

VENTILATION TECHNOLOGIES IN URBAN AREAS

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NATURAL VENTILATION IN OFFICE-TYPE BUILDINGS – RESULTS AND CONCLUSIONS OF MONITORING ACTIVITIES

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SYNOPSIS

Since the beginning of this decade, natural ventilation in office buildings has been receiving specific interest. There are two sorts of application. Natural ventilation can be a strategy for indoor air quality control. It can also be used as night ventilation during warm or hot periods. In this case the objective is to cool down the thermal mass and improve the thermal summer comfort.

The EC JOULE NatVent project wanted to identify the barriers to the application of natural ventilation in office-type buildings in moderate and cold climates and to provide solutions. In the framework of the NatVent project, 19 naturally ventilated buildings across Europe (Belgium, Denmark, Great Britain, the Netherlands, Norway, Sweden and Switzerland) were monitored. This paper briefly presents the monitored buildings and the major findings.

1. THE NATVENT PROJECT

The NatVent project is a seven-nation EC JOULE project. The objective of the project is to overcome the barriers that prevent the application of natural ventilation in office-type buildings. It is intended for countries with low winter and moderate summer temperatures, where summer overheating from solar and internal gains can be significantly reduced by natural ventilation.

2. THE MONITORED BUILDINGS

In the framework of Task 2 of the NatVent project 19 naturally ventilated buildings in seven countries - Belgium, Denmark, Great Britain, the Netherlands, Norway, Sweden and Switzerland - were selected for detailed monitoring. The selected buildings are very diverse. Both existing as well as renovated and new buildings were studied. The objective of the monitoring was to identify the advantages and shortcomings of natural ventilation in ad-hoc buildings. The selected buildings were monitored during one winter and one summer period. Parameters such as temperature, humidity and ventilation rates were measured to identify the efficacy of the ventilation strategies.

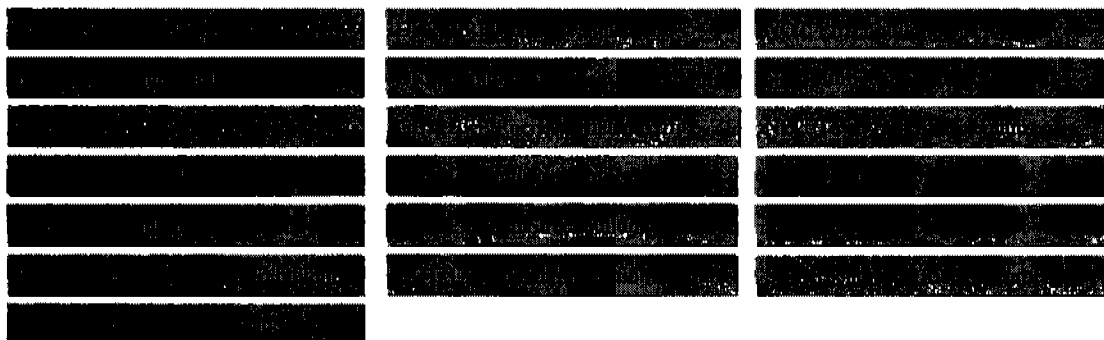


Figure 1: List of the 19 monitored buildings

The results of the monitoring campaigns and an interactive presentation of each building, as well as all the other final products of NatVent are collected on the NatVent CD-rom. The major findings of the monitoring campaigns are given below in eight key messages.

3. KEY MESSAGES AND CONCLUSIONS

3.1. The key challenge is to achieve comfortable buildings that in addition are energy efficient

The indoor air quality in most of the 19 buildings is acceptable. The measured CO₂ levels are within the limits, which are generally accepted. However many buildings suffer from serious overheating problems. A high internal temperature is the most common user complaint in the buildings.

It is clear that indoor comfort should be the starting point of each building design. Due to the oil crisis in the seventies and the environmental concern nowadays, top priority is often incorrectly given to energy efficiency. This leads to energy efficient buildings with too high temperatures in summer, acoustical problems, poor indoor air quality, etc.

Priorities have to be reversed. The main objective is a good indoor climate: thermal comfort, indoor air quality, visual comfort and acoustical comfort.

Because of large internal gains thermal summer comfort is for most office-type buildings the main challenge. A comfortable indoor climate must be achieved by good building design and energy efficient installations. Furthermore it is crucial that the users are able to understand the concept of the building and are able to finance the required investments and running costs.



Figure 2: Global context for energy efficient buildings with good indoor climate

3.2. It is essential to understand the different meanings of natural ventilation

All 19 selected buildings were designated as 'naturally ventilated' buildings. However it was not always clear what was meant by 'naturally ventilated'. This leads to confusion, which is probably not good for the reputation of natural ventilation and which may also indirectly lead to poor design concepts. Therefore, it is essential to clearly identify the meaning of 'naturally ventilated building'.

Basically, there are three different definitions and concepts of natural ventilation:

- A design in which the air is assumed to enter and leave the building through unintentional openings. In the framework of the NatVent project, this type of air flow is not considered.
- A design in which the air quality is determined by a concept of supply and exhaust openings. Wind pressures and the stack effect are the driving forces for ventilation. This concept is called 'natural ventilation for Indoor Air Quality (IAQ) control'.
- A design in which during the summer a cooling effect is created by intensive ventilation with outside air. This concept is called 'natural ventilation for summer comfort'. Given the low temperatures at night time, intensive night ventilation is useful in moderate and cold climates.

3.3. Ventilation for IAQ is an optimisation of IAQ and energy efficiency

When applying natural ventilation during the heating season to control the IAQ, one has to avoid too large ventilation flows (see figure 3a). Large ventilation flows mean large energy losses. The energy impact can be considerable.

Several of the buildings monitored (e.g. DK2, NO2) where natural ventilation is used for IAQ control, have no advanced control strategy for the air flow rates. Although an acceptable indoor air quality is achieved, air flow rates are often substantially above the required air flow rates leading to unnecessary ventilation losses.

In a number of projects (BE1, BE2, BE3), natural ventilation is only used for summer comfort, while mechanical ventilation for IAQ control. It is evident that at present there is a wider range of products and systems available for mechanical ventilation systems to achieve an energy efficient ventilation: good control of the air flow rates, various systems of demand controlled ventilation, heat recovery, etc.

There is a clear need for new components and concepts to optimise and control the air flows in naturally ventilated buildings. In the framework of the NatVent project work was done on pressure controlled air inlets, heat recovery systems, etc.

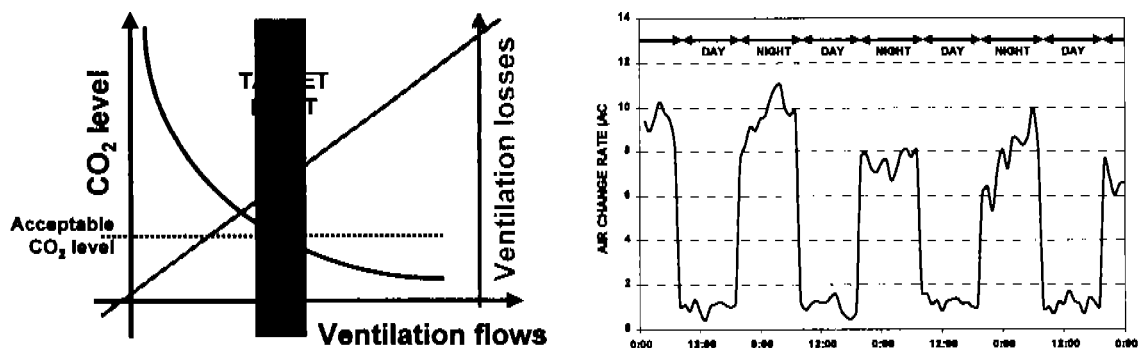


Figure 3a: Optimisation of ventilation flows
 Figure 3b: Ventilation flows for summer comfort and IAQ

3.4. The required air flow rates for summer comfort are much higher than for IAQ control and the thermal mass of the building must be accessible

The concept of ventilation for summer comfort is based on two indispensable elements: firstly large air flows of cold external air and secondly accessible thermal mass.

A first target is to achieve the highest possible air flow rate without specific problems. Control of the air flow rates for summer comfort is in most cases not so critical as it is for ventilation for IAQ (see before). A possible problem can be a (slight) subcooling during the early morning hours leading to complaints by some of the building users. Automatic (central) control is in principle not required. An advantage of automatic control is the possibility of optimising the opening and closing of the intensive ventilation provisions (e.g.: only open when outdoor temperature is lower than indoor temperature). In case of automatic control, it is preferable that the users can overrule the automatic control during most part of the time.

As already indicated, most of the monitored case studies have no explicit splitting between devices aimed for IAQ control and those for summer comfort. In some cases, the designer made a clear separation between both strategies (e.g. in GB2). However, the monitoring results indicated that the control strategy was not clear to the users with the result that the required performances were not achieved.

The second target is to bring the cold external air in contact with the thermal mass. The optimal situation is a building with exposed heavy ceiling, floor and walls. In many cases this is not possible for reasons of cabling and flexibility. However less optimal solutions like only an exposed ceiling or an open false ceiling give acceptable results. The experience of several case studies has learnt that the accessibility of the thermal mass has a major influence on the building design in a very early stage. Furthermore it is often a barrier to the application of ventilation for summer comfort in existing buildings.

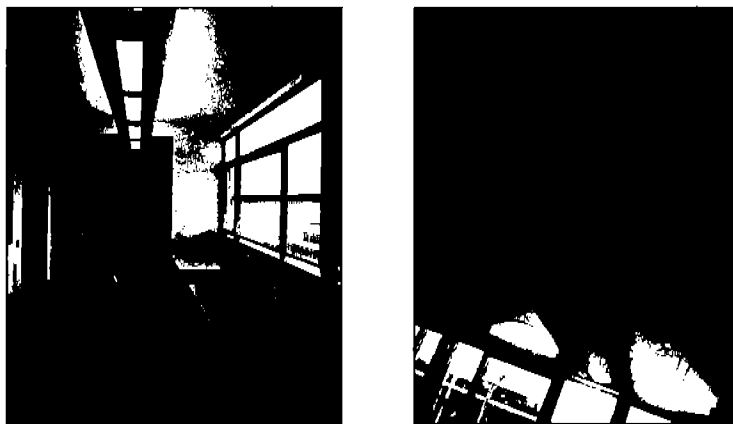


Figure 4: Exposed false ceilings (a. Canning Crescent Centre – b. The Environmental Building)

3.5. Summer comfort requires much more than intensive ventilation

Intensive ventilation for summer comfort can only be a successful strategy if the other elements of the building are also designed for summer comfort. An intelligent choice of glazing type, glazing areas, orientation and shading devices must control the direct solar gains through transparent surfaces. A high insulation level can limit the indirect solar gains

through opaque surfaces. Energy efficient and well-controlled lighting systems minimise the internal gains. It is possible that under certain conditions (e.g. heavy internal loads or limited accessibility of thermal mass) the indoor temperatures are still too high. In this case limited active cooling by hygienic ventilation (also called ‘top-cooling’) can be an effective solution. Thermal simulation is an indispensable tool for the design of buildings with this global strategy. During the pre-design stage a simple, user-friendly tool (e.g. NiteCool, the Natvent program, etc...) gives an estimation of the overall effect of the different measures. At later stage, more elaborated simulations and powerful simulation programs (e.g. ESP-r, Capsol, etc...) may be used.

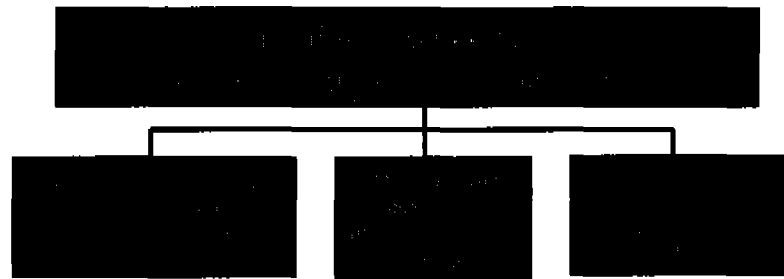


Figure 5: Thermal summer comfort – global strategy

3.6. Estimating the air flow rates is a small part of achieving a successful design

The real target is to realise buildings with a good indoor climate and low energy usage. This comprises the design of the building envelope and the installations. In case of naturally ventilated buildings, it is clear that the design of the natural ventilation is only a small part of the overall design challenge. As far as natural ventilation is concerned, it is evident that one should have a good sizing of inlets and exhausts in order to achieve the required level of ventilation. In addition for a good design it is important that a whole range of other requirements are achieved.

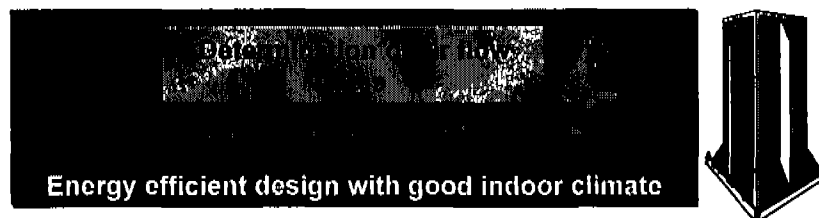


Figure 6: Natural ventilation - the overall context

A successful design can only be achieved if a number of potential barriers are considered and solved. In some of the 19 buildings studied, the natural ventilation operates unsatisfactorily due to incorrect sizing of inlets. However multiple are the design problems due to other reasons. As illustrated in Figure 7, there is a whole range of potential barriers for applying intensive night ventilation. Some of them are of a more technical nature (e.g. the local fire regulations require separation of the various parts of the building, acoustical requirements for buildings used at night time, etc.) others are more linked to the user (e.g. internal doors are closed at night for reasons of privacy, dust entering the offices at night, etc). It is also possible that non-technical reasons are an important barrier for application (e.g. the designer

has to take a larger risk, the impact on the architecture is considered unacceptable, the fee structure for the consultants is not stimulating for such kind of studies).

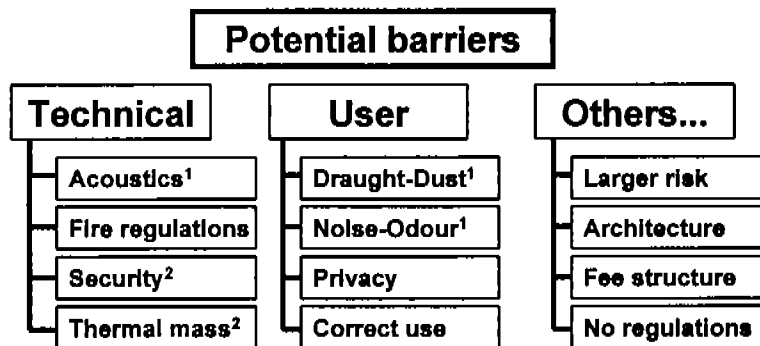


Figure 7: Overview of potential barriers for the application of natural ventilation for indoor air quality¹ and summer comfort²

3.7. The creation of an attractive environment for innovation is extremely important

A number of innovative and/or high performance products and systems relating to natural ventilation of office-type buildings are available on the market or are expected to come on the market during the next years. However, experience from other technological areas clearly shows that innovative and interesting technologies are not necessarily adopted by the decision makers (architects, building owners, etc). Lack of awareness is one possible reason, another reason is that the decision maker is not able to correctly interpret the performances of such systems and/or has doubts about the advantages of the technology. Such an evolution can only be avoided by large dissemination of the knowledge on natural ventilation and by performance-based standards for natural ventilation components, respectively.

3.8. Natural ventilation can be an attractive option, NOT the only option

It is clear that many of the monitored buildings would perform better with a well-designed mechanical ventilation system. Heat recovery and demand controlled air flows are some of the extra possibilities of mechanical ventilation.

However, a well-designed natural ventilation system could also lead to good performances. The NatVent project activities in Work Package 'Providing Technological Solutions' aimed primarily at indicating possible ways for optimisation of natural ventilation strategies. Air inlets with high acoustical performances, with constant air flow and with intelligent control as well as hybrid concepts with low-energy fans and heat recovery broaden the possibilities and the application area of natural ventilation.

Natural ventilation is not by definition the best option. Energy efficient designs with good indoor climate is the challenge and one should try to consider the best of all available options.