The BRE has carried out monitoring tests to measure the winter ventilation performance of the Portland Building, the recently-completed low energy building at the University of Portsmouth.

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Winter ventilation monitoring at the Portland Building

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References

[1]Field J, "University challenge", *Building Services Journal*, 2/97, pp16-21.

[2]Liddament M W, *"A guide to energy efficient ventilation"*, International Energy Agency, AIVC, 3/96.

†The NatVent project partners include the Belgian Building Research Institute, TNO Building & Construction Research (The Netherlands), the Danish Building Research Institute SBI, J&W Consulting Engineers AB (Sweden), Willan Building Services (UK), the Sulzer Infra Laboratory (Switzerland), Delft University of Technology (The Netherlands) and the Norwegian Building Research Institute.

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The Building Research Establishment (BRE) is currently co-ordinating NatVent†, a major pan-European research project involving several European research institutions.

NatVent aims to provide solutions to technical barriers preventing the uptake of natural ventilation and low energy cooling for office-type buildings in those countries with moderate and cold climates.

The project is also seeking to encourage and accelerate the use of natural ventilation and 'smart' controls as the main design option for new build projects and major refurbishments.

As part of the NatVent project, some 19 buildings are being studied in seven European countries. The buildings are specifically designed to incorporate a low energy ventilation strategy. The aim is to use the monitoring results to gain a better understanding of the applicability and limitations of natural ventilation strategies.

The Portland Building at the University of Portsmouth[1], which houses the University's Faculty of the Environments, is one of the three buildings being studied in the UK. This is essentially a naturally ventilated building complete with several ventilation towers which draw air into the staircases via corridor ceiling plenums on each floor.

A monitoring protocol has been developed as part of the NatVent project so that a basic assessment of the ventilation strategy can be carried out with the minimum of monitoring – typically one week each during winter and summer.

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.

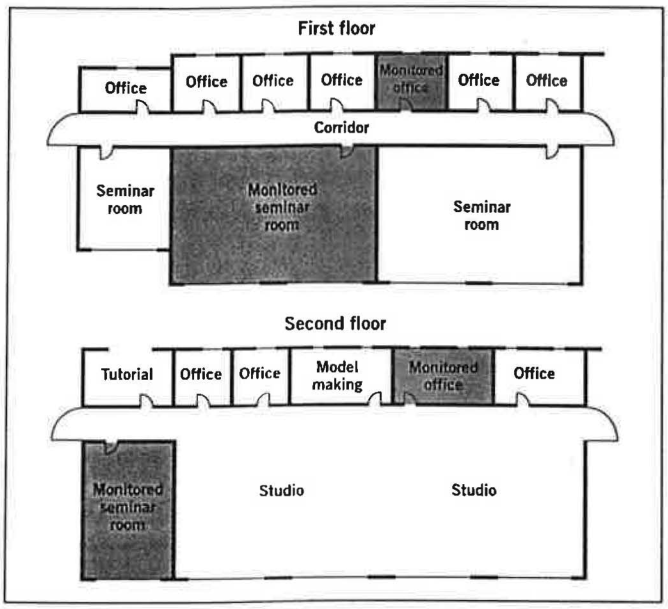


FIGURE 1: First and second floor plan highlighting the monitored seminar rooms and offices. The Portland Building has several towers to aid natural ventilation.

In the summer, the assessment focuses on whether comfort temperatures are established and whether maximum exchange of heat between the building structure and the outside air is achieved, during the day and especially at night when the outside air is relatively cold.

The control of airflow rates on its own is not so important in the summer, provided that it does not result in excessively draughty conditions.

Summer monitoring tests are currently being conducted at the Portland Building, and results are not yet available.

Winter monitoring at Portsmouth

Winter monitoring at the Portland Building was carried out in February 1997 in four rooms located on two floors in the building's naturally ventilated office and seminar wing (figure 1).

On the first floor – which features a central spinal corridor – one office along the north side of the building and one seminar room situated on the south side were monitored.

The tests were repeated on the second floor, where the corridor that separates the seminar room from the offices opens out into an open-plan studio.

On both floors, the offices on the north side have single-sided ventilation from the windows and trickle vents. The seminar rooms and studios are cross ventilated via the openable windows, trickle vents and grilles on the corridor ceiling plenum that connects the space with the staircases.

The following parameters were measured in each of the four rooms monitored:

- ☐ internal and external carbon dioxide (CO_2) concentrations

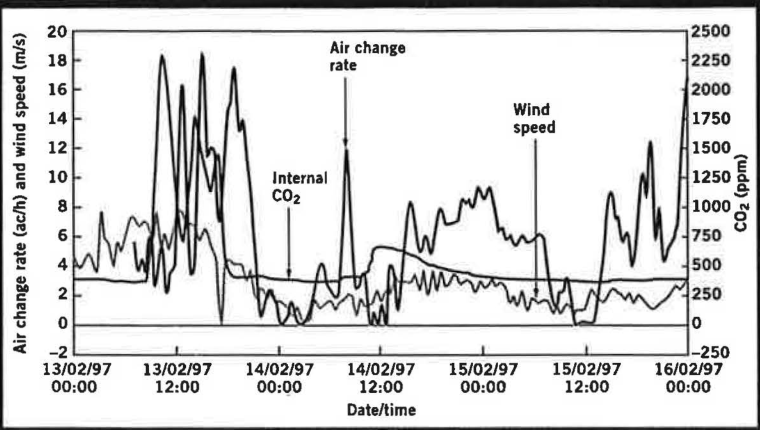


FIGURE 2: Measured air change rate, internal CO_2 levels and wind speed in the first floor seminar room during the three-day monitoring period. Increased occupancy levels on the Thursday resulted in windows being opened to provide the necessary level of ventilation.

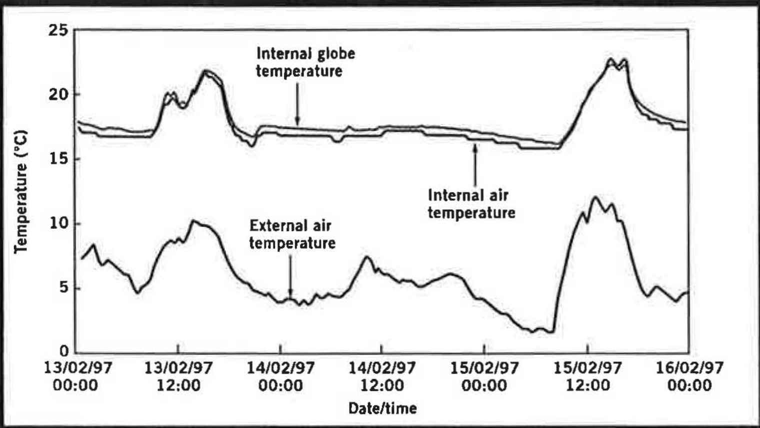


FIGURE 3(A): External and internal air temperature and internal globe temperature in the first floor seminar room over the three-day test period. (Note: the period Thursday 13-00:00 h through to Friday 14-00:00 h is detailed below).

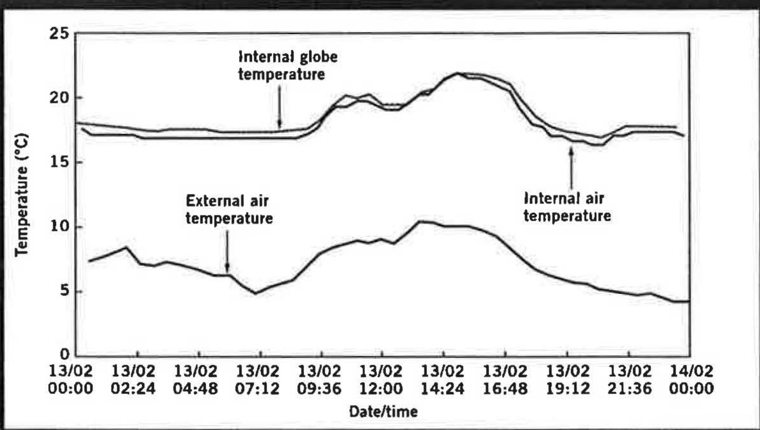


FIGURE 3(B): A time lag of one hour 30 minutes can be seen between the peaks of internal and external temperature during Thursday, highlighting the influence of the thermal mass.

(to be used as the main general indicator for assessing indoor air quality);

- ☐ internal and external water vapour levels (to be used as a secondary indicator for indoor air quality assessment);
- ☐ fresh air flow rates, local wind speed and direction (to evaluate the fresh air provided);
- ☐ internal and external air temperature, internal globe temperature and internal air velocities (for assessing thermal comfort).

Fresh air flow rates are difficult to measure continuously in a naturally ventilated space – the NatVent project overcomes this problem by using the constant concentration technique[2].

The constant concentration technique involves the use of sophisticated equipment to seed both the test room and the rooms surrounding it with tracer gas (namely sulphur hexafluoride), helping to maintain the concentration at a constant level – eg five parts per million (ppm).

The amount of fresh (outside) air entering the room can be calculated by measuring the injected amount of gas required to maintain this concentration level. Since the tracer gas concentrations are the same in all the rooms and corridors surrounding the test room, the airflow rate consists only of air coming from the outside.

First floor seminar room

Tests were carried out in the first floor seminar room to determine the measured internal CO_2 and water vapour levels as indicators of indoor air quality. These measurements indicate whether or not adequate ventilation has been provided during those periods when the building is occupied.

The results showed that the seminar room was used in the morning and afternoon on the Thursday by a large group of people, and also during the Friday morning by a smaller group of people.

Metabolic CO_2 concentrations exceeded 1000 ppm on three occasions during occupancy, although normal levels were restored quickly at the end of the lectures by opening windows.

On the Friday, the CO_2 concentration peaked at 500 ppm and then slowly decayed, indicating background ventilation only. As expected, levels of water vapour increased during occupancy on Thursday. Levels also increased during Friday and Saturday due to occupancy, as well as an increase in external water vapour content.

In terms of relative humidity (rh), the internal values are very stable at somewhere between 60% and 65% rh. Although these values are at the higher end of the comfort scale, they are still within acceptable levels.

Figure 2 details the air change rate per hour (ac/h) and internal CO_2 concentration for the first floor seminar room, in addition to the wind speeds. The average air change rate is calculated at 7·5 ac/h over the three days of monitoring, and there are periods when high ventilation rates coincide with increased occupancy.

An analysis of the wind speed and direction data and the background airflow rates does not show any obvious relationship.

However, a gradual reduction in air change rate is observed on Friday and in the early hours of Saturday, coincident with reduced wind speed.

Figures 3(a) and 3(b) highlight the results of an initial thermal comfort assessment.

FIGURE 4: Measured internal air change rate and CO_2 levels in the single occupancy first floor office.

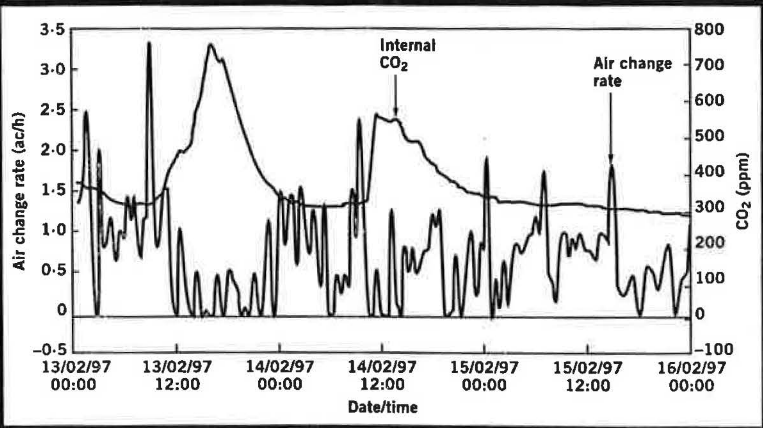


FIGURE 5: Measured internal air change rate and CO_2 levels in the single occupancy second floor office.

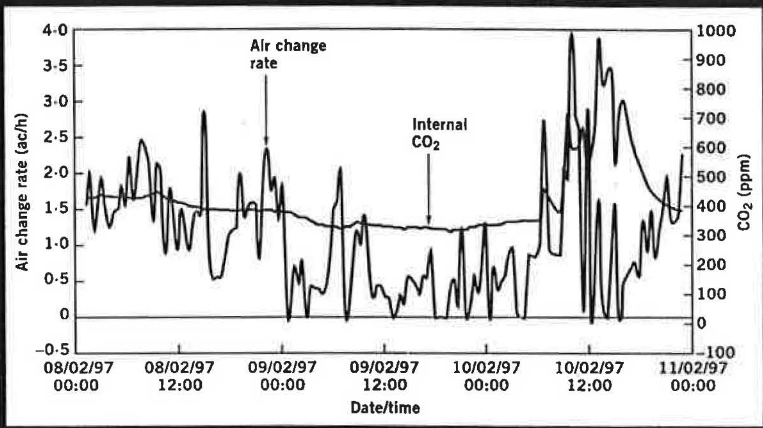
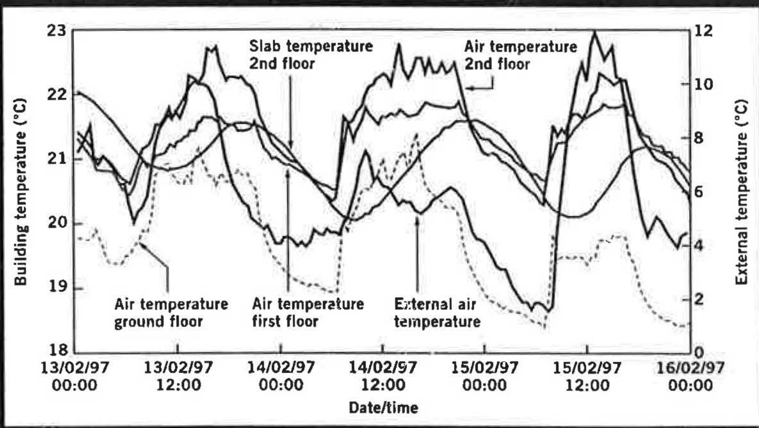


FIGURE 6: Building temperatures in one of the staircases used as ventilation stacks: air temperatures at ground, first and second floor levels and slab temperature at second floor level. (External air temperature is included with a different scale axis).



Internal air temperatures are maintained at reasonable values and, as expected, are influenced by occupancy patterns and external temperatures.

Globe temperature (a measure of the air and surface temperature and an indicator of thermal comfort) is very close to air temperature, indicating no additional sources of internal heating.

Office monitoring

Figures 4 and 5 show airflow rates and internal CO_2 concentrations over the three-day test periods in two single occupancy offices. In both offices, CO_2 levels have been maintained below 1000 ppm. Background ventilation rates are within normal ranges, and affected by occupancy patterns.

Average air change rates during the three-day test periods are 0·7 ac/h for the first floor office and 1·05 ac/h for the second floor office.

The higher measured ventilation rate in the second floor office is due to the open-plan studio space adjacent to it with the additional airpaths (eg plenum), which could enhance the ventilation rate.

Figure 6 plots the internal air temperatures in one of the staircases that is connected to the seminar rooms via the corridor ceiling plenum.

Air temperatures are shown at the level of each of the three floors together with the external air temperature and slab temperature at second floor level (note the different scale for the internal and external temperatures).

From the internal air temperature plots it can be seen that there is air stratification in the staircase as hot air rises to the exhaust at the top. It is expected that this effect would be more prominent in the summer period and allow the ventilation of the seminar rooms during hot, still days.

The slab temperature graph shows the effect of the thermal mass attenuating the influence of external conditions. A definite diurnal time lag exists between slab temperature and external air temperature.

Peak slab temperature is slightly higher on the Friday than on the Thursday of the monitoring period, indicating the influence of the higher external temperature on the previous day, while the peak slab temperature has decreased on Saturday, highlighting the influence of the relatively lower external maximum temperatures on Friday.

There is also a time lag of a few hours between the internal and external air temperatures. This is probably due to the effect of the lower temperatures in the slab combined with the large time lag in the slab temperatures.

This time lag of peak internal air and slab temperatures will help to moderate the influence of external conditions and internal heat gains to maintain internal comfort temperatures in the summer.

Conclusions

The winter monitoring results at the Portland Building show that the natural ventilation strategy provides a satisfactory indoor air quality, as the design intended.

CO_2 and humidity levels are within acceptable values, and comfortable temperatures were recorded with appropriate fresh air ventilation rates.

In addition, there are positive indications for the performance of thermal mass for summer cooling and the role of the staircases for providing stack ventilation.