In search of better air quality

Ventilation is fundamental to indoor air quality. But what kind of ventilation, and how does one respond to heat gains? Nigel Aitkinson considers the issues.

In the UK, improved air quality and lower energy requirements are becoming increasingly important in office ventilation. There are two new design concepts which aim to meet these needs — displacement ventilation, and cooled beams or ceilings. In addition, various combinations of the two have been introduced.

Displacement ventilation would be applicable to offices, if good air quality could be obtained in the occupied zone. However, because displacement ventilation can only handle heat loads up to 40 W/m^2, designers have been combining displacement ventilation with cooled beams or ceilings in an attempt to obtain better indoor air quality compared to conventional mixed-flow systems.

The ventilated cooled beam is currently the most popular system in Scandinavia. Low energy requirements (cooling loads of below 100 W/m^2 and a design room air temperature of 22±2°C) also make it possible to use cooled beams cost effectively in the UK.

Controlled tests

With so many different systems available, and with few guidelines to help designers use them in their offices, Halton has carried out carefully controlled tests in its research and development centre in Finland. Measurements were carried out under constant conditions, using the same design criteria and office environment for each system.

Four different systems were measured: ventilated cooled beam; passive cooled beam with low-velocity floor supply; radiant ceiling with low-velocity floor supply; and low-velocity floor supply on its own.

The ventilated cooled beams are connected both to the supply-air ductwork and cooled water circulation. The unit casing incorporates a central supply air plenum. Cooling is based on induced convection of room air through finned coils on both sides of the casing, providing increased cooling capacity and the required minimum primary airflow, all through the same unit.

Tests of the radiant ceiling with low-velocity supply had to be carried out with a reduced heat load of 50 W/m^2 because a higher cooling capacity was not possible with this test arrangement. Again, temperatures and velocities in the occupied zone were controlled. The temperature gradient was slightly higher than with the passive cooled beams, averaging 2.3 K between 0.1 and 1.8 m. Under 0.9 m it worked as a displacement system, but above that, air-exchange efficiencies indicated a mixed-flow system.

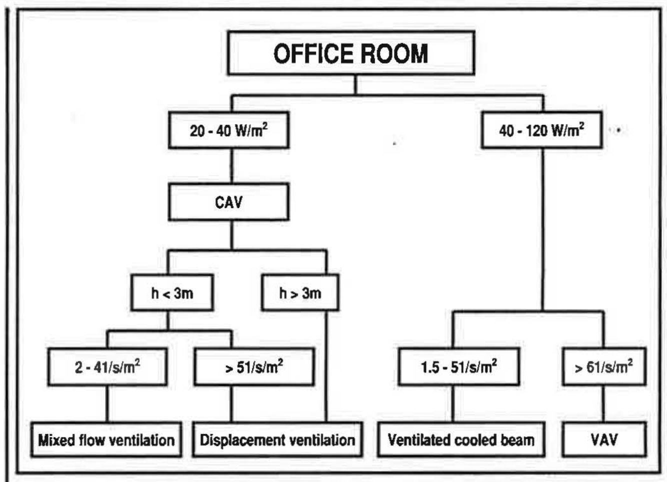
"Normal air-exchange values for mixing systems are 25 to 45%"

Displacement ventilation is normally recommended for use in offices where high loads are lower than 40 to 50 W/m^2. Higher loads require very high airflow rates because the highest temperature difference between supply and exhaust which can be achieved in office rooms is 6 to 7 K.

To investigate the relationships between temperature difference and floor rate, various tests were carried out. Cooling capacity in each case was 100 W/m^2. Design airflow rate with 6 K temperature difference was 160 l/s, which means 18 air changes per hour in this space. With this airflow rate, temperatures were maintained, but with higher velocities — up to 0.23 m/s.

When the airflow rate was reduced to 80 l/s, it was not possible to achieve the designed temperature difference of 12 K. Instead, the temperature in the occupied zone was too high at 26°C. With an airflow rate of 30 l/s, the room air temperature was 30°C in the occupied zone. This indicates insufficient air volume to keep the boundary layer at a high level.

The ventilated cooled beams maintained even temperatures all over the space, and velocities were less than 0.15 m/s, with a supply air temperature of 18°C. the local air exchange efficiencies (measured close to the mannequin) are in the range expected from a good mixed-flow system.



The ideal ventilation system depends on heat loads, design airflow rate and room height.

The passive cooled beam with low-velocity floor supply maintained even temperatures in the occupied zone. Even when the supply air temperature was 19°C, the temperature at 0.1 m above the floor was already 23°C and the temperature gradient between 0.1 and 1.8 m averaged 1 K. Velocities in the occupied zone were also very low — less than 0.12 m/s. Air-exchange efficiency values, however, indicated a low-velocity mixing system, so a higher indoor air quality was not achieved in the occupied zone.

Passive cooled beams rely purely on natural convection of room air through finned coils.

Radiant ceilings use large cooled surfaces at ceiling height, and they work mostly through radiation. One method of ventilating rooms is to have low-velocity terminals in the floor, with exhausts at high level.

The test room was designed to be as close to an office as possible. Total heat loads were 100 W/m^2, including lighting, a computer with fan, mannequin, a warm window at 28°C and panels on the floor, simulating solar radiation. The test room area was 11 m^2 with a design room air temperature of 22±2°C. The supply airflow rate was 2.5 l/s/m^2.

Measurements of air

Temperature and velocity measurements were made in the occupied zone in four different positions at three different heights — 0.1, 1.1 and 1.8 m above floor level. However, measuring only air temperature and velocities does not give an indication of air quality, so air-exchange efficiencies were also measured using a tracer gas (N_2O).

Air-exchange efficiency (E) is the age of the room air (T) compared to the theoretical air change rate (n).

$$E = n/2T$$

Values of air-exchange efficiency indicate how long the air has been in the room when it arrives at a given position. The shorter the time the higher the air-exchange efficiency and the better the possibility of creating good air quality.

Normal air-exchange values for mixing systems are 25 to 45%, and local values are the same all over the space.

For displacement ventilation, the values normally found in high ceiling spaces are 65 to 75%, and local values are higher at low level. In normal office spaces, such high figures cannot be expected because of low convection loads and low location of heat sources, but ventilation systems can be assumed to be displacement in behaviour when local values are high near the floor and steadily decrease with height.

The tests show that differences in air quality, temperature and velocity between the measured systems were not significant. Consequently, minimising installation and running costs become the more important criteria influencing choice.

The ideal ventilation for a given situation will depend on the level of heat loads, design airflow rate and room height.

For small heat loads of 20 to 40 W/m^2, constant air volume (CAV) systems are best.

For offices below 3 m in height and with low airflow rates (2 to 4 l/s/m^2), conventional mixed-flow systems are ideal.

When the room is higher than 3 m, or airflow rates are greater than 5 l/s/m^2, displacement ventilation becomes a viable alternative. For larger heat loads of 40 to 120 W/m^2, ventilated cooled beams and variable air volume (VAV) become cost effective.

The best option depends on airflow rate. For airflow rates above 6 l/s/m^2, VAV is recommended, because the air itself can provide enough cooling capacity. For lower airflow rates (1.5 to 5 l/s/m^2) ventilated cooled beams are viable. □

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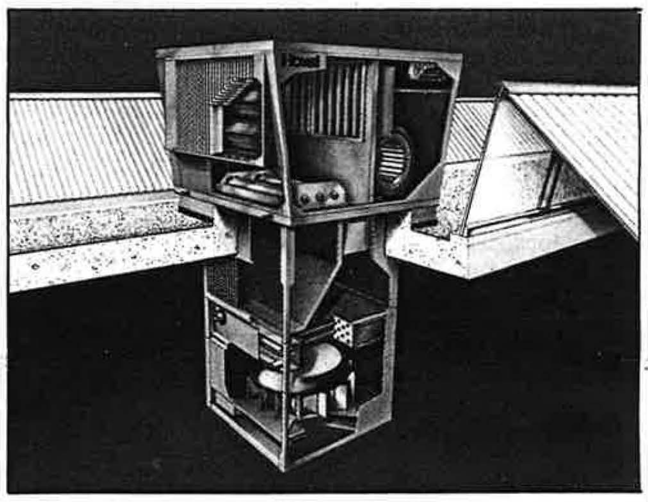
A breath of fresh air



Designed for ventilating industrial spaces with heights from 4 to 13 m is Hoval's air-supply unit.

Hoval has extended its ventilation, heating and heat-recovery range with the ZH supply air unit, suitable for industrial and commercial buildings with hall heights of 4 to 13 m.

Installed in the roof, ZH units are suitable for airflow rates up to 8000 m^3/h. Because they do not require supply and extract ducting they are particularly useful for retrofitting and where there are overhead cranes.

ZH units can provide recirculation heating, fresh-air supply or balance-air supply and extraction where machine extracts are fitted. They are available with cooling coils if required.

Because each unit supplies only a certain area of the hall, different operating modes and temperatures can be provided across the building.

The ZH incorporates the Hoval Air-Injector, a vortex air distributor which ensures that the supply air is draught-free and evenly distributed.

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