All photographs: Roderic Bunn

Above: The first floor walkway through the central concourse showing the rear of auditorium 1.12. Feature lighting is on almost permanently in this well daylit space.

Completed in late 1993, the Queens Building at de Montfort University was lauded at the time for being the first in a new generation of low energy, naturally ventilated buildings. In 1996, it was subject to a post-occupancy analysis under the PROBE[1] project. Ten years later, *Delta T* has returned to see how the Queens Building has fared since the PROBE investigation.

Design description and history

The original brief for the Queens Building called for innovative solutions that would reflect the creative nature of the then-new university. The architects were Short-Ford Associates and environmental engineers Max Fordham LLP, backed-up by an team of advisers, such as Cambridge Architectural Research on the stack-effect chimneys, and Bristol University on the physics of airflow.

The result was a highly insulated, thermally-massive envelope with mostly shallow-plan floor plates and generous ceiling heights. The 10 000 m^2 building is L-shaped, with the south-facing wing comprising a full-height engineering laboratory, and a four-storey east wing containing a complex arrangement of laboratories, classrooms, and offices. The wing is separated by a long, winding lightwell that connects to two auditoriums.

The building is almost exclusively naturally ventilated: cross-ventilation for the narrow wings, and chimney stack-assisted for the main building. The top floors are ventilated by motorised ridge windows.

Results of the original PROBE survey

The PROBE research team found that the commissioning period was compressed into a six-week window before the start of term in October 1993. Unresolved defects meant that the building operated for the first two years with problems in critical mechanical and control systems. For example, motors and actuators serving the rooflights were not properly commissioned, with the result that many motors burned out trying to drive the actuators past their stops.

The building's thermal massing and natural ventilation seemed to be effective at maintaining a comfortable environment, although the occupant survey conducted by Building Use Studies (BUS) showed dissatisfaction with high summertime temperatures, particularly on the third floor, and stuffiness in both winter and summer.

The PROBE researchers found that even copious amounts of daylight were not enough to displace electric lighting. This appeared to be a failing of the control systems and the building's users. Noise was

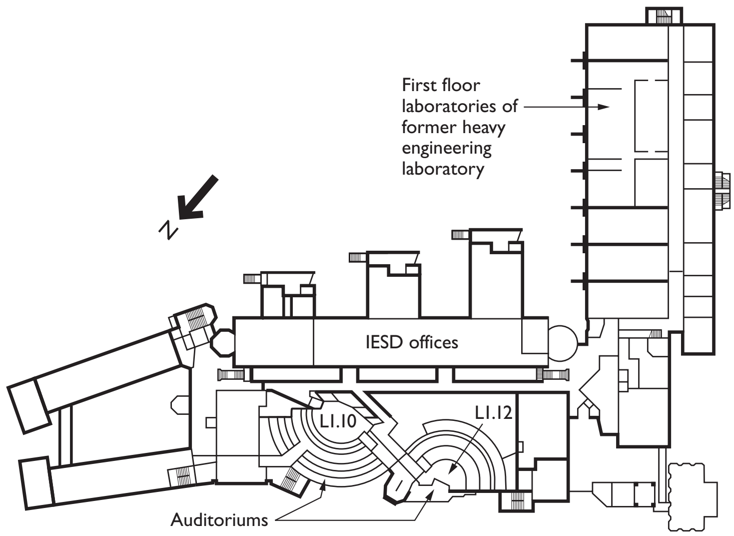
Queens Building

De Montfort University

Roderic Bunn revisits De Montfort University's Queens Building, an award-winning project considered a trailblazer of passive solar design. How is it performing a decade on?

the greatest cause for concern, largely stemming from the open-plan areas that were alien to academic researchers who were used to private labs and offices.

The building's low energy claims were largely borne out in practice. Based on a treated floor area of 8400 m^2, gas and electricity consumption was 143 kWh/m^2/y and 52 kWh/m^2/y respectively. This compared favourably with the Energy Efficiency Offices' low target consumption for university buildings of 185 kWh/m^2/y and 75 kWh/m^2/y respectively.



Ten years on

In the last ten years some parts of the building have changed dramatically while other zones are much as they were in 1993.

The desk-based staff of the Institute of Energy and Sustainable Design (IESD) now occupy the former m&e laboratory, while the double-height, single space of the heavy engineering laboratory has been separated by a mezzanine floor with laboratories on the first floor. The smaller engineering facility on the ground floor now shares space with media units and tv studios.

Energy performance data has been gathered by IESD staff, who have taken an active interest in improving their own space while keeping a keen watch on other parts of the building.

Based in what was the m&e lab, the IESD staff enjoy a large, double-height space that has single-sided natural ventilation with stack-assisted exhaust through motorised rooflights. The copious daylighting from the west-facing elevation came with a glare penalty with low angle sun, something which didn't bother the previous occupants. Full-height blinds with beaded pull-cords have been installed, and the IESD staff use them regularly.

The IESD has replaced the motors for the rooflights. The original motors burned out shortly after they were first installed.

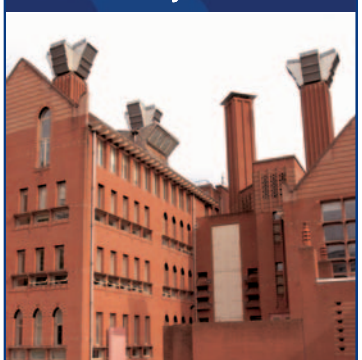
"The Queens Building was one of the first of the new generation of naturally ventilated buildings, and engineers weren't sure how powerful the motors had to be, or how far they should drive open the windows," explained the IESD's Dr Malcolm Cook. "As a result the motors were under too much strain."

A decade might seem an inordinately long time for failed motors to be replaced, but the engineering staff weren't bothered by the leaky rooflights, being able to both move around, and be warmed by large, heat-generating machinery. Today, the IESD staff can open and close the rooflight vents via wall-mounted switches.

The windows serving the IESD offices are mostly manually openable, with a few fitted with new motorised actuators to facilitate night cooling. Once a new bms is commissioned, the motorised openings will enable the IESD to introduce a night-cooling regime.

The pivot mechanism for the manually-openable windows has two settings: open and closed, with no intermediate position.

BSRIA PROJECT REVISIT



BSRIA project revisit articles look at notable buildings designed by BSRIA Members and investigate their performance over time. The engineering services at the Queens Building were designed by environmental consulting engineers Max Fordham LLP.

A building worthy of a revisit is either a construction project notable for its contribution to design innovation and sustainability, or a project that demonstrated a step-change in delivering improvement through the supply chain.

THINGS THAT **WORK**

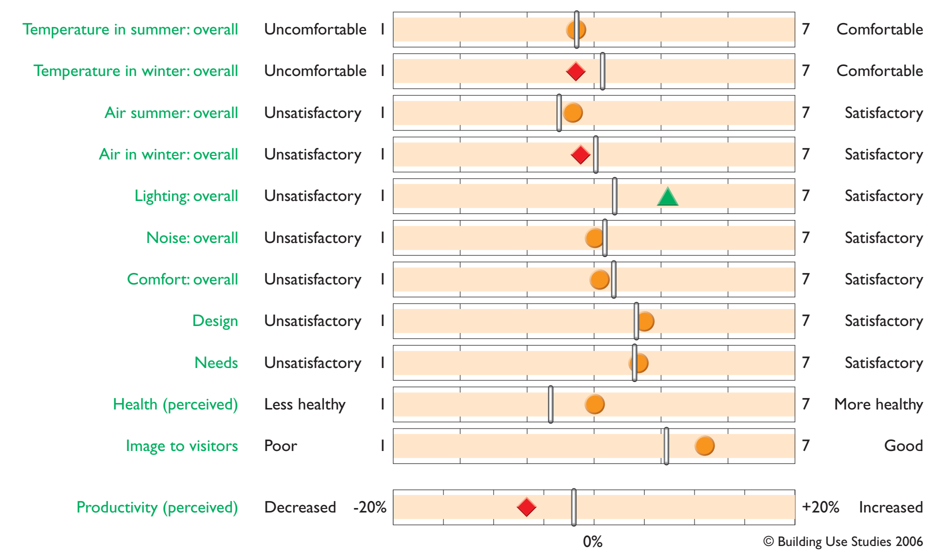
The Institute of Energy and Sustainable Development occupies the former m&e lab. Improved electric lighting, glare control and replacement of the rooflight motors (now under the direct control of occupants) has improved comfort conditions.

TV studios and media facilities have been successfully incorporated into the ground floor of the former heavy engineering hall; whereas...

AREAS OF **CONCERN**

...the laboratories created on the first floor suffer from insufficient buoyancy to drive the natural ventilation. This enters from new vents in the outer wall and out through the ridge vents. Lack of storage space is also a problem.

The former drawing office on the third floor of the main building suffers from overheating. Motors serving the ridge ventilators may be those that burned out soon after occupation. In any case they are switched off. Direct solar gain on the lightweight roof, coupled to high heat gains from computers, make this area very hot in summer. The electric lighting tends to remain on in this well daylit space.



Building Use Studies carried out a new occupant satisfaction survey on the Queens Building using the PROBE methodology. Green triangles represent mean values significantly better or higher than both the benchmark and scale midpoint. Amber circles are mean values no different from benchmark. Red diamonds are mean values worse or lower than benchmark and scale midpoint. Be careful to read the directions of the scales and the scale labels. Benchmarks are represented by the white line through each variable.

machine shop, but sedentary staff require finer control. IESD staff have improved ways of wedging the windows, finding that different sized rolls of Sellotape give different rates of ventilation.

The third floor of the Queens building was originally designed as an open-plan drawing studio, with copious amounts of daylight from glazed ventilators in the roof gables and large, triangular windows on the east-facing elevation.

Drawing boards went out of fashion very early on, and the space was subsequently used by other departments. Today, it is home to banks of computers for student use. As in the machine shop, the motors serving the ridge ventilators burned out. Previous occupants of the space found ways to wedge open the ventilators, but at the time of writing the vents were found to be closed and the motors switched off.

There seems little effective ventilation in the space. With a lack of thermal mass in the roof, heat from the computers and hot air rising up from low levels, the former drawing studio is a hot space in summer.

Auditoriums

The hemispherical auditoriums sit side-by-side along the north-west elevation, with the second auditorium rotated through 180°, ostensibly as a space-saving manoeuvre. Both rely on buoyancy-driven ventilation, with incoming air tempered by traversing a concrete plenum beneath the seating and extracted through tall, insulated chimneys. The strategy has worked well for the auditorium that is orientated with its raked seating backing onto the road, but has arguably failed for the other auditorium.

Some incoming air for the second auditorium does traverse a convoluted route to reach the seating plenum, but the greater proportion takes the line of least resistance, entering the space directly past heating coils set into the perimeter wall. The incoming air is simply not in contact with the heating coils long enough to raise its temperature, and a lack of turbulent flow creates serious stratification problems. The result can lead to an 8°C difference between the upper and lower seating areas.

Malcom Cook postulates that blanking off a proportion of the supply grille may encourage better mixing.

Heavy engineering wing

The former heavy engineering hall has undergone a significant change of use, a reflection of the University's shift from engineering to maths, chemistry and media studies. The installation of a mezzanine, internal solid walls, and partitions on the first floor to create laboratories led to a complete rethink of the ventilation strategy.

As before, fresh air enters the ground floor machine hall via ventilated buttresses. This air now crosses the machine hall and enters a central corridor via a series of transfer grilles. Extract is then out through the original ridge ventilators.

The only way the first floor laboratories could be ventilated was by knocking vents into the brickwork chambers connected to the ventilated buttresses, and hoping that natural buoyancy will be enough to drive the ventilation through the ridge ventilators.

In practice, the laboratories do not seem to get enough air, and conditions are noticeably uncomfortable. The wing has also undergone further changes of use since the ventilation system was reconfigured, and in places it seems unable to cope.

Occupants of the labs also suffer glare from the apex windows, way beyond their reach, and currently they have no blinds or other mechanism by which to control it.

All photographs: Roderic Bunn

Auditorium 1.10 is the building's flagship space. The natural ventilation works well, with heat accumulating at high level and exhausting through two chimney stacks behind the screen. For auditorium 1.12, the heating coils set in the external wall (*inset*) are unable to raise the temperature of incoming air winter.

Energy consumption

In 1996, gas and electricity consumption was 143 kWh/m^2/y and 52 kWh/m^2/y respectively, a low energy performance that has not been sustained. In 2004, the energy figures were 176 kWh/m^2/y for gas and 87 kWh/m^2/y for electricity – close to the original EEO benchmark.

While the increase in electrical use may be a combination of high concentration of computers and the changes of use of the engineering wing, the relatively inefficient electric feature lighting in the main concourse has defaulted to on, despite very good daylighting. Lighting controls in many open plan areas and laboratories seem either non-existent or nonsensical in operation. In one lab, the fluorescent lights were on in the daylit perimeter, but off in the central area. A notable exception is the offices for the IESD where a daylight-linked dimming system has been installed.

The increase in gas consumption is largely attributable to problems with the heating system. Three major problems were resolved in 2005: re-zoning of the heating system so that demand for heat one area of the building doesn't bring on the heating in others, extra pipework to create new heating zones, and the replacement of seized two and three-port valves.

Occupant satisfaction survey

The BSRIA revisit to the Queens Building was conducted in early August 2006, and although this was ostensibly the holiday season, over 50 permanent members of staff were working in the building. An occupant survey was carried out by Building Use Studies. Forty five BUS questionnaires were completed, compared to 75 in 1996.

In general terms, satisfaction with temperature in both summer and winter is the same, although occupants perceive the air in winter to be better. Productivity has improved by around four percent, but the building still suffers a minus score as it did in 1996. Lighting and noise scores are better.

Levels of occupant satisfaction are very dependent on location. For example, the relatively high occupant satisfaction in the refurbished IESD offices is not matched by those occupying the new laboratories.

Conclusions

Does the building deserve its iconic status?

History records that the architecture of the Queens Building has ploughed a rather lonely design furrow. Given that so much of the building's ventilation and daylighting is determined by its bricks and mortar, the Queens Building is rather stuck in a time warp. It's difficult to improve or alter it, apart from changes to heating circuits and replacements of motors and actuators. Elements such as these are not fit-and-forget – they are critical to the building's operation, energy efficiency and occupant comfort.

The saving grace of the Queens Building is that its occupants seem willing to forgive the building's transgressions on comfort and lack of user control in the belief that they are working in a building worthy of being loved for its very idiosyncrasies.

BSRIA acknowledges the help of the Institute of Energy and Sustainable Development, and Adrian Leaman of Building Use Studies for use of the BUS occupant satisfaction survey.

THE PROBE PROJECT

Post-occupancy Review Of Buildings and their Engineering (PROBE) was a research project managed by *Building Services Journal*. Copies of the 1996 PROBE investigation can be downloaded from www.usablebuildings.co.uk.

PROJECT WHO'S WHO

Dr Malcom Cook, Reader in Building Ventilation with the Institute of Energy and Sustainable Development.

"The Queens Building suffers from noise and particulate matter that was not anticipated during design. The street alongside the lecture theatres was going to be pedestrianised, but in the event the local authority put in speed bumps, which creates noise and extra pollution, particularly from accelerating and decelerating buses."