Air Infiltration Review

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European NatVent™ Project Completed

by Vina Kukadia and Earle Perera, BRE, UK

The European NatVent™ project, 'Overcoming Technical Barriers to Low Energy Natural Ventilation in Office Type Buildings in Moderate and Cold Climates', is now completed. Of particular interest was the targeting of building and countries where summer overheating from solar and internal gain can be significantly reduced by low-energy design and good natural ventilation. In addition, natural ventilation solutions to buildings located in urban areas where external air pollution and noise levels are usually regarded as being high were addressed.

Background

Concerns over the adverse environmental impact of high-energy usage required for mechanical ventilation and air-conditioning have been growing over recent years. As a result, the design of energy efficient buildings employing natural ventilation has been encouraged. Such buildings can provide year-round comfort. Furthermore, it is estimated that even a modest 10% take up of these strategies could save about six million tonnes of oil equivalent and 25 million tonnes of avoided CO^2 emissions every year within the EU.

Objectives of NatVent™

The overall strategic aim of NatVent™ was to reduce primary energy consumption (and consequently CO^2 emissions) through efficient natural ventilation strategies in office type buildings but without compromising indoor air quality and comfort. To achieve this main aim, the project had two specific objectives:

- To identify and overcome technical barriers which restrict the implementation of natural ventilation and low-energy cooling in countries with moderate and cold climates.
- To provide practical solutions and guidance and thus encourage the wider uptake of natural ventilation technologies.

An additional priority was to develop natural ventilation solutions to buildings in urban areas where external air pollution and noise levels can be regarded as being high. The project was aimed at both new-designs and major refurbishments.

In this issue

The NatVent™ Consortium

This consisted of:

- Building Research Establishment (BRE) from the United Kingdom as the overall Coordinator of the project.
- Belgian Building Research Institute (BBRI)
- Danish Building Research Institute (SBI)
- Dutch Building Institute (TNO) .
- AB Jacobson and Widmark (J&W) from Sweden
- Technical University of Delft (TUD) from The Netherlands
- Willan Building Group (WILLAN) from the UK .
- Norwegian Building Research Institute (NBI)
- Sulzer Infra Laboratory (SULZER) from Switzerland

The vision of the Consortium was for NatVent™ to play a catalytic role in promoting natural ventilation strategies and technologies.

Key Technical Activities

The objectives were addressed by carrying out the key technical activities as shown in Figure 1.

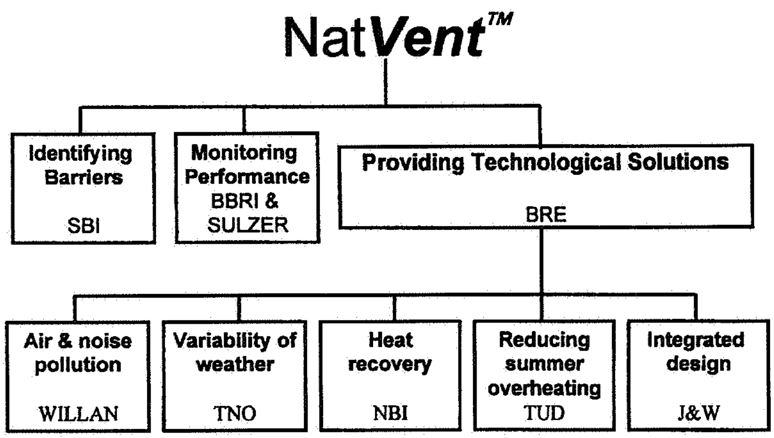

Figure 1: Overview of activities for the NatVent™ project.

Activity 1: Identification of technical barriers to natural ventilation

This activity was led by the Danish Building Research Institute (SBI). Barriers were identified by carrying out structured interviews based on questionnaires among leading designers, architects, consultants, building owners and developers in each of the participating countries. In total 105 interviews were carried out.

The survey identified that, with varying degrees, there is a significant lack of knowledge and experience on specially designed natural ventilation strategies in office buildings compared with that on mechanical ventilation. In addition, there is a lack of source material on natural ventilation knowledge in standards, guidelines and building studies throughout Europe. There was also a universal requirement for new design tools on natural ventilation including calculation rules as well as computer programs, which are numerically advanced but still simple to use by the non-specialist. This work is reported fully by Aggerholm, 1998.

The following five specific issues were perceived as major technical barriers to widespread use of natural ventilation:

- Air and noise pollution in urban areas and city centres
- Variability of weather around buildings and the dependence of natural ventilation on these variable driving forces
- Recovering heat from natural ventilation systems (an issue of concern to countries with very cold winters)
- Combating summer overheating
- Integrating and maintaining natural ventilation systems

Activity 2: Monitoring the performance of buildings.

The Belgian Building Research Institute (BBRI) and Sulzer Infra Laboratory (SULZER) coordinated this activity. Its aim was to establish pragmatic innovative design strategies by monitoring the performance of existing low-energy buildings and providing case studies of current best practice. It was also recognised that ultimately, it is important to demonstrate the viability of natural ventilation in both performance and competitiveness if it is to succeed in the market place. To this end, cost effective and pragmatic measuring procedures and protocols were developed and used to evaluate the performance of existing buildings. Nineteen buildings within the seven EU countries were monitored in detail during the winter and summer periods (Ducarme, 1996). Figure 2 shows that the buildings cover a wide spectrum of shape and size yet they all use low-energy ventilation technology.

During monitoring, parameters such as room temperatures, humidity, carbon dioxide levels and ventilation rates were measured. In one building that was located in a highly polluted area, levels of pollutants such as carbon monoxide and traffic noise were also monitored

Possible shortcomings and advantages from the ventilation strategies used during the summer and winter monitoring periods, and recommendations for achieving overall successful natural ventilation were identified.

Further details of this activity are presented by Demeester (1998)

Activity 3: Providing solutions to technical issues.

This third activity co-ordinated by BRE, was aimed at developing 'smart' naturally ventilated technology systems and components. This was undertaken through the following five key tasks:

(i) Low-energy air supply components for use in buildings in urban locations.

This task was led by Willan Building Services. Its aim was to develop components and strategies for natural ventilation in non-domestic buildings located in urban areas.

As part of this work, existing systems have been evaluated and current standards, performance and specifications compiled. An outcome has been the development of a spreadsheet and Visual Basic design tool to determine air inlet size according to the ventilation requirements of a building. A low pressure drop inlet which is capable of damping noise levels and filtering particles has also been developed. Further details of this activity are described by Ajiboye (1998).

(ii) Controlled airflow inlets to account for variability in weather.

This area was led by the Dutch Building Research Institute (TNO) with the aim of identifying and specifying conditions under which newly-developed natural passive controlled air flow inlets can provide acceptable indoor air quality for occupants' health and comfort in offices. An important aspect is to provide an optimum quantity of fresh air for occupants in a manner that is generally independent of short-term external weather fluctuations. The key component of this device is that it provides uniform flow within the normal natural driving force range down to as low as 1 Pa.

To demonstrate viability, an interactive user-friendly software program was developed. This gives visual indication of ventilation, air quality and thermal parameters for many ventilation and weather configurations. Further details are published by De Gids (1998).

(iii) *Natural ventilation with heat recovery.*

The Norwegian Building Research Institute (NBI) led this task. Its aim was to develop natural ventilation systems with heat recovery. This is needed because in very cold climates, pre-heating of the ventilation air is preferable to eliminate discomfort.

This particular study focused on determining the distribution of available natural driving pressure at key locations within each participating country. An advanced low-energy fan assisted natural ventilation system with heat recovery has been developed. The fan is extremely energy efficient and consumes approximately 0.25W for each l/s of air flowing through the system. Further details are presented by Brunsell et al (1998).

(iv) Low-energy cooling

The Dutch Technical University of Delft (TUD) led this task to develop low-energy cooling strategies. An important aspect of natural ventilation design is to prevent the need for refrigerative cooling. In much of Northern Europe, excessive external temperature and humidity rarely present a problem. Instead, buildings tend to overheat as a consequence of high internal heat loads and solar gains. Hardware and control algorithms have been developed to minimise these problems.

The control strategy for night cooling has focused on:

- predictive control;

- cooling day control;

- set-point control;

- slab temperature control;

- degree-hours control.

Further details of this activity, its findings and products are found in van Paassen and Leim (1998).

(v) Integration of 'smart' systems for optimum year-round performance.

This area was led by AB Jacobson and Widmark. A simple but reliable design tool, integrating all the elements of NatVent™, was developed so that an optimum solution for any building could be found. Key features in the design tool included the following:

- driving forces (wind and temperature);

- air flow through components;

- solar radiation; and

- a thermal model.

These components have been incorporated into a Visual Basic model with a simple user interface. Behind this is an extensive numerical database and pre-selected default data. Further details are described by Kronvall et al (1998).

Products from the Project

The following is a summary of the products that are available from the project:

Reports

- Individual country reports on Technical Barriers
- European report on Technical Barriers
- Building case studies reports
- NatVent™ Guidebook

Design tools

- Spreadsheet based tool for the determination of inlet size and location
- An interactive user-friendly algorithm which gives visual indication of ventilation, air quality and thermal parameters
- Integrated Visual Basic design tool

Components

- Inlet which is acoustically treated and deals with particle attenuation
- Controlled air flow inlet to compensate for the variations in external climate
- Low pressure heat recovery system
- Night cooling devices and controls

The NatVent™ CD

- A CD has been produced containing sample software, a complete guide to NatVent™ solutions, full case study information and other reports and products arising from this activity.

For information about the CD Rom, please contact the project coordinator, Dr Earle Perera at the UK Building Research Establishment Ltd, BRE, Garston, Watford WD2 7JR, Tel: +44 1923 664486, Fax: +44 1923 664796, email pererae@bre.co.uk (BRE is on the Internet at: www.bre.co.uk).

Conclusions

NatVent™ has been successful in identifying the technical barriers that exist amongst building professionals. It has established innovative design strategies by monitoring existing low energy buildings throughout Europe and thus provided case studies of current practice with recommendations.

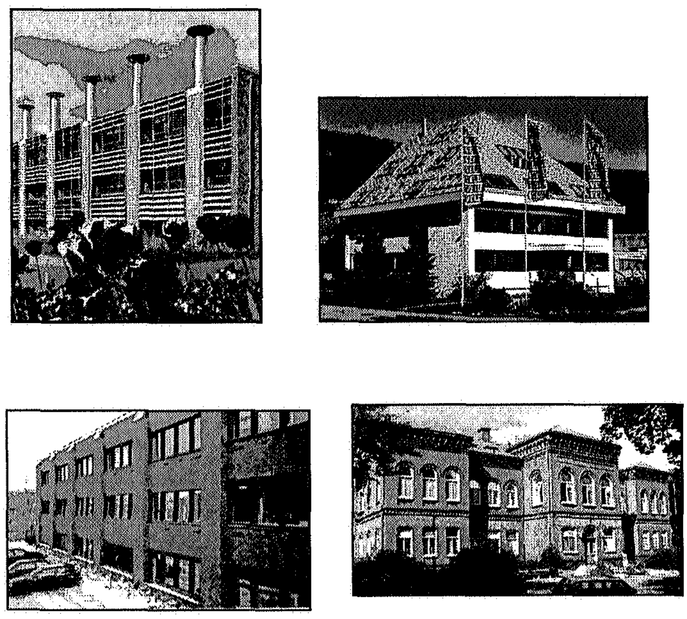

Figure 2: Some of the NatVent™ monitored buildings

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Acknowledgements

The NatVent™ project has been funded partly by the European Commission under the Joule Programme 1994-98; and by the appropriate funding organisation within each participating country. Within the UK, we acknowledge with thanks the funding of the Department of the Environment, Transport and the Regions under the Partners in Technology (now Partners in Innovation) Programme.

Ventilation at the ASHRAE Winter Meeting – a Perspective

(A view on the ASHRAE Winter Meeting, Chicago, January 1999)

by Martin W Liddament, Head of AIVC

Introduction

The ASHRAE Winter Meeting and trade show provides a major opportunity to follow the latest developments in research and application. Substantial new research and ideas were presented in the many technical sessions, symposia, seminars, forums and technical meetings that took place. A summary and thoughts on some of these activities is presented below. Detailed transactions are published by ASHRAE, while abstracts of ventilation related activities will be included in AIRBASE. The Winter Meeting has become an important international event, attracting many participants from all over the world.

CDF Modelling: Turbulence - The End of k-ε?

The reliable representation of turbulence in air flow simulation modelling has proved to be extremely elusive. Unfortunately the grid structure or cell size of conventional finite volume modelling systems can never be small enough to allow for the representation of turbulent eddies. Instead turbulence has to be approximated using empirically derived parameters which are often difficult to quantify. The most common approach is the k-ε model in which the turbulent diffusivity is described in terms of the kinetic energy of turbulence, k, and the dissipation rate of kinetic energy of turbulence, ε. As a consequence, classical computational fluid dynamic (CFD) techniques are difficult to set up and rely heavily on the good judgement of the modeller to apply the correct empirical coefficients. Errors may result in the simulated flow patterns which, although appearing satisfactory, depart significantly from reality. In fact one of the outcomes of the IEA ECBCS Annex 26 study "Indoor Environmental Control of Large Spaces within Buildings" was that satisfactory simulation depended very much on advance knowledge of what the actual air flow rate was. In other words, conventional CFD models perform best only when the results of actual measurements are available for fine tuning.

Efforts to overcome this difficulty are being researched at the National Institute of Standards and Testing (NIST) in Gaithersburg, Washington. Emmerich (1997) reports previous results. The current work, presented at the Winter ASHRAE Meeting, is based on 'Large Eddy Simulation' (LES) and enables millions of cells to be incorporated into a grid system representation of the building. This method has its origins in meteorological modelling but can now be adapted to building physics because of the ever-growing size and speed of workstations and PC's. Depending on the size of the building and computing capacity, each cell can represent a finite volume as small as only 2-3 cm^3. By contrast the maximum resolution of classical k-ε an approach is restricted (by computer size and processing limitations) to the order of tens of thousands of control volumes. The result is that LES simulation can resolve, more faithfully, the turbulent transport of air as well as the mixing of gases and convective motion. Turbulence itself is not separately modelled, as is the case with the k-ε approach but, instead, it materialises as a direct consequence of the simulation process. In essence, therefore, this approach moves away from the empiricism of classical CFD modelling to a much more fundamental solution of the Navier Stokes flow equations. Using this new approach, only one empirical coefficient is applied although the ultimate goal is to eliminate entirely the need for empiricism. An example of the powerful potential of this approach was demonstrated by Kevin McGrattan of NIST (1999) who illustrated its use in the prediction of the transient development of an intense fire. Numerical results of the development of a fire plume showed very good agreement with full-scale measurements.

Development of this code is continuing with the intention of making it available to engineering practices at some time in the future.

Multi-Zone Modelling

Although having a much lower profile in design than computational fluid dynamics, the prediction and understanding of air and pollutant flow into and out of buildings and between rooms within a building is, arguably, fundamental for achieving optimum indoor air quality, comfort and energy efficiency. Various papers reviewed current progress and results based on the 'CONTAM' series of models and COMIS.

Various examples illustrated that good agreement could be obtained between measurement and observation and that these models are effective in analysing many ventilation related problems. Examples illustrated model performance (Musser et al 1999), impact of duct leakage (Walker 1999), energy and air quality (Yoshino et al, 1999) and comparisons of ventilation systems (Herrlin et al, 1999).

In reflecting on multi-zone models it seems that, despite their potential, they have largely failed to inspire the design sector. Although much effort has been devoted to the development of user interfaces, the intricacies of building shape and room layout make this type of model very difficult to set up and visualise. Possibly also, data handling is too complex; the user is faced with too many options and the risk of selecting the wrong data is high. Perhaps too, it is not clear, in their name, as to what these models do. Possibly the next generation of models should at least have their wind speed correction, and wind pressure coefficient generators constrained by default to urban shielding terrain conditions. Realistic envelope leakage should also be incorporated as default data and classified (e.g., in terms 'very leaky' to 'air tight'). This would ensure that such vital information is not forgotten and then enable the user to concentrate on defining specific building characteristics. Furthermore, 'real time' 3-D graphic output is needed to show the progression of flow throughout the building as conditions vary. By linking to readily available combined wind and temperature data, it would be relatively easy to carry out annual hour by hour simulations for energy and ventilation evaluation. Such simulations could then flag conditions which might prove unfavourable, thus enabling problems and solutions to be found.

Protecting Artefacts

A forum on Indoor Air Quality for Museums, Libraries and Archives provided an update on dealing with the problems associated with protecting artefacts. It was reported that Chapter 20 of the forthcoming ASHRAE Handbook (to be published in July) will cover museums and archives. There is also a plan to undertake ASHRAE sponsored research into developing field monitoring techniques as well filter and media assembly testing. Problems discussed at the forum included:

- Acceptable pollutant concentrations: On the whole it was argued that outdoor air can be too polluted for certain exhibits. It was therefore necessary to have good filtration and/or protect individual items.
- Building air tightness: Infiltration can be very high as a consequence of leaky building components. Also pressure testing to quantify and locate leakage sources was often difficult because museums are often large. Methods to detect and reduce infiltration were needed, so that effective filtration could be achieved.
- Visitors: The impact of museum visitors needed to be assessed.
- Weather conditions: Some exhibits are affected by climate conditions, especially humidity. While some control within the space is possible, it might be that critical exhibits should only be displayed in seasons when climatic conditions are generally acceptable.
- Offgassing: This was seen as critical. Offgassing from surfaces and even exhibit housing could cause damage. Wood finishes such as teak and other surface finishes are known to cause corrosion problems. Plastic 'glass' can adsorb and re-emit pollutants.
- Database: a database is needed indicating which pollutants (and concentrations) damage which particular type of exhibit. Also corrosion rates and corrosion tables are needed.
- Education and training: There is sometimes insufficient knowledge within the museum industry about the risk of various pollutants on artefacts. Therefore good guidance documents are needed.

Standards

Standard 62

The main ventilation standard within ASHRAE is Standard 62. This has now been split into:

- 62.1 Ventilation and Acceptable Indoor Air Quality in Commercial Buidings;
- 62.2 Ventilation and Acceptable Indoor Air Quality in Low Rise Residential Buildings.

Standard 62.1 is still subject to much controversy in relation to minimum ventilation rates and health impact. Some of these concerns were raised at a Forum entitled "The implications of Standard 62".

Current issues include:

- The role of the standard, how much should it be associated with health issues;
- Defining minimum ventilation rates;
- Pollutant sources (the need for a regulatory body to define safe pollutant concentrations);
- Comfort issues
- Complexity of calculations;
- Target audience;

Standard 62.2 is currently out for public review.

Standard 161 Air Quality within Commercial Aircraft (Draft)

Currently being drafted is a standard and manual covering air quality in commercial aircraft cabins. This includes contaminants, temperature, humidity, pressure and associated measurements.

Other Presentations

Many other important presentations covering air and ventilation were presented at this meeting. These included Technical Sessions and Symposia on computer models for fire and smoke control, the placement of ventilation air inlets, innovative methods for room air distribution, full scale (air flow) tests in large scale buildings (measurement and CFD), and fault detection. Papers on all these topics are included in the ASHRAE Transactions CD.

ASHRAE Products and CD's

A tour of the ASHRAE meeting bookstore quickly revealed the vast amount of information that has been published by ASHRAE. Of key significance is the extensive use of CD's, which now include ASHRAE Transactions, and the ASHRAE Guide Series. These CD's are very easy to use and have exceptionally good indexing. Much use is made of 'pdf' format, which makes high quality hard copy printing simple and facilitates rapid topic searching and access.

References

Emmerich (1997) Use of computational fluid dynamics to analyse indoor air quality issues.USA, National Institute of Standards and Technology, Building and Fire Research Laboratory, NISTIR 5997, April 1997

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McGrattan (1999) Application of a large eddy simulation model to study room airflow. ASHRAE Winter Meeting, January 1999.

Musser et al (1999) Comparison of residential air infiltration rates predicted by single-zone and multizone models, ASHRAE Winter Meeting, January 1999.

Walker (1999) Distribution system leakage impacts on apartment building ventilation rates, ASHRAE Winter Meeting, January 1999.

Yoshino et al (1999) Numerical analysis of ventilation system performance by COMIS model, ASHRAE Winter Meeting January 1999.

For Further Information...

For further information about this meeting or any other information about ASHRAE, please contact Martin W. Liddament at the AIVC.

International Workshop

Intelligent Natural Ventilation Devices for Indoor Air Quality Control

Brussels, May 19th - 20th 1999

A lack of performance approach as well as differences in national standards, regulations as well as project specific requirements represent a barrier to further developement and market penetration of intelligent natural ventilation devices. The major aims of this one and a half day workshop is to provide a good overview of the present situation in Europe with respect to this issue and to contribute towards the development of better procedures.

Manufacturers, people involved in standardisation, regulation and technical approval bodies as well as architects, consultants and other building professionals will take part to the workshop and exchange their views and future expectations on intelligent natural ventilation devices.

For more information and to take part in the workshop, please contact :

Mr. Stéphane Degauquier
Belgian Building Research Institute
rue de la Violette 21-23, 1000 Brussels
Belgium

Tel. : +32 (2) 655 77 72
Fax : +32 (2) 653 07 29
e-mail : stephane.degauquier@bbri.be

Conference Announcement

20th AIVC Annual Conference

in association with Indoor Air 99

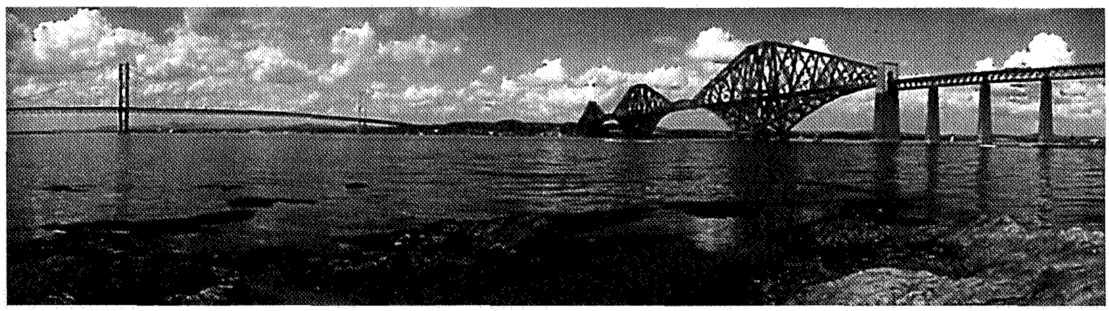
Edinburgh, Scotland, August 8th – 13th 1999

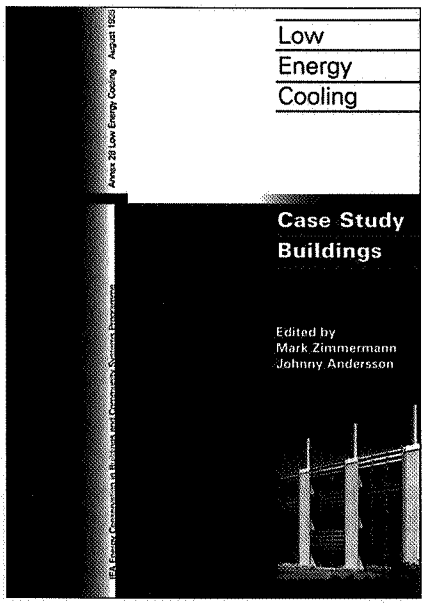
The AIVC's 20th Annual Conference runs in parallel with Indoor Air and participants will be free to attend both Indoor Air and AIVC sessions. Topics cover every aspect of indoor air quality including:

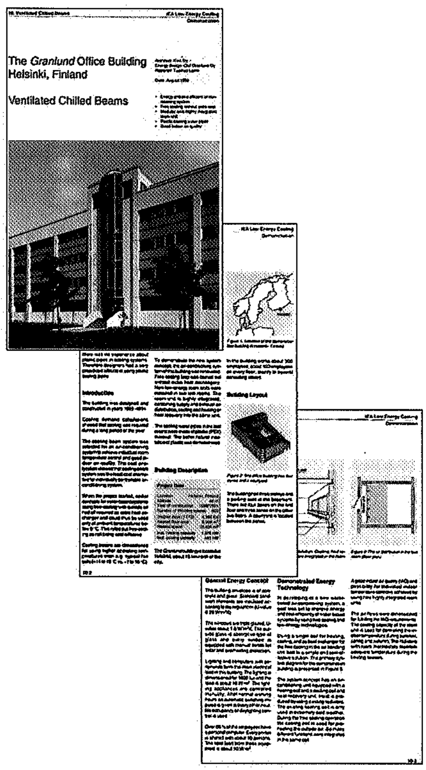
- Ventilation systems and strategies
- Measurement/Modelling
- Ventilation, indoor air quality and health & comfort
- Ventilation and energy
- Guidance (standards, codes and requirements)

Registration should be made through Concorde Services Ltd (Tel: +44 (0) 141 221 5411, Fax: +44 (0) 141 221 2411 email ia99@concorde-uk.com)

For complete details please see the Indoor Air Web Site (http://www.ia99.org)







New Publication

Case Studies of Low Energy Cooling Technologies

As part of IEA ECBCS Annex 28 this report illustrates low energy cooling technologies through demonstrated case studies. Eighteen studies are documented and are aimed at giving feedback on performance and operation in practice including design details and monitored performance data.

Technologies include:

- *Night cooling (natural and mechanical)*
- *Slab cooling (air and water)*
- *Evaporative cooling (direct and indirect)*
- *Desiccant cooling*
- *Chilled ceilings/beams*
- *Displacement ventilation*
- *Ground cooling (water and air)*
- *Aquifer*
- *Sea/river/lake water cooling*

The buildings are located in Canada, Finland, France, Germany, Netherlands, Portugal, Sweden, Switzerland, UK and USA, and hence demonstrate solutions applicable to a diverse range of climatic conditions.

Case studies include office building and commercial centres, dwellings, a bank, hospital and industrial complex. The aim is to provide guidance and evaluation based from experience. Full climatic, building and cost details are presented.

Please quote order number ANN 28 1999:1.

Price £30.00 plus £4.00 postage and handling from:

IEA ECBCS Bookshop,
c/o Oscar Faber Group Ltd.,
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University of Warwick Science Park,
Sir William Lyons Road,
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Great Britain,

Fax: +44 (0)1203 416306,

Web http://www.ecbcs.org

Forthcoming Conferences

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
Brugge, Belgium
Mrs Rita Peys, Conference Manager, Ingenieurshuis - K VIV, Desguinlei 214, B-2018 Antwerpen, Belgium, Tel: +32 3 216 09 96, Fax: +32 3 216 06 89, email: buil@conferences.ti.kviv.be, http://www.ti.kviv.be/conf/buil.htm

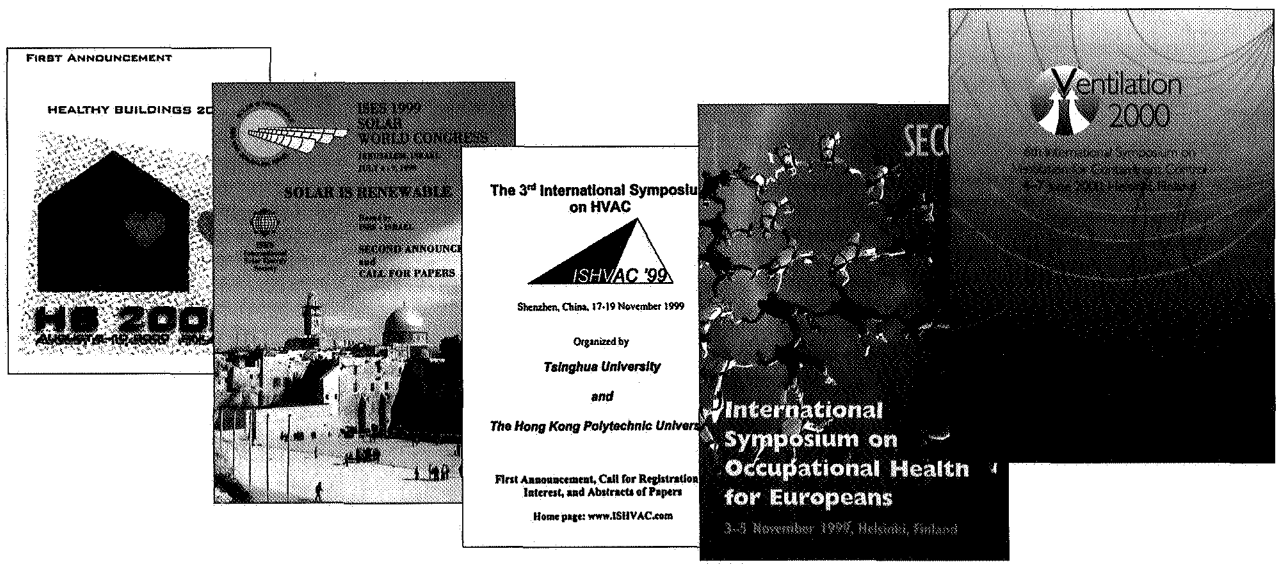
International Conference: Mechanical Ventilation - in Buildings
March 29 - 30, 1999
Welsh School of Architecture, Cardiff University, Cardiff, Wales, UK
Lucy Hammond, Mechanical Ventilation in Buidlings Conference, Welsh School of Architecture, Bute Building, King Edward VII Avenue, Cardiff, Wales CF1 3NB, Tel: +44 (0) 1222 876327, Fax: +44 (0) 1222 874 623, email hammondl@cf.ac.uk

UK-ISES Silver Jubilee Conference
13-15 May 1999
Oak Hotel, Brighton, UK
Mrs C Buckle, The Solar Energy Society, c/o School of Engineering, Oxford Brookes University, Gipsy Lane Campus, Headington, Oxford OX3 0BP, UK, Tel: +44 (0)1865 484367, Fax: +44 (0) 1865 484263, email uk-ises@brookes.ac.uk, http://www.brookes.ac.uk/uk-ises

International Workshop on Intelligent Natural Ventilation Devices for Indoor Air Quality *Control*
19-20 May 1999
Brussels, Belgium
Mr Stephane Degauquier, Belgian Building Research Institute, rue de la Violette 21-23, 1000 Brussels, Belgium, Tel: +32 (2) 655 77 72, Fax: +32 (2)653 07 29, email stephane.degauquier@bbri.be
Aims to provide an overview of the present situation in Europe with respect to this issue and to contribute towards the development of better procedures.

Renewable Energy Europe '99
1-3 June 1999
Frankfurt, Germany
PO Box 9402, 3506 GK Utrecht, The Netherlands, Fax: +31 30 265 09 28, Tel: +31 30 265 09 63, www.pennwell-europe.com
caroline@pennwell.com

ESM 99 13th European Simulation Multiconference Modelling and Simulation - a Tool for the Next Millenium
1-4 June 1999



Warsaw, Poland
http://hobbes.rug.ac.be/~scs/conf/esm99/ or
http://www.informatik.uni-bremen.de/grp/ag-ram/esm99/

Industry & Innovation 1999 ACEEE Summer Study on Energy Efficiency in Industry
June 15-18, 1999
Saratoga Springs, New York, USA
Rebacca Lunetta, ACEEE Conference Office, 1001 Connecticut Avenue, N. W., Suite 801, Washington, D. C. 20036, USA, Tel: (202) 429 8873, Fax: (202) 429 2248, email conf@aceee.org, ACEEE Home Page http://aceee.org

ISES 1999 Solar World Congress
July 4-9 1999
Jerusalem, Israel
ISES 1999 Solar World Congress, PO Box 50006, Tel Aviv 61500, Israel, Tel: 972 3 5140031, Fax: 972 3 5140077 or 5175674, email: ises99@kenes.com, Web: http://tx.technion.ac.il/~meryzse/ises99.html

Indoor Air 99 The 8th International Congress on Indoor Air Quality and Climate
8-13 August 1999
Edinburgh, UK
Prof G J Raw (Indoor Air 99) Building Research Establishment, Watford WD2 7JR, UK Fax: +44 1923 664443 email ia99@bre.co.uk, www.ia99.org

PLEA 1999 Sustaining the Future Energy-Ecology-Architecture The 16th International Conference on Passive and Low Energy Architecture
September 29 - October 1 1999
Brisbane, Australia
Conference Secretariat (Sally Brown), ICTE Conferences, The University of Queensland, Brisbane, Australia 4072, Tel: 61 7 3365 6360, Fax: 61 7 3365 7099, email: sally.brown@mailbox.uq.edu.au

ASTM Symposium on Air Quality and Comfort in Airliner Cabins
October 27-28, 1999
New Orleans, USA
Dr Niren L Nagda, ENERGEN Consulting, Inc., 1990 Wild Cherry Lane, Germantown, MD 20874, USA, Tel: 301 540 1300, Fax: 301 540 6924, email nnagda@paltech.com

International Symposium on Occupational Health for Europeans
3-5 November 1999
Helsinki, Finland
Occupational Health for Europeans '99, Finnish Institute of Occupational Health, Ella Hanninen, Topeliuksenkatu 41a A, FIN-00250, Helsinki, Finland, Tel: +358 9 4747 546, Fax: +358 9 2413 804, email ella.hanninen@occuphealth.fi, http://www.occuphealth.fi/eng/project/oh99

ISHVAC '99 The 3rd International Symposium on HVAC
17-19 November 1999
Shenzhen, China
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Healthy Buildings 2000
6-10 August 2000
Espoo, Finland
Conference Secretariat, Healthy Buildings 2000, PO Box 25, FIN-02131 Espoo, Finland, Fax: +358 9 4355 5655 email info@sisailmayhdistys.fi internet www.hb2000.org www.sisailmayhdistys.fi
Topics are: Criteria for the design and operation of healthy buildings; Economical gains of healthier buildings; Ventilation and air quality; Control of moisture and mould in structures and buildings; Moistureproof materials and constructions; Radon safe structures; Low emission building and interior materials; Quality control of the building process; Design methods for better indoor air quality; Cost effects of indoor climate; Specifications of healthy building design; Prediction and calculation of indoor air quality; How to build and maintain clean ventilation systems; Cleaning of air from particles and gases; Cleaning for healthier indoor climate; Measuring of air quality and indoor climate; Codes and guidelines for healthy buildings; Governmental and voluntary programs for healthy buildings.

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
The conference aims to cover topics including: prediction of air distribution in rooms by analytical, numerical or physical modelling techniques; indoor air quality and thermal comfort; ventilation strategies; measurement and visualization techniques; characterization of heat and contaminant sources; impact of building envelope on the indoor environment; indoor climate performance in occupied buildings.

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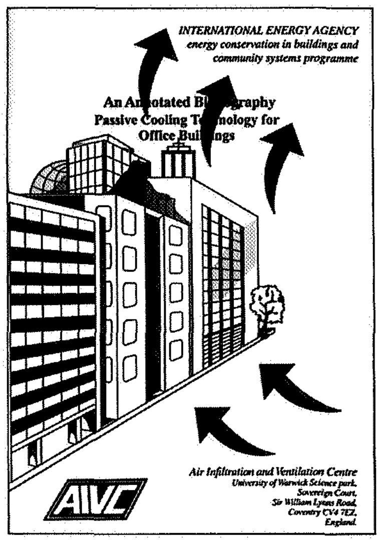

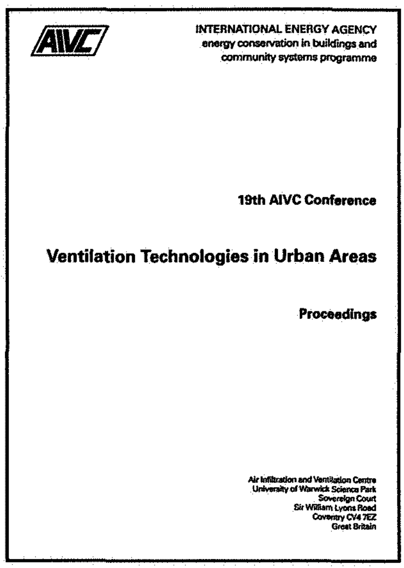

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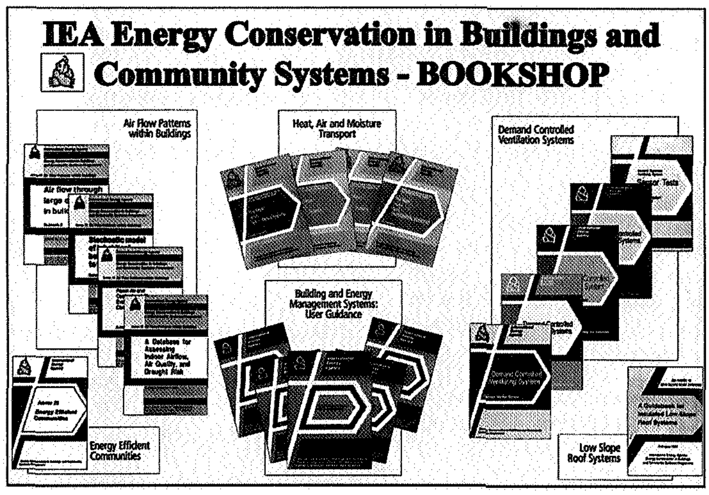

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