Testing a prototype night ventilator

Natural night-time ventilation is often used to pre-cool low energy buildings, but can lead to security risks and weather damage. A prototype night ventilator has been built to combat such problems, but how has it performed in field tests?

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References
[1]Webb B and Concannon P, 'In the cool of the night', *Building Services Journal*, 12/96, p39-40.
[2]Webb B and Kolokotroni M, 'Night cooling a 1950s office', *Architects' Journal*, 13 June 1996, p54-55.

Further reading
'Birth of the cool', Technofeature, *Building Design*, 30 May 1997.

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Natural night ventilation has been used in many recently constructed 'green' buildings, either new build or refurbished, as a low energy strategy to provide 'free' cooling.

However, ventilators that can provide night ventilation – and be left safely open at night without risking weather damage or intruders getting into the building – are not available.

With this in mind, a Partners in Technology project part-funded by the Department of the Environment, Transport and the Regions and carried out by Willan Building Services, Oscar Faber Applied Research and the Building Research Establishment aimed to design, install and test such a prototype night ventilator.

The first part of the project concentrated on thermal and airflow modelling to determine achievable airflow rates for a range of UK weather data[1].

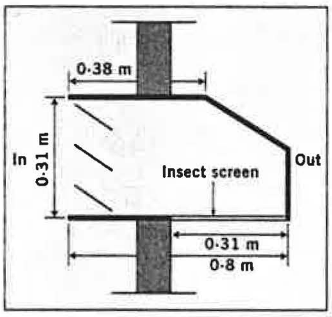
Bearing these results in mind, the project team then designed a prototype ventilator, and the second part of the project has concentrated on field trials of the ventilator. These trials were carried out in the summer of 1997, and have yielded some interesting findings.

Effective opening areas

The preliminary results of monitoring night-cooled offices and carrying out extensive thermal and airflow modelling showed that an effective opening area of approximately 8000 mm^2/m^2 of plan floor area is required to provide maximum potential cooling (ie 20 times the required area for background ventilation).

This effective opening area should be able to provide adequate airflow for worse conditions, ie typical summer external/internal temperature difference and no wind.

ABOVE: Prototype ventilators and sensors installed in the test offices. The ventilators had to be designed to resist weather ingress, and not compromise building security.



LEFT, FIGURE 1: Section through the prototype night ventilator installed in the test office building at the BRE's Garston hq.

Figure 1 shows a section through the prototype ventilator, the design of which had to take into account several factors, including: weather resistance (particularly to driving rain), resistance to the ingress of insects, building security, controllability (either locally – manual or electric) or centrally (via a bems), and the need for minimal maintenance and durability.

The prototype ventilator was installed in an open-plan office on the second floor of a 1960s three-storey office building at the BRE's Garston hq.

Eight occupants were in the office, complete with ten computers, six printers and fluorescent twin tubular surface-mounted luminaires.

Assuming two thirds building occupancy, 50% equipment use and taking into account the floor area (around 90 m^2), the estimated internal heat gains were approximately 30-35 W/m^2.

Construction of the test office

The test office comprises concrete panel infill external walls (north and south) on a girder frame, plastered on the inside and painted on the outside, and one external wall (west) of brick outer with concrete plastered inner.

Internal walls are a combination of stud walling with plasterboard and concrete block faced with plaster.

The office has a plastered and painted concrete ceiling, carpeted floors and steel-framed single-glazed windows with internal venetian blinds.

Exposed thermal mass of the office comprises the plastered concrete ceiling, external west wall and some of the partition walls. This exposed mass makes the office suitable for night cooling by ventilation.

In all, the test office has nine windows, four north-facing and five south-facing. Nine prototype ventilators were installed in early May last year in the lower part of each window, and controlled by a time switch. The ventilators were closed during the day. Occupants used the windows as normal for daytime ventilation.

Measurements were carried out over a period of 19 weeks until the end of last September, covering the whole of the summer cooling period. These measurements included:

- ten-minute average values of air, surface and globe temperatures in a number of locations inside the offices to assess the thermal comfort provided to occupants;
- external air temperature, wind velocity and direction (to estimate the effect of external conditions on the level of cooling provided);
- the ventilation rate of the test room with open ventilators to view the extent to which outside 'cool' air enters the offices;
- pressure differences across the ventilator to estimate the air flow through them.

The ventilators were kept either open or closed on alternate weeks to investigate their effect (when open) on reducing internal temperatures during the day.

Temperature measurements

Generally, internal temperatures were reduced during the day when the ventilators were left open the previous night.

Figure 2 shows the daily variation of the external and internal air temperatures and ceiling surface temperatures on two days, one with open and one with closed ventilators.

These example days were selected because their maximum external temperatures were similar, making comparisons easier.

Slightly higher external temperatures occurred on the day with open ventilators. Higher night-time temperatures were also measured.

Figure 2 shows that when the night ventilators were open, the maximum internal air temperature was 2°C lower than the maximum external temperature, with the ceiling surface temperature 3°C lower.

Daily variation between day and night internal temperature was 4°C, with a corresponding external diurnal temperature range of 10°C.

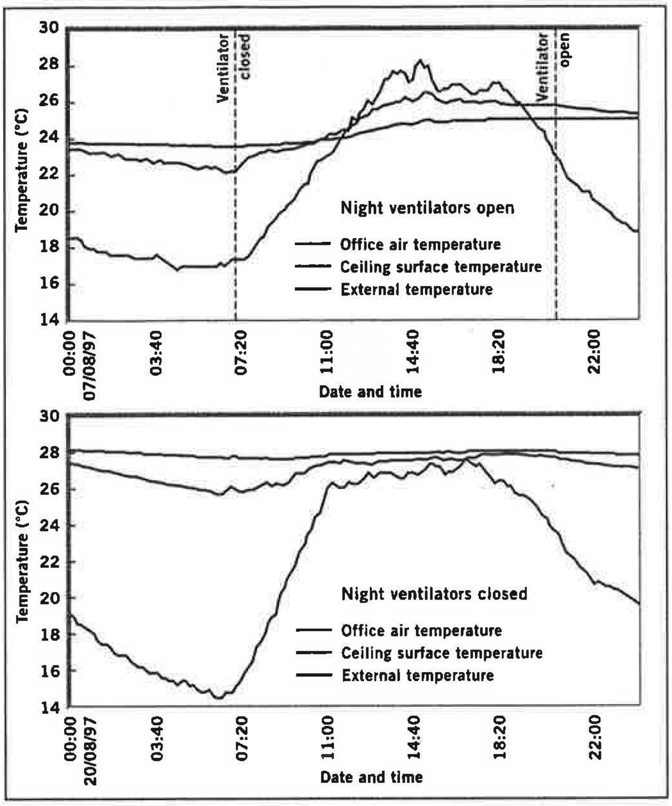


FIGURE 2: Internal temperatures for two days with similar external temperatures, one with open night ventilators, the other closed. Lower internal air temperature, ceiling surface temperature and a larger difference between day and night were measured for the open ventilators.

However, when the ventilators were closed, both the maximum internal air temperature and the ceiling surface temperature were 1°C higher than external air temperature. In this case, the daily variation between day and night temperature was 2°C, with a corresponding external diurnal variation of 13°C.

Such measurements give an encouraging message when compared to thermal simulation results. Simulations considering similar external temperatures indicated that night ventilation would not reduce peak internal temperatures below the maximum external.

For all measured data during morning working hours (for similar external air temperatures), the office air temperatures were up to 3°C lower when the ventilators were open at night.

During the afternoon, maximum internal temperatures were up to 1·5°C lower when the ventilators were open at night, again for similar external temperatures.

Similar patterns were established for ceiling surface temperatures for all measured data. During the morning, surface temperatures were up to 3°C lower when the ventilators were kept open at night than on those days when the ventilators were closed.

A similar difference in temperatures was maintained during the afternoon, with surface temperatures up to 3°C lower for days when ventilators had been open, thus increasing occupant thermal comfort in the afternoon due to the cooler radiant temperatures.

Room ventilation rates

The ventilation rate of the office with open night ventilators was measured on a number of occasions using the tracer gas decay method.

External conditions were found to vary between low wind speeds of around 0·3 m/s and high wind speeds of 4 m/s.

The internal/external temperature difference was in the region of 5°C-6°C. Wind direction varied considerably from parallel to perpendicular to the building. The air change rate varied between 3-20 ac/h.

These results are consistent with modelling predictions carried out to determine suitable opening areas for the ventilator[2].

A correlation exists between ventilation rate and wind speed, suggesting that a restriction of the ventilator opening area is necessary on occasions of high air speed to avoid the effects of overcooling, especially when high winds are combined with low external temperatures.

It should also be noted that thermal modelling indicated that there is a relatively small variation in the maximum internal comfort temperatures in comparison with large variations in the ventilation rate.

As the ventilation rate increases beyond 5 ac/h, the reduction in temperature achieved decreases.

Airflow through the ventilator

The airflow resistance characteristics of the ventilator were tested in the laboratory for a range of pressure differences between 0-50 Pa, and the airflow volume through the ventilator determined.

To determine the pressure difference range likely to occur during the summer, pressure differentials were measured across two of the ventilators in the office – on the south and north sides of the building.

Average pressure differences over the duration of tracer decay tests were in the range 0·5-5 Pa for corresponding wind speeds of 1·2-4 m/s.

No noticeable pressure difference was registered for wind velocities of less than 1·0 m/s, and no high winds were recorded during the hot summer nights.

Ultimately, the test results showed that:

- an effective opening area of 8000 mm^2/m^2 plan floor area is required to provide adequate airflow under unfavourable external conditions (ie those nights with low wind speeds);
- lower internal air and surface temperatures were recorded in the office when the ventilators were open at night under a variety of external conditions;
- the overall ventilation rate was affected mainly by external wind conditions, while the pressure differential measured on site across the ventilators was related to wind speed.

Further research to improve draught proofing, noise attenuation and controllability will be needed before the ventilator can be marketed.