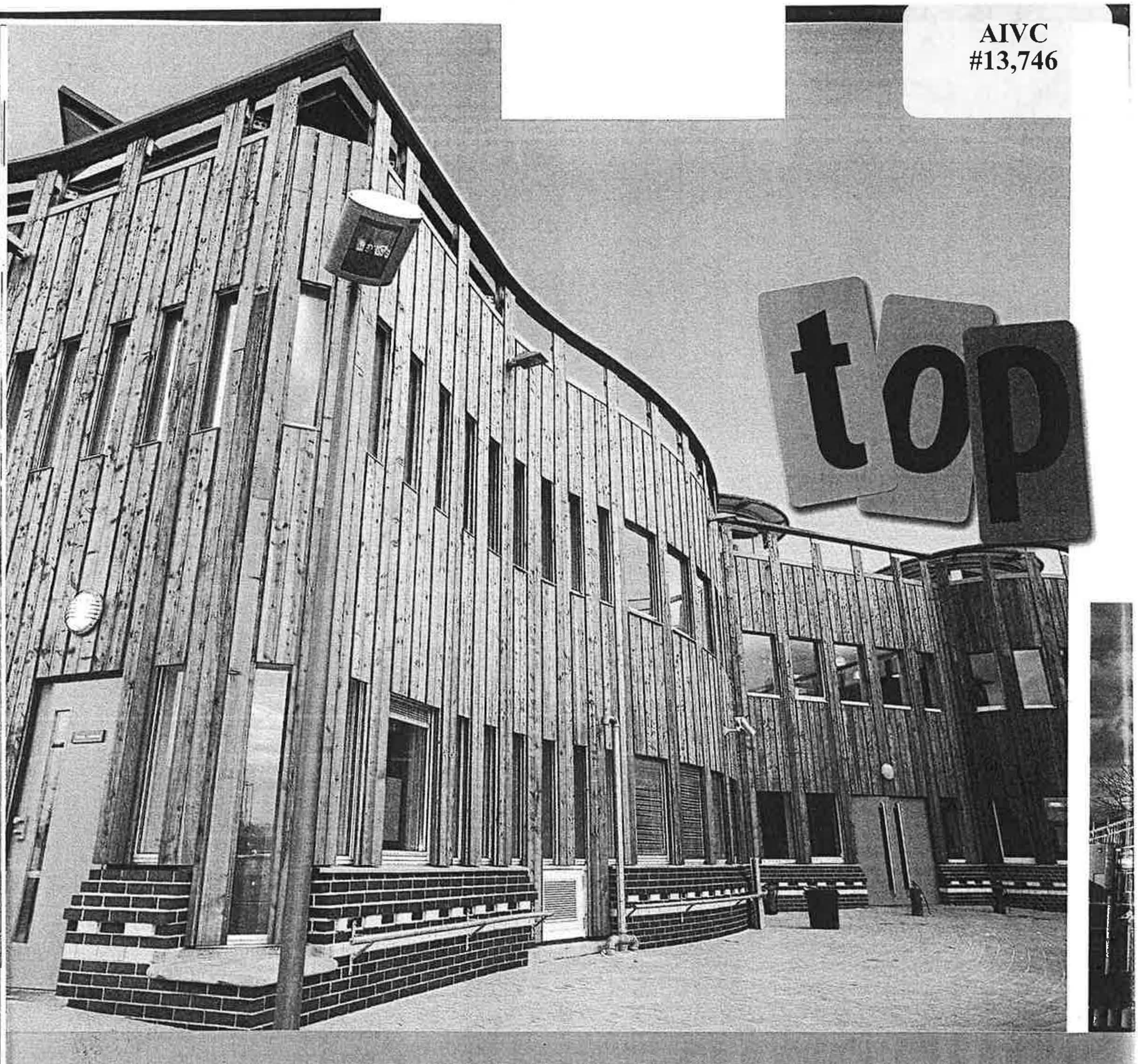


Greenwich Millennium Village School could be the first of a new breed of mechanically ventilated schools. How did the design team manage to overcome restrictive government guidance and beat the capital budgets laid down by the local authority?

BY JOHN FIELD

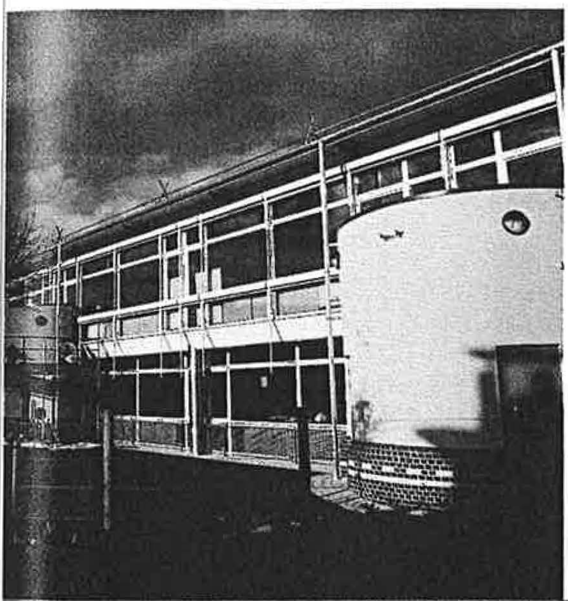
Greenwich Millennium Village School fulfils so many community functions it needs a full-time facilities manager who commands the same respect as the head teacher. Not only that, but the school is developing 'early years' guidance at the same time as helping the Department for Education and Employment (DfEE) resolve the conflicting design requirements of *Building Bulletin 87*.

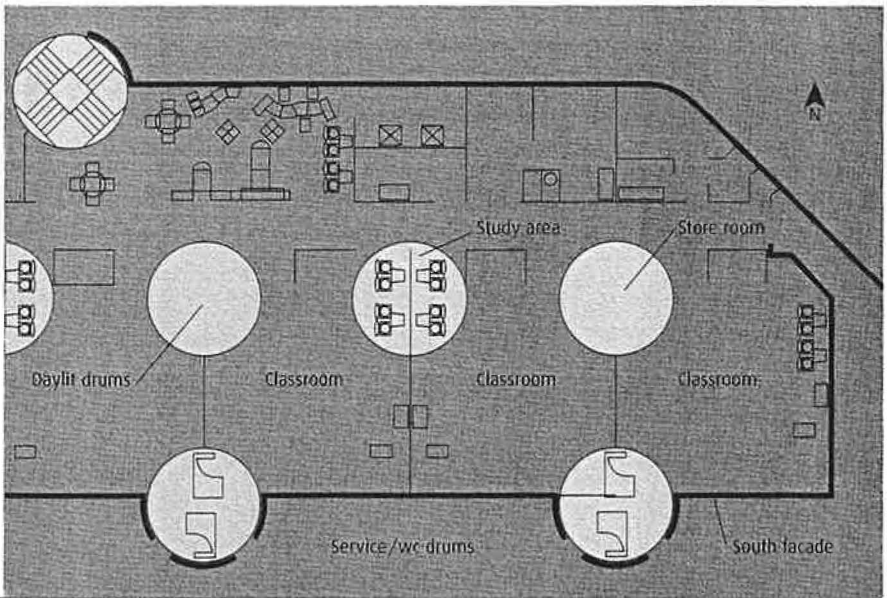
It helped, of course, that the school's consulting engineer, Fulcrum, had recently completed a secondary school, and done so within budget. Fulcrum has persuaded the client that mechanical ventilation and heat recovery, based on the Swedish hollowcore system Termodeck, was superior to a natural ventilation solution – the norm under existing government strictures.

It also helped that the firm had used Termodeck at the Elizabeth Fry Building at the University of East Anglia – a runaway success story in virtually all departments. So when it came to suggesting the use of Termodeck for the Greenwich Millennium Village School, Fulcrum clearly had the confidence to challenge the DfEE over its existing ventilation guidance. After much debate, Fulcrum's experience – coupled to the environmental skills of Edward Cullinan Architects – triumphed over officialdom.

When Fulcrum and Edward Cullinan Architects were briefed for this multi-purpose primary school, there was little in the way of DfEE guidelines for 'early years' provision, or for combining a school with a health centre. The integrated centre with 300 operational days a year (compared with a normal 144) is well beyond the job specification for a head teacher, so a centre manager role is being created at a level comparable to the head teacher.

of the class





Direct briefing from the DfEE has meant that a number of issues were resolved 'on the fly'. As a result the design has been subject to an unusually high level of attention for ventilation, heat loss, acoustics and natural lighting.

The DfEE's guidance for new school premises, *Building Bulletin 87* (*BB87*), requires 8 l/s of fresh air per person. Guaranteed. Fulcrum maintains that, although this guidance has been in force since 1996, it is effectively unenforceable.

Classrooms generally rely on opening windows for their ventilation needs, largely because there is no budget for general mechanical ventilation. The objection to this is that the appropriate and consistent use of windows doesn't happen, as teachers can't afford the time or attention during lessons. Hence the windows are often kept closed – particularly in winter.

In recent monitoring exercises, CO_2 levels of 4000 ppm to 5000 ppm have been measured, which compares badly to a 1000 ppm quality threshold laid down in most literature. A level of 4000 ppm is accepted to cause drowsiness or loss of performance.

Fulcrum's solution to this problem was to propose the Swedish Termodeck technology, an integrated system that involves treated air being circulated through hollowcore concrete slabs before being supplied to occupied spaces.

Termodeck relies on a well insulated, high thermal mass construction, using heavy walls and floors to ensure thermal storage capacity. It also requires surfaces of the slabs to be exposed to the internal space, as exposed soffit or sometimes as flooring, to obtain the benefit for radiant heat transfer.

FROM LEFT: The School's main entrance and south-facing facade with the toilet 'drums'. ABOVE, FIGURE 1: The basic classroom layout showing the relationship of the classrooms to drums.

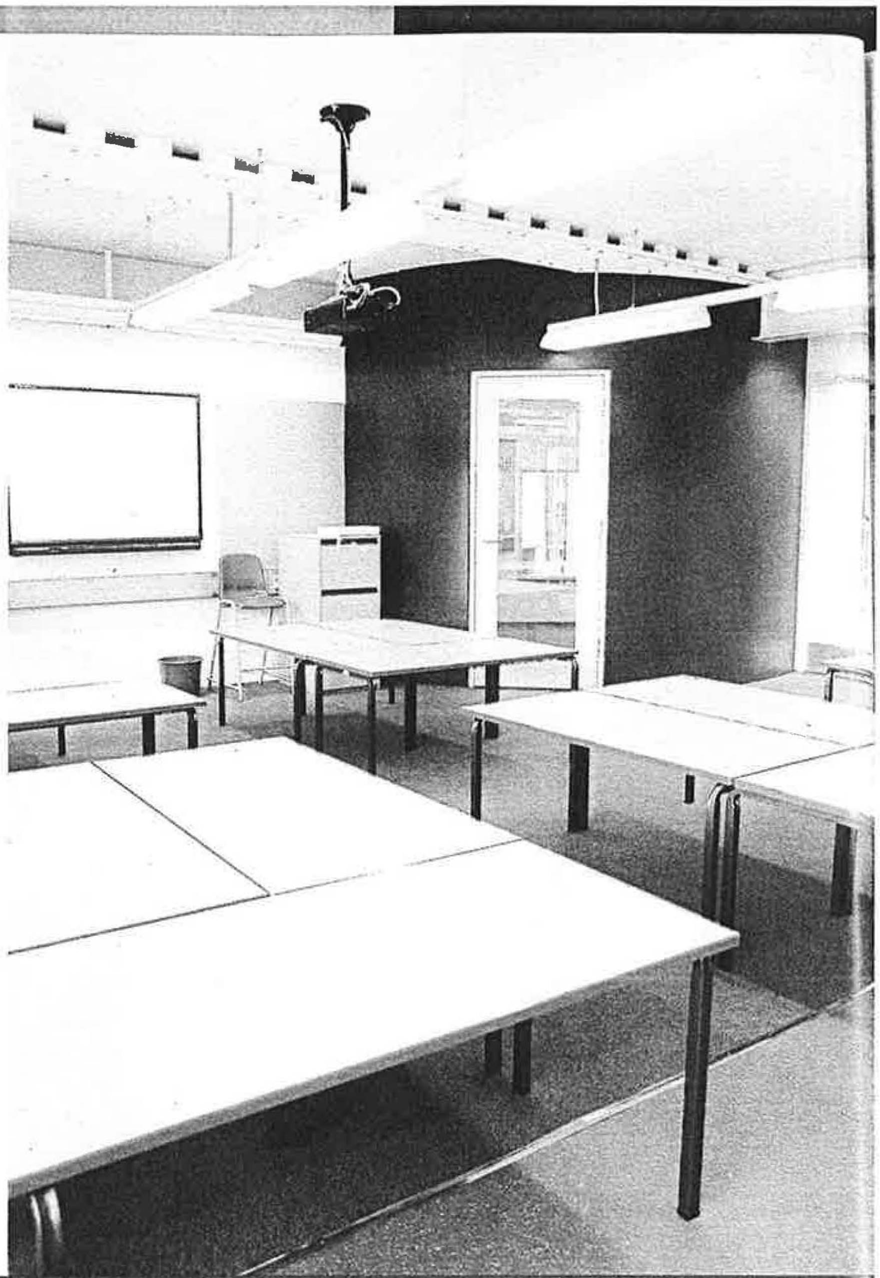
School layout

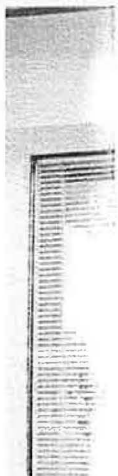
The main classrooms are in the south part of the central two-storey east-west block which uses the Termodeck system. To the North is a hall and ancillary building on two floors. This is circular, but with a rectangular void in the second floor for the upper part of the one-court sports hall, which has displacement ventilation and radiators.

To the south west, a smaller circular building on one floor forms the 'early years' area. This has traditional mechanical ventilation and underfloor heating. To the south-east is a semi-

RIGHT: Inside a typical classroom. Note the exposed Termodeck, the batten fluorescent lighting, and the 0·8 m-wide absorbent panel which combats specular sound reflection from the slab. This panel is located in a natural gap in the ceiling planks and incorporates lighting, power and fire detection cabling.

BELOW: The annexe has a brightly coloured rubber-particle play zone on its roof with a raised central mound which conveniently allows room for an air handling unit.





circular block which forms the health centre. This also uses Termodeck.

Service drums located on the South facade between classrooms are split in two to provide a wc for each class. Access is from either classroom or from outside (on the ground floor).

The school's glazing is designed to a U-value of 1·6 W/m²K. This relies on modular triple-glazing, and in the 'early years' area the glazing incorporates a blind between the inner sealed double-glazed low-e unit and the outer glazing. As it is produced in standard sizes for bulk Scandinavian markets, this glazing was available at a very competitive cost.

Classrooms have larger areas of glazing, aligned with the structural grid. Without suitable mullions to allow use of the standard sizes of triple-glazing, sealed low-e double-glazing was specified instead. Motorised awning blinds are fitted and will be controlled on room temperature, sun and with a high wind-speed cut out.

While the south elevation is mainly glazed except for the service/wc 'drums', the remaining facades have highly insulated construction with vertical cedar panel rainscreen cladding to a U-value of 0·2 W/m²K. The roof, which incorporates the upper Termodeck slab is insulated to a U-value of 0·5 W/m²K.

The mechanical ventilation system

The key to Termodeck is the floor/ceiling slab which is constructed of completely standard pre-cast concrete planks with longitudinal 150 mm diameter hollow cores at 200 mm centres.

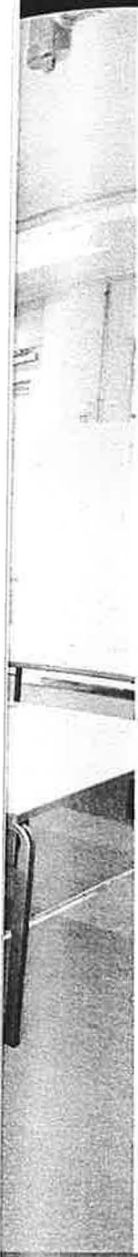
Filtered and tempered fresh air is ducted to the hollow cores in the slab near the corridor-located duct. Air passes back and forth through three cores before being introduced to the room via small circular ceiling diffusers. On the extract side, room air passes through attenuated transfer grilles into the corridor and then to the main extract duct. Generally speaking, 75 mm attenuation grilles are used, but where extra performance is required they are used back-to back to provide 6 dB of attenuation.

As the Termodeck system uses the cores to transport air and heat across the building, the cores are all capped with infill plugs at the building faces, and in the centre of the building between the north and south ventilation zones.

Acoustic performance is critical for Termodeck designs as the exposed concrete ceiling provides little absorption. This can be helped by ordering a special finish to avoid specular sound reflection. For teaching, it is desirable for the voice to carry so the lack of attenuation is desirable but the reverberation time must be controlled.

Here, a 0·8 m strip of absorbent panel protrudes down from the ceiling so that both its surfaces are effective. This panel is located in a natural gap in the ceiling planks. It has also been used to incorporate a service run, including lighting power and fire detection.

Heat recovery is achieved in the building's two air handling units by mechanically flipping two aluminium heat exchangers back and forth between the inlet and extract paths.



In this way the two matrices are alternatively charged and discharged once a minute.

The system sounds Heath Robinsonian, but in reality allows highly effective heat recovery, with 92% being measured in an earlier school. In some conditions the system can recover latent heat. If heat recovery is not required, the flip-flop procedure can be de-activated.

Of course, the flow reversal does have consequences – there is some cross contamination, but it is of the order of 1-2% which is less than for a thermal wheel. The reversal technique also requires that the length of fresh air/discharge ductwork from heat exchanger to outside air has to be minimised.

The Termodeck joints to ducts are ingenious. The technique involves breaking the concrete above and below the hollow core and then using special joining and capping materials to form supply ductwork joints or to add room diffusers.

To form airways between adjacent cores (as supply air passes three times through the slab along neighbouring cores), the concrete between adjacent cores is broken out and capped. These breaking and capping arrangements are designed to ensure that each length of core has access for visual inspection, and the rough bends created apparently contribute critically to heat transfer.

At Greenwich, Fulcrum has used Termodeck at ground floor ceiling level and first floor ceiling (roof) level. The design team investigated the option of a single active slab which relies on the ground floor ceiling also being used for the first floor thermal control, but carpeting, ductwork complexities and the inevitable need to install separate heat emitters for the first floor led to this option being abandoned.

Early years and creche

For the 'early years' single-storey annexe, Termodeck would probably have been the first choice but was not economical for the circular shape. The pre-cast concrete planks would need to be at 90° or 45°, and infill areas would be wasted unless the hollowcores were connected into the air supply system – costly for small areas.

In the event, a zoned underfloor heating system is combined with traditional mechanical ventilation, with air being returned to the central corridor via attenuated transfer grilles. The air handling unit with crossflow heat exchanger and bypass is located above ceiling level.

The annexe has a brightly coloured rubber-particle play zone on its roof with a raised central play mound which conveniently allows room for the air handling unit.

Daylighting

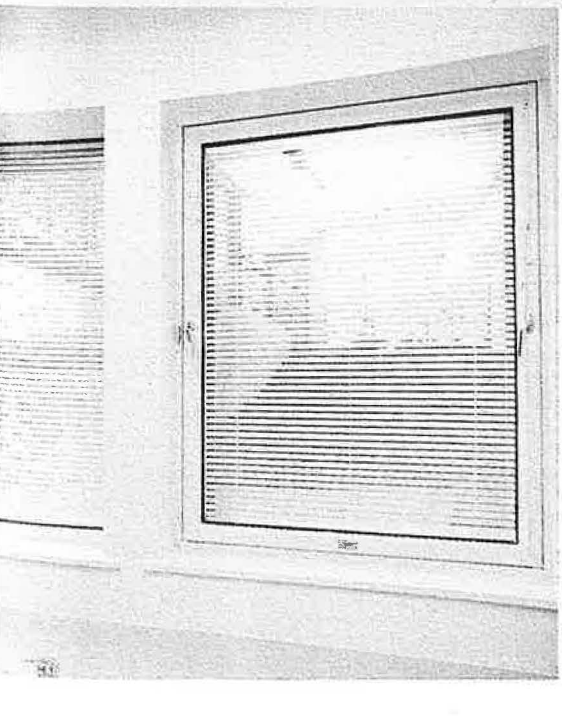
The target 4-5% daylight factor has required concerted attention by the designers. They made use of south-facing classrooms, a room depth of 8 m, full-height glazing and the 4 m-diameter drum lightwells which are split into two semi-cylinders by the dividing wall between classrooms.

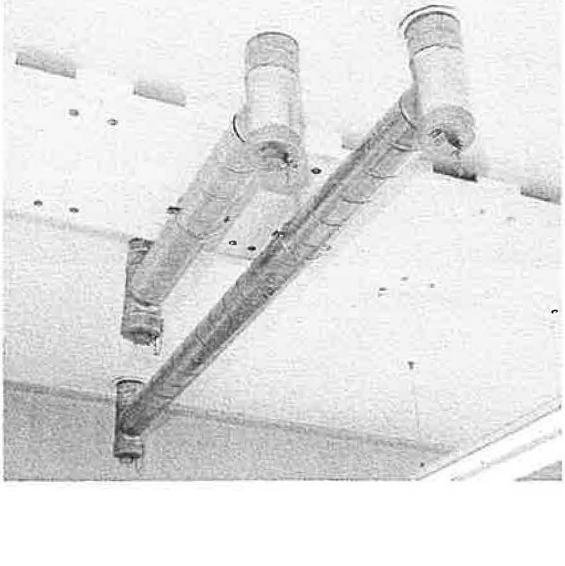
The drum lightwells are not open to the first floor in order to prevent sound or airflow paths between classrooms. There is a fair amount of light obstruction from a structural beam and from the drum's roof covering – an earlier design for an all-over transparent cover was rejected on cost grounds and the replacement has less transparent area.

The drums have a direct cost for roof penetrations, covering and for Termodeck infilling, and also indirect costs for lost usable first floor space. Therefore the natural light the drums bring to the ground floor is quite costly and has to extend to a width of around 8 m.

If the amount of light is compromised too much or if the daylight does not prevent lights being used, one could envisage questions on the drums' cost-effectiveness, even if a solution of this type is required to satisfy the daylight factor targets.

The full-height glazing occupies the entire south facade except for the service pods which take up around 25% of the perimeter. The classrooms are therefore highly glazed – probably to at least 70% viewed from inside – and it will be interesting to see if the 'blinds down lights on' syndrome arises. This default state can reduce the effectiveness of daylighting – notably in





LEFT: Not the prettiest of details, but this shows how the bores between two separate Termodeck slabs were bridged to obtain greater thermal transfer. The link also bridges the acoustic/service panel. Note the ductwork caps which give access for cleaning.

FAR LEFT: The triple-glazing in the 'early years' area with an internal blind between the inner sealed double-glazed low-e unit and the outer glazing.

highly glazed offices. Here, the use of blinds may depend on the use of computer screens, one of the most glare-sensitive elements of modern working and teaching.

As an aside, it is noticeable that the 'blinds down lights on' syndrome is not acknowledged in the DfEE's *BB87* energy calculations. These simply show a steady reduction in lighting energy as the glazing ratio increases to 75%.

Electric lighting

In parallel with the efforts to provide good daylighting throughout, there are also efficient electric lighting systems. Classrooms have high frequency T8 lamps in metal-gauze suspended fittings which provide a pleasing backwash. The fittings are manually controlled, with perimeter lights being separated. Recessed compact fluorescent downlighters are used for other areas.

A quick assessment of specific power use indicates 9 W/m². This is encouraging, and values the daylight from each drum lightwell at £50-£100/y. Automatic passive infrared presence detection is employed for the shared group rooms which are more likely to be intermittently occupied or empty.

The circular hall annexe incorporates training and function rooms and a single badminton court sports hall/gym with a sprung floor. The hall has high-pitch northlight roofing with blackout blinds and dual-light-level T8 fluorescent lighting.

In the annexe, powerful discharge lamps are curiously aimed outwards through the northlights. This is apparently not a error but a demand for the school to be "visible" at night.

Mechanical services

Heat for the classrooms is provided by two sets of three 60 kW wall-mounted Remaha condensing boilers. Here there appears to be a rare slip by the designers as the classic condensing boiler problem has not been resolved: the boilers feed a common header for domestic hot water primaries, main heater batteries and 'early years' heater batteries.

While it is possible to 'time share' the higher temperatures required for hot water, this would require some tricky scheduling and would be difficult to guarantee long-term. At the time of the visit on a very mild day the header was, shall we say, cooking.

Control of building services is by two Trend bems – one for the school and one for the health centre. It was specified that they should be separate but capable of operating together, and so they are currently linked. Fulcrum has modem access to both bems, but only on the basis of a watching brief, with no control function. This ensures that the building managers have clear responsibility for the premises. This will also increase the value of the monitoring being carried out by BSRIA.

Electrical services

The school has flood-wired structured cabling for power, telecommunications, data and aerials, and cable paths are designed with gentle bends to accept fibre. Final distribution is mainly at dado level, but lighting power and some data is taken along the channel above the acoustic ceiling panel.

The extent of providing for all IT eventualities was a point of some discussion with the DfEE client, and was crystallised with unintended humour by a formal edict stating "Remember that today's cleaner's cupboard is tomorrow's important hub room".

A direct-drive Kone Monospace lift is said to use only 30% of the energy of a traditional lift.

Overall assessment

The appearance of the school – pleasing curved cedar-clad facades, north-lit sports hall and all weather pitch to the south – do not give the impression of bumping along the bottom of the cost benchmarks. However, the school's many innovations in planning, functional and design terms can explain the project's considerably increased costs. It's total cost is said to be around £1.5 million.

The effect of the ventilation system on costs is less clear. Fulcrum points out that, with its previous Termodeck school, the firm was not brought in until stage C and the school was kept within normal budgets. Here, the biggest cost issue will be maintenance of the awnings, and there may be some regret for the missed opportunity to use a triple-glazing system with mid-pane blinds throughout. If this is the case, it should be highlighted to prevent a repetition.

The school is highly innovative in planning and engineering terms and has clearly been subject to high levels of personal attention from the humble designer up to the DfEE mandarins. The school asks and answers so many questions it is difficult to know where to end.

Is mechanical ventilation necessary to comply with *BB87*, and is this appropriate? If so, is the approach used better than traditional mechanical ventilation? Is it really more expensive? Does it provide better teaching conditions?

Will the 70% south glazing mean that blinds are normally down (and lights on)? Are the drum lightwells justified, and if not, how else could the *BB87* daylighting requirements be satisfied? And why are the floodlights pointing out of the building? Clearly, BSRIA will have plenty of monitoring to do.

The only point of certainty is that the quantity and quality of design effort put in to this school will ensure the high value of the answers to these questions, whichever way they fall.

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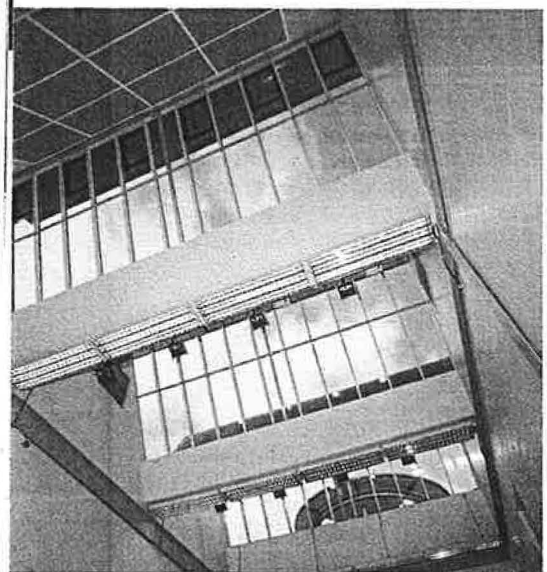

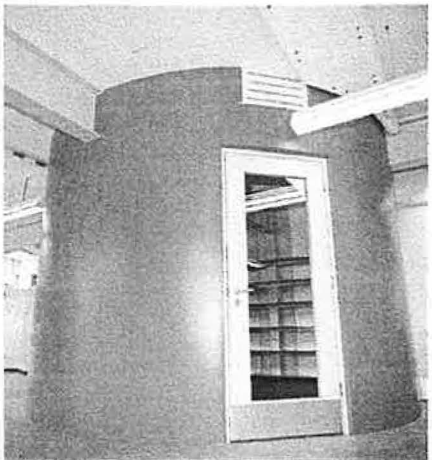

FAR LEFT: The hall has high-pitch northlights and T8 fluorescent lighting. LEFT: One of the brightly painted drums in the classrooms. Those on the south perimeter house toilets, while others inside the classrooms serve as storerooms or study rooms (see Figure 1).