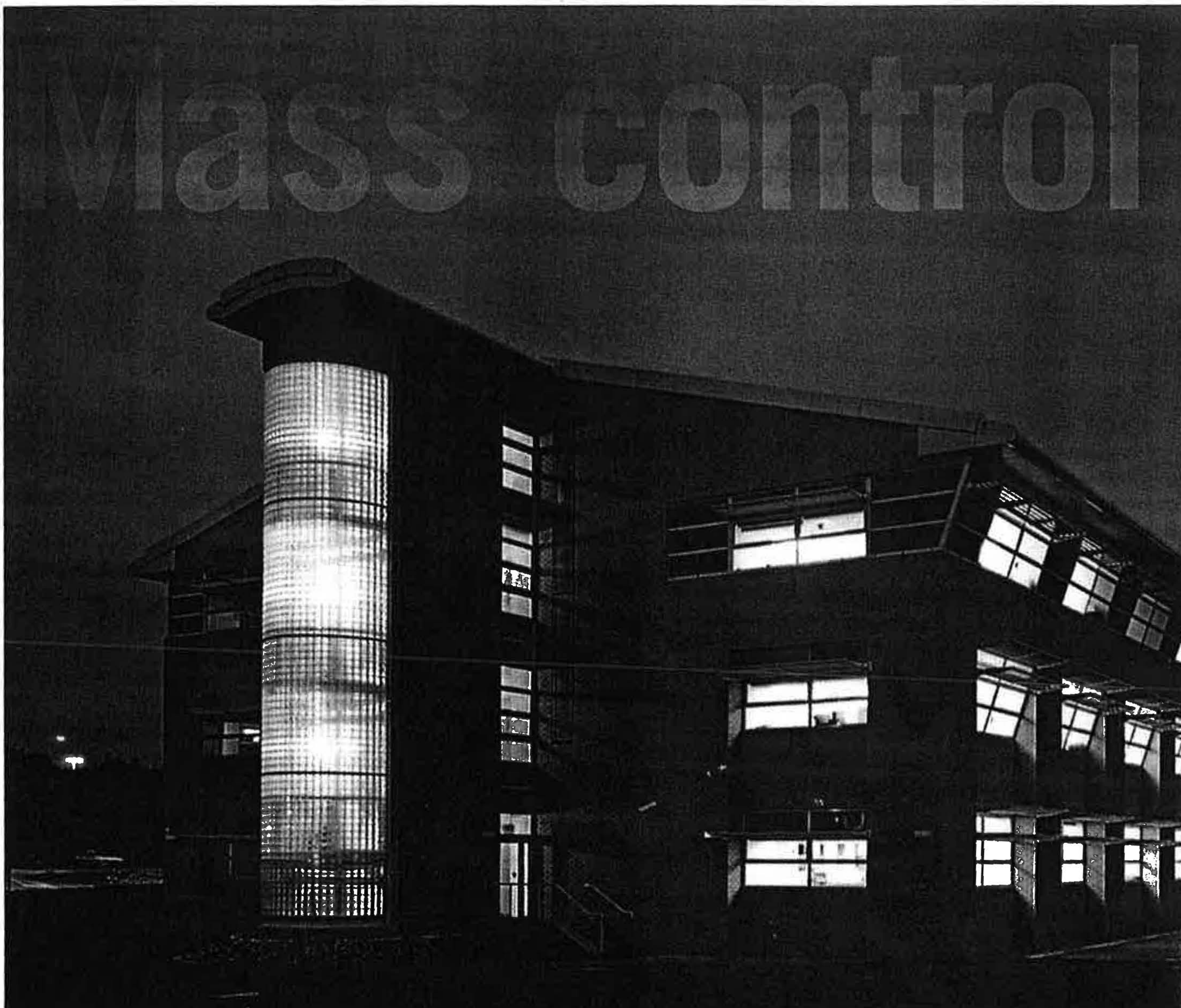
AIVC 10990



The fourth UK office building to feature the Termodeck active thermal storage system has reached completion. Partially a product of the client's dissatisfaction with traditional air conditioning, the resulting building is an interesting fusion of convention and innovation.

BY RODERIC BUNN

Natural ventilation is often regarded by the low energy devotee as the only antidote to full air conditioning. Pumping water or fanning air is considered an unnecessary drain on fossil fuel, a wicked contribution to global warming which could easily be avoided. This is a dangerous precept, and one not borne out by post-occupancy analyses. While absolute efficiency in energy use may be desirable, it is not necessarily practicable, nor does it automatically lead to improvements in thermal comfort, indoor air quality and (user-perceived) productivity.

As is often the case, the answer lies somewhere in the middle. Despite their small number, mixed-mode buildings – those which rely on multiple environmental systems or have zones serviced separately – seem to perform more reliably in energy and comfort terms than their more extreme counterparts.

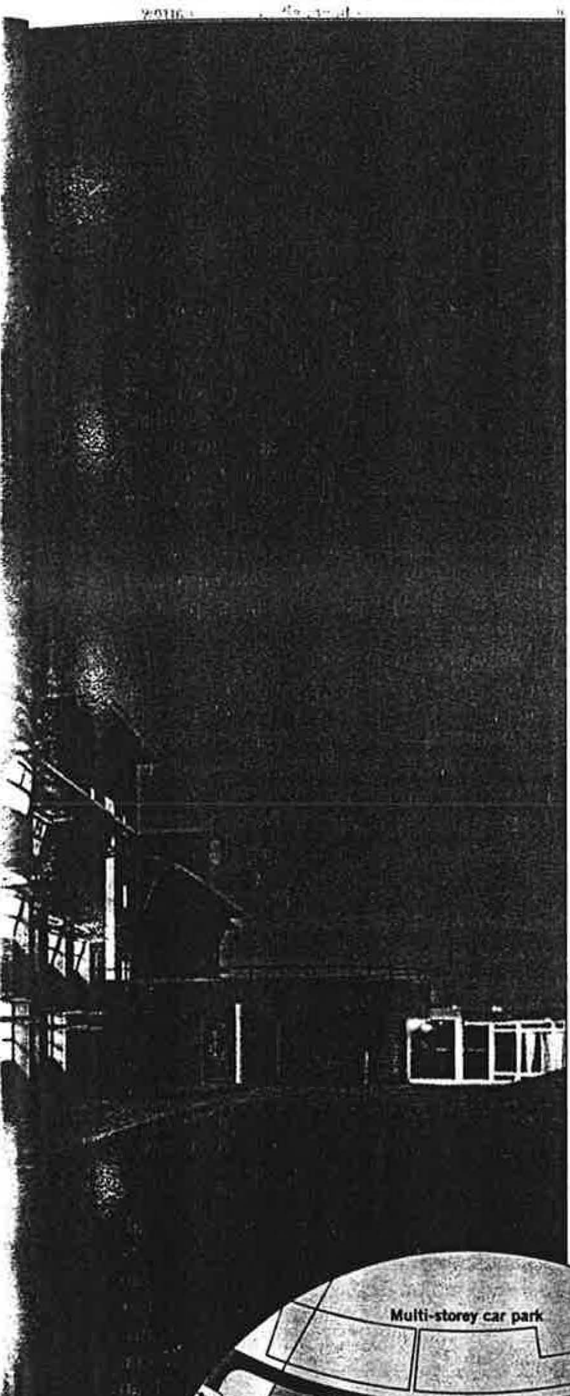
This building, Phase 2a of a much larger office development near Blackpool, veers very close to the mixed-mode label. Built to house around 530 clerical staff working for the Information Technology Service Agency (ITSA), it is one of a handful of UK buildings[1,2] to use Termodeck, the Swedish hollowcore concrete slab system designed to both transport and temper a building's incoming air supply[3].

The ITSA's enthusiasm for such innovation largely stemmed from a growing dissatisfaction with more traditional forms of air conditioning. Whereas the first phase at its Peel Park site relied on a conventional variable air volume system, Phase 2a uses Termodeck in a displacement ventilation mode, along with a small amount of refrigeration in order to provide a flexible means for coping with spot cooling loads wherever the client might choose to put them.

The design brief

The design team of architect Ormrod & Partners and services engineer R W Gregory & Partners was given a brief to investigate more passive forms of architectural engineering for the remaining buildings at the ITSA's new Peel Park location. They worked together with the quantity surveyor and structural engineer on a revised master plan, looking at various site arrangements and testing the feasibility of passive architecture.

The windy coastal location quickly ruled out natural ventilation, and in any case compu-



The ITSA building at Peel Park houses open-plan and cellular office space over three floors either side of narrow daylit atriums, divided into two wings by a central entrance and vertical circulation zone.

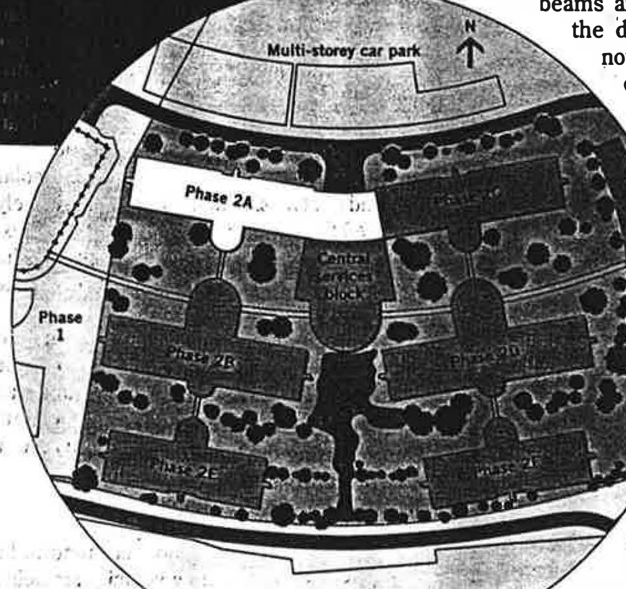
ter simulation revealed that substantial portions of the proposed Phase 2a building would experience excessive summer temperatures, necessitating some form of mechanical ventilation and cooling.

On top of that, the design team faced serious site limitations, both in terms of the ground conditions and in terms of height restrictions imposed by the Civil Aviation Authority, which was concerned about radar interference to several airfields.

The already narrow-plan, east-west facing building came down in height, reducing the floor-to-ceiling height to 2·8 m. Furthermore, the below-ground conditions – alternating beds of clays and sand – led to a floating slab designed to avoid concentrated loads. This meant a quite heavily steel-framed structure, with the frames occurring laterally on 5·4 m centres.

Internally, the building houses open-plan and cellular office space over three floors either side of narrow daylit atriums, divided into two wings by a central entrance and vertical circulation zone (figure 1). The atriums, though confined, allow a reasonable amount of daylight to penetrate to the ground floor offices, in keeping with the client's requirement that no occupant should be more than 7 m away from natural daylight. Curiously, these atriums are only used to contain smoke rather than evacuate it.

With glazed-block circulation corridors ringing the atriums on each level, coupled to the high density of structural columns and beams and head-high desk lockers, the daylight factor will probably not be enough by itself to reduce the reliance on electric lighting.



The building is clad in masonry, with windows set into bays created by external builders work ducts which double up as shading devices against low angle sun. Windows on the first and second floors are angled out to the horizontal, which not only gives the otherwise muted building some architectural sculpting, but aids the fixed external shades in the control of glare. Internally, glare control is managed on the south-facing elevation by two very simple cord-operated blinds: one perforated set for anti-glare control which still allows occupants to see out, and a second full black-out blind.

In simple servicing terms, the building is split into four zones, conforming to points on the compass, with the main air handling plantroom located above a central circulation and reception area containing four office air handling units and two general air handling units for the central zone.

The boiler and chiller plant are housed at the far end of the building in a plantroom sized to meet the needs of future building phases.

Environmental engineering

The services engineer considered various ways of achieving comfort control: conventional mechanical ventilation, chilled beams and displacement ventilation, as well as the Termodeck approach.

In respect of the internal cooling loads, the client anticipated a quite dense loading of 1 person/8 m^2, with an average equipment load of 35 W/m^2, but peaking at higher levels in non-specified locations.

Despite the lack of extensive monitoring data to prove the validity of Termodeck under UK weather conditions, the client was persuaded by the promising research findings produced by the BSRIA and the BRE. These suggested that the system would meet the client's criteria of thermally stable internal conditions, with inherent flexibility to meet future occupancy densities, occupancy times and office partitioning[4].

Its experience with vavair conditioned buildings demonstrated to the ITSA that attempts to set rigid limits on the control of environmental temperature were neither wise nor achievable. The dry resultant temperature limit was thus set at 25° C with an exceedence of 5% of the occupied time, and 27° C with an exceedence of 1% of the occupied time.

The first objective was to minimise solar gain and heat loss, which the architect largely achieved through structural shading and external sun louvres, fixed and triple-glazed windows and, at 0·23 W/m^2K for the walls, quite high levels of fabric insulation.

The second was to make the building airtight, with advice being sought from the BSRIA, whose pressure tests produced an infiltration rate of only 4·76 $m^3/h/m^2$ facade at 50 Pa, a shade inside the BSRIA's own recommended value for a tight building.

Termodeck with displacement flow

Traditional forms of Termodeck[1] tend to be mixing systems, with low velocity air being supplied via terminations in the ceiling slab, the air being pumped through the hollowcores

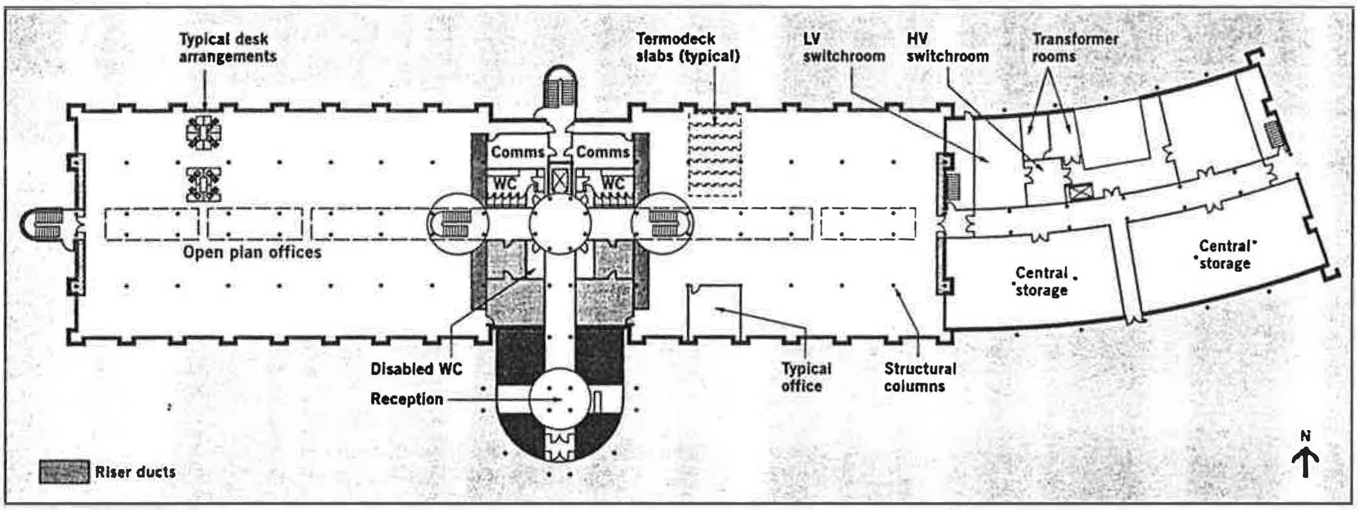
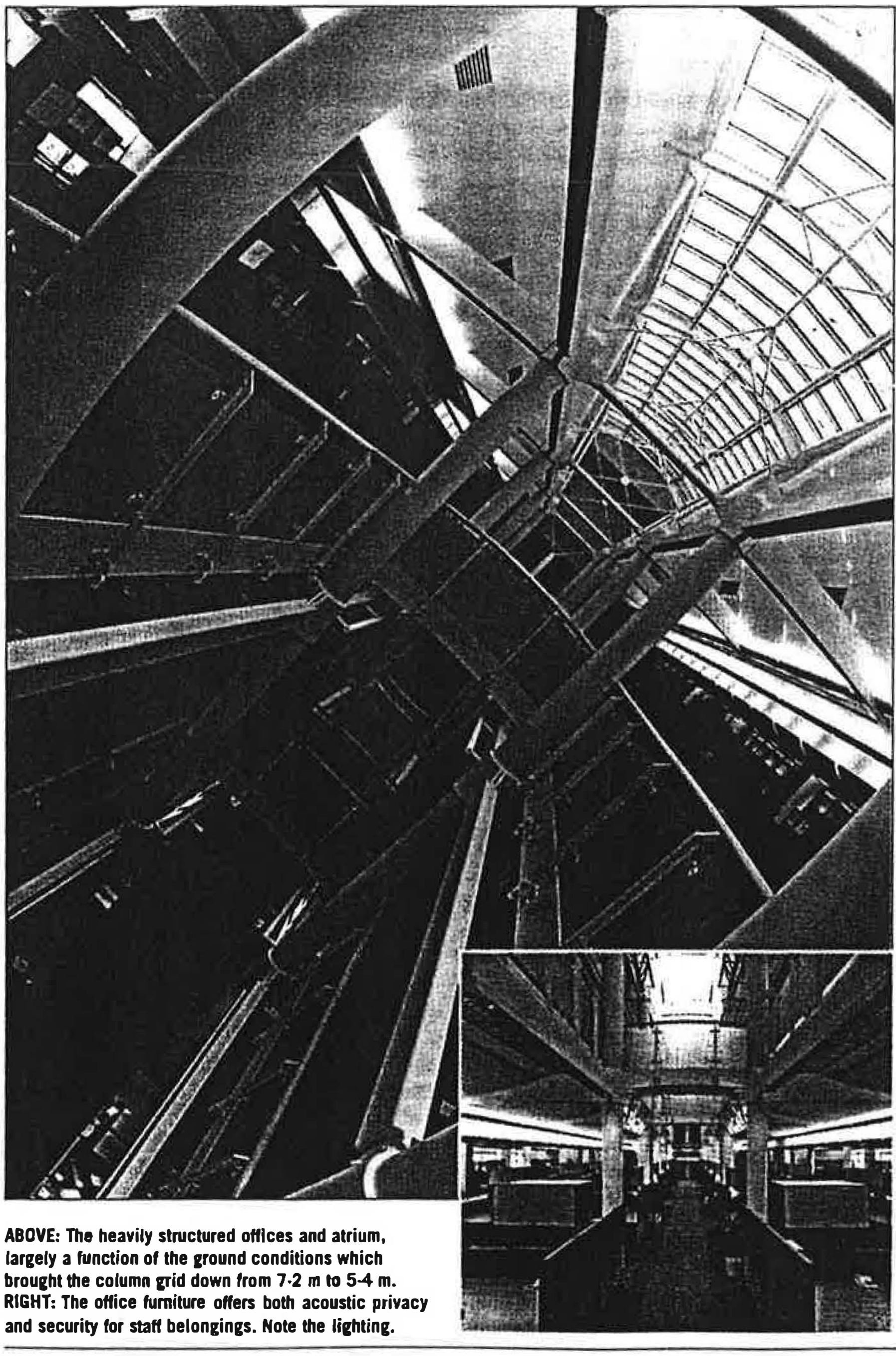


FIGURE 1: Basic layout of the ITSA building showing the relationship of the Termodeck slabs to the office areas (seven to a zone), the risers and the central services.



ABOVE: The heavily structured offices and atrium, largely a function of the ground conditions which brought the column grid down from 7·2 m to 5·4 m. RIGHT: The office furniture offers both acoustic privacy and security for staff belongings. Note the lighting.

before being injected into the occupied zone. Here the design team adapted Termodeck to provide a displacement ventilation system, with air supply via pressurised floor plenums.

Figure 2 explains the configuration. On the ground and first floors the supply air is supplied from the central plantroom to risers located centrally and at the building's east and west ends. Two distribution ducts per zone then run out from either direction onto each floor. While those on the ground and first floors are located behind a service tray doubling as an uplighting fitting, the supply duct serving the second floor runs in the pitched roof void.

As the ducts run out from the risers, spigots pop up to connect to the input end of each Termodeck slab (seven per bay, positioned parallel to the building's facade). The supply air passes through the Termodeck, alternating between one and two passes (with one three pass to cope with high loads) across the bays (figure 3).

Air is then withdrawn from the Termodeck and passed into a header duct that runs across the ceiling, down an external builders work duct and out into the floor plenum below. Air from this pressurised plenum is then injected into the occupied space, at a design volume of 0·025 m^3/s, via simple Gilberts diffusers installed in movable floor tiles.

Return air is collected in the atriums and ducted back to the plantroom air handling units, which have a thermal wheel to dump heat into the incoming 100% fresh air supply.

The central portion of the building, including the reception, communications rooms and meeting rooms, is serviced separately using a general supply and extract system, with both cooling and heating coils in the dedicated air handling units.

Although there was a strong argument in favour of letting the building run free in temperature control terms, largely on the basis of calculations that showed the Termodeck was able to handle fluctuations in internal load, the control of space temperature has been vested in a Landis & Staefa bems.

Figure 3 shows the arrangement whereby higher cooling loads can be satisfied on demand by taking a percentage of the supply air, mechanically cooling it to 14°C depending on external air temperature, bypassing the Termodeck and injecting it straight into the floor plenum.

Internal meeting rooms are equipped with a manual control switch that delivers this extra cooling, but the facility to add mechanical cooling also exists in the open-plan areas, which raises interesting issues of how the controls system will know when the radiant cooling from the Termodeck needs to be boosted by lower air supply temperatures. Thus far, extra cooling has not been required in the open-plan areas.

Of course, the opportunity for a bit of reactive control raises the potential for conflict between controlling off-slab temperature, which should be the primary objective, and controlling the contribution of the refrigeration system. In the two months since the building was occupied, the control loops, set-points and time intervals have been improved to provide better management of the services.

Supply air temperature is now continuously compensated on a floating basis such that adjustments to the supply air temperature are twice the difference between normal return air temperature (initially set at 22°C) and the actual average return air temperature (measured before the exhaust fan). For example, if return air is at 23·5°C, then the supply air set-point would be reduced by 3°C, with the Termodeck slab imparting such heat or coolth to maintain the space temperatures between 21-23°C depending on season.

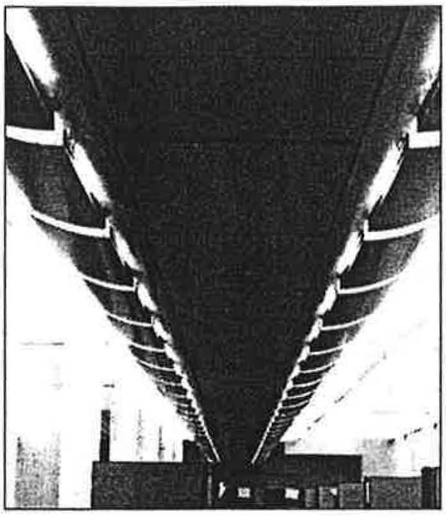
Supplementary cooling has been scheduled to reduce space temperatures if, four hours before occupation, space temperature is above 23°C (this is only likely to occur during extended periods of hot weather).

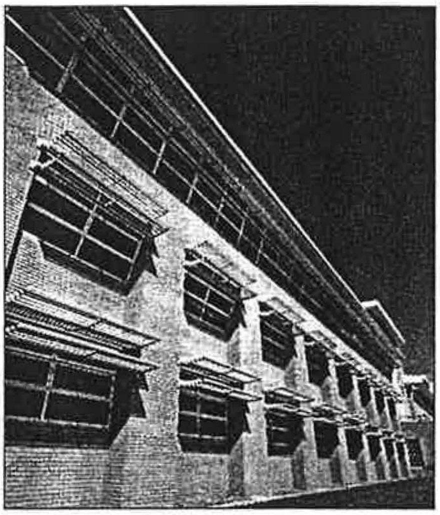
To provide an accurate reading of the off-slab temperature, the bems will also receive readings from a temperature sensor located in one hollowcore duct per zone, with space temperature also monitored from a single zone sensor. During the heating season the inverter-driven fans can modulate to obtain more heat from the thermal wheels.

There is also the question of humidity control to consider, as the inherent tendency of Termodeck would be to dehumidify the supply air through absorption. Wisely, the client has opted to install spray-type atomisers in the air handling units, with the need for space humidification based on an average reading obtained from the return air.

There is no terminal reheat for the open-plan offices, although a wet heating system serving perimeter radiators has been provided for cellular offices, a late addition to the second floor to house a higher than expected number of managers.

The engineer had originally specified condensing boilers alongside conventional constant temperature boilers, but the former were replaced by low NOx boilers as one of the few cost-saving exercises. This heat raising plant, situated in a large plantroom positioned to serve future phases, is also used for perimeter heating and domestic hot water.





LEFT: The services beam showing the uplighting. RIGHT: Glass blocks aid daylight penetration from the atrium.

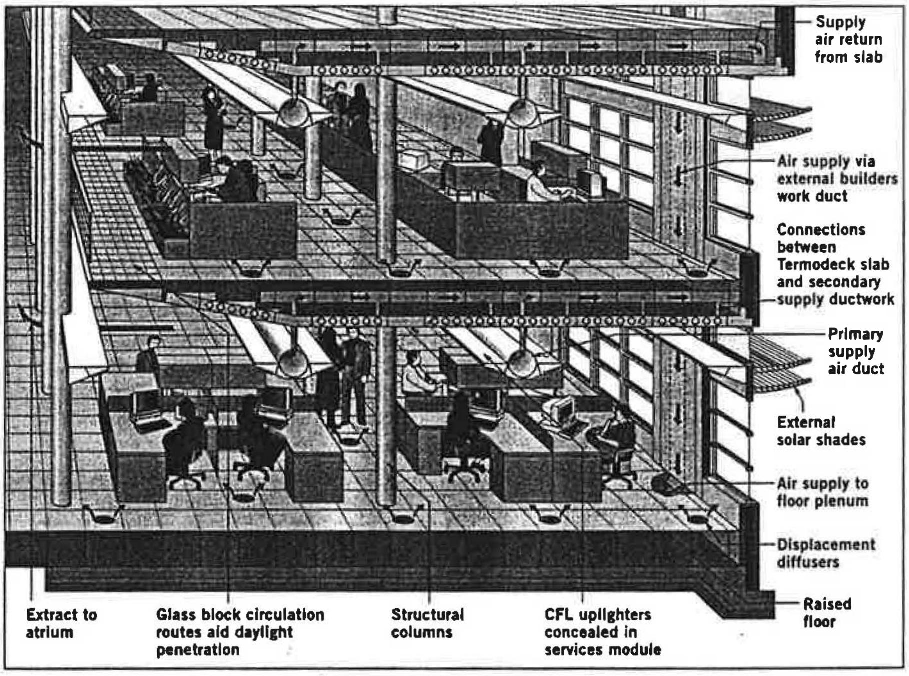


FIGURE 2: A floor zone in cross section detailing the services beam (just above head level) and the ductwork system that connects the Termodeck slabs to the underfloor displacement ventilation.

Electrical services

The building is very conventional in terms of its hv and lv distribution, the former running off two transformers located in the services block. LV distribution to the offices consists of a conventional underfloor busbar feeding to system furniture which is mostly arranged in groups of four.

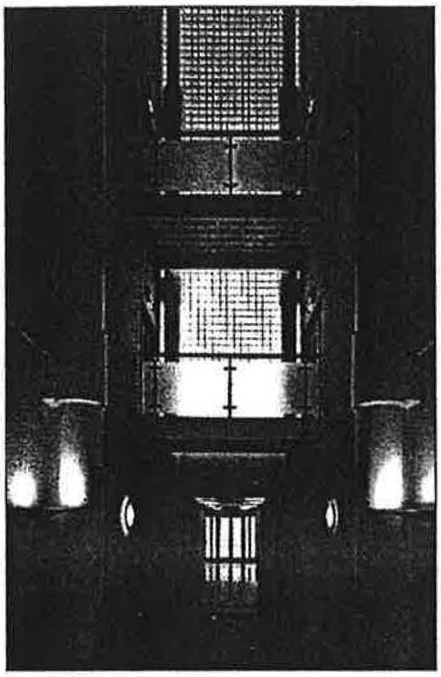
The office lighting system is integrated within the service beams which run the length of the offices. Uplighters either side of the service beams contain compact fluorescent lamps designed to provide around 350-400 lux on the working plane. This is borderline for task lighting, particularly as the Termodeck has been finished with a textured paint that will reduce the amount of reflected light. Task lamps are apparently available on request to the facilities manager.

Each bank of four lamps either side of a service beam is under the control of presence detectors located on the underside of the beam, along with the public address speakers and smoke detectors. Naturally enough, the lightwell contains mixed feature lighting, with a selection of strip fluorescent downlighters located above the lightwell walkways.

Overall assessment

One of the great virtues becoming apparent with Termodeck is that it automatically removes a great many uncertainties often created by interfaces between components of a mechanical ventilation system. It also tends to default to an inherently stable internal condition with very low running costs. Latest figures from the Elizabeth Fry building[5] reveal that delivered gas and electricity consumption is down to 91 kWh/m^2, with gas alone accounting for 32 kWh/m^2.

Of course it requires a big leap of faith by both designer and client to let a building run free, with little in the way of electronic controls to maintain set-points. On the other hand,



The Phase 2a reception and central services block. Bridging corridors connect the east and west wings.

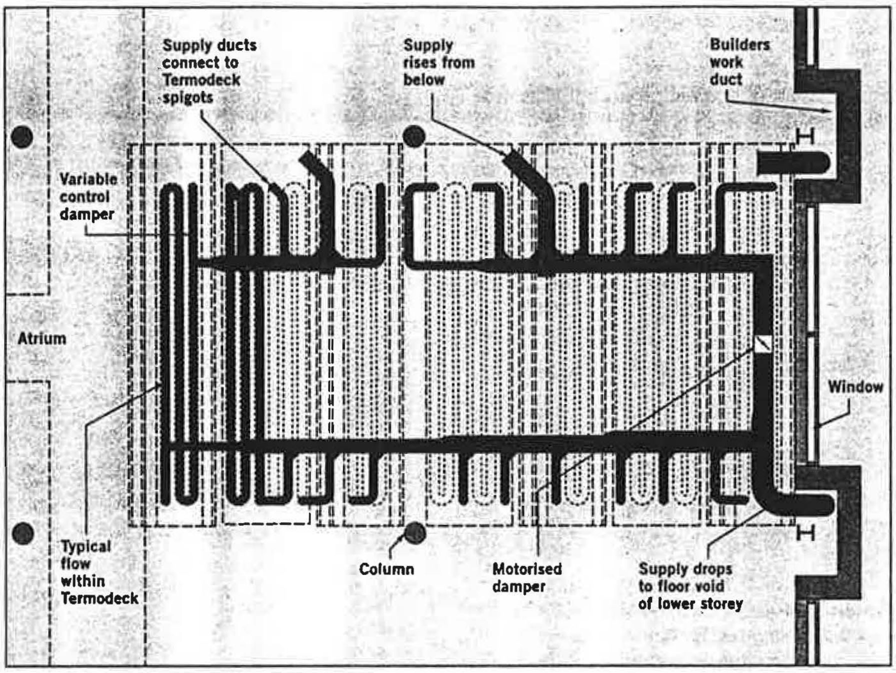


FIGURE 3: A typical ceiling zone showing how the ductwork connects to the Termodeck slabs. Note the motorised damper which enables mechanically-cooled air to bypass the Termodeck and inject directly into the floor void.

there is no way a mechanical cooling system can know or calculate the effect on comfort levels of Termodeck's 70% radiant cooling component.

Perhaps the servicing is a tad complicated for what is essentially a very simple building. It certainly has a lot of components not normally associated with Termodeck: mechanical refrigeration, bypass dampers, inverter-controlled fans, thermal wheels and a perimeter heating system, all of which are in a bems control loop.

Given that research[6] shows that, on average, a Termodeck slab can accept about 75% of the heat in ventilation air, longer Termodeck runs may have been the way to provide the required extra thermal capacity. But with occupancy density projected at 1 person/8 m², and with the likelihood of extended hours of occupancy eating into the night cooling period, the added cooling capacity is defensible, and easier to install now rather than later.

To its credit, the ITSA has recognised the connection between comfort and productivity at the same time as acknowledging that strict control of operative temperature is neither practically achievable nor necessarily desirable. Indeed, the organisation intends to carry out regular occupancy surveys to discover how well the building is performing.

It will be interesting to see whether the ITSA opts for more of the same for its remaining three buildings at Peel Park.

References

[1]Bunn R, 'Teaching low energy', *Building Services Journal*, 4/95.
[2]Bunn R, 'Slab and trickle', *Building Services Journal*, 2/94.
[3]Bunn R, 'Termodeck: the thermal flywheel', *Building Services Journal*, 5/91.
[4]Willis S and Wilkins J, 'Mass appeal', *Building Services Journal*, 1/93.
[5]Unpublished energy report by Databuild for BRECSU, October 1997.
[6]Winwood R, 'Termodeck: in use performance', *Building Services Journal*, 11/97.

ITSA Phase 2a, Peel Park, Brunel Way, Blackpool, Lancashire

Client
Information Technology Services Agency (ITSA)
Project manager and quantity surveyor
Appleyard & Trew
Architect
Ormrod & Partners
M&E co-ordinator
R W Gregory & Partners (Manchester)
M&E consultant
IBSEC
Civil/structural engineer
Curtins
Main contractor
Laing North West
M&E contractor
Crown House Engineering

Contract details
Tender date: December 1995
Form of contract: GC/Works/1
Contract period: 17 months
National Engineering Specification: No

Mechanical suppliers
AHUs: York International
Air curtains: Biddle
Anti-vibration mounts: Sound Attenuators
Atrium swirl diffusers: Gilberts Sheet Metal
Boilers: Broag
Calorifiers: IMI Rycroft
Ceiling diffusers: Senior Colman
Chillers: York International
Computer room a/c: Lennox
Coolant: R22
Ductwork: Mersey Metalworks
Extract fans: Woods of Colchester
Fan coil units: Lennox, Carrier Air Conditioning
Floor diffusers: Gilberts Sheet Metal
Hot water calorifiers: IMI Rycroft
Humidifiers: JS Humidifiers
Louvres: Gil Airvac
Pumps: Pullen Pumps
Pressurisation: Pressmain
Radiators: Stelrad, Runtalrad
Sound attenuation: IAC
Strainers: TA
Tanks: AC Plastics
Toilet extract: NuAire
Valves: TA
Water treatment: Water Technology

Electrical suppliers
BEMS and controls: Landis & Staefa
CCTV: Thorn
Fire alarm/detection and public address: Madewell
Floor boxes: Powerplan
HV switchgear: Merlin Gerin
Lighting controls: Thorn
Luminaires: Concord, Thorn
LV switchgear: Durham Switchgear
Power busbar: Powerplan
Trace heating: Jimi Heat
Water leakage detection: Strabilag (ESH)

Engineering data (nominal)
Gross floor area (gfa): 8650 m²
Net usable area: 6850 m²
Offices: 5170 m²
Conference/meeting: 306 m²
Common rooms: 160 m²
Kitchens: 65 m²
Reception: 15 m²

Structural details
Clear floor void: 400 mm
Floor-to-ceiling: 2850 mm
Ceiling zone: 0 mm
Slab thickness: 200 mm

U-values (W/m²K)
Walls: 0·23
Floor: 0·36
Roof: 0·18
Glazing: 1·40

Energy targets
Not made available
BREEAM rating: Excellent
Fabric air leakage: 4·76 m³/h/m² @ 50 Pa

Design loads
Calculated heating load: 1158 kW
Installed heating load: 1116 kW
Calculated cooling load: 363 kW
Installed cooling load: 384 kW

External design conditions
Winter: -1°C/sat
Summer (a/c): 24·8°C db, 18·7°C wb

Internal design conditions
Winter: 21°C min, 50% rh
Summer (a/c): 23°C, 40/60% rh
Circulation and toilets: 21°C max, 18°C min

Ventilation
Scheduled supply air temperature: 14°C min
Room temperature: 21°C min, 27°C max
Fresh air: 100%
Recirculation: Nil
Filtration EU category: EU3, EU7 (panel plus bag)
Primary air volumes
Primary air: 24·7 m³/s
Total fan power: 62 kW

Noise levels
Offices: NR35
Toilets/circulation: NR45

Occupancy
Offices: 1 person/6 m²
Meeting rooms: 1 person/4 m²

Distribution circuits
LTHW: 82°C flow, 71°C return
DHWS: 60°C flow, 50°C return
Chilled water distribution circuit: 8°C flow, 13°C return

Costs
Total cost: £9.60 m
Building services total: £2.56 m

Mechanical services
Hot and cold water services: £86 890.13
Heating services: £149 842.03
Cooling services: £118 507.29
Ventilation: £590 072.53
Dry risers: £10 680.56
External gas and water: £15 653.84
Record drawings and maintenance manuals: £452.88

Electrical services
Meter and switchgear: £224 840.31
Lighting installation: £498 905.65
Power installation: £235 907.67
Controls: £24 331.26
Fire alarms and detection systems: £101 064.06
Security systems: £121 160.27
CCTV: £91 288.96
Telephone and data: £27 362.88