Wind Effects News

New Frontier of Education and Research in Wind Engineering

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Professor Kareem Awarded with Member of the National Academy of Engineering

Ahsan Kareem, the Robert M. Moran Professor of Civil Engineering at the University of Notre Dame, was one of only 65 members inducted into the National Academy of Engineering (NAE) in its class of 2009 at a ceremony on October 4th in Irvine, California, where he was joined by his wife Gulrukh and son Danyal. Induction into the academy is reserved for those making outstanding contributions to "engineering research, practice, or education" and represents the highest professional honor in the field of engineering, reserved for just only 2000 of the 3 million engineers in the United States. It is a particularly high honor for Civil Engineers, with only 5 of this year's 65 inductees being from this discipline. As one of those five inductees, Prof. Kareem was formally honored for" *...contributions to analyses and designs to account for wind effects on tall buildings, long-span bridges, and other structures."*

Professor Kareem graduated from the West Pakistan University of Engineering and Technology with distinction in 1968 and, through a joint program with the Massachusetts Institute of Technology, he earned his master's degree in structural engineering from the University of Hawaii. After completing his doctoral work under Jack Cermak at Colorado State University, Professor Kareem began his career in academia at the University of Houston, before moving to Notre Dame in 1990. Over a career spanning more than three decades, Professor Kareem has executed diverse research in the area of structural dynamics and in particular on the effects of wind on society. He has become an advocate for comprehensive national policies and design procedures to address wind hazards, leading to the incorporation of his design aids for wind loads into codes and standards both in the United States and abroad. These achievements have earned him every major prize in wind engineering, including:

- the inaugural Alan G. Davenport Medal, presented by IAWE in recognition of his distinguished achievement in the dynamic wind effects on structures
- ASCE's Robert H. Scanlan Medal for outstanding original contributions to the study of wind-load effects on structural design, and
- ASCE's Jack E. Cermak Medal, named for Kareem's advisor, in recognition of his contributions to the study of wind effects on structures.

Professor Kareem also recently received ASCE's State-of-the-Art in Civil Engineering Award for his work on full-scale monitoring of tall buildings in Chicago and was presented on May 19, 2009 with the University of Notre Dame's Faculty Research Achievement Award. This award is bestowed on one of the university's faculty each year for universal recognition as a research leader in both past research accomplishments and future research potential.

2009年7月27日に群馬県館林市で発生した竜巻被害について

岡田玲，川名清三，松井正宏，田村幸雄（東京工芸大学）

平成21年7月27日14時すぎに，群馬県館林市で竜巻が発生し，人的被害，住家損壊・自動車の横転・飛散物による損傷などを含む被害が発生した。この竜巻による被害の現地調査を被害発生23時間後から29時間後（7月28日午後1時～午後7時）にかけて実施した。あらかじめ報道機関や市役所などから得られる情報から被害地域を想定し，それよりも少し広い範囲を調査地域に指定し，自転車で移動しながら調査を行った。被害発生から1日程度たった状態での調査であったが，横転した車などはすでに撤去され，損傷を受けた住家を中心として専門業者による復旧作業が全被害地域通して地域住民同士の協力関係のなか活発に行われていた。本報告では，発生した竜巻の概略を示したうえで行った現地調査結果を報告する。なお，竜巻の詳細な情報は文献1を参照されたい。

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，低気圧の東進に伴って関東地方に近づいた梅雨前線に，南から暖かく湿った空気が流れ込み，大気の状態が不安定になって積乱雲が発達したことが原因とみられるとのことである[1]。前橋地方気象台によると，突風発生時，館林市上空には大きな積乱雲があり，竜巻が発生しやすい状態であった。日本気象協会のドップラーレーダによれば，竜巻の移動速度は45 km/hだったとのことである[2]。

図1に竜巻により生じた被害分布を示す。被害地域の幅は約50メートル，長さは約6.5キロメートルであった。西本町で発生した竜巻は田園地帯を東に進み，市街地に入る新栄町付近でわずかに進行方向を東に変えて進み，瀬戸谷

写真1　破損した体育館の屋根(C地点)

写真2　倒れたフェンス(C地点)

写真3　壁と屋根が破損した工場(D地点)

写真4　倒れたフェンス(A地点)

写真5　飛散物で破損した窓(A地点)

写真6　倒れたクレーン(A地点)

写真7　全壊した倉庫(F地点)

写真8　飛散物が乗った電柱(A地点)

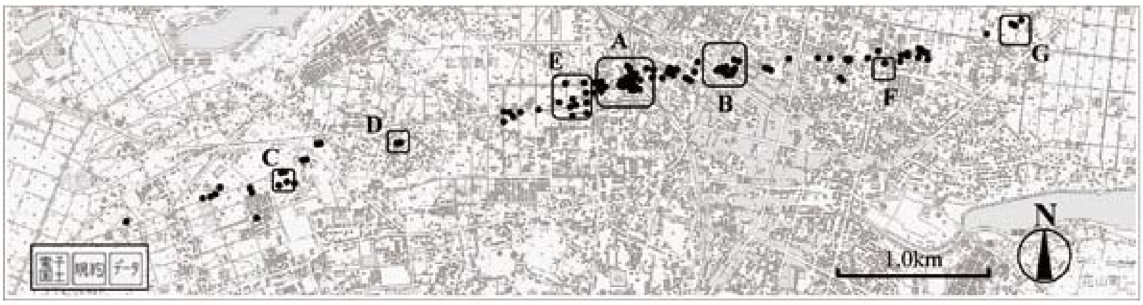


図1　竜巻により生じた被害分布

町をすぎた田園地帯へ抜ける辺りで再度わずかに進行方向を変え，若宮町まで達して消滅したと考えられる。最も激しい被害が集中していたのが被害地域のほぼ中央部に位置する新栄町 (A 地点) であった。次に被害が集中していたのは新栄町から東方に位置する西本町 (B 地点) である。それ以外では，窓が損壊した体育館や倒壊したフェンス (C 地点)，壁が剥離して飛散した工場 (D 地点)，民家 (E 地点)，周辺に大きな被害はなかったが 1 棟だけ全壊していた住家 (F 地点)，住家からの飛散物で破られていたビニールハウス (G 地点) など竜巻の進行ルートに沿って，間をあけながら局所的に大きな被害が見受けられた。例えば F 地点から G 地点の間には田圃が広がっており，一面に稲が植えられていたが，それらへの被害は見受けられなかった。写真 1 ～写真 8 に被害調査で明らかになった被害例を示す。今後二次調査など含め，さらに詳細な検証を継続していく予定である。

ご協力いただいた住民，市役所の方々に感謝いたします。

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

[2] 日本気象協会，ドップラーレーダが群馬県館林市の竜巻をキャッチ!!：http://www.jwa.or.jp/content/view/full/2796/

The 6th International Advanced School (IAS6) on Wind Engineering was successfully held in Beijing, China

Date : August 31-September 4, 2009
Venue : China Academy of Building Research, Beijing, China

From August 31 to September 4, 2009, the 6th International Advanced School on Wind Engineering (IAS6) co-host by Global COE Program of Tokyo Polytechnic University (TPU) and China Academy of Building Research (CABR) was successfully held at CABR, Beijing, China.

The IAS6 invited 17 international distinguished professors in wind engineering field from 9 countries and regions to give their excellent lectures on respective research directions. They are:

Shuyang Cao (Tongji University, China)
Richard G.J. Flay (The University of Auckland, New Zealand)
Yaojun Ge (Tongji University, China)
Kenny C. S. Kwok (University of Western Sydney, Australia)
Partha Sarkar (Iowa State University, USA)
Ted Stathopoulos (Concordia University, Canada)
Yukio Tamura (Tokyo Polytechnic University, Japan)
Youlin Xu (The Hong Kong Polytechnic University, Hong Kong, China)
Lingmi Zhang (Nanjing University of Aeronautics & Astronautics, China)
Qingyan Chen (Purdue University, USA)
Richard de Dear (The University of Sydney, Australia)
Takashi Kurabuchi (Tokyo University of Science, Japan)
Xiaofeng Li (Tsinghua University, China)
Masaaki Ohba (Tokyo Polytechnic University, Japan)
Matthew Santamouris (University of Athens, Greece)
Michael Schatzmann (University of Hamburg, Germany)
Ryuichiro Yoshie (Tokyo Polytechnic University, Japan)

The IAS6 was also regarded as an import international academic activity to China wind engineering society as well as to CABR this year. The president of IWEA, Prof. Yukio Tamura of TPU, the president of China wind engineering committee, Prof. Yaojun Ge of Tongji University and the president of CABR, Prof. Jun Wang attended the IAS6.

The IAS6 received warm responses from related colleges and academic organizations in China. It attracted totally about 80 postgraduate students and young researchers to attend, who came from 22 colleges and institutes, mainly from Tongji University, Beijing Jiaotong University, Harbin Institute of Technology, Shanghai Jiaotong University, Zhejiang University, Peking University, South China

University of Technology and CABR etc..

The 5 day's systematic lectures were divided into two parts: Structural Wind Engineering and Environmental Wind Engineering, and totally 19 ones were given. The involved fields included: wind hazards and extreme wind climate, wind loads of buildings and structures, urban wind environment, CFD numerical simulation and wind tunnel test, outdoor wind environment comfort and indoor ventilation/thermal comfort, urban air pollution and dispersion etc.. They almost included all the important research aspects in the field of wind engineering. On and after the lectures, the young students discussed the problems interested positively.

On August 31, the vice president of CABR, Prof Lin Haiyan and the general engineer, Prof. Zhao Jida attended the opening ceremony as the host, and Prof. Lin gave a short address to welcome all the lecturers and students.

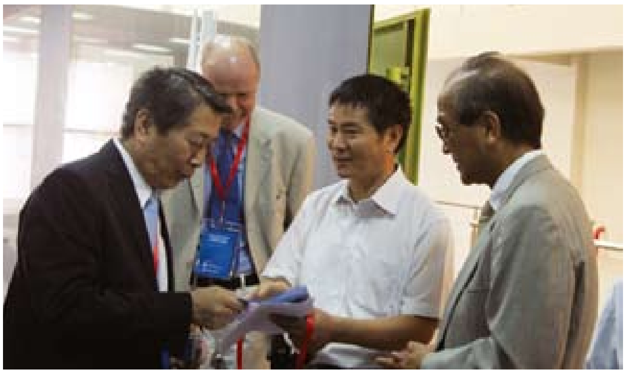
On September 2, the president of CABR, Prof. Wang Jun

interviewed with the IWEA president Prof. Tamura and all the lecturers. He expressed the appreciations to all the invited lecturers, and also expressed a wish for strengthening the cooperation of CABR with international scholars in the research field of wind engineering.

During the break between two parts, the invited lecturers and students visited the newly constructed large-scale boundary layer wind tunnel lad, which were two sections 6m *3.5m and 4m*3m respectively.

On September 4, Prof. Michael Schatzmann and Prof. Richard de Dear gave a warmhearted speech in the farewell banquet as the representatives of all invited lecturers.

The IAS6 was successfully held and closed through the intensive cooperation between the Wind Engineering Research Center of TPU led by Prof. Tamura and the Center of Wind Engineering Research of CABR led by Prof. Jin Xinyang. Many students wrote emails to the organizers of CABR to express their congratulations and appreciations after the IAS6. Through IAS6, it set up a bridge of friendship between the Chinese young students and international scholars.



Vibration Control of Stay-Cable Using Magneto Rheological Damper

Zhehua Wu, Tokyo Polytechnic University

As the most important structural components in cable-supported bridges, stay cables are vulnerable to vibrations with large amplitudes due to relate small mass, low internal structural damping and high flexibility. A number of methods have been proposed to mitigate cable vibrations, such as cable cross tie system, aerodynamic cable surface treatment and damper cable control. However, each has limitations in suppressing the longer cable vibration. As one of smart control devices, magneto-rheological (MR) dampers have significant potential to advance the acceptance of structural control as a viable means for dynamic hazard mitigation. The following paragraph will focuse on the field of control of cable vibration by using MR dampers.

1.Experimental Research

The full-scale experiment using MR dampers was carried out for mitigation cable vibration. Fig.1 shows the dampers were installed on the 154m-long cable near the anchorage in the 3rd QianJiang cable-stayed bridge,China. MR dampers applied constant current are examined by a series of free vibration tests and compared to that of using oil dampers.

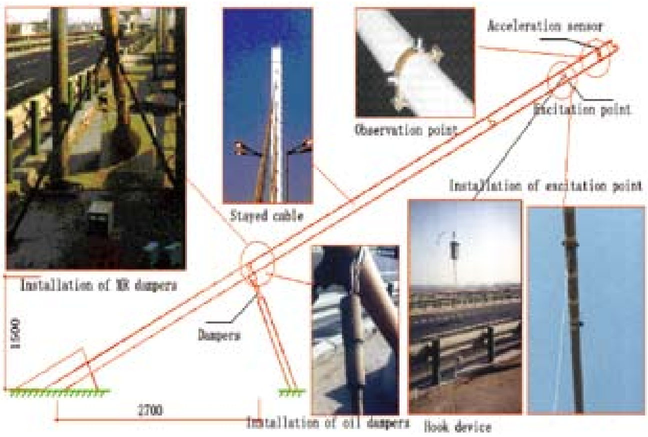


Fig. 1 Experiment setup

The displacement signal is driven by harmonic planar loads, filtered through wavelet decomposition and transformed by Hilbert. The relationship between system equivalent modal damping ratios, resonant frequencies, applied voltages and displacement responses of the cable was pursued. Fig.2 shows that MR dampers can more significantly reduce cable vibration than oil dampers do. The resonant frequencies of the cable installed MR dampers have a little change as shown in Fig. 3.

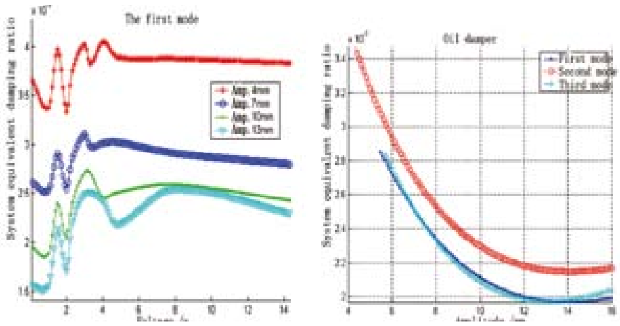


Fig. 2 System equivalent modal damping ratio

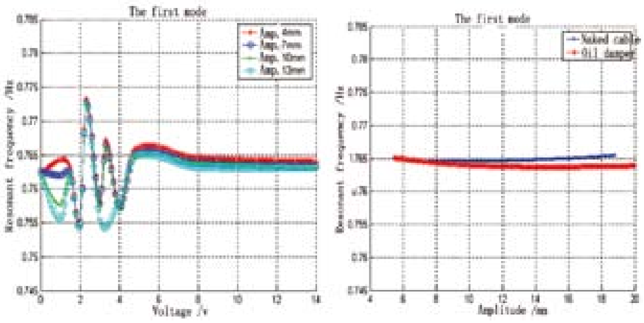


Fig. 3 Resonant frequency

A theoretical model for the cable damper system is formulated by accounting for the cable inclination and sag effect based on the Hamilton's principle. The motion of the cable was computed by using a finite series approximation with the Galerkin method. A static deflection shape as an addition shape function improved the sine series convergence. A nonlinear hysteretic biviscous model is identified for the experimental MR dampers.

Tab. 1 shows the similar phenomenon and conclusions between experiment and numerical simulation.

Tab. 1 System equivalent modal damping ratio and resonant frequency

Parameters	The 1st mode		The 2nd mode		The 3rd mode	
	Exp.	Sim.	Exp.	Sim.	Exp.	Sim.
Damping ratio (%)	0.46	0.49	0.39	0.56	0.38	0.57
Frequency (Hz)	0.76	0.77	1.51	1.53	2.27	2.28

2.Theoretic Research

A stay cable incorporated with MR dampers exhibits pronounced nonlinearity. The Spencer photometric model is used for MR dampers. Fig. 4 shows the dynamic system of a cable and MR damper.

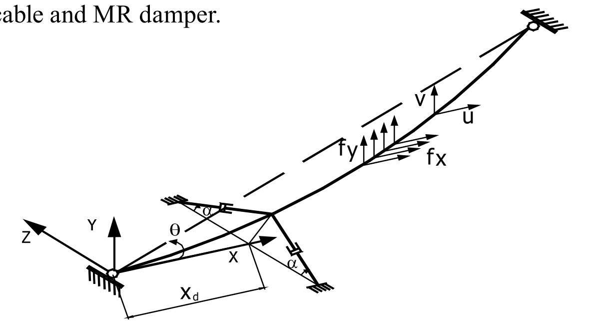


Fig. 4 Mathematical model of cable with attached damper

Evolution principle for controlling effect is based on root mean square (RMS) of structural response. The mitigation performance of damper contribution measured by displacement RMS integrated the whole length of cable and the whole time is expressed by:

$$v_{RMS} = \sqrt{\frac{\int_0^{t_f}\int_0^1 v^2(x,t)dxdt}{t_f}} \quad (1)$$

Where t_f is the total time of vibration response, $v(x,t)$ is the displacement response of cable.The relationship between displacement RMS, the optimal marker of MR damper, the mounting position, the applied voltage, the first frequency of cables (tensile force, length and mass per unit length), Irvine parameter, and excited loads (type, frequency and amount) are studied. To compare MR damper to oil damper, the ratio of displacement RMS is defined as:

$$v_{RRMS} = \frac{v_{RMS}^{MR}}{v_{RMS,opt}^{OIL}} \quad (2)$$

Where v_{RMS}^{MR} and $v_{RMS,opt}^{OIL}$ are displacement RMS using MR and the optimal oil damper respectively. Fig. 5 shows the mitigation effect of the cable is equal to the optimal oil dampers do. MR damper is a type of fail-safe device and can offer comparatively large equivalent model damping ratio without applied voltage. There is optimum voltage on which the maximum modal damping ratio can be achieved. Fig. 6 shows the dynamic control range of MR damper is sufficiently wide and can be more effective in first three frequency modes than oil dampers do.

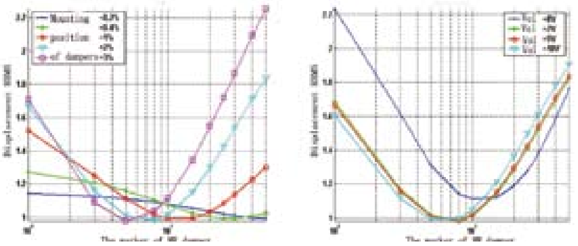


Fig. 5 Mitigation effect of MR damper under random loads

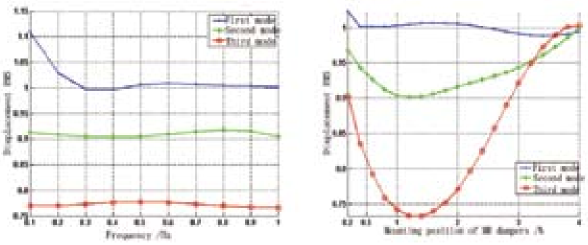


Fig. 6 The frequency mitigation range of MR dampers compared with the optimal viscous damper in the first mode

Based on equivalent RMS cable deflection criteria, the simplifying model is established for MR damper passive control. The damper force is expressed as:

$$F_d = K_{eq}x_d + C_{eq}\dot{x}_d \quad (3)$$

Where K_{eq} and C_{eq} are equivalent stiffness coefficient and equivalent viscous damping coefficient respectively, and x_d and $\dot{x}_d$ are displacement and velocity of damper respectively. The simplifying model not only has the similar effect of mitigation to the Spencer model but also reveal the laws of energy dissipation criteria for MR dampers much better. Fig. 7 shows the mechanics performance of MR dampers is relate to applied voltage, displacement amplitude and frequency, and explains the difference in dynamic response. Using partial least squares in conjunction with the chebyshev polynomial representation, the expression for the simplifying model is built, and is provided to determine the optimal MR damper marker.

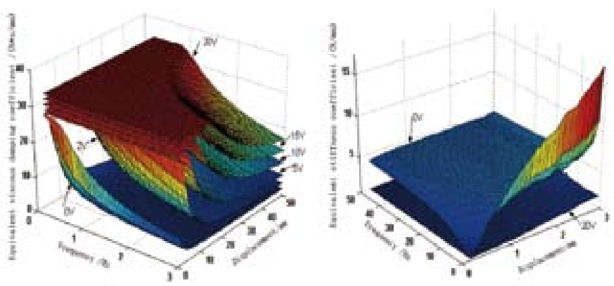


Fig.7 Identification of equivalent stiffness coefficient and equivalent viscous damping coefficient

Recent Topics of POD in Wind Engineering

Le Thai Hoa, Tokyo Polytechnic University

INTRODUCTION

Proper orthogonal decomposition (POD) has been applied widely in many engineering topics including the wind engineering recently due to its advantage of optimum approximation of multi-variate random fields using the modal decomposition and limited number of dominantly orthogonal eigenvectors. This paper presents fundamentals of POD and its proper transformations in both the time domain and the frequency domain based on both covariance matrix and cross spectral matrix branches. Moreover, the most recent topics and applications of POD in the wind engineering will be reviewed as follows: (1) Digital simulation of turbulence fields; (2) Analysis and synthesis of unsteady pressure fields; (3) Random response prediction of structures in turbulence and (4) Modal parameters identification of structures.

POD AND ITS PROPER TRANSFORMATIONS

POD is originally considered as optimum approximation of the multi-variate random field in which a set of orthogonal basic vectors is found out in order to expand the random process into a sum of products of these time-independent basic orthogonal vectors and time-dependant uncorrelated random processes. Let consider the N-variate correlated random process $\upsilon(t)=\{\upsilon_1(t),\upsilon_2(t),...,\upsilon_N(t)\}^T$ is approximated as:

$$\upsilon(t)=x(t)^T\Theta=\sum_{i=1}^{N}x_i(t)\theta_i \quad (1)$$

where $x(t)$: time-dependant uncorrelated random process (principal coordinates); Θ : time-independent orthogonal modal matrix.

Covariance proper transformation in the time domain is to find covariance matrix-based eigenvalues and orthogonal eigenvectors from the zero-time-lag covariance matrix $R_\upsilon(0)$ of the random process $\upsilon(t)$:

$$R_\upsilon\Theta_\upsilon=\Gamma_\upsilon\Theta_\upsilon \quad (2)$$

where Γ_υ,Θ : eigenvalue and eigenvector matrices $\Gamma_\upsilon=diag(\gamma_{\upsilon1},\gamma_{\upsilon2},...\gamma_{\upsilon N})$, $\Theta_\upsilon=[\theta_{\upsilon1},\theta_{\upsilon2},...\theta_{\upsilon N}]$, respectively. Then, the random process and its covariance matrix can be reconstructed approximately using the lowest jth-order truncated eigenvalues and eigenvectors:

$$\upsilon(t)=\Theta_\upsilon x_\upsilon(t)\approx\sum_{j=1}^{\tilde{N}}\theta_{\upsilon_j}x_{\upsilon_j}(t);\ R_\upsilon=\Theta_\upsilon\Gamma_\upsilon\Theta_\upsilon^T\approx\sum_{j=1}^{\tilde{N}}\theta_{\upsilon_j}\gamma_{\upsilon_j}\theta_{\upsilon_j}^T;$$

where :number of truncated covariance modes($\tilde{N}<<N$).

Similarly, spectral proper transformation in the frequency domain is to find spectral eigenvalues and spectral orthogonal eigenvector through the cross spectral density matrix $S_\upsilon(n)$ of the random process $\upsilon(t)$:

$$S_\upsilon(n)\Psi_\upsilon(n)=\Lambda_\upsilon(n)\Psi_\upsilon(n) \quad (3)$$

where $\Lambda_\upsilon(n),\Psi_\upsilon(n)$: spectral eigenvalue and eigenvector matrices $\Lambda_\upsilon(n)=diag(\lambda_{\upsilon1}(n),\lambda_{\upsilon2}(n),...\lambda_{\upsilon N}(n))$ and $\Psi_\upsilon(n)=[\psi_{\upsilon1}(n),\psi_{\upsilon2}(n),...\psi_{\upsilon N}(n)]$, respectively. Accordingly, cross spectral density matrix of random process can be approximated as follows:

$$S_\upsilon(n)=\Psi_\upsilon(n)\Lambda_\upsilon(n)\Psi_\upsilon^{*T}(n)\approx\sum_{j=1}^{\hat{N}}\psi_{\upsilon_j}(n)\lambda_{\upsilon_j}(n)\psi_{\upsilon_j}^{*T}(n) \quad (4)$$

where : number of truncated spectral modes ($\hat{N}<<N$).

SIMULATION OF TURBULENCE FIELDS

The spectral proper transformation can be applied to simulate the multi-variate turbulence fields. For example, simulation of fluctuating wind speeds u(t), w(t) at 30-nodes line-like structure is required at sampling rate of 1000Hz for time interval 100 seconds. Targeted auto power spectral densities of u-, w-components are used the Kaimail's and Panofsky's empirical formula. Coherence function is used by Davenport's exponentially empirical model. First five spectral eigenvalues $\lambda_1(n)\div\lambda_5(n)$ and the first spectral mode on frequency band 0.01÷10Hz is shown in Figure 1 and Figure 2.

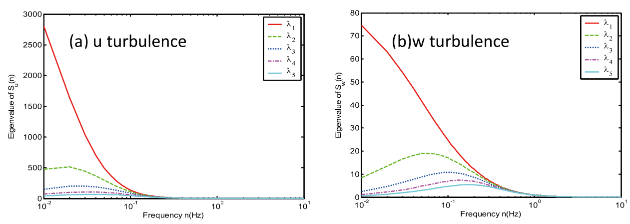


Fig.1 First five spectral eigenvalues

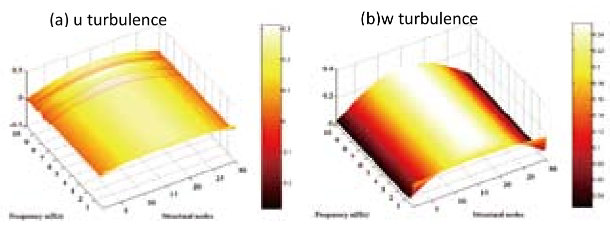


Fig.2 First spectral mode

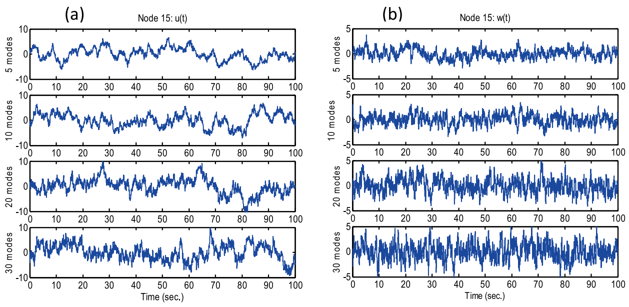


Fig.3 Simulated time series of fluctuating wind speeds u (a) and w (b) at U=20m/s (Node 15)

ANALYSIS AND SYNTHESIS OF UNSTEADY PRESSURE FIELD

Unsteady pressure field on typical square prism B/D=1 has been used for demonstration. Pressure has been measured at lower surface in chordwise directions from position 1 to position 10 under some turbulence flows. Figure 4 shows normalized pressure distribution and power spectral density at some chordwise positions. Spectral peak of 4.15H represents to Karman vortex's frequency at the wake of square prism.

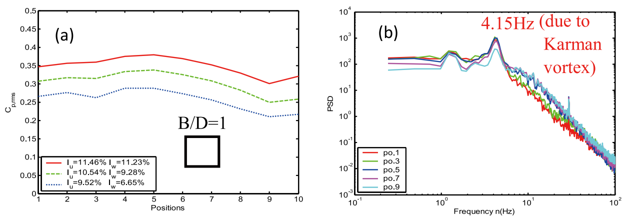


Fig.4 Normalized pressure (a) and power spectral densities (b)

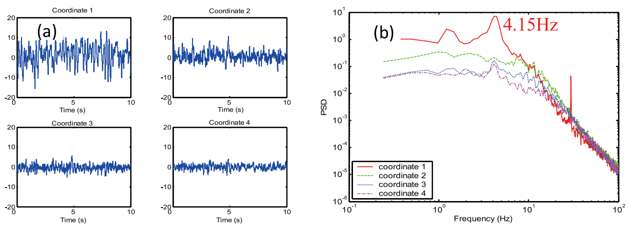


Fig.5 First four principal coordinates (a) and power spectra (b)

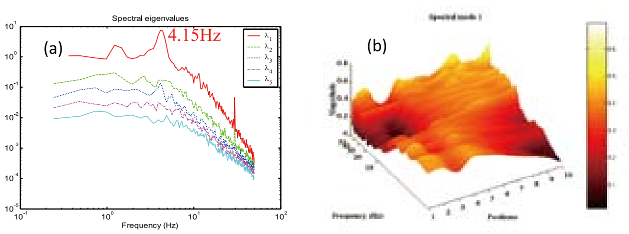


Fig.6 First five spectral eigenvalues and first spectral mode

As can be seen from Figure 5 and Figure 6, only the first covariance matrix-based principal coordinate and also the first spectral matrix-based eigenvalue contain the frequency of the Karman vortex event. In the other word, The first principal coordinate and spectral eigenvalue in these studies have represented to physical phenomenon of the experimental model.

RANDOM RESPONSE ANALYSIS OF STRUCTURES

Random response of structures under turbulence flows can be formulated either in the time domain or the frequency domain using the proper transformation branches. By using POD, random buffeting forces can be decomposed under the concept of orthogonal loading modes, after that are combined with structural modes to estimate the response of structures. Random response of cable-stayed bridge under turbulence has been taken into account for numerical example. Some results of the buffeting response prediction in the frequency domain and the time domain have been expressed in Figure 7 and Figure 8.

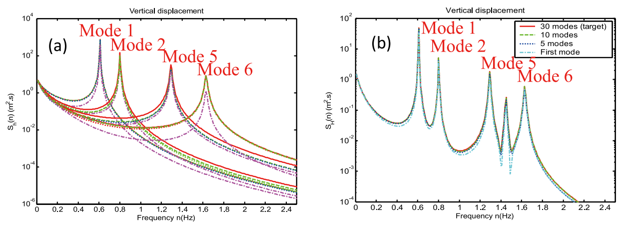


Fig.7 Power spectra of generalized (a) and global responses (b) of vertical displacement

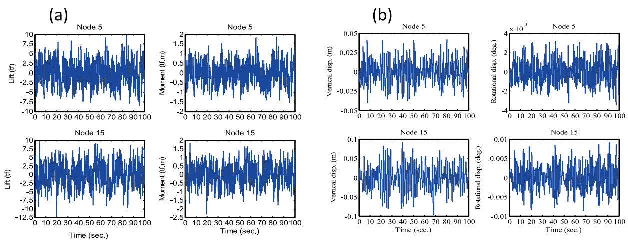


Fig.8 Time series of global forces (a) and global response (b) of nodes 5 & 15 at mean velocity U=20m/s

The advantage of POD for predicting the random response of structure is that only first few covariance modes or spectral modes of random loading can be used for enough accuracy of response estimation.

MODAL PARAMETERS IDENTIFICATION

Modal parameters (natural frequencies, damping ratios and mode shapes) of operational and experimental structures can be identified in the frequency domain and the time domain using the POD via ambient vibration data. Measured data also are organized under any form of spectral matrix, covariance matrix or data themselves (Hankel matrix). Here, modal parameters identification in the frequency domain of 5-storey steel building under ambient data is presented (Figure 9). Figure 10 shows the spectral eigenvalues and first eigenvector of cross spectral matrix of output response.

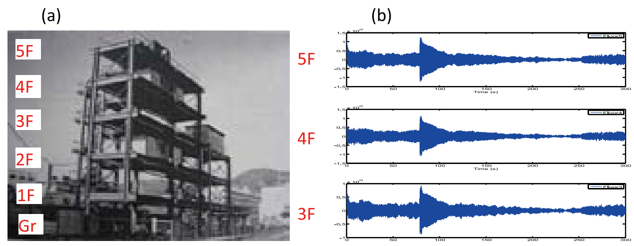


Fig.9 5-storey structure (a) and integrated displacements (b)

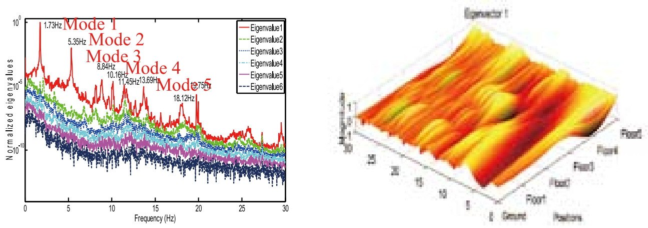


Fig.10 Spectral eigenvalues (a) and first spectral mode (b)

Accordingly, natural frequencies and damping ratios can be extracted from the first spectral eigenvalue, whereas the mode shapes from the first spectral eigenvector.

グローバルCOE　オープンセミナー

本グローバルCOEプログラムでは、どなたでも参加できるグローバル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16回
日時：2009年8月1日(土)16:00-17:00
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：
講演者　宮下康一(風工学研究所)
■講演タイトル：
文化財を対象とした気象観測について

第17回
日時：2009年8月8日(土)14:00-15:30
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：
Andrea Freda (University of Genova)
■講演タイトル：
A conditional approach for the forecast of severe winds

第18回
日時：2009年8月21日(金)13:30-15:00
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

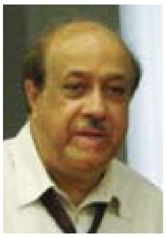
■講演者：
日下博幸(筑波大学大学院 生命環境科学研究科)
■講演タイトル：
世界最新の領域気象モデルWRFとその応用

第19回
日時：2009年9月4日(金)13:00-14:00
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：
S.Vengadesan (Department of Applied Mechanics, IIT Madras, INDIA)
■講演タイトル：
Shear flow effects on flow past square cylinder

日時：2009 年 9 月 12 日 (土) 14:00-15:30
第 20 回 場所：東京工芸大学厚木キャンパス 本館 6 階大会議室

■ 講演者：
Ahsan Kareem (University of Notre Dame)
■ 講演タイトル：
1. Consequences of Urban Aerodynamics and Debris Impact in Extreme Wind Events
2. The Audacity of Change: A Transition to Nonstationary and Nonlinear Era



日時：2009 年 10 月 24 日 (土) 14:00-15:30
第 21 回 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：
曹曙陽
(同済大学教授)
■ 講演タイトル：
台風 18 号に伴う竜巻による茨城県土浦市における被害調査

日時：2009 年 10 月 31 日 (土) 14:00-15:30
第 22 回 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：
坂上博隆 (宇宙航空研究開発機構)
■ 講演タイトル：
高速感圧コーティングを用いた非定常面計測

グローバル COE オープンセミナーの予定は本学ホームページ（http://www.wind.arch.t-kougei.ac.jp/）でご覧いただけます。

お知らせ

International Forum on Tornado Disaster Risk Reduction for Bangladesh
－ To Cope with Neglected Severe Disasters －

開　催　日：2009 年 12 月 13 日, 14 日
会　　　場：バングラデッシュ・ダッカ・シェラトンホテル (13 日)
バングラデシュ気象庁 (14 日)
主　　　催：バングラデッシュ政府（食糧防災省防災局 DMB・気象庁・防衛省），東京工芸大学グローバル COE プログラム（文部科学省 , TPU/GCOE)，バングラデシュ災害予防センター (BDPC)，国際風工学会 (IAWE)
後　　　援：国際協力機構 (JICA)，国連アジア太平洋経済社会委員会 (UNESCAP)，国連国際防災戦略事務局 (UN/ISDR)，世界気象機関 (WMO)，SEEDS，南アジア地域協力連合 SAARC 気象研究所，バングラデッシュ赤新月社 (BDRCS)，国連開発計画 (UNDP)，アジア防災センター (ADRC)

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New Frontier of Education and Research in Wind Engineering

グローバルCOEプログラム『風工学・教育研究のニューフロンティア』メンバー

工学研究科　建築学専攻

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