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NATURAL VENTILATION IN OFFICE TYPE BUILDINGS RESULTS FROM DESIGN CASE STUDIES

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ABSTRACT

Natural ventilation can be a part of a strategy for a good indoor air quality. It can also be a way to realise night time ventilation during warm periods. In this latter case, the aim is to cool down the thermal mass of the building to obtain a better thermal comfort during daytime. Night time ventilation requires high ventilation rates and sufficient accessible thermal mass. The ventilation openings have to be well designed to avoid undesirable effects like rain, pollution and burglary. However a successful design for summer comfort depends on a lot more: solar and internal gains must be well controlled. The summer comfort can be evaluated in advance by means of thermal simulations.
This paper presents four Belgian buildings in which natural night ventilation for summer comfort is a critical issue; it are two new buildings and two renovated buildings.

KEYWORDS
natural ventilation, night cooling, summer comfort, case studies, renovation, thermal simulation, thermal mass, stack effect, cross ventilation, ventilation grilles, shading devices

INTRODUCTION

For most office buildings, the indoor climate under summer conditions is a more critical issue than the indoor climate under winter conditions. Overheating or high energy use for cooling are very common phenomena. The problem of overheating can however be considerably reduced by 'passive measures' like solar shading, intensive night ventilation and well-controlled internal gains.
This paper presents four Belgian buildings, which are designed according to this global concept. Two of the buildings are new buildings and two are renovated buildings. This paper focuses on the aspect of night ventilation. The different ventilation strategies and the applied technology are described.

THE IVEG HEADQUARTERS

IVEG is a distribution company of gas and electricity near to Antwerp, Belgium. Promotion of rational energy use is one of the main objectives of the company. The new headquarter (1.850 m²) has to be a low-energy building based on simple and widely applicable techniques. The new office building is situated besides the existing IVEG building and along a very busy road. The building is very well insulated in order to attain a low heating energy consumption (e.g.: $U_{glazing}$ = 1,3W/m²K).

Because of the noise and the bad air quality at the front side of the building a mechanical ventilation system was chosen to control the IAQ. The ventilation system is an infrared demand-controlled system with heat recovery.

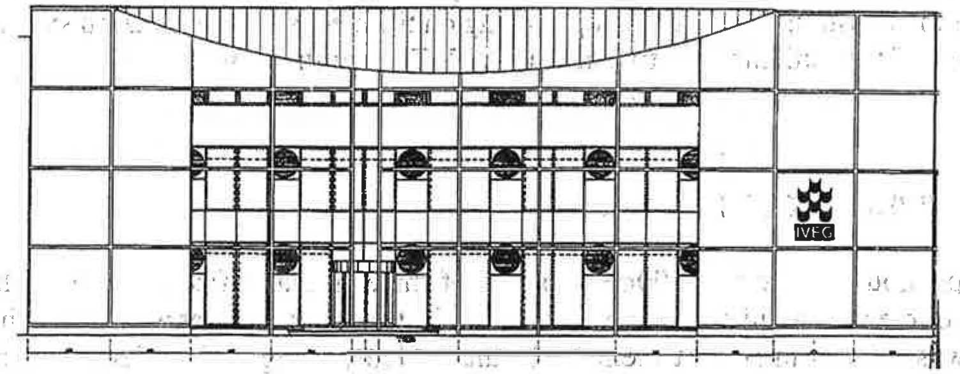


Figure 1: Front façade of the IVEG building with large ventilation grilles

The reduction of active cooling in summertime was a main objective of the building design. Several 'passive' measures are integrated in the final design:

- Reduction of the indirect solar gains by a high insulation level of the roof and the external walls
- Reduction of the direct solar gains by:
  - Selective glazing (g-value: 0,25 / visual transmissivity: 0,43)
  - Automatically controlled vertical external screens on all façades (except North)
- Application of intensive night ventilation and thermal storage

The night ventilation is based on the stack effect of two large chimneys on the roof of the building. Cold external air is supplied through large burglar-proof grilles in the external façades. The internal doors are open at night. Because of fire regulations the ground floor and the first floor are separated and have their own chimney. The building has a lot of accessible thermal mass: the offices have open false ceilings (20%) and tiled floors.

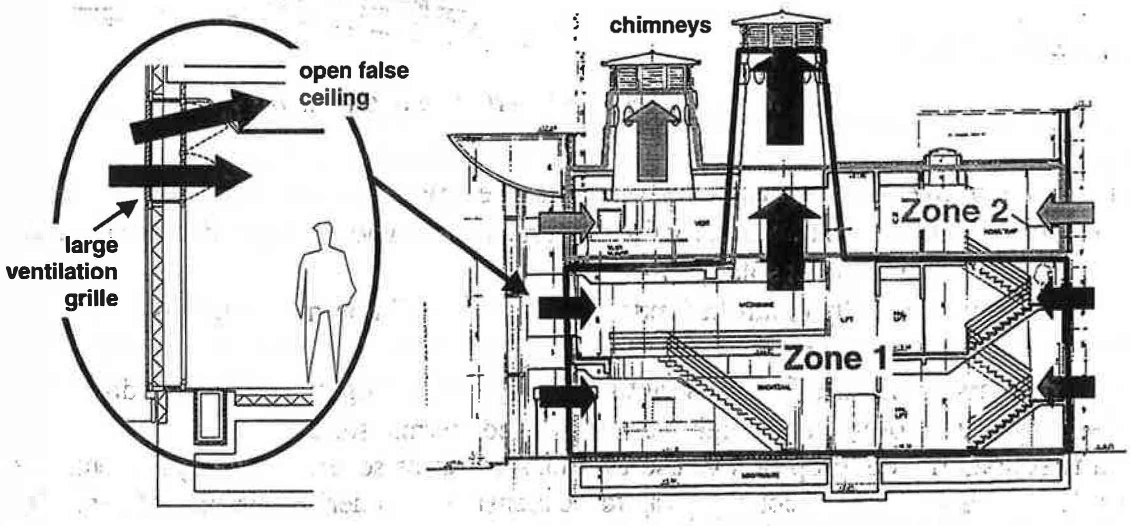


Figure 2: Ventilation concept – detail of air inlet and cross section of the building

The overall impact of the different measures was evaluated by means of thermal simulations with the program ESP-r of the University of Strathclyde. This program allows a coupling of the air flows and the temperatures, an essential element to simulate the thermal stack effect.

According to the simulations, night air changes were approximately 9 vol./h and the internal temperature was only during 60 hours of the office hours higher than 25°C and never higher than 28°C, assuming the Test Reference Year of Uccle. This result was acceptable for the owner. However as there is some uncertainty on the simulation results, it was decided to preserve the possibility to install a top-cooling on the mechanical ventilation system.
The study of the building was finished in 1997. The construction will start in Augustus 1998 and will be finished in the beginning of 1999.

THE KEPPEKOUTER PROJECT

The Keppekouter project (4.500m²) consists of three similar office buildings. The buildings are constructed by a building promoter and are let to other companies. Hence the economic aspect was a very important element of the building design. The Keppekouter project is located at less than 100 meters from a very busy highway (E40: Brussels-Ostend).
In the first building design no active cooling was foreseen. Moreover free-cooling by opening the windows during daytime was impossible due to the noise of the nearby highway. Therefore one of the major renters expected serious overheating problems in summertime. The promoter contacted the BBRI to examine whether it was possible to get an acceptable indoor climate without installing an (expensive) active cooling system.

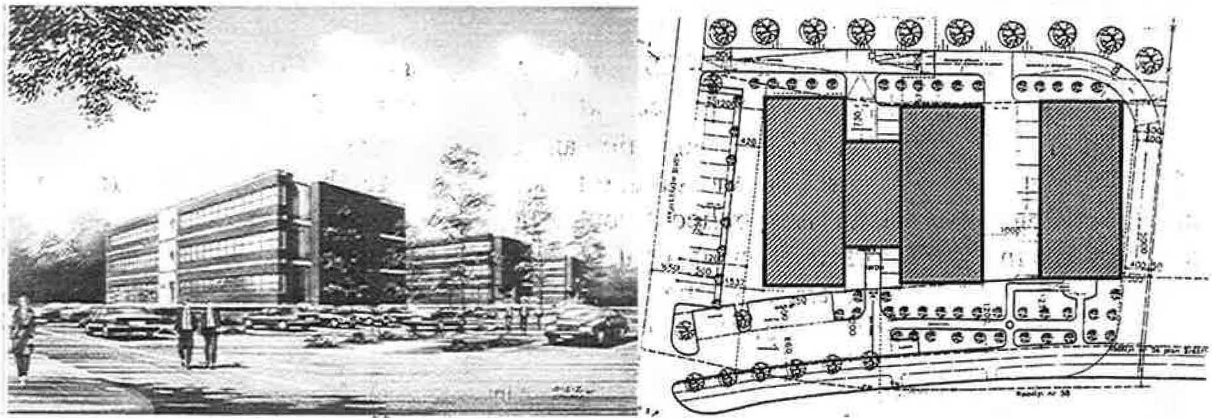


Figure 3: Keppekouter – art view and plan view

The chance of overheating was considerably reduced by:

- Minimising the indirect solar gains (10 cm of glass wool in the roof construction)
- Minimising the direct solar gains by
  - Automatically controlled external screens on all non-north façades
  - Selective glazing
- Minimising the internal gains (automatically dimmed lights near the windows)
- Application of intensive night ventilation and thermal storage

In a first stage it was proposed to use the stack effect of several chimneys to enhance night ventilation. However this concept was too expensive considering the loss of rentable space. Finally it was chosen to ventilate the ground floor and the first floor by cross ventilation and the top floor by means of a mechanical extraction fan. The cold external air can enter the building through large grilles. During warm periods the occupants place grilles in the window frame. The internal doors have to be open at night to allow cross ventilation.
The possibilities of night ventilation are however not fully used in this building, as the accessibility of the thermal mass is moderate. For reasons of flexibility and cost, a false floor

and a false ceiling were preferred. To increase the accessibility of the thermal mass some panels of the false ceiling were replaced with open elements (grid).

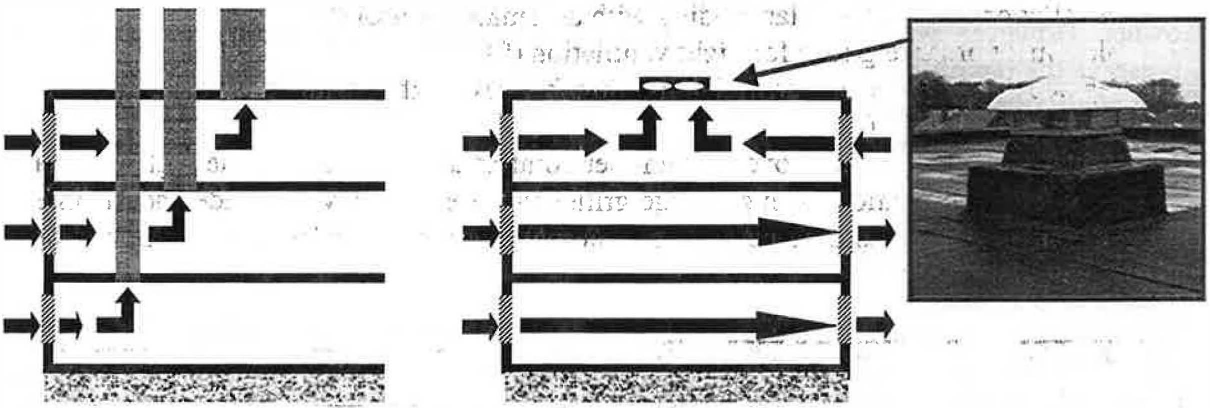


Figure 4: Ventilation concept – original and final concept

During the summer of '97, the building was monitored in the framework of the NatVent project. Monitoring results show very clear the positive effect of the external screens on the indoor comfort. The impact of the night ventilation could be optimised by increasing the accessibility of the thermal mass. The occupants judged the summer comfort as acceptable, only in the morning, indoor temperatures were sometimes too low due to the night ventilation. Installing a timer on the extraction fan will solve this problem.

THE PROBE BUILDING

The PROBE building was built in 1975 and renovated in 1996 and 1997. The building is situated on the BBRI's test site at Limelette. Before the renovation there were serious problems of overheating in summertime and bad air quality in wintertime.

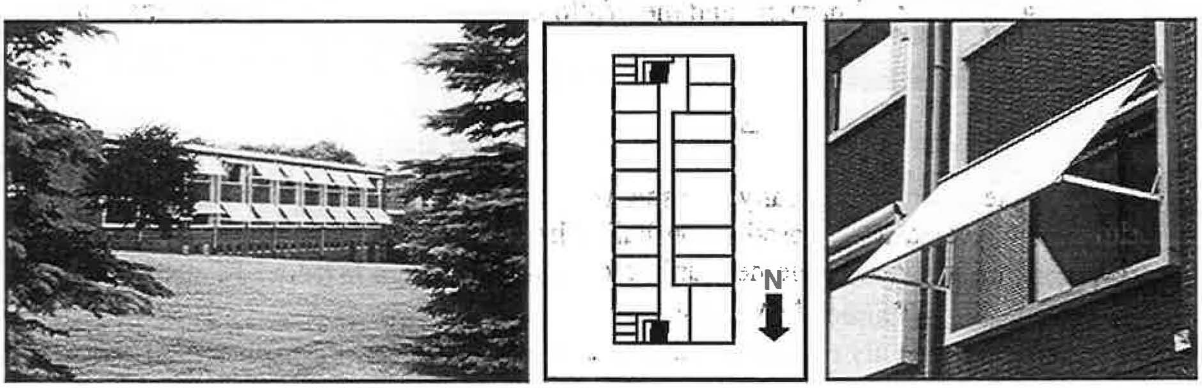


Figure 5: East façade - Plan view – Large ventilation grille and awnings for solar shading

PROBE stands for Pragmatic Renovation of Office buildings for a Better Environment. The renovation consists of a wide range of relatively small-scale improvements, which can be applied to many similar office buildings:

- installation of a new fuel boiler, thermostatic radiator valves and improvement of the regulation system
- replacement of the old roofing and placement of additional insulation on the roof (*)
- installation of a mechanical ventilation with infrared presence detection

- replacement of the single glazing with low-e argon filled double glazing (central U-value = 1,1W/m²K)
- installation of external solar shading with automatic control (*)
- placement of large grilles for night ventilation (*)
- replacement of the old artificial lighting by new lights with luminance control and electronic ballast (*)

The renovation works that improve the summer comfort are marked (*). The night ventilation is based on cross ventilation. At night large grilles in the east and west façade and the internal doors are opened. The building has a large internal mass; it has exposed ceilings and heavy internal walls.

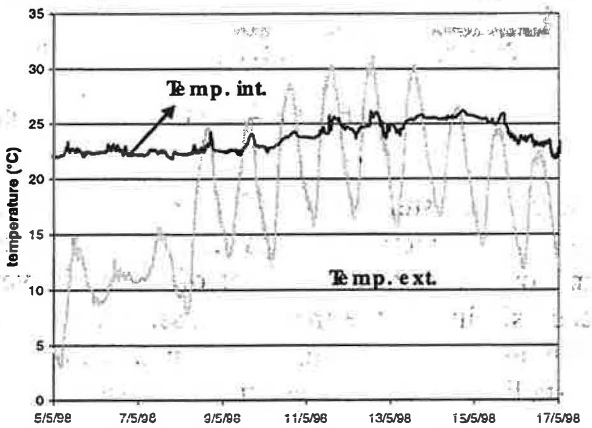


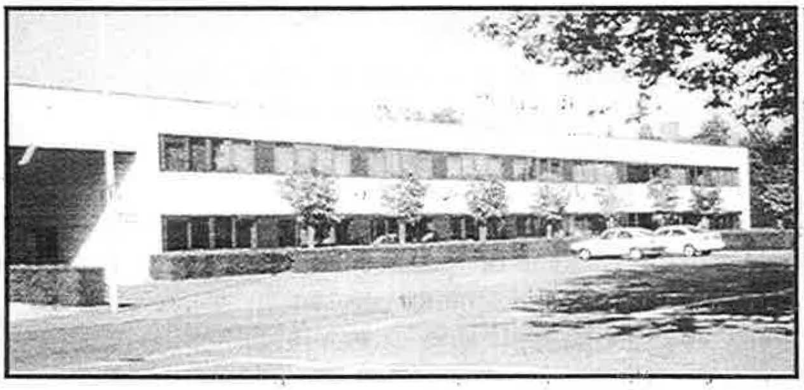
Figure 6a: Office at the west façade – large ventilation grilles and external screens

Figure 6b: Internal and external temperatures during heat wave

Measurements carried out in the framework of the NatVent project show that the overall effect of the different measures leads to an acceptable summer comfort (see Figure 6b).
Several Belgian industrial partners and the Walloon Region fund this demonstration project.

THE RENSON HEADQUARTERS

The headquarters of the company Renson is a two-storey building. The rear façade of the building is connected to the production hall. The front façade of the building is south-west oriented and has a considerable net surface of glazing (25%). Due to this large surface there were considerable problems of overheating during summertime.



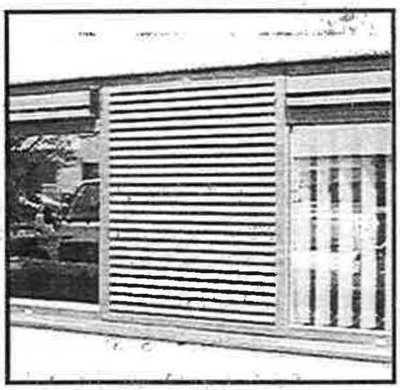


Figure 7: Front façade – Large burglary-proof ventilation grille for night cooling

In 1997 it was decided to renovate the building. The effect of different measures was evaluated by means of thermal simulations with the program ESP-r. Based on the simulation results, the following renovations were proposed:

- Installing shading overhangs on the front façade and replacing the double-glazing by selective glazing. The selective glazing has a g-value of 0,34. This leads to a reduction of the solar gains with 43% (g-value of double-glazing: 0,77). The overhangs shade approximately 75% of the glazing.
- Installation of large grilles in the front façade and a chimney on the roof. The ground floor is ventilated intensively at night through these openings. Due to practical reasons, the first floor it ventilated mechanically at night. The effect of the night ventilation is limited, as the thermal mass of the building is restricted (false ceilings and carpeted floor).

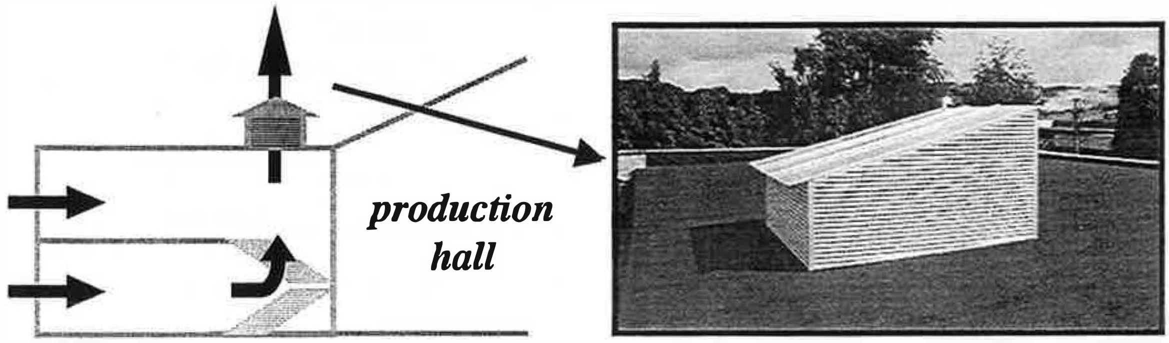


Figure 8: Natural ventilation for night cooling – stack effect

CONCLUSIONS

Some lessons can be drawn from the experience of the four projects:

- There are a lot of practical barriers to the application of natural night ventilation in office buildings: fire regulations, security, privacy,... Accessibility of the thermal mass is often found to be the most serious barrier.
- It is recommended to examine the possibilities of natural ventilation for summer comfort in an early design stage. This increases the chance to solve successfully the different problems.
- Due to the different barriers, the larger uncertainty and the lack of existing examples, the design of a natural ventilated building means an extra risk and effort for the design team (architects, installation engineer, building physicist). As the installation cost is often reduced by the concept of natural ventilation for summer comfort, an adapted fee structure can be necessary.
- Thermal simulations are necessary to evaluate the global effect of the different measures. There is a clear need for simple pre-design simulation tools.
- In a number of cases mechanical ventilation can be an appropriate solution for night ventilation.
- Monitoring results demonstrate that for many office buildings an acceptable indoor climate can be achieved by means of a package of 'passive measures'. Only the global effect of different measures leads to an acceptable summer comfort.
- The global strategy for summer comfort is applicable to new buildings as well as to renovation projects.
- The Keppekouter project proves that the global strategy for summer comfort can be economically interesting for building owners (no cooling installation) as well as building renters (lower energy costs).