Light and airy?

Good 1980s design at the South Staffordshire Water Company. Windows on more than one side improved daylight uniformity, but today present a problem for pc users trying to orientate their vdus away from sources of glare. Similarly, reflected glare on the ceiling from the external light shelves was less of a problem in the days of drawing boards.

A number of recent design guides give recommendations on daylight and natural ventilation. But where are the areas of conflict, and how can they be avoided?

BY PAUL LITTLEFAIR AND EARLE PERERA

Windows have many functions, but two of the most important are the provision of natural ventilation and daylight. In recent years design guidance has appeared on both topics, notably a BSI Code of Practice[1] and a CIBSE Applications Manual on window design[2].

Both documents provide criteria for good daylighting, measured as the average daylight factor which is a measure of the total amount of natural light in an interior. It is a proportional to window area, so larger windows can give both increased daylight as well as scope for natural ventilation.

Windows also represent controllable openings for natural ventilation[3] – *Part F* of the *Building Regulations* recommends an openable area of at least 1/20th of the floor area for 'rapid' ventilation. The recent CIBSE *Applications Manual AM10: Natural ventilation in non-domestic buildings*[4] provides significant information as to the types of windows that could be used for naturally ventilating a building.

In addition to providing glare-free daylight and adequate views out of the building, windows should ventilate effectively (but not cause draughts), allow occupants to adjust finely the openable area and be simple to operate.

Design for natural ventilation needs to recognise the different modes of operation that are required at different times of the year. In summer months, full ventilation through open windows may be required for thermal comfort. In winter, however, only a background level of ventilation is needed in order to maintain indoor air quality. This background level can be provided through trickle vents.

Light distribution

As well as the amount of light and air entering a space, the distribution is also important. For daylight in rooms lit from one side, *BS 8206* gives the following:

$$L/w + L/h < 2/(1-R_B)$$

(where L is room depth, w is its width, h the window head height and R_B the average reflectance of the back of the room). If L is larger than this value the back of the room will look gloomy compared to the brightly-lit front half. In a typical room (h=2·7 m) this gives a limiting depth of around 7 m.

Research work carried out at the BRE confirms that adequate fresh air is provided to this depth from an open window, and measurements indicate that even a depth of 10 m is not an issue. The only issue is that occupants do not perceive this fresh air since the speed of air entering through the window reduces to an imperceptible level at this distance. Local low-speed ceiling fans can help.

Airflow through windows can be in the form of single-sided ventilation or through cross-ventilation. Single-sided ventilation occurs when the window is situated on only one external wall. The exchange of air takes place by wind turbulence, by outward openings interacting with the local external air streams and by the local stack effect.

This is also known as thermal buoyancy ventilation – temperature differences between indoors and outdoors cause density differences in the air which in turn cause pressure differences. These pressures then drive natural ventilation through the openings. Increasing the window head height will promote stack ventilation, and give better daylight penetration to the back of a room.

Designing for cross-ventilation

Cross-ventilation occurs when inflow and outflow openings in external walls have a clear internal flow path between them. Airflows through the openings are determined by the combined effect of wind and temperature differences. It depends on windows (or other openings) on opposite sides of the building being opened sufficiently. Windows on more than one side of a room will also improve daylight uniformity.

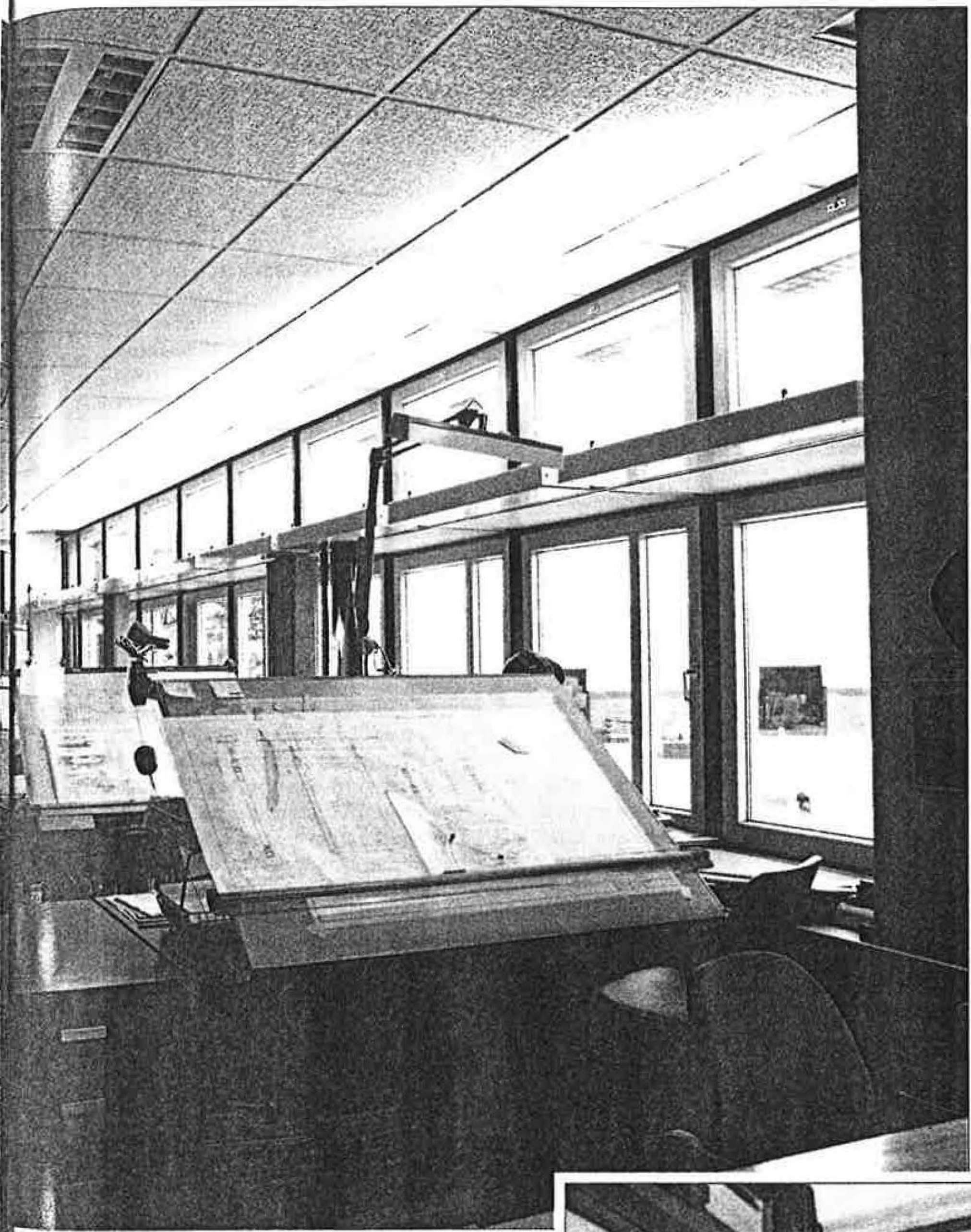
Atriums can provide both daylight and natural ventilation to the heart of a building[5]. However, while natural ventilation into surrounding spaces can be achieved fairly easily, effective daylighting often does not penetrate far into adjoining spaces.

The final daylighting criterion in *BS 8206* is that no significant area of the working plane should be unable to receive direct sky light. This limits the size of external obstructions to the extent that airflow to the outside of the windows will not be restricted.

While daylighting and natural ventilation can complement each other, a well-glazed building may tend towards overheating. Natural ventilation can remove much of this, and daylight can also help by reducing the casual heat gain of electric lighting (assuming that suitable lighting controls are provided).

If there is a conflict, it can arise with solar shading. Conventional internal venetian blinds can make it hard to open windows, and airflows can lead to irritating noises from disturbed blinds. Mid-pane Venetian blinds can help to solve these problems.

Tinted glazing or solar control film is widely used to control glare. The eye can adapt so that it is hard to discern the density of the tint,



but if a window is opened the contrast and colour distortion is readily apparent. This might lead to occupant dissatisfaction with tinted glass.

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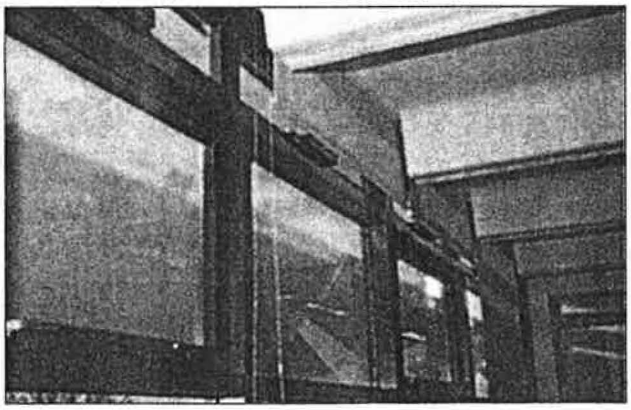
References
[1] *BS 8206 Part 2: Code of practice for daylighting*, BSI, 1992.
[2] CIBSE *Applications Manual: Window design*, CIBSE, 1987.
[3] BRE *Digest 399: Natural ventilation in non-domestic buildings*, BRE, 1994.
[4] CIBSE *Applications Manual AM10: Natural ventilation in non-domestic buildings*, CIBSE, 1997.
[5] Littlefair P J and Aizlewood M E, 'Daylight in atrium buildings', BRE *Information Paper 3/98*.



Good late 1990s design: integrated natural ventilation with daylighting at the Brown & Root headquarters building (*Building Services Journal*, May 1998). The ribbed soffit, coordinated with the window mullions, aids daylight penetration and thermal transfer. Motorised 300 mm toplight windows are used for night-time ventilation, with manually-operated roller blinds for the occupants. The one weak link here is that blinds are meant to be retracted by security staff each night. In many buildings, the natural default may be the down position.

MULTI-PURPOSE WINDOWS: THE PROBLEMS TO AVOID

Toplight windows are often used for single-sided and cross-ventilation, in which role they can be very effective provided the controls can be reached. However, they can be a source of glare, which often results in internal blinds being pulled down, reducing ventilation effectiveness.

Light shelves can let through low winter sun which can cause glare or reflections in vdu screens. Sometimes, stray light can also penetrate around the sides of the light shelf.

Downstand beams parallel to the perimeter walls can sometimes cut off daylight penetration if they are too massive, too deep or, worse still, below the window recess. This can create contrast, which then requires offsetting by electric lighting.

Ceiling design can be critical for improving daylight conditions. It is very important if there are light shelves or other daylight redirecting systems, or electric uplighting. Waffle slab ceilings tend to absorb upward light and reduce reflection further into the space. Troughed or ribbed slabs at right angles to the perimeter (as at the PowerGen hq in Coventry or at the Building Research Establishment's Environmental Building in Garston) do not hinder daylight penetration in this way.

Openable lower windows often lack fine control, and either blow shut or blow paper around. With control vested in those closest to the window, conflicts can arise with occupants located deeper in the space. Designers should anticipate problems of security in many buildings. External security bars and certain types of shading devices can block or restrict outwardly-opening windows, and obstruct cleaning.

Mid-pane blinds are preferable to internal roller blinds if the main window is to be openable, as the latter can flap or rattle causing noise perception problems. However, the choice of mid-pane blind is important. Perforated and translucent types which provide a view through tend to glow too brightly in sunshine, requiring a second line of defence against direct sun.

Internal blinds should fit well, as direct sunlight or bright reveals can cause problems for vdu users.

Manual controls must be robust, and motorised controls must be intuitive to use.

Finally, the use and location of **VDU screens** (and in particular the common 45° position) may drive many aspects of window design and the choice of solar shading. Occupants will need to be able to orientate their screens to avoid sources of glare generated by daylight. Otherwise, the 'blinds down, lights on' syndrome will rule.