Air
Infiltration
Review

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International Energy Agency - AIVC

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Multiple Steady Airflows and Hysteresis When Wind Opposes Buoyancy

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The airflow in a naturally ventilated building is driven by a combination of both wind and buoyancy (stack) forces. Wind creates pressure forces on the building exterior which may assist or oppose the buoyancy-driven flow depending on the location of the ventilation openings, the wind speed and wind direction. The wind force is usually larger than the buoyancy force and is likely to have a significant impact on the buoyancy-driven airflow. We focus here on flows established in buildings with low and high-level openings such as those designed to encourage displacement ventilation. In this mode and in the absence of wind, localised heat sources within the space create a region of warm air above a cooler layer. Warm air flows out through the upper openings and draws in fresh air through the lower openings. For the simplest case of a single heat source at floor level, a steady two-layer thermal stratification results. An assisting wind induces positive wind pressure (or a 'push') at the lower openings and negative wind pressure (or suction) at the upper openings. For opposing winds the reverse is true. Positive pressures normally occur on windward façades and negative pressures in the lee and on the roof.

Research, using a combination of small-scale laboratory experiments and theoretical analysis, has revealed how the steady buoyancy-driven airflow rates and thermal stratification are affected by wind.

Assisting winds

Previous wisdom was to assume the interior was well mixed when the wind blew, but the stratified interior established in the no-wind case is (surprisingly) maintained even at high wind speeds (see Figure 1). Although weak, and contributing little to driving the ventilating flow, the buoyancy force is still able to set the thermal stratification. The rate of airflow and cooling is

In this issue

significantly enhanced compared to the no-wind case [1]. A key design consideration regards the thickness of the warm upper layer. This thickness is set by the dimensionless ratio of wind and buoyancy produced air speeds, known as the Froude number *Fr*, and decreases as *Fr* increases.

Opposing winds

Our research has shown that an opposing wind leads remarkably to the possibility of three different steady flows for the same wind speed. Of these three flows, one is unstable and therefore likely to be maintained for only a short period in practice. The two remaining flows, a displacement and a mixing flow (see Figures 2a & b), are stable and yield dramatically different temperatures and flow rates for the same wind speed. The flow realised in practice depends on the time history of the system as illustrated in Figure 3.

If the wind speed gradually increases (from A towards B, Figure 3) the upper layer gets deeper and hotter, the flow rate decreases, and the displacement flow may persist for a wide range of wind speeds giving poor ventilation. At still higher wind speeds (e.g. point C, Figure 3), or for a sharp increase in wind speed, a transition from displacement to mixing flow occurs (the flow rate 'jumps' from C to D) resulting in a significant decrease in the average air temperature and a reversal in the direction of airflow through the space. Further increases in wind speed (move from D towards E) now enhance the airflow rate and cooling.

Alternatively, if a mixing flow is established by a strong wind (point E) and the wind speed then decreases (move from E towards F), the flow rate decreases and the space gets warmer until at a critical wind speed (Fr_{crit} at F) the flow reverts to a displacement flow ('jump' from F to G). The displacement flow is maintained for further decreases in wind speed (move from G to A).

Hysteresis is apparent as the wind speed required to bring about flow transition is different depending on whether the wind speed increases or decreases; larger wind speeds are required to make the transition from displacement to mixing. Note, for $Fr > Fr_{crit}$ both displacement and mixing flows are possible at each value of *Fr*.

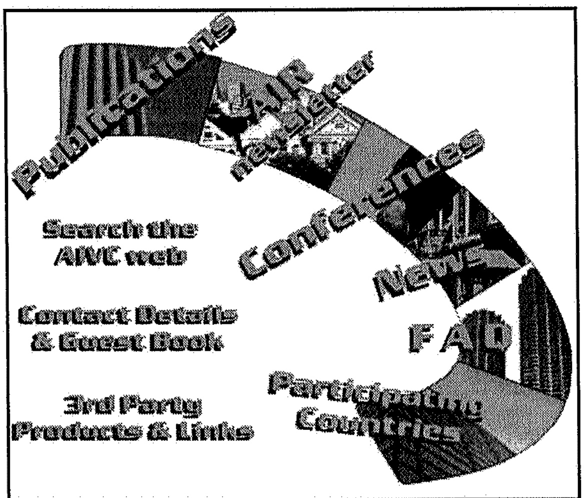
For further information please contact G.R. Hunt.

References

[1] HUNT, G.R. & LINDEN, P.F. 1997 Passive cooling by natural ventilation: salt bath modelling of combined wind and buoyancy forces. *Proceedings of the 18th AIVC Conference on Ventilation & Cooling*, Greece, **1**, 175–183. ISBN 0-946075-95-6.

[2] HUNT, G.R. & LINDEN, P.F. 1999 The fluid mechanics of natural ventilation - displacement ventilation by buoyancy-driven flows assisted by wind. *Building and Environment*, **36**, 707-720.

Air Infiltration Review



International Energy Agency

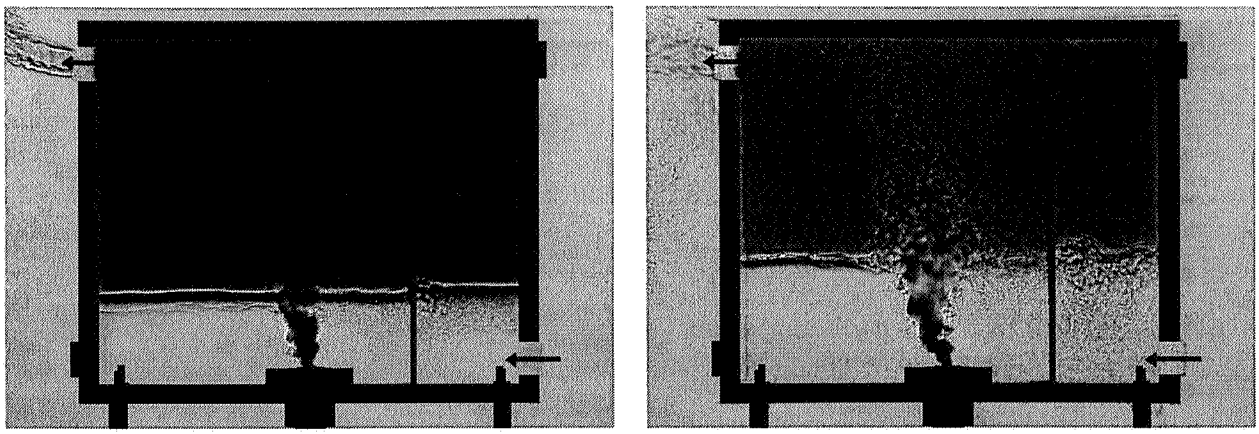
AIVC

Air Infiltration and Ventilation Centre

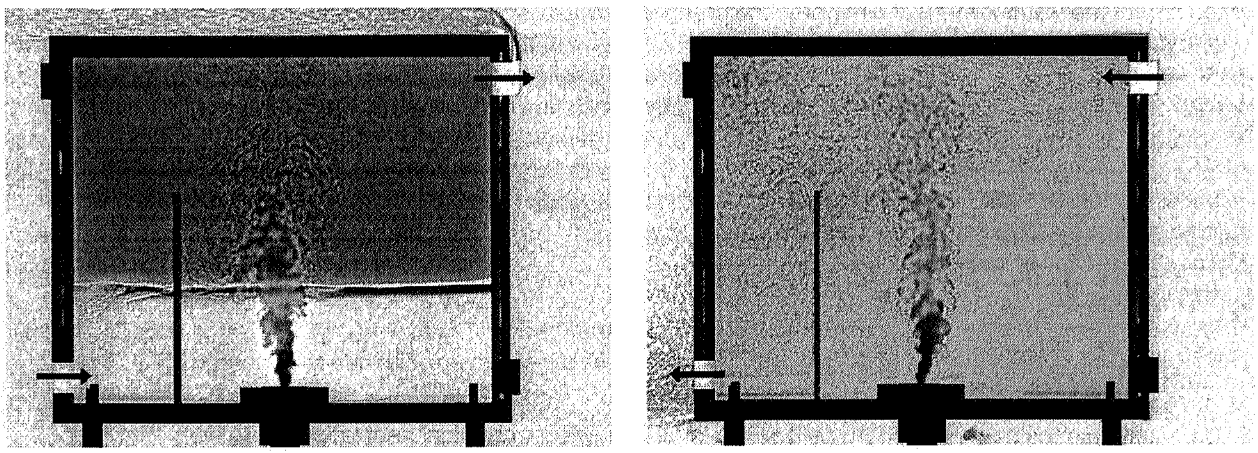
Air Infiltration Review has a quarterly circulation of 3,500 copies and is distributed to organisations in 40 countries. Short articles or correspondence of a general technical nature related to the subject of air infiltration and ventilation are welcome for possible inclusion in AIR. Articles intended for publication must be written in English and should not exceed 1,500 words in length. If you wish to contribute to AIR, please contact the Air Infiltration and Ventilation Centre. Please note that all submitted papers should use SI units.

Edited by Janet Blacknell

AIR is also available online at www.aivc.org



Figures 1a and 1b. Steady displacement flows, a) solely buoyancy-driven flow (Fr = 0), and b) buoyancy-driven flow assisted by wind (Fr = 9). In b) the wind direction is from right to left. Note the thickness of the upper layer is reduced in b). The change in the shade of grey between the images, from dark grey in a) to light grey in b), is indicative of a reduction in temperature. Images shown were taken during experiments using the 'salt-bath' technique. The turbulent plume rising from the buoyancy source can clearly be seen. Arrows indicate the direction of flow through the openings. The vertical line extending from the floor to approximately two thirds of the enclosure height is a gauze baffle that was used to prevent the plume from being deflected by the inflow through the lower openings.



Figures 2a and 2b. The two stable steady flows produced by the same (opposing) wind speed, a) displacement flow, b) mixing flow. Wind direction in a) and b) is from right to left. Vent areas, wind speed and heat gains are identical in a) and b). Note the reversal in flow direction between a) and b). The air temperature is approximately uniform throughout the interior in b).

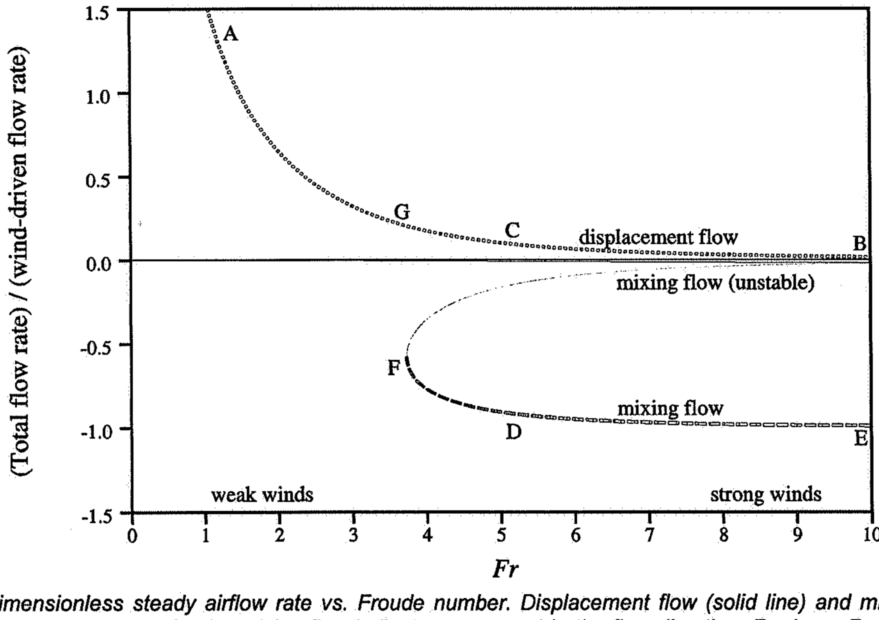


Figure 3. Dimensionless steady airflow rate vs. Froude number. Displacement flow (solid line) and mixing flow (dashed line). The negative flow rate for the mixing flow indicates a reversal in the flow direction. For large Fr read 'large wind speed' and for small Fr read 'small wind speed'. For illustrative purposes the predictions are shown for a dimensionless effective opening area (see, for example [2]) of 0.05.

ASHRAE Presidential Press Briefing Focuses on Ventilation

ASHRAE DALLAS Meeting February 2000

Report by Martin W. Liddament

The Winter ASHRAE meeting began with a press briefing by the ASHRAE President, Harley Goodman on indoor air quality and the development of ASHRAE Standard 62 on minimum ventilation rates. In his address, Harley Goodman stated that, in the last two decades, much progress has been made in improving outdoor air quality. During this same time, however, buildings have become tighter, ventilation rates reduced and many new contaminants have been detected. As a result, indoor pollutant levels are often four or five times higher than outside levels. He noted that people spend almost 90% of their time in buildings of which 65% is spent in the home and that more than half the problems of indoor air can be attributed to improperly operated or poorly maintained heating, ventilation and air conditioning systems.

He drew attention to new and recently published ASHRAE Standards, which impact on indoor air quality. These include:

- Standard 90.1 – 1999 Energy Standard for Buildings Except Low Rise Residential: This establishes minimum energy efficiency levels for buildings, cuts energy costs and short ens design time;
- ASHRAE IAQ standard 62 – 1999, Ventila tion for Acceptable Indoor Air Quality: this recently published version incorporates four new addenda and forms the basis for almost all ventilation requirements for North Ameri can Building Codes;
- ASHRAE Standard 52.2 – 1999 Method of Testing General Ventilation Air Cleaning De vices for Removal Efficiency by Particle Size: This rates the efficiency of filters by the size of particles they remove from the air. It pro vides information on the performance of spe cific filters, allowing designers and building operators to choose filters based on the char acteristics of the contaminants found in build ings.

Draft ASHRAE Standard 62.2 on the Ventilation of Low Rise Dwellings Rules out Natural Ventilation.

Max Sherman of the Lawrence Berkeley Laboratory (and chairman of Standard Committee 62.2) presented, at the Presidential Press Breakfast, an update of the proposed new residential ASHRAE Standard 62.2 entitled Ventilation and Acceptable Indoor Air Quality in Low Rise Residential Buildings. Max stated that this standard focuses on developing the minimum requirements necessary to achieve acceptable indoor air quality for dwellings such that indoor air will not likely pose a significant health hazard and will not be irritating or have unacceptable odours. This first public review draft was published in December 1999 and is aimed at a radical restructuring of domestic ventilation. Key aspects include requirements for:

- Fume spillage testing for all combustion ap pliances;
- Whole house (continuously operating) me chanical ventilation;
- Carbon monoxide detectors in all dwellings;
- Operable windows in most occupied rooms;
- A single infiltration contribution to be factored into the overall air change regardless of ac tual building air tightness.

While conceding that most present houses in the United States get more than enough ventilation from infiltration to satisfy basic needs, many new houses are much tighter and require additional ventilation. Max Sherman went on to say that, "While poking holes in houses would increase the infiltration, the most cost effective way to provide basic ventilation into new construction is to install a small, continuously operating, whole house ventilation system."

ASHRAE Meeting Technical Sessions and Issues Currently being Addressed by ASHRAE

Important areas relating to ventilation and indoor air quality that formed the basis of technical sessions at the ASHRAE Meeting included:

Symposium on Airtightness, Ventilation, Indoor Climate and Energy Performance of Small Commercial Buildings: This symposium covered topics on monitoring airtightness, the impact of airtightness measures on comfort , air quality and well-being and ventilation strategies incorporating airtight design;

Symposium on Building Mass Thermal Storage: Ventilation combined with thermal storage of the building mass can play a key role in providing for energy efficient cooling. Various design, control strategies and case studies were presented. This demonstrated good potential for thermal storage as a means of temperature control in both heating and cooling seasons is possible.

Museums, Libraries and Historical Buildings: This group is investigating the differing requirements between the need to provide for human comfort and the need for preservation of the building fabric and artefacts;

Aircraft Cabin Air Quality: An ASHRAE Standard on aircraft cabin air quality is currently being prepared. Issues under discussion include identifying contaminants and associated acceptable thresholds, and identifying outdoor air ventilation rates and filtration performance;

Smoke Management Design for Large Spaces and Atria: Smoke control management is aimed at providing a safe exit in buildings in which atria are open to occupied spaces;

COMTAM for Windows (Beta version now being tested)

CONTAM is the multi-zone airflow and contaminant transport algorithm developed by the United States Institute of Standards and Technology (NIST). It uses a graphical interface to build up a flow network and has extensive procedures for calculating pressures and air flows due to wind, stack and mechanical systems. It also simplifies data output and the running of ventilation schedules and weather sequences. Originally available as a 'PC' DOS based program, a Windows version is now being tested. The latest public version of CONTAM and all the associated documentation can be downloaded from ftp.nist.gov . Go to the 'PUB' directory and select the CONTAM directory. It is anticipated that the Windows version will be available shortly.

For more information about these and other activities at ASHRAE please contact Martin W Liddament at the AIVC.

Events for Your Diary

ASHRAE Symposium: Experimental Validation of Multizone Network Airflow Models

27 - 31 January 2001

Venue: Atlanta, GA, USA

Contact: Amy Musser, 100 Bureau Drive Stop 8633, Bldg. 226 Rm. A313, Gaithersburg, MD 20899-8633, USA, Fax: +1 301 975 5144, email: amy.musser@nist.gov

Topics:

This symposium will describe experimental efforts that have been made to verify multizone network airflow modelling techniques for analysing infiltration, indoor air quality, and other engineering situations.
Abstract deadline March 15th, 2000,
Paper deadline, May 15 2000.

Bioaerosols and Particulates in Indoor Air - Health Effects: the Role of Ventilation - Seminar

8th November 2000

Venue: Chartered Institute of Building Service Engineers (CIBSE), London, UK

Contact: George Leslie, International Society of the Built Environment (ISBE), PO Box 73, Buckden, Cambs., PE18 9SS, Great Britain, Tel: +44 (0)1480 810687, Fax: +44 (0)1480 810768, email: george.leslie@nationwideisp.net

Topics:

The seminar will cover airborne infectious diseases, allergens, particulates, and papers on ventilation systems, ductwork and filters.

Wind and the Built Environment - Engineering a Solution

by Philippa Westbury and Earle Perera, BRE, UK

The way that wind moves around a building has a direct influence on the performance of HVAC and smoke control systems whether these are mechanical or natural. If systems are designed without an understanding of the local wind climate they may not function properly, leading to possible failure in use, poor air quality, occupant discomfort, and in extreme cases, safety risk.

Wind behaviour is complex, and accurate predictions of how it will interact with a particular building are not straightforward. Wind pressures on the building are dependent not only on the building shape, but also the form and layout of the surrounding buildings, the local topography, the nature of the upstream terrain (is the building in an urban, suburban or rural location?) and the building's geographical location.

Sources of wind data

Empirical information on wind pressures for building services design is available, but it covers a limited number of building shapes, and does not take into account the detailed effects of a building's surroundings. When a building and its surroundings cannot be represented simply, it can be modelled physically in a wind-tunnel test that will provide information on external pressure coefficients, wind speeds and wind flow patterns. This will be especially important if:

- the building shape and/or roof design are unusual
- the building has an innovative natural ventilation design strategy
- the building and/or its neighbours are high-rise (and therefore may produce strong downdrafts)
- the building is very sheltered or parts of the building are underground (important when considering natural ventilation strategies)
- the local topography is unusual
- there are architectural constraints which necessitate unconventional ventilation designs, and require an 'engineered' solu tion.

Wind-tunnel modelling

The wind tunnel represents the wind flow appropriate to the upstream terrain; that is to say, the velocity profile and turbulence or 'gustiness' in the upstream flow are correctly characterised. The model is mounted on a turntable, so that all wind directions can be considered.

Measurements of surface wind pressures (using pressure probes connected to surface locations on the building) and local wind speeds (using hot-wire or pulsed-wire velocity probes) are carried out for each wind direction. Wind frequency data for the site can be combined with wind-tunnel measurements to calculate probabilities that a particular surface pressure or wind speed will occur. Flow visualisation using smoke, along with photography and video-filming, can be used to reveal flow patterns, which provides a qualitative understanding of wind effects. In addition, the 'sand-scouring' technique can be used to identify locations where high-speed wind flows at pedestrian level are likely - sand is distributed evenly around the building development, and subsequently scoured away where the wind speeds are high.

Impact of wind on HVAC design

Wind affects intake and exhaust flow rates, infiltration and exfiltration and interior pressures. It can also cause recirculation of a building's exhaust gases or traffic exhaust back into the intake.

Surface wind pressures obtained from wind-tunnel tests can be used to determine the optimum locations for intakes and exhausts, and fan size. If intakes or exhausts are placed in regions of strongly positive pressure (on the upstream side of the building) or negative pressures (on the roof or downstream side), the wind acts in series with the system fan, and the flow will either be enhanced or opposed. Large ventilating fans may even stall under strong wind conditions. When designing smoke control vents, it is particularly important that strong positive surface pressures do not oppose smoke clearance. Wind pressure data may be especially useful if there is a possibility that adjacent tall buildings cause downdrafts, which result in strong positive pressures. Tests may also be necessary if the building's form or roof shape is unusual, in which case no accurate empirical data will be available.

Wind will have most impact on low-pressure systems, and in some cases may even affect the performance of medium-pressure systems (~250Pa). A robust design will perform well for all wind directions, and not only the prevailing wind direction.

Wind-tunnel testing can also be used to assess the likelihood of cross-contamination between building exhausts and ventilation intakes. In this case, tracer gases of known concentration are introduced from the exhaust stacks, and measurements of the pollutant levels at various inlet locations are made, for a range of wind speeds and directions.

Case study

Wind tunnel testing was used to support HVAC design for a prestigious office development in Central London with an unusual vaulted roof. The building services engineers required wind pressure data to assess the optimum locations of inlets and exhausts for the mechanical and heating systems. In addition, they wanted to assess the suitability of roof locations for the smoke control vents. The wind-tunnel tests confirmed that the intended locations of the smoke control vents were in favourable negative pressure regions. In addition, the tests demonstrated that the fresh air inlets were located in regions favourable to the entrainment of fresh air, and that air discharged from cooling towers would not enter these inlets. Finally, the tests showed that the cooling towers discharged clear of the building so as to prevent saturated vapour coming down onto the glass roof of the atrium.

Impact of wind on natural ventilation

Accurate predictions of surface pressures are often needed to determine the locations of inlets and exhausts for natural ventilation systems, and to size ventilation openings. Wind effects should be taken into account when designing natural smoke ventilation strategies – it is often the case that designers do not consider wind effects in detail, and a building control officer or design reviewer requires evidence that positive wind pressures will not adversely affect smoke ventilation.

Case study

Wind-tunnel testing was used to inform the design of the natural ventilation system for a public building in the South East. The ventilation strategy involved introducing fresh air through underfloor ducts and venting contaminated air through high level vents under the action of stack and wind pressures. In order to optimise sizes and locations of the ventilation openings, the building services engineers required data on external façade wind pressure coefficients. Pressure coefficients were obtained from a scale model tested in a wind tunnel, and fed into a computer prediction program used for evaluating ventilation rates. The ventilation rates for different ventilation configurations, internal surface temperatures, and a range of meteorological conditions were evaluated. A unique aspect of this approach was that the calculated ventilation rates were combined with local meteorological wind speed data in order to predict the statistical occurrence of design ventilation levels during the period when the building was occupied.

Impact of wind on pedestrian environment

As well as affecting the performance of HVAC systems, wind can also cause an unacceptable or hazardous environment for pedestrians. Buildings act as obstacles to the wind, and if they are relatively tall, say over 15 metres, they can deflect high level, high speed winds down to street level. For this reason, wind speeds around a tall building can be much higher than the equivalent wind speeds for an open site. Locations in which wind speeds may be problematic include

- the upstream side of a tall building
- near to the corners of the building
- particularly in passageways which connect the upstream (high pressure) and downstream (low pressure) sides of the building at ground level.

High wind speeds can also reduce the commercial success of a development such as a shopping mall, making shoppers reluctant to visit the site, and businesses reluctant to lease space. If wind speeds are very strong, damage to buildings may result. Measures to remedy these problems (e.g. canopies, baffles) may become necessary, but these are usually costly and may also compromise the architectural design of the development.

To avoid these problems it is important to consider wind effects as part of a desk assessment study, when the site layout, building form and location is being decided. Later on in the design, more quantitative wind speed data may be required for obtaining planning approval, at which stage wind-tunnel testing can be used. The wind-tunnel testing process is an interactive process, in which the building designer works alongside the wind engineer, in order to balance the environmental and architectural constraints. In practice, it may be possible to test a number of building configurations or wind shelter devices in order to optimise the design.

Wind-loading data for structural design

It is often the case that wind pressure data are required by the structural engineer as well as the building services engineer, to inform the structural design. In this case, it is possible to carry out all the necessary measurements within the same programme of wind-tunnel testing, using the same scale model.

Conclusion

The impact of wind on a building's environmental performance is an important consideration for designing effective and energy-efficient HVAC systems. In cases where insufficient empirical data is available, or where wind effects may be critical, wind-tunnel testing provides accurate wind pressure and wind speed measurements. Determining the effects of wind on the surrounding area enables designers to provide comfortable and safe environments for pedestrians.

For further details of environmental wind engineering advice and testing, please contact Dr Philippa Westbury on (tel) 01923 664593, (fax) 01923 664796 or (email) <westburyp@bre.co.uk>.

References

(1) Orme, M, Liddament, M and Wilson, A, "An Analysis and Data Summary of the AIVC's Numerical Database", AIVC TN 44, Air Infiltration and Ventilation Centre, 1994.

(2) Liddament, M, "A Guide to Energy Efficient Ventilation", Air Infiltration and Ventilation Centre, 1996.

(3) BSI, BS6399-2:1997 "Loading for buildings: Code of practice for wind loads", British Standards Institute, 1997.

(4) HP Morgan et al., "Design methodologies for smoke and heat exhaust ventilation", CRC Ltd., 1999.

(5) MDAES Perera, R Tull and M White, "Assessing intake contamination from atmospheric dispersion of building exhaust", Proc. 12th AIVC Conference on Air Movement and Ventilation Control within Buildings, Volume 1, Air Infiltration and Ventilation Centre, 1991.

(6) A Luke, "Natural ventilation chimneys", Building Services Journal, July 1999.

(7) MDAES Perera, RR Walker and RG Tull "Natural ventilation for a Crown court: developing statistical assessment techniques at the design stage", Proc. 9th AIVC Conference on Effective Ventilation, Volume 1, Air Infiltration and Ventilation Centre, 1988.

(8) BRE, "Wind around tall buildings", BRE Digest 390, BRE, 1994.

(9) P Littlefair et al., "Environmental site layout planning: solar access, microclimate and passive cooling in urban areas", CRC Ltd (to be published December 1999).

Forthcoming Conference

Architecture, City, Environment
PLEA 2000 The millennium conference on Passive and Low Energy Architecture
The 17th International Conference on Passive and Low Energy Architecture

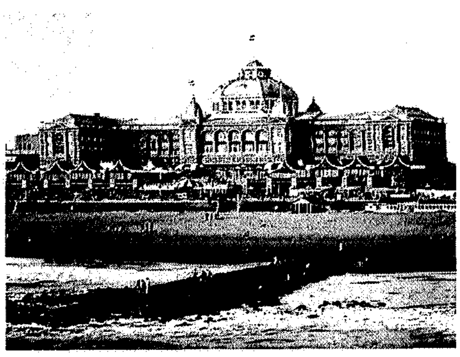
2-5 July 2000
Cambridge, UK
Ms Lynda Bryers, University of Cambridge, Programme for Industry, 1, Trumpington Street, Cambridge CB2 1QA, UK Tel: +44 (0)1223 342100, Fax: +44 (0)1223 301122, email cpi@hermes.cam.ac.uk
This 17th PLEA international conference addresses architecture and the city environment at the turn of the millennium. Taking place in the centre of the historic university city of Cambridge, and with a visit to the "Millennium Experience" in London, the conference objective is critically to review the past and stimulate innovation for the future. In order to promote the highest standards of contributions to the conference, all oral presentations of papers will be either invited or refereed. The conference subtopics are: low energy urban planning and design; modelling the urban environment; comfort in outdoor spaces; health and the urban environment; design tools; case study project; renewables; education; reuse and refurbishment.

Air Infiltration and Ventilation Centre
21st Annual International AIVC Conference

Abstracts - Extended Deadline 31st March 2000

Innovations in Ventilation Technology

Second Announcement and Call for Papers
September 26-29 2000
Steigenberger Kurhaus Hotel, The Hague, Netherlands



Aim of the Conference

Since 1980 the international conference of the Air Infiltration and Ventilation Centre has been an opportunity for specialists from AIVC participating and other countries around the world to meet and discuss current topics in the area of energy efficient ventilation in buildings.

AIVC 2000 will focus on a whole range of topics to be discussed, the most important being the latest innovations in ventilation technology, and recent topical concepts including sustainability, ventilation standards development, simulation and cooling issues.

The main objective of the conference is to consider specific information about the present state and development of ventilation strategies worldwide, discuss currently crucial topics and introduce implemented projects or solutions which have significantly contributed to finding new ways, methods and energy efficient procedures en route to sustainable building ventilation technology.

The conference is a forum for presentation of the latest ideas, experience and considerations in the area of ventilation through lectures, posters and informal discussion.

Themes of the Conference

- New developments;
- Integration of ventilation technology with cooling and heating needs;
- Ventilation monitoring and control systems;
- Case studies;
- Quantifying ventilation need;
- New guidelines and requirements;
- New developments in simulation and design;
- Coping with poor outdoor air quality.

CONFERENCE

Abstracts

Abstracts of proposed papers should be 300-500 words in length and submitted as soon as possible to the Conference Secretariat. Papers for the conference will be selected on the basis of received abstracts and authors will be notified in due course. Completed papers (up to 12 pages in length) will be required by 31st July 2000.

Authors may nominate their paper for full peer review to be considered for publication in a special edition of a recognised journal.

All presented papers received in time for publication (31st July 2000) will be published in the conference proceedings, which will also be available for sale from the AIVC Bookshop after the conference.

All authors will have the opportunity to make an oral presentation in plenary session.

Attending the Conference

The conference will take the form of full oral presentations and shorter oral presentations combined with poster displays.

To be held over four days, the overall cost will include three nights' bed/breakfast, one lunch, tea/coffee/refreshments, conference attendance, proceedings and Gala Dinner. A conference programme with full details will be circulated shortly. The overall cost will be £790.00 for delegates from AIVC member countries*, and £815.00 for delegates from non-AIVC countries. There is also a generous early payment discount for registrations received before 31st July 2000.

For further information please contact the Conference Secretariat:

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Conference Organiser
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Web: www.aivc.org.

Dust Mite Microhabitat Research at BRANZ

Dust mites are considered to contribute adversely to the incidence of asthma as well as to other respiratory allergies (Cunningham 1996). The viabilities of dust mites species depend heavily on the relative humidity of the air in the micro-environments inhabited by them. Thus, a mechanism by which they can be suppressed is dehydration. Previously, attempts have been made to reduce dust mite populations by lowering the ambient humidity for a continuous period of at least several weeks.

In recent years, Malcolm Cunningham of the Building Research Association of New Zealand (BRANZ) has been researching the measurement of temperature and humidity in dust mite microhabitats. One of his principal conclusions (1998) has been that some dust mite micro-environments have temperature and relative humidity profiles very different from ambient room conditions. This implies that controlling the ambient environment does not guarantee that dust mite numbers will be reduced correspondingly. Moreover, population studies have been made for steady state conditions, but in reality temperature and relative humidity each vary transiently. The effect of these changes could be, for example, a short term rise in relative humidity, which can re-hydrate the mites.

Typical dust mite micro-environments include carpet bases, bedding layers and inside furniture. Measurements within them require separations of only a few millimetres. However, existing humidity sensors are not sufficiently compact to achieve this. As a solution to this difficulty, Cunningham (1999) has developed a relative humidity sensor that is small enough for measuring humidities within the regions of interest.

In addition, a model has been developed for predicting microclimates, for example, within carpets. This is presently being validated in New Zealand and the USA (in Florida, for conditions controlled with for instance, air conditioning). This model also takes into account humidification in cold climates.

Cunningham M J (1996), "Controlling Dust Mites Psychrometrically - a Review for Building Scientists and Engineers", Indoor Air, Volume 6, pp. 249 - 258.

Cunningham M J (1998), "Direct Measurements of Temperature and Humidity in Dust Mite Microhabitats", Clinical and Experimental Allergy, Volume 28, pp. 1104 - 1112.

Cunningham M J (1999), "Development and Performance of a Small Relative Humidity Sensor for Indoor Microclimate Measurements", Building and Environment, Volume 34, pp. 349 - 353.

For additional information, Malcolm Cunningham can be contacted by email at: branzmjc@branz.org.nz

Forthcoming Conference

Cold Climate HVAC 2000
The Third International Conference on Cold Climate Heating, Ventilating and Air Conditioning

1-3 November 2000
The Hokkaido University Conference Hall, Sapporo, Japan
Scientific Secretariat, Professor Shintaro Yokoyama, Graduate School of Engineering Science, Hokkaido University, Kita-ku, Sapporo, 060-8628, Japan, Tel: +81 11 706 6281, Fax: +81 11 706 7890 or +81 11 706 6281, email: yokoyama@eng.hokudai.ac.jp, http://www.ec-inc.co.jp/cchvac2000/
The main purpose of the conference is to bring together the best expertise and knowledge on HVAC and related technology applied in the countries of cold climates. The conference is multidisciplinary and has a wide scope. It covers technical, ecological, environmental and economical aspects as well as those related to construction materials and technologies, regulations and standards. The third conference themes are listed below. Each topic area covers research, development, design, new applications and equipment, case studies or future trends: evaluation and control of indoor air quality; evaluation and control of indoor climate; new technology of heating system; new technology of ventilation and air conditioning system; heat recovery system; cold climate building design; low energy building; district heating system and distribution; exterior conditions and snow melting; urban environmental issues in cold climate regions.

AIVC Bookshop Publications

The AIVC Bookshop has an extensive stock of AIVC and other publications. Browse the AIVC Website on www.aivc.org to view the complete collection with summaries and tables of contents. To order any of the publications you see here, simply contact us with the order code and title, and your name, address and payment details, or order online using the shopping basket system.

In the following list, Order Codes appear in brackets e.g., (TN 50), prices for customers in AIVC non participating countries are listed first, followed by the discount price in brackets, e.g., £22.50 (£15.00). The discount price applies to customers in AIVC participating countries only, as listed on page 16 of this newsletter. Please note that some items are restricted to AIVC participants only.

FORTHCOMING

Use the order form to be placed on our forward orders list - you will be invited to order when the item is available.

Ventilation and Acoustics, Ling M K, due 2000 (TN 52) Restricted to participants (£30.00)

Occupant Impact on Ventilation, Liddament M W, due 2000 (TN 53) Restricted to participants (£30.00)

Annotated Bibliography: Duct Cleaning, Limb M J, due 2000 (BIB 10) Restricted to participants (£15.00)

Solar Energy Publications: a selection from the International Solar Energy Society, UK branch. Various prices.

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Ventilation 2000 6th International Symposium on Ventilation for Contaminant Control
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Helsinki, Finland
Secretariat, Ventilation 2000, Finnish Institute of Occupational Health, Solveig Borg, Topeliuksenkatu 41 a A, FIN-00250 Helsinki, Finland, Tel: +358 9 4747 900, Fax: +358 9 2413 804, email solveig.borg@occuphealth.fi, http://www.occuphealth.fi/eng/project/vent2000

Renewables: the Energy for the 21 Century. World Renewable Energy Congress - VI WREC 2000
1-7 July 2000
Metropole Hotel, Brighton, United Kingdom
Professor Ali Sayigh, Congress Chairman and Director General of WREN, 147 Hilmanton, Lower Earley, Reading RG6 4HN, UK, Tel: +44 1189 611364, Fax: +44 1189 611365, email: asayigh@netcomuk.co.uk, http://www.WRENUK.CO.UK
Topics are: policy issues; low energy architecture: LEA; Photovoltaic technology; solar thermal applications; wind energy generation; biomass conversion; related topics; solar energy materials; geothermal applications.

Energex 2000 The 8th International Energy Forum
23-28 July 2000
Las Vegas, Nevada, USA
Dr Peter Catania, Faculty of Engineering, University of Regina, Regina, SK S4S 0A2, Canada, Tel: 306 585 4364, Fax: 306 585 4855, email: ief@cableregina.com Web: www.GlobeEx.com, www.energysource.com/ief/updates, www.cableregina.com/nonprofits/ief/index.htm, or email: globalenergy@pgi.com

Healthy Buildings 2000
6-10 August 2000
Espoo, Finland
Conference Secretariat, Healthy Buildings 2000, attn: Ms Leila Sarajarvi, PO Box 25, FIN-02131 Espoo, Finland, Tel: +358 9 4355 560, Fax: +358 9 4355 5655 email info@sisailmayhdistys.fi internet www.hb2000.org

Efficiency & Sustainability 2000 ACEEE Summer Study on Energy Efficiency in Buildings
20-25 August 2000
Asilomar Conference Center, Pacific Grove, California, USA
ACEEE Summer Study Office, attn: Rebecca Lunetta, PO Box 7588, Newark, DE 19714-7588, USA, Tel: +1 302 292 3966, Fax: +1 302 292 3965, email rlunetta@erols.com Web http://aceee.org

7th International Conference on Air Distribution in Rooms - Roomvent 2000
9-12 July 2000
The University of Reading, UK
Roomvent 2000, Dr Hazim Awbi, Department of Construction Management & Engineering, The University of Reading, Whiteknights, Reading RG6 6AQ, UK, Tel: +44 118 931 8198, Fax: +44 118 931 3856, email: rv2000@rdg.ac.uk, URL: http://www.rdg.ac.uk/rv2000

Energy for Buildings Fourth International Conference
21-22 September 2000
Vilnius, Lithuania
Prof A Skrinska, Organising Committee, "Energy for Buildings", Vilnius Gediminas Technical University, Sauletekio al. 11, 2040 Vilnius, Lithuania, Tel: +370 2 769600, Fax: +370 2 700497, email: energy@konf.vtu.lt

Innovations in Ventilation Technology The 21st AIVC Annual Conference
26-29 September 2000
Steigenberger Kurhaus Hotel, The Hague, Netherlands
Helen Shawcross, Conference Organiser, Air Infiltration and Ventilation Centre, Sovereign Court, University of Warwick Science Park, Sir William Lyons Road, Coventry CV4 7EZ, UK Tel: +44 (0)24 76 692050, Fax: +44 (0)24 76 416306, email airvent@aivc.org

Sustainable Building 2000 International Conference Joint conference of CIB W-100, Buildings and the Environment and GBC 2000, Green Building Challenge
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