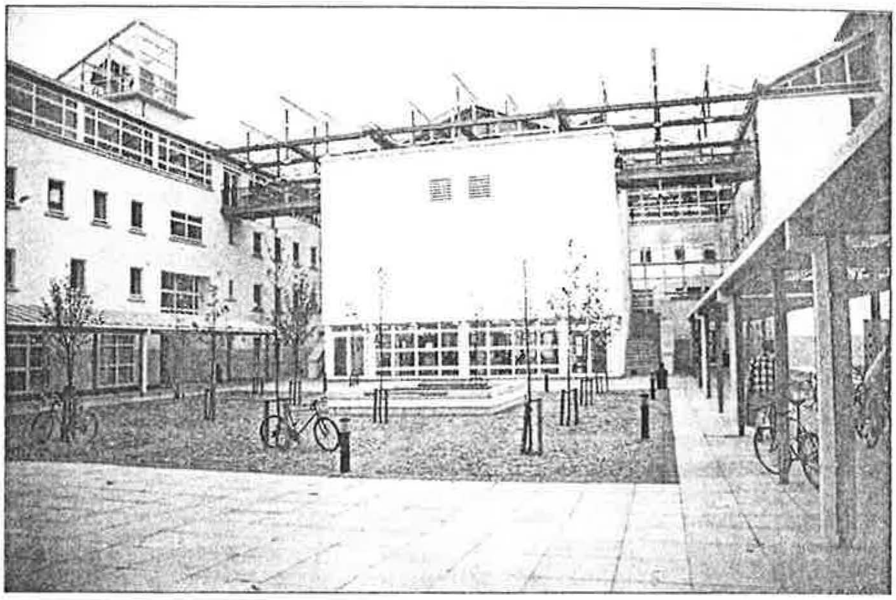
Hampshire County Council has a deservedly high reputation for imaginative, low energy educational buildings. In 1995, County Architect Sir Colin Stansfield-Smith worked his magic for Portsmouth University. Has the mixed-mode solution for the Portland Building done the trick?

BY THE PROBE TEAM



PHOTOGRAPHS: ROBERT GRESHOFF

PROBE 18: Portland Building

The Portland Building is the fifth educational building to be surveyed by the PROBE Team, and the last in the current PROBE series of building investigations.

Designed by Hampshire County Council, the Portland Building houses some 60 staff working in the University of Portsmouth's School of Architecture and the Department of Land and Construction Management. It also contains lecture and seminar rooms, a library/resource centre and other facilities for the Faculty of the Environment.

There are 870 students in the two departments. Along with those from other departments, some 1200-1300 students use the lecture theatres each day.

Together with an existing structure, the 6230 m² (6000 m² treated floor area) E-shaped building, which was completed in June 1996, forms a new pedestrian courtyard uniting the whole faculty. The Portland Building reportedly cost £940/m² (gfa), of which the building services accounted for 26%.

General layout and ventilation design

Full details of the Portland Building's architecture, engineering and space planning are described in the original article in *Building Services Journal*[1]. In brief, the Portland Building's designers employed several environmental systems and ventilation strategies designed to deliver comfortable conditions and be of didactic value to the students.

Externally, the building is a white-painted rendered fortress. Internally, it is light and bright, with white painted walls, windows and steelwork, complete with simple but good finishes. These include wooden flooring, ash-veneered doors with stainless steel ironmongery and laminated timber/steel structures supporting an insulated profiled steel roof. The atrium – called the Forum – is covered with aluminium-framed double-glazing.

The spine of the E-shaped building runs slightly east of north, and contains a three-storey library and resource centre. The central Forum is designed to encourage social interaction between occupants.

The north and south ends of the spine have 80-seater tiered lecture rooms on the ground floor and seminar rooms on upper floors. Each one has openable windows and dx recirculating comfort cooling units.

Five stair towers around the building's periphery act as natural ventilation air exhaust paths for the classrooms, studios and staff offices (with the exception of those on the top floor). Extract to the stairwells is via air transfer grilles located in the bulkheads. Extract rates can be boosted by radial fans in the stairwell turrets, the tops of which are fully glazed to emphasise the climate-responsive nature of the building.

Some of the vertical and sloping elements of this glazing are motorised open when natural ventilation is required. The winter air quality and air change rates of this system have been investigated by the BRE[2].

The in-board staff offices in the north and south wings have ducted mechanical air supply from plant in the glazed stairwell turrets, with outlets via openable windows and trickle vents to the Forum atrium. Surprisingly, no opportunity was taken to install rooflights in the pitched metal-clad roofs to support the (solely) single-sided natural ventilation for the large studios on the top floor.

The central arm of the E-shaped building contains a 200-seat lecture theatre with mechanical ventilation plant in two modules (including lphw heating and dx cooling).

A studio above this lecture theatre is used for project design reviews, while the ground floor beneath is home to a small refectory. This has vending machines for cold drinks and sandwiches, and a small servery for hot drinks (typically 100-150 per day) and microwaved snacks. As it uses disposable crockery and cutlery there is no dishwasher, but there is a small electric water heater.

In the centre of the building is the full-height 270 m² Forum, which has galleries on the west side giving access to the library and its associated administration areas. These galleries contain student computer workstations.

The Forum is ventilated through automatic rack-and-pinion rooflight outlets as well as chain-drive window inlets. Its glazed roofs project east to shelter the main entrances and the external plantroom, which serves the main lecture theatre. Toilets, complete with mechanical extract, are located on each floor near the stair towers.

Operational issues: heating and hot water

There are five separate plantrooms up cat ladders at the tops of the stair towers. Each contains two or three atmospheric gas-fired boilers, hws and solar preheat cylinders (in four of the five), a control panel and ductwork for the flue dilution, toilet extract and office supply systems. A further cat ladder and trapdoor leads to the glazed ventilation turrets above, which house cold water storage cisterns, mechanical ventilation inlets and outlets and 2 m^2 of flat plate solar panels for hws preheating. The plantrooms are cramped, with some pumps inaccessible for maintenance.

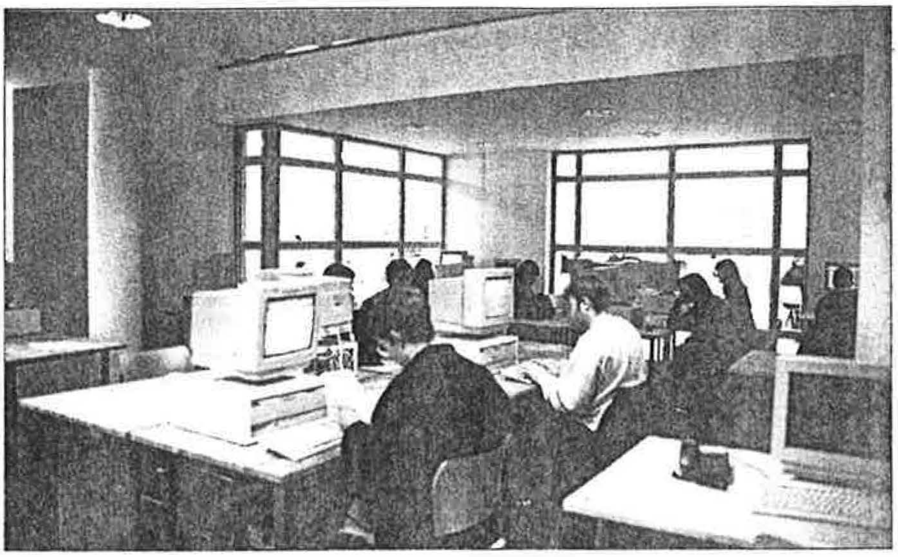
Twelve boilers in all have a total output of 740 kW, or 123 W/m^2. They supply constant temperature primary circuits for domestic-sized hws calorifiers, and compensated circuits for lphw heating. Teaching and common areas have underfloor heating, with plastic pipes in aluminium heat fins between timber battens above the concrete floor plate.

Over 20 sets of local recirculating pumps and mixing valves under local room temperature control circulate water at up to 58°C to the underfloor heating zones. Conventional radiators with thermostatic radiator valves are used in smaller spaces, lobbies, stairways and private offices. Although freely adjustable by occupants, the settings of those inspected were seldom extravagant.

Boiler and main lecture room plant is controlled by a building energy management system (bems) from the Estates Department some two miles away. In spite of this, the boiler plant and the associated fans and pumps cannot be reset centrally, so after a power failure maintenance staff have a laborious round of visits to each tower plantroom.

Heating operates from 07.30 h-21.00 h (weekdays only), with optimum start/stop and automatic cut-off at external temperatures over 18°C. The main lecture theatre plant runs typically from 08.00 h-18.00 h (again, weekdays only). The minimum 20% fresh air is increased as necessary to meet air quality sensor settings, or for free cooling.

The air handling units (ahus) operate in stages – ahu 2 only running if ahu 1 cannot maintain air quality. An (unlabelled) push-button on the rear gallery provides a two-hour run-on beyond bems schedules.



Despite glare from the artificial lighting, students' average perceived productivity at the Portland Building was very good. However, occupants tended to report that the building was "aesthetically appealing, but functionally poor".

The displacement floor diffusers under every lecture theatre seat caused initial complaints of cold draughts, so fan speeds were lowered to reduce supply air volumes. During PROBE visits the system was found to be unbalanced, with loud whistling as the extract fans sucked extra air through cracks around the doors. Occupants said this occurred only intermittently, so probably only one stage of supply is functioning.

Unfortunately, this could not be checked as the semi-external main lecture theatre plant has been adopted as a roost by pigeons, and maintenance access is now impossible for health reasons. Bird netting will be fitted soon and the area cleaned up.

CO_2 emissions and electricity consumption data

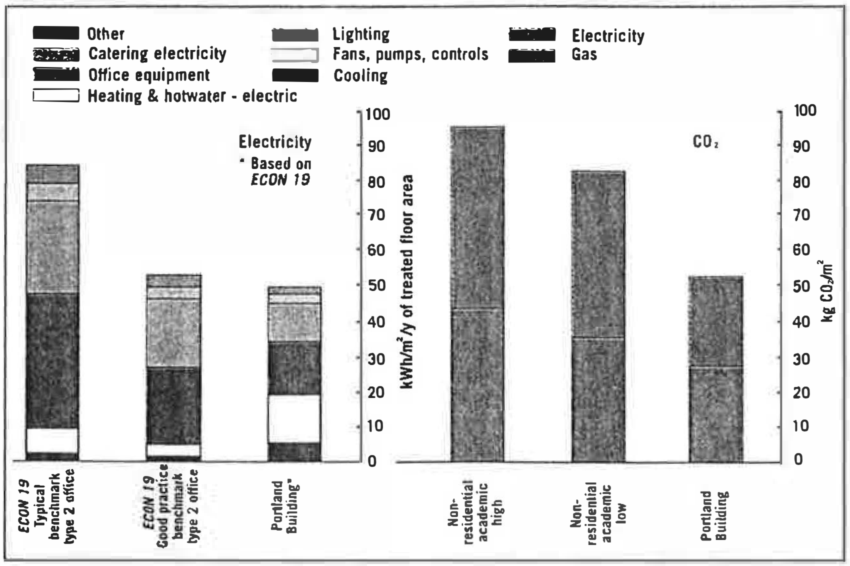


FIGURE 1: End-use energy breakdown at the Portland Building. The conversion factors are: gas – 0·2 kg CO_2/kWh and electricity – 0·52 kg CO_2/kWh. *Electricity use at the Portland Building was calculated from three weeks of monitoring of half-hourly data.

Initially all other systems (including natural ventilation, blinds and the underfloor heating zones) were locally controlled. The local controllers for the recirculating comfort cooling units serving the small lecture theatres and seminar rooms have been installed in services cupboards, which are kept locked. Hence all the systems run constantly at full speed at set-points of (typically) 24°C, with no interlocks to the heating.

Reliance upon natural ventilation in these rooms has also led to problems with air quality, particularly in the lecture rooms where the windows are behind security grilles and are normally blacked-out. Entrance doors were seen to be propped open during lectures to satisfy the need for ventilation.

Natural ventilation controls

Most windows are individually adjustable by occupants, and the gear has sufficient friction not to blow shut in the wind – a common problem. Safety-stays normally restrict window travel to about 100 mm, but where external motorised roller blinds are fitted on the south and west facades it had to be rapidly reduced to 70 mm to avoid collisions.

On the east facade, the levers which release the motorised lower windows from their chain drives were easy for students to undo, but difficult for maintenance to reconnect. Tamperproof guards have now been fitted. This pattern of connection has had similar problems on other sites, for example at the BRE's Environmental Building.

The original local controls for the motorised natural ventilation did not perform well, largely because a single temperature sensor did not give sufficient information. The Forum rooflights and window inlets which were in three independent zones have now been brought under unified bems control, and are opened in three steps as the average of five temperatures rises from 21°C to 24°C.

Thermostats at the top of the ventilation towers didn't work well because the stairwells are thermally massive and a long way from the occupied spaces. The bems now averages five room temperatures and opens the glazed vents at 23°C. This has reduced complaints of overheating, even though the volumes of air handled must be relatively small. If the temperature continues to rise then the booster fans start, but reportedly this seldom happens.

There is no interlock with the room heating. During a PROBE visit on a cold November day the vents in two towers were open.

Motorised windows

The original anemometers – which close the windows if winds are too high – were impossible to reach for maintenance. These were replaced by a single (bems-monitored) unit on the accessible flat roof of a nearby building. Similarly, a single illuminance sensor now controls the roller blinds in the Forum.

There have been several other difficulties with the Forum's rooflights. On occasions they have stuck open, and a special cherry picker has had to be used to reach them. Motors have also been failing. The Estates Department thinks they may be over-stressed and that pneumatic actuators might have worked better.

Time lags in rain detection and actuator response mean that rooflights can take two minutes to close. In a downpour, this can let in a lot of water. Bird droppings on the rain sensor have also sometimes prevented the windows from opening.

As a result of such difficulties the estates officer has forbidden adjustment by occupants, and intends to put a cover over the override panel in reception saying: "Emergency Use Only".

In the three-storey resource centre, the high-level windows have manual override switches in the library office. In practice the windows respond, but one minute later they automatically revert to their previous state. As a result, the switches now languish behind books on a shelf, and the space can get hot.

Contrary to the intent of central control with local override, central control is actually overriding local preferences. Future bems connection of window and blind controls is planned here, when it is hoped the user overrides will also be brought into effective use.

Daylight and solar shading

The Forum provides a very pleasant daylit heart for the building, and daylight provision to the north and south wings is also good. Unfortunately the glazed turrets do not illuminate the stair towers.

Shading devices include fixed external louvres on the south elevation, external translucent motorised roller blinds on the south and west, internal motorised roller blinds in the Forum roof and manually-operated internal blinds in some other rooms.

Users were intended to be able to override the automated blinds to meet preferences, but in practice the automation dominates. For example, the external roller blinds have limited ability for manual override, as the controller deems wind speeds above 3 m/s to be too risky for them to be left down. Many never seem to respond to their local switches.

Electric lighting

Most rooms have high frequency fluorescent luminaires. Typical installed loads are 11 W/m^2, while average illuminance levels are 350 lux. This gives an efficient 3·1 W/m^2/100 lux.

In tune with the desire to provide environmental variety, fittings are quite widely spaced and therefore the lighting is not very uniform, but few people commented adversely on this. The top floor studios have fluorescent uplighters with a high installed load of 34 W/m^2, contributing to the reported overheating of these spaces. Circulation areas are lit by compact fluorescent light sources.

Local light switches are provided for small rooms, while the larger spaces have one or two switches per structural grid. It is not always clear what each switch does. Most rooms used by students have occupancy sensors in series with the manual switches. If a switch is off, the lights remain off. If it is on, the lights come on if anyone enters the room and go off some five minutes after they leave.

The three lecture rooms also have push-button dimming with pre-set levels, plus occupancy sensors and a master switch at the door. Some lecturers have found these controls (and those for the audio-visual system) difficult to use. The larger seminar rooms also include simple dimming systems with rotary wall switches. However, it was not immediately apparent what these did and many seemed to have failed.

Local control has led to quite a haphazard use of lighting. During the PROBE Team visits, some people were working with very little light, while other lights were on unnecessarily in bright daylight. Nevertheless, the combination of good daylight, local control, occupancy sensing and dimming means that, on average, only about half the lights are on during the occupied period. Metering suggests that on bright mornings many lights never get switched on at all, and that many then stay off – even after dusk.

Maintenance issues

The Estates Department had relatively little involvement until the building was handed over. As in other PROBE investigations, senior management at universities seem to think that new buildings should look after themselves, so little resources have been available for understanding and fine-tuning systems.

DESIGNERS' RESPONSE TO THE FEEDBACK STUDY

The design philosophy at the Portland Building was to provide an environment in which the end-user/occupier could exercise a good degree of control over their space, while allowing maximum flexibility in use, *write Stephen Hall and Brian Bland.*

The results of the PROBE study show the value of allowing sufficient time and financial resources to correctly commission all of the building services systems prior to the client taking over the building – and then being able to close the learning loop by modifying and fine-tuning those systems based on feedback from the end-users.

Given that the users have control over their space temperature, it is encouraging to find that energy use at the Portland Building is low. However, it is disappointing to learn that the control of the ventilators had still not been fully resolved at the time of the PROBE Team visit.

Perhaps a simpler system of blind and ventilator control could have been adopted, allowing better use of these systems by the occupants of the spaces. However, automated control would still be required for the shared/communal areas.

Further work is needed in order to get the best results from the building energy management system, and refine the control of the building and its services in order to further reduce energy use while improving the internal environment for end-users.

An interesting point for electrical engineers is that the incorporation of an underfloor heating system with an exposed concrete ceiling for thermal mass limited the options for designing a flexible and accessible power and data distribution system.

The solution of underfloor services outlets on a nominal 2 m square grid was initially considered to be rather generous. However, it is interesting to note that feedback from the PROBE Team visit has revealed difficulties where, subsequently, a high density of computers has occurred within a localised area.

It is very encouraging to discover that the use of local occupancy detectors and daylight linking on a room-by-room basis has largely proven to be successful in reducing lighting energy consumption.

The study has highlighted difficulties for the end-user when local retractive switches operate in conjunction with occupancy detectors, particularly in the larger open-plan spaces. Perhaps in hindsight a visual indication at the switch position to note 'lights on' could well have eliminated some confusion when an occupancy sensor is combined with a lighting scheme employing specular louvre luminaires.

Stephen Hall CEng MCIBSE (mechanical engineer) and Brian Bland AMIEE (electrical engineer) are with Hampshire County Council.

Some items – including the external blinds and opening roof vents – have service contracts with the suppliers, which have proved expensive and have meant that the Estates Department team has limited understanding of their operation.

Since occupation the major changes have been a general increase in the use of computers, leading to occupancy and equipment densities and heat gain and ventilation requirements beyond design expectations in some rooms. Shortcomings have also been revealed in the number of power and data outlets, with limited access to underfloor cable distribution exacerbated by the underfloor heating.

Flush wall sockets have been provided for cleaner's use except on the third floor, where separate floor sockets were installed. However, if the covers are not carefully replaced they become a trip hazard.

Although the building requires relatively little attention a number of features have complicated maintenance, in particular access to lights, window actuators and smoke detectors in the Forum roof. The relatively cramped plantrooms are at the top of cat ladders, and fixed but fragile panels cover many of the underfloor heating manifolds and circulation pumps.

Energy consumption: gas

The most relevant available benchmark for the Portland Building is a 'Type 2' naturally-ventilated open-plan office[3].

In the year to July 1998, gas consumption for space heating and hot water was 100 kWh/m² of treated floor area (130 kWh/m²/y when normalised to the standard 2462 degree days). This is well inside the design target of 165 kWh/m²/y (gfa) and *ECON 19's* 'typical' benchmark of 151 kWh/m²/y. It is also similar to comparable PROBE-investigated buildings including John Cabot City Technology College and the Queens Building at De Montfort University, but higher than the Learning Resource Centre at Anglia Polytechnic University (97 kWh/m²).

Reasons for consumption above *ECON 19's* 'good practice' benchmark of 79 kWh/m² include air infiltration and, according to the occupant survey, possibly warmer than necessary wintertime temperatures. High occupancy densities in teaching rooms will also require more natural and mechanical ventilation than in an *ECON 19* Type 2 office. The lack of condensing boilers and any fine tuning would also contribute to higher consumption.

Energy consumption: electricity

Until the PROBE study it had not been realised that the building's check meter was in error. The current estimate of 50 kWh/m²/y has therefore been based on only a few weeks of half-hourly metering.

The figure is comparable with the APU building (48 kWh/m²) and somewhat better than the 'Type 2' good practice value of 54 kWh/m². In comparison, John Cabot City Technology College consumes 58 kWh/m², and the Queens Building 60 kWh/m². If the actual consumption in a year's time is significantly different, we will report it.

The estimated breakdown into end uses is again based on sparse data. Heating and hot water comes in at 0·5 kWh/m² as only a few handbasins in the studio areas and the café have electric water heaters. None of these operate under time control.

Catering electricity use is estimated at 3 kWh/m². This is mainly for the café and compares well with a good practice figure for a 'Type 2' office. Cooling is estimated at 5 kWh/m², which covers the dx cooling of the lecture theatres and the four seminar rooms. It is high because six units have no controls and run constantly.

Fans, pumps and controls account for 14 kWh/m². Half of this is fans, again notably the six dx units which run constantly at high speed. Pump energy consumption is also higher than usual owing to the large number of small circulation pumps associated with five plantrooms and over 20 underfloor heating circuits.

The relatively low illuminance levels, high lamp efficacy, small zone size of lighting circuits and simple occupancy-responsive control gives a lighting consumption of 14 kWh/m². This is two-thirds of the good practice benchmark and similar to that at APU and John Cabot CTC.

The designers say that cost constraints prevented high-frequency ballasts (used in the larger studios) from being used on the compact fluorescent uplighters on the third floor. Daylight-linking and absence detectors could reduce energy consumption.

The relatively low figure of 11 kWh/m² for office equipment is again similar to comparable academic buildings and a consequence of lower overall densities (5 W/m²). The remainder (1·5 kWh/m²) includes external lighting and telecommunications. It is less than half the benchmark figure, partly owing to less provision than in office buildings.

The occupant survey

Questionnaires were completed by 46 staff with permanent workstations. On average they rate the building well as an all-rounder, coming just within the top 20% of the reference dataset, though people (particularly the archi-

Results from the occupant satisfaction survey

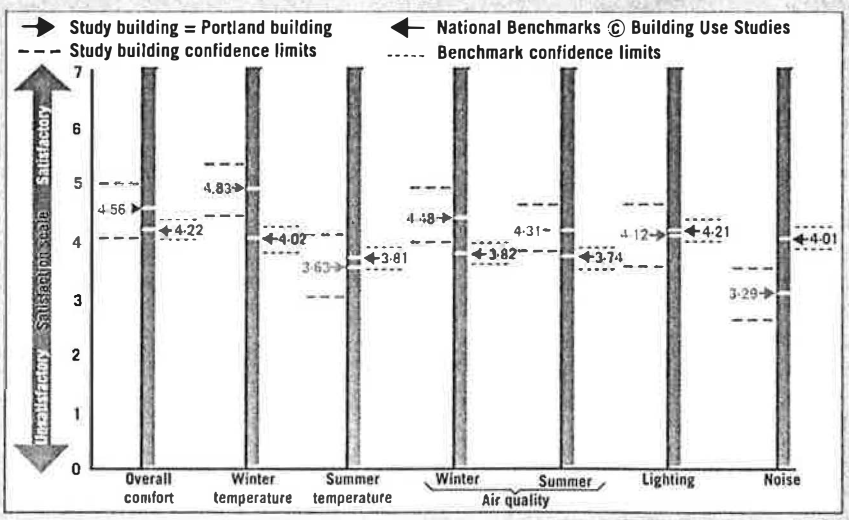


FIGURE 2: Overall satisfaction with comfort conditions at the Portland Building.

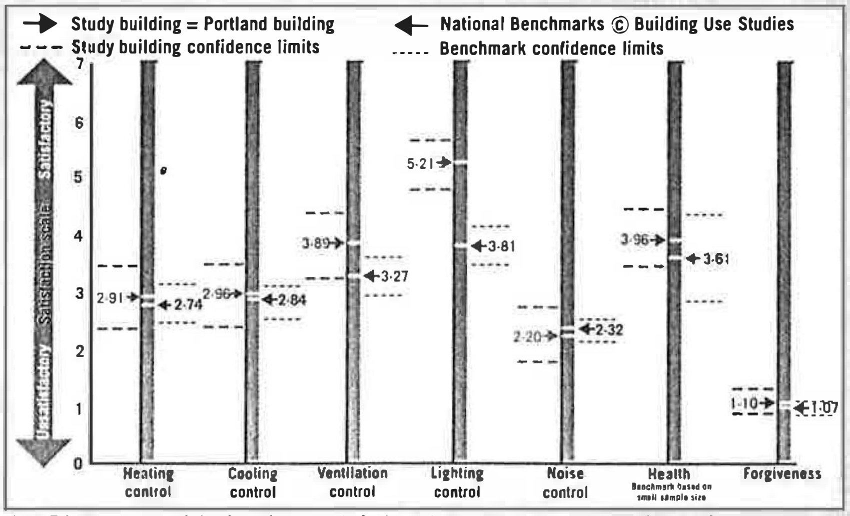


FIGURE 3: Occupant satisfaction with the building's health, management and control strategies.

tectural staff) were happier with the aesthetics than with comfort or functionality.

For individual variables, the most notable were good overall wintertime comfort, even though the building was judged to be hotter, stiller and stuffier than average. Summer comfort was judged average overall, but with a wide range of response and significantly hot.

The building has good perceived air quality, in both winter and summer, but with local problems. It is also significantly noisier than average. The Portland Building aids perceived productivity, with a 4% increase on average. However, complaint levels were higher than "best in class" reference buildings, but not excessively so.

The 210 students completed a shorter questionnaire, and rated the building higher than the staff for nearly all variables. This is not unusual: peripatetic occupiers tend to be more inspired by general ambience and more forgiving of any shortcomings than those who occupy buildings more permanently. The students' average perceived productivity increase (13·8%) was very good indeed.

However, most staff and student responses (including productivity) were much more widely distributed about the average than in most buildings surveyed – some were absolutely delighted and others much less happy. This is not surprising given both the diversity of architectural experience in the building and the variety of environmental control systems, not all of which are yet working optimally.

Overall perceptions of lighting were not significantly different from the UK benchmarks: disappointing in view of the naturally-lit ambience, but possibly the consequence of insufficiently-controlled glare. Although relatively low and controllable, artificial illuminance levels were still regarded as too high, but better than two thirds of those buildings in the UK dataset.

Poor perceptions of noise included banging doors, hard surfaces, booming raised floors in corridors adjacent to offices and seminar rooms and reverberation in the atrium. Some people also mentioned exterior street noise and fumes.

Perceived control over heating, cooling and noise was low, but similar to UK benchmarks. Control over ventilation was somewhat better. Control over lighting was very much better than average, confirming the value of the local switches (despite usability problems).

The building was deemed healthier than average. Surprisingly, in view of the imaginative design, staff rated the building design only slightly better than average, and its effectiveness in meeting their needs only just above the lower quartile.

Adverse comments about needs often appeared to focus on staff offices not being large enough to hold tutorials, together with a more widespread lack of storage space." Aesthetically appealing, functionally poor" was a typical comment. Students were more positive.

Overall building performance

The Portland Building is enjoyed by most of the staff, and by students across the Univer-

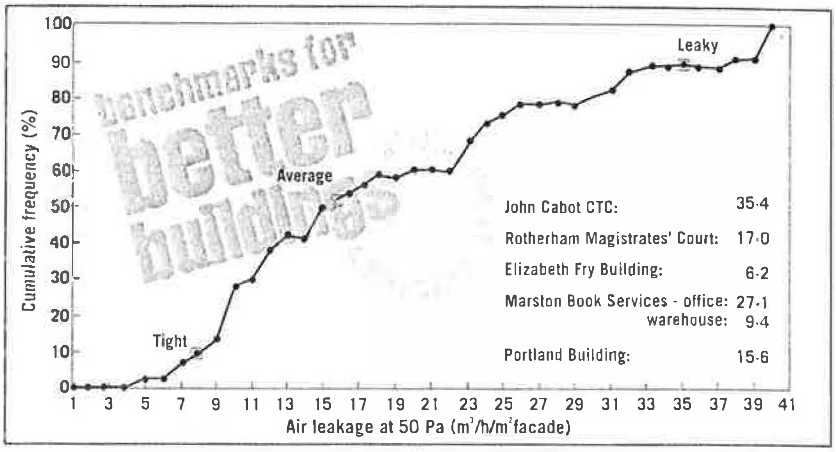
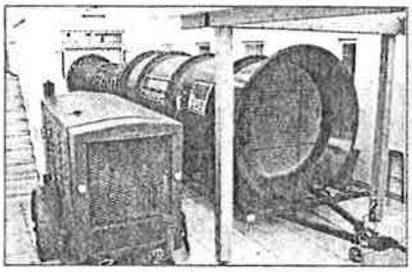


FIGURE 4: The air leakage data for the Portland Building, plotted on the BRE/BSRIA database.

BRE pressure test



PHOTOGRAPH: BRIAN WEBB

The Portland Building was subjected to an air leakage test on 7 November 1998. The test was conducted by the BRE's Brian Webb and Alan Clarke using BREFAN, BRE's large fan pressurisation system.

Prior to the test all the mechanical ventilation systems serving the lecture theatres, offices and toilets were sealed with polythene sheet and/or masking tape. All accessible windows and trickle ventilators were also sealed.

As two windows were stuck open in one of the turrets serving a stairwell, its two transfer grilles were also sealed. Each plantroom door was also sealed.

The BREFAN test rig was connected to the double doors leading to the Forum. A normal fan pressurisation strategy was initially adopted, consisting of running the fan at maximum speed (or at a differential pressure of 70 Pa), and taking a series of ten measurements of the building pressure differential and air volume flow rate through the fan. However, at a relatively high pressure (58 Pa) there was a sudden loss of pressure, indicating that something in the building had opened.

A different strategy was then adopted, involving taking readings at low pressure and increasing the fan speed gradually to obtain higher pressure differential readings. In the time available it was not possible to investigate what component was causing the problem. It may be that one or more automatic windows were being forced open by the pressure.

After the pressure test, the BREFAN was operated in reverse to depressurise the building. Smoke tubes were used to identify air leakage paths where air entered through the building envelope.

The air leakage index (or Q-value) for the Portland Building was calculated to be 15·6 $m^3/h/m^2$ of envelope area at a reference pressure of 50 Pa. This indicates that the building performs about average on the joint BRE/BSRIA database (figure 4). In the BRE's opinion, a tight non-domestic building would have a Q-value of 7·5 of envelope area at a pressure differential of 50 Pa. A leaky building on the BRE/BSRIA database would exhibit a Q-value of 34.

The air leakage audit showed that the roof/wall junctions on the third floor were very leaky. The junctions between the RSJs and timber beams were also found to be very leaky, with large gaps visible. Air was detected coming from the ventilation towers, indicating that these structures were not airtight.

The windows were found to be generally quite good, with minimal air leakage through them. However, there was significant air leakage around the south-facing timber bay windows, especially along the floor joint. The stairwell windows were also found to be slightly leaky at the frame wall junction.

All of the external doors had significant air leakage through them. The fire doors on the ground floor in the small lecture theatre leaked badly, both at the bottom and along the right-hand sides.

The double fire door at the bottom of the stairwell leaked very badly along the bottom and between the doors. The doors in the student common room also leaked down the middle. Significant air leakage was evident in all other external doors.

Brian Webb is a senior scientist with the Building Performance Assessment Centre at the Building Research Establishment. This pressure test was funded by the DETR as part of the BRE/BSRIA/ *Building Services Journal* initiative on improving building airtightness.

sity. Consequently, lecture and seminar room usage has exceeded design values and some facilities have been overstretched, in particular toilet provision. The use of widely-scattered unisex toilets has been unpopular and has exacerbated this situation. Additional central toilets would have been preferred.

The combinations of manual and automated control have created various conflicts. Despite good intentions, usability is disappointing and intentions sometimes not clear, even to teaching staff familiar with passive design.

For automation of windows and blinds, it appears difficult for local control units to make the choices required to implement even a relatively simple strategy – and there has been a tendency of both the automated systems and perhaps also the Estates Department to usurp control from the occupants.

The thought persists that some of these problems might have been better resolved had the client and the design team "gone the extra mile" on usability aspects, with more attention given both to the details of automatic controls and their integration with effective user overrides. That said, usability problems are endemic in the industry. Effective solutions – although relatively simple in principle – are elusive in practice, requiring disproportionately high levels of effort.

Energy consumption is relatively low at the Portland Building, and generally comparable with the best of recent university buildings. However, measures such as condensing boilers (a strange omission, particularly given the underfloor heating and solar panels) and better controls could have reduced it further.

Nevertheless, the current energy and environmental performance is creditable in view of the problems identified, and given the fact that, to date, energy management has been non-existent.

This underlines the robustness of the Portland Building's design. In common with most clients, university authorities need to recognise that new buildings – even largely passive low energy buildings – should not be left to run themselves, and can benefit greatly from fine-tuning.

The PROBE Team for the Portland Building study comprised Mark Standeven, Bill Bordass, Adrian Leaman and Robert Cohen.

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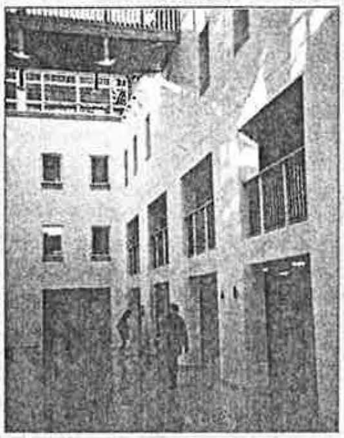
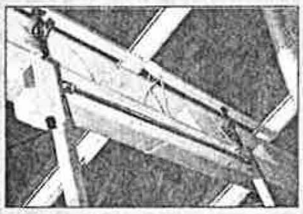
Key design lessons

The Forum is an exciting and uplifting space despite the constraints of the University budget. Together with the external courtyard, the Forum gives identity not only to the building but to the whole faculty. However, lighting, actuators and smoke detectors at high level in the space could have been made more accessible. Retrofitted bems control has improved operation of the motorised windows and rooflights.

The integration of **manual and automated controls** has once again proved more complicated than it looks. Signals from these override switches for the roof ventilators in the resource centre were countermanded by the automatic system a minute later. They have thus fallen into disuse, and the space is often less comfortable than it could have been.





ABOVE: The Forum. A welcome circulation space, albeit with dysfunctional rooflight actuators (LEFT) and some reported noise problems.

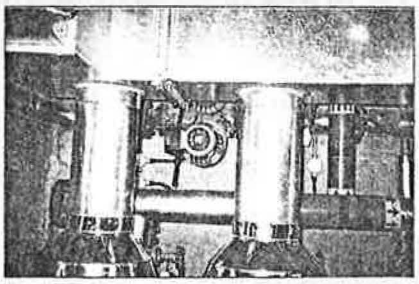
PHOTOGRAPHS: BILL BORDASS

The electric rack-and-pinion window drives are elegantly compact, but reliability has been disappointing – a particular problem owing to their inaccessibility and the amount of rain they can let in. A Government-sponsored project is studying the specification and performance of window control devices.

ABOVE: The turret plantrooms. Attractive, but difficult to access and not airtight.

Although **recirculating comfort cooling systems** have been installed to serve the lecture and seminar rooms, it was assumed that ventilation would be through the window. Blackout, noise and security of the ground floor windows has made this impossible. The doors have to be propped open instead.

Wall-mounted uplighters can create a need for hard hats. Installed in the third floor studios, the uplighting has three times the installed power density of the downlighting on the building's lower floors, contributing to overheating. If designers were to use benchmarks for installed power density more widely, they might have selected different units.



ABOVE: So often a sacrifice on the high altar of 'architecture', cramped plantrooms can create a maintenance headache for the end user.

LEFT: Wall-mounted uplighters should not be a health hazard.