynamic wind pressure characteristics on elliptic cylinders"

Yukio Tamura (TPU, Japan)
"Quasi-static peak normal stress and peak factor"

Masahiro Matsui (TPU, Japan),
"Field investigation on wind induced damage from 2005 to 2007"

Akihito Yoshida (TPU, Japan)
"Wind pressures acting on a circular cylinder with rotors"

Masaaki Ohba (TPU, Japan)
"Prediction of Ventilation Flow Rates Using Semi-empirical Envelope Flow Model and LES"

Ryuichiro Yoshie (TPU, Japan)
"Experimental Study on Air Ventilation in a Built-up Area with Closely-Packed High-Rise Buildings"

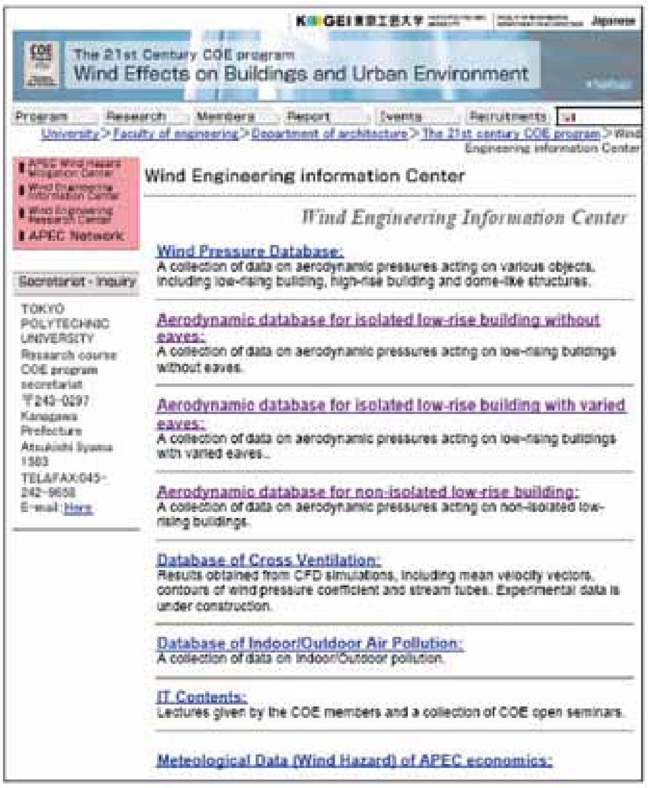
Taich Sirasawa (TPU, Japan)
"Comparison of LES and Durbin type k-εmodel for gas diffusion in weak wind region behind a building"

Kunio Mizutani (TPU, Japan)
"An Experimental and Numerical Study of the Relationship between Ventilation Efficiency and Air Supply/Exhaust System"

Researches Related to the Wind Loads on Row-Rise Buildings

COE 研究員 ：Sun Ying

The majority of structures built all over the world can be categorized as low-rise buildings used for residential, commercial and other purposes. And these buildings are generally susceptible to wind damage caused by typhoons, hurricanes, etc. Due to the large amount of losses caused by natural disasters, it is evident that an improvement in wind resistance of the low-rise buildings will result in a significant reduction in overall economic losses. Over the last few decades, our understanding of wind loading on low-rise buildings has significantly improved, yet a need remains for further examination of a host of issues. It is the time to reflect on these developments, reassess their merits and shortcomings, and identify the need for further studies and summarize.



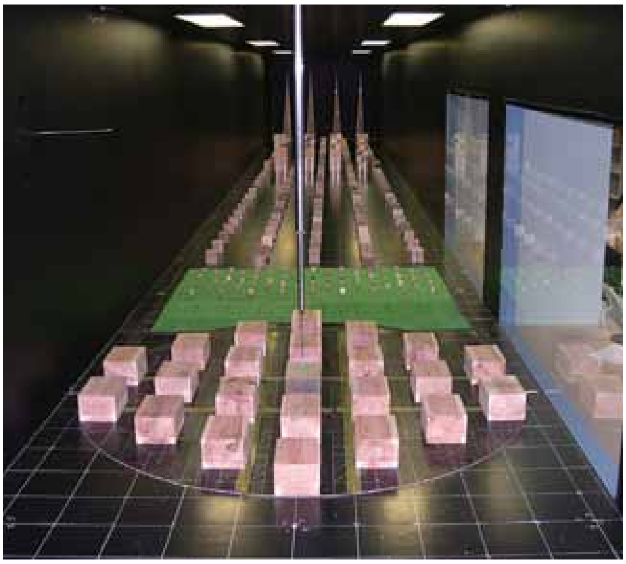
Aerodynamic database for low-rise buildings

An aerodynamic database has been constructed by the Tokyo Polytechnic University as one part of the Wind Effects on Buildings and Urban Environment, the 21st Century Center of Excellence Program, 2003-2007, funded by the Ministry of Education, Culture, Sports, Science and Technology, Japan. As a complement, the aerodynamic database of isolated low-rise buildings with varied eaves and non-isolated low-rise buildings are added, which can provide more detail information about wind loads on such kind of buildings to engineers. Besides the data process for huge amount of wind tunnel results, the connection of database to engineering application, the expansion of usage and flexibility are still under way.

The effect of different factors on wind loads of low-rise buildings

Regarding wind loads on buildings the significance of the geometry was recognized early. Studies carried out have lead to important conclusions regarding the influence of roof slope, aspect ratio, area-average on wind loading. Understandably, several other aspects of the problem, such as presence of canopies or parapets, different surrounding conditions still need attention. Furthermore, there is the realization that knowledge of mean pressures alone is not adequate to ensure the safety of the building and it is necessary to know the fluctuations and the peak values as well, particularly where severe winds are concerned, where the dynamic response becomes important.

It is well known that eaves of low buildings are particularly vulnerable to wind action, because the pressure on windward lower surface that generally reinforces high suction of the upper eave surface will cause severe loading on eaves. However, only a few of studies have addressed this issue involving wind loading on eaves. In the assessment of wind load on roofs and walls, the effects of eaves are often ignored. Most of Standards and Codes of Practice provide limited guidance with regard to wind loads on roof overhangs. Due to lack of knowledge of wind pressure difference with varying eaves, recent wind tunnel tests of TPU were carried out to observe the effect of various eaves on the wind pressures of gable-roof buildings.



In general, low-rise buildings are usually surrounded by surrounding houses, and wind loads on low-rise buildings are definitely affected by these neighboring houses. However, the current wind load design codes usually just consider the effect of roughness of the upwind terrain but neglects the direct effect of neighboring houses. The results show that wind loads in a realistic environment do not always follow the basic wind load characteristics of an isolated building because of interference by neighboring buildings. Systematic experiments were conducted in a wind tunnel in order to find the effect of typical building arrangements on the wind-induced pressures. The primary study goal described here is to better understand and quantify the effect of surrounding buildings on wind load on low-rise buildings.

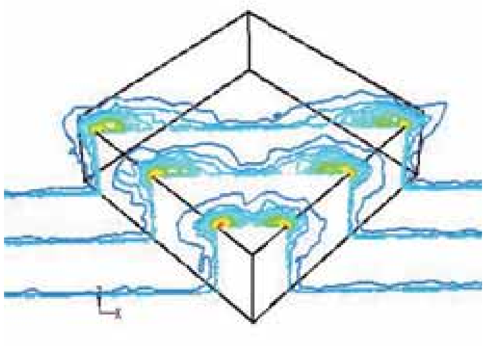
The results of analysis mentioned above will lead to some recommendations for wind standards or building design.

Better evaluation of wind pressures on low-rise buildings

It is recognized clearly that tributary area was a key parameter in the evaluation of wind pressures and area-averaging was very significant but wind codes of practice and design standards did not even consider the significance of variation of the dynamic character of the pressures with the particular location of interest on the building envelope. And the importance of the tributary area has an additional dimension when wind pressure loads acting on systems covering more than one surfaces of the building envelope are considered. The lack of correlation of wind pressures acting on different building surfaces, in addition to the effects of tributary area, are significant factors to be considered in the evaluation of the actual wind load seen by the structure and, consequently, in its design. The method to develop sets of pseudo-pressure coefficients is put forward by Davenport, by which the maximum induced force components are generated. It is accepted by National Building Code of Canada and ASCE-7, but still need refinement to extend.

Better understand the flow mechanism of wind pressures on low-rise buildings

Advanced technology makes computers faster and more powerful, which allows computational dynamics (CFD) procedures to be applied to many experimental flow problems. Today, increasing applications of CFD to wind engineering problems include wind load of building and pollutant dispersion phenomena. Several previous studies have compared measurements made during physical modeling with numerical predictions. It is declaimed that the mean values of pressure predicted were in good agreement with wind tunnel and field test measurements even for the three-dimensional roof corner vortex pattern was successfully simulated. CFD method is very efficient to make flow visualized and better understanding of the flow mechanism around low buildings in complicated conditions, with precondition that the results of wind pressures on surfaces are comparative. In this case, the numerical simulation will be carried out for the analysis of low-rise building with different surrounding cases.



Newly Implemented Method for the Boundary Layer Formation in a Wind Tunnel

JSPS　特別研究員 ：Klára Bezpalcová

Thanks to Ludwig Prandtl, who in 1904 figured out the similarity between atmospheric boundary layer and Prandtl boundary layer on a wall (Triton, 1988), although the Reynolds numbers have different magnitudes for both cases, we are now able to use wind tunnels as a powerful tool to solve many practical problems which occurs in the real atmosphere. In the beginning the problems solved in the wind tunnels were mainly in the field of wind loadings, bluff body aerodynamics, and aeroelasticity. However, in these days this range extended also to environmental task, such pollution dispersion, wind comfort, cross ventilation, etc. The careful check of the theory requirements is necessary to solve all these tasks properly.

The most important requirement for such use of wind tunnels is the similarity between the flows in the atmospheric boundary layer and the wind-tunnel boundary layer. Actually, we are not able to model whole atmospheric boundary layer in a wind tunnel, we are usually modelling only the lowest part of it, so called surface layer. The surface layer has depth approximately 100 m and it is the part, which is most influenced by the surface friction. The properties of the atmospheric surface layer were described in many papers and books, for example: Counihan (1975), Oke (1987), Stull (1997), and Snyder (1981).

The atmospheric boundary layer is naturally developed above 'an infinite' development section, but in the case of a wind tunnel only finite (usually 10 to 20 m) development section is available. Therefore artificial facilities are used to obtain stationary boundary layer similar to the atmospheric boundary layer. The urban canopy is the most important environment when modelling the pollution dispersion processes. Consequently the boundary layer above rough/very rough terrain, which is characteristic by higher turbulence level, is modelled. Another factor is the scale in which the wind-tunnel model was manufactured at. If the scale is larger (e.g. 1:200 or more) also the vortexes have to be bigger. At that case the standard Counihan type elliptic vortex generators and a barrier do not have to be sufficient. A change of the height and density of the roughness elements within the development section can lead to the non-equilibrium boundary layer in the test section.

The newly implemented method for boundary layer formation is based on rather bulky vortex generators (called spires, for their position within the wind-tunnel intersection see Fig.1), which are only two-dimensional. The spires were not placed equally in the wind-tunnel cross-section to compensate lateral heterogeneity found when the spires were placed in regular pattern. The later profiles of mean wind speed, intensity of turbulence, and Reynolds stress measured in the center of the wind tunnel are shown in Fig.2.

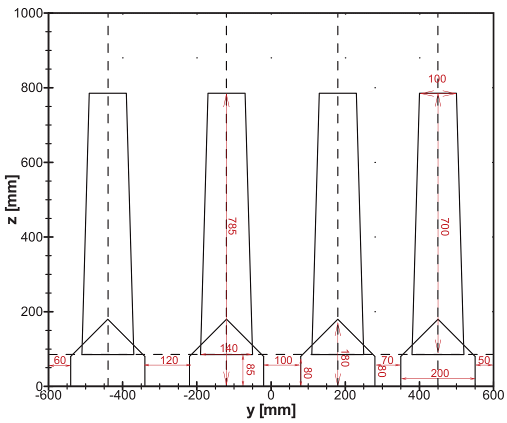


Figure 1: Spire's set-up at the tunnel entrance. All measures are in mm.

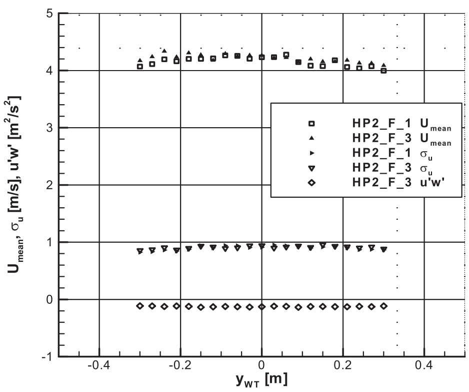


Figure 2: Horizontal homogeneity in the wind tunnel test section.

The turbulence intensity, which this type of spires is introducing to the flow, is higher than in the case of the Counihan type elliptic vortex generators. Thus the roughness elements placed on the wind-tunnel floor can be smaller than roughness elements used together with the Counihan type elliptic vortex generators. Their dimension in our case was 50 mm (length) x 50 mm (width) x 25 mm (height). The roughness elements were placed in regular pattern. The distance between two elements in row was 100 mm, the distance between two rows was also 100 mm, and the following row (in the sense of the flow direction) was shifted of 50 mm to the right hand side. The entire spires and roughness elements arrangement in the wind tunnel is shown in Fig.3.

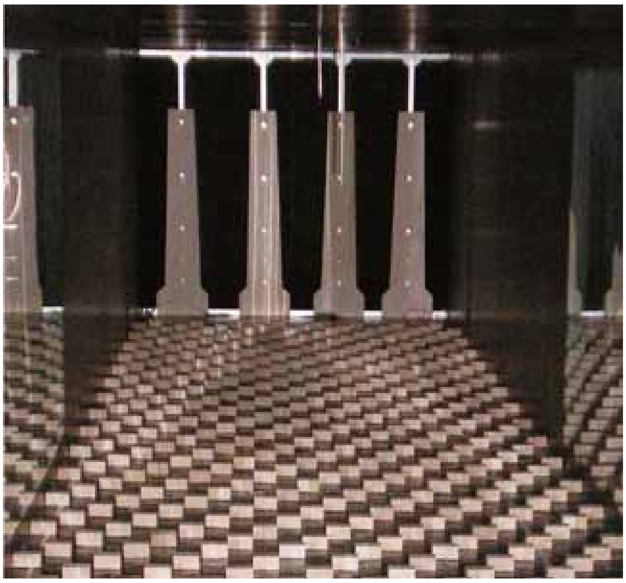


Figure 3: The spires and roughness elements set-up in the wind tunnel.

Mean wind profile

Although the power law exponent approximation is convenient, it has no theoretical basis. When the temperature profile is adiabatic, the wind speed should vary logarithmically with height (Stull, 1997) and it can be described by equation:

$$U(z) = \frac{u_*}{\kappa} \ln\left(\frac{z - d_0}{z_0}\right),$$

where *U(z)* is wind speed measured at the height z, κ= 0.4 is von Karman constant; d_0 is zero plane displacement length; z_0 is roughness length; and u_* is friction velocity. The measured average wind speed profile and its logarithmic fit are shown in Fig.4. The following values were obtained by the logarithmic fit: $d_0 = 8$ mm, $z_0 = 2.5$ mm, and $u_* = 0.44$ m/s. The power law exponent describing this profile is α= 0.25.

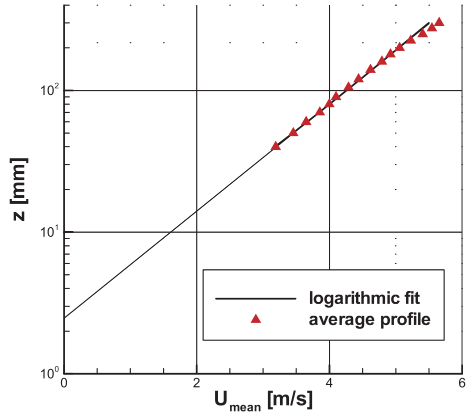


Figure 4: Average mean wind speed vertical profile in semi-logarithmic plot. The extrapolation of the logarithmic fit shows the roughness length parameter.

Intensity of turbulence profile

The intensity of turbulence is defined as a ratio of standard deviation and mean value of the wind speed. Snyder (1981) proposed the universal vertical profile of u wind speed component as

$$I_u(z) = \frac{\bar{u}}{\sigma_u} = \alpha \frac{\ln\left(\frac{30}{z_0}\right)}{\ln\left(\frac{z}{z_0}\right)},$$

where α is the power law exponent, and z is height above ground. The theoretical and observed (which is in quite good agreement with the theoretical one) profiles are shown in Fig.5.

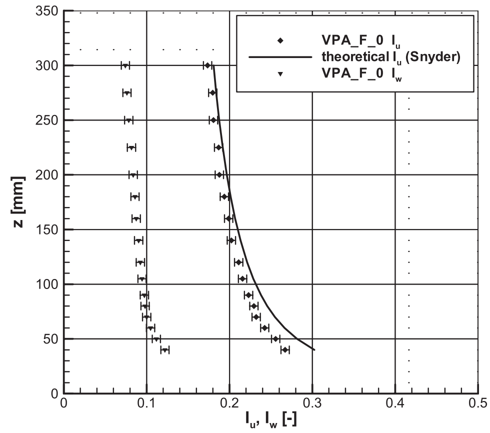


Figure 5: Vertical profiles of turbulence intensity for u- and w-wind component. The intensity of turbulence for u-wind component is compared with theoretical curve proposed by Snyder (1981).

Reynolds stress profile

The Reynolds stress *u'w'* is defined as product of fluctuations of *u* and *w* wind speed components. It is also related to the friction velocity as $|u'w'| = u_*^2$. It should be constant within the surface layer. The measured profile of *u'w'* is shown in Fig.6. Regrettably the values are neither constant nor equal to -0.19 m^2/s^2, which is value equivalent to u_* = 0.44 m/s.

We also evaluated the integral length scales and turbulent energetic spectra based on the autocorrelation curves. Both characteristics agreed very well with the values measured in the real atmosphere.

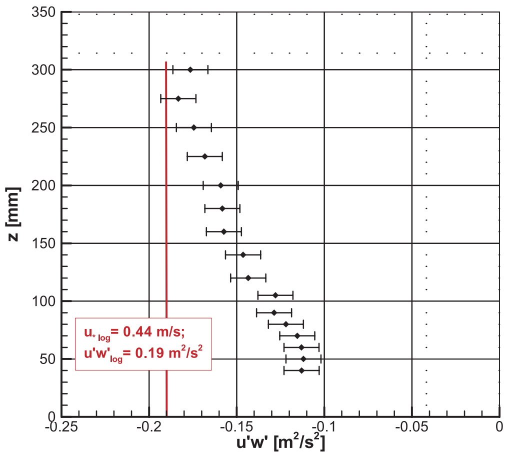


Figure 6: Vertical profile of Reynolds shear stress u'w' and its comparison with value obtained while fitting the logarithmic profile to mean wind speed profile.

Conclusions and future work

The newly implemented method for boundary layer formation did not ensure 'perfect' boundary layer. However, despite of very limited time in the wind tunnel, the obtained boundary layer is closer to an equilibrium boundary layer than the one modelled by conventional means. The boundary layer presented here lacks a little bit of turbulence in the lower levels. If more variability in the roughness elements will be added (for example using to types of them and mixed together) the intensity of turbulence as well as Reynolds stress will increase in the lowest elevations.

References

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COE オープンセミナー

本 COE プログラムでは，どなたでも参加できる COE オープンセミナーを開催しています。これまでに開催された内容を以下にご紹介します。

第 65 回 日時：2007 年 9 月 22 日 (土) 14:00 - 16:00
場所：東京工芸大学厚木キャンパス　APEC 強風防災センター 2 階　セミナー室

■ 講演者：丸山敬（京都大学防災研究所准教授）
■ 講演タイトル：有孔体周りの乱流場の数値シミュレーション

第 66 回 日時：2007 年 9 月 29 日 (土) 14:00-16:00
場所：東京工芸大学厚木キャンパス　APEC 強風防災センター 2 階　セミナー室

■ 講演者：野澤 剛二郎（清水建設）
■ 講演タイトル：自然風の数値シミュレーションと耐風設計への適用

第 67 回 日時：2007 年 10 月 24 日 (水) 10:00-11:30
場所：東京工芸大学厚木キャンパス　APEC 強風防災センター 2 階　セミナー室

■ 講演者：Jean Li (The Univer-sity of New South Wales, Australia)
■ 講演タイトル：GPS for full-scale structural deformation monitoring

COE オープンセミナーの予定は、本学 COE ホームページ (URL: http://www.wind.arch.t-kougei.ac.jp) でご覧いただけます。また、過去のセミナーの模様も、ストリーミングで視聴することが出来ます。

お知らせ

The 3rd International Symposium on Wind Effect on Buildings and Urban Environment (ISWE3) "New Frontiers in Wind Engineering"

開催日：2008 年 3 月 4 日 (月) - 5 日 (水)
会　場：東京ステーションコンファレンス

本シンポジウムでは "New Frontier in Wind Engineering" をテーマに，下記の研究，教育機関を招待し，世界中で計画されている風工学に関する独創的なビッグプロジェクトや風工学分野をリードする研究，教育拠点の紹介を企画しています。また，それらに関連した内容を紹介していただける一般公募も受け付けています。詳細は下記アドレスの Web ページをご覧いただき，奮ってご参加いただけますようお願いいたします。

http://www.wind.arch.t-kougei.ac.jp/ISWE3/

招待講演者 (敬称略)

Ahsan Kareem (University Notre Dame)
Kurt Gurly (University of Florida)
Forrest Masters (University of Florida)
Kishor Mehta (Texas Tech University)
Kenny C.S. Kwok (Hong Kong University of Science and Technology)
Yaojun Ge (Tongji University)
You Lin Xu (Hong Kong Polytechnic University)
Greg Kopp (University of Western Ontario)
Bill Melbourne (Monash University)
Giovanni Solari (University of Genova)
Giorgio Diana (Politecnico di Milano)
Prem Krishna (Indian Institute of Technology, Roorkee)
Chii-Ming Cheng (Tamkang University)
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COE Program TPU
Wind Effects on Buildings and Urban Environment

21世紀COEプログラム『都市・建築物へのウインド・イフェクト』メンバー

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