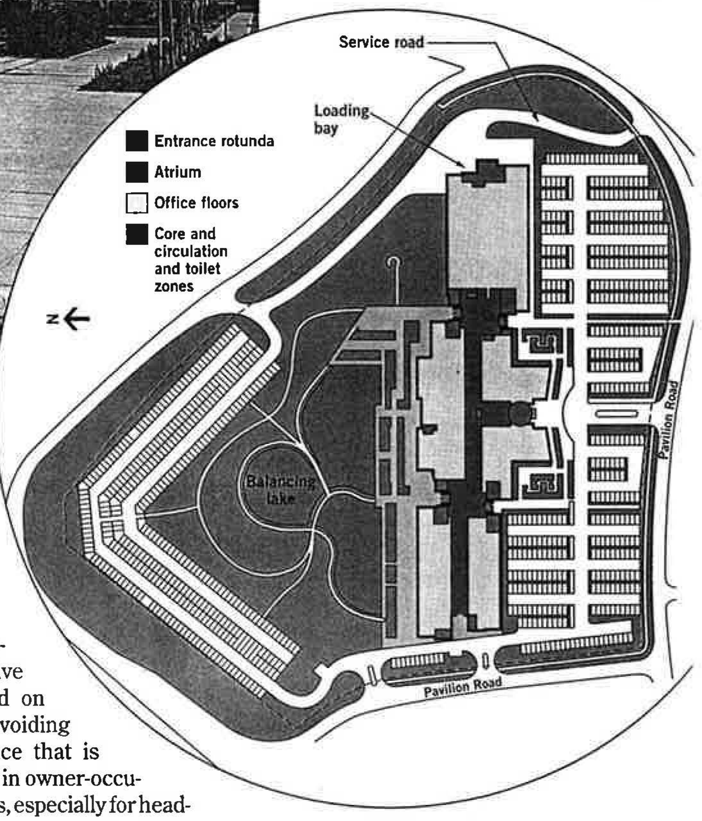
SQUARING TWO CIRCLES

PHOTOGRAPHS: PAUL HARMER

The recipe: a new office for 2500 staff subject to a developer's "green brief". Add the occupier's and the developer's needs, stir with the desire for a prestige hq and simmer with a requirement by the developer to be able to sell or let the building at high quality business park rents. What would you serve up?

BY JOHN FIE



ABOVE: The architects examined several site layouts before settling on a series of rectangular blocks connected by a linear covered street, in the mould of Neils Torp's SAS building in Arlanda, Sweden. The la acts as a reservoir for the chilled water system.

When credit card company Barclaycard needed to relocate from several sites in Northampton, Barclays Property Holdings commissioned a 36 000 m^2 office building on the outskirts of town. In keeping with the property company's environmental policy statement, the building was to be low energy and environmentally benign.

This interest, and the sometimes complementary commercial requirements of the occupier led to a healthy dialogue on environmental standards, costs and benefits – in terms of both the internal environment and of the wider environmental impact.

The resulting building employs a range of established and innovative techniques to achieve low energy performance, and has achieved a rare "excellent" BREEAM rating after considerable commitment from the developer and also the designers.

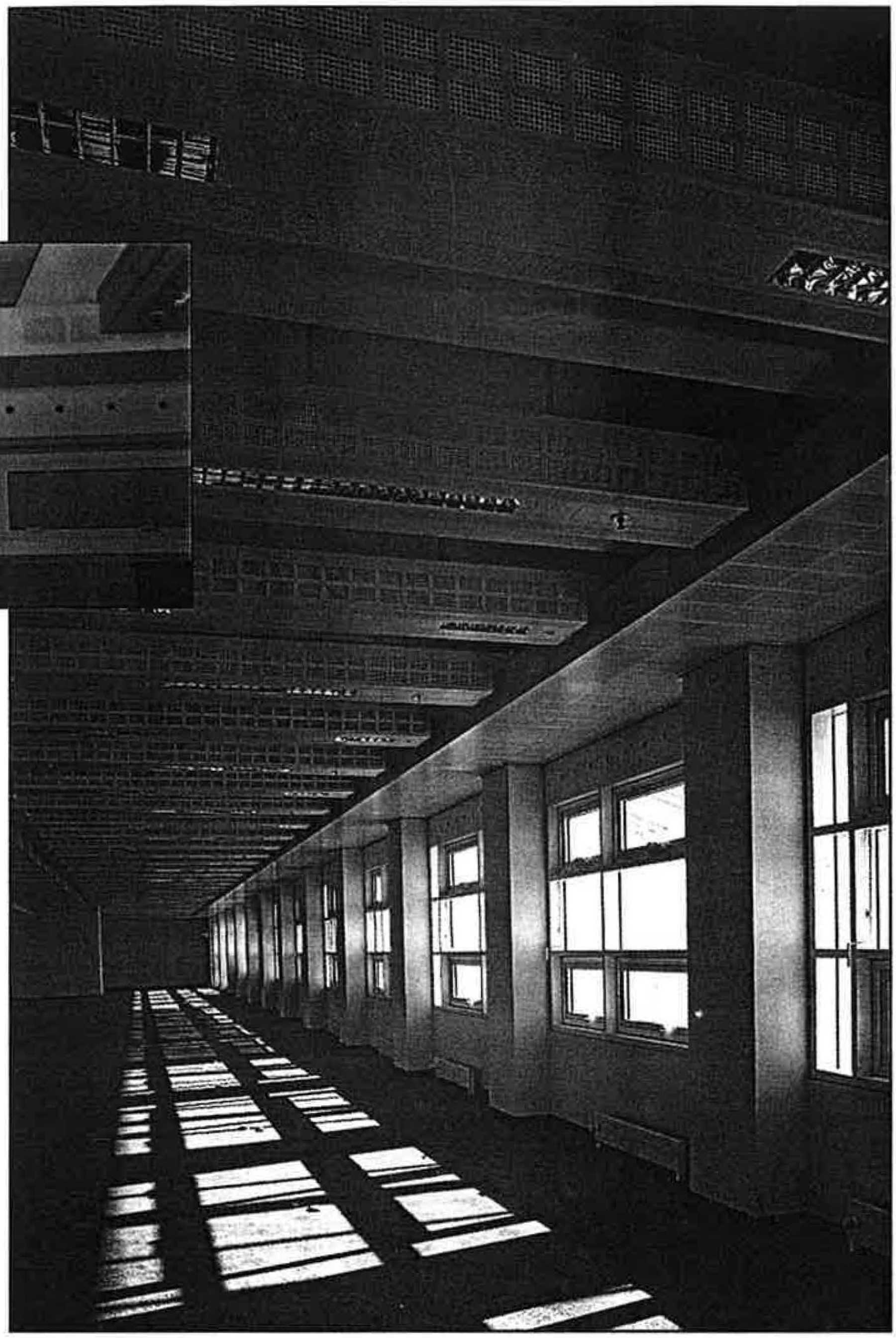
The pre-let arrangement can provide the ideal environment – avoiding on the one hand the neutrality and lack of continuity of speculative development, and on the other hand avoiding the self-indulgence that is sometimes found in owner-occupier developments, especially for headquarters buildings.

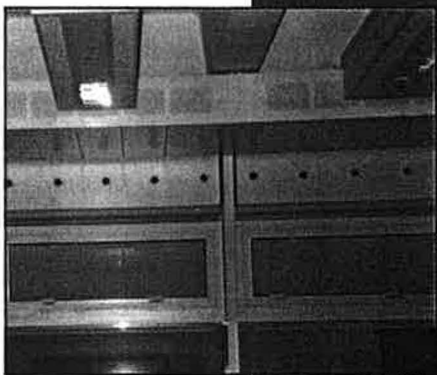
An early decision was made for the building to be naturally ventilated. The occupier, Barclaycard, had envisaged an air conditioned building, but the developer's brief was for a naturally ventilated building. Barclaycard's own research suggested that occupants enjoy control of their local environment and, in particular, openable windows.

An exercise was carried out to measure the level of internal gains in the existing operations. The average loading of 15 W/m² encouraged a naturally ventilated design, providing for lower internal gains than normally specified.

Another crucial decision was to dispense with the suspended ceiling in favour of an integrated "service beam" system, incorporating chilled water coils, luminaires, occupancy sensors, smoke detectors and sprinkler pipework.

Putting all this in one prefabricated component allows the building's mass to be exposed, in this case a ribbed concrete slab. The chilled beam system also permits the use of medium temperature cooling water, and the site's man-made lake has been exploited to provide a regular supply of water at this temperature for much of the year.



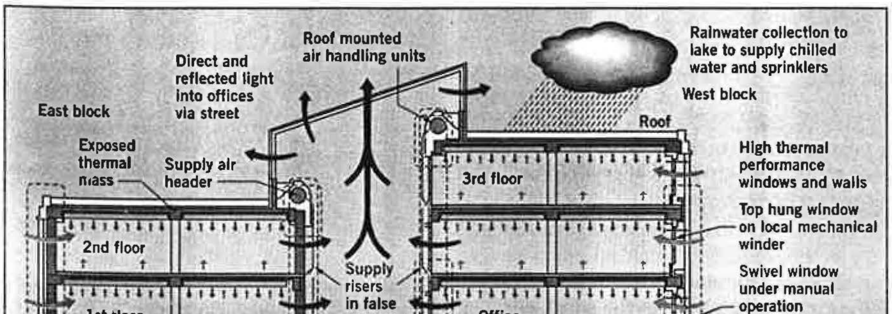


RIGHT: A typical office floor prior to tenant fit-out. Note the Trox service beams installed between the ribbed coffers, the openable windows and the perimeter heating. INSET: Close-up of the permanent circular trickle vents, sized at 160 cm³ per 3 m bay. Overall, the architectural integration could have looked better.

The linear street solved the organisational requirements of the tenant, at the same time protecting the developer's investment by allowing the building to be re-let as three separate buildings. While street atria are no longer uncommon, it is relatively unusual at this scale for the offices to be open to the atrium, as they are in this building and at Powergen[1].

The design concept

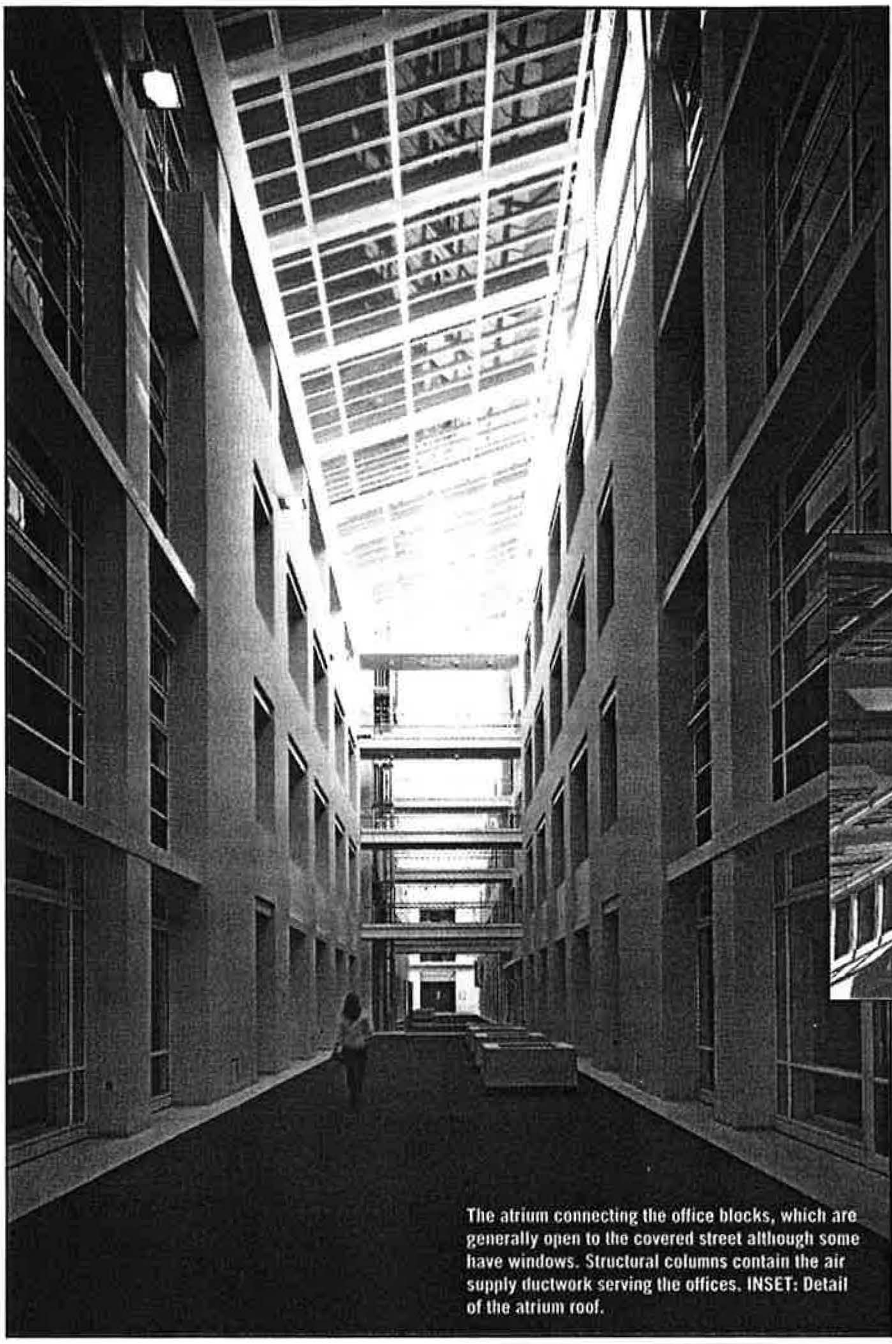
The site was large enough to allow a linear form, and the need for a balancing lake was turned to advantage by using it for both sprinkler water storage and free cooling/condensing water. The site is in a business park just outside Northampton and, being away from public transport routes, includes parking for 1400 cars in a multi-deck park. In common with other out-of-town offices the emphasis on car commuting can provide grounds for criticism for encouraging traffic growth[2].



Section through the Barclaycard offices. 15 m-deep offices allow for natural ventilation and maximum daylighting.

In developing the initial concept, investigations were carried out on various building forms with a 15 m plan depth for natural ventilation. Although natural ventilation would be marginally better served by prism and doughnut building footprints, the linear atrium had telling advantages in both organisational and letting terms.

At conceptual design stage the designers used experience and broad rules of thumb. For example, the floor plan depth of 15 m was seen as a practical maximum, although some



The atrium connecting the office blocks, which are generally open to the covered street although some have windows. Structural columns contain the air supply ductwork serving the offices. INSET: Detail of the atrium roof.

say that floor depths of up to 18 or 20 m can be appropriate for natural ventilation.

The designers' intuition was supplemented by preliminary calculations to optimise the use of passive solar shading, natural ventilation and exposed thermal mass. At detailed design stage more sophisticated calculations and modelling were carried out, including:

☐ detailed thermal modelling to refine the design of individual elements such as ventilation openings;

☐ an assessment of the performance of the building under various conditions;

☐ standard calculation packages were used to assess the duty of the mechanical systems;

☐ specialist modelling was carried out on responses to fire.

Thermal modelling for the Bedford 1987-1993 years, with wind-driven ventilation rates input from previous calculations, was used to assess the extent to which internal temperatures were exceeded, and the effect of night ventilation. Research by Troup Bywaters & Anders' Dr David Arnold revealed how night ventilation reduces the occurrence of certain temperatures – the night ventilation can be seen to be approximately equivalent to a 2°C reduction in internal temperature[3].

The resulting design has two or three storeys to the south of the central linear street, and three or four storeys to the north. Originally the lower block was to the north, but this decision was reversed to allow more light to the street and adjacent offices. The street is staggered horizontally to identify three blocks, but does not extend in the east block to the ground or lower ground floor levels which are deep plan production spaces. The atrium is full height with a substantial 5-10 m reservoir above the upper floors. Offices are generally open to the street, although some offices re- quire separation and have opening interna windows. The raised part of the atrium ha ventilation openings on both sides, controlle by the building management system.

Fire aspects of the atrium have been stud ied in detail and modelled by the Warringto fire research laboratories. The building wa reported to perform well, treated as one zon without compartments. In the worst case o fire at the atrium base, no problems wer found after 22 minutes, whereas the local fir authority had indicated a clearance time fo the building of five minutes. Fast respons sprinklers are installed, but were not em ployed in the study.

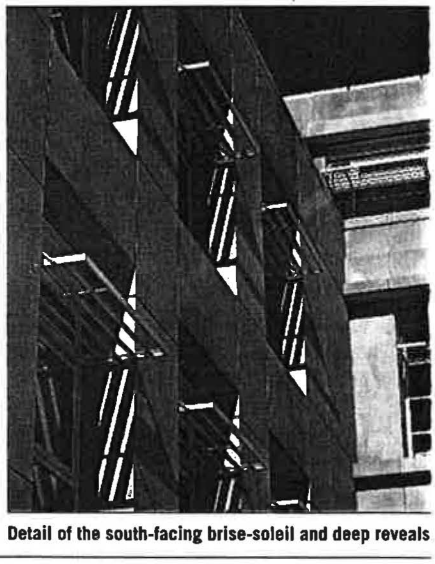
Floor-to-ceiling heights are larger than nor mal at some 3·75 m due to the lack of fals ceiling and a 4·2 m floor-to-floor height, an the concrete soffit i exposed to increas effective therma mass. The south-fac ing windows hav deep reveals an brise-soleil fixe shades.

Permanent back ground ventilation i provided by unob structed tubes whic penetrate the build ing envelope, size at 160 cm² per 3 m bay based on re search carried out b the BRE. It will b interesting to see i these provide suitable ventilation without col draughts or excessive air movement in hig wind conditions.

Ventilation and cooling

Much of the building operates on a cascade o operating regimes from natural/backgroun ventilation with perimeter radiators in winte to displacement ventilation with chilled beam using chilled water in summer (table 1).

Chilled beam cooling is largely self-regulat ing because the beams are only just belov



Detail of the south-facing brise-soleil and deep reveals room temperature (water is circulated at 16-18°C), so their cooling effect decreases greatly as room temperature drops from, say, 25°C to 20°C. Zonal control of the chilled beam system is provided, but there is no local thermostatic control. The highly variable cooling duty provides opportunities to save pumping energy by using variable speed pumps.

The generic chilled beams' appearance is more structured than a traditional false ceiling, and cleaning their open construction may require special procedures. The problem of condensation dripping off the beams has been addressed and a strategy developed to sense potential condensation and turn off plant or raise water temperatures. Modelling shows that this is rare, and can be accommodated within the design limits for internal temperature frequencies.

Chillers are only expected to be used above 25°C ambient, and ammonia refrigerant is used which has zero ozone depletion potential and zero global warming effect. Although any refrigerant escapes would be toxic, this is handled by ammonia detection, automatic purge and provision of safety equipment, such as respirators, to *BS 4434*. Comparisons of relative efficiency were carried out based on the Total Environmental Warming Index (TEWI, also in *BS 4434*) which takes account of the emissions from energy consumption as well as refrigerant escapes. The ammonia system was reported to perform better than R134a, and about as well as R22.

The deep-plan spaces which comprise around 15% of the total floor area have permanent air conditioning. The chilled beam system is employed and there is a facility to fit a false ceiling system. Ventilation is from high level supplies, returning via columns.

The lake has a 3·5 m maximum depth and a volume of 12 million litres. Lake water is used via a heat exchanger in the plantroom. But will the lake always be usable? Biological and possible temperature problems could incapacitate it at critical times, although this has been investigated.

Chilled beams are only installed in alternate service beams, although the design allows for the cooling capacity of the chilled beam system to be doubled if required in high gain areas by installing coils in the blank service beams. In future the whole building could be similarly modified (doubling the chilled beam density) to be used, let or sold as an air conditioned building.

This provision helped reduce the developer's and occupier's risk, and allowed the innovative approach to proceed while protecting the interest of both occupier and owner.

The big question is: will this cascade of operating modes be put into practice? If, initially, with the attention of the designers the building is operated correctly can this be perpetuated? Or in the long term will plant be used to maintain normal air conditioned office conditions?

One key aspect of building management in hot weather is that, as temperatures rise, the tendency is to open windows. If at some stage mechanical cooling is required, it will be wasteful to leave windows open extensively. This was investigated by the BRE in the early 1980s, and the conclusion was that, at or below a critical temperature of around 25°C, there is no stimulus to open windows extensively. So if the building can be maintained at or below this temperature, the problem of throwing mechanical cooling away from open windows will not be serious. This building will provide an interesting test case.

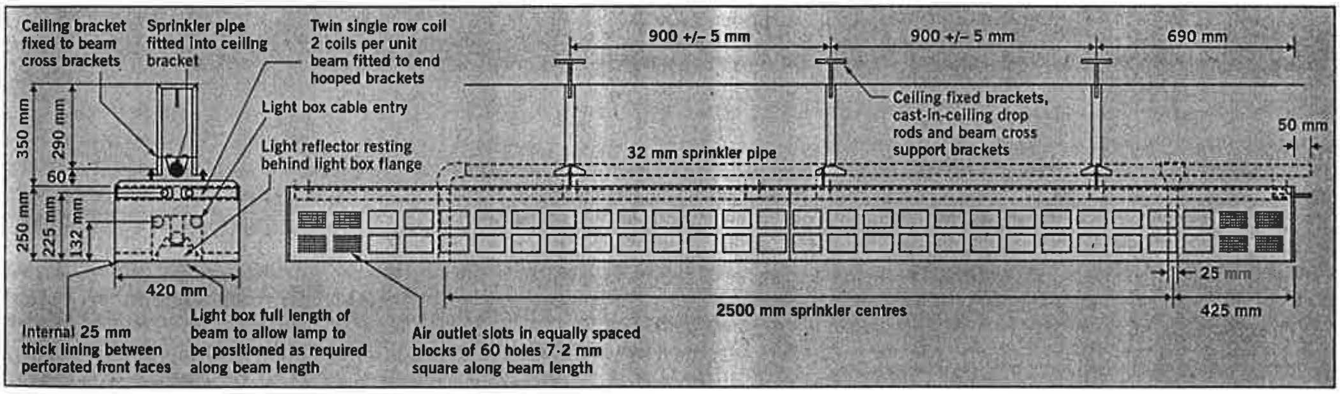
Lighting design

Using the BCO specification, office area lighting was changed from 500 lux to 350 lux. 350 lux is a genuine design level, and is not achieved by de-rating a 500 lux system.

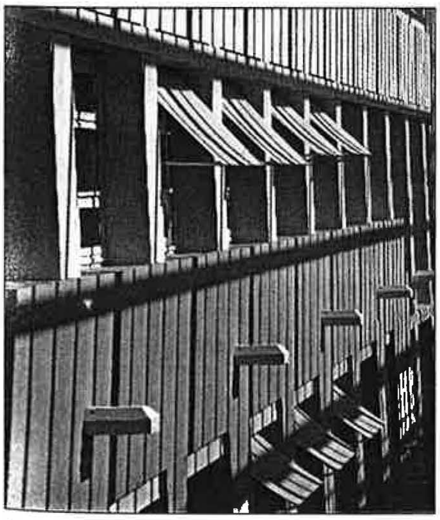
Local automatic control of lighting is via the dimmable Thorn Sensa 2 system incorporating integral presence and illuminance control in each luminaire. Experience has shown that local controls are frequently set conservatively, with long time delays and high switch-on illuminances so that lighting is on far more than it should be.

To avoid this problem, the designers established preferred settings and specified that the lighting installers should set up the lighting with these settings. The settings were established using a mock-up office, with a time delay of 150 s for presence detection.

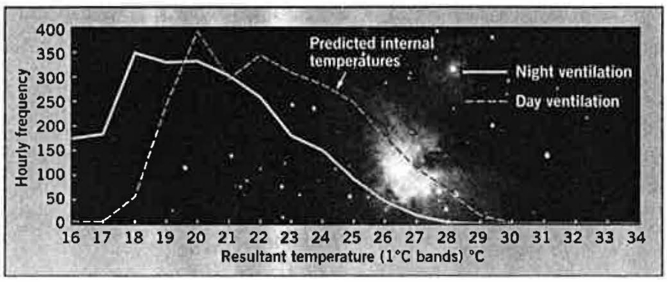
Following lessons learnt from the first gen-



ABOVE: Cross-section of the Trox service beam showing the integrated lighting, cooling and fire detection systems.



Awnings protect atrium windows from direct sunlight.



Thermal modelling predicted a 2°C reduction in internal temperature through night ventilation. Experience with the PROBE buildings indicates that optimising night cooling regimes is heavily dependent on proper commissioning of the bems.

TABLE 1: OPERATING MODES OF VENTILATION AND COOLING

Weather	Operating mode
Cold	Natural/background ventilation with perimeter radiator heating
Mild	Natural ventilation: some windows open
Warm	Natural ventilation: some windows open, possibly augmented by displacement ventilation
Hot	Displacement ventilation: chilled beam cooling using lake water, night ventilation cooling
Very hot	Displacement ventilation: chilled beam cooling using chilled water, night ventilation cooling

eration of local controls, the response to a change in illumination levels from passing clouds was set over quite a long period, with a ten-minute ramp down from 700 lux.

The lighting systems are designed to make maximum use of natural light, and the envelope design includes brise-soleil/light shelves which encourage daylight penetration. The atrium street has been designed and oriented to increase light transfer to adjacent offices.

The linear atrium is quite deep and may present a challenge to the facilities manager to resist having the artificial lights on all day. If so, daylight to the offices could become fairly immaterial. Walking round the offices, albeit on a dull winter day, did not give the impression that general reliance on daylight is practical in the lower offices away from external windows.

Overall, Barclaycard's hq courageously addresses a critical environmental problem that afflicts the majority of large-scale office developments – why is full air conditioning specified to handle internal gain rates which are not normally met in practice, and to provide controlled temperatures and sealed buildings which are unnecessary and widely agreed to be unpopular with occupants?

It can also be said to point the way to the future as it has required an open mind for new approaches by developers, occupants, designers and building managers. The building's operating performance should be of great interest to all these groups.

Given that it is possible to operate the building as an air conditioned building (although this is not the design intention), the key indicators of the success of the low energy design approach will be the percentage of time that the mechanical ventilation, the chilled beam systems and the chillers are operating in year one and later years of the building's life.

John Field MA CEng MInstE MInstP is director of energy consultancy Target Energy Services.

References

[1]Brister A, "The new generation", *Building Services Journal*, 3/95.
[2]"Getting around town", UK Round Table report, *The Independent*, 14 February 1997.
[3]Arnold D, "Natural ventilation in a large mixed-mode building", *Naturally ventilated buildings*, 1996.

Barclaycard hq, Freshfields, 1234 Pavilion Drive, Northampton

Client
Barclays Property Holdings (for Barclaycard)
Project manager
Fleetway House
Architect
Fitzroy Robinson
M&E consulting engineer
Troup Bywaters & Anders
Structural engineer
WSP
Quantity surveyor
Hart Gilmore Associates
Main contractor
Tilbury Douglas Construction
M&E contractor
Crown House Engineering
Commissioning witnessing
TBA Services Management
Acoustic consultant
Hann Tucker Associates

Contract details
Tender date: October 1994
Tender system: Two-stage main contract
Form of contract: JCT 80 (with quantities)
Contract period: 100 weeks

Mechanical suppliers
AHUs: York International
Atrium diffusers: Trox
Boilers: Broag
Burners: Broag
Ceiling diffusers: Trox
Chillers: York International
Computer room a/c: Airedale
Fire-rated ductwork: Hargreaves
Extract fans: York International
Swirl diffusers: Trox
Flues: Selkirk
Plate heat exchangers: HRS
Pumps and pressurisation: Baric
Radiators: Runtalrad
Raised floors: Hewitson
Toilet extract: York International
Underfloor heating: Multibeton
Water treatment: B&V
Valves and strainers: Hattersley

Electrical suppliers
BEMS and controls: Serck Controls
CCTV: Group 4
Communications: Olivetti
Electrical distribution: Klockner Moeller
Electrical accessories: Wandsworth
Fire alarm/detection: Thorn Security
Floor boxes: Ackermann
HV and lv switchgear: Merlin Gerin
Lifts: Express Lift
Lighting controls: Thorn Sensor
Luminaires: Thorn Lighting
Motor control centres: Klockner Moeller
Standby generation: F G Wilson

Engineering data
Gross floor area (gfa): 36 474 m^2
Net usable area: 28 757 m^2
Plantrooms: 2660 m^2
Offices: 26 667 m^2
Computer suite: 240 m^2
Amenity and dining: 1800 m^2
Atria: 2090 m^2

Energy targets (gfa)
BREEAM rating: Excellent
Heating: 99 kWh/m^2/y (gas)
Hot water: 4·3 kWh/m^2/y
Ventilation: 4·1 kWh/m^2/y
Refrigeration: 1·3 kWh/m^2/y
Small power: 16 kWh/m^2/y
Lighting: 12·7 kWh/m^2/y
Other electricity: 1·9 kWh/m^2/y
*Carbon dioxide emissions**
Gas: 21 kg/m^2/y (@ 0·21)
Electricity: 28 kg/m^2/y (@ 0·70)
(*From BREEAM estimates, this assumes 70% natural ventilation, 30% air conditioning and 8 W/m^2 for lighting with good control)

Occupancy
Offices: 1 person/9 m^2

External design conditions
Winter: -4°C/sat
Summer (non a/c): 28°C db, 21°C wb
Summer (a/c): 28°C db, 21°C wb

Internal design conditions
Winter: 20°C min, 30% rh
Summer (non a/c): 25°C
Summer (a/c): 25°C, 55% rh
Circulation and toilets: 18°C min
(Note: except for the conference suite and the restaurant, the relative humidity figures are subject to occupants' use of windows)

Loads
Heating load: 2 MW
Installed heating load: 2·37 MW
Cooling load: 2·05 MW
Installed cooling load: 2·05 MW
Fan power: 1·3 W/litre/s, 2·2 W/m^2 (low pressure, mostly 250 Pa)
Equipment: 15 W/m^2
Lighting: 8·5 W/m^2
Occupancy: 11 W/m^2

Noise levels
Offices: NR 35
Toilet and circulation: NR 35

Structural details
Slab thickness: 150 mm (550 mm ribs)
Clear floor void: 260 mm
Floor-to-ceiling: 3750 mm
Ceiling zone: 550 mm
Net services zone: 660 mm
Live load: 4 kN/m^2
Dead load: 1 kN/m^2

Ventilation
Room temperature: 20°C min, 25°C max
Fresh air: 12 litres/s/person
Max recirculation: Nil
Fresh air minimum via windows and trickle vents: 0·25 ac/h to 3 ac/h.

Primary air volumes
Total fan power: 2·2 W/m^2
Primary air: 8 ahus @ 4-8 m^3/s

U-values (W/m^{2}K)
Walls: 0·45
Roof: 0·25
Glazing: 3·3
Atrium: 3·3

Distribution circuits
LTHW
82°C flow, 60°C return
82°C flow, 71°C return
DHWS: 60°C
Constant temp: 82°C
Chilled water: 15°C

Refrigeration
Chillers: Ammonia
Computer room: R407C

Electrical supply
11 kV, open ring
2 x 1 MVA, 1 x 1·5 MVA transformers
100 kVA ups system
1500 kVA standby power, by 2 x 750 kVA diesel generators

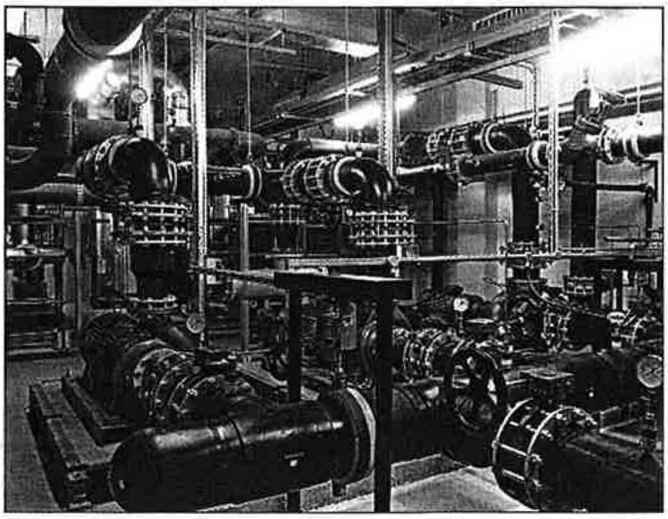
Lighting
Lighting load: 226kW
Efficiency: 2·4 W/m^2/100 lux
Lux levels
Office: 350
Conference: 350
Kitchen: 500
Computer: 350
Toilets: 150
Stairs: 150
Circulation areas: 200
Glare index: *LG3* category 2

Lifts
10 x 13 person @ 1 m/s

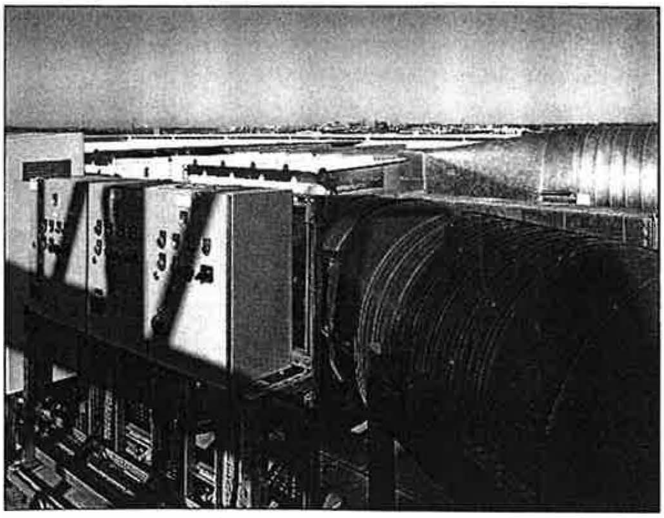
Costs
Total cost: £43.75 million
Building services total: £8.57 million
Total net cost: £917/m^2 (1200 including multi-deck car park and tenant's fit-out adaptions)

Mechanical services cost (£/m^2 nfa)
Ventilation: £15.40
Cold water services: £1.40
Hot water services: £2.25
Heating services: £31.50
Cooling services: £38.00
Drainage: £2.50*
Dry risers: £0·83
External gas/water: £1.19
Chilled beams, cooling and sprinklers: £54.00
Preliminaries: £9.00
(*Above ground, including sewage pumps)

Electrical services (£/m^2 nfa)
Meter and switchgear: £24.60
Lighting: £15.00
Power: £6.00
Lighting fittings: £18.75
Controls and bems: £17.00
Sprinklers: £9.00
Fire detection and alarms: £6.26
Security: £11.00
Lifts: £20.00
Telephone & data: £37.00*
Earthing & bonding: £0.90
Motor control and cabling: £13.50
Preliminaries: £4.80
(*I nfrastructure only)



Inverter-driven pumps are used to meet the highly variable cooling load.



Air handling plant on the building's roof.