The Centre for Mathematical Sciences

Projects with recurring design elements can provide a rare opportunity for architects and engineers to apply the lessons learned from early buildings to those constructed later.

The multi-building Centre for Mathematical Sciences (CMS) in Cambridge offered such an opportunity for the PROBE team, Edward Cullinan Architects, services consultant Roger Preston & Partners and, of course, the client, to identify the virtues and shortcomings in the design concepts and to apply the experience gained to elements of the project still in design or under construction.

This PROBE report is somewhat of a hybrid, being neither an investigation of the long-term operation of a building (in which the conditions and modes of operation are allowed to stabilise over at least two years), nor a handover intervention study. Readers should bear this in mind, particularly when reading the conclusions.

Details of the scheme were featured in the October 2000 issue of Building Services Journal, which readers should refer to for the history of the project and more details on the engineering.

Project history
The project came about from Cambridge University’s pressing need to rehouse the increasingly congested Faculty of Mathematics, together with a generous endowment. The resulting CMS pulls together several departments on a greenfield site less than one mile from the centre of Cambridge. With the site surrounded by houses, there were understandable restrictions on the development’s height and its visibility at night.

The complete development includes a gatehouse, a library, and central building (Pavilion A), surrounded by six pavilions (C to H) and a further double pavilion (I) at the west end. Construction is in three phases: phase 1, Pavilions A, B, C and D was completed in 2000-01, phase 1A – Pavilion E, the gatehouse and library in 2002. Phase 2 – F, G and H – is due to complete in spring 2003.

One thousand undergraduate and postgraduate students study in the CMS – undergraduates in term time only, post-graduates year round. Staff number 150 in Pavilion B.

Core occupancy is Monday to Friday between 09.00 h to 18.00 h, plus term-time lectures on Saturdays between 09.00 h and 13.00 h. The buildings are available for use 24 h/day, but usually only one or two people are in Pavilion B after midnight. Cleaning takes place between 05.00 h to 13.30 h.

The PROBE survey covered Phase 1 and included an occupant survey (concentrating on Pavilion B – the earliest one to be occupied) and a pressure test on Pavilion D (the last building in Phase 1 to be completed).

Pavilion D is connected to the central block at two levels: the basement and the ground floor, where the link is through a common room. Each single pavilion has a lift shaft in the centre.
surrounded by a spiral stair and circular corridor serving staff rooms around the perimeter. Cellular offices predominate, except in the base- ment, which has plant, lecture, meeting and computer rooms. Pavilion B is a symmetric, coursed limestone beam with two central cores and large spaces at the joint. Pavilions B to H are constructed of brick and stone outer leaves, with automatic and manual- ly controlled windows and ventilation openings under zinc-clad pitched roofs. Air is exhausted at high level in various ways (see figure 1)

- in the basement and the ground floor, via high-level motorised ventilators, with automatic and manual control.
- on the first floor, via ‘periscope’ ventilators to ensure at least 0.5 m3/s/m of the floor area.
- on the second floor, via motorised ventilators.

Some of the deeper rooms also have high-level mechanical extractors from fitted steel waterproofed dampers to louvres around the perimeter of a central glazed lantern.

Basics of the building services design

The design was driven by the short, low energy agenda, informed by the first series of PROBE reports with which the design team were familiar. The client was also averse to sealed, air conditioned work spaces, preferring instead Bio-climate spaces with operable windows for their highly cerebral occupants.

The computer and meeting rooms have chilled beams for cooling and background mechanical ventilation (dehumidification where necessary to avoid condensation) The larger lecture rooms have more conventional air systems.

The design team considered various passive and active strategies, finding that a high level of control was necessary to enable the building to achieve its potential.

The four-strong facilities management team beyond practical completion would help to reduce the tensions and frustrations which often arise when users move into and work in new buildings. This would create ‘soft landings’ — as Mark Ray of the multi-skilled designers ABRP Ltd says.

Right has already undertaken some of the following activities at Cambridge and for other clients:
- discussions with an owner, to help them understand the complexities and limitations of the design.
- frequent presence on site during the first few months of occupation.
- participation in meetings of the relevant user groups.
- assessing the building’s performance. The EEMS is now considering taking these into contractual requirements — possibly linked to a system of rewards and penalties for delivery of predicted use performance. Clearly it’s a contentious issue, but familiar to those involved in PFI.

To explore the options, the EEMS, the University Estates Department and a group of the University’s consultants has put together a research project to simulate soft landings contracts. The research (group led by Mark Ray) is about to begin a pilot investigation. For more information, contact EEMS project manager, Colin Saunders via cs294@cam.ac.uk

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Soft landings

Cambridge University is a major client, with some £500 m-worth of projects in the pipeline. Although its Estate Management & Building Service (EEMS) is a repeat client, its intended involvement is more limited.

David Adamson, Director of EEMS thinks that the design and buildings management team beyond practical completion would help to reduce the tensions and frustrations which often arise when users move into and work in new buildings: this would create ‘soft landings’ — as Mark Ray of the multi-skilled designers ABRP Ltd says.

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PROBE

Pavilion B is a typical corner cellular office.

Although manual override is possible. Each 49

beam should the need arise.

Termodeck, which the architects had used

before. However, Termodeck was not well suited

to the first floor to be extracted

under zinc-clad pitched roofs. Air is exhausted

ly controlled windows and ventilation openings

stone outer leaves, with automatic and manual-

air dumping, air infiltration and rain penetra-

air handling units for

ment, which has plant, lecture, meeting and

The occupants believe that the building boosts

comfort overall and needs.

Not only do lift shafts run up their centres,

anyway. Spot measurements by the PROBE

are paid about 2 W/m² per 100 lux, a 30% reduction on

The bms initiates night ventilation in accor-

conditioned work spaces, preferring instead

the second floor offices, owing to the

the fast response of conditions to these controls.

Managing the building is a good all-rounder. The

responsives are in the top decile for overall comfort

Lighting has not yet been implemented. As a

Billings have not yet been implemented. As a

are as lanterns – architectural features at the pin-

ier plant to be held off.

hence the advanced natural ventilation system can there-

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condensation) The larger lecture rooms have more conven-
tional air systems.

The design team considered various passive and active strategies, finding that a high level of control was necessary to enable the building to achieve its potential.

The design team prepared a one-page user

guide, which includes a user requirements form and a

manager, Colin Saunders via cs294@cam.ac.uk

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Although users are requested to switch off their computers on, as to switch them off activates a network information. Manufacturers’ manuals and literature which occupants need to know) and the collection of information between the user guide (which describes what is contained in the manual windows anyway) although achieving ‘insect free’ ventilation is a fine balancing act. The air leakage index (at a reference pressure of 50 Pa) for the all buildings studied by the PROBE team, in their study buildings at the Centre for Mathematical Sciences, and some older buildings. The air leakage index (at a reference pressure of 50 Pa) for the Centre for Mathematical Sciences (Pavilion D). The planar glazing on the first floor above the entrance from the circular corridor. These-window detail, the window is set well aside from the outside doors. Second, bms-controlled motorised windows and vents, and particularly at its junction to the brickwork and at its sill. Second, bms-controlled motorised windows and vents, and particularly at its junction to the brickwork and at its sill. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. The window detail, the window is set well aside from the outside doors. Second, bms-controlled motorised windows and vents, and particularly at its junction to the brickwork and at its sill. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board. Air also leaked through the perforated steel panels and frame, and underneath the sill board.
key design lessons

1. The advanced natural ventilation strategy comprising solar shading, exposed thermal mass, single-sided buoyancy-assisted natural ventilation plus largely secure automatic night ventilation has proved fundamentally sound, as reflected in the occupant survey scores for overall comfort. The manual override on the ventilation is fine in principle but in practice the time taken to drive the windows to new positions has proved troublesome.

2. The occupant survey scores for summertime comfort are relatively good, particularly given that occupants are effectively working in a construction site which may inhibit the opening of windows (note the pole used to operate the catch). Occupants are likely to forgive high temperatures because they have access to controls, plenty of adaptive opportunity, and largely prefer this building to their previous accommodation.

3. Daylighting is said by the occupants to be about right, though with some glare. Sadly, while the lanterns at the pinnacle of each building are a strong architectural expression of low energy design, in practice they contribute little useful daylight to the spaces below. The ventilation ductwork and lifts block out much of the light. The towers also contribute less to ventilation than had been hoped.

4. Energy management is a cause for concern, largely because the building and energy management responsibilities are split. This is typical for most universities, but here the situation is doubly complicated as the site accommodates several departments with shared facilities. Sub-meters are not yet activated.

5. The lighting controls system is in line with PROBE best practice thinking: manual switches with absence detection and photocell dimming. However, the system is suffering teething problems, particularly the pir detectors, which are not set in the best positions to detect the movements of all occupants. Furthermore, the photocell-linked dimming in offices has been omitted from Phase 2 as the client was not convinced of the system’s cost-effectiveness or its value. That said, the occupant survey found that the office lighting controls are well liked. However, control of lighting in circulation areas could be further improved.

6. At 9-12 W/m², the installed lighting power densities are well within the good practice target of 12 W/m². However, the electric light levels of 550 lux exceed the more typical requirement of 350 lux, which means that full advantage is not being taken of the inherent efficiency of the T5 lamps, which could produce the required illuminance with as little as 7 W/m² of installed power. The provision of dimming means it is still possible to control down to 350 lux, but the variety of office shapes and sizes means that lighting loads and light levels vary significantly from one space to another.

Design team response

We are strong supporters of the PROBE programme and the lessons it can provide us with, we are currently working with the University and the PROBE team to try to get the maximum benefit from the study. As stated, the multi-disciplined nature of most university clients make for complex briefing and complex accounting of energy used. At a time of great change in the industry there are three areas that stand out:

- The transformation of the traditional caretaker into a computer-literate building facilities manager with the not-inconsiderable need to manage strong-willed academics. In this case 600 of the brightest mathematicians. It is important that these new professionals become part of the briefing team at the early stages of a project.
- Environmental engineers are also changing as customised control systems grow in complexity, especially in advanced naturally ventilated buildings and as the industry tries to integrate design and assembly/construction. Conventional contracts that aim to hand over a fully functional building on a set day are becoming less and less workable and we are supporting the university in their 'Soft landing' project that recognises the need for the design team to stay engaged for a significant period after the so-called practical completion. (The University does not regard the 'Soft landing' initiative as an opportunity to hand over incomplete buildings which are troublesome to users. Far from it. The aim is to achieve a high level of completeness and functionality at practical completion, with 'Soft landings' offering a relatively short-term opportunity for fine tuning and detailed introduction to the users.)
- We also require more advanced testing of specific elements such as the lantern to try and maximise the natural ventilation and daylighting components of such designs. These elements are often complex assemblies both in terms of coordination and construction, and their effectiveness needs to be carefully monitored at all stages of a scheme.

Our experience in this and other recent projects shows there is very little understanding of measured air-tightness and that whatever case we take in the detail design, a whole other level of understanding and skill in construction is needed if we are to meet the stringent requirements of the new Building Regulations.