Performance of naturally ventilated buildings

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1. Introduction

Achieving good indoor climate conditions 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. An important aspect is creating a good indoor air quality. Full air conditioned systems were in the past considered as the ultimate choice. Today, a more balanced view is found in many countries and among many people. This is partly due to the fact that many mechanical ventilated and/or air conditioned buildings behave not so good as could be expected. As a result, a lot of attention is given to the development of systems which have better performances. In this context, a renewed attention is observed for natural ventilation systems. Also the fact that there is today a better understanding of natural ventilation in buildings explains the increased interest for natural ventilation designs of office buildings. The NATVENT project aims to contribute to a better understanding of the possibilities and barriers for applying natural ventilation in offices[1].This paper indicates the key aspects of the project with the link to the planned monitoring activities.

2. Natural ventilation in buildings : global context

2.1 General

The expression '... natural ventilated building' can cover a whole range of concepts :

- for certain persons (e.g. for many people in countries as Belgium,...), it means that there are no purpose provided provisions and that the air is assumed to enter and leave the building through the uncontrolled leakages in the building envelope;
- for other persons, the notion 'ventilation' is linked to the control of the indoor air quality, and natural ventilation means in this case specific provisions (e.g. trickle ventilators,...) aiming to realise an acceptable indoor air quality. Such a design may include fans, in the

case of the NATVENT project are office buildings with only mechanical extraction fans and natural supply openings considered as natural ventilation buildings;

- a third interpretation is linked to the control of temperature in summer and the avoidance of overheating. In this context, the natural ventilation is normally applied at night time and the aim is then to use the relatively cold outside air as the heat sink for cooling down the building.

The NATVENT project is looking to the second and third interpretation of natural ventilation in office buildings in moderate and cold climates.

2.2 Natural ventilation and IAQ

Natural ventilation as a strategy for achieving acceptable indoor air quality is essentially based on the supply of air to a space and by dilution reducing the pollution concentration in the space. No fan energy is needed (unless mechanical extraction is applied) but during the heating season is energy needed for heating up this air. The natural air flow rates varies as function of time and depend on wind and temperature conditions. Likewise the user can have a substantial impact by window use. Therefore, optimisation is essential so that good indoor air quality and a low energy demand can be combined. Keeping the air flow rates in a certain range is very important.

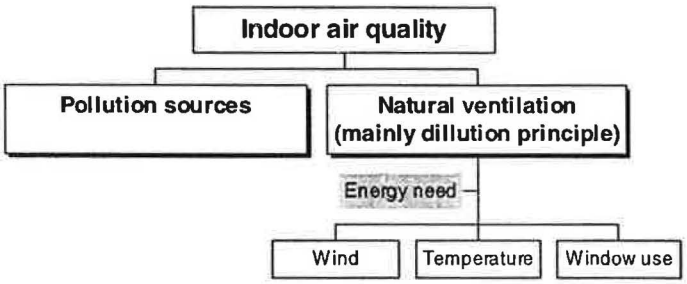

Figure 1 : Natural ventilation for IAQ control

2.3 Natural ventilation and thermal comfort in summer

In case of natural ventilation for thermal comfort in summer, the situation is completely different. Natural ventilation can be applied at daytime and especially at night-time when the outdoor air is relatively cold. The aim is then to have a maximum exchange of heat between the building structure and the outside air. This is achieved by creating large openings in the building envelope allowing to realise high air flow rates.

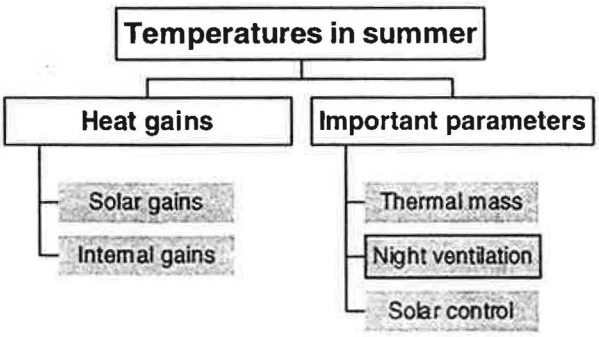

Figure 2 : Natural ventilation and summer temperatures

Whereas for IAQ control, the resulting indoor air quality is linked in a rather simple way to the pollution source strength and the air flow rate, a much more complex relation is found for temperature control in summer. Influencing parameters are the thermal gains (internally, solar gains), the building characteristics (especially thermal mass and insulation level), the use of the building and the natural ventilation.

Control of the air flow rates is on itself not so important : *'the higher the better'* as long as this does not give unacceptable conditions, e.g. draught problems or undercooling in the early morning hours.

The required air flow rates for IAQ control are of a totally different order of magnitude than the air flow rates for contributing to better thermal comfort conditions in summer time. As a result, the openings are also of a totally different size.

The application of natural ventilation for IAQ control is mainly a challenge in winter time because of the energy aspect whereas natural ventilation for temperature control essentially a summer issue is. This is illustrated in table 1.

	Southern climates	Moderate climates	Cold climates
Winter	Natural ventilation for IAQ control		
Summer	Natural ventilation for temperature control		

Table 1:Main challenges for natural ventilation

3. The NATVENT project

3.1 Objectives of monitoring activities

A global description of the NATVENT project is given in ref. 1. Within the NATVENT project, the objectives of the monitoring task can be summarised as follows :

⇒ *To identify shortcomings (and advantages) of purpose build naturally ventilated buildings in central and northern European countries by monitoring 20 buildings during different seasons of the year. In order to obtain a good understanding, detailed studies in 3/4 of these office buildings are planned*

⇒ *To identify the required boundary conditions for achieving successful natural ventilation systems in buildings*

⇒ *To produce a case study book of the investigated buildings as help for future design projects*

⇒ *To produce a guidance book on design for natural ventilation in office buildings*

It is useful to mention that there is another interesting EC project on natural ventilation in the ALTENER programme : the AIOLOS project (December 1995 - May 1997). This project is focusing on natural ventilation for summer conditions project objectives have been described as follows:

'The general aim is to create educational material on the efficient use of natural ventilation for buildings. All material should have a complete, flexible, modular and transferable educational structure, which should have the following specific targets:

	Southern climates	Moderate climates	Cold climates
IAQ control		NATVENT	NATVENT
Temp. control	AIOLOS	NATVENT AIOLOS	NATVENT

Table 2: Activities of NATVENT and AIOLOS

1. *To evaluate and translate the knowledge acquired within the frame of the European research on passive ventilation of buildings, as well as the existing information and knowledge into an complete educational package dealing with the efficient use of passive ventilation for buildings.*
2. *To create the necessary educational infrastructure that can be transferred to all educational activities and can be used by all professionals involved in the field of buildings.*
3. *To provide building professionals with all necessary knowledge, tools and information on the efficient use of passive ventilation in buildings in order to decrease the energy consumption for cooling purposes, increase the indoor thermal comfort level and improve indoor air quality.*

Based on these targets, the proposed final deliverables are :

1. *A handbook*
2. *Case studies on naturally ventilated buildings*
3. *A tool for the evaluation of the performance of natural ventilation as well as of the thermal performance of buildings where it is applied as a cooling technique.'*

3.2 Planning of the monitoring activities

The monitoring activities are one of the key actions in the NATVENT project. The aim of the monitoring is to obtain a better understanding of the possibilities and limitations of natural ventilation in office buildings. The working programme foresees 3 levels in the monitoring activities (Figure 3) :

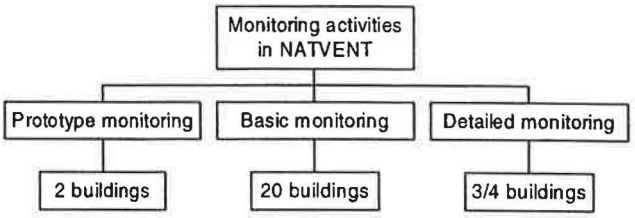

Figure 3 : Monitoring activities in NATVENT project

- prototype monitoring of a few buildings
- basic monitoring in some 20 buildings
- detailed monitoring in a few buildings.

This document gives an overview of various monitoring related aspects and gives practical suggestions for the monitoring activities.

It is not the objective to come to fully standardised monitoring scheme. Nevertheless, a standardisation of certain aspects is crucial in order to avoid to have at the end of the project a cocktail of non-comparable information and/or incomplete information for drawing conclusions.

The timing of the various monitoring activities is given in Table 3.

Activity	1996						1997						1998		
	1	3	5	7	9	11	1	3	5	7	9	11	1	3	5
Procedures	■	■													
Selection buildings		■	■	■	■	■									
Prototype monitoring				■	■	■	■								
Basic monitoring 20 buildings							■	■	■	■	■				
Detailed monitoring										■	■	■	■		
Analysis/synthesis										■	■	■	■	■	
Case study report													■	■	■

Table 3 : Monitoring programme within the NATVENT project

3.3 Building selection

In the framework of the NATVENT project, it is the intention to analyse not only very special buildings which were explicitly designed for natural ventilation but also more common designs. In the selection of the buildings, it is tried to have a reasonable number of both types :

- 'NATVENT' designs

  Designs which are clearly dominated (also aesthetically) by the concept of natural ventilation.

  Examples:

  ⇒ the new environmental office and seminar block (under construction) at BRE;

  ⇒ the Wood Green Community Mental Health Centre, designed by MacCormac Jamieson Prichard

- 'More common' designs

  Designs which can from the outside or inside not directly be associated with natural ventilation (with the exception of ventilation grilles in the facade or openable windows)

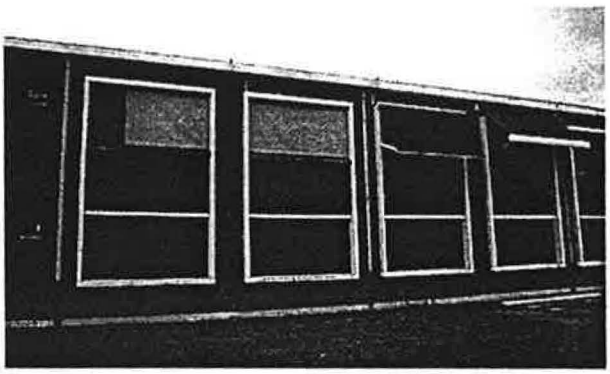

Figure 4 : the 'PROBE' building at BBRI Limelette

Furthermore, new buildings as well as renovation projects are analysed. An example of a renovation project is the Belgian PROBE building (**P**ragmatic **R**enovation of an **O**ffice for a **B**etter **E**nvironment), one of the BBRI offices in Limelette in which a number of cost-effective measures are taken : improved thermal insulation, efficient heating boilers and regulation system, presence controlled mechanical ventilation for IAQ control, night time ventilation for summer control in combination with external shading system and replacement of the single glazing by low e, argon filled double glazing(renovation expected to be finished around April 1997).

As indicated in 2.1, natural ventilation can be applied in relation to IAQ control as well as to temperature control in summer conditions. In a number of buildings to be monitored, a hybrid concept (Table 4) is used : natural ventilation at night-time in summer for the temperature control whereas mechanical supply for the IAQ control.

	Working hours	Night-time
IAQ control	Mechanical ventilation	Mechanical ventilation
Temp. control	Mechanical ventilation	Natural ventilation

Table 4: A hybrid ventilation concept

3.4 Removing the barriers

Realising natural ventilation designs which meet the expectations is more than appropriate control of the air flow rates in winter time and high ventilation rates in summer time. In practice, a whole range of boundary conditions must be realised for obtaining good physical performances and user satisfaction.

But there is more : designers must meet good working conditions for applying natural ventilation designs and must be able to understand the various aspects linked to the problem.

5. Presentations of 2 Belgian case studies

As part of the presentation, 2 building studies, in which we are involved, are briefly presented.

5.1 The PROBE building

The PROBE building (Figure 4) has already been briefly presented in 3.3. It is an example of a low budget retrofitting in which the improvement of the thermal comfort conditions in summer time are an important objective. Night time natural ventilation is a key aspect of the strategy for achieving good thermal comfort during summer. Because of the fact that there are no openings in the flat roof and that only minor renovation works can be considered, the concept of night time ventilation is based on single sided ventilation and/or cross ventilation. Measurements in June 1996 in a limited number of rooms indicated substantial improvements by using single sided ventilation. The IAQ control is done by means of infrared controlled mechanical supply in each office. It allows an optimal control of the air flow rates.

5.2 New office building in the region of Antwerp

BBRI is involved in the consultancy work for a new office building for a distribution company of gas and electricity in the region of Antwerp. The brief for the building is to realise a building with good indoor climate conditions at a low energy demand. Good indoor air quality and the avoidance of overheating are essential requirements. In this case, night time ventilation is applied by making use of large chimneys and large louvres in the facades.

6. Acknowledgements

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7. References

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2. Santamouris M., AIOLOS : creation of an educational structure on the use of passive cooling ventilation techniques for buildings, 17th AIVC conference, Gothenburg, Sweden, September 1996