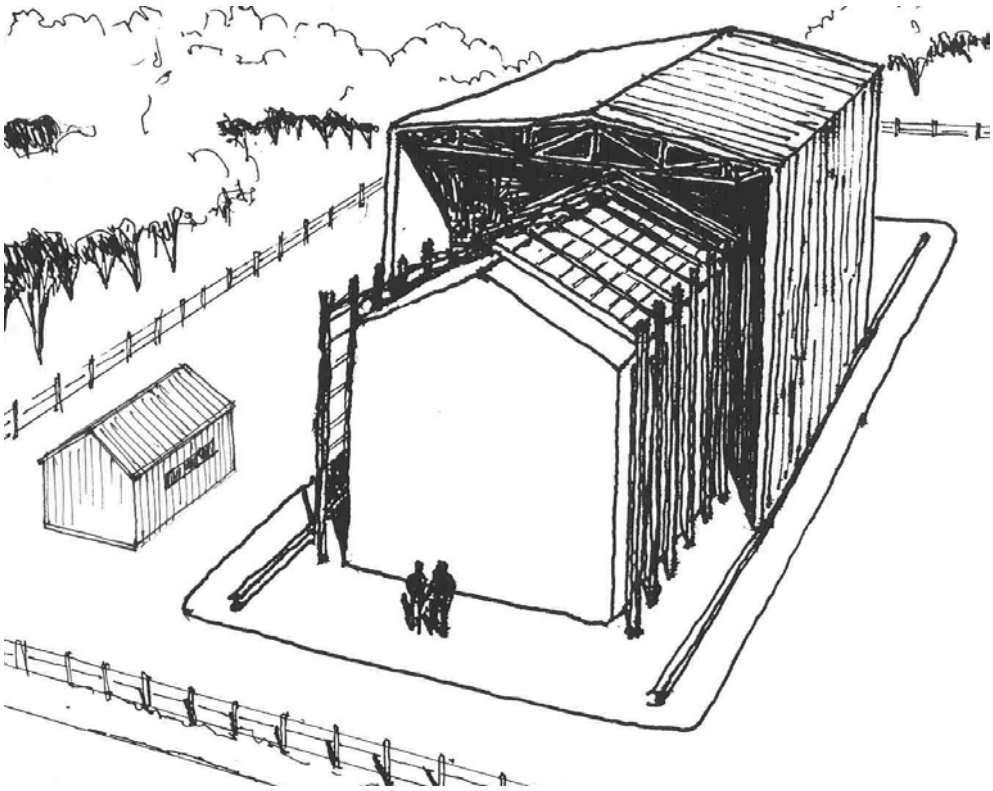
Volume 6, No. 3, September 2004

WIND ENGINEERING SOCIETY Newsletter



Sketch of the 'Three Little Pigs' facility

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Contents

WES NEWSLETTER
Volume 6, No. 3 September 2004

❖ Ramblings

Welcome to the third WES newsletter of 2004 and many thanks to those of you who have contributed. The newsletter contains the usual Snippets of wind related news stories from around the world which this time have been complied by Ms Sarah Jordan, a PhD student at The University of Birmingham. Chris Baker reports from the recent BBVA conference held in Canada and we continue with the Canadian theme by reporting on the "three little pigs" research project. We also have contributions from Nicole Metje, a research fellow at The University of Birmingham who keeps us abreast of the activities of our German Colleagues. It is with regret that we report the passing of Robert Macdonald, a colleague who had many friends within the society. Finally we bring you details of the upcoming WES conference.

I hope you enjoy this newsletter and look forward to seeing you in Cranfield in September.

Mark Sterling

❖ Snippets

- **Technology to warn of Atmospheric Turbulence.** NASA has developed the Turbulence Prediction and Warning System airborne radar to detect atmospheric turbulence encountered by aeroplanes. Movement of moisture in the air is measured, and an advance warning of turbulence gives crew and passengers the chance to take precautionary action. (http://www.e4engineering.com/story.aspx?uid=31184b66-9775-4f15-b617-584c3ed17959&cuid=bdf61544-264a-4a3e-8fd0-3865eb710dd2)

- **UK'S largest wind farm.** When the wind farm at Hadyard Hill in South Ayrshire becomes operational next summer it will be the UK's largest, with seventy giant turbines. This £90 million project was first opposed by the MoD on the grounds that the turbines could block radar signals, and pilots would be at risk of crashing into them as the area is a designated low-flying zone. (http://news.scotsman.com/scotland.cfm?id=777182004)

- **The south wind.** At the beginning of July a storm hit Britain which came from the south bringing with it strong winds, downpours and an autumnal chill. (http://www.timesonline.co.uk/article/0,,2-1170469,00.html)

- **School's wind turbine.** The Ladygrove School in Dawley, Shropshire, now generates its own electricity by having a wind turbine in its grounds. (http://www.shropshirestar.com/cgi-bin/artman/exec/view.cgi?archive=5&num=19787)

- **Is wind bringing U.S. air pollution to U.K?** Scientists from Europe and North America have been conducting the largest experiment on air pollution. The experiment is to determine if the prevailing westerly winds are carrying pollution from America and Asia across to Europe, as it is now realised that certain pollutants, including ozone, are global travellers. (http://www.guardian.co.uk/waste/story/0,12188,1259060,00.html)

- **Wind machine saves Bramley apples.** A farmer installed a wind machine in his orchard near Stonebridge, County Armagh, to protect his crop from frost after being inspired by the machines in Californian fruit farms. The turning rotors of the machine draw down warmer air to replace the cold air around the crops. (http://news.bbc.co.uk/go/pr/fr/-/2/hi/uk_news/northern_ireland/3891915.stm)

- **Weather versus champion hopefuls.** A rowing team aiming to break a world record believed they'd travelled fifty one miles across the Atlantic in twenty four hours. However, they'd only covered six miles and had effectively been rowing on the spot due to struggling against a 'Victor Meldrew' storm. (http://icwales.icnetwork.co.uk/0100news/0200wales/tm_objectid=14453796%26method=full%26siteid=50082%26headline=storm%2dputs%2datlantic%2drowers%2din%2da%2dspot-name_page.html)

- **Offshore wind farm navigation risk management.** British Maritime Technology Ltd has used their marine traffic risk assessment tools on a number

of projects including the Singapore and Hong Kong docks. They are now going to use these tools to evaluate and help mitigate the risks to shipping from offshore wind farms. (http://www.motorship.com/currentnews/article.asp?ARTICLEID=2435)

- **Mini wind turbines for house roofs.** A 2m-high roof-top wind turbine will be tested in Loughborough if the local council give the go-ahead. There is interest in the potential of selling such technology to householders. (http://www.thisisleicestershire.co.uk/displayNode.jsp?nodeId=132683&command=displayContent&sourceNode=132377&contentPK=10732243)

- **Draught-meter invented.** Dr Gunti Gunarathne at the Robert Gordon University in Aberdeen was unable to locate the source of a draught so he developed a hand-held device for tracing the path of moving air. The draught-meter uses a high-frequency ultrasonic signal to detect air movement and measure the draught's speed. (http://www.theherald.co.uk/news/21489.html)

- **Winds enjoy their own sport at the Olympics.** North-easterly winds from the Balkan mountains are playing havoc with the competitors at the Olympic Games, and putting events under threat of cancellation. Winds have assisted some sailing boats while swamping others, and archers have missed the target despite the protection of a windbreak. (http://sport.guardian.co.uk/olympics2004/story/0,14912,1285368,00.html)

- **Problems with predicting Charley.** The difficulty in predicting hurricane intensity was highlighted by Hurricane Charley which was like many summer hurricanes off the U.S. east coast until its intensity suddenly increased with wind speeds of up to 260kph. (http://www.nature.com/news/2004/040816//full/040816-3.html#top)

- **Computer model of Cornish coast storm.** A computer model is being created of the storm that hit Boscastle in August. Professor Ian Cluckie at the University of Bristol wants to unravel the chain of events leading to the freak storm and help predict such events in the future. (http://www.westpress.co.uk/displayNode.jsp?nodeId=146049&command=displayContent&sourceNode=145779&contentPK=10801540)

- **Dust storm problems.** Using four-wheel drives instead of camels is a major cause of the destruction of the lichen and stones which protect the Sahara from the wind, Professor Andrew Goudie of Oxford University told the International Geographical Congress in Glasgow. Storms carry away dust which can be deposited thousands of miles from its source. The dust storm problem is leading to the smothering of coral reefs, the melting of ice in Greenland and is threatening human health. (http://www.guardian.co.uk/climatechange/story/0,12374,1287212,00.html)

(Ed – Thanks to Sarah Jordan for this section).

❖ Robert Macdonald

It is with great regret that we report the death of Robert Macdonald. Robert passed away on the 29/04/04. He was well-known in the atmospheric dispersion community through his work on buoyant plumes and on flow and dispersion in urban street arrays. He often attended WES conferences and always enjoyed his visits to the UK, particularly as he had previously studied at UMIST and his wife is English.

❖ Report on BBAA V

Chris Baker writes:

The 5th International Conference on Bluff Body Aerodynamics and its Applications was held in Ottawa, Canada from 12st to 16th July 2004. This is the latest conference in a series that extends back to the first conference in 1989 that was held in Kyoto in Japan. It was attended by around 120 delegates from about 15 countries. This was a significantly smaller number than for previous conferences in the series, possibly caused by the proximity in time of a conference on Flow

Induced Vibrations, that was held in Paris two weeks before.

The conference consisted of the usual plenary and parallel sessions, and, as would be expected there were the usual mix of good and bad papers. The plenary sessions were particularly useful and I came away with a number of ideas for the future development of research in this area. I personally delivered a paper describing some experimental and modelling work on the slipstreams and wakes of ground vehicles that was well received. The conference organisation was carried out very competently and there were very few hitches with the technical or social programmes. The visit to the wind tunnel laboratories of the National Research Council of Canada was particularly interesting, and the large wind tunnels were very impressive indeed.

As well as the conference I also attended other associated meetings. I attended the meeting of the Executive Committee of the International Association of Wind Engineering as the European / African regional representative, where a number of countries were accepted into membership of the Association and plans were made for the future. I also attended a post conference meeting of the working group that is revising the ISO wind loading code, which was useful in carrying forward the work of this group. The work of this group will be complete by its next meeting (in Tokyo in November 2004) and a draft code will then be circulated for discussion.

As ever with such conferences, the high points were the personal contacts – the renewal of old friendships and the making of new ones. Many of these contacts will have a profound effect on research in bluff body aerodynamics at the University of Birmingham over the next few years (including the possibility of some visiting scholars). The support of the Royal Society for this visit is gratefully acknowledged

❖ Update from Germany

The newsletter 14 from the German wind engineering society (Windtechnologische Gesellschaft, WtG) March 2004 edition included three articles presented at the 8th WtG –D-A-CH conference in 2003.

Zimmerli and Hortmanns compared the current European wind loading standards concentrating on the standards in Austria, Switzerland and Germany. European standards in general are designed such that for international competition contractors can work with the standards applicable to their country and only need to request additional standards specific to another country. The generic standards are part of the Eurocode. Additionally, every EU country can design further working documents which have to be available for any contractor without incurring extra costs and thus disadvantages compared to home contractors.

Zimmerli and Hortmanns compared the standards with respect to coefficient of safety, the design values, pressure coefficients, dynamic factors and eddy fluctuations for the three countries. The differences were discussed and how these differences can be incorporated into the newly proposed Eurocodes. The differences in the different EU countries resulted in a standard which allows individual countries specific exemptions and design of specific details.

A second paper by Sahlmen et al. described the effects of wind loads on cooling towers, specifically looking at the effects of the wind direction on interference based on wind tunnel experiments. Due to space limitations, cooling towers and surrounding buildings (e.g. engine) need to be built closer together. This could result in interference effects leading to a locally increased wind load. However, if the separation of the buildings is below a minimum value, the standards require wind tunnel tests. As an alternative, a direction dependent assumption of the wind load could lead to a quick and practical approach. This could lead to a more economic estimate as areas where no increase in wind load is necessary can be identified and the loading approach optimised.

Koss described the determination of design wind loads for flexible structures. Specifically he concentrated on the comparison of calculating internal forces using static equivalent loads (SEL) and results from wind tunnel tests for a steel frame building. He investigated the accuracy of determining wind design loads for flexible structures based on the use of SEL. Displacements, bending moments and internal forces were compared with varying results for the different variables. A difference of 5% underestimation and up to 10% overestimation between the two methods was regarded as acceptable. It turned out that the SEL method is

not always a conservative approach, but can lead to an underestimation of more than 5% and thus is associated with some degree of doubt. This underestimation was even greater for the vertical support load. Despite the problems described above, Koss suggested that the use of SEL can still lead to acceptable design values as long as the problem of local pressure fluctuations is taken into account.

Nicole Metje

❖ WES Website

Last newsletter I report that the website was currently undergoing a transition from to a new server. The committee has taken the decision to also revamp the site and in doing so bring it into line with disability legislation. It is expected that the new site will be roled out at the end of September.

Mark

❖ The Three Little Pigs Project

The "Three Little Pigs" Project: Testing Full-scale Houses and Light-frame Buildings to Destruction using Realistic, Extreme Environmental Loads

Damage due to natural hazards has increased dramatically in recent years, incurring losses of life and property around the world. Low buildings, and in particular housing, often bear the brunt of this damage. In 1992, Hurricane Andrew hit south Florida, destroying 20,000 houses and causing US $30 billion in damage. If the storm had tracked 50 km further north, the resulting damage costs have been estimated at over US $100 billion.

Houses and other light-frame structures, in spite of their apparent simplicity, are among the most complex structural assemblies. This complexity comes from the highly redundant yet vaguely defined structural system that is not so much "engineered" as "proportioned" based on experience and historical construction practices. The redundancy of these structures makes it extremely difficult to accurately predict how extreme environmental loads, such as wind-induced pressures and drifting snow loads, are distributed through walls, roofs, floors and all their connection points. Full-scale component tests and static loading of complete structures, which have been done on these structures, do not adequately predict their true behaviour under realistic, transient wind loads. Thus, the precise response mechanisms up to failure are not yet known.

A group of 10 North American researchers has been awarded $2.7M from the Canada Foundation for Innovation (CFI) to construct a facility that will be used to apply simulated and naturally-occurring loads to instrumented full-scale houses and low buildings of light-frame construction to investigate the way in which these structures respond and ultimately fail under these loads. This research facility has been dubbed the 'Three Little Pigs' facility; a rendering of the facility is shown on the front page of the newsletter. Two buildings are shown: the test building and a smaller instrumentation building. The test building will contain the built test 'building specimen'. Around this specimen is the reaction frame, to which the loading system will be attached. A 'shell' structure will surround both the test specimen and the reaction frame to protect the loading system from the elements. In order to expose the test specimen to naturally-occurring wind, snow and rain loads the shell structure will be on rails and hence removable; i.e. the house can be loaded with the simulated wind loads under the shell structure, and then exposed to rain and natural wind.

The total cost of the facility is $6.8M. It is anticipated that the Ontario Innovation Trust will match the CFI's contribution ($2.7M) and the remaining 20% ($1.4M) of the total cost is to be obtained from industrial partners. The facility is to be located near the city of London, Ontario, Canada. The principal investigators of the research to be conducted at this facility are primarily from the University of Western Ontario, home of the Alan G. Davenport Wind Engineering Group. These include: F. Michael Bartlett, Ashraf ElDamatty, Jon Galsworthy, Hanping Hong, Diana Inculet, Greg Kopp, Eric Savory, Dave Surry, and Peter Vickery. Dr. David Rosowsky of Oregon State University is also one of the co-Principal Investigators.

Realistic wind loads, which vary both in time and in space, will be simulated in this facility using a novel 'pressure box' system. The fluctuating pressure loads will follow wind tunnel generated time series. The pressure box system will apply fluctuating pressures and suctions to the

surfaces of the building specimen, avoiding the need for 'point' anchorages required by a system of hydraulic actuators. The 'pressure box' system will be comprised of up to 100 mini-units similar to the BRERWULF system, which was developed to apply unsteady pressure loading to roofing panels by Dr. Nick Cook, formerly at the Building Research Establishment (BRE) in the United Kingdom. Dr. Cook is part of the team who is expected to develop the new pressure box system for this project. The mini 'pressure boxes' will be attached to the surface of the test building specimen and will vary in size from 2ft x 2ft up to 8ft x 8ft or so.

Rain often accompanies extreme wind events and enters structures through cracks, openings around windows and vents, windows broken by wind-borne debris, or infiltrates through the surface. This is a complex phenomenon that can destroy the contents of the house or lead to mould growth that occurs when water cannot evaporate. The 'Three Little Pigs' facility will be used to assess the factors influencing the ingress of moisture due to wind-driven rain. The quantities of water entering the house through cracks (both artificially created and those arising from severe loading), vents, breached windows, etc., will be determined. The role of internal pressure and their distributions in the different compartments of a house on water ingress into the structure will be investigated under natural wind conditions. The development of mould growth under realistic environmental conditions will also be investigated.

It has been argued that the failure of many structures during extreme storm events is due to poor construction practices. The 'Three Little Pigs' research facility will be used to gather information on the human error during construction, which will then be correlated with the measured performance of the test building as a whole.

Construction of the facility is to begin in Spring 2005 and be fully operational in Fall 2006, when testing of the first house specimen will begin. If you would like any further information about this project, or would like to contact one of the researchers about a specific topic mentioned here, please contact the author at:

Boundary Layer Wind Tunnel Lab
The University of Western Ontario
London, ON N6A 5B9
email: lms@blwtl.uwo.ca.

Funding for the preparation of the CFI proposal and preliminary research for the project was provided by the Institute for Catastrophic Loss Reduction and the Natural Sciences and Engineering Research Council of Canada.

Lizeanne St. Pierre, M.E.Sc.
Project Manager, Three Little Pigs Facility
The University of Western Ontario

❖ 6th UK Conference on Wind Engineering (WES 04)

15th - 17th September, 2004

And also a special one-day conference jointly supported by the

Royal Meteorological Society and the Wind Engineering Society on

'Extreme winds and developments in modelling of wind storms'

15th September, 2004

to be held at Mitchell Hall, Cranfield University, UK

'Extreme winds and developments in modelling of wind storms'

This special one-day conference is to be held on Wednesday 15th September, 2004 on the subject of Extreme Winds. Three sessions are planned, the first on Meteorology of Strong Winds with an invited paper by Prof. Keith Browning, the second on Modelling Wind Storms chaired by Prof. Lord Julian Hunt and the third on Engineering Application with an invited paper by Prof. Nick Cook. The engineering application will include design wind speeds and wind statistics such as information for pedestrian winds, dispersion and fatigue studies. Papers on aspects of wind and its application to engineering have been requested.

One-page abstracts were requested by 31st March, 2004. Accepted abstracts will need to be developed into extended abstracts of four pages in length and be submitted by 13th August, 2004. These will be bound into a single volume of conference papers available to delegates on arrival.

6th UK Conference on Wind Engineering (WES 04)

This will continue on 16th and 17th September and full registration to the conference will include the special one-day conference on 15th September.

Papers on any aspect of wind engineering can be accepted. Topics in the past have included Bluff Bodies, Street Level Environment, Model, Full-Scale and Desk Studies, Wind Characteristics, Buildings, Dynamics, Fatigue, and CFD.

REGISTER NOW

Please register your interest in these conferences by contacting eileen@ukwes.org More details are available on the Wind Engineering web site @ www.ukwes.org

Both conferences will be held at Mitchell Hall on the Cranfield University Campus. Accommodation is available at the conference venue. Booking details from eileen@ukwes.org

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Roger Hoxey

❖ About WES

ICE Support
Our contact at the Institution for all administrative support has for a number of years been Eunice Waddell. Eunice has performed all her work with great efficiency and enthusiasm. We wish her well in her new role and are confident that she will also excel at this. In the short term Kate Davies will be She can be contacted at
Tel: 020-7665-2238
Fax: 020-7799-1325
e-mail: kate.davies@ice.org.uk
WES website www.ukwes.org

❖ Forthcoming WES Meetings

The following meetings are suggested for this year. Unless stated otherwise all meetings will be held at the ICE from 6 pm.

2 November 2004 Rail aerodynamics.

2 February 2005 Wind tunnel projects.

❖ Other Forthcoming Conferences

2004

- **ERCOFTAC SIG.5** is holding its next meeting on September 9-10th at the University of Nottingham on the topic of Urban Scale CFD

- **6th WES Conference**
  Cranfield University
  15 –17 September 2004

2005

- **10th Americas Conference on Wind Engineering (10ACWE)**
  Baton Rouge, Louisiana, U.S.A., May 31 - June 4, 2005
  http://www.10ACWE.lsu.edu

- **EACWE 4. The fourth European & African Conference on Wind Engineering.**
  Prague, 11-15 July, 2005
  http://www.itam.cas.cz/eacwe2005

- **The sixth Asia-Pacific Conference on Wind Engineering (APCWE VI)**
  Seoul, Korea, September 12-14 2005
  http://apcwe-vi.kaist.ac.kr

2007

- **12th International Conference on Wind Engineering (ICWE12)**
  Cairns, Queensland, Australia, 1 – 6 July
  www.awes.org/icwe12

❖ Contact Point

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Please help to fill this space by contributing news clippings, people news, details of key projects or facilities that might interest others or notices of new books and meetings.

❖ Draft WES04 Programme

WEDNESDAY Morning	9.00	Registration from 9.00 in Mitchell Hall reception area.	
	10.00	**Tea/Coffee**	
	10.30	**WELCOME Paul Freathy WES Chairman**	
		Extreme winds and the ABL : Chairman: Peter Clark	
	10.40	'Sting Jet': source of the most damaging winds in extra tropical cyclones (I.1)	***K. Browning***
	11.20	Probabilistic prediction of extreme winds using ensembles (32)	K. R. Mylne, ***A. Arribas***
	11.40	Equivalence of anemometry for extreme wind monitoring (30)	***A.D. Quinn***
	11.55	Pressure and velocity fluctuations over a rural environment (3)	C.J. Baker, ***M. Sterling***, A.D. Quinn, R.P. Hoxey
	12.15	Spectral properties of discrete vortex structures (39)	***R.P. Hoxey***, A.D. Quinn, P.J. Richards
		Discussion	
	12.40	**LUNCH**	
WEDNESDAY Afternoon		**MODELLING METHODS -** Chairman: Chris Baker	
	13.30	Recent developments in the mesoscale modelling of coastal and detached wind jets (I.2)	***A. Orr***, J. Hunt, J. Sommeria, C. Wang, D. Cresswell
	14.00	Modelling response of mid-latitude storms to climate change (15)	***R. McDonald***
	14.20	Regional extreme wind climates and local winds (17)	***J. Mann***, H. Jørgensen
	14.40	Uncertainty modelling in wind storm loss evaluation. (23)	P. Rockett
	15.00	**TEA/COFFEE**	
		WIND ENGINEERING APPLICATIONS - Chairman: Ian Harris	
	15.20	Penultimate distribution of extreme wind speeds (I.3)	***N. Cook***
	15.50	Extreme winds and the connection to reanalysis data (16)	***X.G. Larsén***, J. Mann, H.E. Jørgensen
	16.10	The setting of operational wind limits for transport systems (24)	***D.M. Deaves***, W.M.S. Bradbury
	16.30	Extreme wind speed climatology in the United States Mid-West (40)	***C. Letchford***, M. Ghosalkar
	16.50	Modelling local wind distribution based on short-term measurements (34)	***A.D. Quinn***
	17.10	**DISCUSSION - CONCLUSIONS**	

THURSDAY Morning		**WELCOME**	
		BRIDGES Chairman James Brownjohn	
	8.30	Introductory paper: Wind induced response of Kessock Bridge (I.4)	***J. Owen***
	9.00	Quasi-steady analysis of dry inclined cable galloping in the critical Reynolds number range (1)	***J.H.G. Macdonald***, G.L. Larose
	9.20	Vortex induced vibrations of Kessock Bridge using CFD (28)	***D.K. Sun***, N.G. Wright, J.S. Owen, K. Liaw
	9.40	Numerical investigation of the effects of pedestrian barriers on aeroelastic stability of a proposed footbridge (20)	***I.J. Taylor***, M. Vezza, I Salisbury
	10.00	**Discussion**	
	10.10	**Poster Presentations**	
		An evaluation of CFD simulation using RANS turbulence models for dispersion around buildings (P1)	***X. Wang***, K.F. McNamara
	10.30	**TEA/COFFEE**	
		SLENDER STRUCTURES AND UNSTEADY FLOW Chairman John Macdonald	
	11.00	Full-scale measurements on a tall building to compare dynamic and quassi-static response to wind (4)	***J. Brownjohn***
	11.20	Hybrid use of GPS monitoring and FEM analysis to detect integrity of buildings (25)	***A. Yoshida***, Y. Tamura
	11.40	Unsteady wind effects on chimneys – model scale data and comparison with theory (10)	***Y-H. Chiu***, D.W. Etheridge
	12.00	Fluctuating flow field pressure measurements using condenser microphone – based static pressure probe (7)	***S.C. Yaragal***, Y. Tamura
	12.20	Investigation into the influence of the orifice on the performance of a liquid column damper (9)	***Shane Colwell***, Biswajit Basu
	12.40	Discussion	
	12.50	**LUNCH**	

THURSDAY Afternoon			
		WORK IN PROGRESS – Chairman Ian Castro	
	13.45	New measurements on the structure of urban-type boundary layers (21)	***R.T. Reynolds***, I.P. Castro
	14.00	LES and DES of flow around cylinders (27)	***KF. Liaw***, N.G. Wright, J. S. Owen, D. Sun
	14.15	Flow over a cube in a thick boundary layer – revisited (35)	***H. Lim***, I.P. Castro, R.P. Hoxey
		URBAN WIND ENVIRONMENT – Chairman: Paul Blackmore	
	14.30	Introductory paper (I.5)	***P. Freathy***
	14.50	Modelling airflow in urban open spaces (13)	***W. Li***, F. Wang
	15.10	Masterplanning: Large scale environmental wind engineering (36)	***B. Vazquez***, G. Knapp
	15.30	The development of the naphthalene sublimation technique to model convective heat transfer from external building surfaces (18)	***J. Smith***
	15.50	**TEA/COFFEE**	
		EXTERNAL AND INTERNAL FLOW – Chairman David Etheridge	
	16.10	The simplified method of estimating total pressure at opening of cross-ventilated building (29)	***M. Ohba***, T. Goto, A. Kurahashi, T. Kurabuchi, Y. Akamine, T. Endo
	16.30	A numerical and experimental study of airflow around and within a cross-ventilated building (31)	***C. Hu***, M. Ohba
	16.50	External flow effects on the discharge coefficient of ventilation openings (11)	***Y. Chiu***, D. Etheridge
	17.10	Comparison of wind tunnel and CFD modelling of airflow over an offshore platform helideck (14)	S. Howell, E. Ferrer, ***E. Garry***
	17.30	Close	
	20.00	**CONFERENCE DINNER**	

FRIDAY Morning		**WELCOME**	
		WIND LOADS – Chairman Nigel Wright	
	8.30	Wind tunnel tests on low-rise cylindrical roofs (6)	***G. Breeze***, P. A. Blackmore, E. Tsokri
	8.50	Codification of wind pressures on barrel-vault roofs (5)	***P. Blackmore***, G. Breeze, E. Tsokri
	9.10	Wind loading on conic shaped roofs (19)	***J. Burton***, P.D. Gosling
	9.30	The application of 2D CFD simulations to the study of the wind flow around a semi-cylindrical structure (22)	D. Taylor, ***A. Aguilø***, R. Wiltshire, A. Quinn
	9.50	The use of CFD in structural engineering (26)	***G. Knapp***, N. Wright, J. Owen
	10.10	**TEA/COFFEE**	
		FLOW PROBLEMS – Chairman Ian Taylor	
	10.40	Spanwise variation in developing rough-wall boundary layers (33)	***P. Hayden***, R.T. Reynolds, I.P. Castro, A.G. Robins
	11.00	Separating 2D and 3D turbulence – Implications for Wind Tunnel and CFD modelling (38)	***P.J. Richards***, B.D. Connell, D.P. Lander
	11.20	The effects of the slipstreams of passing high speed trains on waiting passengers (2)	***C. Baker***, M. Stirling
	11.40	Pressure-wave loading from a large road-vehicle and response of a cantilevered traffic signal mast (8)	***A. Robertson***, A. Quinn, E. Rees
	12.00	Aerodynamics of 2D wind-borne debris in wind-tunnel and full-scale tests (12)	***C. Letchford***, N. Lin, J.D. Holmes
	12.20	Solutions of the debris equations (37)	***C. Baker***
	12.40	Close – Paul Freathy	
	13.00	**LUNCH and DEPART**	