The proof of the building

Outstanding buildings are lauded in the design press when they're built. They reappear when they win awards, then the spotlight goes on to the next new thing. But what's it like to live and work in the buildings? Do they perform as intended? Victoria University researcher Christopher Kendall has surveyed Canterbury University's Mathemetics and Statistics and Computer Science building after four years of occupation to find out, in an EECA-funded study.

Christopher Kendall carried out a post-occupancy evaluation study of the University of Canterbury's Mathematics and Statistics and Computer Science (MSCS) building as a Bachelor of Building Science (Hons) project at the Centre for Building Performance Research, School of Architecture, Victoria University of Wellington. He was supervised by Dr George Baird.

This article is based on their paper submitted to the CIBSE National Conference to be held on 18 June 2002 in London.

The Mathematics and Statistics and Computer Science (MSCS) building at the University of Canterbury, Christchurch (*Energy-Wise News* 59, Sept-Nov 1998), was designed for use of natural ventilation, through the stack effect; passive solar temperature control; and daylighting, using techniques new to New Zealand.

After four years of occupation, the people using the building rate it highly on features such as lighting, comfort, temperature, air quality and noise.

It consumes 143 kWh/m^2 annually, which comfortably comes in under the new target value of 150 kWh/m^2 in the National Energy Efficiency and Conservation Strategy.

This is despite the large number of computers in continuous operation.

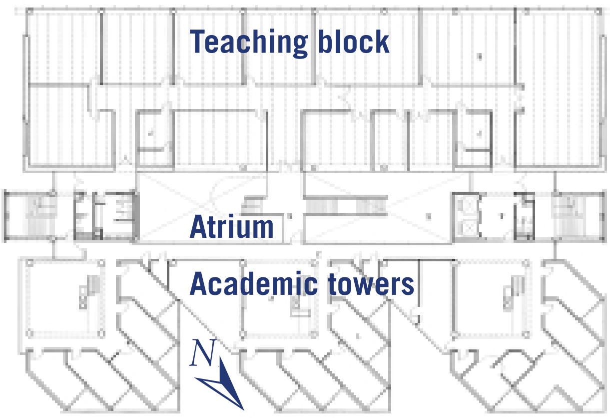
Temperature monitoring in summer and winter shows the building provides comfortable conditions – relatively stable in all seasons, but able to respond to individual requirements.

A questionnaire of the users shows overwhelming evidence of their satisfaction with the building's environment.

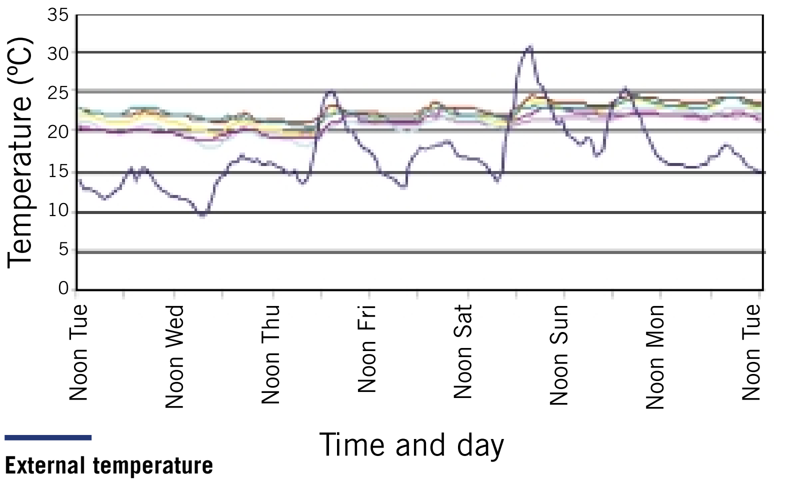
Design process

The university did not want a high energy consuming building.

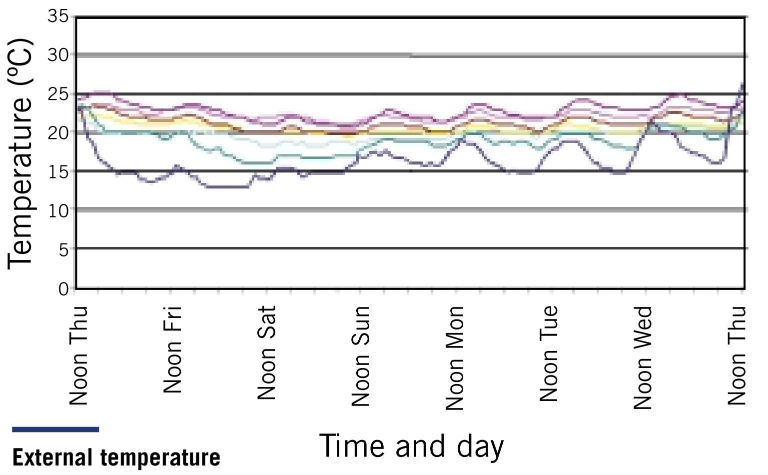
Architectus CHS Royal Associates won the competition to design it. Principal architect Patrick Clifford nominated Dave Fullbrook, from Ove Arup and Partners, to carry out the environmental/services design, based on the firm's international reputation for successful passive ventilation projects. Fullbrook was based in Bristol and initially worked from



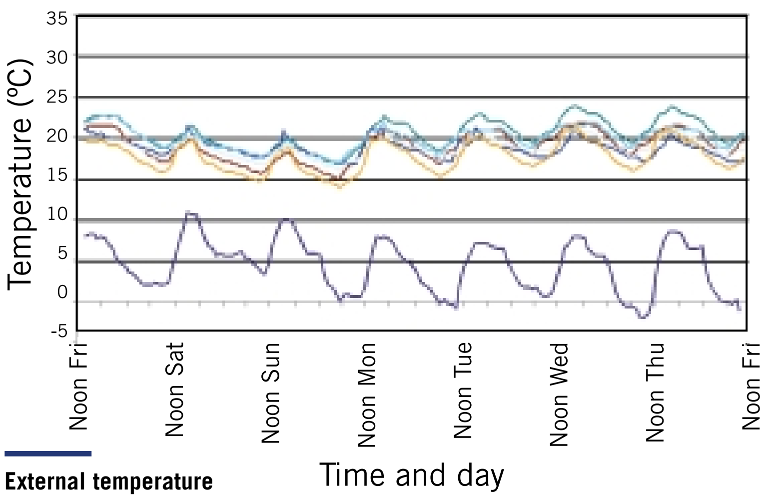
Room temperatures from 6-12 February 2001



Room temperatures from 7-14 December 2000



Room temperatures from 29 June-6 July 2001



The graphs show the temperatures of the academic offices and the outside air in summer (December and February) and winter (June-July). The conditions were at a level that most occupants would consider comfortable. Occupants are able to control conditions by adjusting door louvres, various types of windows, heaters and external shading.

Post Occupancy Evaluation

Post Occupancy Evaluation provides an indication of major successes and failures in a building's performance. It can be used to improve and explain the performance of a building. It is useful not only to the occupants and owners but also to the designers, who can learn about both their mistakes and successes and can apply these findings to future projects.

Showcase building

Christopher Kendall's study is designed to showcase the results that can be achieved when passive design techniques are used in a New Zealand commercial building.

New Zealand has around 86,000 buildings greater than 300m^2 in floor area, which consume 9% of the country's total energy use.

Heating, ventilation and air conditioning systems are often designed for worst-case scenarios, which means they are sized larger and consume more energy than needed, because of a fear of failure. The designers and developers want to avoid a backlash of complaints about the internal environment.

Energy consumption could be reduced easily using knowledge and technology that already exists.

However, there is little incentive for the building industry to act.

Initial capital cost rather than long-term running cost considerations dominate the industry, reducing the incentives that could lead to an increase in energy efficiency.

There are many examples of passively designed commercial buildings internationally that have achieved low energy consumption without sacrificing occupant comfort.

Table 1
Summary of occupant responses

1 = unsatisfactory, 7 = satisfactory

	Staff	Students
Design	5.52	5.61
Needs	5.80	5.56
Winter temperature	5.25	5.43
Summer temperature	5.14	5.35
Air quality overall	NA	5.03
Winter air quality	5.07	NA
Summer air quality	5.23	NA
Noise overall	5.39	5.00
Lighting overall	5.71	5.33
Comfort overall	5.86	5.44

These results compare favourably with Probe surveys of UK buildings.

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there but later joined Arup's Auckland office. [Electrical engineer Franc Coles also moved from Arup in the UK to work on the project.]

In what both Clifford and mechanical services Fullbrook saw as a courageous move, the university pursued what was perceived to be a low-energy option.

Ultimately, the key to the success of the building's environmental design lies in the initial architectural concept, the collaborative approach taken by Clifford to its development, and the designers' ability to exploit its potential for environmental control and low energy use.

The building has been occupied since the beginning of the 1998 academic year.

About the building

The 11,551m² building is comprised of two accommodation blocks: three seven-storey academic towers on the north-east side for staff and postgraduate research, and a four-storey teaching wing on the south-west side for undergraduate studies. These are linked by a glass-roofed atrium with circulation towers at either end.

Above ground level, each of the three academic towers contains three two-storey clusters, each consisting typically of 10 staff offices around a common double-height area, with research students and meeting/seminar rooms in the adjacent triangular space. The offices are orientated directly towards the north.

The four-storey, 15.7 m deep by 55 m long south-west-facing teaching wing is designed to accommodate large open computing laboratories and tutorial spaces. The 6.8 m wide atrium links the two wings. Its sloping glazed roof is oriented to the south-west, while its glazed internal walls have openable windows to the adjoining wings. Bridges link the two main wings at each level.

Environmental control

Heating throughout the campus is provided by a coal-fired medium temperature hot water district heating system. Cooling is obtained from a naturally occurring aquifer under the site. The MSCS building uses both systems, along with local mechanical ventilation plant.

However, the building is designed so the offices and most of the adjacent seminar rooms in the academic towers are naturally ventilated, and heated by a conventional radiator system.

With their deliberately northerly orientation and fixed overhangs, exposed thermally-massive interior walls and ceilings, fixed and adjustable exterior and adjustable interior solar shading devices and a large number of window or louvre opening options, the around 90 offices have a full range of ways to control the environment without using external energy.

Each tower has an air handling unit on the roof for fresh air supply to the double-height spaces and the ground floor.

Nine air handling units in the basement serve the air-conditioned computing labs. The teaching wing has two air handling units. Supply air passes through horizontal ducting which is built in to the concrete structural floor slab. This makes use of the slab's thermal mass to maintain an even temperature.

All the plant and motorised window openers are controlled by the university's building management system. Design temperatures are 25°C for most of the air conditioned spaces in summer and 20°C for all spaces other than the atrium in winter.

A user's guide advises academic staff on how to optimise conditions in their offices under different climatic conditions (*see www.cosc.canterbury.ac.nz/organisation/building*).

Performance in practice

The performance of the building was assessed by monitoring annual energy use, measuring summer and winter inside temperatures and conducting a questionnaire survey of the occupants.

Annual energy use

Annual electricity use was estimated at 875,011 kWh. This consisted of 47% heating, 28% equipment (including around 660 computers), 15% lighting (the lighting power density was just under 10 W/m²), 3% fans and pumps, and 7% miscellaneous.

Heating by the central boiler system amounted to 780,700 kWh for the year 2001, operating from February to October and 6am to 9pm, Monday to Friday.

Summer and winter inside temperatures

Inside and outside temperatures were measured from December 2000 to February 2001, and during June and July 2001.

During the summer, the highest inside temperature recorded was 26°C, in a top floor office, and the lowest 13.3°C, overnight.

During winter, the lowest temperature measured was 14°C and the highest 24.3°C.

The figures illustrate the temperatures recorded in a number of offices in summer and winter weeks. The radiator heating system was operating during the winter period.

Occupant survey

Occupants were surveyed using a "Probe" (Post-occupancy Review of Buildings and their Engineering) questionnaire under licence from Building Use Studies in the UK (*www.usablebuildings.co.uk/Probe/ProbeIndex.html*).

Probe was developed to produce informative reports on the performance of recently occupied buildings that would be of interest to the building industry in the UK. The publication of the results in the *Building Services Journal* was intended to encourage building service engineers to develop new, better designs with the feedback obtained.

Two questionnaires were employed: a standard 63-question version, covering 12 areas of building performance, for academics, administrative staff and postgraduate students; and a shortened version for undergraduate students who occupied the building more intermitently.

Table 1 sets out the results, which show staff and students rate the building highly.

It achieves a level of occupant satisfaction in the top 5% of the Building Use Studies data-set concerned with comfort.

The Building Use Studies benchmarks are recalculated annually, and are based on the previous 50 buildings analysed, which include a range of sizes and designs.

The only issue about temperature was the effect of the cooling down of the building over the weekend in winter in the academic towers. The overall air quality was rated highly, with few exceptions.

Overall air quality was perceived as good. However one recurring comment was that the fully air contitioned computer labs in the basement were stuffy and varied uncomfortably in temperature. The temperature variation could be attributed to the large loads associated with the computers and people in the space. The problem may have resulted from the operation of the air conditioning systems.

The noise levels were generally acceptable but a combination of hard surfaces and internal openings for the natural ventilation system allowed occasionally disruptive sound transmissions.

Lighting was generally acceptable. The only issue raised was short-term glare in the staff offices due to low-angle winter sun.

Overall, the results show the building provides a comfortable environment without relying solely on conventional mechanical HVAC systems. It provides an environment that is at least as good as, if not better than, a conventional alternative, while using less energy.

For more details about the building's design, see the original Energy-Wise News article on EECA's website, under Energy-Wise News, Back issues, Issue 59.

Christopher Kendall has written a detailed 81-page study of the MSCS, *Energy use in a passive solar design building*. Contact Dr George Baird at George.Baird@vuw.ac.nz to enquire.

More coming up

The next issue of *Energy-Wise News* will feature Barbara Joubert's energy audit and post-occupancy evaluation of Nelson's Elma Turner Public Library.