

*INTERNATIONAL ENERGY AGENCY
energy conservation in buildings and
community systems programme*

**An Annotated Bibliography
Natural Ventilation**



*Air Infiltration and Ventilation Centre,
University of Warwick Science Park,
Sovereign Court,
Sir William Lyons Road,
Coventry. CV4 7EZ*



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Mark J Limb

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The Air Infiltration and Ventilation Centre
University of Warwick Science Park
Sovereign Court
Sir William Lyons Road
Coventry CV4 7EZ
Great Britain

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Other bibliographies in this series :

1. Ventilation and Infiltration Characteristics of Liftshafts and Stairwells - A Selected Bibliography. (1993)

2. Garage Ventilation - An Annotated Bibliography(1994)

Preface

International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an International Energy Programme. A basic aim of the IEA is to foster co-operation among the twenty-one IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources and energy research development and demonstration (RD&D).

Energy Conservation in Buildings and Community Systems

The IEA sponsors research and development in a number of areas related to energy. In one of these areas, energy conservation in buildings, the IEA is sponsoring various exercises to predict more accurately the energy use of buildings, including comparison of existing computer programs, building monitoring, comparison of calculation methods, as well as air quality and studies of occupancy.

The Executive Committee

Overall control of the programme is maintained by an Executive Committee, which not only monitors existing projects but identifies new areas where collaborative effort may be beneficial.

To date the following have been initiated by the Executive Committee (completed projects are identified by *):

- I Load Energy Determination of Buildings*
- II Ekistics and Advanced Community Energy Systems*
- III Energy Conservation in Residential Buildings*
- IV Glasgow Commercial Building Monitoring*
- V Air Infiltration and Ventilation Centre
- VI Energy Systems and Design of Communities*
- VII Local Government Energy Planning*

- VIII Inhabitant Behaviour with Regard to Ventilation*
- IX Minimum Ventilation Rates*
- X Building HVAC Systems Simulation*
- XI Energy Auditing*
- XII Windows and Fenestration*
- XIII Energy Management in Hospitals*
- XIV Condensation*
- XV Energy Efficiency in Schools*
- XVI BEMS - 1: Energy Management Procedures*
- XVII BEMS - 2: Evaluation and Emulation Techniques
- XVIII Demand Controlled Ventilating Systems*
- XIX Low Slope Roof Systems
- XX Air Flow Patterns within Buildings*
- XXI Thermal Modelling*
- XXII Energy Efficient Communities
- XXIII Multizone Air Flow Modelling (COMIS)
- XXIV Heat Air and Moisture Transfer in Envelopes
- XXV Real Time HEVAC Simulation
- XXVI Energy Efficient Ventilation of Large Enclosures
- XXVII Evaluation and Demonstration of Domestic Ventilation Systems
- XXVIII Low Energy Cooling Systems
- XXIX Energy Efficiency in Educational Buildings
- XXX Bringing Simulation to Application

Annex V Air Infiltration and Ventilation Centre

The Air Infiltration and Ventilation Centre was established by the Executive Committee following unanimous agreement that more needed to be understood about the impact of air change on energy use and indoor air quality. The purpose of the Centre is to promote an understanding of the complex behaviour of air flow in buildings and to advance the effective application of associated energy saving measures in both the design of new buildings and the improvement of the existing building stock.

The Participants in this task are Belgium, Canada, Denmark, Germany, Finland, France, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and the United States of America.

Natural Ventilation - An Annotated Bibliography

SCOPE

This report is a bibliographic review of technical papers, contained within the AIVC's bibliographic database, AIRBASE, dealing with natural ventilation in buildings. It is aimed at researchers, designers and engineers who would benefit from a bibliographic overview of research into this area.

A list of the references and abstracts cited in this review follow the concluding paragraph.

1. INTRODUCTION

The focus of this review is on natural ventilation strategies and systems, highlighting design features and associated research.

It outlines relevant papers dealing with;

- the main elements of natural ventilation research,
- the fundamental equations, driving forces and associated factors,
- the design and utilisation of windows, purpose provided openings, passive stacks and advanced natural systems, with any design guidance, where applicable.
- case studies showing where such systems can be effectively installed, e.g dwellings, commercial buildings, law courts, schools, industrial buildings and libraries

2. PRINCIPLES

Natural ventilation is the intentional provision of outdoor air into a space through purpose provided openings, such as windows, stacks and vents. It is driven by the action of wind and temperature differences between the indoor and outdoors. The relative importance of these driving forces depends on a number of factors. They include, the height of the building, internal resistance to airflow, location and flow resistance characteristics of the building envelope openings, local terrain and the immediate shielding surrounding the building. The theoretical principles of natural ventilation have been extensively covered by BRE (1978, #234), CIBSE, Vol A (1988), ASHRAE Chapter. 23 (1993), Liddament (1986), Awbi (1991, #5142) and Linden et. al. (1990, #4687). The wide variety of measurement techniques available to measure natural ventilation have been outlined in a review by Roulet (1991, #5832). Scale models can also be used for design to predict the size and occurrence of natural ventilation flows (Chandra et al (1983, #1212). A thermal plume model is described by Cooper (1993, #7879) which gives qualitative information regarding air movement in large, naturally ventilated spaces. Further modelling design guidance is given by (Linden et al, (1990, #4174), Edwards and Linden (1994, #8182), Lane-Serff (1990, #4139) (flume models), Cao (1994, #7946) (wind tunnel), Villenave et al (1994, #8000) (Multizone model for predicting stack ventilation in multi-storey dwellings) and Stankovic and Setrakian (1994, #8037) (Thermal and CFD modelling verses wind tunnel). Weather data for UK naturally ventilated buildings and hourly data for simulation are reviewed by Arif and Levermore (1994, #7996). Solar radiation, outside/inside temperatures, wind speed/direction and weather data for summer conditions are all examined.

3. NATURAL VENTILATION SYSTEMS AND STRATEGIES

Three natural ventilation strategies have been identified.

3.1 Ventilation Through Windows

Traditionally, windows have been used for ventilation. Unfortunately, many windows offer only limited control, allowing the occupants to simply purge the building or room of pollutants, rather than supplying a steady level of ventilation.

One area of research has been to evaluate the effect of windows in providing sufficient fresh air to achieve good thermal and air quality conditions. Such studies do not necessarily deal with the unhealthy effects of high infiltration rates or poor quality glazing, but tend to concentrate on whether windows are opened for sufficient lengths of time to ensure an adequate fresh air supply.

In a study by Zainal and Croome (#4861, 1990) the ventilation characteristics of a lecture room are discussed. The level of comfort and air quality resulting from a number of door-window opening combinations and positions were investigated. Zainal found that when all the windows were closed, the ventilation rate was far too low for comfort and health purposes. An air change rate of between 2.4 and 11.6 ACH (232 to 1121 l/s) were obtainable with various combinations of window opening positions for local wind speeds. This study also revealed the importance of building planning and layout.

Robertson (1990, #4289) related the orientation of window openings and occupant complaints of sensitivity to the indoor environment of a number of buildings. He found that in an untight building, the orientation of the windows resulted in poor indoor air quality in certain rooms. Throughout the houses studied, there was a tendency for the leeward rooms to be under-ventilated, while the air exchange in the house as a whole was found to be adequate. This phenomenon occurred as wind driven flows became the more dominant driving mechanism. In the building under study, the problems were alleviated by the re-allocation of the use of the rooms.

Development in window design to improve ventilation and reduce draughts has also been an area of research. Jong and Bot (1992, #6574) studied the air flows through openings under one-side-mounted casement windows, a form of window design commonly applied to naturally ventilated buildings. In this study, the importance of the ratio between the length and height (the aspect ratio) of the opening is displayed. Experiments were undertaken using windows with aspect ratios of 0.47:1.00 and 1.00:1.00, opened at angles from 0° to 77°. It was noticed that the side areas under the windows were important, being more significant for windows with lower aspect ratios than for windows with higher aspect ratios. Bot proposes a mathematical model to describe the effective exchange area under the window. According to the authors the results of this model could be a useful instrument for predicting the ventilation rate of buildings containing this type of window. Pitts and Georgiadis (1994, #7993) report the results of a laboratory investigation of the pressure difference flow relationship for air movement through windows when a venetian blind is also in position. A number of window openings and blind angles have been tested, with results indicating a significant reduction in air flow when blinds are in the closed position (89°). When the blinds are partially closed (45°) little reduction in flow was noticed. The authors note that care must be taken in setting the blind angles to achieve the best combination of natural ventilation and shading.

A major focus of research into windows has been the window opening behaviour of occupants in a variety of buildings. Some studies have investigated the motivation behind occupant interaction with natural ventilation systems. This includes work by IEA Annex 8, (Dubrul 1988, #2893) who studied motivation, the resulting ventilation rates and energy losses due to window opening behaviour and ways of modifying this behaviour. Fleury and Nicolas (1992, #5973) have since illustrated the crucial role of sociological parameters regarding the occupants window opening behaviour. They recommended that this behaviour should be considered as an integral element in the design of ventilation systems. They concluded that the "women of the house" are the main openers of windows. The size and age distribution of the family are also variables in window opening of the kitchen, bathroom and childrens' room. The orientation of the living room relative to the sun explains occupant behaviour in this room. Window opening in the parents bedroom is so erratic that none of the parameters explain the motivation behind window opening.

Richalet et al (1994, #7956) monitored four classrooms of two secondary schools located around Lyon in France, to analyse the indoor air quality, thermal comfort and occupant behaviour towards the opening of windows. Results indicated that allowable CO₂ levels are exceeded several times a day. Further measurements indicated that while occupants felt uncomfortable, this was not related to their thermal comfort, or indeed high CO₂ concentrations. However these feelings lead people to open windows, provided that outdoor conditions are favourable.

3.2 Ventilation Through Purpose Provided Openings

Purpose provided openings can be used in conjunction with windows, to ensure a steady controllable level of background ventilation. They may also be used to provide additional ventilation at times of excessive moisture emission.

Ventilation through purpose provided openings such as trickle vents etc, has been studied by Jones and O'Sullivan (1986, #2535). Trickle vents are finely adjustable slot ventilators which offer a more efficient method of ventilation control than simply opening windows. Jones and O'Sullivan investigated the use of these devices to improve the distribution of ventilation and reduce the occurrence of condensation in dwellings. They were found to decrease the occurrence of condensation without incurring a significant energy penalty, as well as increasing the distribution of ventilation.

A demonstration of the benefits of using trickle ventilators to control ventilation in well sealed, highly insulated houses is outlined by the UK Energy Efficiency Office (1985, #2144). Different types of trickle ventilators are described and a costs/benefit analysis compared with window opening is considered. The study found that using such devices provided a secure way to ventilate a room and actively reduced mould occurrence. However, during periods of high pollutant emittance, these devices did not provide sufficiently rapid ventilation. Draughts were a further problem associated with a number of vents.

A similar study was conducted by Bassett (1994, #7955) who used a numerical multizone model to calculate the effect of adding stack and window type passive vents to houses over a range of airtightness levels. The investigation found that air flow rates through passive vents in typical New Zealand building and climate combinations were shown to be primarily wind driven. The distribution of hourly ventilation rates depended on the proportions of stack and window ventilators. Mixed window and stack ventilation systems were found to deliver between 0.5 to 1.0 ac/h distribution of hourly ventilation rates, especially when added to the more airtight houses. The author proposes an approximate window ventilator sizing guide, consisting of a linear relationship between the ventilation rate added to a house and the airtightness coefficient of the ventilation system. The experimental results of four passive ventilator systems mounted into the windows of three unoccupied New Zealand houses are discussed by Bassett (1994, #7955). Using the method described in Bassett's, experimental ventilators were sized between 21,000 and 110,000 mm² of opening area. Measured air flow through these passive vents agreed with calculated rates to the same level of accuracy for whole house ventilation rates.

3.3 Passive Stack Ventilation Systems

Passive stack ventilation systems (psv) provide more control over the natural ventilation process, as vertical stacks terminating in the negative pressure region on the roof may be used to extract pollutants (including moisture) from kitchens, bathrooms and toilets. Make up air is delivered through purpose provided openings (such as trickle vents and air bricks) in the building envelope. Semenko (1993, #7227) has reviewed these systems, not only outlining the current minimum ventilation requirements necessary for fresh air ventilation, but also psv systems themselves. Such systems are common in Scandinavia (1986, #2588) and the Netherlands (1987, #2843). They can also be converted into mechanical extract systems by the installation of fans inside the vertical ventilation ducts (Wagenaar 1984, #1700).

De Gids and Duden (1987, #2843), studied the pressure distribution around a building model, in order to investigate the best location and height above the roof for a protruding vertical duct. Results indicated that, if the outlet protrudes at the highest point of the roof (the ridge), then a height of 0.5m for the protruding duct is always sufficient. This ensures that the duct terminates in the negative pressure region above the roof space. On the other hand, Shaw and Kim (1984, #1600) compared five passive stack ventilation system configurations for Canadian houses. The aim of this study was to investigate the effects of weather, airtightness, heating and ventilation systems and how they affect the air change and air pressure distribution of a house. Of the five configurations, the combination of two provided the highest house air change rate. A 10 cm diameter pipe supplying outdoor air to the return duct of the forced air heating system, with an intake opening at ground level, was combined with a 12.7 cm diameter exhaust stack extending from the basement to above the roof. With winds less than 30 km/h, stack action provided the dominant driving force. The indoor location of the vertical stacks had very little effect on house air change rate with the furnace fan operating, but could have a significant effect on the efficient mixing of outdoor air with the air in the living spaces.

Parkins (1991, #4879), undertook a similar study for the UK Building Research Establishment. Using one test house and two configurations of a passive stack system, a comparison of their relative performance was undertaken. The first configuration was a straight duct, with a weather proof terminal, extending from the kitchen ceiling through the bedroom and the attic above, and terminating just higher than the ridge height. The second configuration incorporated two 45 degree bends in the attic section to enable the duct to be connected to a ridge terminal. Two stack diameters - measuring 100mm and 150mm - were used, together with two materials of smooth rigid plastic and flexible plastic on a wire spiral. Several roof terminals were also used and compared. The results indicated that the flow rate measured up the stack was nearly twice as much in the 150 mm diameter stack as in the smaller 100 mm stack for the straight configuration, and only 50% higher for the stack with bends. The inclusion of two 45 degree bends was found to reduce the flow rate by 50%. This research also suggested that the apparent roughness of the flexible stack material, compared with the smooth rigid material, had little or no effect on flow rate.

More recently Parkins (1994, #7954; #7995), related measured flow rates from psv systems to the humidity within the dwelling, in order to determine the effectiveness of commonly found PSV systems in minimising the risk of condensation. In conclusion, she found that psv systems in bathrooms had been designed with ductwork parallel to the loft floor. This configuration had sharp bends in the ducting, which restricted airflow. A general conclusion was that the systems studied had been poorly installed, with too many bends in the ducting and no support. Improved performance was noted when excess ducting had been removed and any unnecessary bends straightened. The systems did cope well with the removal of moisture, keeping the relative humidity below 70% for all but a small percentage of the time. The design aspects which need careful attention are straight ductwork, stacks terminating at or near the ridge, the avoidance of tile ventilators (which often cause reverse flow) and finally, to ensure that terminals are opened enough so as not to restrict air flow.

In the same test house Cripps and Hartless (1994, #7992) use BREVENT, a single zone ventilation model, to compare predictions on passive stack ventilation rates with measured data. They found a good correlation between the predicted and measured duct flow velocities (with predicted rates falling with 10-20% of measured results). They note that more work is needed on the interaction between PSV flow elements and question whether using a multizone model would give better results.

Welsh (1994, #7987) focused on common roof terminals, used in all types of ventilation system exhausts, especially psv systems, passive gas extraction, combustion flues and chimneys. He tested and rated a variety of roof terminals which highlighted terminal wind performance as well as terminal resistance to the exhaust flow. The terminals are ranked according to loss coefficients and wind performance which allows them to be matched more closely to system requirements. He concluded that three groups could be identified; (i) those with large loss factors (most restrictive) were found to be the Gas flue (110mm), H pot 2 and the Grey Vane, (ii) those which were good at inducing up draught, for example Rotating Cowl 1 and H pot 1 and, (iii) the group that was considered to cause flow reversal and included open pipe, Mushroom cap and Chinese hat type terminals.

Gaze (1986, #2545) and Johnson et al (1985, #1779), described the results of measurements undertaken in four small occupied timber framed houses in the UK. These houses were built airtight by UK standards. Overall the system provided a reliable background ventilation rate of 0.45 ach, ranging from 0.3 to 0.6 ach. Gaze concluded that the system would only contribute to condensation control if the property was thermally efficient and properly heated.

Two UK houses were described by Edwards and Irwin (1988, #3130); one was an airtight, timber framed house and the other was leaky and constructed of brick-block. Both houses had been fitted with a psv system. After examining the performance of these psv systems, it was found that in both houses they provided an efficient means of condensation control. However, good design and installation are essential, since extreme airtightness prevents these systems from extracting to their predicted capacity, while high background leakage air means that over extraction is likely to occur.

Design and installation guidance of psv systems in single and two storey dwellings is given by Stephen and Uglow (1989, #4097). They discuss the main factors affecting performance. For example, ducts should be as near vertical as possible because any bends introduced to ensure the duct terminates on the roof ridge, will increase the air resistance and should therefore be of a sweep rather than a sharp bend type. To achieve adequate but not excessive air flow, the diameter of the ducting should be about 100mm to 150 mm. Other information is given regarding noise prevention and how cleaning is accomplished.

French work to model psv systems and the establishment of a French working group to deal with the future technical requirements of these systems, are described by Buty et al (1991, #4698). The results of these studies were not discussed by the authors.

Occupant behaviour with respect to passive ventilation devices has been another interesting area of study. Van Dougen (1991, #4855) found that in buildings equipped with such devices, it was the type of grilles or windows and their user-friendliness, which determined the amount of ventilation, rather than the behaviour of occupants. The amount of ventilation, by means of windows or grilles in the kitchen, living room and bedroom, was not influenced by the number of people in the household. However, a positive relation was found between the use of a high speed ventilator (kitchen extractor hood) (if present) and the number of occupants per dwelling. Van Dougen also found that occupants in general tended to under ventilate.

3.4 Advanced Systems

Recent research has concentrated on ways of improving the control of natural ventilation systems. A number of humidity controlled ventilation systems have been introduced. Wouters and Vandaele (1990, #4832), Szerman et al (1990, #4852), Mansson et al (1992, #5995), and Jardinier and Simonnot, (1990, #4284) describe examples of such systems. For instance hygrostats can be directly connected to air inlets and outlets in the building shell, or alternatively, to wall/window fans or inside a vertical duct. When the humidity levels increase beyond a specified set point the devices either, reduce incoming air, or increase outgoing air, by opening or closing. Alternatively, they can invoke additional ventilation via fans.

Other developments include the introduction of low pressure controlled natural air inlets (Knoll 1991, #5254, #6764). These devices operate as self regulating ventilation air inlets, varying the air supply to rooms over the pressure range 1 to 20 Pa. They also compensate for additional infiltration and pressure fluctuations within the building, by reducing or increasing their airflow. Schultz (1994, #7713), outlines a research project that incorporates heat recovery with a passive stack natural ventilation system, installed in a low energy test house. Air flow and temperature efficiency were measured at several indoor to outdoor temperature differences in the range 10-30K. Measured efficiencies are in the range of 38-43%. Further studies of the air flow patterns in the heat recovery unit are planned to further optimize the system. Other areas still to be addressed include condensation in the unit, air flow control and room draughts.

4. CASE STUDIES

The performance of natural ventilation design features are outlined in a wide variety of case studies. Attention is focused on the effectiveness of natural ventilation systems in providing and maintaining an acceptable indoor environment, with respect to airflow, comfort and/or indoor air quality. Sometimes these parameters are discussed separately, but more commonly they are considered collectively.

4.1 Dwellings

The efficient circulation of fresh air in dwellings is important to maintain good occupant health and to ensure the safe and efficient operation of combustion appliances. It also facilitates the removal of pollutants such as moisture and odours.

Airflow and energy efficiency of natural ventilation systems are examined by O'Sullivan and Jones (1982, #1046). They describe a series of ventilation measurements performed on a group of energy efficient houses designed in the mid 1970's. They found that, although whole house ventilation rates were satisfactory (in the region of 0.5 ach), the distribution of ventilation was such that the living rooms and bedrooms had very low ventilation and, in a number of cases, serious condensation. By installing trickle vents a better distribution of ventilation was achieved and condensation levels reduced. There was found to be no detectable space heating penalty as a result of installing trickle vents.

Wouters et al (1993, #7046) discusses a CEC demonstration project on humidity controlled ventilation performances, based on detailed measurements carried out in 18 apartments in Namur, Belgium. The average total air change rate for these Belgian apartments is around 0.5 ach. On average, 5 Kg/day of water vapour is extracted by the ventilation system and the use of humidity controlled vents act to reduce the energy losses.

A US study of two detached houses outlines the effects on the ventilation rates of opening windows, Alevantis (1989, #7703). Results indicated that, in some cases, opening windows increased ventilation by only 20%, while in other cases, residential ventilation rates were increased by as much as 11 times the original rate. This is explained by the fact that windows situated out of the direction of the prevailing wind are not as effective in providing ventilation as windows which open on the windward or leeward sides.

Hens and Senave (1991, #5565) and Cavallo et al (1990, #4459) investigated a number of naturally ventilated dwellings to evaluate the level of indoor air quality. Work by Hens and Senave, a case study in Zolder-Lindeman, Belgium, provided the opportunity of judging the causes of mould problems and surface condensation in a typical post war dwelling in Belgium. Conclusions suggested that increasing the thermal insulation and ventilation provisions within these buildings would reduce the occurrence of mould and surface condensation. This work was part of the IEA Annex 14 "Condensation and Energy".

The ventilation and humidity conditions in detached Danish houses with psv systems were studied by Bergsoe (1994, #7959) in order to establish good directions and guidelines for psv installation and operation in Danish dwellings. Measurements were undertaken using PFT tracer gas techniques and an occupant administered questionnaire. Results showed that despite low measured ventilation rates, about 97% of the households judged the air quality in their houses to be "fresh" or "ordinary". The structural or design factors associated with these natural ventilation systems were not investigated, but the authors suggest that the ventilation problems associated with lowering the room temperatures and tightening buildings to reduce energy consumption, were associated with a lack of information as well as being technical problems.

Passive stack ventilation systems in use in Polish apartments have been studied by Baranowski (1994, #7963). Gas fired water heaters in windowless bathrooms are common in these flats so an efficient ventilation system is essential to the occupants health. Based on numerical simulations, Baranowski notes that because of the inherent uncontrollability of natural ventilation air flows, providing an adequately sized vertical duct may in certain cases be insufficient to produce adequate ventilation. Therefore, the author states that, at the initial design stage factors such as building location and associated wind rose, apartment layouts and the location of window openings should be considered. The author also suggests that it may be necessary to reconsider the use of gas appliances in such dwellings where the natural ventilation system cannot be relied upon to remove all combustion gases.

A similar study is described by Heikkinen and Palleri (1994, #7983) who use a multizone airflow model to investigate the ventilation heat loss over an entire year for several 3 to 8 storey apartment buildings in Finland. Results showed that airflow rates attained by the psv systems installed into these flats were too high in winter and correspondingly too low in summer. To improve the performance of these systems controlled inlets and outlets were installed, transferring the power to control the air change rate to the air outlets; they have 70% of the total pressure loss. This resulted in improvements in the insensitivity to temperature variation, however the ventilation is much more wind dependent because of cross ventilation. The high pressure loss in the extraction air terminals will reduce the risk of back flow through the extract air duct, which is a common problem in the winter months. The best performance in terms of annual stability and ventilation energy occurs where inlets and outlets are temperature controlled. The overall conclusion of this report is that these systems can work well if the occupants are willing and able to regulate the air inlets as well as the air outlets, although the system can be automated.

The use of various natural ventilation strategies to reduce the exposure to environmental tobacco smoke (ETS) in dwellings are considered by Kolokotroni and Perera (1994, #8024). BREEZE, (a multizone airflow and pollutant transport prediction program) was used to evaluate the movement of tobacco smoke in detached and semi detached houses, especially the migration of tobacco smoke from living rooms to bedrooms. Results indicated that in the heating season the best protection to prevent the spread of ETS was to open the smoking room window and to close the smoking room door. Extract devices, (passive or mechanical) installed to control humidity could also be used to reduce concentration levels without causing discomfort from cold draughts. During warmer days the suggestion was to open the windows in bedrooms, while still keeping the smoking room internal door closed and its window open. Higher air changes will be created in this way which will help to dilute ETS further.

Palmer et al (1994, #7991) investigated two low cost housing schemes incorporating passive stack ventilation systems in the UK. One scheme was a retrofit into refurbished local authority houses in which a package of energy efficiency measures had been taken and condensation was a problem. The other series of tests were conducted on a new installation in a Housing Association development. Results showed airflow rates by the passive ducts equivalent to 1 room air change per hour. Correct siting of roof vents was found to be crucial to the efficient working of the system and where the vents were located at the roof ridge the reverse flow proved to be negligible.

In the paper by Cavallo et al they described the use of natural ventilation as a radon mitigation method, incorporating naturally driven stack flows. Basement ventilation decreases radon levels by reducing the soil to basement pressure differential, which in turn lowers the radon entry into the basement. Dilution of the radon by an increase in the air exchange rate is a secondary effect. Before such systems are used, careful measurements are needed to verify that radon levels in both the living area and the basement are reduced to an acceptable low level with this technique.

4.2 Office Buildings

In commercial developments, the aim of ventilation is to control the level of pollutants and provide thermal comfort and basic ventilation needs. Where adequate natural ventilation cannot be provided (e.g. in spaces greater than 10m deep, White and Walker 1991, #5269), mechanical ventilation is necessary. Examples include tall buildings, industrial or other premises where it is essential to remove dust, toxic or noxious contaminants at or near their source, or where high heat gains occur. Commercial buildings incorporating natural ventilation systems have been studied by a number of researchers. Perera et al (1992, #6489), considered the effectiveness of permanent but controllable background ventilators in naturally ventilated office buildings with different levels of envelope tightness. Results showed that, during the heating season, it is possible to provide adequate background ventilation for occupant comfort by incorporating manually controllable trickle vents within each room. With an airtight envelope, the introduction of these devices allows the flow of air to be controlled. Perera et al suggested that 4,000 mm² open-area ventilators could be used in rooms with floor areas less than 10m² and 400 mm² per m² (of floor areas) for those which are larger.

The results of a study by Croome et al (1992, #6577), on the indoor environment of naturally ventilated offices suggested that, in order to achieve good indoor air quality and thermal comfort, an adequate supply of fresh air is needed. This should be maintained by the opening of windows, or by the installation of controllable vents. The vents would either be manually or automatically operated in relation to odour intensity determined by sensors.

Wapanaar (1992, #6129) reported on the design aspects of naturally ventilated offices in the Netherlands. Natural ventilation during the day was achieved by opening windows, with an additional smaller window to be opened at night to facilitate night-time ventilation. Wapanaar concluded that draught free ventilation, especially during the winter, is an important aspect and deserves more consideration. The integration of several natural climate control options can result in a sufficient standard of comfort.

Two reports, Petherbridge et al (1988, #3274) and White and Walker (1991, #5269) both discuss the effectiveness of natural ventilation in office buildings and give design guidance for optimal natural ventilation airflows. The latter, assessed whether the total supply of single sided ventilation would be adequate to avoid overheating in summer, using existing guidance to assess the thermal performance of the room. They concluded that the risk of overheating may be more than halved by the use of external blinds. They also found that it may be possible to design for natural ventilation of rooms deeper than 6m, and for possible building widths of greater than 15m. For deep plan office spaces they imply the possible use of single sided ventilation. Petherbridge et al (1988, #3274) have produced an environmental design manual dealing with single sided natural ventilation in UK offices during the summer months. This manual also discusses a method of assessing the effect of various types and sizes of windows, the rate of ventilation on summertime comfort conditions and daylighting. It suggests various remedies for existing buildings which suffer from summertime over heating, and attempts to identify how acceptable working conditions can be achieved through natural ventilation.

The use of natural ventilation in mixed mode buildings is discussed by Bordass et al (1994, #8176). The aim of this project is to reduce the dependence on air conditioned systems in buildings. Several types are identified including contingency mixed mode (where the building is not mechanically ventilated or cooled, but has service routes and plant space available as contingency for possible future needs); Concurrent mixed mode (where openable windows and mechanical systems are both available); Zoned mixed mode (where different areas have different systems operating independently as required) and change over mixed mode (where at different times of the year the building is treated differently). Results indicate that where natural ventilation alone was not sufficient, mixed mode concepts showed great potential.

Leaman et al (1994, #8181), compared the use of different ventilation systems in office buildings in the UK, to provide information to potential owners and occupiers regarding the pros and cons of different ventilation strategies. The paper notes that the evidence often points towards naturally ventilated or mixed mode systems being a more appropriate choice for ventilation in office buildings in the UK. The results of experiments carried out in one of the outdoor PASSYS test cells on the BBRI site are described by Ducarme et al (1994, #7957). The objective of these

experiments was to compare the heat balance approach and tracer gas approach when estimating the size of single sided ventilation. They found that the agreement between both methods was good and the heat balance approach proved to be more accurate than the tracer gas technique. In a similar study, Davies and Holmes (1994, #7958) focused on the effects of headwind on single sided ventilation. They concluded that an increase in headwind can be detrimental to single sided natural ventilation. By reducing the air change rate and thereby causing polluted air from the buoyant layer to be mixed with air in the lower layers, this increases the pollution concentrations in those layers. They also state that for single sided ventilation wind effects are largely confined to the region near the doorway, while buoyancy forces dominate the flows away from the doorway region.

Walker et al (1994, #7952) have used PFT techniques to measure the efficiency of ventilation in naturally ventilated office buildings. The authors concluded that local ventilation rates in some rooms were less than half the minimum recommended rate of 5 l/s for single occupancy. Although openable windows were provided, the occupants were satisfied with the indoor environment. This conclusion suggested to the authors the possible need to reconsider the interpretation of the ventilation guidelines; should they be an absolute minimum or a time average minimum over some specified time period?

Stack driven natural ventilation has been applied to larger buildings by the conversion of courtyards and lightwells into naturally ventilated atrium. A number of studies discuss the design and use of atrium in buildings. Bensalem and Sharples (1989, #4120), for example, modelled these features in a wind tunnel. They concluded that, the optimum courtyard orientation of 30 or 45 degrees to the wind had a very beneficial effect on ventilation and resulted in higher wind velocities on the downwind sides. Closing the courtyard and converting it to an atrium, produced the best results, leading to higher air velocities than the open courtyard cases. In a UK study, Walker et al (1993, #7032) used computational fluid dynamics (cfD) combined with measurements to show that effective air exchange in a courtyard does not solely depend on the ratio between its height to its width. In fact, effective air exchange relies more on the surrounding buildings, the shape and orientation of the courtyard building and the position of the open courtyard relative to the upwind edge of the roof.

Smith et al (1992, #6345) also used cfd to aid in the design of a naturally ventilated office case study with an atria in the central core. Results of the summer situation highlighted the inadequacy of solar blinds in a solar chimney and suggested a possible risk of overheating on the second floor. In the winter case study the results showed no indication of cold down draughts from the roof glazing. The authors noted that a more satisfactory approach to calculating natural ventilation required the interdependence of ventilation and air temperature to be recognised. They also stated that, at the present time, there are no procedures to link cfd techniques with a full dynamic thermal model.

A number of other papers also discuss efficient design of atrium for natural ventilation in commercial developments. Robertson (1991, #6291), outlines possible atria configurations and their associated function. In conclusion, he describes the main architectural criteria for the design of atrium connected office spaces not requiring auxiliary energy to achieve acceptable comfort conditions. Simmonds (1993, #7296) describes a new teaching hospital under construction in the Netherlands, which encloses nine linked naturally ventilated atria. The air movement within this space has been simulated and the results indicate that the airflows between the various atria are expected to balance out, or to neutralise themselves. The main factors involved in this balancing are ambient conditions and the wind velocities and direction.

Baker (1986, #2420) on the other hand, outlines the technical factors needed to provide energy efficient sun spaces. These factors include shape, insulation and ventilation of atria and conservatories. Baker makes a number of assumptions. For example, he states that it is difficult to envisage an unheated space ever increasing the heating demand of an adjacent heated building, although it could result in an increase in lighting and mechanical ventilation costs. The atrium form is likely to perform mainly by reducing conductive losses from the surrounding walls, whereas the conservatory form has the potential for major energy saving by the use of solar ventilation pre-heating. Also, where heating is used it should be a local and radiant source simulating the warming effect of the sun, rather than the environment of a cosy living room. A similar review by Mills (1990, #4796) concentrates on atrium design in the UK. Mills outlines a passive solar design checklist and summarises a range of atrium types relative to occupancy criteria. He finishes by identifying the potential for energy efficient designed atria, provided the correct environmental design rules are followed. Subsequently (1993, #7232) he compares both energy consumption and costs in a number of case studies employing atria.

Two International Energy Agency (IEA) Annexes have been established to investigate energy efficient ventilation in large enclosures and in dwellings. Annex 26 is currently studying common ventilation strategies in large

enclosures, such as atrium, whereas Annex 27 has been established to investigate and evaluate domestic ventilation systems. Both these annexes are ongoing.

4.3 Other Buildings

Fletcher and Johnson (1992, #6089), have investigated a number of modern factory units. Increasing energy conservation pressures have led to reductions in infiltration which in turn have resulted in lower ventilation air flows in these units. Previously, natural ventilation was based on a combination of designed natural ventilation and infiltration. Fletcher found that in factory units equipped with roller shutter doors, the measured air change rates exceeded the minimum ventilation criteria. The authors highlighted the importance of properly designed natural ventilation and the avoidance of adventitious infiltration as an acceptable method of providing ventilation.

The results of numerical models are compared with those of measured data by Jones et al (1991, #5258). The aim of this study is to predict the ventilation rates and internal air movement patterns of naturally ventilated industrial buildings. They described zonal modelling and cfd approaches. Both techniques compared well with measured data, despite the availability of only a generalised wind pressure coefficient algorithm and a simple series of envelope leakage measurements.

In order to reduce the high energy demands associated with mechanical garage ventilation, Leene and Knoll (1981, #984) and Kornaat and Lemaire (1994, AIR vol 15No2 March 1994 + #7437) investigated the possible use of natural ventilation in these types of buildings. Using a wind tunnel study, the wind pressure on the walls and roof of a large parking garage beneath a block of buildings and the overall ventilation of the garage, were calculated. The design of this particular garage ensured that the position and area of openings provided sufficient ventilation and that carbon monoxide concentrations outside the garage would remain acceptable. Another bibliography in this series deals with garage ventilation in more detail, and can be obtained from the AIVC.

The energy efficient design of a library equipped with natural ventilation is described by Isaacs and Donn (1991, #6158). The facilities of this building include external shades for high summer sun, which double as reflectors to enhance daylighting deep in the building. A further feature is a central courtyard designed to allow natural light and fresh air to penetrate into the inner recesses of the building. Electrically operated high level windows and manually controlled wall mounted low level vents contribute to the effective natural ventilation of this deep plan building. The overall conclusions of the study indicate that the decision to use natural ventilation, combined with passive solar control devices, was vindicated, as the summer temperature measurements showed that the internal daily maximum exceeded 23°C for less than 5% of the time. In winter, only one area failed to maintain an inside-outside temperature difference of 15°C, but remedial action was simple and of low cost. Other similar investigations include a description of a naturally ventilated laboratory with associated teaching and office rooms by Ford and Short (1991, #6295). This was achieved in an urban environment, using traditional building construction. The building was found to be economically viable in both capital and running costs. Bunn (1993, #7420) and Anon (1993, #7419) also describe various aspects of this building, including the natural ventilation system.

The ventilation of school buildings has been the topic of a number of studies, including a consortium of local authorities (1988, #2963) who discussed natural ventilation design of old and newer schools in the UK. The report considered the inclusion of natural ventilation in the design of new buildings, as well as the refurbishment of existing schools. Based on a workshop, the report revealed that many of the old design rules and simple aids have been forgotten, or simply discarded as being of no value in resolving present day problems. The need for improved designs, with visual models taking into account climate, exposure, daylight provisions, control of insulation, ventilation and thermal design, was highlighted. Khafaji and Murta (1990, #4236) examined the use of natural ventilation in school buildings located in hot and arid climates. They showed that the hybrid school design, comprising central hall with double banked corridors, etc., should be avoided in favour of functional and what the authors called, "climatic layouts". The most suitable design, from a cooling point of view, utilised the stack effect to draw cool air through the building. This design incorporated the use of solar chimneys on the exterior of the building, allowing air to be drawn from the inner zone by convection. The highest sections of the chimneys are of glass and steel in order to increase temperature at high level and so induce stack movement. Dutt et al (1992, #7368) attempted to model the natural ventilation and thermal comfort conditions of a students' hall of residence in a hot climate, in this case Singapore. Results indicated that model predictions would provide a comfortable and adequately ventilated building in such a climate.

Chown (1994, #8184) describes the initial design stage of a naturally ventilated cultural centre in French New Caledonia. The hot climate of the region necessitated that any design would need to provide good thermal comfort

for the occupants. Based on a comfort analysis the authors concluded that natural ventilation would work for the proposed design. Ventilation was provided through a series of openable windows and louvres located in the building shell. A chimney is also used to enhance the stack effect on days when there is little wind.

The design of naturally ventilated courtrooms are described in a guide by Penz (1990, #5380), in which he discusses the general design considerations required for law courts and the implications for natural ventilation. The guide covers not only building shape, including internal and external planning, but also specific design implications, such as window design, inlet and outlets, heat gains and noise control. The main advantages of natural ventilation in this situation are, (a) the energy implication of not installing air conditioning, (b) low maintenance and running cost, and (c) low capital costs. The reliability of the natural ventilation process is enhanced by the fact that it does not require the use of machinery such as fans etc.,. It is also claimed that, in a naturally ventilated space, users feel more in charge of their environmental conditions. Walker and Perera (1991, #4873) describe a new approach to the use of natural ventilation in law courts. Under-floor ducting and controllable roof vents provide the required ventilation, driven by the stack effect. By combining the results of wind tunnel models with local meteorological data, it was predicted that the ventilation requirement, for full or part occupancy, would be met for about 90% of the time for an internal temperature of 21°C. If the internal temperature rises to 25°C the increased buoyancy effect causes adequate ventilation for almost the entire occupancy period.

5. CONCLUSIONS

This bibliographic review has primarily concentrated on highlighting the developments and applications of natural ventilation. It has attempted to show that the choice of ventilation system represents a compromise between reducing heat loss by infiltration and ensuring that occupant health and comfort is maintained. Three basic systems have been identified, each offering different levels of occupant and energy control. Several new developments have also been discussed, including natural ventilation systems, incorporating humidity control and heat recovery. Essentially, the main criteria in achieving a really satisfying indoor climate with good indoor air quality is to provide a proper balance between the building, its use (including occupant patterns) and its ventilation system. Studies discussing these factors have been identified in this review.

However, it has also been shown that there are several practical limitations governing the extent to which air flows of natural ventilation systems can be influenced, since they are subject to the inherent uncontrollability and unreliability of nature. In cases where further control is shown to be needed to achieve efficient ventilation, it may be necessary to develop even better airtight designs (to limit infiltration), and develop more controlled natural ventilation devices. In extreme cases, even mechanical aids may have to be introduced.

6. References

#NO 234 Principles of natural ventilation

AUTHOR Building Research Establishment.
BIBINF B.R.E. digest no.210 8p 5 figs, 7 tabs, 6 refs.
ISBN 0-11-724122-9 #DATE 01:02:1978 in English.
ABSTRACT Discusses the mechanisms which govern natural ventilation. These are wind speed, flow, characteristics of openings in buildings and pressures generated at building surfaces by wind and temperature difference. Gives formulae for simple cases. Outlines ways of determining natural ventilation rates. Gives brief account of the effect of turbulence and openings in one wall only.
KEYWORDS natural ventilation, wind speed, air flow, crack, air change rate,

#NO 984 Natural ventilation of parking garages.

AUTHOR Leene J.A.
BIBINF "Designing with the Wind" CSTB Seminar Nantes 15-19 June 1981 15pp. 8 figs. 9 refs. #DATE 15:06:1981 in English
ABSTRACT A combination of a wind-tunnel investigation and a mathematical simulation technique conducted on models of two-storey parking garage situated beneath a large block of buildings (consisting of houses, shopping centre and offices) shows that wind penetrating the partly open garage facades can provide sufficient ventilation. Studies the effects on ventilation of varying the open area of the facades and of fitting openings in the garage roofs. Measures the effect of such ventilation means on air quality close to buildings.
KEYWORDS natural ventilation, garage, wind tunnel, mathematical modelling,

#NO 1046 The ventilation performance of houses - a case study.

AUTHOR O'Sullivan P. Jones P.J.
BIBINF 3rd AIC Conference "Energy efficient domestic ventilation systems for achieving acceptable indoor air quality" September 20-23 1982 UK p.10.1-10.21 7 figs. 7 tabs. 5 refs. #DATE 20:09:1982 in English
ABSTRACT Describes a programme of ventilation measurements performed on a group of energy efficient houses built in the mid-1970's and situated in Abertridwr, S.Wales. Pressurization, tracer decay and British Gas autovent techniques were employed. Results show satisfactory whole-house ventilation rates (0.5 ac/h), but the living room and bedrooms had very low ventilation rates. Some cases showed serious condensation. "Trickle" ventilation installed in 18 of the houses improved internal ventilation patterns and condensation levels were substantially reduced. Reports on a design methodology for naturally ventilated energy efficient dwellings derived from the measurement programme.
KEYWORDS natural ventilation, tight house, ventilation efficiency, air change rate,

#NO 1212 Outdoor testing of small scale naturally ventilated models.

AUTHOR Chandra S. Ruberg K. Kerestecioglu A.
BIBINF Building and Environment vol.18 no.1/2 p.45-53 1983 15 figs. 7 refs. #DATE 01:01:1983 in English
ABSTRACT Proposes a new experimental technique for investigating the natural ventilation potential of new building designs. The method tests scale models of ventilated buildings outdoors in the natural wind. Results from this method agree closely with data from a similar full-scale building. Discusses use of this method by building designers.
KEYWORDS modelling, natural ventilation, simulation,

#NO 1600 Performance of passive ventilation systems in a two-storey house.

AUTHOR Shaw C Y, Kim A.
BIBINF 5th AIC Conference 'The implementation and effectiveness of air infiltration standards in buildings' Reno, Nevada, 1-4 October 1984, pp11.1-11.27, 17 figs, 2 tabs, 6 refs. #DATE 00:10:1984 in English
ABSTRACT Air change rates were measured in one two-storey detached house with five basic types of passive ventilation systems: an intake vent in the basement wall, an outdoor air supply ducted to the existing forced air heating system, an exhaust stack extending from the basement to the roof, and two combinations of the supply systems and the exhaust stack. An expression was developed for estimating house air change rate from house airtightness, neutral pressure level and indoor-outdoor air temperature difference. Good agreement was obtained for the test house between the predicted and the measured air change rates. The effects of furnace fan operation, air distribution system, and size and location of vent openings on house air change rates are also discussed.
KEYWORDS detached house, air change rate, air tightness, neutral pressure level, temperature difference, natural ventilation, stack effect

#NO 1700 House ventilation - a system classification. Woningventilatie - een systeemklassificatie.

AUTHOR Wagenaar E J.
BIBINF Verwarm. Vent. December 1984, vol 41, no 12, 827-835. 11 figs. #DATE 00:12:1984 in Dutch
ABSTRACT The text of a paper on ventilation equipment and systems for existing air-tight houses, presented at the Bouwcentrum/Vakinfo one-day conference, Rotterdam, November 1, 1984. Treats the application of 1. natural ventilation systems with vertical ducts and adjustable openings, 2. the same with mechanical exhaust via kitchen, bathroom, and toilet, 3. mechanical supply to all rooms and exhaust via kitchen, bathroom, and toilet, 4. balanced supply and exhaust. Treats the possi-

bility of the private buyer or tenant estimating the quality of the house. Refers to the Dutch draft standard NVN 5125 "Energy consumption in dwellings, recommended values and calculation methods". Treats current studies into a method of judging the energy efficiency of the house and ventilation installation combined, being carried out by TNO.

KEYWORDS ventilation strategy, natural ventilation, mechanical ventilation, house, standard

#NO 1779 A passive ventilation system under trial in UK homes.

AUTHOR Johnson K A, Gaze A I, Brown D M
BIBINF 6th AIC Conference "Ventilation Strategies and Measurement Techniques", Het Meerdal Park, Netherlands, 16-19 September 1985. Bracknell, UK: Air Infiltration Centre, 1985. p4.1-4.27. 11 figs, 4 tabs, 4 refs. #DATE 00:09:1985 in English AIVC bk

ABSTRACT A passive ventilation system has been installed in four new houses: it comprises simple ducts which lead up from the kitchen and bathroom to outside near the house ridge and utilise the wind and the temperature difference between inside and outside (stack effect) as driving forces. During occupation the system provided a consistent background ventilation rate: the flows dropped only when it was warm and calm outside (when other ventilation measures might be taken by the occupier), when it was very cold and windy outside the system did not over extract but appeared to self-throttle. Window vents gave the occupiers the option of an increase in ventilation. The occupiers made many favourable comments about the system. Cooking smells and steam had cleared quickly, there were no musty smells in the bathroom, nor stale tobacco smells in the living room after being closed up over night, and there were no significant annoying side effects: they had been able to forget about the system. The fitting of the passive system and associated window vents is recommended in new tightly built houses as a means of providing a continuous controlled level of ventilation, and thus reducing condensation risk. For older less tight houses draughtproofing would be necessary in addition to the system, to prevent over ventilation.

KEYWORDS natural ventilation, controlled ventilation, ventilation strategy

#NO 2144 Trickle ventilators in low energy houses.

AUTHOR Energy Efficiency Office.
BIBINF Energy Efficiency Demonstration Scheme Expanded Project Profile 109. Garston, UK: BRECSU, October 1985. 4p. figs #DATE 00:10:1985 in English
ABSTRACT Describes a demonstration project to show that, in well sealed houses, trickle ventilators can provide an opening large enough to reduce condensation and odour problems, but small enough to avoid any significant increase in energy use.

KEYWORDS ventilation strategy, natural ventilation, house,

#NO 2420 Atria and conservatories.

AUTHOR Baker N
BIBINF In, "The efficient use of energy in buildings," 2nd UK-ISES Conference, Cranfield Institute of Technology, September 17th 1986, p32-41, 6 figs, 3 refs. #DATE 17:09:1986 in English

ABSTRACT The paper examines the factors which influence the energy saving performance of atria and conservatories. Technical factors such as shape, insulation and ventilation are discussed. Factors relating to occupant behavior and indoor planting are also considered.

KEYWORDS conservatory, energy conservation, insulation, occupant behaviour

#NO 2535 The role of trickle ventilators in domestic ventilation design.

AUTHOR Jones P J, O'Sullivan P E
BIBINF 7th AIVC Conference, "Occupant interaction with ventilation systems", Supplement to Proceedings, 29 September - 2 October 1986, Stratford on Avon, UK, Bracknell, AIVC, 1986, p91-97, 2 figs, 2 tabs, 5 refs. #DATE 00:00:1986 in English AIVC bk

ABSTRACT This paper discusses the use of trickle ventilators in the design for natural ventilation in dwellings. The discussion is based around the results of a field monitoring experiment where 17 out of 32 houses were fitted with trickle ventilators as a remedial measure to improve the distribution of ventilation and to reduce the occurrence of condensation. Reductions in condensation, effects on energy use, window opening and occupant views are considered. The paper concludes that trickle ventilators are a successful component part in the design of natural ventilation systems in dwellings.

KEYWORDS natural ventilation, condensation, window opening, energy use, occupant reaction, draughts, UK

#NO 2545 Passive ventilation : a method of controllable natural ventilation of housing.

AUTHOR Gaze A I
BIBINF TRADA research report 12/86, 27p + appendix, 11 figs, 4 tabs, 4 refs. #DATE 00:07:1986 in English

ABSTRACT This report describes research work on a passive ventilation system installed in occupied housing and provides simple design guidance with recommendations for future work.

KEYWORDS passive ventilation, design, stack effect

#NO 2588 Blocks of flats with controlled natural ventilation and recovery of heat.

AUTHOR Eriksson L, Masimov T, Westblom S
BIBINF Stockholm, Sweden, Swedish Council for Building Research, 1986, [D19:1986] 85p, 8 figs, 8 tabs, 11 refs. #DATE 00:00:1986 in English

ABSTRACT Deals with the development of a new ventilation system suitable for installation in existing blocks of flats with natural ventilation. Principle components of the system are automatic temperature control-

led inlet air terminals, and a special device in the form of a cowl which is placed on top of the ventilation chimney.

KEYWORDS flat, ventilation, controlled ventilation, heat recovery

#NO 2843 Three investigations of the behaviour of ducts for natural ventilation. Drie onderzoeken naar de werking van kanalen voor natuurlijke ventilatie.

AUTHOR De Gids W F, Den Ouden H P L
BIBINF TNO Report [1987], 42p. #DATE 00:00:1987 in Dutch, English

ABSTRACT Changing the air in dwellings is necessary from the point of view of both health and comfort, as is the removal of combustion gases. In dwellings removal of air takes place either partly through the facade and partly through ducts or entirely through the ducts. Flow back from the outside to the inside of the dwelling through the ducts must be regarded as a serious defect. Flow back in ventilation ducts involves spreading odours from e.g. kitchens and toilets inside a dwelling, from dwelling to dwelling, the possibilities of draughts due to cold outside air flowing in without being warmed, and concentrated in one location. With a well designed mechanical extraction with a ventilator/fan providing the driving force, back flow will be cut right out. The investigation is in three parts: influence of the location and height of the outlet above the roof; influence of higher surrounding buildings on the pressure build-up around a building; influence of a chimney cowl or a ventilator cowl on the pressure in duct outlets.

KEYWORDS duct, natural ventilation **NOTE:** The report has been translated into English by BRE, also available from AIVC.

#NO 2893 Inhabitant's behaviour with respect to ventilation.

AUTHOR Dubrul C
BIBINF IEA Annex VIII Report, 1988, 3 vols. #DATE 00:00:1988 in English AIVC bk

ABSTRACT Annex VIII is a two year task sharing project, started officially in 1984. Although some research had already been done on the problem of inhabitant's behaviour with regard to ventilation, none had gone so far as to assess whether and how the ventilation behaviour can be modified in order to save energy and by taking into account the conflicting requirements, energy conservation and adequate indoor air quality. The main objectives of this annex were: 1) to determine the actual behaviour of the inhabitants and to correlate it to the outdoor and indoor climate 2) to estimate the amount of energy losses due to this behaviour 3) To study the inhabitants relevant behaviour motivation 4) To study whether such behaviour can be modified and to estimate the amount of energy savings which might result therefrom.

KEYWORDS occupant behaviour, ventilation, energy saving, energy conservation, indoor air quality, indoor climate, energy losses

#NO 2963 Natural ventilation of school buildings.

AUTHOR Second Consortium of Local Authorities
BIBINF Scola/DES Workshop, October 1987, [30p]. #DATE 00:10:1987 in English

ABSTRACT The Workshop provided the opportunity for participants to discuss the problems in meeting the current requirements and to examine ways in which the fresh air requirement may be achieved using controlled natural ventilation. Among topics discussed were the following: What are the methods and design tools for calculation of natural ventilation rates? What are the effects of the difference between summer and winter conditions? What are the implications for existing buildings and what are the opportunities offered by refurbishment of these buildings? How is the quality of ventilation affected by the design and distribution of windows and other openings? Are further considerations necessary for the control of condensation? Are users made sufficiently aware of the value of their contribution in achieving a satisfactory environment? These topics provided the headings for discussion within five groups covering four areas of study, namely: Natural ventilation of new schools (2 groups), refurbishment of existing schools, window design, condensation.

KEYWORDS natural ventilation, school, window, condensation

#NO 3130 Further studies of passive ventilation systems - assessment of design and performance criteria.

AUTHOR Edwards, R E, Irwin C
BIBINF in: "Effective Ventilation", 9th AIVC Conference, Gent, Belgium, 12-15 September, 1988. #DATE 00:09:1988 in English

ABSTRACT Increases in building air tightness for purposes of energy saving have, unfortunately, also led to a significant increase in the number of instances of condensation damage, particularly in domestic properties. The cost effective control of condensation is a large problem in the United Kingdom, especially for local authorities with large housing stocks. The use of ducted passive ventilation systems, relying upon stack and wind effects to provide extraction, has several advantages, one of which is that the occupants of dwellings fitted with such systems need little, if any, knowledge of the principles involved, or instructions in its use, to derive maximum benefit. This paper describes two programmes of research carried out on two houses fitted with passive systems; the first house is a highly airtight, timber framed structure, whilst the second is a significantly leakier council owned property of traditional construction. The effect of passive ducts upon the ventilation rate in each dwelling is measured and related to internal/external temperature difference, windspeed and direction. The measured ventilation rates are used to

calculate likely rates of moisture extraction during occupation, and the resulting effects upon condensation risk are assessed in the light of the predicted minimum ventilation rates necessary in order to avoid condensation. Theoretical calculations of the expected flow rates through passive systems are presented, and are shown to be in broad agreement with measured values. Finally, design considerations of importance when specifying passive systems are discussed.

KEYWORDS passive ventilation, design, condensation, air tightness, ventilation rate

#NO 3274 Environmental design manual - summer conditions in naturally ventilated offices.

AUTHOR Petherbridge P, Milbank N O, Harrington-Lynn J

BIBINF UK, Building Research Establishment, 1988, 71pp. #DATE 00:00:1988 in English

ABSTRACT This manual presents a method of assessing the effect of the window size and type, the kind of construction and the rate of ventilation on summertime comfort conditions and daylighting in offices in the British Isles. The method is intended for use in the design procedure together with other guidance to help set design parameters - such as window size - or to check a preliminary design proposal when most design options are still open. The method can also be used to help decide remedies for summertime overheating in existing buildings as well as identifying when acceptable working conditions can be achieved without recourse to mechanical air conditioning or ventilation. The manual deals with rooms with one external wall, primarily offices.

KEYWORDS design, natural ventilation, office building, human comfort, window, ventilation rate

#NO 4097 Passive stack ventilation in dwellings.

AUTHOR Stephen R K, Uglow C E

BIBINF UK, Building Research Establishment, IP21/89, 4 pp, 5 refs. #DATE 00:00:1989 in English

ABSTRACT Comprehensive guidance on the performance of passive stack ventilation systems is not yet available, and research continues. This paper gives interim advice on the design and installation of psv systems in single- or two-storey dwellings, and discusses the key factors affecting performance.

KEYWORDS stack effect, ventilation system

#NO 4120 Natural ventilation in courtyard and atrium buildings.

AUTHOR Bensalem R, Sharples S

BIBINF Netherlands, Kluwer Academic Publishers, 1990, proceedings, "Second European conference on architecture: Science and technology at the service of architecture", held Paris, France, 4-8 December 1989, p 293-295, 3 figs, 5 refs. #DATE 00:00:1990 in English
ABSTRACT This paper reports on an experimental investigation into the ventilative performances of courtyard and atrium buildings for cooling purposes. Several

models of these structures were tested in isolation in a wind tunnel. The ventilation was assessed from actual airflow rates measured by the means of orifice plates inserted in the models. The effect of the courtyard geometry and its orientation to the wind were examined as well as the possibilities of inducing higher ventilation rates by roofing the courtyard and exploiting the pressure field over the roof. The study highlighted the prime importance of the orientation of the building to the oncoming wind and the potential and limitations of some ventilation strategies that could be used in the atrium structures.

KEYWORDS natural ventilation, atrium

#NO 4139 Laboratory and mathematical models of natural ventilation.

AUTHOR Lane-Serff G F, Linden P F, Smeed D A
BIBINF Norway, Oslo, Norsk VVS, Roomvent 90, proceedings, 13-15 June 1990, paper 17, 12 pp, 10 figs, 12 refs. #DATE 00:06:1990 in English

ABSTRACT Heat sources within a building lead to temperature differences between the building and the outside air, and this can be used to drive ventilation flows using the "stack effect". It is these buoyancy-driven flows that are investigated in this paper. A description of the use of laboratory models to investigate spaces with internal heat gains is given, together with the scaling laws necessary to apply the results to a full-scale building. For this technique salt solutions of different concentrations are used in the model to represent air at different temperatures, and thus different densities, in the real building. An outline of a mathematical model is also given, and the general features of natural ventilation are discussed. It is found that the flows can be divided into two broad categories: mixing and displacement modes. The modelling techniques are applied to proposed building projects. The use of modelling studies in the design process is discussed.

KEYWORDS mathematical modelling, natural ventilation

#NO 4174 Simulation of natural ventilation in buildings by means of fluid flows applied to the case of Crown and County Courts.

AUTHOR Linden P F, Lane-Serff G F, Penz F

BIBINF Netherlands, Kluwer Academic Publishers, 1990, proceedings "Second European conference on architecture: science and technology at the service of architecture", held Paris, France, 4-8 December 1989, p 138-142, 8 figs, 5 refs. #DATE 00:00:1990 in English

ABSTRACT The use of natural ventilation to provide air changes within a building is investigated. The driving forces for the flows considered are buoyancy forces produced by temperature differences within a building and between the interior and the exterior air - the "stack effect". Wind-driven ventilation, which usually produces increased ventilation rates is not considered here. The use of small-scale models is described in which water is used as the working fluid and variations in salt

concentrations represent different air temperature in the full scale building. A description of the use of laboratory models to investigate a building with internal heat gains is given and the scaling laws necessary to apply the results at full scale are derived. An outline of a mathematical model is also given and some general features of buoyancy driven natural ventilation are described. These modelling techniques are applied to a proposed design of a Crown Court.

KEYWORDS simulation, natural ventilation, air flow

#NO 4236 Controlled ventilation as a cooling agent in school design for arid tropical areas.

AUTHOR Khafaji O M A, Murta K H

BIBINF Netherlands, Kluwer Academic Publishers, 1990, proceedings Second European conference on architecture: science and technology at the service of architecture, held Paris, France, 4-8 December 1989, pp111-114, 10 figs. #DATE 00:00:1990 in English

ABSTRACT This paper studies the utilization of natural ventilation in school buildings for hot arid regions. It attempts to provide natural ventilation by the controlled movement of cool air. This is to be assisted by special use of stack effect system in building. To achieve such goals, two typical problems have to be resolved; firstly, external temperatures should be reduced to the minimum; secondly, pressure differences between inside and outside should be increased to the maximum. The outcome of this study indicated that, typical layouts (central hall, double banked corridors, etc...), should be avoided. The solution should incorporate functional and what it may call climatical layouts. The conventional methods of applying the stack effect system are not effective in these circumstances. An original method has been developed to utilise the stack effect system to use convection currents to draw cool air through the building.

KEYWORDS cooling, controlled ventilation, hot climate, dry climate

#NO 4284 Principle and aim of a natural humidity-controlled ventilation system.

AUTHOR Jardinier P, Simonnot J

BIBINF Netherlands, International CIB W67 Symposium, "Energy, Moisture and Climate in Buildings", 3-6 September 1990, Rotterdam, p119, 6 figs. #DATE 00:00:1990 in English

ABSTRACT The aim of the natural humidity-controlled ventilation system AERECO is to improve ventilation in dwellings in existing residential buildings where ventilation ducts coming up to the roof can already be found. This paper intends to explain the purpose of the natural humidity-controlled ventilation system AERECO, why such a solution turned out to be developed, the expectable performing results calculated by the means of an adapted calculation programme in the field of a study that has been worked out for the French Ministry of Housing.

KEYWORDS humidity, controlled ventilation

#NO 4289 Room orientation and health in naturally ventilated buildings.

AUTHOR Robertson H J

BIBINF UK, Selper Ltd, 1990, "Indoor air quality and ventilation in warm climates", proceedings of a conference held in Lisbon, Portugal, 24-26 April 1990, pp33-44, 5 figs, 15 refs. #DATE 00:00:1990 in English

ABSTRACT Orientation of opening windows of 48 buildings in south-east Australia is related to occupant complaint of sensitivity to the indoor environment. Where certain rooms were reported as being worse than others in the same building, nearly all orientations were leeward of winds prevailing in Melbourne. This trend was also evident for bedrooms of complaint persons, but not for a small sample of comparable bedrooms in non-complaint houses. The possibility that these rooms are under-ventilated despite construction not being deliberately air-tightened is discussed, along with design implications for healthier warm climate buildings.

KEYWORDS natural ventilation, health, building design

#NO 4459 Use of natural ventilation to control radon in single family dwellings.

AUTHOR Cavallo A, Berkner C, Gadsby K

BIBINF Canada, Indoor Air '90, Proceedings of the 5th International Conference on Indoor Air Quality and Climate, Toronto, 29 July - 3 August 1990, Volume 3 "Characteristics of Indoor Air", pp 489-494. #DATE 00:07:1990 in English

ABSTRACT A fundamental assumption in radon mitigation work, that natural ventilation is not a very effective means of lowering indoor radon levels in buildings, has been reexamined and found to be fundamentally incorrect in a natural ventilation experiment in a research house. Measurement of the pressure field of a basement in conjunction with the building air exchange rate shows that ventilation reduces radon levels in two ways. The first is by dilution, the second is by modification of the pressure field of the building shell. This experiment indicates that the second effect is much more important than the first (dilution), and that natural ventilation can cause a much larger reduction in radon levels than was previously believed.

KEYWORDS natural ventilation, radon

#NO 4687 Emptying filling boxes: the fluid mechanics of natural ventilation.

AUTHOR Linden P F, Lane-Serff G F, Smeed D A

BIBINF Journal of Fluid Dynamics, Vol 212, 1990, pp 309-335, 20 figs, refs. #DATE 00:00:1990 in English

ABSTRACT This paper describes the fluid mechanics of the natural ventilation of a space connected to a large body of stationary ambient fluid. The flows are driven by buoyancy differences between the interior and exterior fluids. Connections with the ambient fluid are high level and low level openings. Two main forms of ventilation are identified: mixing ventilation and displacement ventilation. Mixing ventilation occurs when the

incoming ambient fluid mixes with the fluid within the space, as is the case if dense fluid enter through a high level inlet. In this case vertical stratification is weak. Displacement ventilation occurs when dense fluid enters at low levels and displaces the lighter fluid within the space out through high level openings. A strong stable stratification develops in this case, and there is little mixing between the incoming fluid and that in the interior. Both of these modes of ventilation are studied theoretically and the results are compared with laboratory experiments. Transient draining flows which occur when a space initially contains fluid of a density different from the ambient are examined. The presence of internal sources of buoyancy allows steady states to be established, and the effects of point, line and vertically distributed sources are studied. These steady states are extensions of filling box models, with the addition of continuous exchange of fluid with the environment outside the space. A major result of this work is that the form of the stratification within the space depends on the entrainment caused by the convective elements (plumes) produced by the buoyancy sources, but is independent of the strength of the sources. The strength of the stratification and the magnitudes of the velocities do, however, depend on the source strength. The effects of opening size(s) and configurations are determined, and criteria for producing a particular stratification within the space are established. Applications of this work to the ventilation of buildings are presented.

KEYWORDS natural ventilation, mixing ventilation, displacement ventilation

#NO 4698 New developments in natural ventilation. Nouveaux developpements en ventilation naturelle.

AUTHOR Buty D, Villenave J-G, Cloiseau D
BIBINF "Ventilation et Renouvellement d'Air dans les Batiments", AIVC/AFME Workshop held 18-22 March, 1991, Lyon, France, 7pp, 3 figs, 3 refs. #DATE 00:03:1991 in French

ABSTRACT This paper deals with new developments in studies and modelling of passive stack ventilation systems. The first part describe the activity of a working group dealing with technical requirements on stack ventilation. The second part expose some results on a CSTB - GdF study on combustion products released by stack ventilation ducts. The use of Computational Fluid Dynamics for pressure drops calculation in ducts is illustrated.

KEYWORDS passive ventilation, stack ventilation, duct

#NO 4796 Environmental design of atrium buildings in the UK.

AUTHOR Mills F
BIBINF USA, ASHRAE Transactions, Vol 96, Part 1, 1990, pp 14-22, 1 fig, 4 tabs, refs. #DATE 00:00:1990 in English

ABSTRACT Atrium buildings were first prominent in the U.K. in Victorian times when glazed features were incorporated into building designs to improve daylight quality while providing shelter. Many fine examples of this form of architecture still exist, the most popularly known types being shopping arcades and main line railway terminals. U.K. developers and their architects, impressed with the success of atria in North America, have adopted this approach to U.K. developments and, since 1980, more than 200 examples of various types have been constructed. The approach to the servicing of these atria has been cautious, with little definitive design guidance in existence. Some early schemes followed the North American approach of heating, ventilating and, in some cases, air conditioning atria, while others adopted a pioneering approach seeking to embody passive solar principles. This paper outlines these developments in design and gives examples of recently completed projects. The case is made for a passive solar approach that can be successful in the temperate climate of the U.K. in the majority of cases provided correct design principles are followed. The same approach is suited to those parts of Europe sharing similar climatic conditions to the U.K.

KEYWORDS atrium, passive solar design

#NO 4832 Experimental evaluation of a hygroregulating natural ventilation system.

AUTHOR Wouters P, Vandaele L
BIBINF UK, AIVC 11th Conference, "Ventilation System Performance", held 18-21 September 1990, Belgrate, Italy, Proceedings published March 1990, Volume 1, pp 149-156, 5 figs, 4 tabs, 2 refs. #DATE 00:03:1991 in English

ABSTRACT In the framework of a CEC-DGXVII demonstration project a hygroregulating natural ventilation system is being evaluated in 52 occupied apartments. Therefore a multi purpose automated tracer gas equipment has been developed enabling the detailed monitoring of air flow rates in 60 rooms continuously. In addition the humidity levels, CO₂ levels and air temperatures are measured as well as the outdoor climate. The first measurement campaigns partly used for evaluation of the measurement system are reported and show an impressive amount of data enabling various types of detailed analysis. The ventilation and air quality parameters of the apartments equipped with humidity controlled ventilation system are compared with those of the reference apartments.

KEYWORDS natural ventilation, apartment building, tracer gas, humidity control

#NO 4852 Humidity controlled natural ventilation without auxiliary energy supply.

AUTHOR Szerman M, Erhorn H, Stricker R
BIBINF UK, AIVC 11th Conference, "Ventilation System Performance", held 18-21 September 1990, Belgrate, Italy, Proceedings published March 1990, Volume 2, pp 53-62, 6 figs, 7 refs. #DATE 00:03:1991 in English

ABSTRACT As a consequence of measures required for reducing the heating energy consumption in residential buildings, there have been more and more complaints in the last few years on the appearance of mould in dwellings. In most cases, it is retrofitted or renovated old buildings which are affected. Mould growth is frequently the result of a severe reduction in the natural air change rate in old buildings following the installation of airtight windows, while user habits remain the same as before. Each day, an average amount of 8 to 15 litres of moisture is generated in dwellings, which is usually conveyed to the outside through window joints. However, airtight windows and insufficient ventilation cause indoor air humidity to rise. This may lead to surface humidity on cold external walls, e.g. at thermal bridges, thus providing ideal conditions for mould growth. The effect is enhanced unless the insulation level of the external wall is greatly improved so that the surface temperature of the exposed areas is increased. According to [2], mould growth is influenced by the following parameters: nutrient availability, temperature, pH-value of the substrate and, in a decisive manner, the amount of water in the substrate. According to [3], in one third of all cases, the damage is obviously caused by user-related, high indoor air humidity. This is the result of tests performed in 300 old buildings, where several examinations were carried out in different dwellings. Besides, structural deficiencies such as thermal bridges or insufficient humidity protection of the building envelope were identified as being responsible for the remaining cases of damage. It can therefore be concluded that, supposing the construction is sound, it is the user-related indoor moisture load that should be reduced to prevent humidity damage and resulting mould growth.
KEYWORDS humidity, controlled ventilation, energy conservation, mould

#NO 4855 The influence of different ventilation devices on the occupants behaviour in dwellings.

AUTHOR van Dongen J E F
BIBINF UK, AIVC 11th Conference, "Ventilation System Performance", held 18-21 September 1990, Belgrate, Italy, Proceedings published March 1990, Volume 2, pp 101-120, 4 figs, 7 tabs, 8 refs. #DATE 00:03:1991 in English

ABSTRACT On basis of several case studies into the ventilation behaviour in dwellings in the Netherlands, it is possible to answer the question whether the type of ventilation device influences the behaviour of the occupants during mild winter periods (5 Deg C). The dwellings are discerned in three types: * those with natural ventilation through passive stacks only; * those with mechanical exhaust ventilation provisions; * those with balanced mechanical ventilation provisions. By means of questionnaires in each of these dwellings characteristics of the households and the ventilation behaviour has been assessed. Consequences with respect to the air change rates will be discussed too.
KEYWORDS occupant behaviour, ventilation system

#NO 4861 Ventilation characteristics of selected type of buildings and indoor climate.

AUTHOR Zainal M, Croome D J
BIBINF UK, AIVC 11th Conference, "Ventilation System Performance", held 18-21 September 1990, Belgrate, Italy, Proceedings published March 1990, Volume 2, pp 195-210, 4 figs, 4 tabs, 9 refs. #DATE 00:03:1991 in English

ABSTRACT The paper presents results of ventilation characteristics of a lecture/seminar room obtained by various door-window opening combinations and positions, and the level of comfort and air quality resulted by the given window-ventilating modes. Applying statistical methods, formulae of air change rate for the test room under its normal operating condition i.e. when all window and external door are shut and when particular windows are opened is also presented and graphs in relation to dominance factors such as wind and buoyancy effects, are given. It is found that, under its normal operating mode the natural supply of outdoor air is far too deficient for health and comfort purposes. Means of improving the thermal environment and indoor quality to meet the fresh air requirements as recommended by both the ASHRAE and CIBSE Guides are suggested by proper selection of window opening patterns. Assessments of thermal comfort using a thermal comfort meter and occupancy odour or freshness were also conducted.
KEYWORDS air change rate, window opening, thermal comfort, air quality

#NO 4873 Designing for natural ventilation: law courts.

AUTHOR Walker R R, Perera MDAES
BIBINF UK, Chartered Institution of Building Services Engineers, 1991, CIBSE National Conference 1991, held at University of Kent, Canterbury, 7-9 April 1991, pp 201-205, 5 figs, 8 refs. #DATE 00:00:1991 in English

ABSTRACT There is considerable interest in possible designs for naturally ventilated Law Courts, which avoid the need for air conditioning. However, design requirements make it difficult to locate windows for ventilation purposes. A proposed alternative is based around the concept of providing summertime ventilation via an underfloor duct and controllable vents at roof level, under the action of wind and buoyancy forces alone. This option was assessed through a computer study to predict the ventilation flows into several variations of a general court-room design over a range of meteorological conditions and internal temperatures. The ventilation performance during the summer months was assessed using a new statistical approach. Improvements to the performance of the above design are demonstrated by results for a proposed Crown Court complex to be built near Canterbury.

KEYWORDS natural ventilation

#NO 4879 Experimental passive stack systems for controlled natural ventilation.

AUTHOR Parkins L M

BIBINF UK, Chartered Institution of Building Services Engineers, 1991, CIBSE National Conference 1991, held at University of Kent, Canterbury, 7-9 April 1991, pp 508-518, 10 figs, 2 tabs, 5 refs. #DATE 00:00:1991 in English

ABSTRACT The modern trend towards more airtight energy efficient housing requires additional care in providing controlled ventilation. Passive Stack Ventilation (PSV) is one way of providing the necessary control. The Building Research Establishment (BRE) is carrying out research into the performance of PSV systems in dwellings. Several different PSV systems were installed in a test house and the flow velocity through them measured under a range of meteorological conditions. The results of these tests are presented and the effect of bends in the duct and duct diameter are discussed.

KEYWORDS natural ventilation, residential building, testing house

#NO 5142 Ventilation of buildings.

AUTHOR Awbi H B

BIBINF UK, E&FN Spon, 1991, 313pp. #DATE 00:00:1991 in English

ABSTRACT Chapters include: human comfort and ventilation; ventilation requirements; air infiltration and natural ventilation; principles of air jets; air diffusion devices; design of room air distribution systems; numerical evaluation of room air movement; measurement of indoor climate.

KEYWORDS ventilation system

#NO 5254 Controlled natural ventilation.

AUTHOR Knoll B, Kornaat W

BIBINF UK, AIVC 12th Conference, "Air Movement and Ventilation Control within Buildings", held 24-27 September 1991, Ottawa, Canada, proceedings published September 1991, Volume 1, pp 193-218. #DATE 00:09:1991 in English

ABSTRACT Natural ventilation of dwellings is commonly applied, especially in mild and moderate climates. The disadvantage of natural ventilation is the poor control of both flow directions and flow rates within the ventilated building. To improve control, the use of mechanical exhaust is often recommended. Though this may improve total ventilation, the ventilation of separate rooms often is insufficient still. Our approach was to try and find a highly controlled natural ventilation system, whose control is highly independent of weather changes and dwelling properties, just like in thermostatic temperature control. Therefore a study has been carried out, using a ventilation calculation model.

KEYWORDS natural ventilation, controlled ventilation, model, air tightness

#NO 5258 The simulation of infiltration rates and air movement in a naturally ventilated industrial building.

AUTHOR Jones P, Alexander D, Powell G

BIBINF UK, AIVC 12th Conference, "Air Movement and Ventilation Control within Buildings", held 24-27 September 1991, Ottawa, Canada, proceedings published September 1991, Volume 1, pp 273-284. #DATE 00:09:1991 in English

ABSTRACT This paper describes the application of numerical models to predict the ventilation rate and internal air movement patterns for a naturally ventilated industrial building and compares the results with measured data. Two modelling techniques have been employed. Firstly, a zonal network model (HTBvent), using leakage area data derived from fan pressurisation measurements, was used to predict the time varying ventilation rate in response to variations in wind velocity and internal-external air temperature difference. The results compare well with measurement data (obtained using constant concentration tracer gas techniques) over a wide range of ventilation rates. The results demonstrate the use of zonal models to estimate the thermal benefits of applying sealing measures to building components. Secondly, a computational fluid dynamics (CFD) model (DFS-AIR) was used to predict the ventilation rates and also the internal air movement resulting from natural ventilation, for selected external conditions. The predicted ventilation rates again agree well with measurement data. The resulting air movement patterns can be used to indicate the effectiveness of natural ventilation and the implications for comfort throughout the occupied space. The general conclusion was that these modelling techniques, having been successfully tested against measurement data, can be used in the design of naturally ventilated buildings.

KEYWORDS infiltration rate, air movement, natural ventilation, industrial building, simulation

#NO 5269 Single-sided natural ventilation - how deep an office?

AUTHOR White M, Walker R

BIBINF UK, AIVC 12th Conference, "Air Movement and Ventilation Control within Buildings", held 24-27 September 1991, Ottawa, Canada, proceedings published September 1991, Volume 1, pp 473-474. #DATE 00:09:1991 in English

ABSTRACT This report describes tracer gas measurements of the local mean age of air at different locations within an office room. These results are used to assess the distribution of fresh air at different depths, and to give guidance on the depth over which single-sided ventilation is effective.

KEYWORDS natural ventilation, office building, tracer gas measurements, ageing

#NO 5380 A design guide for naturally ventilated courtrooms.

AUTHOR Penz F

BIBINF UK, Property Services Agency, January 1990, 13pp. #DATE 00:01:1990 in English

ABSTRACT Provides guidance on the practical application of the principles of natural ventilation to a court building design.

KEYWORDS natural ventilation, public building, building design

#NO 5565 IEA Annex 14: the Zolder case study.

AUTHOR Hens H, Senave E

BIBINF Denmark, *Indoor Air*, No 3, 1991, pp 213-228, 6 figs, 9 tabs, refs. #DATE 00:00:1991 in English

ABSTRACT The Zolder case was one of the six case studies on mould problems and surface condensation, initiated within the International Energy Agency (IEA) Annex 14 on "Condensation and Energy". This project, a joint research effort of Belgium, the Federal Republic of Germany, Italy, the Netherlands and the United Kingdom, was completed in March 1990. Complex relations between mould, surface condensation, energy conservation and parameters such as the outdoor climate, the thermal quality of the building, the ventilation and the occupants' behaviour are explained, followed by an analysis of the Zolder-Lindeman case. This illustrates the extent to which mould may deteriorate the livability of a social housing estate. On three houses, different mitigation measures were evaluated before and after implementation: loft space insulation, inside insulation, double glazing, outside insulation, natural ventilation, and demand controlled ventilation. The results for one of the three show that the severe mould problems resulted from the combination of poor overall insulation quality and the impossibility of ventilating properly. A thermal retrofit, together with the installation of a natural ventilation system, proved to be successful.

KEYWORDS mould, surface condensation, energy conservation

#NO 5832 Air flow patterns within buildings: measurement techniques.

AUTHOR Roulet C-A, Vandaele L

BIBINF UK, Air Infiltration and Ventilation Centre, Technical Note AIVC 34, December 1991 (IEA Annex XX Final Report). #DATE 00:12:1991 in English

ABSTRACT This handbook is concerned with the measurement of those parameters which are important in gaining an understanding of air infiltration and ventilation. The handbook has been designed so that the material suited to your particular level of interest or current expertise, is readily accessible. The flow chart in Figure 1.1 illustrates the structure. The introduction provides a general overview of infiltration and ventilation in buildings. Ventilation studies are discussed and the aims of the handbook outlined. Part I defines the parameters which are important, presents the reasons why they should be measured and gives a guide to the selection of techniques for particular applications. Summaries of the main techniques available are presented, which are cross referenced with the main body of the handbook. Part II presents the theory and practice of measuring the airtightness of the building envelope and

its components. Leakage location and leakage path distribution within the building is also examined. Part III presents the theory and practice of measuring air exchange rates and the related contaminant flow rates. Air exchange between a building and the external environment is examined, as is the air exchange between the various internal spaces of a building. Part IV presents some measurement methods which may be useful to qualify the indoor air and the efficiency of the ventilation system. Measurement of contaminant concentrations are however not described, since another book will be necessary to describe all the possible methods to analyze the thousands of possible contaminants. Part V describes measurement methods which are able to qualify a system, namely to measure the flow rates in the ventilation network and to control its airtightness.

KEYWORDS air flow, measurement technique, air leakage, ventilation system, energy efficiency

#NO 5973 Occupant's behavior with respect to window opening: a technical and sociological study.

AUTHOR Fleury B, Nicolas C

BIBINF UK, Air Infiltration and Ventilation Centre, 13th AIVC Conference, proceedings, held Hotel Plaza Concorde, Nice, France, 15-18 September 1992.

#DATE 15:09:1992 in English

ABSTRACT The occupant's behavior with respect to window opening may greatly affect the ventilation system, the energy consumption or/and the indoor air quality. In order to quantify the magnitude of opening times, many surveys have focused on climatic parameters and concluded to the temporal correlation between the time-length of opening and the outside temperature or the solar irradiation. In this paper, we study the influence of sociological and technical parameters on the average time of opening during the winter. The research is based on a sociological survey and a two year monitoring of thirty houses with recording sensors on every window. The wife at home or not, the size and age distribution of the family are key variables in the kitchen, bathroom, children's bedroom. The orientation of the living room related to the sun explains the occupant's behavior in this room. For the parent's bedroom, none of the selected parameters emerges, the distribution and frequency of opening time are so erratic. The type of ventilation systems, natural versus mechanical, is not the main explainable variable, as well as the degree of equipment of the family.

KEYWORDS occupant behaviour, window opening, ventilation system, sensor

#NO 5995 Humidity controlled exhaust fan in a natural ventilated single family house.

AUTHOR Mansson L-G, Boman C-A, Jonsson B-M

BIBINF UK, Air Infiltration and Ventilation Centre, 13th AIVC Conference, proceedings, held Hotel Plaza Concorde, Nice, France, 15-18 September 1992.

#DATE 15:09:1992 in English

ABSTRACT A humidity controlled exhaust fan have been tested during the winter season 1991/2. The test have been carried out in a detached one storey house with a flat roof. The relative humidity (RH) have been measured in the following modes: * natural ventilation only * wall mounted fan, setpoint 70% RH, and natural ventilation * fan in the exhaust duct, setpoint 70% RH. The relative humidity levels have been monitored in the shower room and in the other part of the dwelling. The temperatures have been measured in the exhaust duct and in four places in the dwelling. It is concluded that a wall mounted fan can keep the relative humidity close to 50% RH, causes backdraught in the exhaust duct, and usually has to be switched off manually. A fan mounted in the exhaust duct gives a higher average RH than natural ventilation only.

KEYWORDS humidity, controlled ventilation, exhaust, fan, natural ventilation

#NO 6089 Ventilation of small factory units.

AUTHOR Fletcher B, Johnson A E

BIBINF Journal of Wind Engineering and Industrial Aerodynamics, No 40, 1992, pp 293-305, 7 figs, 2 tabs, 8 refs. #DATE 00:00:1992 in English

ABSTRACT Ventilation rates have been measured using tracer gas techniques in a number of modern factory units with no mechanical ventilation. Wind direction remained fairly constant throughout the tests on individual units, enabling the variation of ventilation rate with wind speed to be determined. In the second phase of the work, measurements were made on a single building under a wide range of weather conditions. Although no correlation with wind direction was apparent, it was shown that the ventilation rate varied not only with wind speed, but also with the difference between the internal and external temperatures, i.e. the "stack effect".

KEYWORDS factory, ventilation rate, tracer gas measurements, natural ventilation, wind speed, stack effect

#NO 6129 Design aspects of naturally ventilated offices in the Netherlands.

AUTHOR Wapenaar P H

BIBINF Netherlands, CADDET Newsletter, No 2, 1992, pp 7-9, 5 figs, 1 ref. #DATE 00:00:1992 in English

ABSTRACT In this article, a case is presented for the use of natural ventilation in a new office building. The designers of the new town hall in Apeldoorn, the Netherlands, have tried to avoid installing a complete air-conditioning system by exploiting all the natural possibilities which the building/construction offers to create a proper thermal climate. To achieve a high quality, both from a building physics and an energy point of view, certain functional, building, and HVAC design parameters have been determined at an early stage.

KEYWORDS building design, office building, natural ventilation

#NO 6158 Nelson city council library energy efficient design. Monitoring and evaluation report.

AUTHOR Isaacs N, Donn M

BIBINF New Zealand, Ministry of Commerce, Energy Management, Monitoring and Evaluation Report No 13, November 1991, 67pp. #DATE 00:11:1991 in English
ABSTRACT The Elma Turner Library opened on 28 February 1990. In the centre of Nelson, the design of the single-storey 1800 m² library, a converted car sales building, was helped by intensive daylight and thermal performance analysis. Although the building was to be naturally ventilated, the analysis suggested it would not overheat in summer. The energy efficient features of the building include clerestory windows; external sunshading serving also to reflect daylight deep into the building; a central courtyard to let natural light and fresh air deep into the building; electrically operated high-level windows and manually operated wall-mounted low-level louvres for controlled and effective natural ventilation; electric ceiling fans to help air movement; higher levels of thermal insulation that would be normally used in a commercial building; and electronic controlled ceiling-mounted radiant heating panels. From 1 April 1990 to 1 May 1991, the operation of the energy systems was monitored with temperature and electricity meter readings recorded by library staff each working day at 9 a.m. Detailed temperature and energy records were collected by computer link for the period March to May 1991. Photographs of daylight and sunlight penetration were taken once a month. Physical measurements of cloudy sky daylight conditions were made on a 2 m grid over the whole of the main floor area. A steady-state heating energy use and cool down temperature test were conducted on the weekend of 27 July 1990. Air change rate measurements were taken from 11-23 February 1991 using a passive sampling system.

KEYWORDS library, energy efficiency, large building

#NO 6291 ATRIA - temperate climatic responses.

AUTHOR Robertson G

BIBINF Kluwer Academic Publishers, 1991, proceedings "PLEA 91: Architecture and Urban Space", Ninth International PLEA Conference, Seville, Spain, September 24-27 1991, pp 251-256. #DATE 00:00:1991 in English

ABSTRACT This paper reports on the continuing work in Auckland, New Zealand, to formulate design guidelines for architects operating in temperate climate zones to produce atria spaces associated with commercial buildings - particularly offices - which are energy efficient and architecturally plausible. The apparent lack of recognition of the inherent characteristics of the atrium form has led to the production of too many examples which, if not air conditioned, are uncomfortably hot or cold; and if air conditioned are particularly large energy users. It is argued that in temperate climate conditions the advantages of a non air conditioned atrium are particularly attractive and vital if adequate responses to

global climate change phenomena are to be adopted by the architectural community in the decades ahead. Work is progressing to finalise design nomographs for use by architects at the preliminary design stage, which is seen as the critical time in the process. The "art" of the architect must prevail at this stage with fine tuning by computer analysis later in the design process. The complexity and often contradictory nature of the thermal design components in office space design is recognised. If energy efficient building are to result, then these components must be considered at the earliest stage or just energy efficient mechanical plant systems will result. Designer checklists are provided.
KEYWORDS atrium, building design, office building, energy efficiency, natural ventilation

#NO 6295 Design of a naturally ventilated laboratory building in Leicester, England.

AUTHOR Ford B, Short A

BIBINF Kluwer Academic Publishers, 1991, proceedings "PLEA 91: Architecture and Urban Space", Ninth International PLEA Conference, Seville, Spain, September 24-27 1991, pp 319-324. #DATE 00:00:1991 in English

ABSTRACT This paper provides an overview of the design of the new School of Engineering and Manufacture for Leicester Polytechnic, incorporating new laboratories for electrical and mechanical engineering students plus general teaching spaces and two auditoria. The site for the new building is at the heart of the Polytechnic's city centre campus. Its urban location has placed particular demands on the design. Nearly all laboratory, teaching and offices are naturally ventilated and daylit. Detailed design is nearing completion and construction on site started in June 1991.

KEYWORDS natural ventilation, laboratory, cooling

#NO 6345 Prediction of natural ventilation air flows in a non-urban office.

AUTHOR Smith M G, Walker R R, Perera M D A E S
BIBINF Roomvent '92, Third International Conference, Aalborg, Denmark, September 2-4 1992, Publisher: DANVAK, Lyngby, Denmark, Volume 3, pp 463-478. #DATE 02:09:1992 in English

ABSTRACT Except in the simplest cases, calculating natural ventilation air flows requires the use of a computer model. This paper illustrates appropriate steps which may be taken in solving a modelling problem using the example of a case study of the design of a naturally ventilated building. A single-cell ventilation model was used to assess the adequacy of ventilation under expected wind conditions. In a two-step procedure, air flows obtained, in conjunction with predictions using a dynamic thermal model, were used as boundary conditions in a computational fluid dynamics model to predict the internal environment. The inter-dependence of internal temperatures and ventilation rate was highlighted, and possible methods are suggested to model this consistently.

KEYWORDS prediction, natural ventilation, air flow, office building, modelling, CFD, ventilation rate

#NO 6489 Controlled background ventilation for large commercial buildings.

AUTHOR Perera M D A E S, Marshall S G, Solomon C W

BIBINF UK, Air Infiltration and Ventilation Centre, 13th Annual Conference, "Ventilation for Energy Efficiency and Optimum Indoor Air Quality" held Nice, France, 15-18 September 1992, pp 33-49, 10 figs, 14 refs. #DATE 00:09:1992 in English

ABSTRACT This study assessed the effectiveness of permanent but controllable background ventilators in naturally ventilated, office-type buildings with different envelope tightness. It was shown that, during the heating season, it is possible to provide adequate background ventilation for occupant comfort by incorporating commercially-viable, manually-controllable trickle ventilators within each room. Recommendations for possible consideration may be that 4,000 mm² open-area ventilators could be used in rooms with floor areas less than 10 m² and 400 mm² per m² (of floor areas) for those which are larger.

KEYWORDS building envelope, air tightness, controlled ventilation, office building, natural ventilation

#NO 6574 Flow characteristics of one side mounted windows.

AUTHOR de Jong T, Bot G P A

BIBINF UK, Energy and Buildings, No 19, 1992, pp 105-112, 10 figs, 1 tab, 17 refs. #DATE 00:00:1992 in English

ABSTRACT Full-scale measurements of the flows through openings under one-side-mounted casement windows are reported. Together with previous studies on scale-model windows, the results provide a sound basis for a quantitative approach to describe the flow characteristics of this window-type. Since the design of windows considered is commonly applied in naturally ventilated buildings, the presented description of the flow through those window openings can be widely employed.

KEYWORDS air flow, natural ventilation, window

#NO 6577 Comfort assessment in a naturally ventilated office.

AUTHOR Croome D J, Gan G, Awbi H B

BIBINF UK, Pergamon Press, 2nd World Renewable Energy Congress, "Renewable Energy Technology and the Environment", Vol 4, Solar and Low Energy Architecture, edited by AAM Sayigh, held Reading, UK, Sept 1992, pp 1854-1869, 4 figs, 4 tabs, refs. #ATE 00:09:1992 in English

ABSTRACT Experiments were carried out to measure the indoor environmental parameters such as air change rate, air velocity, turbulence intensity and air temperature in a naturally ventilated office. Subjective assessment was made to evaluate the thermal comfort and

indoor air quality in the office. The effect of opening windows and the door on the indoor comfort conditions was also investigated. Models were developed for assessing the indoor environment which were based on the field measurements.

KEYWORDS natural ventilation, office building, thermal comfort, draughts air movement

#NO 6764 European patent application: self regulating ventilation grate.

AUTHOR Anon

BIBINF European Patent Office, 1992, 9pp, 4 figs.

ABSTRACT Patent describing a self-regulating ventilation grate with an inlet opening, an exhaust opening and in between a variable passage opening. In case of an increasing overpressure the valve will rotate, so that the distance becomes smaller. During the turning, the valve rolls over a spherical bearing surface. This makes the grate fit, i.e., self-regulating, for pressure differences up to about 40 Pa.

KEYWORDS patent, instrumentation, ventilation rate

#NO 7032 Natural Ventilation via Courtyards: Theory & Measurements.

AUTHOR Walker R R, Shao L, Woolliscroft M

BIBINF UK, Air Infiltration and Ventilation Centre, 14th AIVC Conference, "Energy Impact of Ventilation and Air Infiltration", held Copenhagen, Denmark, 21-23 September 1993, proceedings, pp 235-250. #DATE 21:09:1993 in English

ABSTRACT Existing regulations concerning the design and construction of residential buildings which are naturally ventilated via courtyards and lightwells have origins in daylighting rather than in aerodynamics. The design of narrow, high-sided courtyards which achieve healthy conditions for occupants has long been a problem and a subject of various guidance and research, although many doubts and gaps in knowledge still remained. The work described below resolves these problems, and the coherent theory developed may lead to clearer guidance on the design of courtyards for natural ventilation. A fresh approach was adopted using computational fluid dynamics (CFD) software as an integrated technique in combination with measurements at both model and full scale. The adequacy of infiltration and ventilation rates in rooms opening onto the courtyard was also assessed. The salient results were used to develop a coherent descriptive model which explains the apparent discrepancies in earlier work and enabled revised design guidelines to be presented.

KEYWORDS natural ventilation, atrium, computational fluid dynamics

#NO 7046 Natural Ventilation in 18 Belgian Apartments: Final Results of Longterm Monitoring.

AUTHOR Wouters P, Geerinckx B, L'Heureux D

BIBINF UK, Air Infiltration and Ventilation Centre, 14th AIVC Conference, "Energy Impact of Ventilation and Air Infiltration", held Copenhagen, Denmark, 21-23

September 1993, proceedings, pp 369-378. #DATE 21:09:1993 in English

ABSTRACT In the framework of a CEC demonstration project on humidity controlled ventilation, detailed measurements are carried out in 18 apartments in Namur, Belgium. The paper gives a brief description of the building, of the airtightness of the apartments and of the ventilation provisions. The largest part of the paper deals with the major outcomes of the study. This includes the following issues: air flow rates: on the average, dependency of wind and temperature difference; indoor air quality indicators: CO₂ and water vapour; behaviour of the humidity controlled system; energy losses due to the ventilation. Finally, some conclusions about the ventilation performances and of the monitoring programme are given. The demonstration project showed very well the influence of the building characteristics on the performances of the ventilation system.

KEYWORDS natural ventilation, apartment building, field monitoring, humidity controlled ventilation

#NO 7227 Passive stack ventilation: A review of ventilation needs and passive stack ventilation

AUTHOR Semenenko P

BIBINF UK, CIBSE, proceedings of CLIMA 2000, 1-3 November 1993, Queen Elizabeth II Conference Centre, London, 1993, paper no. 326.

ABSTRACT Modern standards in the construction of dwellings and commercial buildings have concentrated efforts towards increasing insulation values of the external fabric and reducing filtration by draught proofing. Consequently, the rates of natural ventilation that once existed have reduced considerably. This reduction of ventilation creates a stale environment that allows hazardous substances to accumulate and increases the risks associated with condensation. This paper reviews the minimum requirements necessary for fresh air ventilation, and which is the primary function for ventilation needs. The paper suggests the best ways of achieving secure and dedicated passive natural ventilation without the use of any electrically driven fans. A review of current research into passive stack ventilation systems has shown that such systems provide controllable and satisfactory rates of natural ventilation. They are also cost effective, user friendly, silent in operation and require virtually no maintenance.

KEYWORDS refrigeration refrigerants fluorocarbons R142b

#NO 7232 Passive atrium design

AUTHOR Mills F A

BIBINF UK, CIBSE, proceedings of CLIMA 2000, 1-3 November 1993, Queen Elizabeth II Conference Centre, London, 1993, paper no. 17.

ABSTRACT This paper identifies the key design strategies for the construction and operation of energy efficient atrium buildings based on passive solar design techniques drawing from applied research design studies using recently constructed buildings as references. The

paper summarises the overall results of this research work which studied a range of key design issues, comparing the reference (as built) buildings with alternative passive design solutions. Energy consumption and energy costs are compared with the alternative construction costs to identify the cost effectiveness of the passive approach. In addition related operational criteria have been examined - the robustness of the building to different types of use (e.g. increased computer loads), internal planning flexibility, security, fire safety, operating and maintenance costs. The perception of the passive solution to occupants was also studied. The project identified four principle design approaches for passive solar atria: NATURAL LIGHTING - admitting daylight (and sunlight) into the heart of a deep plan building; THERMAL INSULATION - providing a "free running" or partially heated buffer space between the treated areas of a building and the outside climate; NATURAL VENTILATION - using an atrium to create a stack effect through a building so that occupied areas can be naturally ventilated in summer instead of air conditioned; PLENUM SPACE - using the atrium as a supply, extract or recirculation plenum integrated into the building's air conditioning systems.

KEYWORDS atria passive designing research monitoring buildings commercial models performance energy_conservation lighting natural_ventilation solar_heat_gain

#NO 7296 Measurement and simulation results of naturally ventilated atria

AUTHOR Simmonds P.

BIBINF USA, Ashrae, 1993, "Building design technology and occupant well-being in temperate climates". International conference, held February 17-19, 1993, Brussels, Belgium, pp 245-252, 5 figs, 2 tabs, refs. #DATE 00:02:1993 in English

ABSTRACT A new teaching hospital in Groningen, the Netherlands, will be finished around the year 2000 and will have 1,000 beds. Nine atria will cover the pedestrian areas. These atria are not heated or mechanically ventilated, not even during the summer. Smoke extract openings in the roof provide natural ventilation. When the first atrium was finished in 1988, eight temperature recorders were placed in it. Measurements were also continuously made of the outside air temperature, solar intensity, and the position of the openings (open or closed). The measured results were then compared to the original calculations to see if it was necessary to make design, construction, or operational changes for the future atria. Because the nine atria will be linked to each other by pedestrian walkways, the movement of air (if any) between the atria needed to be investigated. Computer simulation was used to simulate bulk air movements into and within the building, driven by wind pressures, buoyancy forces arising from internal and external temperature differences, and mechanical ventilation systems in the surrounding buildings. The provisional results of the comparison concerning fresh air

ventilation, total air ventilation, and low-level/high-level temperature differences all correspond to each other. It is expected that the differences between the simulation results and the actual recorded measurements will be minimal. If this is true, then it will provide an exceptional design tool for the future atria. This paper describes the environment that was created using the original design data, the measured results, the experiences of the users, and the computer simulations.

KEYWORDS natural ventilation, atrium, simulation, hospital.

#NO 7368 Full scale and model investigation of natural ventilation and thermal comfort in a building.

AUTHOR Dutt A J, Dear R J de, Krishnan P.

BIBINF Journal of Wind Engineering and Industrial Aerodynamics, Vols 41-44, 1992, pp 2599-2609, 10 figs, 14 refs. #DATE 00:00:1992 in English

ABSTRACT Application of a new experimental technique for the investigation of natural ventilation and thermal comfort in a building situated in Singapore is described. The investigation comprised full scale experiments in a naturally ventilated dining room of students' hall of residence and scale model tests of the building in a boundary layer wind tunnel. There was good agreement of results obtained from full scale tests and model tests. Thermal comfort analyses were based on a "tropicalized" PMV index as applied to mean conditions observed in the full scale experiments.

KEYWORDS natural ventilation, thermal comfort, wind tunnel.

#NO 7419 Will natural ventilation work?

AUTHOR Anon.

BIBINF UK, Building Services, October 1993, pp 41-42, 3 figs, 1 tab, 3 refs. #DATE 00:10:1993 in English

ABSTRACT Describes how the De Montfort University School of Engineering's natural ventilation system had to be modelled to show it would work. The building is one of the largest naturally ventilated buildings in Europe, and could become a seminal example of how to rely upon temperature and air pressure differences to drive ventilation. The building contains a variety of spaces including two auditoria, drawing studios, laboratories and classrooms.

KEYWORDS natural ventilation, building design, modelling.

#NO 7420 Learning curve.

AUTHOR Bunn R.

BIBINF UK, Building Services, October 1993, pp 20-23. #DATE 00:10:1993 in English

ABSTRACT Describes the naturally ventilated School of Engineering at UK De Montfort University in Leicester and suggests how it could influence a new breed of environmentally sensitive buildings.

KEYWORDS natural ventilation, building design.

#NO 7437 Natural ventilation of parking garages : dimensioning of ventilation units with the assistance of air flow models.

AUTHOR Kornaat W, Lemaire A D.

BIBINF UK, Air Infiltration Review, Vol 15, No2, 1994, (preprint), 9 pp, 6 figs, 8 refs. #DATE 00:00:1994 in English

ABSTRACT Parking garages require ventilation because the exhaust fumes produced by the vehicles have to be discharged. This can be achieved with a mechanical or a natural ventilation system. A natural ventilation system has several important advantages compared with a mechanical system. As a rule natural ventilation systems are simpler, cheaper and have fewer breakdowns, furthermore a natural system requires less maintenance and uses no energy (for air transfer). For the dimensioning of the necessary ventilation units in a parking garage, the calculating regulations (for The Netherlands) are given in NPR 2443 "parkergarages" [1]. Recently the department of indoor environment, building physics and systems of TNO Building and Construction Research has carried out further investigations regarding naturally ventilated parking garages. Using a multi cell ventilation model [2] research has been carried out to check if enough natural ventilation can be maintained, while the regulations according to NPR 2443 are not precisely taken into account. In this article one of these investigations [3] will be discussed. This concerns an investigation by which also the airflow (concentration distribution) is investigated with a so called CFD-Model [4], which stands for Computational Fluid Dynamics.

KEYWORDS natural ventilation, garage, air flow, modelling.

#NO 7703 Occupant Controlled residential ventilation.

AUTHOR Alevantis L E, Girman J R

BIBINF Indoor Air Quality 89 conference, pp 189-191. #DATE 00:00:1989 in English

ABSTRACT The effects of opening windows on the ventilation rates of two detached houses and a two-storey condominium were studied. The scenarios studied under various wind conditions included, when possible, opening windows on the windward side, the leeward side, both the windward and leeward sides, and on the two other sides not in the direction of the prevailing wind. Two window settings, either three inches or wide open, were employed in each scenario. In some cases, opening windows increased ventilation by as little as 20%, while in other cases residential ventilation rates were increased by as much as 11 times the original rate. Use of a kitchen range hood nearly doubled the ventilation rate in two residences. While opening the main garage door increased garage ventilation rates from as little as 4 times to as much as 25 times the initial rate.

KEYWORDS occupant control, window opening, exhaust hood

#NO 7713 Natural ventilation with heat recovery.

Naturlig ventilation med varmegenvinding

AUTHOR Schultz J M

BIBINF Denmark, Danmarks Tekniske Hojskole, Laboratoriet for Varmeisolering, Meddelelse nr. 249, December 1993, 66 pp, 106 refs #DATE 00:12:1993 in Danish

ABSTRACT The aim of the project Natural ventilation with heat recovery was to investigate the possibilities of utilizing the stack effect (caused by the difference between indoor and outdoor temperature) for ventilation of dwellings with a certain degree of heat recovery on the exhaust air. In this report the theory for calculation of the temperature driven pressure difference is treated, as well as the theory for calculation of the efficiency of stack effect heat recovery unit. The theoretical expressions have been implemented in a specially developed computer program with the emphasis on the simulation of the performance of the heat recovery system. The computer program has been used for parameter analyses of the influence of temperature difference, duct size and shape, duct length and material etc on the recovery efficiency and air flow through the system. Based on the results from the parameter analyses, a prototype of stack effect driven heat recovery unit was conducted and tested at the Thermal Insulation Laboratory (TIL). The unit was designed for the installed in a low energy experimental house on the campus, and the air flow and temperature efficiency was measured at different indoor to outdoor temperature differences in the range 10-30K. The investigation shows that it is possible to obtain satisfactory heat recovery in a stack effect driven system. However, for practical use, further knowledge on the air flow patterns in the heat recovery unit and further optimization of the system is needed. Also the design of the prototype focused on demonstrating and monitoring the principle - a design for general use must also address issue as air flow control, draft in the room, condensation in the unit, installation of the unit and cleaning of the ducts.

KEYWORDS natural ventilation, heat recovery

#NO 7879 The theory of plumes adapted to model air movement in naturally ventilated buildings.

AUTHOR Cooper P

BIBINF Belgium, International Building Performance Simulation Association, (IBPSA), 1993, proceedings of "Building Simulation '93", 3rd International IBPSA Conference, Edited by A E Delsante, J W Mitchell, R C van de Perre, held August 16-18, 1993, Adelaide, Australia, pp 443-448. #DATE 00:08:1993 in English

ABSTRACT This paper describes ongoing research toward the development of simplified techniques for the prediction of air movement in large, naturally ventilated spaces containing hot and/or cold surfaces. The situation where two distinct sources of heat are present on the floor of a naturally ventilated room is discussed. Thermal stratification develops such that two layers of warm air form above a lower layer of ambient temperature. The heights and temperatures of these layers are predicted

using forced plume theory, i.e. where a plume is initiated from a source of buoyancy with finite mass and momentum flux). Interface heights are found to depend on room height ventilation opening size and on the ratio of the heat fluxes from the two sources. The intensities of the heat sources have no influence on interface heights. A theoretical and experimental investigation of a naturally ventilated enclosure containing both positive and negative sources of buoyancy is also presented. Large glazed spaces such as atria exhibit significant thermal stratification due to radiative heating of internal surfaces. The possibility of extending the plume analysis for isolated sources of buoyancy in a space to that where the sources of buoyancy are distributed is discussed.

KEYWORDS air movement, natural ventilation

#NO 7946 Cross ventilation and room partitions: wind tunnel experiments on indoor airflow distribution

AUTHOR Cao Q, He X G

BIBINF USA, ASHRAE Transactions, Vol 100, Pt 2, 1994, (preprint), 12pp, 13 figs, refs. #DATE 00:00:1994 in English

ABSTRACT Environmental concerns and escalating energy costs are creating a demand for proper use of natural ventilation to provide thermal comfort. This paper presents the results of wind tunnel experiments studying the effect of interior partitions on natural cross-ventilation by directly measuring air velocity and turbulence distributions inside a building model. The results demonstrate that manipulating the configuration of internal partitions as a less expensive alternative to many other architectural configurations can significantly modify the effect of cross ventilation and thermal comfort conditions. Particularly compared to traditional solid-wall configurations, open-plan configurations with low partitions improve internal airflow distribution and occupants thermal comfort inside a naturally ventilated building in a hot climate

KEYWORDS cross ventilation, wind tunnel, air flow

#NO 7952 Efficiency of ventilation in office buildings.

AUTHOR Walker R R, White M K, Kaleem R, Bergsøe N C

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 1-12.

ABSTRACT Inadequate ventilation is often cited as the cause of unhealthy air quality within office buildings, whilst excessive ventilation is similarly assumed to be the cause of discomfort and energy waste. However, the reality is that very little data is available to assess the significance of these problems on any large scale. The perfluorocarbon tracer (PFT) technique offers the potential for overcoming the problems of applying conventional tracer techniques to large or multi-roomed buildings. Methodologies are described for its applica-

tion to measure ventilation in a selection of different office building types, based on the concept of homogeneous tracer gas emission. Local ventilation rates are measured in a multicell office building, with both mechanical and natural ventilation. These illustrate the distribution of ventilation and highlight implications for air quality and energy efficiency. A multicell computer model is used to validate the field protocol and to compare predictions with measured results. A simplified PFT measurement system based on standard commercial equipment is described, to encourage wider use of the method.

KEYWORDS (office building, health, human comfort, tracer gas)

#NO 7954 Case studies of passive stack ventilation systems in occupied dwellings.

AUTHOR Parkins L

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 25-34.

ABSTRACT A possible alternative to mechanical extract ventilation for kitchens and bathrooms is passive stack ventilation (PSV). BRE has carried out work on this type of system in a test house under controlled conditions. To find out how well they worked in practice, four occupied dwellings were monitored over a period of 2-3 weeks each. Each dwelling had two ventilation ducts. Air flow rates within the ventilation ducts were measured, together with humidities, temperatures and climatological data. The results show that the risk of problems due to condensation can be reduced by the use of this type of ventilation system. The systems were found to have been poorly installed and where possible the faults were corrected as part of the study. Nevertheless the systems successfully kept down moisture levels below 70% RH for all but a small proportion of the time. The design and performance of the systems is discussed and advice given on how these could be improved. This study demonstrates the need for clear and simple guidance on PSV systems to enable them to work.

KEYWORDS (mechanical ventilation, kitchen, bathroom, duct, humidity, moisture)

#NO 7955 Passive ventilators in New Zealand homes: Part 1: numerical studies and Part 2: experimental trials.

AUTHOR Bassett M R

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 35-56.

ABSTRACT New Zealand homes have traditionally been ventilated through open windows and by background infiltration. In recent times, new materials and construction practices have led to more airtight buildings, and open windows are seen more and more as a

security risk. These trends call for new ventilation options that are inexpensive and consistent with home security, weathertightness and draught control. This paper is part one of a study of passive ventilation options for NZ homes. It explores numerically a range of ventilator sizes and locations in typical homes modelled in the climate of major New Zealand cities. Part two offers experimental verification of the ventilator performance data calculated here. A numerical multi-zone air flow model was used to calculate the effect of adding stack and window type passive vents to houses of a range of airtightness levels. Wind pressure was found to be the dominant driving force of air flows delivered by window-mounted passive ventilators. Stack ventilators reduced the strong dependence of window ventilator air flows on wind speed when both types were present in a building, but when the ventilation system made small changes to the overall airtightness of the house, the role of the stack ventilator was less obvious. A simple linear function linking ventilator opening area with average added ventilation rate is presented for wall-mounted passive ventilator systems in NZ buildings. The second paper is part two of a study of passive ventilation options for NZ homes. The first part explored numerically, a range of ventilator sizes and locations in typical homes modelled in the climate and wind conditions of urban New Zealand. This paper offers experimental verification of the ventilator performance data calculated earlier. Passive ventilators were installed in the window systems of three houses in Wellington. Airtightness characteristics and wind speeds were measured and used to predict ventilation rates for "vents open" and "vents closed" conditions. These predictions compared favourably with ventilation rates measured with an automated tracer gas dilution method, offering support for earlier numerical determination of passive ventilator performance. A simple linear function linking ventilator open area with average ventilation performance has been supported.

KEYWORDS (residential building, passive ventilation, numerical modelling, air tightness)

#NO 7956 Ventilation by the windows in classrooms: a case study.

AUTHOR Richalet V, Beheregaray B, Guarracino G, Dormier C, Janvier L

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 57-66.

ABSTRACT Four classrooms of two secondary schools located around Lyon in France have been monitored. The objectives are to analyse the quality of the indoor air and the thermal comfort and also the behaviour of the occupants towards opening of windows. This paper briefly describes the context and the nature of the monitoring campaign, and presents the results of the measurements with direct interpretation of the ventilation needs. Then, we try to make a statistical analysis of the

influencing factors that lead to the opening of windows, but our study is limited because of the small number of collected data.

ABSTRACT Results from this study show that allowable CO₂ levels are overpassed several times in a school day. The presence of a mechanical ventilation system leads to lower peaks but the fresh airflow is too small to prevent an indoor confining, that is also revealed by the aerobiological analysis. These measurements confirm a certain ill-being of the surveyed people, not in relation with thermal comfort. This feeling leads people to open windows provided that outdoor conditions are favourable (temperature, wind speed, noise, outside odours,...)

KEYWORDS (window, school, ventilation system, occupant behaviour)

#NO 7957 Single-sided ventilation: a comparison of the measured air change rates with tracer gas and with the heat balance approach.

AUTHOR Ducarme D, Vandaele L, Wouters P

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 67-76.

ABSTRACT In the frame of the European PASCOOL project, several experiments regarding single sided ventilation were carried out at BBRI in the outdoor PASSYS test cell. The test room of 30m³ has a vertical window of about 1m². During a first measurement period, an open cold box, which allows one to control the vertical wind speed, was placed in front of this window. During a second measurement period, the window was directly exposed to "real wind". The air change rates were evaluated by using two different methods: a tracer gas technique and the heat balance approach. The heat balance approach is very attractive in this test cell because the heat flow through the cell envelope can be accurately determined thanks to the Pseudo-Adiabatic-Shell. The tracer gas measurement is made difficult because a clear air flow pattern appears and accordingly, the concentration in the room is not homogenous. An error analysis has been applied on both methods. The agreement between both methods is very good and the heat balance approach proved to be more accurate than the tracer gas technique. A correlation model was derived from the first measurement period.

KEYWORDS (air change rate, tracer gas, thermal performance)

#NO 7958 Natural ventilation through a single opening - the effects of headwind.

AUTHOR Davies G M J, Holmes M J

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 77-92.

ABSTRACT The airflow between a warm room and cool exterior can be significantly affected by an external

headwind. Pollutant concentrations within the space depend on the relative sizes of the wind and the undisturbed stack driven flow. Two scenarios are described. Firstly, a space is filled initially with buoyant polluted air. The space is then naturally ventilated through a single opening. In the "no wind" case, a gravity current of external air flows into space. All the polluted air is expelled from the room. At high wind speeds the turbulence associated with the headwind produces mixing just inside the doorway. Under some conditions, ventilation levels are reduced. The second scenario considered is the natural ventilation of a space containing a continuous source of buoyant pollutant. For weak headwinds, fresh external air flows into the room and the pollutant concentration in that lower layer remains close to zero. High headwind speeds again generate doorway mixing. Air flowing into the space becomes contaminated with pollutant. These flows were studied experimentally using small-scale saline modelling techniques. Simple mathematical models are presented which agree closely with the experimental results. In both the transient and continuous cases, an increase in the headwind could lead to reduction in ventilation and an increase in internal pollutant levels. Natural ventilation through a single opening is not necessarily enhanced by wind.

KEYWORDS (natural ventilation, openings, wind effects, air flow, turbulence)

#NO 7959 Investigation of ventilation conditions in naturally ventilated single family houses.

AUTHOR Bergsoe N C

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 93-100.

ABSTRACT The reason for the present project is the need for more reliable information about the actual ventilation conditions in naturally ventilated, detached houses. The aim has been to quantify the ventilation and humidity conditions and to establish a better basis for elaborating directions and guidelines on proper ventilation of detached houses. A national questionnaire survey covering more than 2100 households has been carried out, together with detailed investigations in about 150 houses. The investigations comprised measurements of the average outdoor air supply and the average relative humidity. The main bedroom was investigated separately. The measurements were performed during the heating period. Passive measurement techniques were used. Results show that the air change rate on average is about 0.35 h⁻¹. In more than 80 per cent of the houses the air change rate is lower than the recommended rate of 0.5h⁻¹. The relative humidity is on average 0.45 in the living-room and 0.53 in the bedroom.

KEYWORDS (natural ventilation, humidity, questionnaire, residential building, measurement technique)

#NO 7963 The role of infiltration for indoor air quality

AUTHOR Baranowski A

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 133-140.

ABSTRACT Multifamily buildings with natural ventilation are still being built and exploited. Such buildings are often equipped with individual gas-fired water heaters located in windowless bathrooms. It implicates the possibilities of improper gas exhaust as a result of the decrease of infiltration, what could be sometimes even harmful for the occupants' health. Based on the numerical simulations, analysis of ventilating air flows in typical multifamily dwelling house will be carried out. It will be shown that effectiveness of natural ventilation in particular flats depends not only on the active factors determining infiltration phenomenon (like wind and temperature difference) but is also strongly connected with flat location inside the complex structure of a building.

KEYWORDS (infiltration, indoor air quality, natural ventilation, combustion product, numerical simulation)

#NO 7983 Improvement of domestic ventilation systems.

AUTHOR Heikkinen J, Pallari M-L

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 333-342.

ABSTRACT The aim of the study was to identify methods for the renovation of ventilation systems in domestic buildings which are 3-8 storeys high. Three typical buildings were selected and the problems in ventilation were examined. The designers made their proposals for repairs and the research team analyzed the solutions and made improvements. The special problems compared with new buildings included less airtight building envelopes and leakages in existing ventilation ducts. An analysis was performed, using a multi-zone airflow model, for the whole year and therefore the ventilation heat loss could be found in each case. As anticipated, the airflow rate of passive stack ventilation was too high in winter and too low in summer, but the system can be improved by means of controlled air inlets and outlets. A mechanical extraction system can be improved with demand-controlled ventilation instead of time control. The installation of heat recovery system requires improved sealing of the building envelope to minimize cross ventilation. The proposed systems will be tested and followed up later in experimental buildings.

KEYWORDS (ventilation system, high rise building, building envelope, duct)

#NO 7987 The testing and rating of terminals used on ventilation systems.

AUTHOR Welsh P

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 1, pp 371-380.

ABSTRACT Terminals are used on all types of ventilation system exhausts, often to prevent rain water and animal entry, but also to prevent wind induced flow-reversal and enhance wind induced updraught. There are many different terminal designs available displaying a wide range of characteristics. This report discusses a terminal testing and rating method. The tests highlight terminal wind performance as well as terminal resistance to the exhaust flow. The terminals are ranked according to loss coefficients and wind performance which allows them to be matched more closely to system requirements. Whilst the data gathered here can help with the choice of terminal for any ventilation system, it is probably most applicable to those systems affected by the wind. Such systems include passive stack ventilation, passive gas extraction, combustion flues and chimneys. This paper is intended as a test guide for manufacturers and a source of information to help system designers with terminal selection.

KEYWORDS (ventilation systems, wind effects)

#NO 7991 Passive stack ventilation.

AUTHOR Palmer J, Parkins L, Shaw P, Watkins R
BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 411-420.

ABSTRACT The adequate ventilation of houses is essential for both the occupants and the building fabric. As air-tightness standards increase, background infiltration levels decrease and extra ventilation has to be designed into the building. Passive stack ventilation has many advantages - particularly when employed in low cost housing schemes - but it is essential that it performs satisfactorily. This paper gives the results from monitoring two passive stack ventilation schemes. One scheme was a retrofit into refurbishing local authority houses in which a package of energy efficient measures had been taken and condensation had been a problem. The other series of tests were conducted on a new installation in a Housing Association development. Nine houses were monitored each of which had at least two passive vents. Measurements were taken over periods of three weeks in each dwelling and included; wind speed and direction, internal and external temperatures, humidity, and air velocity in the ventilation duct. The data were recorded every quarter hour. The results show air flow rates by the passive ducts equivalent to approximately 1 room air change per hour. The air flow in the ducts was influenced by both, internal to external temperature difference and wind speed and direction. An important finding was the need to site the vents in the correct location. In those houses where the vents were installed on the roof slope facing the prevailing wind, a location not recommended in current guidance,

the air flow was in the reverse direction for the majority of the time due to the design of the terminal. However, in those houses with correctly sited vent terminals of recommended design, reverse flow was negligible.

KEYWORDS (passive ventilation, stack effect, building material, condensation, refurbishment, duct)

#NO 7992 Comparing predicted and measured passive stack ventilation rates.

AUTHOR Cripps A, Hartless R

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 421-430.

ABSTRACT BRE have experimental data for the flows found in Passive Stack Ventilation (PSV) ducts from a test house in Garston. These data cover different duct diameters, number of bends and roof terminals,, all measured over a variety of weather conditions. In the first part of this paper the data are analyzed to separate temperature and wind effects, and to see how well they fit well to the expected model of duct flow. The second part gives a comparison of the same data with predictions from the single zone ventilation model BRE-VENT. Extensive research at BRE has improved the modelling of PSV ducts within this computer model, and this new information was used to try to calculate the flows in the duct for the measured weather conditions. The results show good correlation between the predicted and measured duct flow velocities. Care was needed in identifying the effective volume of the building to give this good result. More work is needed on the interaction between PSV flow elements and whether using a multi-zone would give better results.

KEYWORDS (stack effect, ventilation rate, duct, air flow)

#NO 7993 Ventilation air flow through window openings in combination with shading devices.

AUTHOR Pitts A C, Georgiadis S

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 431-440.

ABSTRACT In the UK the increased use of natural ventilation in buildings is being encouraged, particularly during hot weather as an alternative to air conditioning or mechanical ventilation. In order to take advantage of this option building designers need to be able to estimate potential air flows. Conventional calculation methods assume windows to be simple openings, however in practice the situation is more complex since during hot weather the opening is likely to be shielded by some form of solar shading device. This paper reports the results of a laboratory based investigation of the pressure difference-flow relationship for air movement through windows when a venetian blind is also in position. A variety of window opening variations and blind angles have been tested. The results indicate a signifi-

cant reduction in air flow when blinds are in use in the closed position (angle 85 degrees); the results for partially closed position (45 degrees) show little reduction in flow. The form of the window opening also has an important effect. Care must therefore be taken in setting blind angles so as to avoid reducing beneficial natural ventilation air flow whilst maintaining shading.

KEYWORDS (air flow, window, openings, shade, air movement, blind)

#NO 7995 A study of various passive stack ventilation systems in a test house.

AUTHOR Parkins L M

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 445-454.

ABSTRACT The Building Research Establishment has set up various passive stack ventilation systems (PSV) in a test house in order to assess their performance. The test house used was a two storey, end terrace dwelling on the BRE site at Garston. A PSV was installed in the kitchen of the test dwelling. The duct material, diameter and configuration were varied to determine any differences that they would make to the air flow rates obtained in the duct. In addition, three different ridge terminals were tested and three ceiling inlets. Air flow rates and temperature in the duct were recorded, together with internal and external temperatures and wind speed and direction. Each system was monitored over several weeks to obtain a spread of climatic data. Comparisons have been made of the results obtained from each system. Regression analysis has been carried out and predictions of flow rate up the stack, for a typical temperature difference and wind speed, are given for each PSV system.

KEYWORDS (stack effect, test house, duct, roof)

#NO 7996 A review of weather data for natural ventilation.

AUTHOR Arif M J M, Levermore G L

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 455-464.

ABSTRACT This paper briefly reviews the weather data available for natural ventilation and briefly reviews hourly data for simulation. It starts by reviewing the need for basic data for initial manual calculations. It then discusses the hourly weather data available for example the UK CIBSE Example Weather Years, and the European Community Test Reference Years. These are mostly selected for energy analyses rather than design, but there is still a need for establishing general criteria for weather data for design of HVAC services and natural ventilation. The paper examines weather data for summer conditions and the need to consider solar radiation as well as outside/inside temperatures and wind speed and direction for natural ventilation. A

simulation of a typical building is used to demonstrate the importance of solar radiation.

KEYWORDS (natural ventilation, weather, calculation techniques)

#NO 8000 Two-zones model for predicting passive stack ventilation in multi-storey dwellings.

AUTHOR Villenave J G, Millet J-R, Riberon J

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 509-516.

ABSTRACT Proper dimensioning of natural ventilation system for multi-storey buildings is a critical matter, because the air flow rate depends on many parameters as outdoor temperature, wind distribution of air inlets and envelope air leakage, characteristics of outlets and cowl. The computer code GAINÉ BIZONE predicts the ventilation rates in multi-storey dwellings equipped with passive stack ventilation system. Each level is treated as a two-zones configuration, but each zone is linked to the collective ventilation shaft of the building. The model calculates the pressures in every zone of the building and the ducts, using iterative method to balance the mass flows in and out of each zone. One of both zones represents the kitchen, the other one the rest of the dwelling including the bathroom and the toilets. The kitchen door that links the both zones is represented by an internal transfer opening. The model takes into account the common cowls used to avoid reverse flow, but also the cowls with motorised device. The latter are very useful, especially to achieve the peak flow rate when cooking or when the stack effect is insufficient because of moderate wind and outdoor temperature. In addition, the model makes it possible to treat a gas appliance linked to the exhaust duct of the kitchen. The basic modelling method used is known as the 'ping-pong' method because the two-zones model combines two models which are called in turn. In the first step, the ventilation rates are calculated in a stack of storeys representing a part of dwellings, then for the other part. The both models are called in turn until that, for each dwelling, the exchanged flow rate between the two zones are balanced. Examples of applications conducted with the two-zones model are presented in this paper.

KEYWORDS (stack effect, residential building, modelling, natural ventilation)

#NO 8024 Natural ventilation strategies to mitigate passive smoking in homes.

AUTHOR Kolokotroni M, Perera MDAES

BIBINF UK, Air Infiltration and Ventilation Centre, 1994, "The Role of Ventilation", proceedings of 15th AIVC Conference, held Buxton, UK, 27-30 September 1994, Volume 2, pp 759-770.

ABSTRACT This paper investigates possible natural ventilation strategies to reduce exposure to environmental tobacco smoke (ETS) in dwellings. Particular attention is paid to the migration of tobacco smoke from

the living room (usually the smoking room) to the bedrooms which may be occupied by children. This addresses an area of current concern regarding the possible association between passive smoking and adverse health conditions; in particular the link between parental smoking and respiratory illness in children. The study used the multizoned airflow prediction program BREEZE to evaluate the movement of tobacco smoke from the smoking rooms to the bedrooms in typical detached, semi-detached and terraced dwellings for a variety of natural ventilation strategies. Typical smoking patterns were emulated and contaminant movements analysed, taking into account factors such as wind speeds and direction and air temperatures. Some of the results obtained were compared with limited full-scale measurements acquired elsewhere to provide the necessary confidence in the predictions. Controlling pollutant concentration by ventilation can be an energy intensive process, especially during the heating and cooling season. Since almost all dwellings in the U.K. are naturally ventilated, providing optimum ventilation with minimum ventilation heat loss is of concern only during the heating season. Results from the study indicate three possible strategies to mitigate the effect of passive smoking in dwellings; two which could be used during the heating season and one for the remaining times of the year.

KEYWORDS (natural ventilation, passive smoking, residential building, respiratory illness)

#NO 8176 Naturally-ventilated and mixed-mode office buildings: opportunities and pitfalls.

AUTHOR Bordass W T, Entwisle M J, Willis S T P
BIBINF UK, CIBSE (Chartered Inst of Building Services Engineers), 1994, proceedings of CIBSE National Conference 1994, held Brighton Conference Centre, 2-4 October 1994, Volume 2, pp 26-30.

ABSTRACT General conclusions from case studies of occupied offices designed to minimise or avoid air-conditioning are outlined. While many buildings performed reasonably well, some issues repeatedly caused difficulty in practice, and require some more careful attention at the design stage. They include: design, performance, and control of windows - utilisation of mass - performance, control and energy efficiency of passive cooling - automatic control of lights and blinds - control and management generally.

KEYWORDS (natural ventilation, office building, blind)

#NO 8181 Ventilation of office buildings: deciding the appropriate system.

AUTHOR Leaman A J, Cohen R R, Jackman P J
BIBINF UK, CIBSE (Chartered Inst of Building Services Engineers), 1994, proceedings of CIBSE National Conference 1994, held Brighton Conference Centre, 2-4 October 1994, Volume 2, pp 90-101.

ABSTRACT The main purpose of this paper is to help potential owners and occupiers of buildings understand the advantages and disadvantages of different types of ventilation systems, and assist designers to help their clients make informed choices. We attempt to give a realistic picture of the main strategic issues involved taking into account the perspectives of both designer and client. These perspectives will almost certainly change from one situation to the next. Sometimes the client's priorities will take precedence over purely technical, design or environmental criteria. This paper focuses on office buildings though many of the principles outlined may be applied to other non-domestic building types.

KEYWORDS (office building, ventilation system)

#NO 8182 Theory and practice - natural ventilation modelling.

AUTHOR Edwards M, Linden P, Walker R R
BIBINF UK, CIBSE (Chartered Inst of Building Services Engineers), 1994, proceedings of CIBSE National Conference 1994, held Brighton Conference Centre, 2-4 October 1994, Volume 2, pp 102-108.

ABSTRACT A case history is given for a building where natural ventilation was modelled at design stage and subsequently tested to verify the model and the design assumptions. The paper describes the building; the natural ventilation modelling; saline modelling - techniques of scaling, air temperature and ventilation rates and performance predictions; the testing of the performance of natural ventilation; recommendations to practising building service engineers considering using natural ventilation and natural ventilation modelling.

KEYWORDS (natural ventilation, modelling)

#NO 8184 The design of a naturally ventilated cultural centre in French New Caledonia.

AUTHOR Chown M, Guthrie A
BIBINF UK, CIBSE (Chartered Inst of Building Services Engineers), 1994, proceedings of CIBSE National Conference 1994, held Brighton Conference Centre, 2-4 October 1994, Volume 2, pp 121-133.

ABSTRACT The paper describes the analysis undertaken to verify the performance under conditions of natural ventilation of a new cultural centre in French New Caledonia. The performance was defined as the percentage of time internal conditions fell outside the comfort boundaries as defined by Gagge and Fanger. The client brief required that the maximum number of occasions conditions could fall outside comfort conditions should not exceed a maximum of 5% during any month. Wind tunnel tests and environmental computer analysis of the building were carried out to simulate internal conditions using hourly weather data and the subsequent results used to optimise the design of the building.

KEYWORDS (natural ventilation, public building, wind tunnel)

Natural Ventilation Bibliography Update March 1998

#NO 8291 Chilled beams provide perpetual cooling

AUTHOR Brister A.

BIBINF UK, Building Services, January 1995, pp 17-20.

ABSTRACT Describes the mixed-mode approach to cooling used in a new office building in Henley on Thames, UK with design limited by the necessity of fitting into the existing design of the town. The mixed mode approach means that natural ventilation is sufficient for most of the year, with closed windows and comfort cooling only taking over during hot summer spells.

KEYWORDS cooling, thermal comfort, energy saving

#NO 8302 Investigation of air backflow conditions: case study of multifamily dwelling houses

AUTHOR Nantka M B, Baranowski A

BIBINF Poland, Silesian Technical University, 1994, proceedings of Roomvent '94: Air Distribution in Rooms, Fourth International Conference, held Krakow, Poland, June 15-17, 1994, Volume 1, pp 165-172.

ABSTRACT There are still built and used many multifamily buildings with natural ventilation, so-called window ventilation. Such buildings are usually equipped with hot water systems. Gas heaters are placed in windowless bathrooms with ventilation and waste gas ducts. This paper presents the results of measurements in existing buildings and effects of computer simulation achieved by means of improved mathematical model. The range of air backflow conditions is determined, based on comparison of these results.

KEYWORDS natural ventilation, window, mathematical modelling

#NO 8365 Description and analysis of single side ventilation experiments

AUTHOR Agiriou A, Asimakopoulos D N, Dascalaki E, et al

BIBINF France, Ecole Nationale des Travaux Publics de l'Etat, November 1994, proceedings of the European Conference on Energy Performance and Indoor Climate in Buildings, held Lyon, France, 24-26 November 1994, Vol 1, pp220-225.

ABSTRACT Single-sided ventilation experiments have recently been held in Athens, Greece, within the frame of the CEC Research Programme, PASCOOL. The aim of the experiments was to study single-sided ventilation efficiency, using a single tracer gas decay technique. The experiments were held in a naturally ventilated office room at the National Observatory building and in a Test Cell facility, during the summer of 1993. A total of twenty four different opening configurations were studied under various climatic conditions. Experimental results are compared against predictions from existing models. Resulting relations of the discharge coefficient to geometrical and climatic parameters, specifically, indoor-outdoor temperature difference and wind speed are presented. Additionally, the relative importance of the buoyancy and wind effects to the single-sided ventilation efficiency is investigated.

KEYWORDS tracer gas, ventilation system, decay rate, natural ventilation, wind effects, ventilation efficiency

#NO 8388 Natural and innovating heating and ventilating systems applied to buildings in rural and isolated areas

AUTHOR Kamal Gohar M, Mohamed F A.

BIBINF France, Ecole Nationale des Travaux Publics de l'Etat, November 1994, proceedings of the European Conference on Energy Performance and Indoor Climate in

Buildings, held Lyon, France, 24-26 November 1994, Vol 2, pp610-615.

ABSTRACT This paper describes methods that could be applied conveniently in rural and isolated areas to achieve comfort living with low cost efficient passive energy system, using simple devices. Some study cases and test results are presented here to illustrate: i) The essentials of town building planning together with the proper building clusters, arrangements, window design...etc to make the best use of the natural daylight, ventilation and solar energy for different types of building. ii) The advantages of using shrubs and trees to improve the climate conditions and other architectural applications in the site under consideration. Examples of selecting the suitable types and dimensions of window, trees and building arrangement for different applications are shown in this paper; which may be taken as a guide to be followed when studying other similar cases.

KEYWORDS daylighting, passive solar design, natural ventilation, shading

#NO 8395 A project for a solar passive building in Venice

AUTHOR Rossi Prof I G, Bevilacqua G, Ficcadori I, Pancaldi P.

BIBINF France, Ecole Nationale des Travaux Publics de l'Etat, November 1994, proceedings of the European Conference on Energy Performance and Indoor Climate in Buildings, held Lyon, France, 24-26 November 1994, Vol 2, pp729-734.

ABSTRACT Our aim is the appropriate integration between the solar passive techniques and the peculiar features of the traditional architecture. We have designed the building on the waterside keeping in mind the timeless principles of the venetian architecture: tripartition, great openings for daylight and ventilation, internal courtyard. We think this is the best attitude to obtain integration with passive solar strategies giving a new meaning to the building. Appropriate sunshading devices are displayed to control both external and internal heat gains. In this way it is possible to avoid overheating and reduce energy consumption. Our target is to increase the user's comfort lowering the energy expense. Natural ventilation is the only suitable cooling strategy we can use because of the venetian climate, which is warm and humid during the summer. The ventilation through the building is enhanced by the aerodynamic shading-cover which conveys the wind into courtyard. This space may be used as a public meeting place. When the wind is calm, the building ventilation is assured by solar chimneys: these chimneys, using stack effect, are able to ventilate the building even if the windows are closed to prevent overheating. On the south the large glazed surface is shaded by light shelves which distribute daylight in the room without any interference with the view of the surroundings.

KEYWORDS passive solar building, building design, shade

#NO 8461 Analysis of indoor ventilation rates through the technical evaluation of frames. Analisi del regime di circolazione dei flussi d'aria all'interno dell'unità ambientale attraverso la valutazione dell'elemento tecnico in fessura.

AUTHOR Fiore V, Viola S

BIBINF Italy, proceedings of Healthy Indoor Air '94, held Anacapri, Italy, 6-8 October 1994, pp 45-49.

ABSTRACT According to the theses that natural ventilation can be considered as one of the techniques for reducing indoor air pollution, the paper aims to show the role played

by frames - as elements of outside vertical lock for interiors spaces-toward air fluxes' trend. Choosing traditional frames -with two shutters opening by rotation around vertical axes-as specific objects of observation, the study has been based on the definition of a relationship of direct dependence between technical solutions adopted for traditional frames and indoor air circulation systems. In this way, the study has been organised in two phases: analysis of traditional frames, evaluation of their influence on natural ventilation. While in the first phase, the exam of handle-able devices and of context's elements has lead to the definition of all the factors influencing natural ventilation and of regulability indicators, in the second phase the role played by each factor in air circulation systems has been considered.

KEYWORDS ventilation rate, natural ventilation, window

#NO 8511 Controlled ventilation windows

AUTHOR Van Paassen A H C, Lute P J

BIBINF UK, James and James, 1994, European Directory of Energy Efficient Building, 1994, pp 56-59, 3 figs, 2 refs.

ABSTRACT This article describes a system which maintains heating, ventilation and cooling by controlling motors fitted to the air-conditioning unit or radiator, the ventilation openings in the window and the outside shading device. The room controller controls this system such that comfort is obtained with the lowest energy consumption by giving priority to heating with solar radiation and cooling with natural ventilation. The following aspects are discussed: the characteristics of natural ventilation, and the way it can be controlled with motorized windows; The reduction in energy consumption. With computer simulations it has been demonstrated that, in climates similar to that of the Netherlands, controlled windows can save a lot of energy. For example, in buildings with 40% window area, heavy internal walls and internal loads lower than 20W/m², mechanical cooling can be avoided with this system. In other cases an appropriate combination of controlled natural ventilation and mechanical cooling leads to an enormous reduction in energy consumption. It can be reduced to 20% of the amount that is normally required in buildings with closed facades. Another advantage is that cooling units with a 50% smaller capacity can be installed. The system is being tested in an office building.

KEYWORDS Controlled ventilation, window, shade.

#NO 8547 Which ventilation system?

AUTHOR Leaman A, Cohen R, Jackman P J J

BIBINF UK, Building Services, February 1995, pp 37-39, 1 tab, 6 refs.

ABSTRACT Discusses the difficulty of making an informal choice from the many different types of ventilation systems available. Ventilation is a vital part of a building's operation, and also interacts with many other aspects such as energy performance and comfort; thus it is essential that the choice of ventilation system is considered early in the design process. There are essentially four methods of ventilation available to client and designers - full air conditioning, mechanical ventilation, natural ventilation and mixed-mode ventilation.

KEYWORDS ventilation system, occupant reaction, health, workplace.

#NO 8549 Performance and feasibility of passive climate systems

AUTHOR Van Paassen A H C, Lute P J

BIBINF UK, paper from Clima 2000, London, 1993, 10 pp, 5 figs, refs.

ABSTRACT A so-called passive climate system is devised setting the level of heating and ventilation by controlling motors fitted to radiators, ventilation openings in windows, Venetian blinds and outside shading. Moreover, it will switch on the lighting when natural lighting is inadequate. The system comprises a weather station on the roof, a network of sensors and controllers in each room hooked up to a central computer. The room controllers can be overridden manually by the occupants. With computer

simulations it has been demonstrated that though air cooling with opened windows and predictive control a comfortable indoor climate can be realized year round, provided that the internal load lies between 15 and 20 W/m². Higher loads require additional mechanical cooling. A proper combination of controlled natural ventilation and mechanical cooling leads to an enormous reduction in energy consumption. The ability to remove internal heat and the costs of the passive climate system are compared with that of more conventional systems.

KEYWORDS passive ventilation, thermal performance, shade.

#NO 8700 Design Studies for an environmentally-sound office building.

AUTHOR Harris D J, Burch J, Haqjoo D, Harrison P.

BIBINF UK, Building Research Establishment, proceedings of the first international conference on Buildings and the Environment, 16-20 May 1994. Session: Case Study Buildings, Paper 10, 8 pp., 4 figs. 1 tab, 4 refs.

ABSTRACT Three designs for an environmentally-sound office building on a given site are presented, illustrating contrasting approaches to the task. At one extreme is a highly-insulated building with relatively small windows and natural ventilation, and at the other, a double-skin glass box with low insulation levels, mechanical ventilation with heat recovery, and sophisticated electronic controls; an intermediate approach includes an atrium on an east-west axis, trombe walls and a mixture of automatic and manual controls. The designs are described in detail and the energy consumption is analysed. So long as the relevant issues are addressed, both high-technology and more traditional approaches to building design are capable of providing valid solutions with respect to minimising the overall environmental impact.

KEYWORDS office building, building design, retrofitting.

#NO 8873 Predicting single side natural ventilation rates in buildings

AUTHOR Dascalaki E, Santamouris M, Argiriou A, Helms C, Asimakopoulos K, Papadopoulos K, Soilemes A.

BIBINF Canada, proceedings Indoor Air Quality, Ventilation and Energy Conservation in Buildings, Second International Conference, held May 9-12, 1995, Montreal, edited by Fariborz Haghighat, Volume I, pp401-408.

ABSTRACT Single-sided ventilation experiments have recently been held in Athens, Greece, within the frame of the CEC Research Programme, PASCOOL (1). The aim of the experiments was to study single-sided ventilation efficiency, using a single tracer gas decay technique. The experiments were held in a naturally ventilated office room at the National Observatory building during the summer of 1993. A total of nineteen different configurations were studied under various climatic conditions. Experimental results are compared against predictions from existing network ventilation models. Resulting relations of the discharge coefficient to geometrical and climatic parameters, specifically, indoor-outdoor temperature difference and wind speed are presented. Additionally the relative importance of the buoyancy and wind effects to the single-sided ventilation efficiency is investigated. The heat and mass transfer characteristics of the studied cases are analysed and discussed. Finally, a new accurate model for the prediction of the air flow rates in single side ventilated buildings is proposed.

KEYWORDS prediction, natural ventilation, tracer gas

#NO 8876 Study of cross-ventilation in apartment with large openings - comparisons between wind tunnel tests and simulations

AUTHOR Wang Z.

BIBINF Canada, proceedings Indoor Air Quality, Ventilation and Energy Conservation in Buildings, Second International Conference, held May 9-12, 1995, Montreal, edited by Fariborz Haghighat, Volume I, pp449-455.

ABSTRACT Cross-ventilation is natural ventilation through opening windows and doors, which is the most effective cooling method against the hot humid climate in southern China. The traditional method of study air movement within apartments were wind tunnel experiments, which not only cost money, time consuming, but also are poor flexibility to parametric changes. This paper studies cross-ventilation in naturally ventilated apartment with large openings by means of Computer Fluid Dynamics (CFD). The particular attention is paid to applications of CFD in cross-ventilation apartments. Its purpose is to compare simulations with wind tunnel tests, establishing the realistic boundary conditions and examining the accuracy of the simulations in cross-ventilation studies. The existing commercial CFD program Flovent, developed by Flomerics Limited, UK, are used for simulations. A typical Chinese apartment for young couple, located in Guangzhou, Southern China, is selected for a case study. The wind tunnel tests of the young couple's apartment were made by the National Swedish Institute for Building Research. The discrepancy between numerical and tests values are about 10%, the worst case is less than 17%. They may be too large for structure design problem, but for environmental design such an error may be acceptable. Therefore, it has proved the application of CFD in cross-ventilation and has demonstrated the potential of the numerical method for predicting cross-ventilation in apartments.

KEYWORDS cross-ventilation, apartment, openings, wind tunnel, simulation

#NO 8896 Effectiveness of trickle ventilators in providing adequate fresh air in commercial buildings during the heating season

AUTHOR Kolototroni M, Perera M D A E S, Marshall S G.
BIBINF Canada, proceedings Indoor Air Quality, Ventilation and Energy Conservation in Buildings, Second International Conference, held May 9-12, 1995, Montreal, edited by Fariborz Haghighat, Volume 2, pp947-955.

ABSTRACT This paper presents the findings of a field study carried out in the winter of 1993/94 to examine the effectiveness of trickle ventilators in providing adequate fresh air in commercial buildings during the heating season. Two specially constructed deep plan office rooms were used for the measurements. Trickle ventilators were installed in one room while the other was used as a control room. Varying levels of occupancy were simulated in both rooms by constant carbon dioxide (CO₂) injection (to simulate metabolic emissions) and heat sources. Internal measurements included CO₂ levels, air velocity, temperature and air change rates using the sulphur hexafluoride (SF₆) tracer gas decay technique. External wind velocity and direction and air temperature were also monitored. Comparisons between the calculated fresh air supply from the CO₂ constant injection method and the SF₆ decay method indicated good agreement. Parallel SF₆ decay measurements have reconfirmed that CO₂ monitoring could be used as a marker of indoor air quality in offices. Using CO₂ monitoring levels as markers of fresh air adequacy, measurements indicate that for average occupancy (8-10m² per person) trickle ventilators with an openable area of 400mm²/m² of floor area are capable of providing the necessary fresh air for average weather conditions. Tests also showed that air transfer grilles installed on internal doors are essential to ensure adequate performance. Internal air velocity measurements indicated that even with the simplest design of trickle ventilators cold draughts are not a problem at desk and head height. Higher velocities at ankle level were observed indicating cold downdraughts. These, however, could be corrected by the design and/or the position of the ventilator and radiators.

KEYWORDS commercial building, natural ventilation, carbon dioxide

#NO 8930 Natural ventilation processes in glazed spaces.

AUTHOR Cooper P

BIBINF AIRAH J, Vol 49, No 2, February 1995, pp 26-29, 8 figs, 1 tab, 13 refs.

ABSTRACT States that large glazed spaces, such as atria, have become a common feature of high quality commercial buildings. The implications of their use for air conditioning system designers are considerable. The thermal performance of glazed spaces in buildings is a complex issue requiring analysis of turbulent natural convective heat transfer in large enclosures. To date, no simple design method has been developed to predict important parameters such as contaminant dispersal and temperature distribution within a multi-storey atrium or possible over-heating in the upper levels. Reports on research into the development of a simple means of predicting thermal stratification in large spaces containing one or more sources. Presents results from a monitoring study of a two-storey atrium showing how even relatively small atria can exhibit significant stratification between two adjacent floors. Compares the results with a theoretical analysis based on the theory of plumes which provides a simple model of stratification in naturally ventilated spaces.

KEYWORDS natural ventilation, window, atrium, commercial building

#NO 9006 Natural ventilation has its place.

AUTHOR Rea T

BIBINF UK, Electrical Contractor, February 1995, pp 27-30.

ABSTRACT A collection of three articles detailing arguments against new passive stack ventilation guidelines from fan manufacturers, design guidance on solving condensation and stale air problems, and guidelines for providing the right environmental control in hotels and restaurants.

KEYWORDS natural ventilation, stack effect, ventilation system, building regulations

#NO 9042 Performance of natural ventilation in dwellings. A longitudinal computational simulation study.

AUTHOR Kronvall J, Blomsterberg A

BIBINF UK, Air Infiltration and Ventilation Centre, 16th AIVC Conference Implementing the results of ventilation research, held Palm Springs, USA, 18 - 22 September, 1995, Proceedings Volume 1, pp 25-36.

ABSTRACT The paper presents the results of a simulation study performed by means of the COMIS multizone infiltration and ventilation model. The simulations were carried out for a two-storey single-family passive-stack-ventilated house in a cold climate (Stockholm, Sweden). Main conclusions of the study include the following: it is possible - during at least 75% of the heating season - to achieve a ventilation rate in the whole house of at least 0.5 ach or approx. 30 l/s only if the house has a leakage rate above approx. 10 m³/m².h@50 Pa or has purpose-provided supply air devices in the facade with a total area (far) greater than 400 cm²; that the flow rates in the vertical shafts from kitchen, WC and bathroom are small but quite stable, in the range of approx. 3-4 l/s each; that all bedrooms (on the first floor) are under-ventilated as far as outdoor air is concerned; and that the living room (on the ground floor) is the only room in the house with - in most cases - adequate ventilation. Possibly, but this was not proven, the performance of the passive stack ventilation could be improved, especially in the bedrooms, if the air supply devices in the facade were to be placed lower than in the simulations (2.1 m above the floor level) and/or each bedroom was equipped with an individual exhaust shaft combined with a more or less airtight door. In order to increase the shaft flows it would, of course, also be possible to increase the height of the shafts above roof level and/or use a cowl of a special design. The work was undertaken as part of the IEA Annex 27 project: evaluation and demonstration of domestic ventilation systems.

KEYWORDS stack effect, residential building, simulation, cold climate

#NO 9205 Natural ventilation by means of twin-face facades. Natuerliche Be- und Entlueftung von Raecumen durch Doppelfassaden.

AUTHOR Ruscheweyh H, Ziller C, Thiel D
BIBINF Germany, Ki Luft- und Kaeltechnik, No 9, 1995, pp 415-418, 6 figs, 6 refs.

ABSTRACT Due to an increasing sensibility regarding environmental factors criteria like a decreasing energy consumption and emission problems become more and more important. In order to minimize the energy expenditure of a modern facade and to guarantee an adequate in-door-climate, new designs and developments are necessary. Twin-facade systems are representing an excellent attempt to fulfil these requirements. Using twin-facade-faces, it is possible to ventilate rooms in high rise buildings which are more exposed to wind loads by means of common windows without the necessity of an air conditioning installation. They offer new possibilities of protection against extreme weather conditions and improve sound insulation. In model tests the ventilation rate of several types of twin-face-facades is investigated by simulating the thermal forces governing the phenomena of natural ventilation. The results of this experimental tests show that natural ventilation of rooms by a twin-facade system can be realized even in cases of extreme winds or high solarization.

KEYWORDS natural ventilation, energy consumption, indoor climate, window, high rise building

#NO 9230 Ventilation and air quality in office buildings. Ventilation og luftkvalitet i kontorbygninger.

AUTHOR Valbjorn O
BIBINF Denmark, TFVVS Danvak, March 1995, Vol 31, No 4, pp 4-6, 1 tab, in Danish.

ABSTRACT Discusses the Danish National Building Institute SBI Report 240 Ventilation and Air Quality in Office Buildings, in which the results of a study of three office buildings are discussed. The aim was to examine the total effect on the indoor air quality of the volumetric air flow rate, the air exchange between offices and corridors, the adsorption and desorption of pollutants as well as window ventilation. States that to some extent the results can explain why naturally ventilated buildings are in many cases regarded as satisfactory. Concludes by suggesting that a suitable building layout can create satisfactory indoor air conditions with lower rates of ventilation than normally recommended.

KEYWORDS indoor air quality, office building, air flow

#NO 9276 Control of natural ventilation.

AUTHOR Martin A J
BIBINF UK, Building Services Research and Information Association, BSRIA, Technical Note TN 11/95, 1995, 91pp.
ABSTRACT Natural ventilation has the potential to replace or supplement air conditioning, comfort cooling and mechanical ventilation. Whilst there are obvious environmental advantages, there are problems of achieving adequate control as the flow of air must be controlled to limit energy consumption and maximise thermal comfort. This Technical Note provides guidance on the application of BMS (Building Management System) controls to natural ventilation. The use of automatic controls is not a panacea for ventilation problems. A vent under occupant control should generally be provided, thus allowing the building occupants to manipulate their own environment. However, the provision of automatic control of air inlet vents and inaccessible air outlet vents results in improve ventilation rates, particularly in the summer, thus enhancing the working environment. Further to this, automatic controls offer the opportunity for night cooling techniques thus helping to ameliorate daytime heat gains. The Technical Note presents a number of generic control strategies for natural ventilation, mixed mode ventilation and night

cooling, which are used to control this enhanced daytime ventilation and night cooling. Procedures for commissioning and fine tuning buildings using these strategies are described, together with appropriate control setpoints. An analysis of the costs of buildings utilising various ventilation types is provided. The guidance is reinforced with the results of monitoring carried out in three naturally ventilated buildings. A description of the buildings is presented together with details of the control strategies and the results of the monitoring. General conclusions regarding the control strategies and the performance of the ventilation system in each of the buildings are presented. Finally, a description and details of the control strategies of eight further buildings utilising controlled natural ventilation are presented.

KEYWORDS natural ventilation

#NO 9281 Natural speculation.

AUTHOR Bunn R
BIBINF UK, Building Services, November 1995, pp 20-25.
ABSTRACT Describes the achievement of a highly integrated and flexible mixed-mode building, capable of operating either on natural ventilation or full air conditioning. The building is naturally ventilated. While a sealed office building could fail if the air conditioning were to break down, a naturally ventilated, non air conditioned building can also suffer if there is limited use of the structure's thermal mass, poor control of natural daylight and no secondary means of ventilation in winter when windows are seldom opened. Hence this building is of heavyweight construction with exposed concrete columns and precast, trough profiled concrete ceilings.
KEYWORDS office building, natural ventilation, building design, energy efficiency

#NO 9282 Natural ventilation in offices.

AUTHOR White M, Walker R
BIBINF UK, Building Services, November 1995, p51, 1 fig.
ABSTRACT Reports on the various design guidance issues surrounding the provision of efficient single-sided and cross-ventilation in office buildings. A series of measurements were carried out in several deep office spaces to address the influence of the following factors on the adequacy of natural ventilation: single sided ventilation compared with cross-ventilation, the effect of office depth, the effect of window level, the effect of partitions and the possible impact of wind shelter. Conclusions were that local ventilation rates are generally evenly spread in deep office rooms using either cross or single-sided ventilation. Higher level windows appear to reduce draughts nearby at working level. Current guidance on thermal comfort and draught risk appears unreliable for natural ventilation when cooling is desirable in warm conditions.
KEYWORDS natural ventilation, office building, building design, cross ventilation

#NO 9306 Operation of a mechanically assisted natural ventilation system. Mise au point d un systeme de ventilation naturelle assistee mecaniquement.

AUTHOR Amphoux A, Villenave J G
BIBINF France, Agence de l Environnement et de la Maitrise de l Energie, (ADEME) 1995, proceedings of Ventilation des Batiments: Etat des lieux - Prospective, held Sophia Antipolis, 25-26 October 1995, organised by GEVRA, Groupe d Etude sur la Ventilation et le Renouvellement d Air, pp 186-194.

ABSTRACT This paper presents work to bring into operation an assisted mechanical static ventilator. The objective being in natural ventilation to approach as closely as possible the losses defined by the French 1982 regulation. The minimum characteristics of the apparatus have been defined by calculation with the aid of the GAIN code developed at CSTB. The work showed that the apparatus has the characteristics of a static extractor class B and must have a two speed motor to allow: at slow speeds to provide sufficient air when the thermal motor is insufficient

and at fast speeds to allow the evacuation of kitchen pollutants at meal preparation.

KEYWORDS natural ventilation, kitchen, odour

#NO 9414 Single sided natural ventilation measurements.

AUTHOR Eftekhari M M

BIBINF UK, Building Serv Eng Res Technol, Vol 16, No 4, 1995, pp 221-225, 6 figs, 11 refs.

ABSTRACT This paper investigates air movements and temperature distributions inside an office which is naturally ventilated. An existing environmental chamber with a volume of approximately 45 m³ is used to represent an office. The outside air is supplied into the environmental chamber through three different supply positions on the wall. Measurements of air temperature and velocity are carried out in the environmental chamber at different heights and positions in the chamber. The internal wall surface temperatures and outside air temperature are also monitored. The mean air velocity is measured at the same points as the air temperatures using omnidirectional anemometers. The outputs from the anemometers are fed into microcomputer; these data are analysed for comfort using the predicted percentage of dissatisfaction (PPD) method of Fanger's thermal comfort criterion.

KEYWORDS natural ventilation, measurement technique

#NO 9532 Mixed-mode HVAC - an alternative philosophy.

AUTHOR Arnold D

BIBINF USA, Ashrae Transactions, Vol 102, Pt 1, 1996, preprint, 6 figs, refs.

ABSTRACT This paper examines an alternative strategy for heating, cooling, and ventilating buildings that attempts to combine the best features of both natural and mechanical systems. It involves a holistic approach to design that treats the building and engineering equally. Such climate-responsive integrated building/engineering systems are intended to operate in the natural mode whenever possible to minimize energy use and only use mechanical systems under peak conditions at the extremes of external temperatures. The period of use of natural systems can be extended by using passive cooling techniques and fabric thermal storage. Some of the building mass, walls, ceiling slabs etc, are used as thermal storage media and are allowed to cool overnight and absorb heat the next day. The technique requires some automated control of natural ventilation but both reduces energy use and, by virtue of the thermal mass involved, limits the rise in internal temperature on occasions when normal design criteria are exceeded. The paper described the philosophy and operation of mixed-mode systems used in conjunction with fabric thermal storage and suggests some guidelines for the development of the design of a practical system.

KEYWORDS ventilation system, heating, temperature

#NO 9820 Possibilities of energy conservation in multi family dwelling houses in the consideration of the effectiveness of natural ventilation.

AUTHOR Baranowski A, Pudelko D

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 3, pp 285-290.

ABSTRACT The possibilities of energy conservation for a typical multi-family building are presented in the paper. For this purpose, the simulation of retrofitting the building by means of insulating external walls and windows leakages was carried out. Based on the numerical simulations, analysis of ventilating air flows in this multi-family building were carried out. Results of these calculations were used as an input data for energetic audit of this building. For this purpose, the TRNSYS program was used yielding the total heat balance for the whole building. Analyses of the total thermal load were shown for comparing the thermal comfort

in the separate flats and also for indicating the energy conservation due to retrofitting.

KEYWORDS energy conservation, natural ventilation, ventilation effectiveness

#NO 9821 Estimating potential for indoor thermal comfort from natural ventilation.

AUTHOR Aynsley R

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 3, pp 291-298.

ABSTRACT A 1:100 scale model of a house with a clear plastic roof was placed in a boundary layer wind tunnel. Flow visualisation using foam polystyrene beads was videotaped from above the model for each of 16 compass-point wind directions. Miniature cylindrical hot film anemometer probes were located at an equivalent of 1 metre above floor level in the living room, kitchen and bedrooms from below the wind tunnel floor. A similar reference hot film anemometer probe was mounted upstream from the model at a height equivalent to 10m above ground level.

KEYWORDS thermal comfort, natural ventilation, roof, wind tunnel

#NO 9841 Experiments in natural ventilation for passive cooling.

AUTHOR Flourentzou F, van der Maas J, Roulet C-A

BIBINF UK, Air Infiltration and Ventilation Centre (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 1, held 17-20 September 1996, Gothenburg, Sweden, pp 121-134.

ABSTRACT A naturally ventilated three level office building has been used to study basic stack ventilation configurations and the interaction between ventilation and the subsequent cooling of the building structure in summer. The research was performed in the framework of a European project on passive cooling of buildings and the objective was to validate simple ventilation algorithms and to give an experimental basis to design guidelines for night cooling techniques. The multilevel office allowed the studying of the influence of openings (size and position) on the neutral pressure level (NPL) and on airflow rates. Various cross-ventilation situations have been studied. A single flow path configuration was obtained by closing all windows and doors in the building envelope with the exception of the roof exhaust and one office window as the ventilation air inlet. Air flow patterns were traced with smoke and tracer gas. In a first set of experiments, where the only driving force is stack pressure, air velocities and the position of the NPL have been measured, and contraction and velocity coefficients as used in the Bernoulli model have been observed. In a second set of experiments, the resulting effective area of a combination of two openings in series was studied. Air flow rates derived from velocity measurements in the open doorways were found to be in agreement with the flow rates obtained with a constant injection tracer gas technique, with an uncertainty of +/- 20%. Overall agreement was found between the velocity measurements and simplified models based on the Bernoulli equation. In order to cool multiple levels of a building with outside air, the position of the neutral pressure level should be controlled. The restrictions on opening size and position are discussed.

KEYWORDS natural ventilation, passive cooling, office building, stack ventilation

#NO 9853 The influence of outdoor air vents and airtightness on natural ventilation - calculations based on measurements.

AUTHOR Blomsterberg A

BIBINF UK, Air Infiltration and Ventilation Centre (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 1,

held 17-20 September 1996, Gothenburg, Sweden, pp 253-262.

ABSTRACT Many modern buildings in the Nordic countries have mechanical ventilation. Passive stack ventilation is, however, an accepted ventilation system in the Nordic countries according to the current building codes. The building authorities need to be able to supply guidelines on natural ventilation systems in modern buildings. In order to fulfill the requirements on a healthy indoor climate at a reasonable energy cost. Therefore a project was initiated by the Nordic committee on building regulations. The aim of the project was to present functional and technical requirements on natural ventilation systems. The paper discusses the influence of outdoor air vents and airtightness on passive stack ventilation for Nordic dwellings. Calculations, based on measurements, were performed for a one storey one-family house, a 1 1/2-storey one-family house and two apartments in a three-storey building. Cumulative distributions of ventilation rates for a year were calculated, using a multi-zone air flow model, for individual rooms. It is shown that the ventilation rate will vary very much, without any interaction from the occupants or an automatic control system. A modern system for passive stack ventilation must include a system for control of the air flows in order to avoid excessive use of energy and inadequate indoor air quality.

KEYWORDS air tightness, natural ventilation, cold climate, passive stack ventilation

#NO 9871 Reduction of flow loss due to heat recovery in PSV systems by optimum arrangement of heat-pipe assemblies.

AUTHOR Riffat S B, Shao L

BIBINF UK, Air Infiltration and Ventilation Centre, (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 2, held 17-20 September 1996, Gothenburg, Sweden, pp 447-455.

ABSTRACT Natural ventilation is being applied to an increasing number of new buildings to minimise reliance on mechanical ventilation and so reduce emission of greenhouse gases. However, passive stack ventilation (PSV) systems are currently designed without incorporating heat recovery leading to significant wastage of energy. Heat recovery systems have not been used in naturally-ventilated buildings because the pressure loss caused by a conventional heat exchanger is large compared to the stack pressure and could cause the ventilation system to fail. In addition, the stack pressure decreases owing to reduction of the temperature difference associated with the heat exchange, although this problem can be lessened by appropriate siting of the heat exchanger to maximise the effective stack height. In this study, natural convective flow through PSV stacks were computed using CFD to determine the effect of the layout of heat-pipe assemblies as well as the effects of spacing and length of fins on reduction of flow rate through the stack. Among the layout patterns examined, the arrangement where the assemblies are placed in a pattern of an arrow facing the flow direction produced the least insertion flow loss. The flow loss due to the insertion of the heat pipe assemblies (IFL) was found to increase sharply with the number of fins and reached over 30% when only 4 fins were used. IFL also increased with fin length but the rate of increase reduced for larger fin lengths. Therefore, for a given total surface area of fins, using fins with a larger length causes less flow loss than fins with a smaller spacing.

KEYWORDS heat recovery, natural ventilation

#NO 9875 The efficiency of single-sided and cross ventilation in office spaces.

AUTHOR White M, Walker R

BIBINF UK, Air Infiltration and Ventilation Centre, (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 2, held 17-20 September 1996, Gothenburg, Sweden, pp 487-496.

ABSTRACT This paper reports on work carried out at BRE to address the need for guidance on designing for natural ventilation via single-sided and cross-ventilation in office spaces and the limits of application on terms of plan depth. Present guidance suggests that natural ventilation will be adequate up to 6 m from the ventilating facade. This leads to the conventional design of offices up to 6 m deep on either side of a central corridor, giving as a rule of thumb a width of 15 m for a building with natural cross-ventilation. The present work looks at the opportunities for going beyond these rules of thumb. The implications for thermal comfort and draught risk are also assessed. In the conclusions issues such as, local ventilation rates, ventilating air penetration from a facade, the use of artificial mixing (eg ceiling fans) on hot days, the position of windows, and means of enhancing internal air speeds and air change rates are discussed.

KEYWORDS cross ventilation, building design

#NO 9879 Evaluation of a controlled natural ventilation system.

AUTHOR Carlsson T

BIBINF UK, Air Infiltration and Ventilation Centre, (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 2, held 17-20 September 1996, Gothenburg, Sweden, pp 529-538.

ABSTRACT The project described in this paper has performed simulations using a multi-zone air flow model (4(COMIS)) of three different passive stack ventilation systems. The objective of the simulation calculations was to evaluate system performances and to make suggestions for possible improvements of the systems.

KEYWORDS passive stack ventilation, natural ventilation, air leakage

#NO 9886 Natural ventilation studies within the frame of PASCOOL project.

AUTHOR Santamouris M, Dascalaki E, Allard F

BIBINF UK, Air Infiltration and Ventilation Centre, (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 2, held 17-20 September 1996, Gothenburg, Sweden, pp 601-609.

ABSTRACT Natural ventilation studies were carried out within the frame of PASCOOL EC Research Project. Research on this topic included experimental and modelling work aiming to fill the existing gaps in our knowledge of indoor air conditions in naturally ventilated buildings. Experiments were carried out in full scale and test cell facilities during the summer period. Single sided and cross ventilation as well as air flow through large internal openings were the basic topics that were studied. Existing models were validated and new ones were developed. A new computational tool for ventilation prediction was developed, based on the airflow network modeling. An intermediate approach, between network and CFD was proposed to take into account the impact of non-homogeneity on the indoor air motion.

KEYWORDS natural ventilation, passive cooling

#NO 9894 Natural ventilation of a high rise building with a twin face facade.

AUTHOR Ziller C, Sedlacek G, Ruscheweyh H, Oesterle E, Lieb R D

BIBINF Germany, Ki Luft- und Kaeltechnik, No 8, 1996, pp 343-346, 8 figs, 15 refs.

ABSTRACT Twin-facade systems represent an excellent attempt to fulfil energy conservation and emission reduction requirements. Using twin face facades makes it possible to ventilate rooms in high rise buildings which are more exposed to wind loads with ordinary windows, and reduce the need for air conditioning. The article describes the planned twin face system of one of the buildings at the Daimler Benz Project at the Potsdamer Platz in Berlin. In model tests the ventilation rate of the facade was

investigated by simulating the thermal forces governing the phenomenon of natural ventilation. Ventilation rates for different flap configurations of the outer facade and different window openings are given. The investigations show that natural ventilation can be achieved even in cases of extreme wind or high solarisation. By considering the average temperature and wind data it can be demonstrated that the operation of the air conditioning plant can be reduced to a few weeks per year, with a matching reduction in energy consumption.

KEYWORDS high rise building, natural ventilation, wind effects, ventilation rate

#NO 9898 On the combination of air velocity and flow measurements in single sided natural ventilation configurations.

AUTHOR Dascalaki E, Santamouris M, Argiriou A, Helmis C, Asimakopoulos D N, Papadopoulos K, Soilemes A
BIBINF Energy and Buildings, No 24, 1996, pp 155-165, 12 figs, 6 tabs, 12 refs.

ABSTRACT Single sided natural ventilation configurations are very frequent especially in building in urban environments. Four single sided ventilation experiments were carried out in a full scale outdoor Test Cell facility. Air velocity measurements were taken at various heights in the middle of the opening. The average air flow rate through the opening was derived by using the tracer gas decay technique. This work presents the results of an investigation into the relationship between the air velocity at the opening and the bulk air flow rate measurements. The paper presents description of the experimental set-up as well as a qualitative discussion of the results.

KEYWORDS air flow, natural ventilation, tracer gas

#NO 10035 Distributions of sensory evaluations on thermal and cross ventilation conditions in naturally ventilated temperate climate classrooms.

AUTHOR Iino Y, Hoyano A
BIBINF Indoor Air '96, proceedings of the 7th International Conference on Indoor Air Quality and Climate, held July 21-26, 1996, Nagoya, Japan, Volume 1, pp 1031-1036.

ABSTRACT Using data from a large number of teacher questionnaires distributed to public elementary schools in Kawasaki, Japan, we determined factors having the strongest influence on their sensory evaluations of thermal and cross-ventilation condition in natural-ventilated temperature-climate classrooms. These influential factors were derived from various factors regarding thermal-related environmental control used by teachers and classroom architectural planning factors. Then, using data from student questionnaires, we determined seating-dependent distributions of similar sensory evaluation for groups of classes with respective category of influential factors. As the result, windows and door were fully opened except being closed for the safety and noise control reasons. The class directional orientation and the window types related to architectural openings had the strongest influence on sensory evaluations. The classrooms facing southward and having window types tend to be fully opened provided the most comfortable thermal environment.

KEYWORDS occupant reaction, cross ventilation, school

#NO 10069 Two dimensional numerical study of airflow through large openings.

AUTHOR Li K, Teh S L
BIBINF Indoor Air '96, proceedings of the 7th International Conference on Indoor Air Quality and Climate, held July 21-26, 1996, Nagoya, Japan, Volume 2, pp 1027-1032.

ABSTRACT Natural ventilation is important to indoor air quality because its rate is usually low and cannot be easily adjusted. The results of a numerical study on the airflow within a single-sided naturally ventilated room with a large opening is presented here. Lam-Bremhorst low-Reynolds-number k-ε model together with a self-developed two-dimensional flow simulation code based on SIMPLE algorithm was used. External temperatures in equatorial

climate similar to those of Singapore were selected. Two room set-ups were examined. The first is with a heat source and the second a split unit air-conditioner. Air exchange rates were predicted. It is found that the presence of the circulation fan in the split unit air-conditioner will decrease vertical temperature gradient in the opening region and hence the ventilation rate is lowered.

KEYWORDS numerical modelling, air flow, openings

#NO 10296 Performance indices for fabric thermal storage.

AUTHOR Braham D, Warwicker B
BIBINF UK, CIBSE, 1996, proceedings of CIBSE/ASHRAE Joint National Conference Part Two, held Harrogate, 29 September - 1 October 1996, Volume 1, pp 59-69.

ABSTRACT This paper reviews the development of performance indices for fabric thermal storage from the original BRE office research data to the two mixed mode design options currently available, each having different design priorities, namely naturally ventilated or mechanically ventilated. Naturally ventilation mixed mode designs appear to be less suitable for UK locations and also appear to have significantly greater annual energy consumption. In addition to the comparison of energy consumption criteria, the paper also reviews recent Scandinavian indoor climate classifications. It recommends linking an appropriate UK indoor climate classification with an environmental energy index as an easily understood reporting procedure for a future national database.

KEYWORDS thermal storage, office building

#NO 10316 Air distribution in a naturally ventilated office.

AUTHOR Salemi R, Alamdari F, Fishwick P J
BIBINF UK, CIBSE, 1996, proceedings of CIBSE/ASHRAE Joint National Conference Part Two, held Harrogate, 29 September - 1 October 1996, Volume 2, pp 321-331.

ABSTRACT Computer simulations of airflow and thermal environment within a typical workplace at the perimeter of a building are reported. The computations are performed using a special purpose finite volume flow model, based on computational fluid dynamics (CFD) techniques. Measurements of air velocity and temperature in a mock up office space incorporating sash windows were used to verify the predicted data obtained from the computer model. The model was subsequently used to study the effects of various opening areas on the overall ventilation rates and probable occupants thermal comfort. Comparisons are also made with the design recommendations given in BS 5925.

KEYWORDS air distribution, natural ventilation, office building

#NO 10333 Night cooling control strategies.

AUTHOR Martin A
BIBINF UK, CIBSE, 1995, National Conference '95, Eastbourne, 1-3 October 1995, Volume 2, pp 215-222.

ABSTRACT Night cooling offers the potential to minimise or completely avoid the use of mechanical cooling and to improve internal environmental conditions in naturally ventilated buildings. By allowing cool night time air to flow through a building the heat built up in the previous day is removed and storage of the cool air in furniture, fabric and fittings is achieved, consequently providing a cooling effect the following day. This paper outlines BSRIA's (the UK Building Research and Information Association) research concerning control strategies for night cooling that can be used for both active and mixed mode ventilation systems. Adoption of appropriate control strategies is essential to ensure the full potential of night cooling systems are realised.

KEYWORDS cooling, ventilation system

#NO 10337 Guidelines for the design and operation of natural and mixed mode ventilation systems in commercial buildings.

AUTHOR Jones P J, O'Sullivan P E, Bowman N, et al
BIBINF UK, Building Environmental Performance Analysis Club, (BEPAC), 1997, "Sustainable Building", proceedings of a conference held 5-6 February 1997, Abingdon, UK.

ABSTRACT Describes a project whose aims are to provide valuable information and guidance to the debate about using natural or mixed mode ventilation rather than full air conditioning in commercial buildings, and the possible problems this may introduce. Aims to assess health and comfort, to inform design, to assess design practices, and to assess the costs and benefits. Seeks to fulfil these aims by conducting detailed case studies in eight buildings, four designed to meet 1990 UK Building Regulation requirements, and four designed around innovative natural or mixed mode ventilation requirements.

KEYWORDS commercial building, natural ventilation, field monitoring

#NO 10496 The Queen's Building for Anglia Polytechnic University.

AUTHOR Turrent D, Barlex M
BIBINF Japan, PLEA 1997 Kushiro Secretariat, proceedings of a conference held 8-10 January 1997, Kushiro, Japan, Volume 2, pp 145-152.

ABSTRACT This is one of the first generation of Learning Resource Centres to be built at UK Universities. It provides 6000m² of accommodation including a library, 700 study spaces, TV studio, seminar rooms, offices and catering facilities. The building is designed to use natural ventilation rather than air conditioning, thus saving on energy and CO₂ emissions. Two central atria provide daylight to the centre of the building as well as a route for exhausting ventilation air utilizing the stack effect (the natural buoyancy effect of warm air rising). The combination of exposed thermal mass internally and night time ventilation provides a means of 'free' cooling in summer. High performance triple glazed windows incorporate an upper section which opens automatically, controlled by the BEMS (Building Energy Management System) depending on internal/external temperatures. Twin light shelves are also built into the windows to reduce glare on VDU screens around the perimeter and to reflect daylight onto the ceiling. Low energy lighting is controlled to respond to daylight levels and provide background lighting to study areas, supplemented by individual task lights. All timber used is from certified sustainable sources. Natural materials have been used throughout e.g. stone, timber, linoleum. Results from the first year of monitoring show a 74% reduction in energy and 82% reduction in CO₂ emissions compared to an equivalent air conditioned building. Results from users surveys shown that the light and airy qualities of the building are well liked and comfort conditions are good, even in the hot summer of 1995.

KEYWORDS natural ventilation, stack effect, thermal mass, cooling

#NO 10497 The passive cooling effects of the natural ventilation system from under floor pit to wind tower.

AUTHOR Iwamura K, Hoyano A, Shirai K, Tsuchiya Y
BIBINF Japan, PLEA 1997 Kushiro Secretariat, proceedings of a conference held 8-10 January 1997, Kushiro, Japan, Volume 2, pp 153-158, 4 figs.

ABSTRACT With the awareness of environmental problems as the starting-point, various investigations and trials aimed towards a sustainable society have been commenced; in recent years, the architectural field too has seen such research and development of passive methods. These methods are based upon traditional and previously practiced passive architectural techniques, but are inseparable from the latest technology. One such project, of profound importance to the nation, is the promotion of and research towards "SYMBIOTIC HOUSING", which is to be

friendly and symbiotic with both the environment and human-beings from the ecological and economical viewpoints. With this objective in mind, in 1994, a timber-frame building was designed by the author in the city of Iwaki for the public promotion of such a movement. This project has been followed by a year long data measurement and analysis, in order to evaluate the passive cooling effects of the natural ventilation system from under-floor pit to wind-tower.

KEYWORDS passive cooling, natural ventilation

#NO 10554 Hardware and controls for natural ventilation cooling.

AUTHOR Liem S H, van Paassen A H C
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 59-68.

ABSTRACT This research is part of project NATVENT TM, a concerted action line of nine institutions of seven European countries under the Joule-3 program. It aims to open the barriers that blocks the use of natural ventilation systems in office buildings in cold and moderate climate zones. Natural night-time ventilation cooling is a very effective means to remove the heat, accumulated in the building fabrics during office hours. Moreover, it requires no energy at all. Cooling with natural ventilation has its limits; more than 6 air changes per hour have no more cooling effect. So precautions have to be taken to reduce the heat gain during the day by limiting the glass area to approximately 40% and using effective sun shading devices. The internal heat load is also limited to 25 W.m⁻². Hardware for night cooling are the traditional types of windows and trickle ventilators. To obtain the most benefit of night rolling, automatic control is essential. For this the control strategies is of utmost importance. Specially for night-time ventilation cooling developed control strategies are incorporated in the predictive control, cooling day control, setpoint control, slab temperature control, degree hour control.

KEYWORDS natural ventilation, cooling, controls

#NO 10555 A study of window location and furniture layout to maximise the cooling effect for an urban Taiwanese apartment by night ventilation.

AUTHOR Chao N-T, Wang W A, Chiang C M
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 69-76.

ABSTRACT The year-round climate of Taiwan is warm and humid. Apart from the hottest months in summer, there are four months suitable for nocturnal ventilation to acquire indoor cooling. The urban Taiwanese apartments are small due to the limited usable land. To maximise the spatial use, a relative large occupant-defined space is developed. This space can be divided into two or three sub-spaces with wall units or smaller pieces of furniture when needed. Based on a previous study in a typical occupant-defined space, some wintertime design principles of furniture layout to achieve high indoor air quality were obtained. To provide an overall picture of the natural ventilation design for such a space, this study investigates the impacts of window location and furniture layout on the summertime indoor thermal comfort and air quality by night ventilation. Different furniture layouts have neglected effects on indoor thermal comfort when the layout does not obstruct the primary supply air stream. More spatial divisions by wall units can help to removal CO₂ effectively by minimizing mixture among stratified thermal layers. Lower window location makes the penetration of supply air stream deeper into the room, which results in a cooler region away from the window. Lower window location achieves lower indoor CO₂ concentration level than higher window location.

KEYWORDS cooling, apartment, window

#NO 10567 Heat pipe heat recovery for passive stack ventilation.

AUTHOR Riffat S B, Gan G, Shao L, Siren K, Oliveira A, Afonso C, Kofoed P

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 185-194.

ABSTRACT Four types of heat-pipe heat recovery systems were tested for application in passive stack ventilation. The effects of fin shape, pipe arrangement and air velocity on the heat recovery effectiveness were investigated. The air velocity was found to have a significant effect on the effectiveness of heat recovery; the effectiveness decreasing with increasing air velocity. The pressure loss coefficient for heat pipe units was also determined. It was found that at low velocities for natural ventilation the pressure loss coefficient decreased with increasing air velocity but the total pressure loss increased with the velocity. It is recommended that in naturally-ventilated low-rise buildings, without the wind effect or solar energy, the design duct mean velocity should be less than 1 m/s in order for a heat recovery system to function properly. The use of a solar chimney and/or wind turbine could increase the range of air velocity and so the amount of heat recovery.

KEYWORDS heat recovery, passive stack ventilation

#NO 10568 Deterministic and non deterministic methodologies for the prediction of the air velocity in single sided natural ventilation configurations.

AUTHOR Dascalaki E, Santamouris M

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 195-204.

ABSTRACT An extensive experimental program on single sided natural ventilation was carried out within the frame of PASCOOL EC research project. Within the frame of these activities, four single sided natural ventilation experiments were carried out in a cell test, a full scale outdoor facility. Experimental data were used as input for numerical simulations that were carried out using air flow calculation tools based on network modeling as well as computational fluid dynamics (CFD). Finally, fuzzy logic techniques were used to predict the air velocity profile in the middle of the opening. This paper presents the simulation results using the above approaches as well as a comparison with measurements.

KEYWORDS air velocity, natural ventilation

#NO 10571 On the ventilation and daylight efficiency of various solar shading devices.

AUTHOR Tsangrassoulis A, Santamouris M, Asimakopoulos D

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 225-234.

ABSTRACT Solar control devices placed in front of large building openings disturb air flow and the radiation transfer. Although solar radiation transfer through obstructed openings is a relatively well researched area, very little information is available regarding the air flow perturbations and daylighting alterations created by external solar control devices. The present paper reports a series of experiments aiming at investigating natural ventilation and daylight phenomena associated with the use of specific shading devices. Experiments have been carried out in outdoor test cells and twenty eight different configurations have been tested for several window characteristics under various climatic and radiation characteristics. Based on the experimental results, specific modeling activities have been undertaken and theoretical methods of calculating air flow and daylight through openings equipped with specific solar control devices have been developed and are now presented. Theoretical predictions are compared with the

corresponding experimental data and a very satisfactory agreement has been found for both air flow and daylight process.

KEYWORDS shading, passive solar design

#NO 10580 Solar assisted natural ventilation with heat pipe heat recovery.

AUTHOR Siren K, Riffat S, Afonso C, Oliveira A, Kofoed P

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 323-330.

ABSTRACT Natural passive stack ventilation (PSV) consumes no power and so produces no harmful emissions, has no running cost, no noise of operation, requires little maintenance and because it involves no moving parts, operation is reliable. However, virtually all PSV systems are designed and constructed without incorporating heat recovery, leading to wasteful heat loss. The goal of the research reported here, is to develop a passive stack ventilation system with heat recovery for use in naturally ventilated buildings. The heat recovery unit is based on the heat-pipe principle. A recovery unit having a sufficiently high effective and a very low pressure drop is aimed at. The drawback of an efficient heat recovery is, that it reduces the stack pressure by reducing the temperature difference between the supply and exhaust air flows, which can cause the ventilation system to fail. To avoid this problem, a solar chimney and a wind generator driven fan are integrated into the system to assist the air flows and to maintain them on a sufficient level from the viewpoint of indoor air quality. On the other hand, for the air flows not to be too high, a control unit is added to the system. A pilot plant shall be constructed, where all above mentioned features are included and this plant shall be monitored for six months to find out its performance. Until now several versions of the heat recovery unit have been tested. The highest effectiveness has been around 55% with two banks of heat pipes and a flow velocity of 1 m/s. With the same velocity the pressure loss through a two bank section is 4.5 Pa. The solar chimney has been studied both theoretically and experimentally. According to computations, the performance of the chimney is not very sensitive to small changes in direction on both sides of the south. Measurements indicate a 47% increase in air flow compared to a conventional stack. The air flow control unit has been developed and tested. It works well according to a control strategy specified for the PSV system. The work continues by designing and optimisation of the pilot plant.

KEYWORDS heat recovery, passive solar design

#NO 10645 EC 2000 high performance buildings that reduce or avoid air conditioning.

AUTHOR Burton S, Daggart J

BIBINF France, Centre Scientifique et Technique du Batiment, proceedings of the Second International Conference on Buildings and the Environment, held Paris, June 9-12 1997, Volume 2, pp 385-392.

ABSTRACT This paper outlines progress in the THERMIE Target project Energy Comfort 2000 after three and a half years. Seven of the eight buildings are under construction and the eighth will be starting on site in May 1997. The project covers the design, construction, commissioning and monitoring of the buildings which are offices, university buildings, and public and recreational buildings, together with "horizontal activities" which link the projects together. All buildings have been designed to save at least 50% of the energy consumption of conventional buildings and to avoid or minimise the use of air-conditioning, by passive design methods. Results from monitoring of the first completed building show that it has saved 74% of the energy of an equivalent air-conditioned building, with the majority of the occupants believing that the building provides comfortable internal conditions. The many useful results from EC2000 are being produced for dissemination in the form of

"Information Dossiers", subject to date include fire safety in atria, natural ventilation design, control strategies and windows.

KEYWORDS thermal comfort, public building, atrium, natural ventilation

#NO 10680 Winter ventilation monitoring at the Portland Building.

AUTHOR Kolokotroni M, Shaw R, Webb B, Perera E
BIBINF UK, Building Services Journal, July 1997, k pp 47-49, 6 figs.

ABSTRACT Winter ventilation performance of the Portland Building, the recently completed low energy building at the University of Portsmouth, UK has recently been monitored by the UK Building Research Establishment as part of the "NatVent" project, which aims to provide solutions to technical barriers preventing the uptake of natural ventilation and low energy cooling for office-type buildings in countries with moderate and cold climates. The monitoring results will be used to gain a better understanding of the applicability and limitations of natural ventilation strategies. During winter, the main focus of the tests is to examine whether acceptable indoor air quality is provided, whether airflow rates are kept within a certain range to avoid discomfort due to draughts and to minimise any excess energy which may be needed to heat the incoming air. The results showed that the natural ventilation strategy provides a satisfactory indoor air quality, as the design intended. CO₂ and humidity level are acceptable, and comfortable temperatures were recorded with appropriate fresh air ventilation rates. There are also positive indications for the performance of thermal mass for summer cooling and the role of the staircases for providing stack ventilation.

KEYWORDS monitoring, natural ventilation, building design

#NO 10723 The effects of human behaviour on natural ventilation rate and indoor air environment in summer - a field study in southern Japan.

AUTHOR Iwashita G, Akasaka H
BIBINF UK, Energy and Buildings, No 25, 1997, pp 195-205, 10 figs, 10 tabs, 5 refs.

ABSTRACT Residents completed a questionnaire survey assessing indoor environment and residents' behaviour (i.e. when they opened windows/doors, when they operated air conditioners, and so on) during the period of ventilation measurement. The purpose of this study is to measure the ventilation rate in occupied dwellings in Kagoshima City, located in the southern part of Japan, using the tracer gas method and to investigate the relationship between the occupants' behaviour in each dwelling and the energy consumption for air conditioning during the summer period. Based on the continuous measurement of the ventilation rate in eight dwellings, the proportion between the total ventilation rate (ventilation rate during occupancy of the dwellings) and the basic ventilation rate (ventilation rate during non-occupancy and with door/windows closed) is discussed. The measuring principle applied is the constant tracer gas method. The main conclusion is that there is a large difference between the mean basic ventilation rate and the mean total ventilation rate. If the size of the basic ventilation rate and the user-influenced ventilation rate in the investigated dwellings are compared, it can be seen that 87% of the total air change rate is caused by the behaviour of the occupants.

KEYWORDS occupant behaviour, ventilation rate

#NO 10776 Air flow distribution in a naturally ventilated light weight room.

AUTHOR Eftekhari M M, Pinnock D J
BIBINF "Energy and the Environment: Efficient Utilisation of Energy and Water Resources" First International Conference, proceedings, held October 12-14 1997 Limassol, Cyprus, Volume 2, pp 437-442, 2 figs, 6 refs.

ABSTRACT The objective of this research is to investigate air flow distribution inside a light weight test room which is single sided naturally ventilated. The ventilation rate into the room is controlled by adjusting four sets of louvres. The local outside temperature, humidity, pressure, wind velocity and direction were measured. Inside the room the velocity and direction of the inflow air across the high and low level openings, temperature and velocity distribution at four locations and six levels across the room were recorded. The results demonstrated that a displacement mode of ventilation was maintained in the space when the wind came from behind the test room. When the wind impinged on the louvre bulkhead the displacement flow in the room reduced. A simulation package was used to calculate the Predicted Mean Vote (PMV) values for different measured indoor velocities. The predicted thermal comfort indicated that PMV values were significantly improved with a high internal air velocity.

KEYWORDS natural ventilation, air flow distribution, thermal comfort.

#NO 10781 Investigation of natural ventilation with computational fluid dynamics. A comparison study with wind tunnel results.

AUTHOR Kindangen J, Krauss G
BIBINF Architectural Science Review, Vol 39, June 1996, pp 113-120, 6 figs, 9 refs.

ABSTRACT This paper presents an investigation into natural ventilation in the field of computational fluid dynamics using in particular rather rough mesh cells. The CFD results were then compared to the wind tunnel results obtained by Gouin at Centre et Technique du Batiment (CSTB) in Nantes. The role of eaves, and that of window configuration on windward and leeward sides of buildings was also investigated to search for a better airflow.

KEYWORDS wind tunnel, air flow modelling

#NO 10782 Naturally ventilated buildings. Buildings for the senses, the economy and society.

AUTHOR Clements-Croome D
BIBINF UK, E&FN Spon, 1997, 187pp.

ABSTRACT Based on a seminar on specifying environmental conditions for naturally ventilated buildings. Aims to contribute to knowledge about setting standards for naturally ventilated buildings. Chapter headings are: the sense of beauty, from homogeneity to heterogeneity, specifying indoor climate, the user's role in environmental control: some reflections on theory in practice, environmental criteria for naturally ventilated buildings, against the draft CEN standard: pr ENV 1752, an adaptive approach to thermal comfort criteria, natural ventilation: prediction, measurement and design reality, specifying environmental conditions for naturally ventilated building - a consultant's view, and natural ventilation in a large mixed mode building.

KEYWORDS indoor climate, natural ventilation, standard

#NO 10800 Casing the joint.

AUTHOR Field J
BIBINF UK, Building Services Journal, October 1997, pp17-21.

ABSTRACT Describes an innovative building which turns the atrium idea inside out by encasing the whole structure with a glass framework. The result is a low cost building with significant energy advantages. The atria create the opportunity for natural ventilation of the offices for much of the year, although the building has a mixed-mode strategy. In winter the atria afford elevated temperatures, while in summer they provide pleasantly cool conditions with the possibility of wind and some stack-induced ventilation.

KEYWORDS atrium, natural ventilation, stack effect

#NO 10871 Reflections on mixed mode.

AUTHOR Field J
BIBINF UK, Building Services Journal, June 1997, pp 20-24.

ABSTRACT Describes the new Lincolnshire University building, designed with a mix of passive design, mixed mode services, full air conditioning and a covered street. Passive design principles are employed to minimise basic heating and cooling loads. The building has high insulation levels and exposed thermal mass. Teaching rooms to the south are air conditioned, with displacement ventilation and cooling via chilled beams, while the north elevation has openable windows for natural ventilation. One problem has been instructing the occupants on the natural ventilation operations; occupants had not appreciated that windows could be opened onto the central street to encourage significant additional ventilation. The problem was increased by the simultaneous operation of naturally ventilated and air conditioned systems on either side of the building, incorporated in the same design format.

KEYWORDS air conditioning, natural ventilation

#NO 10929 Investigation of the impact of natural ventilation through windows on the thermal comfort.

AUTHOR Zeldler O, Fitzner K

BIBINF Belgium, Proceedings of Clima 2000 Conference, held Brussels, August 30th to September 2nd 1997, paper 126, 11pp, 6 figs.

ABSTRACT Within the framework of the research project SANIREV, the Herman-Rietschel-Institute has made tests on the use of window ventilation. For different roomloads and outdoor conditions the room conditions were determined. Room flow caused by open windows can be calculated using displacement flow methods. The results presented show that an open window can transport cooling loads in summer and interseason. The maximum specific cooling power is 35 W/m². Below 10 Deg. C outdoor temperature thermal comfort can no longer be guaranteed. Opening windows in office buildings has a limited application area. The thermal comfort is more important than the cooling power, in summer a higher temperature is more acceptable as draught in the cool season.

KEYWORDS natural ventilation, window, thermal comfort

#NO 10935 A methodology for the practical assessment of natural ventilation designs in industrial buildings with reference to the indoor thermal comfort.

AUTHOR Rousseau P G

BIBINF Belgium, Proceedings of Clima 2000 Conference, held Brussels, August 30th to September 2nd 1997, paper 163, 11pp, 1 tab, 2 refs.

ABSTRACT The design of natural ventilation devices in industrial buildings is complicated by the nonlinear interaction between the air flow rate and the indoor air temperature. Designs are therefore usually based on relatively simple calculations of the areas of ventilation openings to provide a specified flow rate at a given indoor/outdoor air temperature difference. However, the practical performance testing required for acceptance of the ventilator design still remains a difficult and dubious task. Although detailed integrated simulation tools for naturally ventilated buildings have recently been unveiled, these tools are not yet accessible to practising building services engineers. In this paper a simplified methodology for the practical assessment of natural ventilation designs with reference to the thermal environment in industrial buildings is proposed and successfully applied. The methodology is based on continuous temperature measurements over a period of time combined with simplified predictions of indoor thermal parameters for extreme environmental conditions. In the development of the methodology there is a strong emphasis on its comprehensibility and ease of use by practising building services engineering consultants. Graphical representation of the results ensures easy interpretation of the data. A complete case study with measurements and simulations is presented to illustrate the methodology as it is applied to a caphouse building at a large aluminium smelter.

KEYWORDS natural ventilation, industrial building, thermal comfort

#NO 10936 Natural ventilation and artificial neural networks.

AUTHOR Kindangen J I, Krauss G, Depecker P

BIBINF Belgium, Proceedings of Clima 2000 Conference, held Brussels, August 30th to September 2nd 1997, paper 181, 15pp, 6 figs, 3 tabs, 18 refs.

ABSTRACT This study presents a new method of interior air motion assessment using artificial neural networks. The air motion inside a building depends not only on the external wind velocity, but also to a great extent on most of architectural parameters such as position and orientation of building, size and configuration of windows, roof geometry, whether the building is stilted or not, etc.. The difficulty to evaluate the interior velocity coefficient, a non-dimensional parameter that is the measure of relative strength of the interior air movement, if we would take into account a number of architectural parameters; this encouraged us to use this approach. After presenting the general setting of our work, we introduce the neural networks in describing their main properties and the methods of their implementation. We have applied these ideas to our study and presented the initial obtained results. The utilization of the neural networks as a model-free predictor is a way of interesting investigation which facilitates designers or architects to take into account a number of influential parameters in natural ventilation investigating. Moreover, this allows to assess indoor airflow pattern without doing a costly experiment or running an expensive and complicated flow field simulation code. **Keywords:** architectural parameters, artificial neural networks, interior velocity coefficient, naturally ventilated buildings, humid tropical climate

KEYWORDS natural ventilation, air movement

#NO 10959 Indoor air quality control by a fuzzy reasoning machine in naturally ventilated buildings.

AUTHOR Dounis A I, Bruant M, Guarracino G, et al

BIBINF Applied Energy, Vol 54, No 1, 1996, pp 11-28, 12 figs, 2 tabs, 18 refs.

ABSTRACT This paper investigates the performance of a fuzzy reasoning machine for the control of indoor air quality in naturally ventilated buildings. Simulations have been performed using a new airflow and pollutant transport model, which has been developed and validated for this purpose; CO₂ concentration was used as the indoor air quality (IAQ) index for these simulations. Results have shown that satisfactory IAQ levels can be maintained, while good stability of the control parameter (i.e. window opening area) was achieved. The impact of such a controller on indoor air temperature was also studied. The performances were not a good as expected, but were not negligible when compared with the normal conditions of use of the building.

KEYWORDS natural ventilation, indoor air quality

#NO 8222 A testing time for natural ventilation.

AUTHOR Stevens B.

BIBINF UK, Building Services, November 1994, pp 51-52, 3 figs, 2 refs.

ABSTRACT Describes the findings of recent heat load tests carried out to establish the effectiveness of passive engineering design of the School of the Built Environment at UK's De Montfort University. The tests indicated that the nighttime cooling of the heavyweight structure of the building, coupled with the natural ventilation seems to work well.

KEYWORDS natural ventilation, building design, energy efficiency, cooling, thermal mass, chimney

#NO 8225 Natural ventilation in non-domestic buildings.

AUTHOR Anon

BIBINF UK, Building Research Establishment, BRE Digest 399, October 1994, 8p, 13 figs, 5 refs.

ABSTRACT Gives designers and building users background information and design guidance on using

natural ventilation in energy-efficient non-domestic buildings. Natural ventilation can provide year-round comfort, with good user control, at minimum capital cost and with negligible maintenance. Considers ventilation requirements, general design guidance, mechanisms of natural ventilation, design options, and advises influencing design options.

KEYWORDS natural ventilation, health, energy efficiency

#NO 8272 Making light work

AUTHOR Bunn R.

BIBINF UK, Building Services, November 1994, pp 20-24, 1 fig.

ABSTRACT Describes UK Anglia Polytechnic University's recently completed Learning Resources Centre which has been constructed on a 'design and build' plan with passive solar design and natural ventilation. Considers building layout, life safety issues and mechanical ventilation, which is included if only minimally.

KEYWORDS passive solar design, natural ventilation, building design

#NO 8275 A study of solar chimney assisted wind tower system for natural ventilation in buildings.

AUTHOR Bansal N K, Mathur R, Bhandari M S.

BIBINF UK, Building and Environment, Vol 29, No 4, 1994, pp 495-500, 2 figs, 3 tabs, 8 refs.

ABSTRACT The concept of a solar chimney coupled with a wind tower to induce natural ventilation has been studied analytically in this paper. It is estimated that the effect of a solar chimney is relatively much higher for lower wind speeds. For ambient wind speed of 1.0 m/s. for example, the wind tower alone creates a mass flow rate of 0.75 kg/s only, while the solar chimney assisted system is able to create an air flow up to 1.4 kg/s at 700 W/m² incident solar radiation.

KEYWORDS passive solar design, chimney, wind effects, natural ventilation

#NO 8293 Passive cooling by night ventilation

AUTHOR Maaß J van der, Florentzos F, Rodriguez J-A, Jaboyedoff P.

BIBINF Paper from European Conference on Energy Performance and Indoor Climate, Lyon, 24-26 November 1994, 6 pp, 3 figs. refs.

ABSTRACT A study of passive cooling by natural ventilation is presented. The objective is to improve the understanding of the interaction between natural ventilation and the building thermal inertia and to develop design guidelines for the exploitation of night ventilation techniques. This objective is reached by comparing full scale measurements with both detailed and simplified dynamic simulations. Temperatures have been measured in offices of a massive three level office building for various natural ventilation strategies. Experimental results are discussed in terms of simple design parameters: (i) the neutral pressure level of the building determining the main air flow pattern, and (ii) the thermal effusivity characterizing the thermal inertia of a building zone. The further development of design guidelines for the practical application of natural cooling by night ventilation discussed.

KEYWORDS cooling, ventilation system, natural ventilation, office building

#NO 8659 The potential of natural ventilation and passive cooling alternatives for improving ambient comfort conditions and achieving energy savings. A case study for an educational building retrofit.

AUTHOR Garcia-Chavez J R

BIBINF Israel, The Desert Architecture Unit, J Blaustein Institute for Desert Research, Ben-Gurion University of the Negev, 1994, edited by Y Etzlon, E Erell, I A Meir and D Pearlmuter, proceedings of 11th PLEA International conference, "Architecture of the Extremes", held 3-8 July 1994, Dead Sea, Israel, 79-87.

ABSTRACT Natural ventilation and passive cooling alternatives offer real opportunities for improving the ambient comfort conditions in large educational buildings located in temperate climates of Mexico, whilst reducing the energy consumption due to the use of mechanical systems for space climatisation. This research will examine the potential of natural ventilation and passive cooling alternatives in a library, with an occupancy of 1500 persons. Interviews carried out with users confirmed the unsuitable ambient comfort conditions within the space, which in turn affect their school work activities. The alternatives proposed for investigation consist of a "stack effect" convective air flow system, using existing service ducts; a new fenestration system on the south facade; implementation of an integrated energy efficient lighting system (lamps, luminaires, ballasts and controls); and landscaping design using vegetation, as well as a controlled water stream and a fountain outdoors, for a more favorable microclimate next to the building, thus providing a net precooling effect. Selected plant materials were also integrated indoor, to contribute in the relaxation and well-being of the occupants. It is expected that the alternatives proposed for investigation provide an improvement of the ambient comfort conditions of the occupants, as well as energy savings, with a satisfactory payback period. It is also expected that the results of this work can be useful for other buildings with similar conditions in Mexico.

KEYWORDS natural ventilation, passive cooling, thermal comfort, retrofitting

#NO 9072 Automatic control of natural ventilation and passive cooling.

AUTHOR Martin A

BIBINF UK, Air Infiltration and Ventilation Centre, 16th AIVC Conference Implementing the results of ventilation research, held Palm Springs, USA, 18 - 22 September, 1995, Proceedings Volume 2, pp 359-368.

ABSTRACT The material presented in this paper highlights some aspects of

two research projects, The control of natural ventilation, and Night cooling strategies. The research has led to the development of generic control strategies. These have evolved from consideration of the control strategies used in naturally ventilated buildings utilising Building Management Systems (BMS) control together with experience obtained from monitoring three naturally ventilated buildings. The site monitoring has also led to recommendations being provided for commissioning and fine tuning procedures.

KEYWORDS natural ventilation, cooling, energy efficiency

#NO 9599 Design of the new School of Engineering and Manufacture, de Montfort University, Leicester, UK

AUTHOR Ford, B., Short, A.

BIBINF Health Estate J. December 1994, vol.48, no.10, 10-13, 5 figs.

ABSTRACT Presents an overview of the design of the building with about 100,000m² of accommodation, which provides new laboratories for electrical and mechanical engineering students plus general teaching spaces and two auditoria. Located at the heart of the city centre campus, conventional wisdom would suggest that much of the building should be mechanically ventilated, if not air conditioned. However nearly all the laboratories and teaching spaces are naturally ventilated and daylight, including the two 150-seat auditoria. Describes the development of the design and the environmental strategy incorporated within it from an early stage.

KEYWORDS universities, laboratories, auditoria, ventilation, natural ventilation, lighting

#NO 9602 Passive solar design of the Montessori farm school

AUTHOR Cohen, R.R; Ruysssevelt, P.A. and Abu-ebid, M

BIBINF CIBSE National Conference 1991 Canterbury, 7-9 April 1991, 305-312, 4 figs., 3 tabs.

ABSTRACT Halcrow Gilbert Associates were requested to provide energy design advice at the post outline planning stage for a new Montessori School in Berkshire. Describes the design changes which were adopted to achieve energy savings and improvements to the internal environment. The passive solar features incorporated into the design were an atrium, rooflights in the classrooms and a natural ventilation scheme. Measures to prevent overheating included eave overhangs, blinds and nighttime ventilation. Shows the impact of each design change on energy consumption and environmental conditions and demonstrates the benefits of sophisticated, yet flexible and fast-response design tools which are necessary for a real building project.

KEYWORDS passive, solar energy, schools, energy conservation, atria, skylights, natural ventilation, overheating, blinds, nighttime, ventilation, shade, energy consumption

#NO 9707 Assessing environmental conditions in a naturally ventilated lecture theatre.

AUTHOR Clancy E M, Howarth A T

BIBINF France, Ecole Nationale des Travaux Publics de l'Etat, November 1994, proceedings of the European Conference on Energy Performance and Indoor Climate in Buildings, held Lyon, France, 24-26 November 1994, Vol 3, pp 866-873, 4 figs, 1 tab, 5 refs.

ABSTRACT A program of work involving the measurement of ventilation rates, air velocities and temperatures has commenced within the new Engineering and Manufacture Building, De Montfort University, and some initial results are reported here. Measurements have been recorded for "summer" conditions, average and maximum occupancy levels. Results obtained so far indicate that ventilation rates through one of the theatres are driven by both stack and wind induced effects, and can be much higher than predicted by computer and physical models. Room air temperatures show little variation with time, due to the heavy weight nature of the building structure and its exposed areas. Further work will examine mid-season and winter conditions and will contribute to a design guide for large naturally ventilated spaces.

KEYWORDS natural ventilation, auditorium, indoor climate, ventilation rate

#NO 9783 Natural ventilation in an auditorium: the role of thermal storage in the energy consumption and comfort of De Montfort University auditorium.

AUTHOR Alulfi D, van der Maas J

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 2, pp 291-298.

ABSTRACT Different design problems related with the natural ventilation of an auditorium are discussed and analysed. The results of different dynamical simulations of air temperatures and air flow rates are presented. The influence of the thermal mass and ventilation opening areas for both comfort and energy consumption is discussed. Dynamical thermal simulations are performed over a whole year, and the energy consumption for both ventilation and space heating is taken into account. This allows to compare the energy consumption of the space with either natural or mechanical ventilation using the same conditions of occupancy and climate. For the case of mechanical ventilation, the electricity used for fans and cooling is included as well. Control strategies of the natural ventilation system are discussed and their influence on the indoor climate and energy consumption is shown.

KEYWORDS natural ventilation, auditorium, energy consumption, thermal comfort

#NO 9812 Comparison of measured and calculated environmental conditions for a naturally ventilated auditorium.

AUTHOR Clancy E M, Scholzen F, Howarth A

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96,

held Yokohama, Japan, 17-19 July, 1996, Volume 3, pp 223-230.

ABSTRACT Measurements of ventilation rates, air velocities and temperatures have been obtained for a naturally ventilated auditorium in the Queens Building, De Montfort University, Leicester, UK. Modelling of "winter" conditions in the above space has been carried out using a transient CFD simulation; this has produced values for air temperatures and room air velocities, at different points in time, using external pressure boundary conditions at inlets and outlets. A comparison is made in this paper between the measured and calculated results. This work emphasises the difficulties in modelling large naturally ventilated spaces and the importance of accurate representation of boundary conditions.

KEYWORDS natural ventilation, auditorium, ventilation rate, computational fluid dynamics, stack ventilation

#NO 9958 A passive evaporative cooling system by natural ventilation.

AUTHOR Giabaklou Z, Ballinger J A

BIBINF Building and Environment, Vol 31, No 6, 1996, pp 503-507, 3 figs, 13 refs.

ABSTRACT Evaporative cooling is used extensively for cooling climates with medium to low humidity. In residential buildings the conventional mechanical systems to be both noisy and unsightly. Here a proposal is presented for a passive evaporative cooling system which makes use of natural ventilation at the building facade. The system makes use of the evaporative effect from water falling vertically along guides to produce a reduction in the temperature of the air entering the building. It can also be used as a design element in the building facade. Such a system provided an inexpensive, energy efficient, environmentally benign and potentially attractive cooling system. A numerical study is presented to demonstrate the system efficiency and air flow rate through a building, making use of measured outside wind speed and direction, building geometry and surroundings. The likely effect of the system on the indoor air temperature is discussed; further work is being undertaken to explore the integration of such a system into the building fabric.

KEYWORDS passive cooling, natural ventilation

#NO 10306 Chilled beams in naturally ventilated buildings.

AUTHOR Arnold D

BIBINF UK, CIBSE, 1996, proceedings of CIBSE/ASHRAE Joint National Conference Part Two, held Harrogate, 29 September - 1 October 1996, Volume 1, pp333-338.

ABSTRACT There has been a recent growth of interest in the use of passive cooling in buildings, particularly in the use of chilled ceilings, including both beams and radiant panels. However, there is still concern about the risk of condensation on cold surfaces and water dripping onto occupants or furnishings, especially where there is no control over the level of humidity for instance in naturally ventilated buildings. This paper reports on practical experience gained from the design, installation, commissioning and "running in" of four installations, completed in the early summer of 1995, in different buildings. The paper describes some of the problems encountered, during the "running-in" period and, how they were resolved.

KEYWORDS natural ventilation, passive cooling, condensation, humidity

#NO 10474 Out of Africa.

AUTHOR Smith F

BIBINF UK, HAC, May 1997, pp 16-21.

ABSTRACT Describes the design, construction and operation of a naturally ventilated office building in Harare, Zimbabwe, with extensive use of passive cooling. Harare's climate has average temperature swings of 10-14 Deg. C, so an acceptable inside environment without conventional air

conditioning was considered possible. The building chosen for the experiment was Eastgate, Zimbabwe's largest commercial office and shopping development. The building consists of two narrow, nine storey blocks orientated east/west and separated by a 16m wide covered pavement with a glazed roof 35m above. The long narrow blocks gave the required bulk and good natural lighting possibilities. A combination of in situ concrete and double thickness brick in the exterior walls moderates temperature extremes. The chosen design approach for ventilation was to develop a pattern of air shafts and air voids, integral with the structure, which would allow cool air to enter the building at its base and warm air to discharge at roof level. The building would be cooled by the flow of cool nighttime air drawn through the slightly warmer building. Displacement ventilation was adopted to supply air to the offices during daytime. Energy consumption figures were favourable, showing that Eastgate has a power consumption of 9.1 kWh/m² compared with a sample of six other Harare developments varying from 11 kWh/m² to 18.9 kWh/m².

KEYWORDS natural ventilation, hot climate

#NO 10478 Passive cooling of buildings.

AUTHOR Santamouris M, Asimakopoulou D (eds.)
BIBINF UK, James and James Ltd, 1996, 472pp.

ABSTRACT Provides information on all available passive cooling methods and techniques, their potential effectiveness, their basic principles and the criteria needed to identify those most appropriate for specific types of buildings. Also includes presentations of several easy to use methods that are available for calculation of the cooling potential of the most important techniques, as well as of the overall thermal performance of buildings. The chapters cover cooling in buildings; passive cooling of buildings; the Mediterranean climate; microclimate; urban design; thermal comfort; cooling load of buildings; heat attenuation; natural ventilation; solar control; ground cooling; evaporative cooling; radiative cooling; simplified methods for passive cooling applications.

KEYWORDS passive cooling

#NO 10566 Passive cooling by natural ventilation, salt bath modelling of combined wind and buoyancy forces.

AUTHOR Hunt G R, Linden P F
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 175-184.

ABSTRACT We examine conditions under which the natural forces of wind and buoyancy may be harnessed in order to provide ventilation for cooling. Steady-state, displacement flows driven by combined buoyancy and wind forces are simulated at small scale in the laboratory using a Perspex box to represent a generic room or single-spaced building. Density differences necessary to simulate the stack effect are produced using fresh salt water solutions. Wind flow is simulated by placing the box in a flume tank; the flume produces a flow of water past the box and this flow is used to represent the wind. By measuring salinity and the position of the stratification within the box, equivalent temperature profiles and ventilation flow rates in naturally ventilated buildings are deduced. Results of these experiments are compared with the predictions of a theoretical model. It is shown that if ventilation openings are located so the wind assists the stack-driven flow the ventilation may be significantly enhanced and passive cooling achieved. The cooling capacity of the ventilation system is shown to depend upon the relative magnitudes of the wind and buoyancy produced velocities, the area of the openings and the height of the space. It is shown that by harnessing the wind to assist the buoyancy-driven flow it is possible to i) reduce the temperature of the warm upper layer, ii) increase the depth of the lower layer at ambient temperature and iii) increase the ventilation flow rate.

KEYWORDS cooling, wind effects

#NO 10570 Office night ventilation pre-design tool.

AUTHOR Kolokotroni M, Tindale A, Irving S J
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 213-224.

ABSTRACT NiteCool was developed under the Energy Related Environmental Issues in Buildings (EnREI) DOE Programme and is designed especially for the assessment of a range of night cooling ventilation strategies. The program is based on a single zone ventilation model and is configured to analyse a 10m x 6m x 3m cell of an office building. It is intended to be used at the early stages in the design process to help the designer to make informed decisions on the construction, opening configuration and operation of the building. The user input is restricted to a few parameters from which a weekly internal temperature profile is predicted together with the energy consumption and the peak cooling capacity requirement relative to a reference system (with no night cooling). In this way, various building and system designs can be investigated by manually adjusting parameters until the comfort/energy consumption design criteria are met. The program can also be used to calculate the size of openings required to achieve a certain flow rate under given design conditions. This is a very quick and easy way to investigate the feasibility of using natural ventilation to improve comfort levels in buildings.

KEYWORDS office building, cooling

#NO 10648 Using air flow and comfort analysis to avoid air conditioning in Spain.

AUTHOR Goodwin A, Doggart J
BIBINF France, Centre Scientifique et Technique du Batiment, proceedings of the Second International Conference on Buildings and the Environment, held Paris, June 9-12 1997, Volume 2, pp 437-444.

ABSTRACT New office buildings in Spain are nearly always designed to be air conditioned. The architect Emilio Miguel Mitre Associates (EMMA) has designed a building which avoids air conditioning, thereby reducing energy demand. The design uses the principles of high thermal mass combined with night ventilation, reduction of solar gain during the summer months, high levels of insulation, evaporative cooling, and buried pipes to provide cooling when the external temperature rises above 30 C. ECD Energy and Environment were commissioned to investigate the effects of these measures on the predicted internal temperatures and energy consumption using the computer simulation package, TAS. The analysis showed the internal temperatures will be acceptable when external temperatures are below 30 C. When temperatures rise above 30 C the cooling effect of the air which has passed through the buried pipes will be effective in keeping the internal temperatures below 30 C. It was also demonstrated that the predicted energy consumption of the building will be less than one quarter of its air conditioned equivalent.

KEYWORDS air flow, thermal comfort, natural ventilation

#NO 10731 Solar building study. Gateway Two - summary report.

AUTHOR Anon
BIBINF UK, Energy Technology Support Unit, ETSU S 1160/SBS/11, 8pp.

ABSTRACT Total annual fuel use for the building, including the atrium, was satisfactory at 194 kWh/m² GFA. Reduction of an unnecessarily high nighttime electricity use would improve this. Space heating of the offices at 81 kWh/m² was very good in comparison with performance indicators. Natural ventilation via the atrium provides an adequate fresh air exchange rate to the offices. Summertime overheating is largely avoided by a combination of natural ventilation and high thermal mass. The atrium is well liked both aesthetically and as an amenity, adding to the building's overall appeal. The building cost £584/m² which

compares well with references. The incorporation of an atrium did not increase the overall building cost whilst removing the need for expensive HVAC.

KEYWORDS passive solar building, atrium, thermal mass, natural ventilation

#NO 10879 Natural cooling techniques.

AUTHOR Santamouris M

BIBINF In: Workshop on Passive Cooling, held Ispra 2-4 April 1990, edited by E Aranovitch, E de Oliveira Fernandes, T C Steemers, pp 143-153, 15 figs, 61 refs.

ABSTRACT This paper presents the state of the art on the natural cooling techniques. The development on the evaporative, radiative and earth contact cooling techniques and components is discussed. A classification of the existing systems and techniques is attempted and the knowledge on the more important of them is presented. Advantages and disadvantages of the classified systems are evaluated and their suitability for European climates is discussed. The lack of information as well as the existing scientific gaps on the subject are identified. Finally, future research actions are proposed for each topic.

KEYWORDS cooling, natural ventilation

#NO 8235 On the energy consumption and indoor air quality in office and hospital buildings in Athens, Hellas.

AUTHOR Argiriou A, Asimakopoulos D, Balaras E, Dascalaki E, et al.

BIBINF UK, Energy Conser.. Mgmt, Vol 35, No 5, 1994, pp 385-394, 11 figs, 1 tab, 11 refs.

ABSTRACT Energy audits and a parallel investigation of indoor air quality in 30 air-conditioned and naturally ventilated office buildings in Athens, as well as a hospital building, have been underway since 1990. These audits have been conducted for the first time in Hellas and include information on the buildings' energy consumption, indoor and outdoor air quality, employee health symptoms and comfort conditions. The results indicate that there are serious IAQ problems in office buildings, which have been found to be the direct cause for a number of employee health problems related to the working environment. Preliminary measurements of NO₂ in the indoor environment of a hospital show that the concentrations do not exceed the WHO limit values. Energy audits Indoor air quality Health symptoms Comfort Nitrogen dioxide and sulphur dioxide measurements.

KEYWORDS energy audit, health, human comfort

#NO 8307 Experimental and numerical study on natural ventilation of atrium buildings

AUTHOR Guntermann Klaus

BIBINF Poland, Silesian Technical University, 1994, proceedings of Roomvent '94: Air Distribution in Rooms, Fourth International Conference, held Krakow, Poland, June 15-17, 1994, Volume 1, pp 235-244.

ABSTRACT Construction of atrium buildings becomes more and more popular. In cities shopping centres and office buildings are connected and have their access via these atrium buildings. The major purpose of these buildings is a protection against outdoor climate, i.e. wind, rain, snow, and extreme temperatures in winter, increasing the comfort standard of the building environment. In Germany these glazed buildings usually do not have mechanical ventilation systems. Natural ventilation is provided by openings in the facade and the ceiling area of the atrium building. Performance, size and location of these openings primarily influence the ventilation effectiveness. A combined study of experimental investigations and numerical simulations provide a comprehensive information in the design phase. The study will be introduced and explained by examples.

KEYWORDS natural ventilation, atrium, ventilation effectiveness

#NO 9137 Natural ventilation in atria.

AUTHOR Anderson K T

BIBINF USA, Ashrae Transactions, 1995, Vol 101, Pt 2, preprint, 9pp, 9 figs, refs.

ABSTRACT Natural ventilation by thermal buoyancy and wind is very suitable for the ventilation of atria, provided the geometry and the openings are well designed to fulfill required ventilation rates and control needs. This paper presents a set of formulas for determining air velocities, temperature differences, and ventilation capacity in relation to openings, heat loads, and building geometry. Optimal opening areas, the influence of temperature stratifications, threshold values for the opening ratios, as well as control strategies are discussed. The set of formulas constitutes an easy-to-use design method that can be programmed as an independent computer program or be integrated into a simplified building energy simulation program.

KEYWORDS natural ventilation, atrium

#NO 9416 Air movement simulation of natural ventilation in a new administration building with two atria.

AUTHOR Ho C

BIBINF H and V Engineer, Vol 68, No 725, 1995, pp 5-7, 11, 5 figs.

ABSTRACT This paper discusses a recent consultancy project for a large public company. The company had taken the bold and admirable step of deciding to design a new administration building without air conditioning systems. The natural ventilation had still to provide an acceptable working environment and not overly restrict the use of the building in terms of partitioning and layout.

KEYWORDS air movement, simulation, natural ventilation, atrium

#NO 9597 A monitoring exercise for a school atrium

AUTHOR Penz, F.

BIBINF Appl.Energy 1986, vol.22, no.1, 1-13, 13 figs, 1 tab, 2 refs.

ABSTRACT Describes an investigation by the Martin Centre for Architectural and Urban Studies into the potential of improving buildings by glazing over existing courtyards and lightwells. The aim was to increase current knowledge of the environmental performance of glazed courts to reveal the potential of existing courts. Part of the study involved monitoring a primary school fitted with a glazed courtyard. Presents an analysis of the temperature recorded in the atrium space and the adjacent classes. Discusses the phenomenon of stratification as well as the effect of natural ventilation on overheating.

KEYWORDS Monitoring, atria, schools, glazing, thermal comfort

#NO 9815 Natural ventilation in atria - a case study.

AUTHOR Svdt K, Heiselberg P, Hendriksen O J

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 3, pp 247-254.

ABSTRACT This case study comprises a monitoring programme as well as a Computational Fluid Dynamics (CFD) analysis of a natural ventilated atrium. The purpose has been to analyse the performance of a typical natural ventilation system in Denmark under both summer and winter conditions. The monitoring programme consisted of measurements in two short-term periods under summer and winter conditions, respectively. Vertical temperature distribution, surface temperatures, air change rates and thermal comfort conditions were measured. CFD simulations

were carried out in the same cases. The influence of the inlet opening position and the solar radiation on thermal comfort and ventilation capacity were also investigated. The results showed a well working natural ventilation system under both winter and summer conditions. The results also showed that CFD simulation was a useful tool to predict the performance of the system.

KEYWORDS natural ventilation, atrium, computational fluid dynamics

#NO 9978 Air movement in naturally ventilated buildings.

AUTHOR Awbi H B

BIBINF Pergamon, 1996, "Renewable Energy", proceedings of the World Renewable Energy Congress, held Denver, Colorado, USA, 15-21 June 1996, Volume 1, pp 241-247.

ABSTRACT The air movement and the distribution of CO₂ in naturally ventilated office room and an atrium is investigated using computational fluid dynamics. The results show that natural ventilation is capable of achieving acceptable CO₂ levels. Adequate comfort levels could also be achieved for a typical UK summer climate in both types of buildings. Both wind-driven and buoyancy-driven flows are considered.

KEYWORDS natural ventilation, air movement, carbon dioxide, cross ventilation

#NO 10327 A review of physical modelling techniques to aid in the design of natural ventilation building components.

AUTHOR Swainson M K, Batty W J

BIBINF UK, CIBSE, 1995, National Conference '95, Eastbourne, 1-3 October 1995, Volume 2, pp 158-165.

ABSTRACT Current trends towards the natural ventilation of buildings have led to the adoption of both atria and chimneys. In order for them to be effective a detailed understanding of the physical processes involved is required. To this end the use of physical models has been employed. However, at present most models assume similarity of the flows through an assumption of high levels of turbulence, thus allowing boundary layer flows to be ignored. When turbulence cannot be globally assumed, then either full scale models or reduced scale models with alternative working fluids must be employed. Previous use of CFC based refrigerant gases in reduced scale models is now unacceptable on environmental grounds and the new HCFC and HFC gases have been investigated as potential replacements. From the data presently available only moderate scale reductions are possible while maintaining both thermal and dynamic similarity.

KEYWORDS natural ventilation, modelling, building component

#NO 10466 Squaring two circles.

AUTHOR Fie J

BIBINF UK, Building Services Journal, April 1997, pp 18-22, 1 tab, 3 refs.

ABSTRACT Describes the new Barclaycard office building designed to operate with natural ventilation. It has a "street" atrium and offices 15m deep, with careful attention to daylighting. An average loading of 15 W/m² internal gains prompted a naturally ventilated design. In addition, integrated "service beams" were used instead of suspended ceilings, incorporating chilled water coils, luminaires, occupancy sensors, smoke detectors and sprinkler pipework. The chilled beam system permits the use of medium temperature cooling water from the site's man made lake.

KEYWORDS office building, natural ventilation, atrium, cooling ceiling

#NO 8340 Partition effect on room ventilation

AUTHOR Cao Quingsan, He Xiaohua G.

BIBINF Poland, Silesian Technical University, 1994, proceedings of Roomvent '94: Air Distribution in Rooms, Fourth International Conference, held Krakow, Poland, June 15-17, 1994, Volume 2, pp 277-298.

ABSTRACT Environmental concern and escalating energy cost is increasingly demanding for proper use of natural ventilation to provide thermal comfort. This paper presents a wind tunnel experiment studying the effect of interior partition on natural cross-ventilation by directly measuring air velocity and turbulence distributions inside a scaled

model. The result demonstrates that manipulating the configuration of internal partitions, as a less expensive alternative to many other architectural configurations, can significantly modify the effect of cross-ventilation and thermal comfort condition. Particularly, compared to traditional solid-wall configurations, open-plan configuration with partial height partitions remarkably improves internal airflow distribution and occupant's thermal comfort inside a naturally ventilated building in hot climate.

KEYWORDS partitioning, natural ventilation, hot climate, thermal comfort, wind tunnel, cross ventilation

#NO 8622 Cross-ventilation and room partitions: wind tunnel experiments on indoor airflow distribution.

AUTHOR Quingsan Cao, Xiaohua G He

BIBINF USA, ASHRAE Transactions, Vol 99, Part 2, 1993, pp 208-219.

ABSTRACT Environmental concerns and escalating energy costs are creating a demand for proper use of natural ventilation to provide thermal comfort. This paper presents the results of wind tunnel experiments studying the effect of interior partitions on natural cross-ventilation by directly measuring air velocity and turbulence distributions inside a building model. The results demonstrate that manipulating the configuration of internal partitions, as a less expensive alternative to many other architectural configurations, can significantly modify the effect of cross-ventilation and thermal comfort conditions. Particularly compared to traditional solid-wall configurations, open-plan configurations with low partitions improve internal airflow distribution and occupants' thermal comfort inside a naturally ventilated building in a hot climate.

KEYWORDS cross ventilation, partitioning, wind tunnel, air distribution

#NO 9598 A lesson in school building

AUTHOR Brister, A.

BIBINF Bldg. Serv. CIBSE J, May 1994, vol.16, no.5, 16-20, 2 figs, 1 tab.

ABSTRACT Describes the new, 6.3 million pounds John Cabot City Technology College near Bristol. The school, which houses 900 pupils, had to meet design criteria laid down by the Department for Education's (DfE) Design Note 17 plus certain requirements from Cable and Wireless, such as information technology links with its own recently completed training college in Coventry. Deals with the service strategy of avoiding complex equipment, using systems of proven technology with low maintenance requirements and maximising the use of natural light and ventilation. Notes the use of blinds, cross-ventilation with ventilating 'chimneys' at ceiling level, and heating by radiators with low temperature hot water and underfloor heating for the main hall. Describes the heating plant and electrical services, with lighting above DfE guidance levels. Illustrates diagrammatically the environmental strategies for different parts of the building and summarises important facts about the building in a table.

KEYWORDS Schools, natural ventilation, designing

#NO 9789 Natural ventilation in a long-span wooden dome with a membrane roof.

AUTHOR Takemasa Y, Hayakawa S, Togari S, Sakura I

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 2, pp 351-358.

ABSTRACT Recent days have seen growing expectations for energy conservations to protect the global environment. Natural energy has been utilized in many kinds of buildings, and a multi-purpose dome need not be an exception. This report describes the results of summer and winter thermal environment measurements in a long-span wooden dome with a membrane roof located in the northwest of Japan. This report discusses in detail the effects of natural cross

ventilation in the summer and the utilization of daylight transmitted by the membrane roof. The measurement results indicate that utilization of natural energy helps conserve energy.

KEYWORDS natural ventilation, roof, cross ventilation, energy conservation

#NO 9814 The natural ventilation of an enclosure by the combined effects of buoyancy and wind.

AUTHOR Hunt G R, Linden P F

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 3, pp 239-246.

ABSTRACT This paper describes an innovative study in which small-scale laboratory experiments and simple theoretical models examine natural ventilation by the combined effects of stack and wind and are used to predict the airflow and temperature stratification within an enclosure under a wide range of climatic conditions. In the present experiments a Perspex tank of rectangular cross-section is suspended in a flume. The flume produces a controllable, steady horizontal flow which is used to model the wind. A number of openings in the tank both at high/low levels and on windward/leeward faces allow a wide range of generic ventilation flows to be examined. In this paper two main ventilation flows have been identified: i) those where the buoyancy and wind forces reinforce one another and ii) those where the buoyancy and wind forces oppose one another. The experiments have shown that the type of ventilation flow observed, ie. whether displacement or mixing, is critically dependent upon the relative magnitudes of the wind and buoyancy forces as well as upon the size and location of the openings. Some of the implications of the flows to the natural ventilation of enclosures are discussed.

KEYWORDS natural ventilation, wind effects

#NO 1021 The effects of reduced ventilation on indoor air quality in an office building.

AUTHOR AUTHOR Turle I, Holloway C D, Miksch R R.
BIBINF BIBINF Report No. LBL-10479 May 1981 48pp. 10 figs. 9 tabs. 11 refs. #DATE 01:05:1981 in English

ABSTRACT **ABSTRACT** Describes the monitoring of indoor air quality in a San Francisco office building where occupants had registered eye, nose and throat irritation complaints. Data was taken under two different ventilation rates. Carbon dioxide concentrations increased as the ventilation rate decreased, odour perceptibility increased slightly at the lowest ventilation rate, and other pollutants generally showed very low concentrations, which increased when ventilation was reduced. In no case, however, did levels exceed current healthstandards for outdoor air, nor was any one contaminant found to be responsible for the medical symptoms reported by occupants.

KEYWORDS **KEYWORDS** pollution, air quality, health, carbon-dioxide, carbon-monoxide, organic compound, nitrogen oxides, office building, odour,

#NO 8392 Passive cooling by night ventilation

AUTHOR Van der Maas J, Florentzou F, Rodriguez J-A.

BIBINF France, Ecole Nationale des Travaux Publics de l'Etat, November 1994, proceedings of the European Conference on Energy Performance and Indoor Climate in Buildings, held Lyon, France, 24-26 November 1994, Vol 2, pp646-651.

ABSTRACT A study of passive cooling by natural ventilation is presented. The objective is to improve the understanding of the interaction between natural ventilation and the building thermal inertia and to develop design guidelines for the exploitation of night ventilation techniques. This objective is reached by comparing full scale measurements with both detailed and simplified dynamic simulations. Temperatures have been measured in offices of a massive three level office building for various natural ventilation strategies. Experimental results are

discussed in terms of simple design parameters: (i) the thermal effusivity characterizing the thermal inertia of a building zone. The further development of design guidelines for the practical application of natural cooling by night ventilation is discussed.

KEYWORDS passive cooling, natural ventilation, office building

#NO 8546 Point of Law

AUTHOR McLaughlin T

BIBINF UK, Building Services, February 1995, pp 17-20, 4 figs, 1 ref.

ABSTRACT Describes a naturally ventilated magistrates courthouse in Fareham, UK, designed with low energy principles in mind. The design is minimalist with the emphasis on natural lighting and vandal-proof decor.

KEYWORDS energy conservation, natural ventilation, public building

#NO 8760 Natural ventilation of car parking buildings. Natuurlijke ventilatie van parkeergarages

AUTHOR Kornaat W.

BIBINF Netherlands, TVVL Magazine, No 4, 1995, pp 28-31, 3 figs, in Dutch.

ABSTRACT Car park buildings have to be properly ventilated to remove exhaust gases. Unjustly natural ventilation often is regarded to be insufficient. This article deals with the advantages of natural ventilation. With air movement modules the effect of a natural ventilation system can be made understandable and the design can be ameliorated. The ventilation and the flow rate of a car park building can be determined, advancing the applicability of natural ventilation.

KEYWORDS garage, motor vehicle, natural ventilation, pollutant

#NO 8828 Ventilation conditions in modern naturally ventilated single family houses

AUTHOR Bergsec N C.

BIBINF Denmark, TFVVS Danvak, Vol 30, No 10, August 1994, pp 57-60, 4 figs, 2 tabs, in Danish.

ABSTRACT States that based on the need for more certain knowledge of the ventilation and moisture conditions in modern, naturally ventilated single-family houses, the Danish Building Research Institute has carried out a nationwide questionnaire investigation and has conducted measurements in around 150 occupied houses. The aim was to establish an improved basis for the preparation of regulations and guidelines on appropriate ventilation for single family houses. Presents selected results and discusses them.

KEYWORDS natural ventilation, residential building, moisture, questionnaire

#NO 8859 Naturally ventilating UK non-domestic buildings: status and future policy

AUTHOR Perera M D A E S, Shaw M R, Treadaway K.

BIBINF Canada, proceedings Indoor Air Quality, Ventilation and Energy Conservation in Buildings, Second International Conference, held May 9-12, 1995, Montreal, edited by Fariborz Haghighat, Volume I, pp273-280.

ABSTRACT Increased concern over the adverse environmental impact of energy use has encouraged the design and construction of energy efficient buildings, and many are suited to natural ventilation. In the temperate UK climate, naturally ventilated buildings can provide year round comfort, with good user control, at minimum capital cost and with negligible maintenance. The principle of good ventilation design is to build tight - ventilate right. That is, to minimise uncontrolled (and, usually unwanted) infiltration by making the building envelope airtight, while providing adequate fresh air ventilation in a controlled manner. It is necessary to emphasise that a building cannot be too tight - but it can be underventilated. This paper shows that there is considerable scope for making UK buildings tighter and indicates the level of benefits that will

accrue. UK activity in this area is identified, including proposed statutory control in the form of revised Building Regulations for England and Wales, which will address issues of tightness for the first time. Information is available on ventilation requirements necessary to satisfy safety and health criteria. However, criteria relating to comfort, especially those associated with odour, metabolic CO₂, and summer overheating are still being investigated. This paper sets out current thinking in this area, including policies relating to minimising effects of tobacco smoking in public and commercial buildings. The paper concludes by identifying currently available UK design guidance natural ventilation. Various instruments which are underpinning these changes, such as revisions to the Building Regulations for England and Wales, codes and standards professional guidance and support for policy-interests are identified. **KEYWORDS** natural ventilation, energy efficiency, thermal comfort

#NO 8931 Design considerations for naturally ventilated buildings.

AUTHOR Awbi H B

BIBINF UK, Renewable Energy, Vol 5, Part II, 1994, pp 1081-1090, 6 figs, refs.

ABSTRACT This paper discusses the parameters which should be considered in designing natural ventilation systems and presents a procedure for calculating the air flow rate due to wind and buoyancy. examples are given of systems using solar-induced ventilation which could have applications in ventilating commercial buildings.

KEYWORDS natural ventilation, building design, solar heating, air flow

#NO 9033 Natural and low energy cooling in buildings.

AUTHOR Anon

BIBINF Greece, Centre for Renewable Energy Sources, May 1994, EC Directorate-General for Energy (DG XVII) A Thermie Programme Action, 20pp, 40 figs, 1 tab, 11 refs.

ABSTRACT Describes alternative methods of cooling buildings to reduce the excessive use of energy consuming air conditioning. In comparison to passive solar heating, natural cooling has only recently become the object of research and development as cooling was not a top priority in most northern developed countries. The aim of this brochure is the dissemination of existing knowledge and the demonstration of successful components or case studies. The various passive or low energy cooling technologies fall into two main categories: those that protect the building via design measures or special components that limit or moderate the solar and thermal gains; and those that reject the excess heat to an environmental heat sink. In many cases a natural method on its own may not satisfy the needs of a whole building and so a mixed strategy may be required. Considers heat prevention, heat dissipation, developments and tools, evaluation and seven case studies.

KEYWORDS cooling, natural ventilation

#NO 9093 Natural ventilation with heat recovery.

AUTHOR Schultz J M, Saxhof B

BIBINF UK, Air Infiltration Review, Vol 15, No 4, September 1994, pp 9-12, 4 figs, 1 tab, 3 refs.

ABSTRACT This paper presents a research project, of which the primary goal was to investigate the possibilities of designing a natural ventilation system with heat recovery solely driven by the indoor-outdoor temperature difference. The theory used for design of a prototype system and the prototype itself is described as well as the measured performance. The project has shown that it is possible to design a natural ventilation system solely driven by the difference between the temperature indoors and outdoors with a heat recovery efficiency of 40-45%.

KEYWORDS natural ventilation, heat recovery, temperature difference

#NO 9304 Energy demonstration CEE-AERECO . Natural humidity driven ventilation for existing

buildings. Demonstration energie CEE-AERECO: ventilation naturelle hygroreglable pour l habitat existant.

AUTHOR Jardinier P

BIBINF France, Agence de l Environnement et de la Maitrise de l Energie, (ADEME) 1995, proceedings of Ventilation des Batiments: Etat des lieux - Prospective , held Sophia Antipolis, 25-26 October 1995, organised by GEVRA, Groupe d Etude sur la Ventilation et le Renouveaulement d Air, pp 160-171.

ABSTRACT A detailed experiment was undertaken devoted to natural ventilation en existing buildings and more particularly to the process of humidity driven natural ventilation. On three experimental sites, 30 residences equipped with humidity driven system and 30 ventilated according to local regulations were subjected to comparative measurements on ventilation losses and on air quality during tow heating periods 1988-89 and 1989-90. The results have enabled the authors to check the foundation of the hypotheses which the following concept rests on: the correlations between wind speed, outdoor temperature and humidity show that humidity driven ventilation can be a good solution. The correlations between the developments of humidity levels and carbon dioxide levels inside buildings show that humidity can be considered a satisfactory indicator of the need for air renewal. Recommendations are made to adjust the characteristics of the products to actual conditions of use. A large part of the knowledge obtained has not been considered, and the authors offer a set of diskettes which allow us to further consider the limits of natural ventilation and the differences between ordinary and humidity driven systems.

KEYWORDS humidity control, ventilation system, natural ventilation

#NO 9316 Studies of natural ventilation within the framework of the PASCOOL project. Etudes de la ventilation naturelle dans la cadre du projet PASCOOL.

AUTHOR Limam K, Allard F, Santamouris M

BIBINF France, Agence de l Environnement et de la Maitrise de l Energie, (ADEME) 1995, proceedings of Ventilation des Batiments: Etat des lieux - Prospective , held Sophia Antipolis, 25-26 October 1995, organised by GEVRA, Groupe d Etude sur la Ventilation et le Renouveaulement d Air, pp 313-321.

ABSTRACT The study outlined here concerns natural ventilation, and falls within the framework of the PASCOOL programme. This research project includes experiments as well as modelling work aimed at filling the gaps in knowledge which persist vis a vis natural ventilation in buildings. Experiments and tests an a large scale have taken place during the summer periods 93 and 94 in various European countries. Develops and validates existing models. In addition, calculation tools to predict ventilation are developed.

KEYWORDS natural ventilation, modelling, calculation techniques, ventilation rate

#NO 9400 Flow loss caused by heat-pipes in natural ventilation stacks.

AUTHOR Shao L, Riffat S B, Whittle J K

BIBINF UK, University of Nottingham, Institute of Building Technology, 1995, 17pp, 5 figs, 2 refs.

ABSTRACT Natural ventilation systems assisted by passive stacks are currently designed without incorporating heat recovery leading to wasteful heat loss. Heat recovery is not used because the pressure loss caused by a conventional heat exchanger is large and could cause the ventilation system to fail. The heat pipe promises higher capacity because it has much higher thermal conductance than conventional heat exchangers. Individual heat pipes can be independently located in ventilation stacks, making it easier to achieve lower pressure drops. Experimental results show that for a heat recovery efficiency of 50% and stack flow speed of 0.5 m/s, the pressure loss across an existing type of

heat-pipe assembly is about 1 Pascal. Computer simulation of pressure and flow loss caused by heat-pipes was carried out using computational fluid dynamics. It has been shown that heat-pipes located at the bottom of the stack produce greater insertion flow loss (IFL) than those located at the top and heat pipes next to the stack walls give rise to less IFL than those in the centre. Furthermore, it has been shown that the IFL is the preferred indicator. The temperature of the heat pipe has little effect on flow loss performance of the heat exchangers.

KEYWORDS stack effect, heat loss, natural ventilation

#NO 9528 Canterbury conviction.

AUTHOR Anon

BIBINF UK, Building Services, January 1996, pp 18-22, 2 refs.

ABSTRACT Reports on Canterbury Combined Court Centre where passive design techniques are used, marking a return to naturally ventilated law courts.

KEYWORDS passive ventilation, natural ventilation

#NO 9566 Air quality monitoring in hospital departments: Influence of outside pollutants and inside human activities on global hospital air quality.

AUTHOR Basillco S, Rubino F M, Bernazzani G, Bocchi G, Colombi A, Ronchin M, Occhipinti E

BIBINF Healthy Buildings 95, edited by M Maroni, proceedings of a conference held Milan, Italy, 10-14 September 1995, pp 1055-1060, 3 figs, 4 refs.

ABSTRACT In order to investigate the factors influencing air quality inside hospitals, the concentration of atmospheric gases and of pollutant vapours was monitored in air-conditioned and naturally ventilated hospital buildings located in urban areas with different vehicular traffic density. The quality of inside air is strongly dictated by outside pollution, the latter mainly depending on hospital position with reference to automotive sources, as far as showed by measured CO and CO₂ time profiles. CO₂ indoor pollution is mainly dependent from human presence and its effect is particularly relevant in conditions of crowding and insufficient ventilation of environments, where CO₂ build-up higher than 3500 mg/m³ can cause subjective discomfort. Indoor pollution from volatile organics can be traced to peculiar sources and is characteristic of hospital activities, with respect to other collective buildings, mainly due to the extensive use of cleaning products and sanitary auxiliaries.

KEYWORDS hospital, pollutant, indoor air quality, carbon dioxide

#NO 9635 Natural ventilation in the United Kingdom: design issues for commercial and public buildings.

AUTHOR Perera M D A E S, Gilham A V, Clements-Croome T D J

BIBINF UK, Building Serv Eng Res Technol, Vol 17, No 1, 1996, pp 1-5, 2 figs, 15 refs.

ABSTRACT The principle of good design for natural ventilation is to "build tight - ventilate right". A building cannot be 'too tight', but it may be under-ventilated. There is considerable scope for making UK buildings tighter. However, simpler techniques need to be developed (especially in large non domestic buildings) to identify envelope tightness and associated leakage paths. Also guidance needs to be provided on constructing tighter envelopes. Studies necessary to assess the implication of tighter buildings are described. Sufficient information is available on ventilation requirements necessary to satisfy safety and health criteria. However, criteria relating to comfort, especially those associated with odour, metabolic CO and summer overheating need to be investigated. The paper also discusses minimising the effects of tobacco smoke and controlling other internally generated pollutants. Guidelines for natural ventilation design may conflict with other design or climate-responsive strategies, future work should address this, and address issues such as ventilation openings (to provide both "background" and "rapid"

ventilation) and design for deeper, naturally ventilated buildings.

KEYWORDS natural ventilation, commercial building, public building, air leakage

#NO 9675 Probe 5.

AUTHOR Standeven M, Cohen R

BIBINF UK, Building Services J, June 1996, pp 35-39, 3 refs.

ABSTRACT Post-occupancy review of the Uk Cable and Wireless College. Considers service issues, natural ventilation performance, lighting and control, restaurant and eating areas, energy issues, and occupancy issues.

KEYWORDS occupancy effects, natural ventilation

#NO 9784 Natural ventilation caused by stack effect in large courtyard of high-rise building.

AUTHOR Kotani H, Narasaki M, Sato R, Yamanaka T

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 2, pp 299-306.

ABSTRACT In the large courtyard of high-rise residential buildings, the exhaust from the kitchen, and the gas water heater, is sometimes discharged into the public corridors, which can pollute the air. The exhaust heat caused the stack effect, so the outdoor air flows through the openings at the bottom of the courtyard to the top. The purpose of this study is to describe these ventilation characteristics and to predict the airflow rate for removing the pollutants. Firstly, model experiments were conducted to know the temperature distribution and airflow rates. The result showed that the characteristics are influenced by the size of the bottom opening area and the position of heat sources. Secondly, the comparison between mathematical calculation and experimental data were nearly in agreement, except for some inconsistencies at the top of the courtyard. This was due to the air down flow, when the bottom opening area was not large enough.

KEYWORDS natural ventilation, stack effect, courtyard, high rise building

#NO 9810 Natural ventilation of enclosures with multiple point sources or a vertically distributed source of buoyancy.

AUTHOR Cooper P, Linden P F

BIBINF Japan, proceedings of the 5th International Conference on Air Distribution in Rooms, Roomvent '96, held Yokohama, Japan, 17-19 July, 1996, Volume 3, pp 203-210.

ABSTRACT ABSTRACT

This paper describes research into the flow and stratification in naturally ventilated rooms containing either point sources of heat or a distributed source of heat on one vertical wall. Plumes from point sources on the floor of the room with vents at the top and bottom produce a vertical density profile consisting of several distinct, fully mixed layers. The paper includes a summary of a theoretical model that predicts the depths and densities of these layers. The positions of the interfaces between the layers are found to be function only of the effective area, A, of the enclosure openings the height of the enclosure, H, and the ratios of the strengths of the two sources of heat. The theoretical approach has been validated using water-filled scale models. In the case where one wall of the room is uniformly heated a multiple-layer stratification also develops.

KEYWORDS natural ventilation, air flow

#NO 9873 Natural ventilation design for a concert hall.

AUTHOR Cohen R R, Davies R M, Standeven M A

BIBINF UK, Air Infiltration and Ventilation Centre, (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 2, held 17-20 September 1996, Gothenburg, Sweden, pp 467-475.

ABSTRACT This paper describes the ventilation analysis undertaken during the design of a new music centre for which it was desired to avoid the use of air conditioning and conventional ducted mechanical ventilation. The main objective was to predict the thermal comfort of occupants in the centre's main auditorium during summertime performances. The analysis was done using computational fluid dynamics (CFD) and a dynamic thermal model. The CFD results were used to decide the size and location of openings for natural ventilation, which led to the final design having a much better distribution of incoming fresh air than the initial design. The peak fresh air ventilation rate was reduced, but this did not significantly increase the risk of summertime overheating. The dynamic thermal analysis predicted that the time when the temperature would be over 25 degrees C ranged from 0.3 performance hours/year with a dense concrete roof construction and an orchestra of 30 to 3.5 performance hours/year with a lightweight roof and an orchestra of 100. Given that the larger orchestra would not be formal and so could wear lighter clothing, it was concluded that natural ventilation should be a viable strategy for controlling the risk of summertime overheating. However, given uncertainties regarding the usage of the space and UK summertime temperatures in the future, it was recommended that provision was made in the design to enable mechanical cooling to be added at a later date.

KEYWORDS natural ventilation, building design, auditorium, large building

#NO 9887 Wind towers - old technology to solve a new problem.

AUTHOR Harris D J, Webb R S

BIBINF UK, Air Infiltration and Ventilation Centre, (AIVC), 1996, proceedings of 17th AIVC Conference, "Optimum Ventilation and Air Flow Control in Buildings", Volume 2, held 17-20 September 1996, Gothenburg, Sweden, pp 613-621.

ABSTRACT Wind towers (scoops situated on the roofs of buildings to catch the wind) have been in use for centuries in the Middle east and Pakistan, to provide ventilation and cooling with minimal mechanical plant. In Europe, the problem of cooling buildings has generally not been significant, but in recent years there has been a trend towards substantial increases in internal heat gains from IT equipment etc and overheating in summer has become one of our major concerns. This has been dealt with by the use of air conditioning, but in many instances this could be avoided by making better use of natural ventilation through wind towers. This paper reviews the use of wind towers for cooling spaces, and reports on work currently being carried out, using wind tunnel tests on scale models, to examine the adaptation of these principles for use in modern office buildings, in order to avoid expensive air conditioning.

KEYWORDS wind effects, ventilation system, cooling, wind tunnel tests

#NO 10029 Pressure and flow loss in natural ventilation stacks due to insertion of heat pipes for heat recovery.

AUTHOR Shao L, Riffat S B

BIBINF Indoor Air '96, proceedings of the 7th International Conference on Indoor Air Quality and Climate, held July 21-26, 1996, Nagoya, Japan, Volume 1, pp 871-876.

ABSTRACT Study of pressure and flow loss caused by heat-pipes for heat recovery was carried out using computational fluid dynamics. It has been shown that heat-pipes located in the bottom of the stack produce greater insertion flow loss (IFL) than those located at the top. In addition, heat-pipes located next to the stack walls give rise to less IFL than those placed in the centre. The results also showed that a smaller insertion pressure (IPL) caused by a heat-pipe corresponds to a greater IFL and vice versa. It has been demonstrated that IFL is the preferred indicator for loss caused by obstacles submerged in stack flows. The temperature of the heat pipe has little effect on flow loss performance of the heat exchangers.

KEYWORDS stack effect, natural ventilation, heat recovery

#NO 10077 Development of a natural ventilation system using a pitched roof of breathing walls.

AUTHOR Sugawara M, Hoyano A

BIBINF Indoor Air '96, proceedings of the 7th International Conference on Indoor Air Quality and Climate, held July 21-26, 1996, Nagoya, Japan, Volume 3, pp 717-722.

ABSTRACT Numerical simulations are carried out to evaluate the employment of a newly proposed natural ventilation system which uses a pitched roof made of Breathing Walls. The system was developed to provide sufficient ventilation for obtaining a healthy/comfortable indoor independent of other architectural elements of a house, i.e. side walls, floor members, etc. Simulation results based on typical weather climate in Tokyo, Japan showed that a pitched roof of 6-cm-thick Breathing Walls containing 11 perforated aluminum foil sheets provide 0.5 air changes per hour, and that the equivalent thermal transmittance is 0.34 and 0.38 W/m squared degrees C providing that no internal condensation occurs at the maximum wind speed of 10 m/s.

KEYWORDS natural ventilation, roof, wall

#NO 10121 Salt bath modelling of air flows.

AUTHOR Hunt G, Linden P, Kolokotroni M, Perera E

BIBINF UK, Building Services, January 1997, pp 43-44, 2 figs.

ABSTRACT Describes how stack and wind effects on buildings can be modelled in the laboratory using the salt bath technique. Applications include analysis of night cooling by natural ventilation and prediction of the air behaviour in a building which needs to be flushed through in a certain time.

KEYWORDS modelling, air flow, stack effect, wind effects, natural ventilation

#NO 10136 University challenge.

AUTHOR Field J

BIBINF UK, Building Services Journal, February 1997, pp 16-21.

ABSTRACT Describes the Portland Building, a newly built faculty building for the UK's Portsmouth University, which is designed to maximise use of natural ventilation features. With white facades and extensive use of wood, the extensively daylight structure is supported by natural ventilation, high use of thermal mass and the adoption of mechanical systems only where absolutely necessary. The building's simple operation strategy works without the need for a building energy management system.

KEYWORDS building design, natural ventilation

#NO 10295 NATVENT - European project on overcoming technical barriers to low energy natural ventilation.

AUTHOR Kolokotroni M, Kukadia V, Perera M D A E S

BIBINF UK, CIBSE, 1996, proceedings of CIBSE/ASHRAE Joint National Conference Part Two, held Harrogate, 29 September - 1 October 1996, Volume 1, pp 36-41.

ABSTRACT This paper describes the objectives and research methodology of a 30-month research project carried out under the European JOULE programme with the involvement of seven countries with cold or temperate climate. The project aims to contribute to reducing energy consumption and consequent CO2 emission in buildings by overcoming barriers preventing the wider uptake of technologies for natural ventilation (NV) and low-energy cooling and encouraging and accelerating environmentally-friendly natural ventilation and 'smart' controls as a main design option. The paper provides an overview of the work programme and the methodology adopted for the various research steps and describes the approach of the technical tasks. It also identifies the dissemination routes and the

anticipated benefits to the construction industry and the environment.

KEYWORDS natural ventilation, energy saving

#NO 10314 BRE office environment survey: comfort and health in naturally ventilated versus air conditioned offices.

AUTHOR Oseland N A, Aizlewood C E

BIBINF UK, CIBSE, 1996, proceedings of CIBSE/ASHRAE Joint National Conference Part Two, held Harrogate, 29 September - 1 October 1996, Volume 2, pp 159-166.

ABSTRACT The thermal environment was continuously monitored for one week in winter and one week in summer in four naturally ventilated (NV) and four air conditioned (AC) UK offices. Occupants considered the NV offices to be comfortable across a wider range of temperatures than AC offices in winter, but the range was similar in summer. The neutral temperature in NV offices was 1.3 Deg C lower in winter and 2.2 Deg. C lower in summer than in AC offices. However, there was only a marginal difference in clothing insulation and activity levels between the two types of office. Discrepancies of up to 4 Deg. C were found between the observed neutral temperatures and those predicted by international standard ISO 7730. Health questionnaires were completed in the same buildings, and sensory panel evaluations of air quality were made.

KEYWORDS office building, natural ventilation, field monitoring

#NO 10329 Control of natural ventilation.

AUTHOR Martin A

BIBINF UK, CIBSE, 1995, National Conference '95, Eastbourne, 1-3 October 1995, Volume 2, pp 175-181.

ABSTRACT Natural ventilation has the potential to replace or supplement air conditioning, comfort cooling and mechanical ventilation. Whilst there are obvious environmental advantages there are problems of achieving adequate control. The flow of air must be controlled to limit energy consumption and maximise thermal comfort. The paper outlines the research undertaken by BSRIA (the UK Building Services Research and Information Association) over a two year period to produce guidance on the "Control of Natural Ventilation". The research undertaken has led to the development of generic control strategies. These have evolved from consideration of the control strategies used in automatically controlled, naturally ventilated buildings together with experience obtained from monitoring three naturally ventilated buildings.

KEYWORDS natural ventilation, thermal comfort, field monitoring

#NO 10330 An inverse solver for sizing passive ventilation openings.

AUTHOR Irving S J, Concannon P J

BIBINF UK, CIBSE, 1995, National Conference '95, Eastbourne, 1-3 October 1995, Volume 2, pp 182-187.

ABSTRACT There is an increasing interest in controlled passive ventilation in commercial buildings. Passive ventilation is not a soft option for designers. Designing a building for controlled passive ventilation requires a sound grasp of the fundamental building physics associated with air flow. This paper describes the development of a simplified design method which can be implemented either as a manual worksheet or as a simple computer program (an illustrative spreadsheet tool has been prepared). This will provide designers with a simple entry route to designing natural ventilation schemes, particularly at the early design stage when the basic form and organisation of the building is being established.

KEYWORDS openings, commercial building, passive ventilation

#NO 10331 The proposed CIBSE applications manual on natural ventilation.

AUTHOR Irving S J, Uys E, Gilham A

BIBINF UK, CIBSE, 1995, National Conference '95, Eastbourne, 1-3 October 1995, Volume 2, pp 188-191.

ABSTRACT Natural ventilation is being increasingly adopted as a design approach for non-domestic buildings. The achievement of a successful design requires very careful attention be given to the design development, both in the strategy and the detail. The design also requires close interaction between the client and the whole of the design team. It was felt that it would be very helpful to produce a single publication which offered the industry appropriate guidance to allow energy, environmental and economic issues to be assessed when designing for natural ventilation. This paper describes the general structure and content of the manual, which is currently in final draft form prior to review by the UK CIBSE Technical Publications Committee.

KEYWORDS natural ventilation, commercial building, building design

#NO 10376 Wind and ventilation symposium. Wind en ventilatie.

AUTHOR Stuurgroep windtechnologie

BIBINF Netherlands, TUE Eindhoven, Stuurgroep Windtechnologie, proceedings of a symposium held 14th November 1996, University Eindhoven.

ABSTRACT Collection of papers on energy efficient ventilation; performance of naturally ventilated buildings; natural ventilation in parking garages; ventilation of parking garages with wind tunnel simulations; standards in natural ventilation; the Cp generator: a wind pressure database.

KEYWORDS wind effects, ventilation system

#NO 10377 Performance of naturally ventilated buildings.

AUTHOR Wouters P, Ducarme D, Vandaele L, Demeester J
BIBINF Netherlands, TUE Eindhoven, Stuurgroep Windtechnologie, proceedings of a symposium held 14th November 1996, University Eindhoven.

ABSTRACT Achieving good indoor climate and at the same time an energy efficient and environmentally friendly office building is a clear challenge. This is valid for new buildings as well as for retrofitting activities. A lot of attention has recently been given to the development of systems which have a better performance than mechanically ventilated or air conditioned buildings, in particular natural ventilation systems. Also today the fact that there is a better understanding of natural ventilation in buildings explains the increased interest for natural ventilation designs for office buildings. The NATVENT project aims to contribute to a better understanding of the possibilities and barriers to the applications of natural ventilation in offices. This paper indicates the key aspects of the project with the link to the planned monitoring activities.

KEYWORDS natural ventilation, office building

#NO 10378 Natural ventilation of garages. Natuurlijke ventilatie vanparkeergarages.

AUTHOR Kornaat W

BIBINF Netherlands, TUE Eindhoven, Stuurgroep Windtechnologie, proceedings of a symposium held 14th November 1996, University Eindhoven.

ABSTRACT Little research has been carried out into the natural ventilation of parking garages. Wind driven systems can have many advantages over mechanical systems with fans.

KEYWORDS natural ventilation, garage, fan

#NO 10445 Naturally ventilated buildings with heat recovery: CFD simulation of thermal environment

AUTHOR Gan G, Riffat S B

BIBINF UK, Building Serv Eng Res Technol, Vol 18, No 2, 1997, pp 67-75, 9 figs, 1 tab, 17 refs.

ABSTRACT This paper presents a methodology for predicting air flow and thermal comfort in naturally ventilated buildings. Numerical simulations were carried out for a naturally ventilated room with heat-pipe heat

recovery. The RNG k-e turbulence model was used for simulations. Calculation of air flow rates in the room took into account not only of driving forces (wind and stack effects) but also flow resistances (pressure loss due to heat pipes and other duct fittings and friction loss in air ducts). The potential of a heat-pipe heat recovery system to produce adequate thermal comfort in naturally ventilated buildings is investigated using CFD. The importance of proper control of air flow rate is highlighted.

KEYWORDS natural ventilation, heat recovery, computational fluid dynamics

#NO 10446 Code of practice for ventilation principles and designing for natural ventilation.

AUTHOR British Standards Institution

BIBINF UK, British Standard BS 5925:1991, 38pp.

ABSTRACT This British Standard gives recommendations on the principles which should be observed when designing for the natural ventilation of buildings for human occupation. Section 1 gives general information. Section 2 outlines the main reasons for the provision of ventilation and, where possible, recommends quantitative air flow rates. It is shown that these form the basis for air supply recommendations for different types of buildings and rooms characterized by usage. The basis for the choice between natural and mechanical ventilation is given. Section 3 gives recommendations on the design of natural ventilation systems and on the estimation of air infiltration rates in housing. Appendices include a bibliography, recommendations on evaluating contamination risks, on calculating ventilation rates to reduce the risk of surface condensation under steady state conditions, on determining ventilation requirements, on calculating reference wind speed, and on calculating natural ventilation rates for a simple building.

KEYWORDS natural ventilation, standard

#NO 10455 Natural ventilation takes off.

AUTHOR Hult M

BIBINF Swedish Building Research, No 1, 1997, pp 8-10.

ABSTRACT In the project "Schools with natural ventilation", seven Swedish schools - four recently built and three modernised - are described and evaluated. Evaluation refers to the indoor environment and to some extent to energy use and costs. This article sets out some of the results of the recently completed analysis of the recently constructed schools. They are all country schools. Staff and pupils consider the air to be healthy. The ventilation systems are silent. The only problem is the possibility of moisture and mould growth which was found where underground pipes entered one school. Average air change rate in classrooms during school hours was 2 ach in three schools and 2.4 in the other.

KEYWORDS natural ventilation, school, mould, moisture

#NO 10479 Avoiding or minimising the use of air conditioning - a research report from the EnREI programme.

AUTHOR Willis S

BIBINF UK, Building Research Establishment (BRE) BRECSU, Best Practice Programme, General Information Report 31, 1995, 35pp.

ABSTRACT Summarises the results of a two-year study carried out under the Energy Related Environmental Issues Programme. Its purpose was to assess the current status of theory and practice in low energy building design in the UK. Contains summarised information on the present state of the art in lighting (natural and artificial), thermal mass and admittance, storey height and stratification, building depth, and "mixed mode" design. In addition reports on case studies of twelve office buildings monitored to ascertain how to successfully design and manage a non air conditioned office building, and the degree to which the features incorporated were working in practice. Around half of the case studies were also investigated through interviews and questionnaires to assess how the occupants reacted to

their environment. Concludes with basic principles for non air conditioned buildings; minimise heat gains from the sun, lighting, equipment, and occupancy gains; ensure effective ventilation of the whole building, in all seasons, and at night; size thermal mass according to likely gains and ventilation strategy; design for easy management and low energy default states.

KEYWORDS natural ventilation

#NO 10480 The practicalities of natural ventilation from concept to construction.

AUTHOR CIBSE

BIBINF Proceeding of a conference by the Building Services Engineering Centre, London, held Tuesday 10 December 1996.

ABSTRACT Papers cover descriptive outline of natural ventilation mechanisms; and addressing air tightness.

KEYWORDS natural ventilation, air tightness

#NO 10556 Use of solar energy for ventilation cooling of buildings.

AUTHOR Gan G

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 77-86.

ABSTRACT This paper discusses summer cooling of buildings by means of natural ventilation. Computational fluid dynamics is used to predict the ventilation rate in a room with a Trombe wall. The effect of Trombe wall insulation on the room thermal environment is investigated. It is shown that to maximise the effect of ventilation cooling, the interior surface of a Trombe wall should be installed.

KEYWORDS passive solar design, cooling

#NO 10565 A design tool for natural ventilation.

AUTHOR Svensson C, Aggerholm S

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 163-174.

ABSTRACT A difficulty when designing natural ventilation in office buildings is the lack of simple design tools. In order to be able to predict natural ventilation air flow rates and indoor air temperatures at the design stage, a computer model has been developed within the EU-JOULE project NatVent TM. The program is an integrated model with a thermal and an air flow model coupled together. It can be used early in the design process to determine possibilities and restrictions in the use of natural ventilation in an office building. The most important objectives while developing the program have been to create a robust underlying theoretical model and an easy-to-use interface. Set in the Windows environment, the required input data are easily overviewed at all times. A key issue has been to use data which are easy to quantify, even at an early stage in the design process. The paper discusses briefly the theoretical model as well as the NatVent TM computer program. The program will be subject to extensive user tests during the autumn of 1997 and will be released in the spring of 1998.

KEYWORDS natural ventilation, office building, building design

#NO 10573 Controlled air flow inlets.

AUTHOR De Gids W F

BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 245-256.

ABSTRACT Within the EU project NATVENT, which deals with the application of natural ventilation in office type buildings, one of the items to be studied was controlled air flow inlets. Natural air supply is a key part in the design of natural ventilation in offices. In cases these air supplies are designed in the wrong way one may expect complaints

in terms of draft and stuffiness. Size and controls on inlets are vital elements in design. Controlled air inlets may help to overcome the problems of draft and stuffiness, and may contribute to an energy efficient design of the building. Several types of control can be considered such as: pressure control, humidity control, pollutant control and temperature control.

KEYWORDS air flow, inlets

#NO 10576 Prediction of the potential of self regulating natural ventilation devices: methodology and practical results.

AUTHOR Wouters P, Ducarme D, Renson P, Lernout W
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 277-286.

ABSTRACT The performances of self regulating natural ventilation devices (devices of which the opening section varies as function of the pressure difference across the device) strongly depend on the type of building and its leakage characteristics. In like manner, the climatic conditions strongly impact on the achieved ventilation rates. As a result, it is not possible to express the potential benefit of self-regulating natural ventilation devices in an unambiguous way. This is not contributing to a good understanding of the potential of such devices in daily practice. In order to increase the transparency of the results, a method has been developed which allows comparing the performances of various natural ventilation devices (fixed devices, self-regulating devices, etc.) for a range of building types and climatic conditions. The paper presents the simulation concept and the possibilities of the VENTEX programme. Results obtained for a range of combinations of ventilation devices are presented and discussed.

KEYWORDS natural ventilation, controls

#NO 10577 Natural ventilation and the role of passive stack chimneys in traditional excavated and surface dwellings in Santorini.

AUTHOR Tsikouris K, Young A
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 289-300.

ABSTRACT This paper considers the role of passive stack chimneys in controlling indoor thermal conditions in the vernacular houses on the volcanic island of Santorini. The quality of the environment within these dwellings is disputable, mainly because of the high humidity levels. A monitoring study was carried out in four actual dwellings in Santorini, two built on the surface and two excavated into the soft volcanic rock. The temperature and relative humidity of their main space and their chimneys were monitored and compared to the simultaneous external conditions. The results of this study were then used in a computer simulation package, modelling the performance of the dwellings and the chimneys in terms of air movement and air change rates. This showed that in most cases, chimneys proved to be efficient, establishing continuous air movement if located correctly, i.e. in the space where ventilation is mostly needed. The air flow characteristics of the chimneys seemed to be based on a diurnal cycle related to the external temperature fluctuation, but with a time lag. By designing a chimney carefully and using the materials in an appropriate way, the ventilation problems of these dwellings can be solved at low cost, both in terms of running costs and energy consumption. In the last few years, natural ventilation has been adopted by many European designers, as the importance of energy conservation is increasingly realized. The study of the role of passive stack chimneys in natural ventilation can not only be useful for the restoration of such vernacular dwellings, but can also be used in the design of new, environmentally friendly, buildings.

KEYWORDS natural ventilation, passive stack

#NO 10579 Energy recovery possibilities in natural ventilation of office buildings.

AUTHOR Skaret E, Blom P, Brunzell J T
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 1, pp 311-322.

ABSTRACT The paper deals with energy consumption and heat recovery in office buildings with natural ventilation. Net energy consumption for ventilation is calculated for 7 European countries. The calculations are done with various air flow rates and occupancy. The calculations shows differences between the seven countries, but the net ventilation heat loss is substantial for all. Norway and Sweden will benefit most from heat recovery. Several heat recovery concepts for natural ventilation are presented. Advantages and disadvantages with the various systems are discussed, also with respect to requirements as thermal comfort, air flow control, air cleaning and operation/maintenance. The paper also analyses the distribution of natural driving forces for ventilation both in various countries and in different parts of the heating season. The calculations indicate a need for assisting fans.

KEYWORDS heat recovery, air flow, fan

#NO 10610 Barriers to natural ventilation design of office buildings.

AUTHOR Aggerholm S
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 2, pp 623-632.

ABSTRACT Perceived barriers restricting the implementation of natural or simple fan assisted ventilation systems in the design of new office type buildings and in the refurbishment of existing such buildings have been identified in seven central and north European countries with moderate or cold climate: United Kingdom, Belgium, The Netherlands, Switzerland, Norway, Sweden and Denmark. The barriers were identified in an in-depth study with structured interviews based on questionnaires among leading designers and decision makers: architects, consultant engineers, contractors, developers, owners and governmental decision makers. The study is part of the NatVent TM project being carried out under the EC JOULE programme. The interviews identified a significant lack of knowledge and experience on special designed natural ventilation in office buildings compared to the knowledge and experience on mechanical ventilation. In addition there is a lack of sources to natural ventilation knowledge in standards, guidelines and building studies and a desire for new design tools on natural ventilation including calculation rules and easy-to-use, simple and advanced computer programmes.

KEYWORDS natural ventilation, office building, building design

#NO 10611 Feedback on the design of low energy buildings.

AUTHOR Azzi D, Virk G S
BIBINF UK, Air Infiltration and Ventilation Centre, proceedings of "Ventilation and Cooling", 18th Annual Conference, held Athens, Greece, 23-26 September 1997, Volume 2, pp 633-640.

ABSTRACT This paper presents results from the monitoring of a low energy building, namely, the Portland Building (University of Portsmouth UK) during February and July 1997. The BMS Research Group at the University of Portsmouth has instrumented the building so that its performance can be compared with the predictions obtained at the design stage. The Building has been operational since July 1996 and the monitoring exercise commenced in January 1997. Sensors monitor air temperature, air relative humidity and slab temperature in selected areas of the building. Analysis of the data collected shows that the CO₂

and water vapour levels are acceptable during the winter period and that the number of air changes per hour in the office and seminar room under consideration are adequate. The variations of air temperature in July 1997 inside a seminar room are compared with predictions from a simulation exercise carried out using ESP-r (simulation package) at the design stage and found to be in agreement. The underlying work is on-going and aims at providing feedback on the design on naturally ventilated buildings as well as improving the operational control aspects.

KEYWORDS low energy building, building design

#NO 10651 Natural ventilation research at Cambridge University - the combined effects of stack and wind.

AUTHOR Hunt G R, Linden P F

BIBINF UK, IBSPA News, 1997, pp 2-3.

ABSTRACT Describes research currently being conducted to examine natural ventilation flows driven by combined buoyancy and wind forces, and how laboratory techniques to simulate these flows at small-scale have been developed. New mathematical models have been developed to predict the temperature and stratification within the space and these are in good agreement with the results of the experimental studies.

KEYWORDS natural ventilation, stack effect, wind effect

#NO 10765 Natural aspiration.

AUTHOR Field J, Pearson A

BIBINF UK, Building Services Journal, September 1997, pp16-20.

ABSTRACT Describes how the new Learning Resource Centre at the University of Derby has pioneered a novel method of driving stack-assisted natural ventilation. States that persistent reference to basic design principles, linked with an awareness of recent feedback from buildings in use has produced a building with a sound design basis and many novel but not overly technical features. Comments on ventilation and daylighting, mechanical systems, the lighting design, roof vents, thermal and simulation.

KEYWORDS building design, stack effect

#NO 10816 Control is at the heart of the matter.

AUTHOR Saxon A

BIBINF UK, HAC, July 1997, pp 42-46.

ABSTRACT Compares the benefits of naturally ventilated offices versus air conditioned offices in relation to sick building syndrome problems, and introduces the new pre-standard pr ENV1752, which classified buildings into categories according to their indoor air quality, using this to specify necessary ventilation strategy.

KEYWORDS standard, health, ventilation rate

#NO 10847 NatVent European project: guidance on technical solutions for low energy ventilation in office buildings.

AUTHOR Kolokotroni M, Perera E, de Gids W, van Paassen D, et al

BIBINF "Energy and the Environment: Efficient Utilisation of Energy and Water Resources" First International Conference, proceedings, held October 12-14 1997 Limassol, Cyprus, Volume 2, pp 385-392, 2 figs, 9 refs.

ABSTRACT Natvent (TM) is a seven nation pan-European project which aims to reduce primary energy consumption (and consequently CO₂ emissions) in buildings by providing solutions to barriers which prevent the uptake of natural ventilation and low-energy cooling in countries with moderate and cold climates. It also aims to encourage and accelerate the use of natural ventilation and 'smart' controls as the main design option in the new-designs and major refurbishments of office-type buildings. This paper reports on the current findings of the task to provide solutions by developing 'smart' natural ventilation technology systems and component solutions to overcome the identified technical barriers. This includes the investigation of strategies and components to control the incoming air flow, to minimise overheating, to recover heat, to attenuate the

effects of urban pollution and noise and to integrate ventilation strategies. The paper also outlines the preliminary structure of a guidebook which will describe and summarise the findings. The guidebook aims to increase confidence of how to achieve Indoor Air Quality (IAQ) and Comfort in office buildings using low energy ventilation strategies for the designers and his client.

KEYWORDS low energy ventilation, natural ventilation, office buildings, technical solutions, smart components, heat recovery, urban pollution, summer overheating.

#NO 10849 Heating low energy buildings.

AUTHOR Irving S J

BIBINF UK, Building Services Journal, September 1997, p 51, 2 figs.

ABSTRACT Describes how the trend towards natural ventilation and low energy cooling systems is affecting the ways in which engineers design and operate heating systems in low energy buildings.

KEYWORDS low energy building, heating

#NO 10859 Natural ventilation in non-domestic buildings. Applications manual AM10:1997

AUTHOR Irving S J, Uys E

BIBINF UK, Chartered Institution of Building Services Engineers, 1997, 99pp.

ABSTRACT Provides guidance on natural ventilation that is strategically important to architects, building services engineers, clients and their advisors. Covers natural ventilation as a design strategy; developing the brief; satisfying the brief - selecting a strategy; ventilation components and system integration; design calculations; case studies.

KEYWORDS natural ventilation

#NO 10862 BRE team attacks "barriers" to natural ventilation.

AUTHOR Anon

BIBINF UK, HAC, October 1997, p 26.

ABSTRACT Describes the first results of a study which has found that technical barriers to natural ventilation can be overcome and installation, maintenance and running costs can be reduced substantially. The study is monitoring three large town centre buildings in the UK and a range of similar buildings throughout Europe. A survey of building owners in seven countries found that the perceived barriers to natural ventilation are: summer overheating; control of pollution; inconsistency of the weather; recovering heat from waste air; integrating natural and mechanically based systems. Design guidance to avoid these problems is due out next year.

KEYWORDS natural ventilation

#NO 10870 Low energy strategies in urban areas.

AUTHOR Twinn C

BIBINF in: Ventilation and air pollution: buildings located in urban and city centres. Proceedings, edited by V Kukadia, UK, Building Research Establishment, June 1997, Seminar, CR 133/97.

ABSTRACT In urban areas where traffic fumes contaminate the outdoor air, there seems less incentive to install natural ventilation systems. However the new generation of naturally ventilated buildings prove that good indoor air quality can indeed be supplied. The priority must be to design the building fabric as the primary internal climate modifier, and introducing building engineering systems to assist the building fabric to recycle ambient energy. The New Parliamentary Building being constructed in Westminster, London addresses these points. Starting with the prerequisite of a sealed facade, the design fully uses the passive abilities of the building's materials and form to maintain the indoor climate. Subsequently building services systems were chosen to enhance these abilities and introduce energy saving measures.

KEYWORDS outdoor air, motor vehicle, pollutant, natural ventilation, energy conservation

#NO 10948 Insufficiency of natural ventilation against NOx concentrations caused by domestic gas cookers.

AUTHOR Zorraquino J V M, del Campo Diaz V J
 BIBINF Belgium, Proceedings of Clima 2000 Conference, held Brussels, August 30th to September 2nd 1997, paper 358, 11pp, 1 fig, 6 tabs, 14 refs.

ABSTRACT The paper shows the results obtained and the solutions proposed in an investigation of more than 70 dwellings in northern Spain, using approved and calibrated measuring devices, aimed to find out how dwellings matched the criteria for the permanent ventilation opening which must exist in premises with gas powered domestic food cookers. The investigation showed that regulations are often breached, and that peaks of NOx concentration can occur relatively quickly even when the amount of these pollutants emitted by cookers is below the limits approved by research institutions. Also gives some results from dwellings with extractor devices, which have proved inadequate in some cases.

KEYWORDS nitrous oxides, gas appliance

#NO 8407 Natural ventilation of a large-scale wholesale market building

AUTHOR Murakami S Dr. Kato S Dr. Deguchi K Dr.
 BIBINF USA, ASHRAE, 1995, proceedings of ASHRAE Centennial Conference, held 28 January - 1 February 1995, Chicago, USA, 11pp, 19 figs, 11 tabs, refs.

ABSTRACT A wholesale market building 180 m by 540 m by 28 m (590 ft by 1770 ft by 92 ft) in size was designed to make use of natural ventilation to save energy and also to be maintenance free. During the building design stage, model experiments and numerical analyses were conducted, and the ventilation system and building shape best suited to natural ventilation were selected. After the building was constructed, the ventilation characteristics of the indoor space were verified by the field tests, the results of which corresponded well to those given by the model experiments.

KEYWORDS natural ventilation, large building

#NO 8690 The naturally air conditioned house.

AUTHOR Mortensen N.
 BIBINF AIRAH Journal, August 1994, pp 11-14, 2 refs.

ABSTRACT This paper outlines the development of energy efficient design from Ancient Greece to the present time. It describes the valuable sources of appropriate technology which were developed intuitively prior to the industrial revolution, and how present-day research into energy efficient solutions to the problems of our built environment is coming up with techniques known to pre-industrial man. The elements that influence energy efficient design will be

discussed and conclusions drawn regarding their appropriate use. Evidence will be presented which shows how high mass, when correctly used can be our greatest ally for producing environmentally sensitive buildings.

KEYWORDS air conditioning, residential building, energy efficiency.

#NO 9196 The sky-scraper - naturally ventilated? New responses to ecology in high-rise buildings.

AUTHOR Daniels K, Stoll J, Pueltz G, Schneider J
 BIBINF Belgium, Brussels, Top E, [1995]

ABSTRACT Recently, design competitions for two sky-scraper projects in Frankfurt, Germany, were launched with the requirement of implementing ecological measures high on the list of design criteria. The participating architects proposed a wealth of design solutions, of which two will be presented here as case studies. Both are based on the same principles but are significantly different in conception. As can be seen from the following accounts, the successful execution of an ecological sky-scraper requires not only a close co-operation among all disciplines involved but also demands an open-minded awareness of physical interactions within the building. With this in mind, well-balanced and professional solutions can be achieved.

KEYWORDS high rise building, natural ventilation

#NO 10318 The applications of a new convenient technique for monitoring ventilation performance of building in use.

AUTHOR Walker R R, White M K
 BIBINF UK, CIBSE, 1996, proceedings of CIBSE/ASHRAE Joint National Conference Part Two, held Harrogate, 29 September - 1 October 1996, Volume 2, pp 360-368.

ABSTRACT Ventilation rates in buildings need to be measured, for example to check that design requirements are met, to monitor performance in use and to assess remedial measures. However, conventional measurement techniques cannot easily be applied to large or multi roomed buildings. A new approach has been developed which offers the potential to overcome these problems. This report describes an application of the technique to monitor ventilation rates throughout two four storey naturally ventilated office building "in use", both in summer and winter. Results illustrate the distribution of ventilation and whether ventilation requirements were met in winter. Results in summer reveal air change rates achieved in practice for the purposes of avoiding overheating.

KEYWORDS monitoring, ventilation system, measurement technique

AIVC Air Infiltration and Ventilation Centre

The Air Infiltration and Ventilation Centre provides technical support in air infiltration and ventilation research and application. The aim is to promote an understanding of the complex behaviour of air flow in buildings and to advance the effective application of associated energy saving measures in both the design of new buildings and the improvement of the existing building stock.

