Air Infiltration Review

a quarterly newsletter from the IEA Air Infiltration and Ventilation Centre

International Energy Agency - AIVC

Vol. 20, No 1, December 1998

19th Annual AIVC Conference Report

Ventilation Technologies in Urban Areas

Hotel Rica, Holmenkollen Park, Oslo, Norway

The theme of the 19th Annual AIVC Conference this year was 'ventilation technologies in urban areas'. The conference, held between 28th-30th September, 1998 at Hotel Rica, Holmenkollen Park, Oslo in Norway, was attended by 76 delegates from 19 countries, who presented a total of 54 papers and posters.

Keynote Speech - Energy Efficiency Measures in Norway

The keynote speaker at the conference was Roar Brunborg, Deputy Director General of the Norwegian Ministry of Petroleum and Energy. Mr Brunborg stressed that although Norway is an energy rich country, measures still need to be taken to avoid wasting energy. He indicated that about half of the country's energy supplies are derived from renewable energy sources.

The following energy efficiency measures were indicated by Mr Brunborg to currently exist in Norway:

- information and training,
- introduction of energy efficient technologies and renewable energy sources,
- creation of networks -
  - an industrial energy efficiency network, and
  - a network for the building sector,
- normative measures, and
- research and development.

As well as the aforementioned measures, Norway is an active participant in international research projects, such as the IEA Energy Conservation in Buildings and Community Systems Programme.

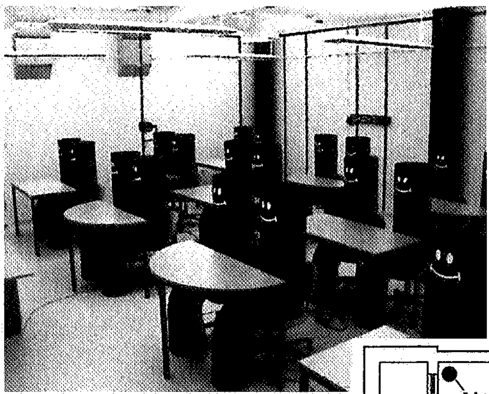
Displacement Ventilation Theme in Best Paper and Best Poster

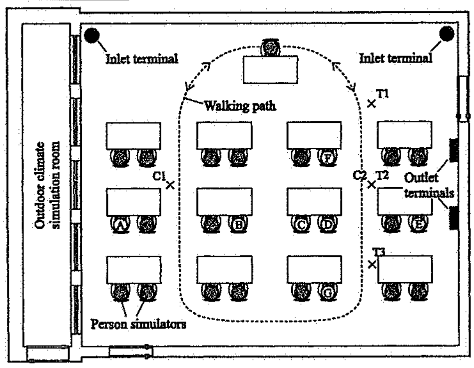
For his contribution to the conference, "A Semi-Empirical Flow Model for Low-Velocity Air Supply in Displacement Ventilation", Eimund Skaaret (NBRI, Norway) won the Best Paper award. Adding to available design methods for displacement ventilation, this model enables the calculation of the near zone for arbitrary air flow rate, supply air temperature and supply diffuser size of similar shaped diffusers. In addition, he has provided manufacturers with criteria on which to base performance documentation of air diffuser devices. Continuing this topic, the Best Poster, awarded to Magnus Mattsson (KTH, Sweden), was

In this issue

also concerned with displacement ventilation. In his poster, "Displacement Ventilation in a Classroom - Influence of Contaminant Position and Physical Activity", he showed how a single person walking around a classroom full of seated individuals can improve the air change efficiency. He based his conclusions upon experiments in a full-scale test room. Furthermore, he concluded that people sitting furthest away from the air supply might receive the least contaminated air, because a large proportion of the air reaching the breathing zone is reflected from the furthest wall from the supply.

The classroom with person simulators





Sketch of the set-up in the classroom

Natural Ventilation

Design

James Axley (Yale University, USA and Visiting Researcher at the AIVC) presented the initial results of work he undertook at the AIVC in summer 1998. (This work will be more fully documented in a forthcoming AIVC Technical Note.) His presentation showed how using 'pressure loop equations' may lead to feasible design solutions for natural ventilation systems. Also on the subject of natural ventilation design, Yuguo Li (CSIRO, Australia) has made a theoretical investigation of a building with two openings at different heights, a heat source, solar heat gain, and conduction losses (although no thermal mass). He showed how this can lead either to upward or to downward flow depending on the strength of the heat source. Furthermore, increasing or decreasing the heat source strength is shown to lead to flow reversals, in which the flow direction jumps suddenly from one direction to the other.

The Urban Environment

Natural ventilation in urban environments was considered by Matheos Santamouris (University of Athens, Greece). He presented the results of measurements made in ten 'urban street canyons', located in Athens, Greece, together with ventilation rate modelling results based on those measurements. From the modelling, it transpired that the flow reduction may be up to ten times that corresponding to a building without shielding, in undisturbed ambient wind conditions. He concluded that this may have implications for natural ventilation potential under those conditions.

David Etheridge (University of Nottingham, UK) gave an account of a wind tunnel experiment designed to study the effect of natural ventilation opening position on internal concentration of traffic generated pollutants. The experiment simulated the circumstance of a building situated next to a busy main road. The results suggested that by placing ventilation openings at roof level or on the leeward face of the building, a reduction of up to one third could be achieved compared with a cross ventilation strategy.

Another contributor also made use of wind tunnel experiments: Fernando Marques da Silva (LNEC, Portugal) reported how natural urban ventilation may be assessed through an integrated model. In his approach, wind information is transferred from an undisturbed area, such as an airport, by numerical modelling. This is then used as a boundary condition in wind tunnel experiments. These provide not only the pressure distribution for the specific building, but also the general patterns of flow around it. This pressure distribution is then integrated with internal building characteristics and internal heat sources or sinks in models to give an idea of the internal flow patterns.

Air Infiltration Review

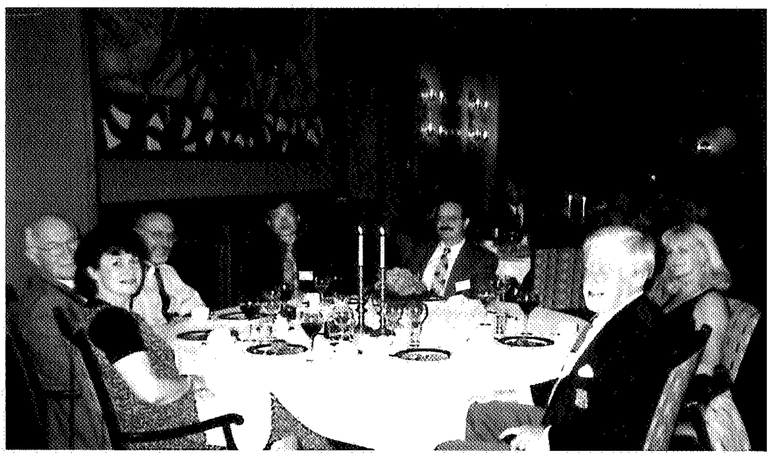
Editor: Janet Blacknell

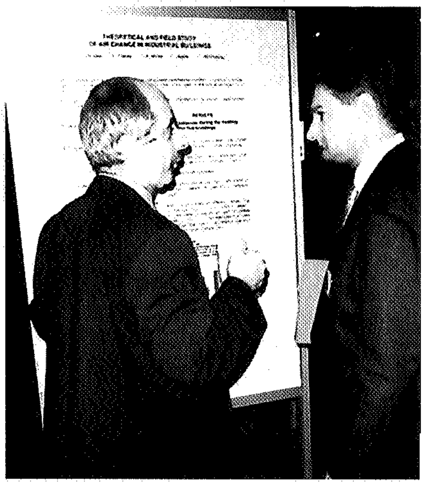
Air Infiltration Review has a quarterly circulation of 3,500 copies and is currently distributed to organisations in 40 countries. Short articles or correspondence of a general technical nature related to the subject of air infiltration and ventilation are welcome for possible inclusion in AIR. Articles 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.

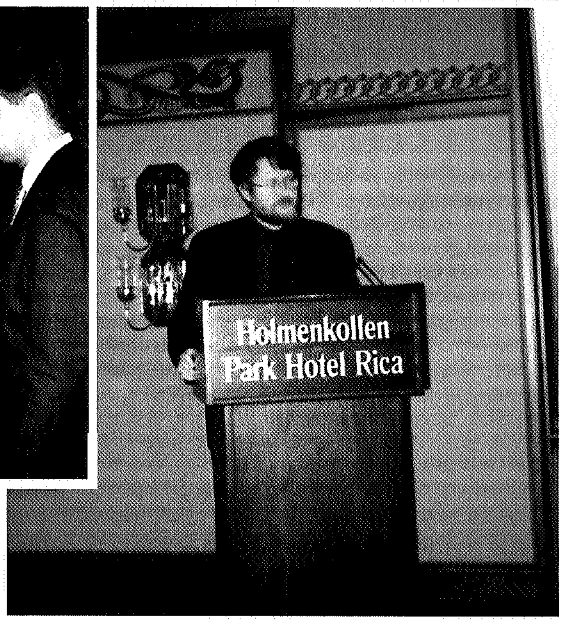
NATVENT

In a session solely concerning the EU NATVENT Project, Søren Aggerholm (Danish Building Research Institute, Denmark) examined perceived barriers to natural ventilation in office buildings. These barriers have been identified through interviews conducted with leading designers and decision makers. Although in general the interviewees expected an increased uptake of natural ventilation in offices in future, they seemed to perceive a current lack of knowledge and experience with natural ventilation. Crucially, they commented that at present there did not seem to be enough information in existing standards and guidelines, case studies, or easy to use design tools available.

The same session also included a discussion of the control of night cooling with natural ventilation. AHC Van Paassen (Delft University of Technology, Netherlands) related how he has used sensitivity analysis to investigate various control strategy and ventilation opening configurations, for both high and medium thermal inertia buildings. For high inertia buildings, in order meet a given comfort criterion, the maximum allowable daytime heat gains were determined to be between 27 W/m^2 to 32 W/m^2, and 22 W/m^2 to 26 W/m^2 for medium inertia. An effective ventilation opening area of 2% of the net floor area, using cross ventilation, appeared to be the optimal solution.







Montage - Clockwise from top: AIVC staff and delegates at conference banquet; keynote speech presented by Roar Brunborg; Jean-Robert Millet discusses his poster with Marco Perino.

tiveness is taken into account in the ventilation requirement calculations.

Yuichi Takemasa (ETH Zentrum, Switzerland) proposed a new concept for building performance evaluation, 'occupant contaminant inhalation' (OCI), that uses the total mass of pollutant inhaled by persons who occupy a building during its operational life. He also proposed a further, related concept of 'contribution rate of contaminant sources' (CRCS), for assessing the contribution of individual contaminant sources to indoor concentrations and OCI values.

Indoor Pollutants and their Control

Hiroshi Yoshino (Tohoku University, Japan) explained the principles behind the revised Japanese Ventilation Standard for Acceptable Indoor Air Quality (HASS-102) created by SHASE. The Standard specifies maximum acceptable indoor air concentrations for CO_2, CO, suspended particulates, NO_2, SO_2, HCHO, radon, asbestos and TVOC's. It states that ventilation airflow rates to obtain these concentrations should be calculated for each one. For other unidentified pollutants, the ventilation airflow rate that provides 1000 ppm CO_2 concentration is assumed to give acceptable indoor air quality. The overall basic ventilation requirement is then the maximum value among these airflow rates. When pollutants are not completely mixed with the indoor air, ventilation effec-

Sometimes pollutants from exhaust air may unintentionally become re-entrained back into the intake air of the same or neighbouring buildings. Jerzy Sowa (Warsaw University of Technology, Poland) discussed different types of regulatory requirements for the prevention of re-entrainment of pollutants due to improper location of exhausts. He examined advantages and disadvantages of different types of models and their application in standards. Amongst his conclusions was that differing assumptions and simplifications made in the models cause widely varying predictions of pollutant dilution for the same distance between exhaust and air intake.

A new experimental method for the determination of the performance of air filters has been developed by

Paolo Tronville (Politecnico di Torino, Italy). This is intended for filters for general ventilation applications. In his presentation, he stated that with this method, the fractional efficiency may be found for particles lying in the range 0.2 micrometres to 3 micrometres. Furthermore, he maintained that it improves on the traditional 'dust spot efficiency' method, by allowing more information to be obtained in a shorter time.

Mechanical Ventilation

The EU JOULE-TIPVENT Project, "Towards Improved Performances of Ventilation Systems", has a range of objectives, centring on: understanding the impact of air flow rate requirements in standards on the energy demand of residential and office buildings; monitoring case studies of mechanically ventilated buildings; impact of standards and regulations on performance, and performance checking and improved (smart) design of mechanical ventilation systems. Peter Wouters (BBRI, Belgium) gave an introduction to this project. (See also feature later in this newsletter.)

A case study building with an active envelope has been examined in detail by Dirk Saelens (KU Leuven, Belgium). This envelope incorporates forced convection and was designed to shelter the building from a high external noise and pollution load. It also acts as an active solar collector, decreasing cooling loads in summer, and operates as an air-to-air heat exchanger, recovering heat losses in winter. The general inference from this study was that good design and workmanship are essential to fulfil claimed performances of active envelopes.

Remediation and Renovation

Achim Trogisch (University of Applied Sciences Dresden, Germany) has made filtering and humidity measurements in dwellings of the exhaust air of bathrooms that lack windows. (Approximately 70% of dwellings in the eastern states of Germany are ventilated by natural window airing.) However, some occupants are reluctant to use the windows for ventilation due to the consequent energy cost. This may lead to mould growth. In his presentation, he suggested certain solutions to this problem.

The occupants of a block of flats in Finland were questioned about their perception of indoor air related problems before and after renovation of the ventilation system. Jari Palonen (Helsinki University of Technology, Finland) explained that the previous system, a mechanical exhaust only system without outdoor air inlets, had given rise to complaints, particularly about draught, traffic noise and dust from the street. After the installation of a new type of fresh air window, with air filtration as well as good acoustic performance, substantial improvements were found in the occupants' reactions.

Urban Transportation

Hoo Jee Poh (Nanyang Technological University, Singapore) has made a study, using computational fluid dynamics, on the effects of an air curtain upon heat and mass transfer by air movement in a bus. When the external temperature is 30 °C, and the internal temperature is controlled at 24 °C, opening of the door causes a rapid increase in internal temperature, requiring additional cooling energy and causing thermal discomfort. Using simulation, he determined that an air curtain blowing vertically downwards at 6 m/s between the interface of the hot and cold air (with a 5 s door opening delay) was best for maintaining the internal temperature.

Heat Recovery

Tests on five units combining supply and exhaust fans, filters and a heat recovery exchanger have been performed by Anne-Marie Bernard (CETIAT, France), in order to determine their thermal performance. The units are intended for use in balanced residential ventilation systems. Additionally, the influence of humidity and frost on their efficiency has been examined. The energy saving was found to be about 43% if the unit is positioned in the attic, or 66% if it is in the heated volume of the dwelling. Frost may lead to a decrease in efficiency, necessitating the use of a supplementary coil for its avoidance.

A simulation of infiltration heat recovery was reported by Max Sherman (LBNL, USA). In this study, a laminar flow model was used to simulate the air flow in various cavity wall configurations, both with and without insulation. He indicated that most heat recovery occurs at low air velocities and with long flow paths. This allows sufficient time for the heat transfer to take place. Therefore, in general, more heat recovery is observed when insulation is present.

Guest Speaker at the Conference Dinner and Closing Session

An entertaining speech was given by the Guest Speaker at the Conference Dinner, Dr Bent Børresen (Techno Consult, Norway). After the final session on the following day, the conference was summed up by Willem de Gids (TNO, The Netherlands). Then the Awards for Best Poster and Best Paper were presented by Martin Liddament, Head of the AIVC, before he closed the Conference. The AIVC would like to extend their thanks to all the contributors and participants in this year's Conference.

Towards Improved Performances of Mechanical Ventilation Systems

TIP-VENT Project

P. Wouters, Ch. Delmotte (Belgian Building Research Institute)

J-C. Faÿsse (Aldes Aéraulique)

Context

Mechanical ventilation systems have become of common use in most of the buildings throughout Europe.

Although the improved thermal insulation of buildings has reduced the energy consumption due to the transmission losses, the same tendency is not observed when looking at the ventilation.

In the future, it is possible that the specific energy consumption for ventilation will increase because of a wider use of ventilation systems and the request for higher airflow rates.

The TIP-VENT project aims to contribute to the improvement of the performances of mechanical ventilation systems for better energy performances and better indoor climate conditions.

Web site

The composition of the TIP-VENT team is representative of all sectors concerned: manufacturers, consultant engineers, research centres and universities. Nevertheless it is important to also generate an information exchange with the entire HVAC sector in order to reach the goals of the TIP-VENT project. Such an exchange can be done through the new web site specially developed for TIP-VENT.

The web site contains information concerning the project with a description of each of the 7 different tasks. Each task leader can include a special page with more precise data and a form to collect the comments of the visitors.

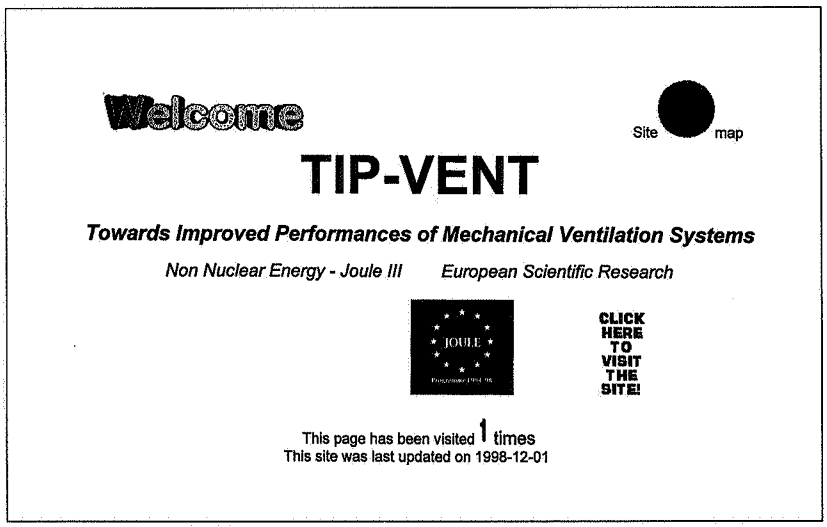
One can also find the list of participants with a short summary of their main activities and the names of the contact persons.

The objective of the web site is moreover to give information about the CEN TC 156 European normalisation relative to building ventilation.

The TIP-VENT site is now available on the World Wide Web at the following address: http://www.tip-vent.com. Don't hesitate to visit it and send your professional comments about the research.

If you find the site interesting, please let others know, and why not include it in your own site.

Research funded in part by the European Commission in the framework of the Non Nuclear Energy Programme JOULE III



Welcome page of the site

4th UK Conference on Wind Engineering

Wind Engineering Society

On the Persistence of Low Wind Speed Conditions

by D M Deaves and I G Lines
W S Atkins Safety & Reliability, UK

Introduction

Light wind conditions are important in the assessment of risks from releases of hazardous gases, in the assessment of urban air quality, and also in the determination of ventilation requirements for buildings. Although very light winds would often present the worst case of high concentrations, especially in the near field, or of poor ventilation, their effects are not often assessed. This is due to the limitations of currently available dispersion models at low wind speeds, the assumed low frequency of such weather conditions, and the lack of understanding of their characteristics.

One characteristic which becomes increasingly important at low wind speeds is their persistence. In gas dispersion studies, for example, it is not clear that any low wind speed which is considered would persist for long enough for the gas to be still travelling at this low wind speed in the far field. Similarly, low wind speeds would only cause a problem for natural ventilation design if they were sufficiently persistent. In order to assess these effects, recent studies of dispersion at low wind speeds have included the analysis of wind data recorded at 1Hz using lightweight cup anemometers over a period of one year. This analysis is discussed below.

Use of Low Wind Speed Data

It was shown by Deaves & Lines (1996) that standard Meteorological Office wind speed data recorded by Munro cup anemometers was unreliable at low wind speed. It was also shown how sonic and lightweight cup data could be used with confidence down to very low wind speeds. Thus 10 minute mean sonic anemometer data from Cardington and Camborne were analysed to determine some features of the persistence of low wind speed conditions. It was clear from these preliminary analyses that the 10 minute averaging period was too coarse to ascertain persistence for very low wind speed conditions. One year of lightweight cup data from Folkestone were therefore analysed further. The raw data were in fact available at intervals of 1 second, although these were considered unnecessarily short, as any variations would primarily consist of turbulent fluctuations. Some data analysis was therefore performed to give either 1 minute or 10 minute means for use in the persistence analyses.

The data from Folkestone were collected by Eurotunnel for use in their wind alert system. Since the worst case conditions for their application are for those periods when the gust ratio (peak/mean) is high, some method of identifying these periods has been incorporated into the data. This has resulted in the designation of each hour of data as either convective (i.e., unstable) or non-convective (neutral or stable); these categorisations have been used in some of the analyses described below.

Duration and Distribution of Low Wind Speed Episodes

Initially, all periods ("episodes") when the one minute mean wind speed remained below specified threshold values were identified and grouped into those of the same duration. This was undertaken for threshold wind speeds of 0.2 m/s, 0.4 m/s etc... 2.0 m/s. An example of the data, for a threshold wind speed of 0.8 m/s, is shown in Figure 1 where it is presented as a cumulative distribution. From this, it can be seen that 40% of all episodes less than 0.8 m/s last for only 1 minute, and that 95% of all such episodes last less than 21 minutes. Those durations for which 50, 90 or 95% of the episodes are less than this duration are designated t_{50}, t_{90} and t_{95}, and have been determined for each wind speed up to 2 m/s. The results are presented in Table 1.

u (m/s)	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
t_{50}	1	1.3	1.6	1.5	1.4	1.4	1.4	1.4	1.5	1.6
t_{90}	3	6.5	9	12	16	16	15	14	15	15
t_{95}	4	9	14	21	26	32	33	33	34	37

Table 1: Episode duration timescales (minutes) for low wind speeds

For wind speeds (up to 1 m/s), it appears that an "episode duration timescale" (taken as t_{95}), increases approximately linearly with wind speed.

Calculation of Wind Speed Persistence

When applying low wind speed conditions within a risk assessment, it is useful to know how long a low wind speed episode is likely to persist. Whilst the above analysis gives an indication of the durations of low wind speed episodes, a more relevant estimate of persistence can be calculated by manipulating the data plotted on Figure 1, which are based on the percentages of "episodes" of given lengths for a specified wind speed, to give the percentages (q_i) of actual time for which the given durations (i) are recorded.

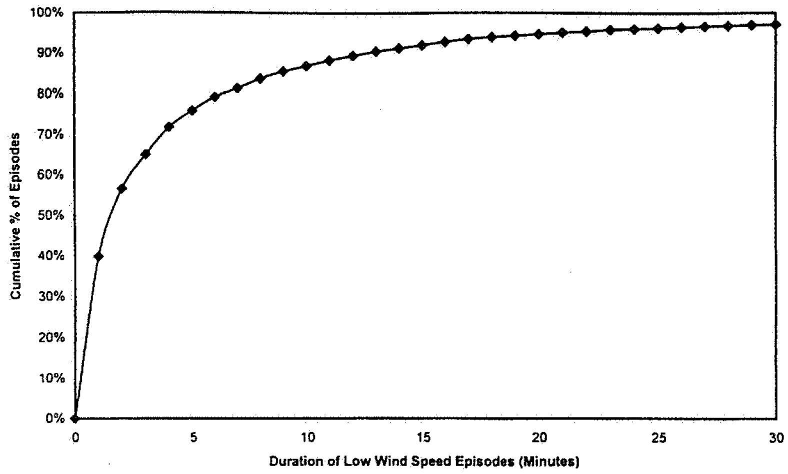


Figure 1: Cumulative distribution of low wind speed episode durations for the threshold wind speed of 0.8 m/s based on one year's data

Defining: q_i = % of all minutes with wind speed u which are in episodes lasting i minutes.

p_{iT} = probability that a random event during an episode of i minutes will still have T minutes to run. (=(i-T)/i)

P_T = probability that a low wind speed u will persist for a time T minutes

Then $$P_T = \frac{1}{100}\sum_{i=T}^{\infty} q_i p_{iT} \qquad (1)$$

This has been calculated for each threshold wind speed, and the results are shown in Figure 2, in which the plotting on ln P_T against T suggests an exponential decay of P_T over a large range of T. Values of durations for which P_T = 0.5, 0.1 and 0.05 are designated T_{50}, T_{10} and T_5, and are presented in Table 2.

u (m/s)	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
T_{50}	1.2	2.0	3.1	5.2	8.0	10.7	13.8	17.5	21	27
T_{10}	4	8.5	16	30	53	70	110	160	185	225
T_5	5.5	12	23	44	90	125	190	230	270	310

Table 2: Persistence timescales (minutes) from Figure 2.

It is clear that a range of different timescales can be calculated for each wind speed. It is not clear, however, which is the most appropriate for use in risk assessment. Taking T_{50} would give very short timescales, such that even a 2 m/s wind would not be expected to last 30 minutes, as a result of which it was decided to use T_{10} as a realistic persistence timescale.

The values of T_{10} increase with u, and appear approximately to follow the following variation, with u in m/s and T_{10} in minutes:

$$T_{10} = 50u^2 \qquad (2)$$

Wind Direction Variability

A further parameter of interest is the directional variation during periods of low wind speed. For this analysis, the one minute means were used, and the wind directions were considered during those episodes when the wind speed was less than specified threshold values. For each period, the one minute mean wind directions were used, and their standard deviations about the mean over the period were calculated. Thus, for each period, for example of 12 minutes duration, the 12 one-minute directional means are averaged and the standard deviation of that group is determined. If there are, say, 50 such 12-minute periods, this provides a set of 50 standard deviations (σ_i) each of which is a measure of the variability of wind direction for that particular set of low wind speeds. The mean and standard deviation of the σ_i are then calculated, and the 95% confidence

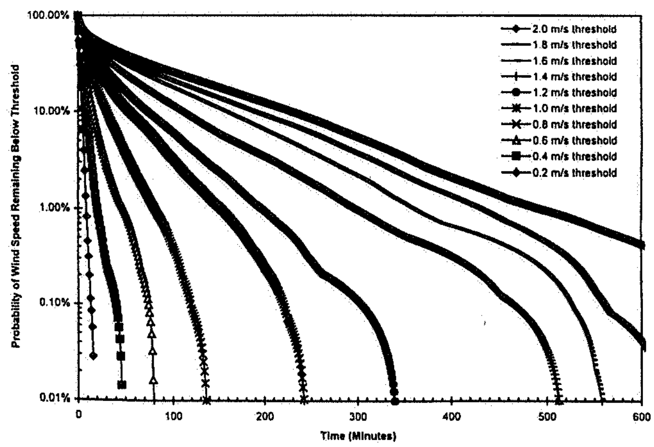


Figure 2: Probability of wind speed remaining continuously below various thresholds for increasing times.

limit on this variability is obtained for each wind speed band and each duration. From the data analysed, the following observations can be made regarding directional variability:

- Directional variability decreases with increasing wind speed

- There is no discernible trend to suggest any change of variability with the duration of the low wind speed event

- The lowest wind speed band shows directional variability of order +/- 90 Deg.

Conclusions

It is clear that low wind speed episodes are only likely to last for relatively short periods. Preliminary analyses of 10 minute means, using a limited amount of data from Cardington and Camborne, suggested that a persistence timescale, t_o could be defined which increased approximately linearly with wind speed, for speeds above 1.5^{-2} m/s, with a quadratic variation evident for lower wind speeds. The more detailed analysis using a complete year of 1 minute means from Folkestone has confirmed that the variation at the lowest wind speeds is quadratic, and has enabled the constant of proportionality to be refined, as in Equation 2.

In addition to these useful quantitive results, the following qualitative remarks can be made, based also on detailed analysis of specific low wind events:

- The greatest variability in both wind speed and direction at low wind speed occurs for convective (unstable) conditions.

- After periods of low mean wind speed, it is almost certain that the wind speed will increase within a few minutes.

- As the wind speed increases after a low wind episode, certain directions are likely to be preferred, but only when convective conditions prevail.

- Directional variability decreases with increasing wind speed.

Reference

Deaves, D M & Lines, I G (1996). "The nature and frequency of low wind speed conditions", Wind Engineering Society Conference, Oxford, September 1996.

IEA ECBCS Air Infiltration and Ventilation Centre

20th AIVC Annual Conference

in association with Indoor Air '99

August 8th - 13th 1999, Edinburgh, UK

This year the Air Infiltration and Ventilation Centre's annual conference is being held in partnership with Indoor Air 99. The main aim of the conference is to give an overview of the state of the art in the interdisciplinary field of indoor air quality and climate, and thus to promote better indoor environments. The focus is on good scientific research in any relevant field, such as the medical, physical, chemical, material, behavioural and biological sciences. A wide range of subjects will be covered, including:

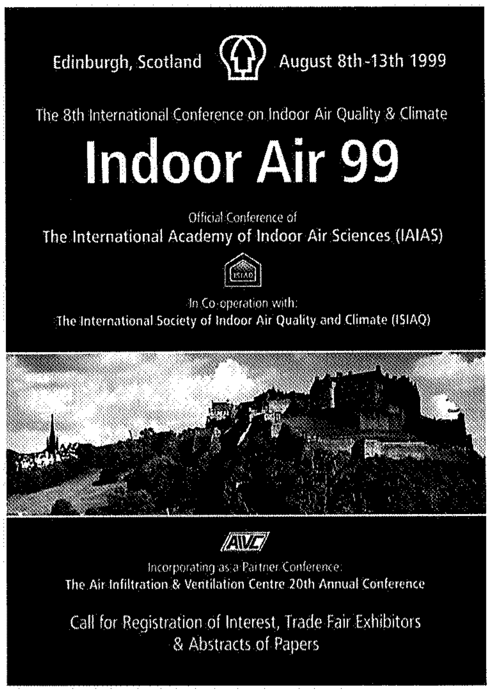
- *all types of indoor air pollutant plus thermal and moisture problems;*
- *health, comfort and human performance in relation to the indoor environment;*
- *ventilation, infiltration and building services;*
- *building design and materials;*
- *measurement, modelling and research methods;*
- *the scientific basis of policy and regulation.*

A trade fair will also be held for the promotion of services and technology.

Fees range between £400 and £600 (sterling) per delegate.

Please obtain full details of attendance from:

Mrs Claire Aizlewood, Secretary of Indoor Air 99, BRE, Garston, Watford WD2 7JR, UK,
Tel: +44 1923 664123, Fax: +44 1923 664443, email: ia99@bre.co.uk



IEA Energy Conservation in Buildings and Community Systems, Annex 26

Ventilation of Large Spaces in Buildings

Large enclosures have become a major feature of modern building design. Spaces such as atria and covered areas are used in all varieties of buildings including office complexes, shopping malls, airports and public buildings. Essentially they create an environment protected from the outdoor climate in which a wide range of activities is possible. However, such spaces demand very careful design to ensure good indoor air quality and thermal comfort and to protect occupants from the risk of fire and smoke spread.

Technical Synthesis Report

The Technical Synthesis Report aims to provide a technical summary of the work of Anmex 26 in relation to airflow in large enclosures. Its aim is to provide details of what was accomplised and summarise information about proven technology for the design of ventilation in such spaces.

The report covers analysis and prediction techniques, measurement techniques, case studies, and lessons learned.

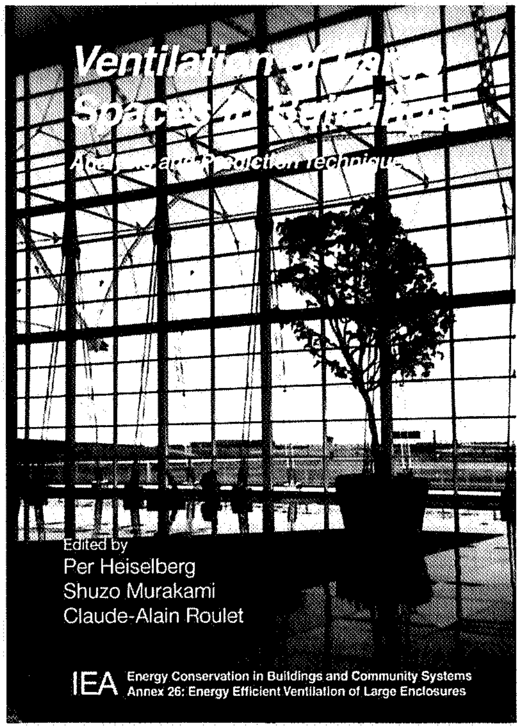
Available from AIVC Bookshop, Price £20.00 plus postage

Analysis and Predition Techniques

Contains the results of the joint activities in IEA-ECBCS Annex 26 and it gives an overview of the techniques to analyse, measure and model air flow and ventilation in large enclosures. Advice is given on the application of different analysis methods, on the advantages and disadvantages, on selection and use and on type of results to expect. Many are new methods designed especially for large enclosures or are methods whose application to large enclosures are not well known.

Problems and physical characteristics of large enclosures and what makes them different from small rooms are stated. Several analysis models are described from "easy-to-use" equations for flow elements such as jets, plumes or boundary layer flows, over engineering and zonal models, which include building dynamic models, to complicated computational fluid dynamic models.

Measurements in large enclosures require detailed planning to be successful, and the book introduces a method to plan measurements and gives advice on what to be aware of in particular before and during measurements. Both new techniques developed for large enclosures and application of existing techniques are described.



Working examples of all methods are included, which covers a wide range of large enclosures, such as one industrial hall, two atria, two auditoriums, one stadium and one gymnasium. Both successful and unsuccessful applications are included with comparisons between different models and between models.

Available from AIVC Bookshop, Price £40.00 plus postage

Case Studies

During Annex 26 many research groups studied the performance of various types of large enclosures. To develop a better understanding of the ventilation situation in large enclosures, many different measurement techniques were applied to case study buildings. This book contains brief descriptions of most of the buildings examined by Annex 26 participants. The goal of this book is to provide the reader with an overview of the various building types including information about the building performances.

In addition, contact names for further information are provided with each case study.

Available from Lehrstuhl fuer Waermeuebertragung und Klimatechnik, RWTH Aachen, Eilfschornsteinstrasse 18, D-52056 Aachen, Germany Tel: +49 241 80 5400, Fax: +49 241 8888 143, email: www@wuek.rwth-aachen.de

Forthcoming Conferences

World Renewable Energy Congress 1999
10-13 February 1999
Murdoch University, Perth Western Australia
Dr Kuruvilla Mathew, Environmental Science, Murdoch University, Murdoch WA 6150, Australia, Tel: +61 8 9360 2896, Fax: +61 8 9310 4997, email mathew@essun1.murdoch.edu.au, Website: http://wwwphys.murdoch.edu.au/acre/

World Sustainable Energy Day 1999: Renewable energy and energy efficiency for the EU
4-5 March 1999
Wels, Austria
OO Energiesparverband, Landstrasse 45, A-4020 Linz, Austria, Tel: +43 732 6584 4380, Fax: +43 732 6584 4383, email esv1@esv.or.at

VHExCo 99 The International Ventilation Hygiene Conference and Exhibition
March 24-25 1999
National Motorcycle Museum, Solihull, Birmingham, UK
VHExCo 99, Criterion Publishing Ltd, 2 Darsham Walk, Lums Yard, 32 High Street, Chesham, Bucks HP5 1EP, Great Britain, Tel +44 (0)1494 791 222, Fax: +44 (0)1494 792223

Intelligent and Responsive Buildings CIB Working Commission WO98 International Congress
March 29-30 1999
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