

ENVIRONMENT DESIGN GUIDE

THE ERSKINE BUILDING, CANTERBURY UNIVERSITY, CHRISTCHURCH – A CASE STUDY OF BUILDING PERFORMANCE

George Baird

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Summary of actions towards sustainable outcomes

Learnings

- In addition to the reduced environmental impacts achieved by energy efficient and green buildings, they can perform very well from the users' point of view.
- A collaborative design approach is vital for effective environmentally sustainable design. Geographical separation of key members of the design team need not inhibit successful integrated design.
- Persuade clients to allow sufficient design time for the exploration of alternative designs and technologies.
- Ensure that every construction element performs several functions.
- Provide the building users with a range of options for ventilation and glare control. These measures help to increase the positive experiences of building occupants.
- Compose a user manual which explains how the building works in lay terms for the occupants. The Erskine building provides occupants with a user manual to increase the likelihood of the building performing at an optimum level.
- When analysing user surveys, place more credence on the scores than the comments. Assuming a high response rate (an essential prerequisite for this kind of activity), the scores will reflect the majority, while the comments (which typically emanate from one third of the respondents) will often tend to be negative.

Related EDG Papers

- CAS 42, November 2006, 'The Post-Occupancy Evaluation of Passive Downdraft Evaporative Cooling and Air Conditioned Buildings at the Torrent Research Centre, Ahmedabad, India'
 - CAS 45, May 2007, '40 Albert Road, South Melbourne: Designing for Sustainable Outcomes – A Review of Design Strategies, Building Performance and Users' Perspectives'
 - GEN 33, February 2010, 'Users' Perceptions of Health and Productivity in Sustainable Buildings'
 - DES 25, February 2005, 'Green Building'
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The aim of this study was to investigate the design of the Erskine Building at Canterbury University in New Zealand to assess its performance as a passively designed educational building. Although it has been 12 years since the building was complete it is still noteworthy as an example of sustainable design excellence and for its high user performance rating. Interviews with the client and design principals showed it to be an example of high-level, early concept stage integration. A detailed energy audit revealed an energy use index already less than the latest target benchmark for existing buildings in New Zealand of 150 kWh/m² per year. Temperature measurements in the staff offices indicated that the occupants were able to maintain conditions related to their individual preferences. Most gratifying of all, a questionnaire survey conducted in 2001 revealed that the building was rated very highly in terms of its acoustic, lighting, air quality, summer and winter temperatures, and overall comfort performance, by both the staff and students who used it. The paper concludes with the main lessons learnt from the investigation that could usefully be applied to contemporary projects.

Keywords:

building performance, post occupancy evaluation, university building, user survey



Figure 1 View from the north of the academic towers

(Source: Baird 2010)



Figure 2 Typical mid-floor plan

(Source: Architectus 1998)

1.0 PROJECT OUTLINE

1.1 Project details

Client

University of Canterbury

Architects

Architectus, Auckland and CHS Royal Associates, Christchurch

Environmental and Building Services Consultant

Ove Arup and Partners, Bristol, UK and Auckland, NZ

Structural Engineer

Holmes Consulting Group

Main Contractor

Naylor Love, Canterbury

Cost at completion

NZ\$17M

Year of completion

1998

Building type

Tertiary education facility

Building area

11,551 m²

Awards include

1998 New Zealand Institute of Architects (NZIA) Regional and National Architectural Awards

1999 Association of Consulting Engineers New Zealand (ACENZ) Gold Award for Engineering Excellence

2.0 BACKGROUND

Completed in time for the commencement of the 1998 academic year, the Erskine Building is located in the University of Canterbury in Christchurch, New Zealand. More than a decade later it remains noteworthy for its performance, even by comparison with more recent examples of environmentally sustainable design.

The Erskine building was designed to house two academic departments, the Mathematics and Statistics department, and the Computer Science department. The 11,551 m² building has a 32 m by 55 m footprint and is split approximately equally between a seven-storey academic block, containing staff and postgraduate students, and a four-storey undergraduate teaching block. The two blocks are linked by a five-storey high, glass roofed atrium space which is used for circulation and to harness natural light, and a basement area which mainly contains teaching spaces and ventilation equipment.

While the design brief for the building was fairly generic, the university was clear that energy efficiency was to be addressed as they did not want a high energy consuming building. Christchurch, located at around 44°S latitude, enjoys like most of New Zealand over 2000 hours of bright sunshine well spread throughout the year, and has winter and summer design temperatures of −1°C and +26 °C respectively (ASHRAE 2001). Though few designers and clients were achieving the efficiency potential for buildings at the time, the university pursued what it perceived to be a low energy option.



Figure 3 The south-west elevation of the teaching block

(Photo: George Baird, 2001)

3.0 DESIGN PROCESS

Having won the competition for the building with a concept that utilised natural ventilation and daylighting, the architect took an integrated approach to the design of the structure and services (Architectus 1998). While the client approved of this approach, some persuasion was needed to assure them that this would be feasible, given that the services engineer's base was on the other side of the world at Arup's Bristol office in the UK.

Several features of the design process contributed to its ultimate success. Arguably prime among these was the fact that the design team was given adequate time before going to tender (around six months each for both the design phase and the documentation phase). The client was also very much involved in the process. Ultimately, however, the key to the success of the environmental design of this building lay in the initial architectural concept, the collaborative approach taken by the architect and services engineer to its development, and the services engineer's ability to exploit its low energy and natural environmental potential. This level of collaboration was achieved despite these two principals being just about as geographically far apart as is possible during the important early concept development phase of the exercise.

4.0 BUILDING DESIGN

4.1 Planning

With its long axis lying north-west to south-east, the Erskine building (see Figure 2) is comprised of two accommodation blocks. Three, seven-storey academic towers on the north-east side house staff and postgraduate research (see Figure 1), and a four-storey teaching block on the south-west side houses undergraduate studies (see Figure 3). These are linked



Figure 4 Typical double-height space with staff offices clustered around a common area

(Photo: George Baird, 2001)

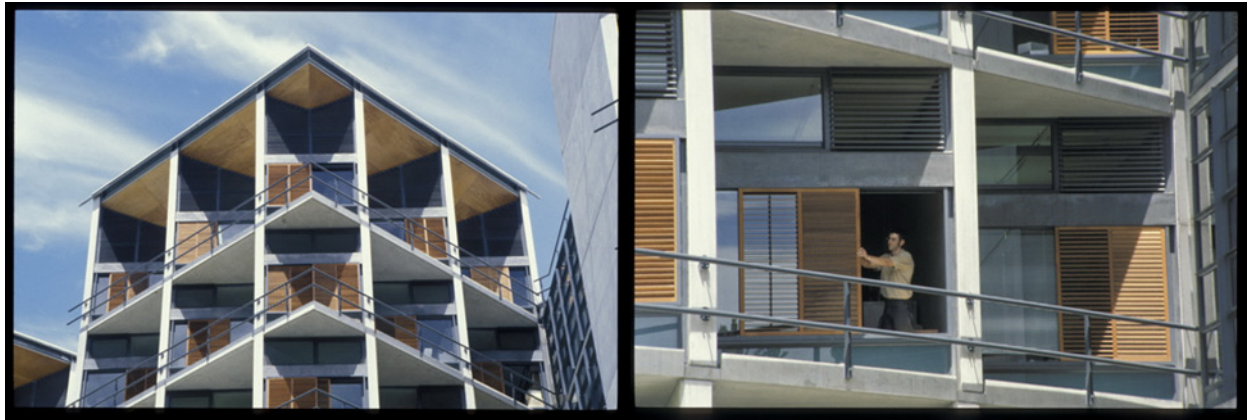


Figure 5 The academic towers orientate staff offices to the northern sun

(Photo: George Baird, 2001)

by a glass-roofed atrium with circulation towers at either end, and a basement area containing mainly teaching and service spaces.

Above ground level, each of the three academic towers contains three two-storey clusters, each cluster consisting typically of ten staff offices around a common double-height area (see Figure 4), with research students and meeting/seminar rooms accommodated in the adjacent triangular space.

The offices themselves are cellular (see Figure 5) and orientated directly towards the north (which is the sunny side in the Southern Hemisphere). The ground floor of the academic towers contains larger teaching spaces and some administration offices.

The four-storey, 15.7 m deep by 55 m long, south-west facing teaching block is designed to accommodate large open computing laboratories and tutorial spaces (see Figure 6). These spaces are sufficiently flexible to allow

them to be organised into completely open, deep-plan configurations or as smaller spaces on either side of an offset corridor. The 6.8 m wide atrium (Figure 7) together with its flanking circulation towers runs the entire length of the building and links the two wings visually. Its sloping glazed roof is oriented to the south-west, while its glazed internal walls have openable windows to the adjoining academic towers which are automated, and manually operated in the Teaching Block. Within the atrium, three centrally placed bridges, which are connected by an open stairway from the ground floor, link the two main wings at each level.

4.2 Building Structure and Fabric

Structurally speaking, the rectangular form of the teaching block provides inherent strength and stiffness, and according to the architects (Architectus 1998) 'the majority of the lateral load resistance is given by the teaching block which acts as an anchor for the entire building'. The architects go on to say that 'the lateral load-resisting system in the teaching block consists of reinforced concrete shear walls at either end of the building, along the wall of the atrium and around the plant rooms'. For the academic towers the lateral load resistance 'is provided by the reinforced-concrete frames around the double-height spaces'. This resistance is transferred to the teaching block shear walls via the diaphragm slabs of the atrium's bridges and cores, aided by steel braces linking the roof of the teaching block to levels six and seven of the academic towers. They also note that 'the precast concrete diagonal walls offer minimal load resistance due to their narrow base configuration, and are mainly used as gravity support elements. Their load is taken by the sculptured pilotis at the base of the towers, and transferred back to the moment-resisting frame in earthquake conditions. These pilotis are positioned to ensure that the structure is balanced and there is no net overturning under normal gravity loading.'

External walls of the academic towers are made up of 260 mm thick precast concrete panels with 40 mm of polystyrene insulation sandwiched between a 70 mm outer layer and a 150 mm inner layer of concrete.

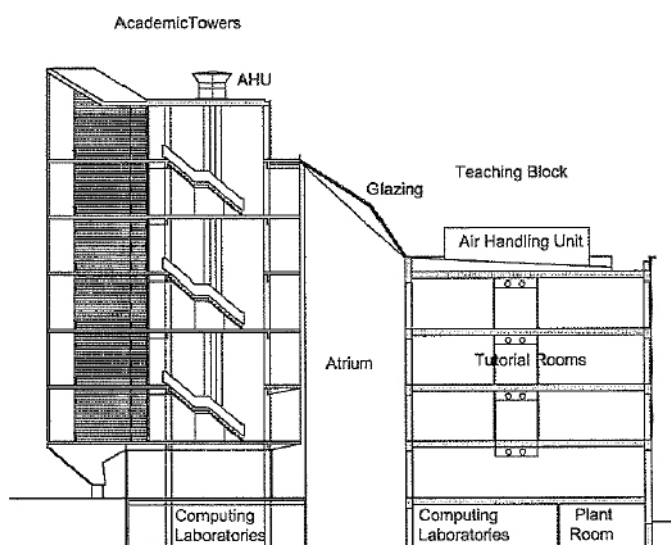


Figure 6 Cross-section of the building (atrium bridges and stairs omitted for clarity)

(Source: Architectus 1998)



Figure 7 The atrium showing the interconnectivity of the two wings of the building

(Source: Baird 2010)

The whole panel assembly is tied together with a fibre-composite connector to avoid thermal bridging. Also used for the construction of refrigerated storage areas, this construction provides good insulation, well positioned thermal mass, and an acceptable internal finish. Also providing useful internal thermal mass are the hollow 'sine-wave' ceilings used in the teaching block which are constructed of precast concrete and allow clear spans across the teaching block (see Figure 8). As well as an appropriate span, these also offer space for ventilation ducting, and distribution routes for wired services.

Internal walls within both towers are constructed mainly of blockwork, and the end walls of the atrium are constructed of exposed-aggregate precast concrete panels.

5.0 SERVICES

5.1 Heating and Cooling

Heating throughout the campus is provided by a coal-fired district heating system. This had been converted from steam to medium temperature hot water (at



Figure 8 Sine-wave ceiling to computer labs

(Source: Baird 2010)

115°C) during the late 1990s, with the addition of a 12 MW medium temperature hot water boiler and the connection of a heat exchanger to one of the existing 5.7 MW steam boilers. Cooling is obtained from a naturally occurring aquifer under the site from which water is extracted at 12.5°C and returned at an acceptable 18°C.

The building makes use of both of these systems, together with local mechanical ventilation plant. However the design of the building is such that the offices and the majority of the adjacent seminar

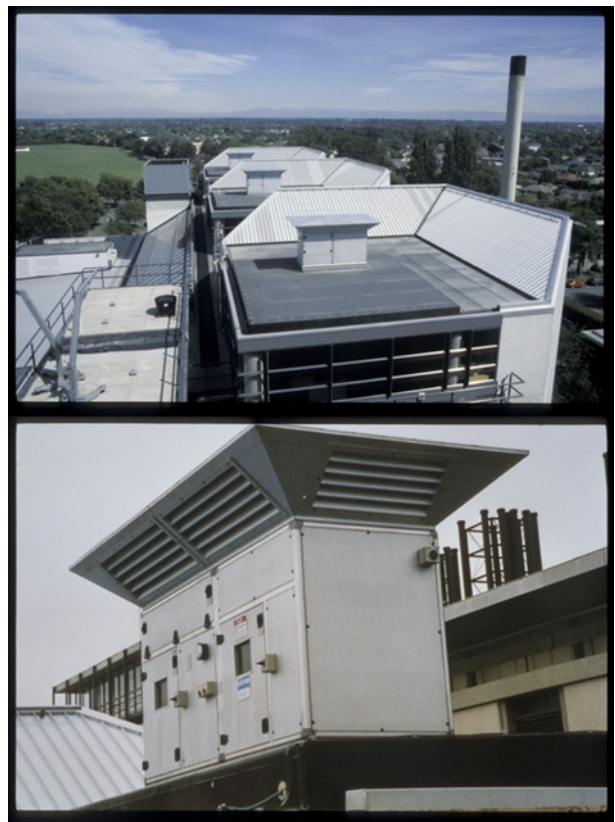


Figure 9 Air handling units located on the top of each academic tower

(Photo: George Baird, 2001)

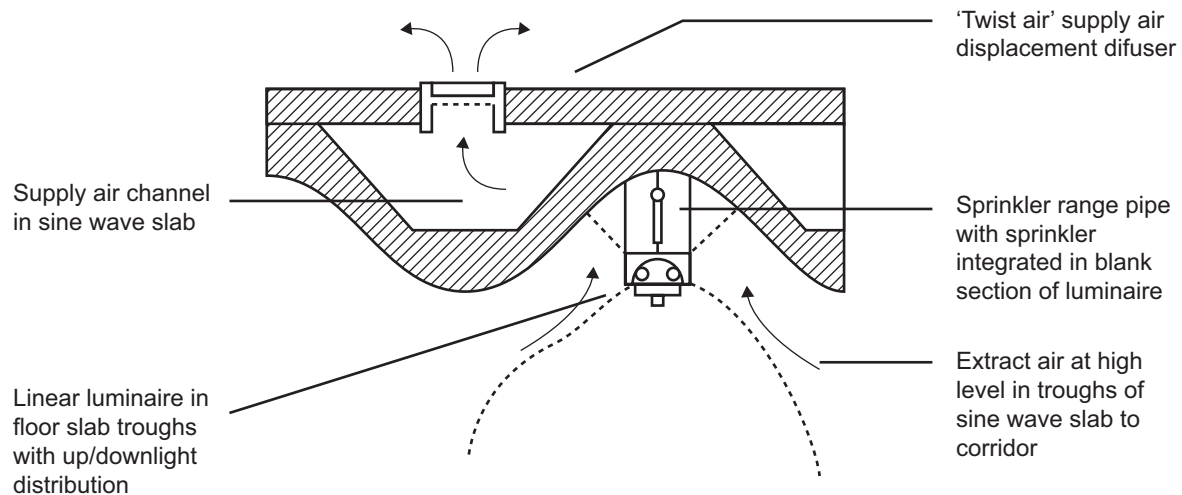


Figure 10 Cross section of floor and ceiling slab

(Source: Architectus 1998)

rooms in the academic towers are cooled via natural ventilation and heated by a conventional hydronic system of radiators. The 90 or so office modules in the academic towers are equipped with a full range of passive thermal environmental control systems which include:

- a deliberately northerly orientation and fixed overhangs
- exposed thermally massive interior walls and ceilings
- fixed and adjustable exterior and adjustable interior solar shading devices
- a large number of window/natural ventilation opening options

5.2 Ventilation

An air handling unit (AHU) is located on the top of each tower (see Figure 9). These supply fresh air to the double-height spaces within the academic towers and the ground floor seminar rooms and offices. For its ventilation, the atrium is totally dependent on the infiltration of outside air via the entranceways and on 'spill air' from the adjacent spaces. The air is exhausted via automatically opening windows at high level on the sloping glazed roof – these are also used for smoke exhaust in the event of a fire.

The teaching block is served by two AHUs, each one serving around half the plan area of each floor. These are housed in separate roof-top plant rooms, positioned centrally over the areas served and the corresponding vertical distribution shaft. Supply air is distributed via the vertical shaft to then pass through horizontal 'ducting' formed in the concrete structural floor slab before being supplied to the space above through circular floor diffusers as shown in Figure 10. By using the structure of the floor slab to contain conditioned air, maximum use of the thermal mass of the slab is utilised in maintaining an even temperature within the teaching block. The exterior rooms on these levels also have hydronic radiators around their perimeter as appropriate.

Separate AHUs in the basement provide air-conditioning to the nine load intensive computing laboratories, enabling flexible timetabling of their use (Figure 11).

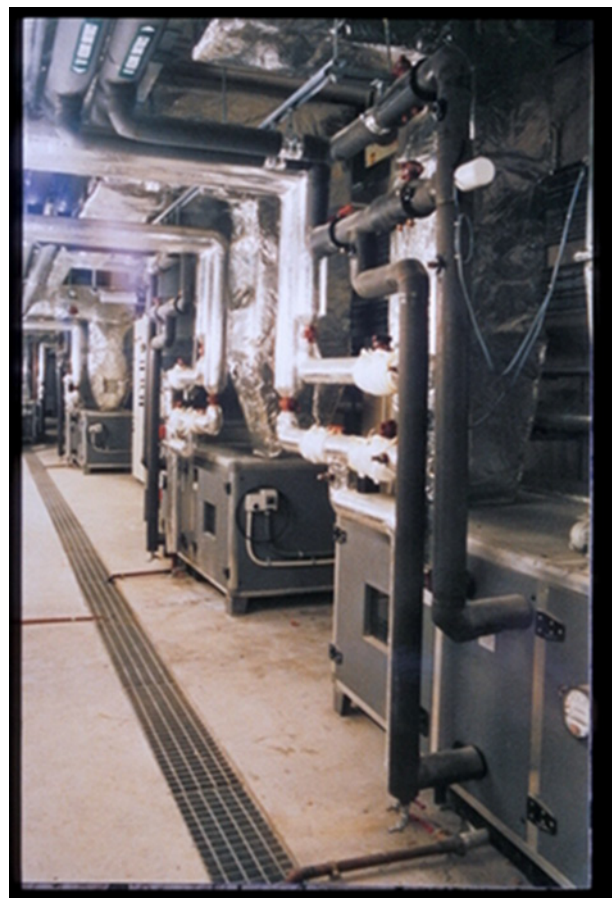


Figure 11 Some of the nine AHUs located in the basement, each one serving a different computing laboratory

(Photo: George Baird, 2001)



Figure 12 Natural light from the atrium penetrates the building's internal circulation

(Photo: George Baird, 2001)

5.3 Operation

All the thermal environmental control plant and motorised window openers are under the control of the university's computer-based building management system, which monitors inside temperatures throughout the building. The building has its own weather station on the roof measuring temperature, humidity, airspeed and rainfall. Design temperatures being 25°C for most of the air-conditioned spaces in summer and 20°C for all spaces other than the atrium (target 16°C) in winter. Appropriate algorithms in the building management system ensure the systems operate to maintain these conditions in the teaching spaces.

Conditions in the staff study area are under the personal control of the individual occupants via the thermostatic radiator valves and the several window opening and shading options available to them.

The central boiler system operates from 6.00 am (from 5.00 am on Mondays) to 10.00 pm on weekdays all year round.

As well as exerting overall control of these systems, the Facilities Management group at the university monitors electricity consumption and provides details of usage and savings for all of their buildings on campus. Their website (see Appendix A) publishes monthly and annual kWh/m² profiles for every building.

5.4 Lighting

All of the above-ground spaces in both blocks and the atrium have been designed to allow maximum use of daylighting. In the teaching block the single-sided staff studies are on the perimeter, while the double-height spaces and adjacent seminar rooms get daylight from the exterior and the glass-roofed atrium. In the case of the teaching block, daylighting is available through both the exterior and the atrium facades (Figure 12). The basement computing laboratories are totally artificially lit, though there is a limited amount of daylight as the atrium penetrates right down to that level. Local control of the artificial lighting is by means of occupancy sensors.

6.0 ENERGY AND THERMAL PERFORMANCE

The performance of the building was assessed in three ways: by monitoring annual energy use, by measuring summer and winter inside temperatures, and by conducting a questionnaire survey of staff and students.

6.1 Annual Energy Use

Heating from the central boiler system was separately metered (BTU, British thermal unit) for the Erskine Building and amounted to some 780,700 kWh for the year 2001. Annual electricity use amounted to some 875,011 kWh. Thus the overall annual energy use index (AEUI) worked out to be 143 kWh/m² per year. This was estimated to consist of approximately:

- 47 per cent heating
- 28 per cent equipment (there were around 660 computers operating in the building)
- 15 per cent lighting (the lighting power density was just under 10 W/m²)
- 3 per cent fans and pumps
- 7 per cent miscellaneous

All things considered, such as low outside temperatures, long hours of operation and large numbers of computers and the 'free' cooling offset provided by utilising the aquifer this is a creditable AEUI for a tertiary education building of this type. The reported figure for 2009 was 148 kWh/m² per year (Sellin 2010).

While any kind of benchmarking can be fraught with caveats, the figures for this building may be compared with recent CIBSE overall building benchmarks for education building types. These range from 167–223 kWh/m² per year for good practice and from 196–261 kWh/m² per year for typical practice (CIBSE 2006).

6.2 Summer and Winter Inside Temperatures

Inside temperatures (in the occupied zone of staff offices mainly) and outside temperatures were measured from December 2000 to February 2001, and during June and July 2001 using calibrated portable thermohygrographs. During the summer period, the

highest inside temperature recorded was 26°C (mid-afternoon, in one of the top floor offices), the lowest being an overnight low of 13.3°C. During winter, the lowest temperature measured was 14°C (again overnight) and the highest 24.3°C. Appendix B, C, and D illustrate the temperatures recorded in a number of offices over three different weeks in summer and winter, noting that the radiator heating system.

Overall, it was found that the level of control given to the occupants allowed a range of temperatures to be achieved, depending (as will become apparent in the next section) on the preferences of the occupants.

7.0 OCCUPANT PERCEPTIONS

7.1 The survey

For the 2001 occupant survey, two questionnaires developed by Building Use Studies (www.usablebuildings.co.uk) for use in the Probe investigations (Post Occupancy Evaluation 2001) were used under license to measure user perceptions.

Long form

The sixty or so questions of the two-page standard questionnaire, designed for 'permanent staff', cover a range of issues. Fifteen of these elicit background information on matters such as the age and sex of the respondent, how long they normally spend in the building, and whether or not they see personal control of their environmental conditions as important. The remainder ask the respondent to score some aspect of the building on a seven-point scale; typically from 'unsatisfactory' to 'satisfactory' or 'uncomfortable' to 'comfortable', where a seven would be the best score.

The following aspects are covered: operational (space needs, furniture, cleaning, meeting room availability, storage arrangements, facilities and image), environmental (temperature and air quality in both winter and summer, lighting and noise), personal control (of heating, cooling, ventilation, lighting and noise), and satisfaction (design, needs, comfort overall, productivity and health).

The two-page version was administered to academics, administrative staff, and postgraduate students, and 71 per cent were returned (57 out of 80 distributed).

Short form

A shorter one-page questionnaire, designed to elicit information from more 'transient' building users who were only in the building for short periods (undergraduate students in this case) was also used. This has 14 questions covering the same general aspects, but in much less depth, so that it can be administered and filled in quickly on the spot. Responses were received from 205 students.

Method

Analysis of the responses yields the mean value (on a seven-point scale) and the distribution for each variable. In addition to calculating these mean values, the analysis also enables the computation of a number of

ratings and indices in an attempt to provide indicators of particular aspects of the performance of the building or of its 'overall' performance.

For all of the 57 staff respondents (11 female and 46 male) the building was their normal place of work and the majority (68 per cent) had worked in the building for more than a year and had thus experienced it in operation over all seasons.

7.2 Analysis

The average scores of the staff and students for each of the relevant survey questions are listed in Appendix E under four Factors: Operational, Environmental, Control and Satisfaction. The table also indicates those aspects of the building that the staff perceived as being significantly better, similar to, or worse than the 'benchmark' (which is simply the average of the previous 50 buildings surveyed – which includes a mixture of commercial office and academic buildings) and/or scale mid-point. Overall, 37 aspects were significantly better, four significantly worse, while the remaining four aspects had much the same score as the benchmark. This is an exceptionally good result by comparison with a recent worldwide survey (Baird 2010) of 30 sustainable buildings.

All of the Operational Factors were significantly better than their respective benchmarks, with the score for building image the highest of this group, with an average value of 6.26 (where the 'ideal' score would be a seven).

Similarly, most of the Environmental Factors rated better than their corresponding benchmarks. Exceptions to this occurred in winter when, despite high overall comfort scores, staff perceived the air as slightly too still and dry; and their responses suggested there was too much glare from sun and sky (a score of 4.46 compared with an 'ideal' of four in this instance).

Scores for the Control Factors averaged 4.21 as compared to a relatively low benchmark of around 2.60. All scores were better than their individual benchmarks, with control of ventilation (5.23) and lighting (5.09) scoring particularly well. The proportion of respondents deeming personal control as important averaged a relatively high 46 per cent.

Average perception scores for the Satisfaction Factors were all well above their respective benchmarks and scale mid-points.

The perceptions of students, who responded to only eight overall variables sought in the shorter questionnaire, were mostly lower than those of the staff, but none dropped below 5.00.

7.3 Users' Comments

Overall, the results show that the Erskine building was rated highly by both staff and students, achieving a level of occupant satisfaction in the top five percentile of the 2001 Building Use Studies Benchmark dataset relevant to comfort (specifically noise, lighting, summer temperature, winter temperature and overall comfort). Some 144 responses were received from staff under

the nine headings where they were able to add written comments – 28 per cent of the 513 respondents (57 respondents by nine headings).

Appendix F indicates the numbers of positive, balanced, and negative comments – in this case around 34 percent were positive, 13 per cent neutral and 53 percent negative. In the context of this type of survey a ratio of negative to positive comments of 1.55 would be considered a relatively 'good' result. In a recent survey of 30 sustainable buildings (Baird 2010) the average ratio was found to be 2.25.

Lighting – While lighting overall rated highly, glare from the sun made up the majority of the negative comments (11 out of 15 received). Low-angle winter sun on computer screens in the middle of the day seemed to be the main issue.

Noise – Negative comments on noise were mainly focussed on internal noise from nearby offices, meetings in the adjacent common space, and from colleagues on the phone but with their office doors open. However the scores for these factors were all better than their respective benchmarks.

While the design of the building attracted a good number of positive comments from staff and students, comments on noise were almost entirely negative, with the sounds from computers, other people and the HVAC system being recurring themes.

Thermal comfort – Summer and winter temperatures were perceived as being comfortable by both groups, the only issue being the effect of the cooling down of the building over the weekend in winter on Monday morning temperatures in the academic block.

Air quality – With few exceptions, the overall air quality in the building was rated highly. However a combination of hard surfaces and internal openings for the natural ventilation system allowed occasionally disruptive sound transmissions.

Other – Asked to add any further comments on the environmental conditions, those received were predominantly negative, with a few mentioning the floor vents in that context.

7.4 Lessons Learnt

Arguably the main lesson one can take from the Erskine building is the importance of an integrated and collaborative conceptual design process with adequate time allowed for the detailed design and documentation phases. These two factors enabled building elements to be designed to perform several functions; the investigation of relatively novel energy sources such as the aquifer; and the eventual operation of the building to be thought through in detail. Clearly geographical distance between the architects and the services engineer was no barrier to such close collaboration.

Occupant operation – Enabling staff to control conditions in their individual offices directly, by the provision of a range of natural ventilation openings, shading devices, and thermostatically controlled radiators was clearly appreciated and well utilised,

though it was noted that some of the automated controls for the atrium openings had yet to be fully commissioned even after several years of occupancy.

Health – Most notably, the staff reported feeling healthier in the building, scoring it 4.52 on a seven-point scale, compared with a reported median value for conventional buildings of 3.2. Unusually, health attracted only positive and balanced comments (see Appendix F) whereas for most other aspects they were mainly negative.

Thermal mass – The judicious use and placement of thermal mass and insulation resulted in very stable thermal environmental conditions in the building. However a relatively inflexible district heating control system, based on time-of-day, day-of-week, and time-of-year, made insufficient allowance for Monday morning heat up or the occurrence of cold days in the summer season.

User manual – Of the 30 or so premises investigated in a recent worldwide survey of sustainable buildings by the author (Baird 2010), this was the only one which had a user manual (University of Canterbury 2007). Made accessible on the University's website it was specifically designed to help the users to understand and operate the building to achieve comfortable environmental conditions. Provision of such a manual really is essential for occupants to understand the building and the consequences of their behaviour. The design team is to be congratulated in ensuring one was produced and disseminated in this way.

Stagnant air – This was one of the few things that the occupants marked down. The air in wintertime was perceived to be too dry and still (both scoring around three by comparison with an 'ideal' of four), no doubt a consequence of low ambient air temperatures and use of the trickle ventilators under these conditions – difficult to mitigate without providing, for instance, desk or ceiling fans.

Glare – Direct glare from the sun (with a score of 4.46 on a scale where one would be the 'ideal') was noted as an issue, somewhat unexpectedly given the predictability of sun angles and the extensive provision of shading and adjustable louvres. Perhaps this needs to be given more thought in the layout of staff offices. In fact this was found to be a surprisingly common issue during the recent worldwide survey of sustainable buildings mentioned above (Baird 2010).

Noise – Noise too has been found to be a common issue in such buildings, and this case was no exception. The building received a score of 4.07 for noise. Some 66 per cent of staff comments and 100 per cent of undergraduate students identified outside noise as a predominantly negative feature of the building. Particular care needs to be taken as the 'routes' provided to enable natural ventilation also act as noise transition pathways.

8.0 CONCLUSION

The Erskine building has proved to be a good example of the kind of hybrid design that uses both active and passive thermal environmental control systems. The success of the project resulted from a well-integrated design process involving collaboration between architects and service engineers from the commencement of the project. The building's energy use index, despite its large number of computers in virtually continuous operation, is a realistic 143 kWh/m² per year, comfortably under the all-inclusive aspirational target value of 150 kWh/m² that had been set under the New Zealand national energy strategy. The use of the aquifer for cooling, rather than a conventional refrigerated cooling system, will account for some of this efficiency.

From the results of the temperature monitoring that was carried out in both summer and winter, it was evident that the building provides conditions that are relatively stable in all seasons but able to respond to individual requirements, and which would be considered comfortable by the occupants.

Most significant of all, the results of the Probe questionnaire survey provide overwhelming evidence of the satisfaction of the users with the environment provided by the building.

ACKNOWLEDGEMENTS

The author thanks Patrick Clifford of Architectus and Dave Fullbrook of Arup for speaking so openly about the design of the building. Many people at the University of Canterbury have been of great assistance. It is my pleasure to acknowledge the help of the following: Doug Lloyd and Robbie Lancaster, Assistant Engineer and Operations Supervisor respectively, and their colleagues at Works and Services; Tim Bell and Doug Bridges, Heads of Department of Computer Science and of Mathematics and Statistics respectively, and their staff; Graham Furniss from Geography and Alan Tucker from Mechanical Engineering.

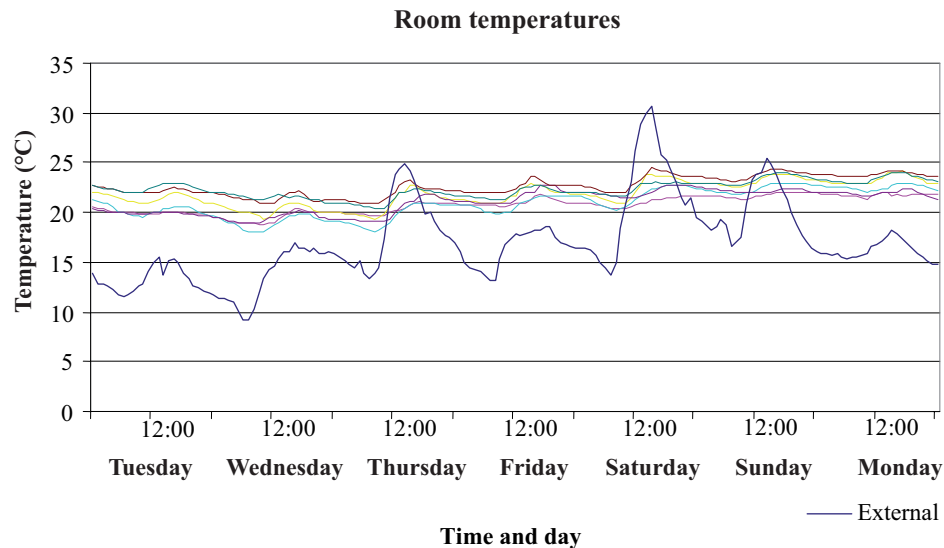
The author also acknowledges grants from the Faculty of Science and from the School of Architecture at Victoria University of Wellington, together with the generous assistance of Adrian Leaman of Building Use Studies (BUS) Ltd in connection with the analysis of the user survey, and Research Assistant Chris Kendall in connection with the data collection onsite.

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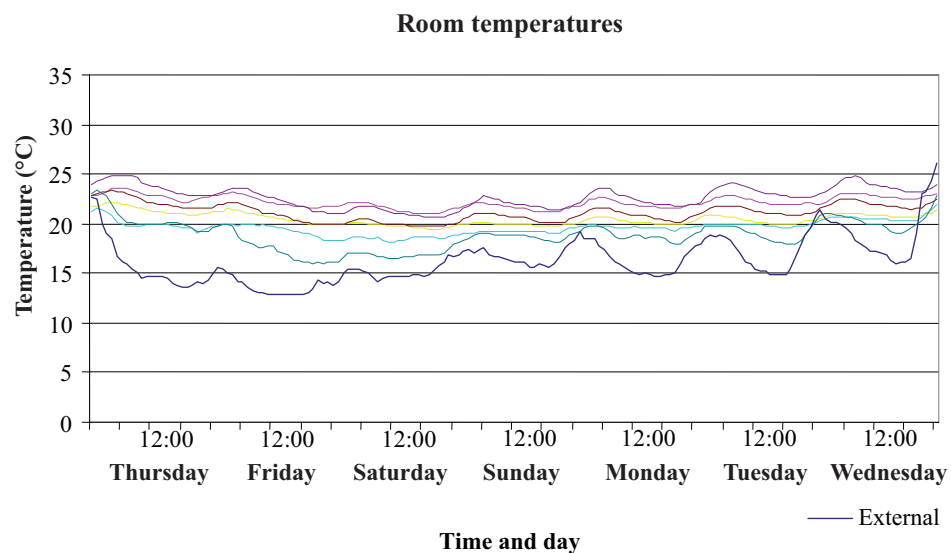
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APPENDIX A

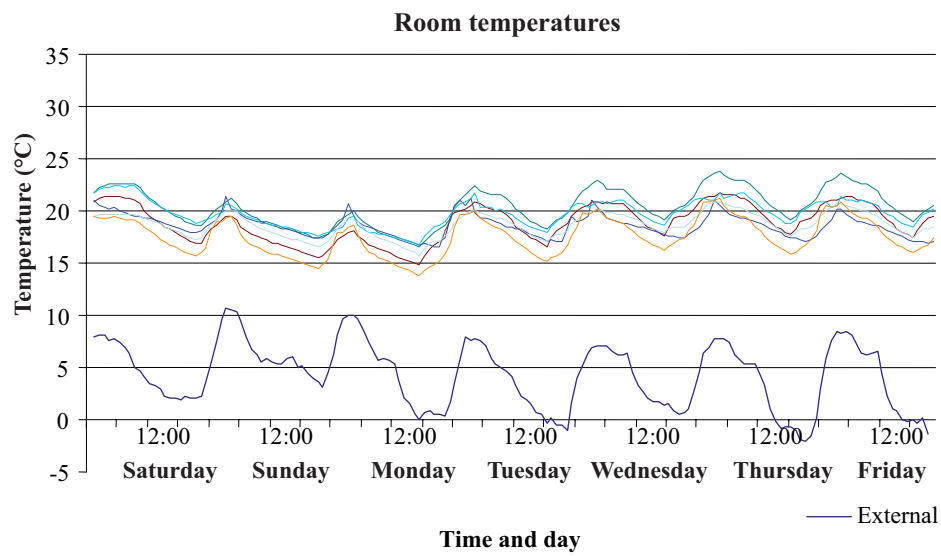
University of Canterbury Facilities Management: www.fm.canterbury.ac.nz/engineering/energyreadings/index.shtml Please note that the Erskine Building is labelled 'Maths – Computer Studies' in this website.

APPENDIX B – WEEK A – DURING SUMMER (6/2/2001–12/2/2001)**Room temperature monitoring**

(Source: Baird and Kendall 2003)

APPENDIX C – WEEK B – DURING SUMMER (7/12/2000 – 14/12/2000)**Room temperature monitoring**

(Source: Baird and Kendall 2003)

APPENDIX D – WEEK C – DURING WINTER (29/6/2001–6/7/2001)**Room temperature monitoring**

(Source: Baird and Kendall 2003)

APPENDIX E – TABLE OF AVERAGE STAFF SCORES

The average staff scores for each Factor and whether they were significantly better, similar to, or worse than the BUS Benchmarks (student scores in brackets) are noted below.

	Score	Worse	Similar	Better		Score	Worse	Similar	Better
OPERATIONAL FACTORS									
Image	6.26			•	Cleaning	5.68			•
Space in building	5.26			•	Availability of meeting rooms	5.57			•
Space at desk - too little/much ⁴	4.37			•	Suitability storage arrangements	5.29			•
Furniture	5.64			•					
ENVIRONMENTAL FACTORS									
Temp and Air in Winter					Temp and Air in Summer				
Temp overall (5.43)	5.25			•	Temp overall (5.35)	5.14			•
Temp – too hot/too cold ⁴	4.17			•	Temp – too hot/too cold ⁴	3.49			•
Temp – stable/variable ⁴	4.04			•	Temp – stable/variable ⁴	4.08			•
Air – still/draughty ⁴	3.02	•			Air – still/draughty ⁴	3.27			•
Air – dry/humid ⁴	2.91	•			Air – dry/humid ⁴	3.22	•		
Air – fresh/stuffy ¹	3.56			•	Air – fresh/stuffy ¹	3.25			•
Air – odourless/smelly ¹	2.87			•	Air - odourless/smelly ¹	2.80			•
Air Overall (5.03)	5.07			•	Air overall (5.03)	5.23			•
Lighting					Noise				
Lighting overall (5.33)	5.17			•	Noise overall (5.00)	5.39			•
Natural light – too little/much ⁴	4.18		•		From colleagues – too little/much ⁴	3.98			•
Sun and sky glare – none/too much ¹	4.46		•		From other people – too little/much ⁴	3.91			•
Artificial light – too little/much ⁴	3.93		•		From inside – too little/much ⁴	4.27			•
Art'l light glare – none/too much ¹	2.95			•	From outside – too little/much ⁴	4.07		•	
					Interruptions – none/frequent ¹	5.39			•
CONTROL FACTORS b					SATISFACTION FACTORS				
Heating	51%	4.14		•	Design (5.25)	5.61			•
Cooling	42%	3.44		•	Needs (5.56)	5.80			•
Ventilation	51%	5.23		•	Comfort overall (5.44)	5.86			•
Lighting	46%	5.09		•	Productivity %	+9.80			•
Noise	40%	3.18		•	Health	4.52			•

Notes

a – Unless otherwise noted, a score of 7 is 'best'; superscript 4 implies a score of 4 is best, superscript 1 implies a score of 1 is best.

b – The per cent values listed here are the percentages of respondents who thought personal control of that aspect was important.

APPENDIX F – NUMBERS OF STAFF RESPONDENTS

The number of staff respondents who offered positive, balanced and negative comments on nine aspects of performance (student responses to three aspects in brackets) are listed below.

ASPECT	NUMBER OF RESPONDENTS		
	POSITIVE	BALANCED	NEGATIVE
Design	13 (21)	3 (2)	6 (11)
Needs	2	1	3
Comfort overall	2	0	7
Noise overall	1 (0)	3 (0)	15 (29)
Lighting overall	2	2	15
Productivity	3	7	1
Health	5	3	0
Work well	21	-	-
Hinder	-	-	29
General environmental			
(students only)	(1)	(1)	(32)
TOTALS (STAFF ONLY)	49	19	76
PER CENT	34	13	53