The Portland Street Building, Portsmouth

Building Description

The Portland Building (Figure 1) was designed by the Hampshire County Council Architects department and completed in 1995. It is a four-storey building. In plan view it is E-shaped, with the southern wing extending out almost twice as far as the northern wing (see Figure 2). The outer wings contain teaching rooms and offices arranged on either side of a central corridor, and there are five open staircases. In the central wing, there is a ground floor restaurant with the main lecture theatre above it. The main spine of the building houses a resource centre. Extending the full length of the building, between the resource centre and the wings, there is a full height atrium with a glazed roof and solar shading.

The building is of heavyweight construction with exposed thermal mass in the form of concrete columns and ceilings in some of the rooms. Heating is provided by an under-floor hot water system.

Ventilation Philosophy

Apart from the lecture theatre, the building is naturally ventilated with a combination of single-sided, cross- and stack-ventilation.

During winter, the ventilation system should provide acceptable indoor air quality (IAQ), while keeping airflow rates within a reasonable range to avoid discomfort due to draughts and to minimize the excess energy required to heat incoming air.

In the summer, providing comfortable temperatures is the priority. Night ventilation is used to cool down the building fabric, which can then absorb the heat of the day. This can enhance comfort by:

- reducing rises in indoor air temperature,
- reducing surface temperatures,
- off-setting the maximum indoor air temperature till later in the day, possibly until after working hours.
Ventilation Technology

The area of interest for this study is the southern 'office and seminar' wing. Trickle ventilators, located in the upper part of the timber window frames, are used to provide background ventilation in winter. Additional ventilation is provided through openable windows in all rooms. The windows also have blinds. In most of the office rooms, single sided ventilation is provided through the windows and trickle vents.

In the seminar rooms, there is an air path through extract grilles, which connect the rooms to the staircase via a plenum in the corridor ceiling. The staircases are glazed at the top and act as 'towers' or solar chimneys to enhance stack driven ventilation. The 'towers' have fans, which are activated when the pressure difference created passively is insufficient to create the required air movement. The fans can also be used to assist night cooling if necessary.

The three lower floors in the wing are connected to the staircases, but the top floor is mainly cross ventilated via clerestory windows. This floor has a timber roof and glazing and so has less exposed thermal mass than other parts of the building.

Monitoring Programme

In each of the rooms monitored, the following parameters were measured:

- Internal and external CO₂ concentrations (to be used as the main general indicator for IAQ assessment),
- Internal and external water vapour levels (to be used as a secondary indicator for IAQ assessment),
- Fresh air flow rates (measured using a constant concentration tracer gas technique), local wind speed and direction (to evaluate the fresh air provided),
- Internal and external air temperature, internal globe temperature and internal air velocities (to assess thermal comfort).

Temperatures in the floor slabs and staircases (towers) were also monitored so that the stack effect and night cooling strategy could be assessed.

Summer monitoring was carried out in June 1997. Two rooms on the first floor were monitored, an office on the north side and a seminar room on the south side of the wing (see Figure 2). In winter, monitoring took place in February 1997. In addition to the first floor rooms, an office and a seminar room on the second floor were monitored. Measurements taken in the first floor office are used here to represent the monitoring results.

Summer Monitoring Results

Figure 4 shows the monitoring results for the first floor office during the summer period.

The air change rate peaked at about 2.5 ach, with an average of about 0.5 ach. The data showed an increased air change rate during periods when the room was occupied e.g. because of window opening.

CO₂ concentrations in the office peaked at about 1400 ppm on two occasions. At other times, concentrations generally peaked at between 800 to 1000 ppm. The percentage relative humidity is generally within the range 45 to 60 % and does not exceed design value of 65 %. These re-
sults indicate that indoor air quality is acceptable.

The internal temperatures for both the first floor office and the seminar room showed that the design value of 25°C was not exceeded, even though the external temperature design value of 27°C was exceeded on many occasions. Globe temperatures were lower by an average of 1 to 2 °C, indicating the effect of thermal mass.

Night Cooling: Additional measurements of internal, external and slab temperatures in the first floor office were made for three months in the summer. These showed that the slab temperature could be as much as 2 °C lower than the indoor air temperature during hot periods. The slab and air temperatures showed a much lower variation in amplitude than the external temperature, and there was a time lag so that, for example, the maximum internal and slab temperatures occurred later than the maximum external temperature.

Measurements of air and slab temperatures on the first and third floors were also made so that comparisons could be made between the high thermal mass first floor and the third floor which had a much lower thermal mass. Figure 5 shows the results for five working days during a very hot period in August. External air temperatures were relatively high and exceeded 30°C on two days. Internal temperatures on the first floor were very stable and the external temperature peaks were reduced by a maximum of 8°C in the case of air temperature and 10°C in the case of slab temperature. On the third floor, however, although internal temperatures remained lower than external temperatures during the hottest days, they exceeded the external temperatures on other occasions. This is possibly due to solar gains.

Other measurements for less extreme weather conditions confirmed that the first floor temperatures were relatively stable while the third floor temperatures were more variable and followed the external temperatures more closely. Solar gain had a big influence on temperatures on the third floor which could be too cold on cool, cloudy days. However, after a series of cooler days (peak temperatures between 20 and 25 °C), night cooling caused temperatures on the first floor to become uncomfortably cold (below 20°C), while solar gains meant that comfortable temperatures were experienced on the third floor.

Although the use of thermal mass and night ventilation can reduce the effect of external hot weather and establish comfort in the building, manual or automatic Building Energy Management (BEM) controls are needed so that the benefits are not offset by overcooling of the building during cooler spells.

Winter Monitoring Results

Figure 6 shows the winter monitoring results for the first floor office.

The air change rate peaked at about 2.5 ach, with an average of 0.7 ach over the whole period. There are periods when the higher ventilation rates coincide with occupancy. An analysis of the wind speed and direction data and the background air flow rates did not show any obvious relationship. However, a gradual reduction in air change rate was observed on Friday and early Saturday coincident with reduced wind speed.

CO₂ concentrations in the first floor office peaked at about 1000 ppm and were
The NatVent Project

NatVent is aimed at reducing energy consumption and carbon dioxide emissions by developing and demonstrating natural ventilation solutions. This project is targeted at climates in which overheating can be avoided by good architectural design and by minimising internal heat gains. By introducing natural ventilation, the complexities of mechanical systems and associated energy demand is eliminated, while the need for air conditioning is minimised. These case study summaries are intended to provide innovative examples of the use of natural ventilation and to demonstrate performance, pitfalls and solutions.

The NatVent Partners

Project Partners are:
Belgium: Belgium Building Research Institute,
Denmark: Danish Building Research Institute,
Netherlands: TNO Building Construction and Research, Delft University of Technology,
Norway: Norwegian Building Research Institute,
Sweden: J&W Consulting Engineers AB,
Switzerland: Sulzer Lab,

Conclusions

During the summer the short term monitoring on the first floor indicates that generally thermal comfort is maintained, CO2 and relative humidity levels are within acceptable specified limits and that acceptable fresh air ventilation rates were achieved. However, on some occasions internal temperatures were low, particularly on the first floor, due to overcooling at night time.

Winter monitoring results indicate that the natural ventilation strategy provides a satisfactory indoor air quality as intended by the design. CO2 and humidity levels are within acceptable values and comfortable temperatures were recorded with appropriate fresh air ventilation rates. There are also positive indications for the performance of thermal mass for summer cooling and the role of the staircases for providing stack ventilation.

In conclusion, the measured data indicate:
- adequate ventilation is provided;
- comfort internal temperatures are maintained although there were some low temperatures on the 1st floor;
- high thermal mass ensures thermal stability.

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