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IEA-ECBCS Annex 35 HybVent

The Hybrid Ventilation Process -Theoretical and Experimental Work

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Introduction

Hybrid ventilation systems can be described as systems providing a comfortable internal environment using both natural ventilation and mechanical systems, but using different features of the systems at different times of the day or season of the year. The operating mode varies according to the season and within individual days, thus the current mode reflects the external environment and takes maximum advantage of ambient conditions at any point in time.

The scope of this annex is to obtain better knowledge of the use of hybrid ventilation technologies. The annex focuses on development of control strategies for hybrid ventilation, on development of methods to predict hybrid ventilation performance in office buildings and on implementation and demonstration of hybrid ventilation in real buildings.

Thorough understanding of the hybrid ventilation process is a prerequisite for the successful application of hybrid ventilation, for development of optimum control strategies and for development of analysis methods for hybrid ventilation design. A part of the work in the annex is therefore focused on theoretical and experimental studies of different elements of the air flow process from air flow around buildings, air flow through openings, air flow in rooms to air flow between rooms in a building.

In this issue

Hybrid ventilation air flow process

The key difference between natural and mechanical ventilation air flow processes lies in the fact that neither volume flow rate nor flow direction at the ventilation openings are predetermined in the former system. Natural forces drive natural ventilation. The stack pressure is determined by the temperature difference between the indoor and outdoor air, which is, in turn, affected by ventilation flow rates. The wind pressure is strongly affected by the microclimate around the buildings, which is again affected by landforms, vegetation and other surrounding buildings. Natural ventilation driving forces are highly unsteady and both flow rates and air flow directions can vary considerably during the running period and not necessarily in phase with the occupants needs.

In the design of building and natural ventilation and control system this can be solved to some extent. In hybrid ventilation, additional mechanical systems are installed to solve the remaining problems. For example, too low volume flow rates in summer, dehumidification of humid air and/or unwanted flow directions in occupied hours. However, optimisation of the use of mechanical systems and the energy consumption requires a detailed knowledge of the hybrid ventilation air flow process.

In annex 35 individual elements of the air flow process are investigated as well as the air flow process of whole systems. The following gives an idea of the work and refers to already published results.

Climate data and air flow around buildings

Climate data is crucial in hybrid ventilation analysis, in particular in natural ventilation mode analysis. Usually, climate data is only available from meteorological stations. The local conditions are, as mentioned before, strongly affected by the microclimate around the buildings, which is again affected by landforms, vegetation and other surrounding buildings. The data from meteorological stations is, therefore, not always representative for the building location and a transformation of meteorological data into local ventilation input data is necessary. In annex 35 research groups work on transformation of wind data and on estimation of the "heat island effect", which results in considerably higher temperatures in city centres compared to meteorological stations in open country.

Pressure distribution on building surfaces

Wind forces appear in natural ventilation calculations in the form of wind pressure coefficients acting over building surfaces, where ventilation openings are intended. The dimensionless coefficient is an empirically derived parameter that accounts for the changes in wind-induced pressure. Its value changes according to wind direction, building surface orientation, and topography and roughness of the terrain in the wind direction.

Typical data for simple solid models is given in tabular form in the literature. The use of these pressure coefficients is largely a matter of convenience as this data measured for wind loading purposes is readily available. However, several investigations have shown that the pressure difference across buildings varies with the relative size and location of openings, [Aynsley]. In annex 35, wind pressures around buildings with openings and the impact on ventilation performance is investigated by experimental studies in wind tunnels and theoretical CFD studies. Wind pressures around buildings is also studied in two of the pilot studies.

Air flow characteristics of openings

Computation of natural ventilation air flow through small openings is most commonly done using discharge coefficients. These quantify the airflow efficiency of an opening or alternatively the air flow resistance of open-

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ings. Many of the discharge coefficient values used are derived from data traditionally used for fluid flow in pipes. Entry conditions such as incidence of openings to the approaching wind can significantly influence discharge due to momentum effects at windward openings. Also downstream conditions significantly influence the discharge, but are rarely accounted for.

In the case of discharge coefficients for window or door openings, a value of 0.6 for a sharp-edged rectangular opening is often used. Preliminary results from laboratory experiments show that the discharge coefficient cannot be regarded as constant. Figure 1 shows for a side hung window that the discharge coefficient both is a function of opening area, air temperature difference and air flow rate.

There is no established theoretical justification for assuming that the wind pressure coefficient approach and the Bernoulli's equation are applicable for calculating flows through large external openings in buildings. Unfortunately this question has significant implications for the methods of calculating wind-induced natural ventilation in multi-zone methods. Treatment of various openings in analysis methods needs to be based on the physics of the flows through the openings. Fracastoro et al. are investigating air flow through large openings by CFD-calculations to predict air change rates and temperature conditions under different climatic conditions, [Fracastoro et al].

Air flow characteristics for other elements

As such, there are no real hybrid ventilation components. A hybrid system in nearly all cases exists as a combination of components, which can be used in purely natural systems or purely mechanical systems. However, in order to allow correct design and functioning of a hybrid ventilation system, availability of appropriate components is essential and often there is a large potential for performance improvements.

Sandberg has shown the advantages of using solar chimneys for both cooling of building integrated photovoltaics and as driving force for a hybrid ventilation systems. In both situations a high flow rate with a low temperature is preferable and a design method has been developed and verified by experiments, [Sandberg].

Air flow in and between rooms in a building

The air flow process in and between rooms in a building is very important for the performance of hybrid ventilation systems but is not very well understood. However, a better understanding is needed before major improvements in design and analysis methods can be achieved. Several research groups are studying and developing models for inter-zonal buoyancy driven and forced air flows through both vertical and horizontal openings, [Chen et al.] and [Delsante et al.].

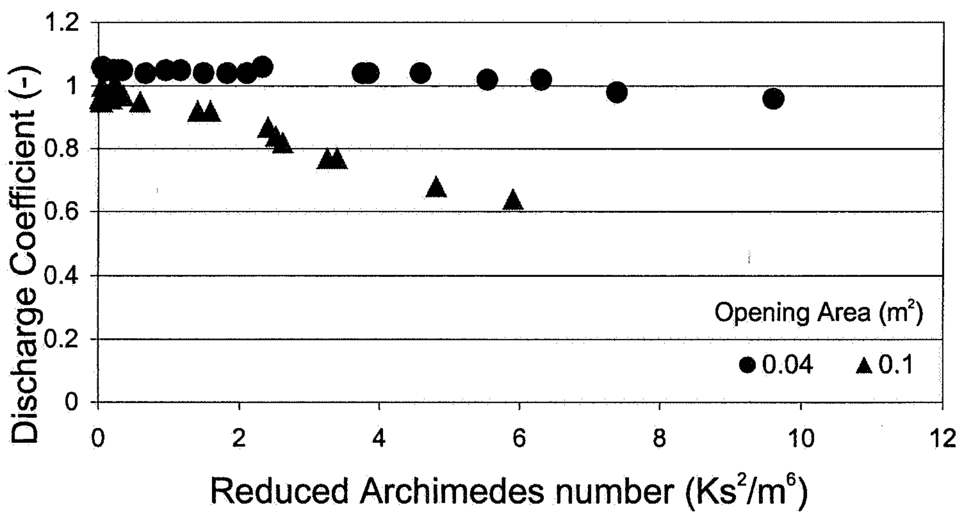

Figure 1: Discharge coefficient for a side hung window as a function of opening area, and air flow rate and temperature difference expressed as a reduced Archimedes number. Heiselberg et al., 1999

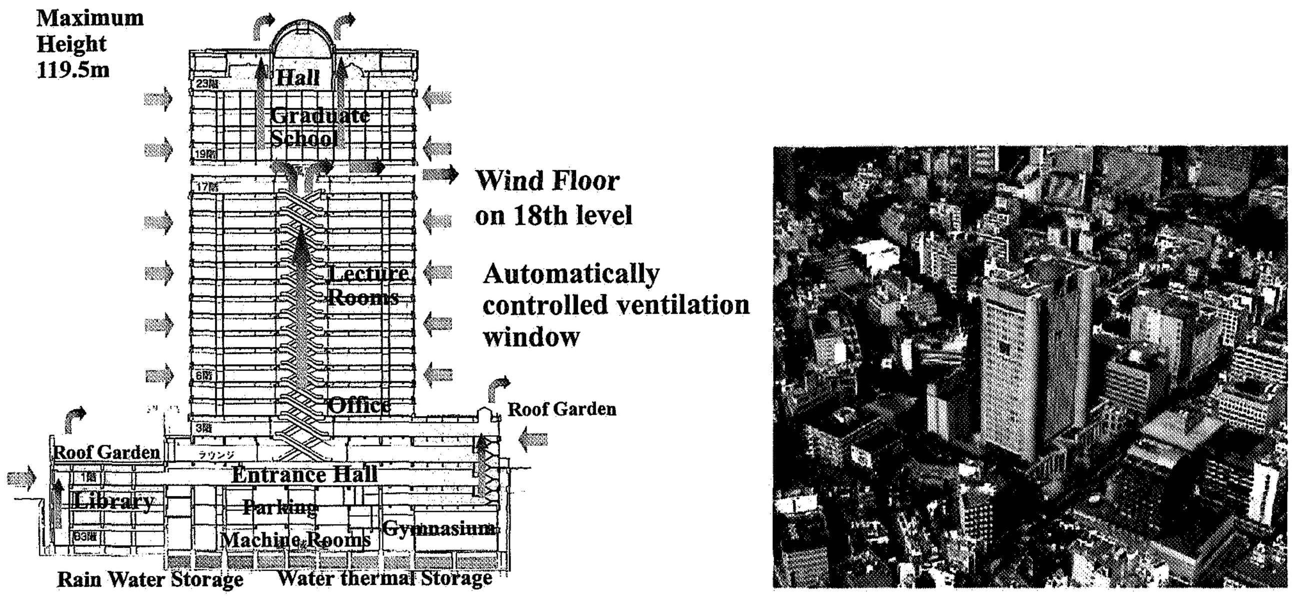

Figure 2: Principle of natural ventilation system and wind floor for Liberty Tower Building, Meiji University. Chikamoto

Air flow process for whole systems

A number of countries use simulation studies with different simulation techniques to study the whole system air flow process and to develop hybrid ventilation concepts for office and educational buildings. An example is the Liberty Tower of Meiji University [Chikamoto et al.], where the application of a wind floor to induce natural ventilation in a high rise building has been investigated, see Figure 2.

The centre core between the 1st and 17th floor formed by the escalator space is used as course of air flow for natural ventilation induced by thermal buoyancy. Above the centre core, on the 18th floor, the wind floor creates a driving force for ventilation on every floor that stimulates air intake via perimeter counter units and exhaust through the opening at the top of the centre core. As the wind floor is open to four directions, the driving force is expected to be stable through the year regardless of wind direction. CFD simulations have shown an expected increase in ventilation rate by 30 % by utilization of the wind floor to increase the driving force by wind. The Liberty Tower is one of the pilot studies in Annex 35 and the monitoring programme will show if expectations can be fulfilled.

Annex 35 Website

All information about the annex is available on the Annex 35 Website (http://hybvent.civil.auc.dk) and the papers referred to in this article are also available.

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One Day Seminar Focuses on Ventilation Design

A recent seminar, held at the UK Institution of Mechanical Engineers in London UK focused on performance standard related aspects of ventilation design.

International Perspectives on Ventilation Standards

Ventilation standards

The meeting began with an outline of the issues surrounding current ventilation standards given by Martin Liddament of the AIVC. His paper dealt with the processes that were needed to secure good indoor air quality. This covered recently introduced standards and guidelines for securing the quality of outdoor air as well as indoor air. In outlining the development of relevant standards he stressed that standards have evolved through a complex matching of the concerns of populations with the lifestyles and patterns of activities that take place. In setting requirements for the indoor environment, however, the primary concerns are invariably health and safety. Since the role of ventilation is to dilute and remove pollutants from a space, ventilation is fundamental to securing a healthy indoor environment.

Sustainability and energy efficiency

The energy crisis of the 1970's focused attention on the huge amount of energy consumed in non-industrial buildings for thermal conditioning, lighting and general activities. In Europe this amounts to approximately 40% of primary energy use, and matches that of the entire transport sector. Attempts were made therefore, to minimise such use, largely by the introduction of new Building Regulations combined with energy codes. Although by the mid 1980's energy availability became less of an issue, attention began to concentrate on the pollution of the Earth's atmosphere and, in particular, the steady growth in atmospheric carbon dioxide concentration. Energy utilisation again became the main focus of attention because it was identified as a major contributor to the problem, mainly as a result of the burning of fossil fuel. At the same time, problems associated with transition to nuclear energy production began to unfold, resulting in the major energy consuming countries either abandoning their nuclear programmes or severely curtailing them.

Although considerable research is taking place on the development of 'sustainable' energy production, the available growth from these sources is currently insufficient to offset the current need for fossil fuel. As a consequence, energy conservation is again at the forefront of the international agenda.

The importance of energy efficient ventilation

Since between about a third and a half of the energy is dissipated from a building via the flow of air, ventilation also forms a cornerstone of energy policies. There is the potential, therefore, for conflict between the air quality role of ventilation and its perceived adverse impact on energy use and carbon dioxide emissions. It is the rationalisation of this conflict that has stimulated much of the development of ventilation related requirements in recent times. Sometimes requirements have impacted in ways that were not anticipated, therefore it is essential to understand how each component related to ventilation impacts on each other. As an absolute minimum, the interaction of the components summarised in Figure 1 must be understood by anyone attempting to provide a successful ventilation standard. In addition the type of building and the climate in which it is located plays a critical role.

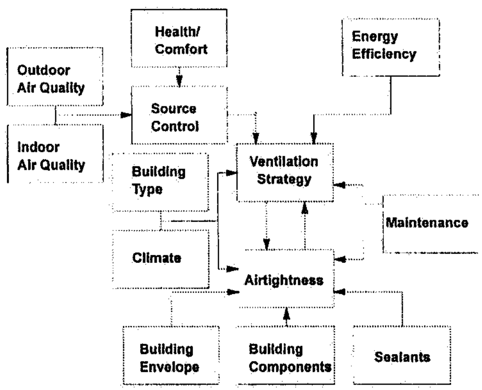


Figure 1: Interaction of Components Related to Energy Efficient Ventilation

News from Europe

Alan Green of Trox (UK) Ltd outlined progress on the Development of a European Standard for IAQ. The current status and recommendations for progress are that:

1. Two new items are to be undertaken

    a) Ventilation for Buildings: Design Criteria for the Indoor Thermal Environment
    b) Ventilation for Buildings: Design Criteria for the Indoor Acoustic Environment

2. To consider the work on Ventilation for Buildings – Design Criteria for Indoor Air Quality at a later date recognising that ISO/TC 205 has now initiated work in this area.

The next meeting of CEN 156 Plenary is in October of this year when it will decide how to implement part 1 of the above recommendations.

Within some European countries there is a view that thermal comfort and acoustic environment proposals in prENV 1752 were not that contentious and that it should be a relatively simple matter to produce draft standards to cover these two topics.

As far as ISO/TC 205 activities are concerned, they are at an early stage. Consideration is being given to the folllowing topics for Building Environment Design:-

1. The Indoor Environment – General principles
Scope – The general principles of building environment design for new construction and the retrofit of existing buildings as relating to the indoor environment.

2. Indoor Air Quality
Scope – Building environment design for new construction and the retrofit of existing buildings as relating to indoor air quality.

3. Indoor Thermal Environment
Scope – Building environment design as relating to the indoor thermal environment for new construction and the retrofit of existing buildings, excluding the scope of ISO 7730.

4. Indoor Acoustic Environment
Scope – Building environment design for new construction and the retrofit of existing buildings as relating to indoor acoustic environment.

5. Indoor Visual Environment
Scope – Building environment design for new construction and the retrofit of existing buildings as relating to indoor visual environment.

As with all ISO Committee activities it will be a few years before final draft documents become available. The current situation can therefore be summarised as follows:-

1. There is a CEN report on Indoor Environment covering Indoor Air Quality Thermal Comfort and Noise.

2. CEN TC 156 has to decide how to deal with thermal comfort and the acoustic environment and the associated time scales to draft standard availability.

3. As far as IAQ is concerned the next potential standard input will be in a few years from ISO, subject to a successful work programme.

Minimising Pollutant at Air Intakes

Steve Irving of Oscar Faber reviewed work on minimising pollutant at Air Intakes. He said that there has been a significant increase in interest in air quality issues over recent years. This has been brought about through a number of factors.

An increased understanding of the effects of pollutants on human health and well being.

A recognition that there can be conflicts between energy conservation and indoor air quality. Ventilation rates for adequate indoor air quality have been the subject of considerable debate within the framework of both European and ASHRAE standards.

The resurgence of interest in engineered natural ventilation as a design strategy. External noise and pollution are arguably the main factors that limit the application for such buildings in urban areas.

Pollution in the outdoor air can have a significant effect on the quality of ventilation air, and thereby influence indoor air quality (IAQ). External pollution sources include:

General background pollution from industrial processes etc remote from the building location.

Local but widespread pollution sources, especially exhausts from vehicular traffic

Specific local sources like boiler flues and ventilation exhausts.

There is an increasing body of knowledge about how pollution in urban areas is generated and dispersed and this has been summarised in a recently published CIBSE Technical Memorandum (Minimising pollution at air intakes, TN21, CIBSE, 1999).

The document gives general guidance on how to locate ventilation inlets to minimise the effects of external pollution on the intake air. Methods outlined in that document provide a basis for estimating the concentration of the pollutant at the ventilation intake(s) from known sources.

Probe Case Studies

Finally Robert Cohen of Energy for Sustainable Development Ltd, gave a presentation on the UK 'Probe' project which was aimed at evaluating post occupancy evaluations of sixteen buildings. Ventilation was a key factor of performance in all of the buildings. In total sixteen buildings were studied covering air conditioned (AC), 'mixed mode' (MM) naturally ventilated (NV) and advanced naturally ventilated (ANV) buildings.

Concern about occupant satisfaction first came to the fore in the 1980s with the discovery that chronic ill-health was often building-related (that is, reported symptoms like lethargy, headaches, dry eyes and dry throat appeared during the day and went away again after people left in the evening). These clusters of chronic symptoms tended to be found in deep-plan, air conditioned offices, so it was naturally, but rather prematurely, concluded that AC was the cause.

The Probe dataset supports more recent findings that things are not quite so cut-and-dried. For instance, TAN has many of the risk factors associated with chronic ill-health (very deep plan form, AC, open office layout) but staff perceive it as comfortable, healthy, and improving their productivity at work. FRY also scores very well on occupant comfort, but – in constrast to TAN – it has many physical and work-related characteristics which one would expect to create good scores. In essence, best results occur when;

Features like shallow plan depths, openable windows, comfortable thermal conditions (especially in hot summer periods), acoustic separation and good views out are all present. Ideally, as at FRY and WNC, there should also be no need for high management intervention to achieve an acceptable working environment; though – as at FRY – considerable management effort may be required during the early life of the building to learn how best to operate the building routinely.

If some or all of these features are absent for any reason (e.g. if the building is large, complex and deep-plan) this must be compensated for by all-round excellence in facilities services such as cleaning and a responsive help desk (e.g. TAN, C&G and to some extent CRS).

These need to be additionally underpinned by a stream of managed feedback about performance, not just relating to occupants' main preoccupations like comfort, but also data on areas such as energy and maintenance outcomes.

This managed feedback stream creates the self-fulfilling loops so necessary for quality control (e.g. at TAN). Outcomes should be constantly re-assessed against benchmarks and/or in-house targets (e.g. FRY which was monitored by a research team) and remedial action taken where necessary (e.g. TAN, which, after Probe improved its – already excellent – response rate, revised its energy management strategy, and made alterations, in particular replacing the eddy current VAV drives with much smaller motors with inverter speed control).

Code	Name	Function	HVAC type	TFA (m²)	Date
TAN	Tanfield House	Very deep plan admin centre	AC	19800	09/95
C&G	Cheltenham & Gloucester Building Society	Deep plan headquarters	AC	17400	02/96
WMC	Woodhouse Medical Centre	Doctors' and dentists' surgeries	NV	640	08/96
HFS	HFS Gardner House	Headquarters office	AC	3800	10/96
RMC	Rotherham Magistrates Court	Courtrooms and offices	MM	4350	12/97
CAF	Charities Aid Foundation	Principal office (pre-let)	MM	3700	02/98
FRY	Elizabeth Fry Building	University teaching	MM	3130	04/98
CRS	Co-operative Retail Services	Large head office	AC	17300	10/98

Probe Buildings

There is little direct relationship between comfort and energy efficiency, but an important indirect one, in that good management of the procurement of a building and its subsequent operation can help to deliver simultaneous comfort, energy and organisational benefits. In Probe:

In the AC buildings, C&G was closest to combining comfort and energy efficiency in an intensively-managed building, though even they were wary of anything which might threaten quality of service to occupants. C&G was also easier to run than the other, more innovative, AC buildings; so used the least energy in spite of its less advanced specification: a lesson perhaps in avoiding complication. TAN was the most intensively managed, but at the time of Probe energy efficiency was low on its management's agenda.

The MM buildings also had shortcomings, particularly high fan energy consumption at RMC and CAF, but in spite of this CAF used about half as much as the similarly sized, occupied and sited AC HFS. Even the now-excellent FRY did not perform optimally until after independent monitoring had clearly identified a need for attention. However, overall MM appears a promising alternative to AC for both energy and comfort.

Most of the ANV buildings were unable to achieve high levels of comfort and energy efficiency at the same time, partly bacause their management teams, responsible for an estate of buildings could not provide the necessary levels of support within their budget allocations.

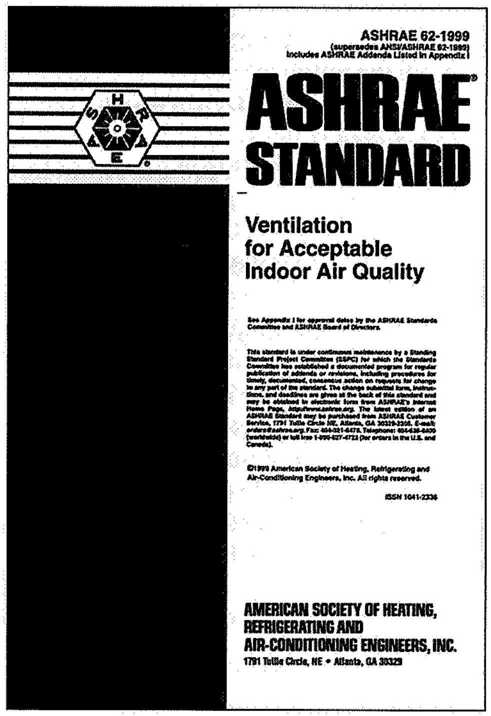
The potential for NV to provide a comfortable and low energy solution for simple buildings is epitomised by the intrinsically low energy and low management WMC. Interestingly, here the only unusual piece of active technology – the background mechanical ventilation eat recovery system – had defeated the occupants and fallen into disuse. WMC also demonstrated the great difficulty of getting even simple modifications to happen after completion: here by nobody getting round to adding remote controls (rods, cords or motors) to the roof windows.

Most buildings are built individually to a site, context, design and specification which may be similar, but is seldom identical to, previous buildings. New techniques and technologies promise major benefits, but in practice there will always be "bugs". Feedback is therefore essential, and while as much as possible should be got "right first time", for most buildings – and particularly for elements such as their ventilation services which respond dynamically – it is entirely reasonable to expect a period of "sea trials" following initial commissioning and beyond practical completion so that systems can be find-tuned and problems can be identified and tackled more quickly.

A full set of proceedings is available from The Director of Publications, The Institution of Mechanical Engineers, Birdcage Walk, London SW1H 9JJ, Telephone +44 (0)20 7222 7899

ASHRAE Standard 62-1999 Ventilation for Acceptable Indoor Air Quality

Recently published, the standard is under continuous maintenance by a Standing Standard Project Committee (SSPC). There is a documented program for regular publication of addenda or revisions.



Ventilation in Brazil

Prof. Francisco Radler de Aquino Neto is the president of the Brazilian Environmental and Quality Control of Indoor Air Society (BRASINDOOR), founded in 1995. He also represents the Chemistry Institute for the Federal University of Rio de Janeiro (IQ-UFRJ) and is Head of the Laboratory for the Support of Technological Development (LADETEC). Prof. de Aquino Neto was invited to observe the Air Infiltration and Ventilation Centre Steering Group Meeting, held at the Indoor Air '99 meeting in Edinburgh, Scotland in August 1999. At this meeting he presented an overview of certain building ventilation issues in Brazil.

Air Conditioning and Indoor Air Quality

Air conditioning

There are guidelines for project, maintenance and care of air conditioning systems. Also, air conditioning standards are based on ASHRAE (1992), but these have not quite been adapted to local requirements. During the Brazilian "economic miracle" of the 1970s, there was a boom in the installation of air conditioning equipment. Since then the quality of systems has decreased. There has been less money available to buy high grade systems and corporate downsizing has limited the managerial quality of buyers. This has proved to be a perfect environment for persuasive, yet less scrupulous and unskilled sales people. In fact, service companies do not charge for the project itself, only for installation. This results in poor quality, and higher installation and maintenance costs. In particular, concerns about humidity control, air intake location and air treatment are seldom incorporated into projects.

Indoor Air Quality

Brazilian IAQ Legislation was started by the Ministry of Health. Guidelines are currently under revision for fungi, CO_2, particulates, temperature & relative humidity; air draught.

Energy saving is still a big issue. The climate in Brazil is very diversified. For example, the relative humidity ranges between 16% and 90%.

IAQ-related associations
Representatives of SMACNA, ASHRAE

Equipment factories/sellers: ABRAVA, SINDRATAR

Service companies: ANATAI (the Brazilian Duct Cleaning Association)

Academic: BRASINDOOR

IAQ measurements - physical and chemical aspects

A particular IAQ problem is that ethanol (usually contaminated with ethanal) is a commonly used cleaning material in Brazil. Furthermore, humidity control is seldom incorporated into projects. There is a general lack of data and policy, with measurements made only for a few cities and other locations.

Measurements already undertaken
CO
Nicotine
ETS
Total suspended particles
Temperature & relative humidity
Formaldehyde & acetaldehyde
TVOC & speciated VOC's
SVOC
Still very limited sampling
Microbiological
Bacteria
Acarus
Fungi
Quite widespread sampling

Lack of Data/Policy
CO_2
NO_x
Rn
O_3
Solanesol
PAH
Pesticides
Epidemiological studies
Clinical & IAQ studies
Enlarge database
Epidemiological studies
Clinical + IAQ studies
Fungal toxins

IAQ in Brazil – Historical Background; institutions involved in IAQ research

Physico-Chemical Aspects

1992 - 1995 LADETEC / IQ-UFRJ + LAGA-IQ/USP (Atmospheric chemistry lab. Chemistry Institute São Paulo University)

1995 - 1998 LADETEC / IQ-UFRJ

1998 - 1999 LADETEC / IQ-UFRJ + CESTEH-FIOCRUZ (Center for occupational health and human ecology from Fundação Oswaldo Cruz)

1999 - LADETEC / IQ-UFRJ

Microbiological Aspects

1992 - CONTROLBIO + FSP/USP (Public Health Faculty/ São Paulo University

LADETEC / IQ-UFRJ

Main Research Studies 1992-1999

LADETEC employs 55 research staff, but only 5 directly involved with IAQ issues. Its future prospects depend on immediate funding and medium range goals. Areas already covered:

Preliminary diagnosis of Sick Building Syndrome (SBS)

Diagnosis after evaluation and remediation of SBS prone areas

Follow up of offices refurbished floors

Library collection infestation by fungus

AIVC Bookshop

JOURNALS

Air Infiltration Review. Quarterly newsletter containing topical and informative articles on air infiltration research and application. (AIR)

Recent Additions to AIRBASE. Quarterly listing of items added to AIRBASE, AIVC's bibliographic database, the AIVC Library.(RA)

AIRBASE

The AIVC's bibliographical database, containing over 12,000 records on air infiltration, ventilation and related areas, is available on CD (AB). Enquirers in AIVC member countries have access to the AIVC's extensive library, which runs alongside.

WORLD WIDE WEB

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

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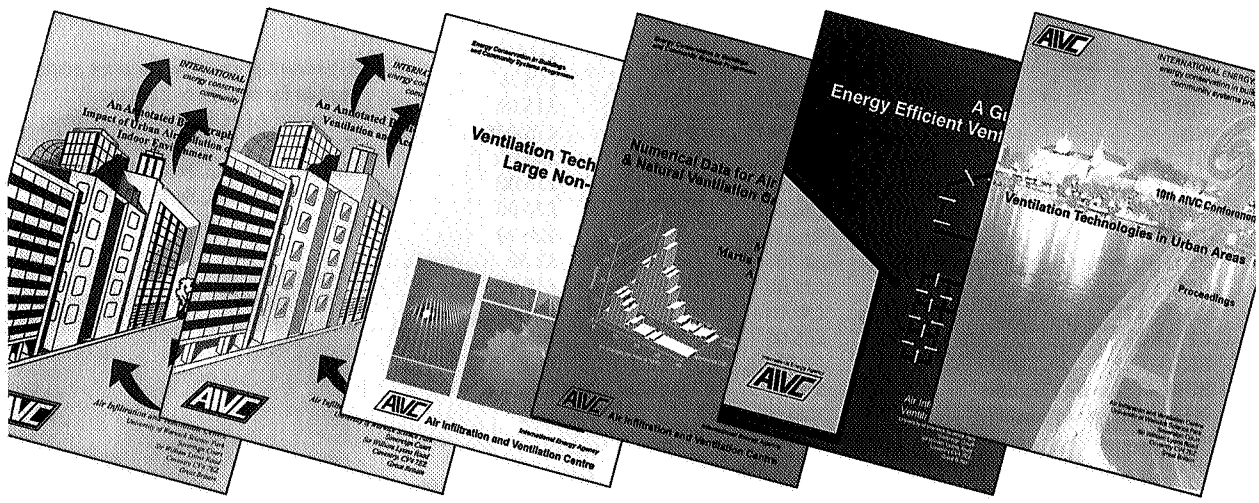

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AIVC CONFERENCE PROCEEDINGS

Papers from earlier AIVC Conference Proceedings are also available. Contents pages can be forwarded on request. (Code CP)

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LITERATURE LISTS

Literature lists are searches carried out on the AIVC's bibliographical database, "Airbase". They are an up-to-date selection of material, usually between 30-40 abstracts, which provide a useful introduction to the relevant subject area. Papers listed are available from AIVC library. Contact AIVC for full list. (Code LL)

20. Computational fluid dynamics
21. Displacement ventilation
22. Moisture and condensation
23. Sustainability
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1999:4 Improving ductwork: a time for tighter air distribution systems, Carrie F R, Andersson J, Wouters P (eds.)

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9-10 March 2000
Wels, Austria
OO Energiesparverband, Landstrasse 45, A-4020 Linz, Austria, Tel: +43 732 6584 4380, Fax: +43 732 6584 4383, Email: office@esv.or.at, Web: www.esv.or.at

Ventilation 2000 6th International Symposium on Ventilation for Contaminant Control
4-7 June 2000
Helsinki, Finland
Secretariat, Ventilation 2000, Finnish Institute of Occupational Health, Solveig Borg, Topeliuksenkatu 41 a A, FIN-00250 Helsinki, Finland, Tel: +358 9 4747 900, Fax: +358 9 2413 804, email solveig.borg@occuphealth.fi, http://www.occuphealth.fi/eng/project/vent2000

Renewables: the Energy for the 21 Century. World Renewable Energy Congress - VI WREC 2000
1-7 July 2000
Metropole Hotel, Brighton, United Kingdom
Professor Ali Sayigh, Congress Chairman and Director General of WREN, 147 Hilmanton, Lower Earley, Reading RG6 4HN, UK, Tel: +44 1189 611364, Fax: +44 1189 611365, email: asayigh@netcomuk.co.uk, http://www.WRENUK.CO.UK

Architecture, City, Environment
PLEA 2000 The millennium conference on Passive and Low Energy Architecture

The 17th International Conference on Passive and Low Energy Architecture
2-5 July 2000
Cambridge, UK
Ms Lynda Bryers, University of Cambridge, Programme for Industry, 1, Trumpington Street, Cambridge CB2 1QA, UK Tel: +44 (0)1223 342100, Fax: +44 (0)1223 301122, email cpi@hermes.cam.ac.uk

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

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

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

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

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

Innovations in Ventilation Technology
The 21st AIVC Annual Conference
26-29 September 2000
Steigenberger Kurhaus Hotel, The Hague, Netherlands
Helen Shawcross, Conference Organiser, Air Infiltration and Ventilation Centre, Sovereign Court, University of Warwick Science Park, Sir William Lyons Road, Coventry CV4 7EZ, UK Tel: +44 (0)24 7669 2050, Fax: +44 (0)24 7641 6306, email airvent@aivc.org

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