Air Infiltration Review

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International Energy Agency - AIVC

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NATVENT™

Overcoming Technical Barriers to Low Energy Natural Ventilation in Office Type Buildings in Moderate and Cold Climates

Led by the Building Research Establishment, UK
(Research carried out within the framework of **THE EUROPEAN COMMISSION**
Non Nuclear Energy **JOULE** *Programme 1994-1998)*

Introduction

A consortium of nine organisations from seven European countries is currently undertaking a 30 month research project concerned with overcoming the technical barriers to low energy natural ventilation in office type buildings. This work commenced in February 1996 as part of the European JOULE Programme. The intention of this article is to outline the objectives of this research activity and to summarise the results of current progress.

Scope of Project

The main scope of the project is to reduce primary energy consumption (and consequently CO_2 emissions) in buildings by:

(a) providing solutions to overcome barriers to the uptake of natural ventilation and low-energy cooling in countries with moderate and cold climates, and

(b) encouraging and accelerating the use of natural ventilation and 'smart' controls as the main design option in new-designs and major refurbishments of office-type buildings.

This project is targeted at countries with low winter and moderate summer temperatures, and where summer overheating from solar and internal gain can be significantly reduced by low-energy design and good natural ventilation. An additional priority is natural ventilation solutions for buildings in urban areas where external air pollution and noise levels are regarded as being high.

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The work is divided into three work packages:

- **WP 1**: identifying perceived barriers to natural ventilation through in-depth structured interviews among leading designers, architects, building owners and developers. A Europe-wide questionnaire has been produced with input from all nine Partners within the NATVENT consortium, and interviews in all the seven participating countries have been carried out. The responses are currently being analysed and a report will be produced comparing country-specific barriers.
- **WP 2:** evaluating the performance of existing ad hoc buildings designed and constructed specifically as energy-efficient naturally ventilated buildings. Eighteen such buildings within the seven EU countries have been identified for monitoring (details of all these buildings will soon be available in a brochure). The intention is to identify any shortcomings and the advantages from such strategies, as well as specifying the overall design and construction conditions required for achieving successful natural ventilation. Parameters such as temperature, humidity and ventilation rates have been measured in pilot studies, and detailed monitoring will take place during both winter and summer periods to identify the efficacy of the different ventilation strategies used for each period.
- **WP 3**: developing 'smart' naturally ventilated technology systems and component solutions to overcome barriers identified. This is being done through the following five activities:

(a) Developing specifications and design solutions for natural ventilation air supply components for use with high external pollution and noise loads. Existing systems have been evaluated and current standards, performance and specifications compiled.

(b) Identifying and specifying conditions under which newly-developed natural ventilation 'smart' constant air inlets can provide acceptable indoor air quality for occupants' health and comfort in offices. An inventory of available components has been made and their performance and requirements are being evaluated.

(c) Developing systems which can provide natural ventilation in cold climates and recover heat without incurring an unacceptably high energy consumption penalty. Characteristics have been defined, a theoretical outline produced, and existing systems are being evaluated.

(d) Developing natural ventilation systems and controls suitable for optimal night cooling. A full literature review has been carried out and system design and control algorithms are well under way.

(e) Addressing and defining robust performance specifications for integrated performance of 'smart' systems for optimum year-round performance. A simulation based on a robust theoretical model has been developed, and work on maintenance needs is on-going.

Effective and widespread dissemination and communication of the results is a key activity. Preliminary results are being disseminated to a wide spectrum of the construction industry, to building designers, architects, researchers and services engineers through national and international conferences and workshops. A network of European architects is being established to provide advice to the consortium. Work is underway to disseminate further results from the project including a specific NATVENT international conference, guide books, a non-technical promotional video and design tools. Exploitation of hardware and software products will follow as appropriate.

Work Package 1: Overcoming Barriers - State of the Art Review

(Led by the Danish Building Research Institute)

To our knowledge, this is the first time a pan-European view has been canvassed to establish the general views of and identify the barriers as seen by building designers, architects, consultants, owners and decision makers regarding natural ventilation in office buildings. Identifying the barriers by means of a questionnaire was seen as the first step in providing solutions to overcome them.

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.

Two parts to the questionnaire were prepared for structured interviews covering:

- **General view on natural ventilation in office buildings:** this focused on general knowledge, viewpoints, experience and perceived problems with natural ventilation systems in office type buildings.
- **Specific building project**: this focused on the decisions actually made during the design or refurbishment of an office type building.

Generally fifteen interviews in each of the seven participating countries were performed during August to November 1996. In the UK, an additional twelve interviews were performed. The persons interviewed were selected with the intention of identifying the variation in opinions and viewpoints on natural ventilation in office buildings. The number of designers and decision makers interviewed were limited due to limited financial resources in the project. Analysis of the questionnaires is currently taking place and a first draft analysis will be available shortly.

Work Package 2 Performance of Naturally Ventilated Buildings

(Led by the Belgian Building Research Institute)

The specific objectives of WP 2 for the first year of work according to the technical programme were:

- To formulate a building description form and select appropriate buildings to be monitored in the seven participating countries.
- To formulate a standard measurement procedure and protocol to be applied during the monitoring of buildings.
- To collect information about NATVENT Partners' equipment available for monitoring.
- To perform prototype testing in two selected buildings in order to assess the adequacy and the applicability of the defined measurement protocol.
- To produce a conference paper on the findings to date.

Among the criteria for selection were the degree of innovation of the natural ventilation concept, the relevance of the concept on a European scale, the overall energy design, and so on. In order to describe the naturally ventilated buildings proposed for monitoring in a standard way, a building description form was produced.

Natural ventilation was considered in terms of the control of indoor air quality and providing thermal comfort in summer.

SULZER and CSTC have co-operated to develop appropriate measurement protocols. Based on discussions and on the availability of equipment, standard measurement protocols have been agreed. Table 2 summarises the parameters which will be measured. This is a minimal requirement, and each team may extend the measurement procedures (more measurement locations or other variables) to their specific case studies. The defined measurement protocol has been applied in two buildings: one in the United Kingdom (GB2) and one in Switzerland (CH2). Both teams have reported on their experience in implementing the proposed measurement techniques and the results of their investigations.

Monitoring has now begun in those buildings where IAQ control is achieved only by natural ventilation, as this aspect is crucial during the winter period. All the buildings will then be measured during summer 1997 to assess the efficiency and applicability of natural ventilation for summer thermal comfort control.

Detailed studies are planned in some of the selected buildings to investigate specific points of interest (e.g. impact of different strategies, impact of height and orientation of offices, longer measurement period, occupant behaviour and so on).

Parameters	Minimal duration		Interval	No. of Locations		
	heating season	cooling season		r	c	o
Temperature	1 week	3 months	30 min	4	1	1
IAQ (CO_2, H_2O)	1 week	1 week	30 min	4		1
Ventilation rate	1 week	1 week	30 min	4	1	1
Indoor air velocity	1 week	1 week	30 min	1	0	0
Wind	1 week	1 week	1 hour	0	0	1

Table 2: Overview of the monitoring parameters and the duration of the measurements (r: room, c: corridor, o: outside)

Work Package 3 'Smart' Technology Systems and Components

(Co-ordinated by the Building Research Establishment, UK)

The overall objective of this work package is to provide solutions for the shortcomings identified in WP1 for the application of natural ventilation. To date, the results emerging from the interviews carried out under WP1 and the paper study of the current practice as applied in buildings included in WP2 reconfirm that the most likely technical problem areas are as outlined and being investigated by the five activities of this work package. Activity 1 addresses issues of building location in relation to external pollution and noise, activities 2 and 3 address problems associated with winter provision for IAQ, and Activity 4 addresses summer overheating problem areas. Activity 5 aims to integrate solutions for year-round optimum performance.

1. Air supply components

(Led by TNO, The Netherlands)

The specific objectives of this Activity for the first twelve month period were:

- To evaluate existing systems used for filtration of external pollutants and noise reduction.
- To collect information on standards/guidelines and research in this area for each participating country.
- To establish parameters and performance specifications by simulation studies.
- To produce a report on the availability, requirement and performance of filtration systems.
- To produce a conference paper.

Information on guidelines and standards for air pollutants and noise levels for all the participating European countries has been reviewed. Existing systems used for filtration of external pollutants and noise reduction have been evaluated. A report on the availability, requirement and performance of filtration systems and a conference paper are in progress.

2. Constant (natural) air flow inlets

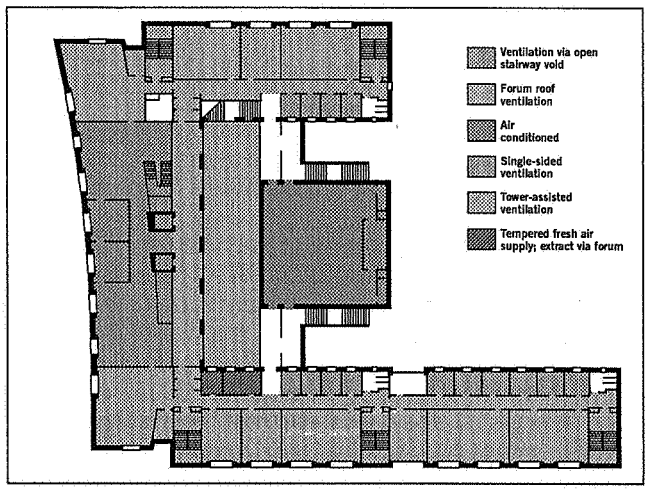
The specific objectives for this period were as follows:

- To carry out a review of available constant air flow inlets and their performance.
- To prepare a list of guideline values for parameters associated with indoor air quality.
- To produce a report on the performance and requirement of constant air flow inlets.
- To produce a conference paper on the findings.

Currently an inventory of available air flow inlets has been made; these include:

- sensor controlled inlets based on indoor air quality
- pressure controlled inlets
- moisture controlled inlets
- temperature controlled inlets

The main characteristics such as principles and limitations and their applications in the total ventilation system have been studied. Consideration has also been given to their contribution in relation to the summer cooling problem.



Portsmouth University's new environment faculty building, built with mixed mode design and using natural ventilation, one of the buildings to be monitored in the present study

(Reproduced with permission from Building Services Publications Ltd, London,UK)

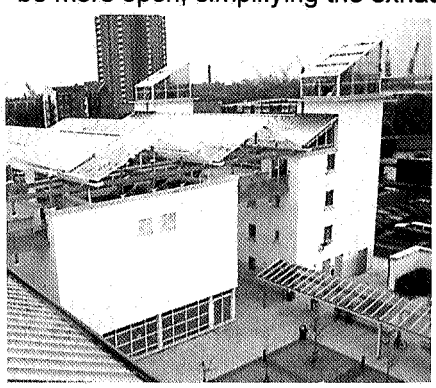
3. Advanced natural ventilation systems with heat recovery

(Led by the Norwegian Building Institute)

The specific objectives for the relevant period were:

- To carry out a review of ventilation systems with and without heat recovery to include natural driving forces, airflow rates and control, duct systems, etc.
- To identify the characteristics of an advanced natural ventilation system suitable for office type buildings in cold climates.
- To begin evaluating existing systems and the development of advanced systems.
- To produce a conference paper on the findings.

To evaluate the potential for heat recovery, the natural driving forces for different countries throughout the whole year have been calculated based on a 'typical' office module and hourly data. It was found that there is a large variation in the driving force between the cities and within the cities themselves and that available pressure differences are in the range 10-20 Pa for the majority of the time. Different concepts for heat recovery systems have been evaluated. Both simple and more advanced concepts have been studied, for example, simple concepts using air-to-air recuperative heat exchangers, practical concepts which utilise wind forces and separated air supply, and extract systems which may provide the additional benefits of wind conditions, the possibility of cleaning the supply air and better distribution of the supply air. All practical solutions may involve a close integration with the building design, reducing the need for ordinary ducting. The building design may be more open, simplifying the exhaust air stack.



There are numerous architectural possibilities here.

4. Night cooling controls

(Led by Delft University of Technology, The Netherlands)

The specific objectives for the first 12 month period were:

- To carry out a state-of-the-art review on the availability of hardware suitable for night cooling.
- To prepare a report and a conference paper on the findings.
- To begin the design of night cooling ventilation systems.

Progress has concentrated on automatic control of the hardware for night cooling based on a number of strategies. Merits and limitations of these control strategies with computer simulations are being carried out and compared with each other. The computer simulation package SIMULINK is being upgraded and linked to a weather module, a thermal module, a ventilation module and a control module.

5. Integration and maintenance

(Led by J&W Bygg & Anläggning AB, Sweden)

The main objective of the work during 1996 was to establish the major part of a robust theoretical model and a computer simulation program for determining the indoor conditions in a naturally ventilated office building - in terms of outdoor air flow rates and indoor air temperatures. At present, there is no competing code on the market comparable to the simulation program being worked on in this project. It may be anticipated that the use of the simulation program in the project work as a whole, will be extremely beneficial for the technical outcome of the NATVENT project. A 'beta' version of the simulation program, based on a robust theoretical model, has now been developed and has been called 'NATVENT'. This program is written in Visual Basic for Windows, thus allowing an extremely user-friendly performance for architects, designers etc.

The work on the maintenance part of this activity has resulted in a technical paper by A.H.C van Paassen and B.P. Gröninger entitled "Comparison of heating, ventilation and air-conditioning systems with respect to reliability, maintenance costs, energy consumption, first costs and comfort".

Conclusions

Considerable progress has already been made in understanding the performance and needs of naturally ventilated buildings. The questionnaire survey, monitoring programme and component design activities have helped considerably in developing natural ventilation strategies.

The Natvent Consortium

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Theme of Conference

Hot climates and high building heat gains both contribute to the need for the cooling of indoor spaces. In an effort to control energy demand, much research is focusing on techniques aimed at minimising the need for refrigerative cooling. These approaches are invariably linked to ventilation techniques and air movement. The objective of this conference is to review this area of activity.

Abstracts approximately 300-500 words are invited, on the following, or related, topics.

Specific areas of interest include:

- *Ventilation for cooling*
- *Night cooling*
- *Architectural strategies*
- *Strategies for non residential buildings*
- *Strategies for dwellings*
- *Impact of air infiltration*
- *Achieving acceptable indoor comfort (Temperature, humidity, air speed etc)*
- *Calculation for design*
- *Measurement methods*

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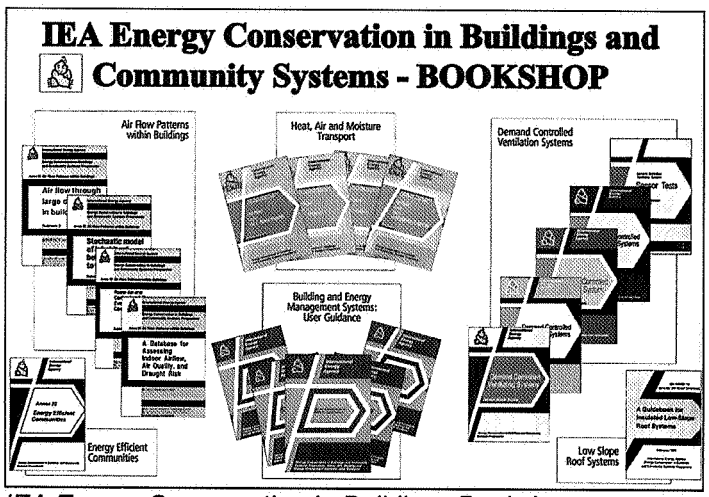
Air Infiltration and Ventilation Centre

A New Service from AIVC

Energy Conservation in Buildings and Community Systems Bookshop

by Janet Blacknell

In conjunction with the International Energy Agency's Energy Conservation in Buildings and Community Systems Program, of which AIVC is one of thirty four annexes, a new Bookshop and Information Service is being built up, aimed at providing a service to all annex projects, and to increase awareness among researchers, practitioners and other interested parties of the valuable work carried out by the program.



IEA Energy Conservation in Buildings Bookshop - a new AIVC service

The Bookshop currently holds an extensive catalogue of IEA "ECBCS" publications, including final reports, summary/overview reports and related papers from journals and conferences. A more general collection of selected International Energy Agency publications and information is planned.

Past and Present Topics of the Program

Current and Completed Projects are:

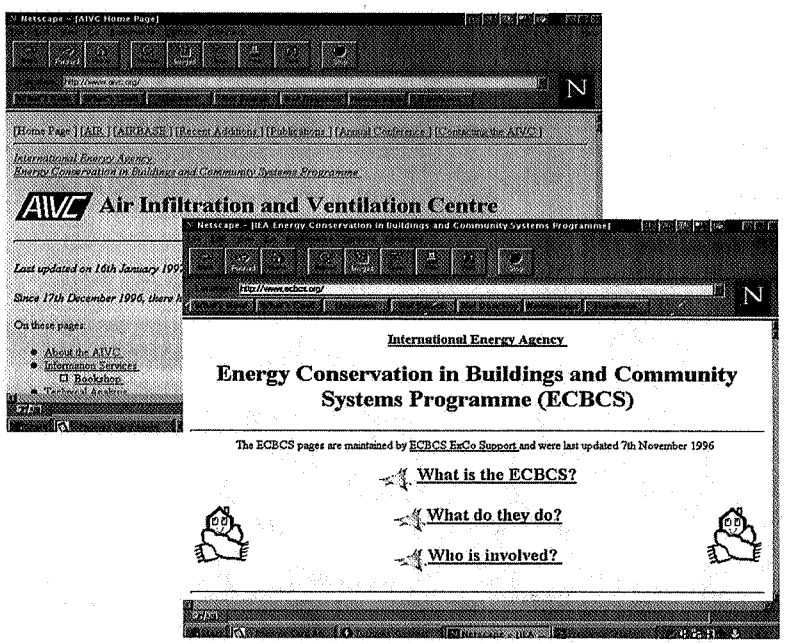
- *Load Energy Determination of Buildings*
- *Energy Conservation in Residential Buildings*
- *Air Infiltration and Ventilation Centre**
- *Energy Systems and Design of Communities*
- *Local Government Energy Planning*
- *Inhabitant Behaviour with Regard to Ventilation*
- *Minimum Ventilation Rates*
- *Building HEVAC Systems Simulation*
- *Energy Auditing*
- *Windows and Fenestration*
- *Energy Management in Hospitals*
- *Condensation and Energy*
    - *Energy Efficiency in Schools*
    - *Building Energy Management Systems - User Interfaces and System Integration*
    - *Building Energy Management Systems - Evaluation and Emulation Techniques*
    - *Demand Controlled Ventilation Systems*
    - *Insulated Low-Slope Roof Systems*
    - *Airflow Patterns within Buildings*
    - *Environmental Performance of Buildings*
- *Energy Efficient Communities*
- *Multizone Airflow Modelling*
- *Heat, Air and Moisture Transport in New and Retrofitted Insulated Envelope Parts, "HAMTIE"*
- *Real Time Simulation of HEVAC Systems for Building Optimisation, Fault Detection and Diagnosis (BOFD)*
- *Indoor Environmental Control of Large Spaces*
- *Evaluation and Demonstration of Domestic Ventilation Systems**
- *Low Energy Cooling Technologies**
- *Daylighting in Buildings**
- *Bringing Simulation to Application**
- *Energy Related Environmental Impact of Buildings**
- *Integral Building Envelope Performance Assessment**

- *Advanced Local Energy Planning**
- *Computer Aided Fault Detection and Diagnosis**
- *Working Group - Indicators of Energy Efficiency in Cold Climate Buildings**
- *Future Buildings Forum**

**Ongoing projects*

Awareness

The Bookshop has evolved over the last year, and interest continues to grow as a result of information dissemination activities including posters and exhibitions, mailshots and the Web pages. As a result, enquiries have shown a healthy increase in January 1997 to the extent that publication requests for January alone match those for June to December 1996. Web enquiries in January have shown a 30-40% increase over the previous average, with visits to "Recent Additions to Airbase", the latest abstracts of material added to the AIVC library running at 90 visits per month.



Web pages

Bookshop Information and Material

As well as the AIVC's considerable output of technical publications, produced over eighteen years (listed on page 15), a catalogue of publications from the 34 above listed projects is also available from the Air Infiltration and Ventilation Centre.

For more details about the new bookshop and information on future developments, please feel free to contact us at the AIVC, or to visit the Bookshop on the Web at http://www.ecbcs.org/ECBCSs.html

Latest Publications of Interest

Heat, Air and Moisture Transport in New and Retrofitted Insulated Envelope Parts

The project aimed to model and study the physical phenomena behind heat, air and moisture transport, and to analyse the consequences for energy consumption, hygrothermal performance and durability. The final report is in three volumes:

Modelling (Volume 1)
by Hugo Hens
Concerned with model and algorithm development, the report details improvements in modelling as well as the testing of simplified models with a potential to predict the combined effects of heat, air and moisture transport on thermal performance, hygrothermal response and durability. Summarises four years of common work.(ANN 24 1996:1) Also a companion volume of summary reports for the common exercises (ANN 24 1996:2)

Environmental Conditions (Volume 2)
by Sanders C
Covers the choice of environmental parameters, a methodology for handling them and the development of sample sets of environmental conditions. Chapters cover environmental data currently used in HAMTIE analysis, internal and external conditions. (ANN 24 1996:3)

Material Properties (Volume 3)
by M Kumar Kumaran
Deals with the terminology, symbols, thermal, hygric and air properties of materials and layers for heat, air and moisture transport in insulated building envelope parts. (ANN 24 1996:4)

Real Time Simulation of HEVAC Systems for Building Optimisation, Fault Detection and Diagnosis (BOFD)

Source Book
edited by J Hyvarinen, S Karki
Describes the basic concepts and the fault detection and diagnosis approaches applied in the project. A major part of the book is devoted to important faults of typical HVAC systems. (ANN 25 1996:1)

Technical Papers from Annex 25
edited by J Hyvarinen
Compilation of papers produced in the course of the project, covering HVAC system applications, method applications, and generic BOFD tools.(ANN 25 1997:1)

Ventilation in Schools
A New Annotated Bibliography from the AIVC

by Mark Limb, AIVC Scientist

The AIVC's series of annotated bibliographies aims to review and technically assess current literature and provide a concise but in depth overview of particular subjects. The latest addition to this series is described below.

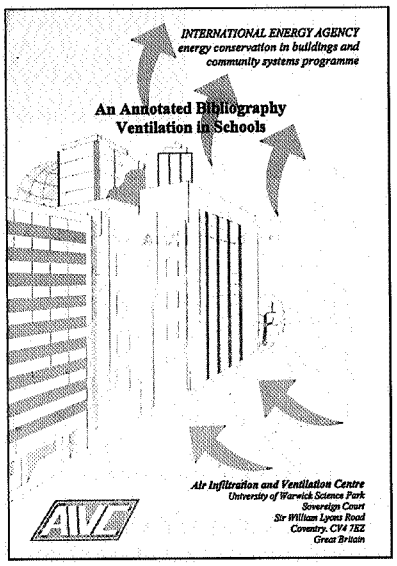
With over one hundred references, the document is divided into ten sections as follows:

- *Introduction*
- *Previous International Energy Studies*
- *Ventilation Rate Standards and Requirements*
- *Mechanical Ventilation*
- *"Mixed Mode" or "Hybrid" Systems*
- *Natural Ventilation*
- *Infiltration in Schools*
- *Indoor Air Quality:*
  - *Carbon dioxide (CO_2) as an indicator of poor air quality*
  - *Radon Ingress into Educational Buildings*
  - *Other indoor air quality studies relating to educational buildings*
- *Conclusions*
- *References*

Choice of Strategy

The choice of ventilation strategy for schools is governed by a variety of factors not the least of them being an often severe restraint on budget. Ultimately, the need is to design and install efficient, effective and easily maintainable systems. Important design factors include climate, periods of occupancy, and the variable nature of occupant activities (for example , class teaching, physical education and laboratory studies). To ensure a good environment in which the learning process is maximised, it is important to consider all these needs. A review of the scientific and technical literature has revealed a variety of design solutions and case studies, which include mechanical, natural and hybrid ventilation strategies, combined with various heat recovery and cooling methods. Buildings covered by this report are predominantly schools although some examples of university and higher educational establishments are also included.

Most educational buildings represent a difficult combination of ventilation problems. These typically include a relatively transient population where intense periods of work are regularly punctuated by periods of intense movement. Local climate typically dictates the type of ventilation system adopted within educational buildings.



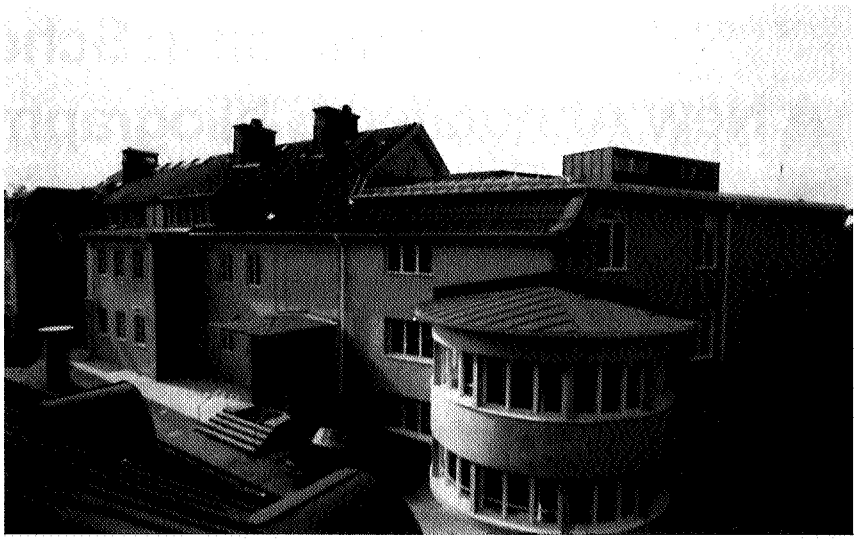
Natural Ventilation Systems

Natural ventilation systems are commonly found in operation in schools which experience a temperate climate. Ventilation using windows, or stack driven flow are typical strategies. In some regions where the climate is more favourable, passive solar designs are common. However, it is important when considering natural ventilation systems to ensure an adequate number of windows to provide sufficient daylighting. Where these windows are used for ventilation there should be enough at both high and low level, and the position should enhance the designed ventilation system. They should also give good overall control, being sufficiently airtight to restrict air leakage for energy and comfort reasons, but easily openable for ventilation. Recent studies have suggested that with the extended use of IT and increased pupil density in most modern schools the use of single sided ventilation cannot be relied upon to satisfy ventilation requirements. Cross ventilation is suggested as being a more appropriate alternative.

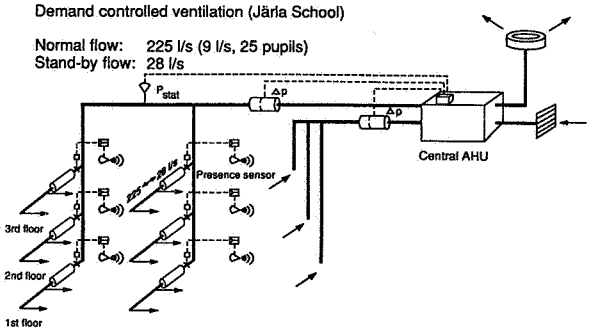
The risk of solar overheating in schools with large glazed areas is an important consideration. Therefore use should be made of shading, the surrounding area, thermal mass and reflective colours. The use of a central atrium to drive this ventilation system is not uncommon. One advantage of these systems is that they include ventilation preheating, where cool air trapped in these features is heated by solar radiation and is then used to ventilate the remaining classrooms. Several case studies are discussed in the review outlining the use and applicability of these different systems.

Infiltration Problems

Infiltration is an important consideration: poor workmanship and a general lack of understanding regarding the sealing of air leakage cracks are frequently cited as its main cause. Several studies investigate the level and influence of infiltration in school buildings.



Mechanical ventilation is found more commonly in areas that experience climatic extremes, such as hot, humid parts of the US. Although the wide range of activities currently undertaken in many modern schools means that mechanical ventilation is capable of meeting these differing needs throughout the whole day, which often extends beyond the normal school day. In rooms with very high cooling demand, such as computer suites and kitchens requiring continual ventilation, which cannot be guaranteed by natural means, the use of HVAC systems is essential.



Järla school in Nacka, Sweden, site of an eighteen month investigation into the performance of a demand controlled ventilation system. A comparison of displacement and mixing systems found significantly lower CO_2 concentration for the displacement system.

The Importance of Good Maintenance and Design

Due to the strict budget constraints that now exist in most schools, the designer must consider a number of vital aspects from the beginning, such as the most apt and suitable choice of system for the specific school and the system's flexibility. Adequate HVAC control must be included and any BEMS must be properly programmed. A good level of maintenance is essential, and so the system should have as simple a design as possible. A planned maintenance schedule is also important; deferred maintenance operations can often result in major equipment breakdown. A thorough understanding of the system and its uses can have significant benefits, for example, the way in which the school buys its energy. Utility companies may give special rates or discounts to schools under certain conditions or incentive programs.

The review outlines several case studies of different HVAC systems including air conditioning and demand controlled ventilation . Several systems incorporate heat recovery devices, such as heat pumps, and heat exchangers. Although mechanical ventilation systems operate during periods of occupancy, it has been suggested that the air in classrooms is purged during the relatively short break periods, by opening windows and doors. This represents an economically attractive form of ventilation, because the ventilation periods are short. Maintaining this activity does however require strict discipline, particularly in winter, since draughts, noise and outdoor pollution can often present problems.

Carbon Dioxide and Radon Problems

Indoor air quality concerns in schools centre around high levels of $C0_2$ and radon, although moisture, thermal comfort and the effect of external pollutants have also been studied. High levels of carbon dioxide have been associated more with insufficient and inadequate ventilation than with excessively high emittence from pupils and staff. Suggested remedies more often than not include improving the present ventilation system or in some instances upgrading part or the entire system, the effect of which is to increase the ventilation rate. With radon, the solutions are not as straightforward. Pressurisation or suction are the two opposing methods, each being effective for particular individual cases. It would seem that most other IAQ problems encountered in schools can be remedied or avoided by effective design and careful maintenance and investment.

Altogether the 102 papers outlined in this review consider a wide variety of ventilation problems in schools, and demonstrate that there is no definitive answer as each building is an individual entity and as such may exhibit quite different problems from its neighbour. To order your copy of this and other publications please return the order form enclosed with this newsletter.

New Technical Note from AIVC

Technical Note AIVC 48

The Role of Ventilation in Cooling Non-Domestic Buildings

by Steve Irving, Oscar Faber Group Ltd

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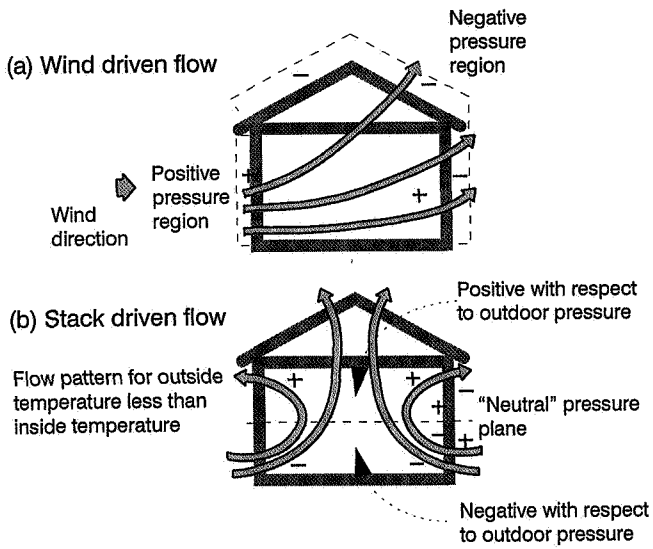
This short introductory note aims to set the need for cooling into the context of overall building design, and to stress the role of ventilation in meeting the cooling need.

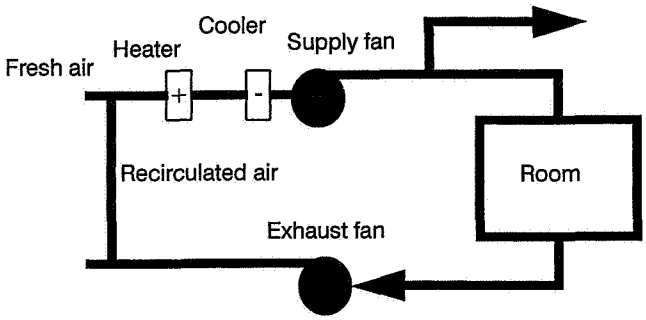
Careful consideration needs to be given by the designer to cooling and dehumidifying buildings in order to maintain thermal comfort in summer conditions. In some hot and/or humid parts of the world, summer cooling can be a requirement for residential buildings, including single family dwellings, but less attention has so far been paid to non-domestic buildings.

The Note demonstrates that the key issues are to achieve a good envelope design in order to minimise the cooling load, also illustrating the importance of the fan energy consumption in the overall energy balance of an air cooling system. Good design must therefore seek to optimise the ventilation system design and control strategy, to deliver the required occupant comfort in an energy efficient way.

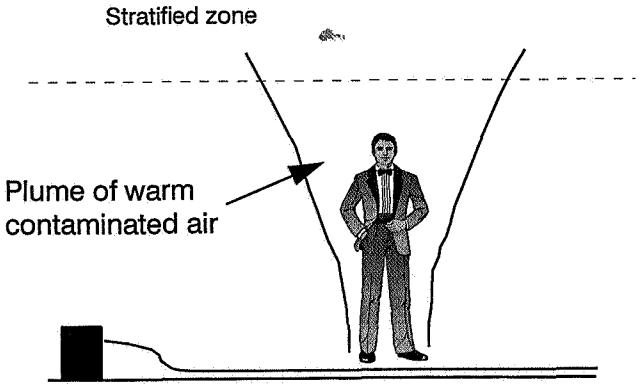


Typical natural ventilation strategies; natural ventilation is becoming a commonly adopted design strategy in many parts of Europe.

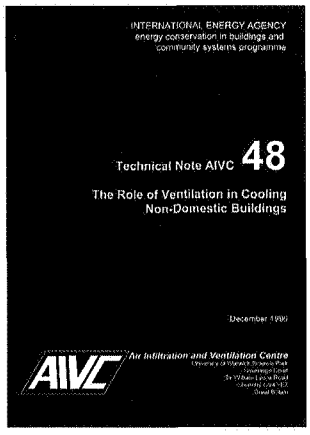
In addition to a valuable bibliography of other cooling-related publications, the Note includes chapters on ventilation and cooling requirements; factors affecting cooling load; ventilation and cooling systems; and energy issues in ventilation and cooling, covering space cooling load, plant load and fan energy.



Simplified schematic illustrating energy issues related to ventilation and cooling: the primary energy transfers occur where air is introduced into the room, at the air handling plant, and at the fan.



A displacement ventilation system.



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The AIVC's home page holds Air Infiltration Review, publications and conference details and a searchable database based on the current edition of Recent Additions. The address is http://www.aivc.org/

GUIDES

Guide to Energy Efficient Ventilation, Liddament M W, 1996, GV

TECHNICAL NOTES

Air Infiltration Calculation Techniques,1986,Applications Guide, CT
Air infiltration control in housing, 1983, Handbook, HNBK
Validation and comparison of mathematical models, 1983, TN 11
Wind pressure data requirements, 1984, TN 13
Wind Pressure Workshop Proceedings, 1984, TN 13.1
Leakage Distribution in Buildings, 1985, TN 16
Ventilation Strategy - A Selected Bibliography, 1985, TN 17
Airborne moisture transfer: workshop proceedings, 1987, TN 20
Review and bibliography of ventilation effectiveness, 1987, TN 21
Inhabitants' behaviour with regard to ventilation, 1988, TN 23
AIVC Measurement Techniques Workshop, 1988, TN 24
Subject analysis of AIRBASE, 1989, TN 25
Minimum ventilation rates, IEA Annex IX 1989, TN 26
Infiltration and leakage paths in single family houses, 1990, TN 27
A guide to air change efficiency, 1990, TN 28
A guide to contaminant removal effectiveness, 1991, TN 28.2
Reporting guidelines for airflows in buildings, 1991, TN 32
A review of building air flow simulation, 1991, TN33
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A Strategy for Future Ventilation Research and Applications, Liddament M W, 1992, TN 37
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A Review of Ventilation Effeciency, Liddament M W, 1993, TN 39
An Overview of Combined Modelling of Heat Transport and Air Movement, Kendrick J F, .1993, TN 40
Infiltration Data from the Alberta Home Heating Research Facility, Wilson D and Walker I, 1993, TN 41
Current Ventilation and Air Conditioning Systems and Strategies, Limb M J, .1994, TN 42
Ventilation and Building Airtightness: an International Comparison of Standards, Codes of Practice and Regulations, Limb M J, 1994, TN 43
An Analysis and Data Summary of the AIVC's Numerical Database, Orme M S, 1994, TN 44
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1994 Survey of Current Research, Limb M J, 1995, TN 46
Energy Requirements for Conditioning of Ventilation Air, Colliver D, 1995, TN 47
The Role of Ventilation in Cooling Non-Domestic Buildings, Irving S J, 1997, TN 48

ANNOTATED BIBLIOGRAPHIES

(Participants only - price see order form)
Ventilation and infiltration characteristics of lift shafts and stair wells, 1993, BIB1
Garage Ventilation, 1994, BIB2
Natural ventilation, 1994, BIB3
Air intake positioning to avoid contamination of ventilation air, 1995, BIB4
Heat pumps for ventilation exhaust air heat recovery, 1996, BIB5
Ventilation in Schools, 1997, BIB 6

AIVC CONFERENCE PROCEEDINGS

Earlier AIVC Conference Proceedings are available as individual papers. Contents pages can be forwarded on request.
'Ventilation System Performance' Belgirate, Italy, 1990, (11th)
'Air Movement and Ventilation Control within Buildings', Ottawa, Canada, 1991, 3 volumes, (12th)
'Ventilation for Energy Efficiency and Optimum Indoor Air Quality', France, 1992, (13th)
'Energy Impact of Air Infiltration and Ventilation', Denmark, 1993, (14th)
'The Role of Ventilation', Buxton, UK, 1994, (15th)
'Implementing the Results of Ventilation Research', Palm Springs, USA, 1995, (16th)
'Optimum Ventilation and Air Flow Control in Buildings', Gothenburg, Sweden, 1996, (17th)

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Reykjavik, Iceland
Contact: Skogarhild 18, IS 101 Reykjavik, Iceland

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9-12 June 1997
Marrakesh, Morocco
Send abstracts to: Dr F Haghighat Centre for Building Studies, Concordia University, 1455 De Maisonneuve Blvd W, Montreal, Quebec, H3G 1M8 Canada Fax: 514 848 7965 For general information: Prof A Mir, Ecole Superieure de Technologie, BP 33/S Agadir, Morocco Fax: 212 8 22 78 24 or 212 8 22 72 60

CIB TG8 Second International Conference Buildings and the Environment
9-12 June 1997
Paris, France
Contact: Scientific Secretariat, Dr Sylviane Nibel, ENEA, Department CSTB 84, Avenue Jean Jaures, BP 02 77421, Marne la Vallee Cedex 2, France Tel: +33 (1) 64 68 8301 Fax: +33 (1) 64 68 83 50 email nibel@cstb.fr

July

1997 ACEEE Summer Study on Energy Efficiency in Industry "How Industry will produce energy efficiency services in the 21st century"
July 8-11, 1997
Sheraton Saratoga Springs, New York, USA
Contact: Debbie Giallombardo, ACEEE Conference Office, 1001 Connecticut Ave NW, Suite 801, Washington DC 20036, USA Tel: 202 429 8873 Fax: 202 429 2248 email ace3-conf@amail.pnl.gov www http://crest.org/aceee

August

Heat Pumps in Cold Climates
11-12 August 1997
Acadia University, Wolfville, Nova Scotia, Canada
Contact: R L Douglas Cane, Caneta Research Inc, 7145 West Credit Ave., Ste. 102, Bldg 2, Mississauga, Ontario, Canada L5N 6J7, Tel: 905 542 2890, Fax: 905 542 3160, email caneta@compuserve.com

Clima 2000 '97
August 30 - September 2, 1997
Brussels, Belgium
Contact: Clima 2000 '97, c/o SRBII, Ravenstein, 3, B-1000 Brussels, Belgium Tel: +32 2 5117469 Fax: +32 2 511759

September

ISBE Indoor and Built Environment Problems in Asia
4-5 September 1997
Kuala Lumpur, Malaysia
Contact: Dr H H Lim, Medviron Consultants, Sdn Bhd 257-2, Jalan Tun Sambanthan 50470, Kuala Lumpur, Malaysia

Building Simulation '97 International Building Performance Simulation Association Fifth International Conference
September 8-10 1997
Prague, Czech Republic
Contact: Secretariat Building Simulation '97 Faculty of Mechanical Engineering, Dept of Environmental Engineering, Czech Technical University in Prague, Technicka 4 166 07, Prague 6, Czech Republic Tel/Fax +42 2 2435 5616 email bs97@fsid.cvut.cz

Air Conditioning in High Rise Buildings '97 International Conference
9-12 September 1997
Shanghai, China
Contact: Prof W D Long, Shanghai Society of Refrigeration, 47 Nanchang Road, Shanghai 200020, P.R. China Tel: 86 21 63722229 Fax: 86 21 63277108

Ventilation '97 5th International Symposium on Ventilation for Contaminant Control
14-17 September 1997
The Westlin Hotel, Ottawa, Ontario, Canada
Contact: Ventilation '97, ACGIH, 1330 Kemper Meadow Dr., Cincinnati, Ohio 45240, USA Tel: (513) 742 2020 Fax: (513) 742 3355 email ACGIH_mem@pol.com

International Energy Agency
Air Infiltration and Ventilation Centre
18th Annual Conference Ventilation and Cooling
23-26 September 1997
Athens, Greece
Contact: Mrs Rhona Vickers, Conference Organiser, Air Infiltration and Ventilation Centre, Sovereign Court, University of Warwick Science Park, Sir William Lyons Road, Coventry CV4 7EZ, Great Britain

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