BEDP ENVIRONMENT DESIGN GUIDE

CONVERSION OF A HERITAGE LISTED INDUSTRIAL BUILDING – UTAS SCHOOL OF ARCHITECTURE AND DESIGN

Roger Fay and Ceridwen Owen

The School of Architecture and Design at the University of Tasmania relocated at the beginning of 2007 to a converted 1950s heritage listed industrial building near the centre of Launceston. This conversion offered many opportunities, but it also presented many design challenges; particularly in relation to the provision of thermal comfort within a large highly glazed uninsulated volume. Preliminary data after a year of operation indicates the building is meeting energy and water targets. Reflective feedback from users, architects, engineers and builders provides insight into the successes and shortcomings of the building and the lessons learned.

1.0 PROJECT DETAILS

Architects in Collaboration
Six Degrees Architects and Sustainable Built Environments

Builder
Vos Construction

Building Services
Engineering Solutions Tasmania (EST)

Structural Engineer
George Apted and Associates

3D Building Services Modelling
Construction Modelling Australia

Cost at Completion
\$6.55M including fees and services (approximately \$1,450/m²)

Year of Completion
2007

Building Type
Tertiary education facility

Building Area
4500 m² (gross)

Awards
RAIA Tasmanian Chapter Awards (2007) – ESD, Heritage, Public buildings

RAIA National Awards (2007) – ESD, Heritage

Timber Design Award

2.0 BACKGROUND

The School of Architecture and Design, until 2006, was located on the University of Tasmania's Newnham campus in the suburbs of Launceston. Over a period of more than a decade, and as a result of continuous growth in student numbers (a five-fold increase between 1982 and 2002), the school's teaching, research, workshop and office spaces were dispersed across three buildings and over three levels. This resulted in a school that had little visual coherence and one that did not reflect the school's approach to teaching and research or the values it held, particularly in relation to sustainability. As a tool for teaching, the existing buildings were not exemplars of good design. Given the growth in student numbers the university determined that the existing facilities were no longer adequate, and a feasibility study was undertaken to examine the options for renovating the school's existing buildings. Two practices working in collaboration, Sustainable Built Environments (SBE) and Six Degrees Architects (6º) were engaged to undertake this study, which commenced in late 2003. During the study, the consultants were asked to investigate the cost of both constructing a new building at the Newnham campus and converting an existing heritage-listed industrial building located at Inveresk, near the city centre and adjacent to the School of Visual and Performing Arts.

3.0 PROJECT BRIEF

Initially, the School sought to renovate the existing buildings but it became apparent that this would provide a relatively expensive yet temporary solution. Addressing sustainability and meeting the spatial requirements associated with future growth would be difficult. In 2003, the cost of a basic renovation of the existing buildings was estimated to be \$3.8M, of building a new building on the campus \$6.4M and of refurbishing the existing heritage listed Exhibition Building at Inveresk \$5M, though renovating the existing buildings would involve additional decanting costs and logistics problems. A decision was made to relocate the school to Inveresk.

The school had written a functional brief for the project setting out spatial requirements, sustainability requirements and providing information about the School's vision and modus operandi. In addition, the design was to respond to particular characteristics of the School of Architecture and Design and the region in which it is located, including:

- studio-based architectural education predicated on the notion of architecture as a social art
- medium sized school with strong collegial relationships between students and staff
- sustainable and community-responsive approach to design
- importance of the workshop in the life of the school

- workshop centred learning-by-making as a distinctive teaching approach
- strong relationship between design computing and learning-by-making
- strong focus on sustainability and place-oriented research
- strong research group addressing many aspects of timber production and use – then the Timber research Unit and now the Centre of Sustainable Architecture with Wood (CSAW)
- strong tradition of arts and crafts and use and production of timber in Tasmania
- one third of the students are international
- flexibility and adaptability of the new spaces.

Figure 1. External image of the building
(Source: Roger Fay, 2008)

4.0 DESIGN PROCESS

The architectural collaboration utilised charrettes as a way of engaging with stakeholders (staff and students) and this proved to be an effective method of interrogating the school's vision and needs. The design process involved an initial two-day charrette as a means of teasing out the brief and gaining stakeholder agreement on a vision for the development, sustainability goals and targets before commencing design. Architectural and engineering consultants were involved and agreement was reached on key issues. Of the three resultant design options generated by the design team, one option was selected and this was further developed through ongoing discussion with all stakeholders.

Computer Modelling

During design development, SBE undertook comfort studies and energy modelling of various building design strategies and decisions were made following discussions between building users and the consultants, including the quantity surveying consultants. It was also agreed that 3D modelling of building services would be undertaken to aid construction and reduce service clashes.

4.1 Environmental Goals and Targets

Acknowledging that energy and water autonomy was likely to be difficult to achieve on a standard university building budget, it was nevertheless set as a goal. The agreed outcome was not to be *"a heroic building form, but an architectural discourse that extends the life and relevance of existing building stock, reinterprets and capitalises on industrial workshop volumes, and generates form in response to climate, the human psyche and the provision of energy efficient thermal comfort".*[1] Putting on a jumper in cold conditions was preferred to high technology solutions.

In general terms, the targets for the building were:

- greenhouse neutrality
- autonomy in water supply and wastewater disposal
- high indoor environmental quality
- increase in site biodiversity
- economic and employment growth
- cultural growth through education

Energy

Two external benchmarks were used including a study of energy use by one university building in New Zealand – Victoria University of Wellington School of Architecture (VUW) and Tertiary Education Facilities Management Association (TEFMA) benchmarks. This led to the establishment of an energy target that was a 25 per cent reduction compared to VUW. It was proposed that greenhouse neutrality would be achieved through on-site energy generation and carbon sequestration.

Victoria University of Wellington	– 576 MJ/m^2/annum
TEFMA benchmark	– 670 MJ/m^2/annum
Project energy target	– 433 MJ/m^2/annum

Water

In relation to water, it was calculated that the provision of 132,000 litres of storage (6 x 22,000 litre tanks) would meet all non-potable water requirements for toilet flushing and garden watering. This would reduce mains water use by 46 per cent.

4.2 Location and Climate

Launceston is located in the north of Tasmania and its latitude is 41.45°S. Situated on the Tamar River, approximately 60 km south of Bass Strait, it has an inland climate with cold nights and relatively warm days, generally classified as cool temperate. The winter mean minimum temperature for July is 2.2°C and the annual mean minimum temperature is 7.2°C while the summer mean maximum for February is 24.4°C and the annual mean maximum temperature is 18.4°C. Mean annual rainfall is 665.7 mm. The annual mean 9 am humidity is 79 per cent while that for the 3 pm humidity is 56 per cent (Bureau of Meteorology data).

5.0 BUILDING DESIGN

5.1 Existing Building Fabric

The heritage-listed industrial building, which now houses the School of Architecture and Design, was constructed in 1951 as a diesel workshop for the

1 Preliminary Sketch Design Report, April 2005.

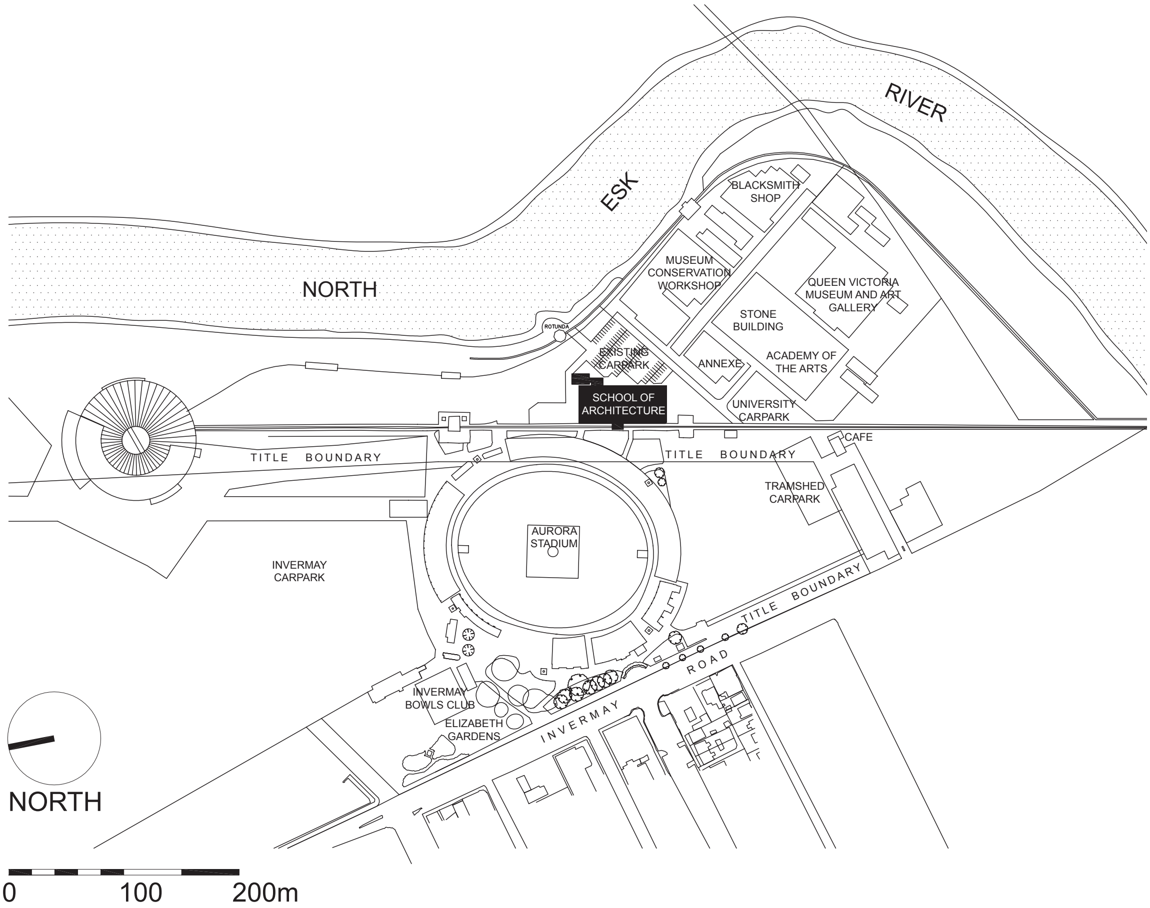

Figure 2. Location/site plan
(Source: Six Degrees Architects, 2005)

Tasmanian Government Railways. Following the decommissioning of the railway system it was refurbished in 1995 to become the Exhibition Building for the annual Launceston Show. The extant structure of the single-storey industrial shed remained substantially intact. The building comprises an enclosed footprint of approximately 2600 m² with a height of 12m. It is divided into two structural bays with concrete columns supporting gantry cranes and a timber-truss saw-tooth roof structure. The long sides of the building facing predominantly east and west are substantially glazed with steel-framed single glazed panels, while the north and south ends formed the primary access to the building through a series of roller shutter doors. The corrugated steel roof has aluminium foil reflective insulation but in other respects the building is uninsulated. The floor slab and lower portion of exterior walls are of concrete construction.

5.2 Concept and Layout

In addition to the project brief and ESD targets discussed above, the key issue underpinning the design of the school was maintaining the existing character of the building. With respect to the heritage listing of the building, the primary concerns were preserving the clarity of the existing spatial volume, concrete structure

Figure 3. Existing building prior to construction
(Source: Roger Fay, 2006)

and sawtooth roof, and the presence of the gantry cranes. A further driving factor was the connection between the original function of the building as a workshop for trains and its new life as a 'workshop' for architecture students.

The main functions are 'compressed' within a new three-storey structure occupying the eastern edge of the building, retaining much of the volume of the original workshop. Dedicated teaching spaces, administration and academic offices are located on the ground and first floor while the top storey is configured as an open-plan flexible studio space. The main public facilities, incorporating a lecture theatre and learning hub accessible to all the university's students, are located at the south end of the building with the workshop and vehicle loading to the northern end.

This compression strategy offered numerous environmental benefits including opportunities for operational flexibility in the open-plan studio spaces and the possibility of expansion. The design approach was tied to an early briefing decision to reduce servicing requirements by client acceptance of broader thermal comfort conditions in certain areas. Functions requiring greater thermal and acoustic control are contained along the eastern edge of the building allowing a rationalisation of building services to these areas. In contrast, the main space retains the less stringent thermal and acoustic characteristics of the 'workshop' with limited levels of servicing. Thus, the movement of

Figure 4. The 'cliff' (internal view)
(Source: Roger Fay, 2008)

occupants between contained/serviced and open/free-running spaces becomes part of the thermal and acoustic control strategy for the building.

5.3 Construction and Servicing

The renovation and refurbishment is contained within the existing footprint of the building, offsetting the requirement for environmentally and economically costly footings on the filled site if an extension was required. The lightweight construction of the internal three-storey structure is supported by the existing concrete columns, thus obviating the need to reinforce the existing or provide new structure.

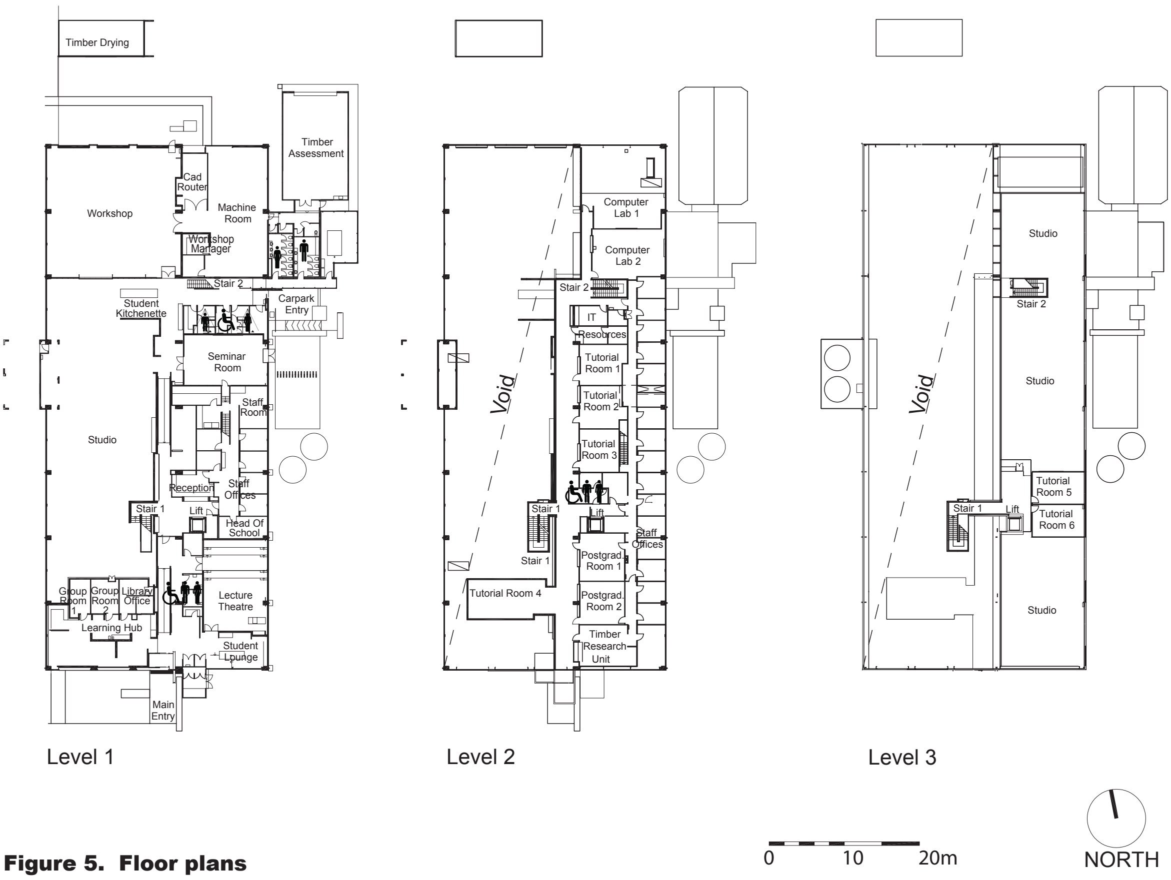

Figure 5. Floor plans
(Source: Six Degrees Architects, 2005)

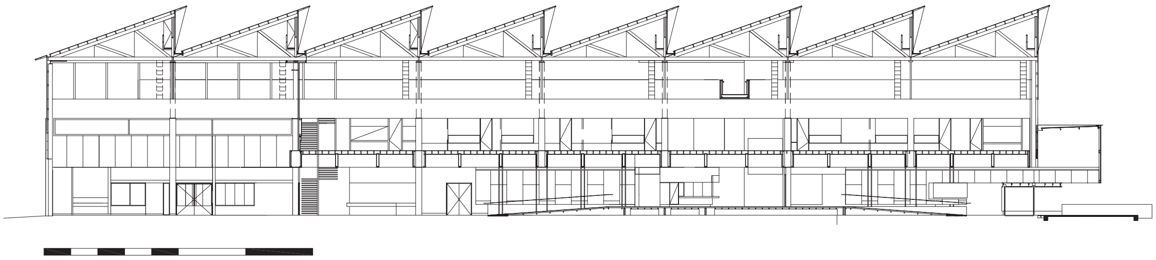

Figure 6. Longitudinal section
(Source: Six Degrees Architects, 2005)

Floor Structure

A primary structure of steel web trusses spans the 12m between the existing concrete columns. Over this sits a secondary structure of laminated radiata pine gang-nailed trusses and timber floors. The absence of additional structural columns or walls maximises possibilities for future adaptation. The timber trusses are clad and braced in hoop pine plywood, with coffered ceilings between revealing the structural grid, while the main service duct is clad in contrasting black plywood cladding, usually used for concrete formwork.

Servicing

Servicing is contained within a central duct running the length of the eastern bay allowing for future flexibility, ease of access and minimal pipe runs. The organisation of structure and servicing is deliberately legible, responding to the workshop context of the building and providing students with a direct visual means of comprehending the building layout. Additional finishes and materials are limited to minimise resource use and environmental impact.

Construction Time

The project was completed within a relatively short, eleven months. A fully dimensioned and specified 3D model of the building services was commissioned to mitigate any potential construction conflicts on site; however as discussed below, the value and necessity of this exercise was later questioned by both builder and architect.

Figure 7. Interior volume with three-storey glass wall to workshop
(Source: Roger Fay, 2008)

6.0 ENVIRONMENTAL INITIATIVES

6.1 Energy Efficiency

Lighting

The existing building had ample natural light, with south-facing clerestory windows and substantial glazing on all four facades. Daylight penetration has been optimised by maintaining the building's large full-height open volume and minimising enclosed spaces. Daylight to these internal spaces and corridor on the ground and first floor of the three-storey structure has been maximised by the use of corrugated acrylic cladding between the offices and internal corridor and through glazed openings to the central tutorial and postgraduate rooms. The use of T5 fluorescent lighting controlled by motion sensors and timers provides energy efficient artificial lighting when daylight fades.

Heating

Heating the open-plan design provided a significant challenge to the designers. Heritage listing also constrained alterations of the existing building fabric, though the existing external wall and roof were insulated with 30mm foil-backed polystyrene panels where they abutted the new three-storey structure. The existing steel-framed single-glazed windows and limited opportunities for north solar access in the large open volume necessitated a reliance on active heating systems for the ground level open studios.

Figure 8. Construction photograph
(Source: Roger Fay, 2006)

Life-cycle analysis demonstrated that a hydronic heating system fired by a gas boosted, air-sourced heat pump offered the most favourable outcome in terms of cost and greenhouse gas emissions. This system has an estimated 10-year payback and a greenhouse gas reduction of 85 per cent or a total saving of 1.160 tonnes of CO_2 over a 20-year period compared with a natural gas boiler. A water-sourced heat pump offered a similar payback and even greater greenhouse gas reductions; however this system was rejected on capital cost grounds as well as the complication of gaining approval from relevant authorities to access river water.

A gas boosted, evacuated tube collector solar hot water system provides 70 per cent of the domestic hot water requirements with excess heat directed to the hydronic heating system. Hot water for space heating is reticulated at 65°C to radiators in offices and computer rooms and to an air-handling unit in the lecture theatre. On the second floor studio water is circulated through heating coils under the plywood floor and the area is zoned for flexible occupant-control during out of hours usage. Cost limitations determined that the ground floor studio spaces be fitted with overhead electric radiators.

Cooling

Passive cooling strategies have been used where possible with operable windows in enclosed offices, studios and the labs and stack ventilation in the main building volume. Two sets of louvres are located at the north and the south end of the building and are controlled by the Building Management System (BMS).

A raised floor was required to bring the offices on the ground level above the 100-year flood level. This subfloor space provided an opportunity for the seminar room and lecture theatre to be cooled via a thermal labyrinth located under the raised ground floor to the offices. The labyrinth comprises a 623m long, 0.5m high, clay brick wall, which, in addition to the existing 150mm concrete floor slab, provide 870m² of surface area. The underside of the plywood floor is insulated with polystyrene. Cool air from the labyrinth is admitted through floor ducts under the seating in the lecture-theatre, and exhausted passively through the central ceiling duct.

Modelling of the labyrinth using the IES Virtual Environment software demonstrated that overnight purging of the labyrinth between 12pm and 7am would provide sufficient coolth for daytime operation. The labyrinth also provides some winter-heating capacity with warm air from the upper floor spaces exhausted through the labyrinth in the afternoon, providing heat storage for the following day. The passive ventilation strategies enable the building to operate on 100 per cent fresh air intake. The only active cooling system installed or planned is a split-system air-conditioning unit servicing the computer lab and server rooms. The internal tutorial, post-graduate and photocopy rooms will be fitted with mechanical ventilation to improve air quality.

Figure 9. Second floor studio hydronic heating system
(Source: Roger Fay, 2006)

Figure 10. Labyrinth thermal control system
(Source: Roger Fay, 2006)

6.2 Water Management

Supply

The primary water management strategy in the building is the collection and use of rainwater from the extensive roof area for non-potable supplies. Four 22,700L poly tanks are provided to supply the estimated 270kL per annum demand for toilet flushing and cleaning and 100kL per annum for irrigation. The tank sizes were modelled to meet 100 per cent of demand in years of average rainfall with mains back up provided for drought years. This equates to the displacement of approximately 46 per cent of the building's calculated mains water use.

Further reductions through the use of rainwater for potable supplies and recycling of waste water for non-potable supplies were considered but were rejected due to the complexities of the constant monitoring required to guarantee water quality and the capital and operational costs that such systems would entail.

Demand

With the inclusion of demand management strategies such as water efficient fittings and fixtures, flow restriction valves and waterless urinals, the total mains demand for basins, kitchens and showers is estimated to be 422kL per annum or 2150L per term day.

Figure 11. Water tanks
These are 2 of the 4 rainwater tanks provided.
(Source: Roger Fay, 2008)

6.3 Materials

An ESD matrix was used to select environmentally preferable materials for the project. This information was derived from SBE's materials database together with information from environmental materials resources such as EDG, Ecospecifier, Vic Urban Ecoselector and GreenSpec (USA). Selection criteria considered included embodied and operational energy, transport energy, resource efficiency, emissions, toxicity, biodiversity and habitat, durability, maintenance, and the availability of legitimate certification and testing.

Key materials selected comprise in-situ concrete elements, concrete block walls, plantation hoop pine plywood wall and ceiling cladding and flooded gum

Figure 12. Internal corridor with translucent wall panels
Daylight penetration is maximised
(Source: Roger Fay, 2008)

Figure 13. Computer studio
(Source: Roger Fay, 2008)

plywood flooring, routed plantation formwork-plywood feature cladding, metal and fibreglass wall cladding, hardboard and canite wall finishes, linoleum benches, rubber flooring and carpet manufactured with post-consumer recycled content.

Finishes are limited so as to reduce maintenance, maximise durability and maintain high levels of indoor environment quality. Where sealants are required, these have been restricted to natural oils and water-based polyurethane. Elements that would normally be concealed by additional layers of materials, such as the plywood wall and floor bracing and the foil-backed polystyrene roof insulation above the studios, have been left exposed, reducing the environmental and economic cost of materials in the project. The overall result is a pared-back palette of materials that complements the industrial aesthetic of the existing building.

6.4 Other Environmental Initiatives

Education

The building integrates several other sustainability initiatives such as a construction environmental management plan, bicycle facilities and educational opportunities afforded by making visible many of the building's environmental features including hydronic heating manifolds and plant room, water tank floats and evacuated tube collectors. In addition, graphic and textual signage is provided to explain key environmental initiatives and a computer display board that provides building performance data, including energy and water use, has recently been installed.

Unfortunately some environmental opportunities identified as 'wider initiatives' in the sketch design report have not been adopted. For example, on-site electricity generation was considered but rejected on cost grounds. Life-cycle costing demonstrated that an investment of $30,000 in a PV solar array would offer a reduction in energy of approximately 3 per cent, but would have a payback of more than 50 years, even with existing Government rebate schemes. A small-scale low velocity hydro turbine utilising the 2.5m tidal range in the North Esk River adjacent to the site, was also considered but rejected, due to cost as well as the complications of obtaining approval from the relevant authorities. A proposed solar air heater on the northern wall of the building was also deleted in the final budget rationalisation; however a similar system will be installed on the northern wall of the new extension for the School of Fine Furniture, which is currently under construction.

The sketch design report also identified landscaping as one of the more innovative environmental opportunities for the project. Proposals included the development of a community garden that could provide seed gathering, propagation, food production and biodiversity habitat as well as shading to the building fabric. In addition, a wood lot of cabinet timbers on site was suggested as a means of offsetting CO_2 emissions as well as connecting with the research focus of the school through the Centre for Sustainable Architecture with Wood (CSAW).

A more substantial carbon sequestration program, through an off-site tree-planting initiative, was suggested as a means of producing a carbon neutral building. It is estimated that this would entail the planting of 190 trees per year to offset the estimated annual generation of 48 tonnes of CO_2.

None of these initiatives are likely to be implemented in the short term.

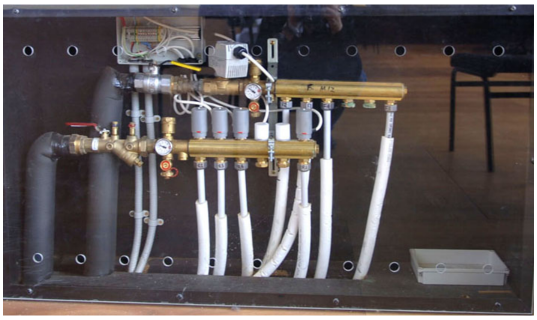

Figure 14. Exposed hydronic heating manifolds
(Source: Roger Fay, 2008)

7.0 POST-OCCUPANCY EVALUATION

User Perspective

A post-occupancy evaluation encompassing indoor environmental quality is being undertaken as a research higher degree project by a student at the University of Tasmania but the results are not yet available. However, anecdotal evidence, indicate that users are generally very satisfied with the exception of thermal comfort, which is linked to the still being resolved performance of the building's passive design and associated mechanical systems.

Actual Performance

Target annual consumption was 430 MJ/m^2/annum.

Actual energy consumption is 425MJ/m^2/annum.

The actual performance figure is based on actual 2007 electricity consumption and includes the use of 'non-official' staff use of supplementary electric heaters in their offices during periods when the hydronic system has not been operating correctly due to problems with boilers. The decision has been made to replace the boilers.

Although the building is not fully commissioned, these preliminary figures are very encouraging and correspond with the design team's predicted energy consumption.

7.1 The Client's Perspective

From the first day of occupation students and staff have enjoyed working in the building. The ambience of the spaces, the quality of natural light, the extensive use of exposed timber, the innovative use of materials and technologies and the visible application of sustainability principles represent to the community of users the values developed within the school and described by one colleague as 'humane modernism'.

Noise

Nevertheless, the openness of the building, particularly the teaching spaces, has led to acoustic problems; not so much by noise passing from the workshop to studios, but rather by the noise generated by students and staff engaged in their day-to-day activities. With adapted behaviour, noise now appears to be less of an issue.

Thermal Comfort and Ventilation

Thermal comfort problems are generally associated with commissioning and cost cutting of the passive design features. On very hot days in summer, the lecture theatre, offices and studios suffer from overheating. The labyrinth cooling system to the lecture theatre and large seminar room generally works well but is unable to provide a sufficient level of thermal comfort on very hot days. Preliminary testing indicates that carbon dioxide levels may also be high and this is being evaluated.

Cost cuts led to the elimination of sun shading to most of the west facing windows which has caused over-heating and glare on sunny afternoons. While the offices have blinds, they are black and located on the internal face of the glazing rather than externally, which would have prevented the ingress of direct solar heat gain. External blinds will be installed when funds become available, and future landscaping to the east will also provide summer shading.

The BMS operated louvres to the clerestory glazing in the roof do assist in the removal of hot air by stack affect. However, two banks of louvres per bay do not provide sufficient openings to adequately ventilate the building volume.

Staff in particular wanted offices with natural light and controllable ventilation. This was achieved; however, two large postgraduate offices were located in the middle of the building without direct access to natural light. They receive borrowed light but it is insufficient. To rectify this, the school will install glass louvred windows to these spaces to increase the amount of borrowed light, improve ventilation and provide views from the offices to the larger building volume and beyond that to the exterior. The tutorial rooms have a similar concern with ventilation. As one of the energy saving strategies, a switch has to be activated to turn on the ventilation system to each tutorial room and even then it operates for a set time. Staff and students were not aware of this for many months and, even now, often forget that the system is not continuous or automatic. This problem could be alleviated by using appropriate automatic operation and sensors.

The key disappointment for users to date has been the lack of reliability of the heating systems and this has been attributed to commissioning difficulties that are yet to be fully resolved. These teething problems have not dampened student and staff enthusiasm for the building, as it is understood that a building of this complexity will take time to be fully commissioned.

Light

The top floor studios receive abundant diffuse natural light for most of the day from south facing clerestory glazing and the ground floor studios from large areas of west facing glazing and clerestory glazing. Students and staff have measured the lighting levels in the top floor studio and expressed some dissatisfaction. The Electrical Engineer notes that while the lighting levels are acceptable for drawing studio work, it was designed on the assumption that task lights would be provided where necessary. This has resulted in a Learning-by-Making studio project in which students designed and fabricated low energy studio task lighting using LEDs.

7.2 The Architect's Perspective

This section was written with the assistance of Peter Malatt from Six Degrees Architects and Chris Barnett formerly of Sustainable Built Environments.

One of the most unusual aspects of the project is the collaboration between architects and environmental consultants with both taking a joint leadership role in the procurement of the building. This has proved highly successful with ESD thinking firmly embedded within all key design decisions. Together with the design charrette, it has enabled clear communication and mutual understanding of aims, objectives and opportunities for the project.

At a conceptual level the building performs well; however, there remains a disparity between the theoretical and actual operational performance of the building. A key difficulty has been the commissioning of the systems, including the combined heat pump, gas boost and solar hot water unit and the operation of the centralised BMS.

One possible solution is to reduce complexity by specifying more familiar technologies, particularly in regional contexts such as Launceston where access to specialised consultants is more limited. Another is to focus on low-tech systems that rely on user control rather than a centrally controlled BMS; however this is problematic in the tertiary education context with a large and changing user base and 24 hour occupation of the building.

Had there been sufficient budget for an independent commissioning consultant appointed to the project, they could monitor both the initial installation as well as the ongoing performance of the building on an annual basis. This information would also help determine the actual effectiveness of environmental 'features' such as the labyrinth and the proposed solar air heater.

Budget limitations have affected building performance by the omission of items such as external shading devices and high-performance glazing and the reduced specification of other items such as internal blinds and louvres. Primarily these omissions relate to summer cooling performance, which was seen to be of lower importance than winter heating for the Tasmanian climate and tertiary education context. Consequently, uncomfortable conditions have been experienced over the last two summer periods, which have seen higher than average temperatures. In retrospect, data sets used for the thermal model have proved inadequate for the warming climate conditions that are being experienced globally and in this project a greater emphasis could have been placed on passive and active cooling strategies.

7.3 The Builder's Perspective

This section was written with the assistance of Mr Stuart Whiteroad of Vos Construction.

The 3D Building Information Modelling was time-consuming, costly and caused delays because it was not undertaken early enough. Though intended to reduce service clashes, they still occurred. Theoretically this process could have reduced service clashes prior to construction and allowed for their redesign. This negative view of building information modelling is shared by the architects.

Some difficulties were encountered during construction though they did not lead to construction delays or additional costs. They included:

- the large steel and timber structure required the use of a forklift and crane inside the existing structure
- working in an existing structure added difficulties since many of the existing columns, for example, did not line up
- use of the hydronic heating and the BMS proved a little difficult due to inexperience with this type of system, and many problems arose during commissioning and during occupation of the building
- the extensive use of timber panelling required a lot of care in fixing panels to ensure services mounted in walls and floors were not damaged; and nails pierced some services which were difficult to repair because they were concealed
- the amount of dust from the timber panelling (predominantly plywood, formply and hardboard) required the majority of site personnel to wear respirators of some description
- confined space management was implemented while working in the underground trenches, which meant monitoring of all air while personnel worked in the trenches
- access for services was quite difficult due to the type of construction

- the nature of the project allowed extensive training for personnel in the use of timber and linings that commercial builders would not otherwise work with
- local materials suppliers learned about novel materials that would not normally be used.

7.4 The Engineer's Perspective

This section was written with the assistance of the project engineering consultant, Steven Banbury, of Engineering Solutions Tasmania.

The architects and engineers faced a challenge in working with a heritage-listed building that is constructed of a lightweight uninsulated fabric with leaky (air and at times water) facades, large areas of glazing facing east and west and an inadequate budget for external shading. However, within these considerable constraints, the thermal and lighting design has been very effective.

The underfloor heating of the second floor studio provided a thermally comfortable and energy efficient working space. Given that this is a lightly insulated space with no thermal mass, high ceilings, and large areas of single glazed clerestory windows, the heating solution has been very successful.

Another success is the strategy of treating the 'shed' as a naturally ventilated space, using windows at ground and first floor levels and operable louvres in the second floor clerestory glazing to cool the space. However, the strategy would have been more effective if additional louvres were added as mentioned above.

The use of smaller spaces such as tutorial rooms as withdrawal spaces that can be heated on demand is an effective solution to the problem of providing out of hours workspaces for students. Students are also able to switch on the heating to each of the top floor studios in zones. The building has been divided into 31 zones, each of which can be switched on independently out of hours.

The labyrinth heating and cooling to the lecture theatre and seminar room has been quite effective, though it is recognised that students and staff complain of stuffiness that indicates that CO_2 levels are high, and this requires further investigation. The engineer notes that this is surprising given that the system delivers up to 18 litres/person/second of outside air. It is recognised that the labyrinth cooling system runs out of capacity by mid afternoon on hot days, which is a constraint of the thermal mass surface area available.

The use of electric radiant panels to heat the ground floor studio and workshop provides reasonably comfortable conditions, except on the coldest days, though this system consumes 50 per cent of the total energy used in the building. Radiant floor heating would have had lower operational costs and provided increased thermal comfort.

The hydronic radiant heating to offices and tutorial rooms has been generally successful but there have been commissioning and equipment problems that have, at times, reduced their effectiveness.

There were early technical problems with the evacuated tube hot water system that resulted in very poor performance, but these have now been resolved.

There have been a number of problems with the systems controls, or moreover – user awareness of these systems. For example, the manual over-ride allowing clerestory louvres to open during hot weather have been opened by students and staff in cold weather. Automatic closers on a timer could overcome this. Other system problems were a result of users being unaware that they were able to switch heating and ventilation to particular zones. Similarly, radiator controls to individual panels in offices and tutorial rooms, though simple to operate, have not been used to their best advantage.

The building contains a large number of mechanical and electrical systems that provide a valuable educational tool for students. Steven Banbury has observed that students he has assisted in design studios have been designing for a greater variety of localised heating, passive, and naturally ventilated systems, than they had prior to the move to the new building.

The lessons from this building:

- improve the facades by fully insulating, and add insulation to the entire ceiling, not only the ceiling above the second floor studios
- reglaze windows with low-E glass and provide external shading
- increase amount of operable windows and add ceiling fans to increase air movement in the second floor and further assist stack affect cooling
- increase the hydronic underfloor heating (2/3 of the total floor area is heated by heat pumps using only 20 per cent of the building's total energy, 1/3 of the floor area is heated by electric radiant heating using 50 per cent of the total energy).

7.5 The Maintenance Perspective

Despite the design rationale of flexibility, the university's maintenance contractor observed that access to electrical and communications systems for maintenance and future alterations, is difficult. Ceiling and duct claddings are not easily removable and there are few easily accessible voids in which to run new services. (The addition of ventilation ducts to internal rooms has proved to be difficult, confirming this observation.)

High-level lighting to the large three-story volume is beyond the reach of mobile scaffolding or cherry pickers and will make lamp replacement expensive.

8.0 CONCLUSION

The building is very successful. Visitors often express the view that it is an inspirational place in which to study architecture and most students and staff would agree. This has been achieved on a modest university budget, even allowing for the use of expensive mechanical systems and the communications-intensive nature of university buildings; however, the building has not been without some problems. They have primarily been due to commissioning and design shortcomings or to budget cuts.

Some of the problems now experienced were either, expected, and therefore regarded as acceptable or could have been addressed had the budget been larger. Many of the problems experienced relate to the commissioning of the building, and the university's project manager, an experienced mechanical engineer, believes not enough time was allowed for this phase.

Nevertheless, the building is achieving most of the targets set in relation to energy and water. Given the complexity of the mechanical systems, a manual written for lay people, should be provided to users so they are able to maximise their own comfort and minimise energy use. This was not addressed by the educational signage or handover documents and in retrospect should have been specified as one of the deliverables from the design team.

Through this project, the School of Architecture and Design, as a client, has learned or had confirmed the importance of having a strong and sustained vision for the project and one that has ambitious sustainability targets; an informed and responsive team of consultants that works collaboratively from the outset; a capable and experienced building contractor responsive to the project's ambitions; and in the case of a university, the backing of senior management and project managers who in the event of budget pressures do not excise the sustainability components of the project, and who preferably take a life-cycle approach to costing.

Finally, with the best will in the world, not all strategies are successful. The responsibility of the building user/owner is to share the successes and failures with the design community. Published post-occupancy evaluations of building performance and user satisfaction are essential if building performance is to improve.

BIOGRAPHY

Professor Roger Fay is the Head of the School of Architecture and Design at the University of Tasmania. His research focuses on sustainable design, particularly in relation to the environmental rating of buildings and building life-cycle energy, and housing affordability and sustainability. Roger has been published nationally and internationally, and was a member of the team that developed the National Australia Building Environmental Rating System for the Australian Government.

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