major issues
The Centre for Building Performance Research assisted the architects with Suncode thermal analysis and Radiance daylight analysis during the refurbishment of a warehouse into a set of studios and staff offices to be occupied by a School of Architecture and a School of Design. The resulting award winning building has been occupied since 1994. The principal argument for the central atrium was as a source of light and air to the centre of the building. The measurement programme is intended to compare the predictions of the daylight studies with the actual levels of daylight delivered. The opportunity is also being taken to compare users’ subjective opinions about the architecture studios facing the sun on the outside northern facade of the building and the architecture studios exposed only to the sun that comes through the roof of the atrium.
site
The building is located in Te Aro, the warehouse and light industry district surrounding the Central Business District of Wellington. It occupies most of a city block, fronting onto streets on the North, East and West. The major frontage to the North, where the 3 storey high glazed front of the atrium pierces the facade is set back 30m from a major traffic through route behind a public park. The building was a plain reinforced concrete frame 1970's building with grey tinted glass in metal frame windows on the North, East and West. As it is built right up to the boundary to the South, it has no South facing glazing. The top floor was added during the refurbishment and has Evergreen single glazed windows. Apart from the atrium, there is no roof glazing.

site data:
land use urban, mixed use
floor area 14,300m²
footprint/site area 3600m²
floor area ratio 4

building
An Air New Zealand freight depot and the National Archives store were housed in the original building. It was refurbished in 1993/4. The industrial ethic re-design has no false ceilings, exposed ductwork and cable trays. The ground floor was and remains almost totally underground. It houses the workshops. The first floor has an interfloor height of 4.5m and has been almost completely re-glazed. It houses the library, major lecture theatres and admin offices. The second floor and the top floor which was added during the refurbishment have interfloor heights of 4m and house staff offices and seminar and studio spaces. Design analysis demonstrated that winter solar gain into the atrium had the potential to collect up top 40% of the total winter heating requirement, if the roof were fully glazed. In the final design, the potential contribution is nearer 15-20%.

building data:
construction date 1974/1994
building owner Unipol Ltd
architect Craig, Craig, Moller Architects
HVAC engineers Becca Consultants
analysts CBPR, Victoria University
total floor area 13,000
floor are of typical floor 3,300
floor to floor height 4.0-4.5m
floor to ceiling height 3.8-4.3m
number of occupants approx 200
specific total energy use gas:628,098; electricity: 569,200 kWh/yr
heating strategy perimeter: hot water convection units
core: hot water “batteries” in air supply
cooling strategy core: mechanical ventilation to max 5ACH fresh air
insulation: walls: ??
roof: 150mm glass fibre
windows: glazing types: existing windows: (measured visible transmittance) 0.5
new windows: atrium roof glazing: (“evergreen” glazing) visible transmittance
daylighting strategies

The central atrium is 39m long, 8m wide and 17m high. It has large double glazed "lights" which comprise approximately 50% (156m²) of its roof area, in addition to the completely glazed North (facing solar noon) wall. Sunshades are provided over the North windows only on the new top floor. Exterior light shelves were found to be too costly as they would have required a far stronger structure between the strip windows. Angled light shelves are provided in the atrium to improve the availability of light in the top floor offices and studios. The studios on the floor below this have larger windows facing into the atrium to increase their daylight collection effectiveness. The glazing of the new floor and of the atrium is “Evergreen” single glass.
data for selected spaces:

<table>
<thead>
<tr>
<th>Space Type</th>
<th>Floor Area</th>
<th>Depth of Studio</th>
<th>Width of Studio</th>
<th>Floor to Ceiling Height [min/max]</th>
</tr>
</thead>
<tbody>
<tr>
<td>4th year arch studio</td>
<td>250.0m²</td>
<td>13.2m</td>
<td>19.0m</td>
<td>3.0m/4.0m</td>
</tr>
</tbody>
</table>

window and glazing properties: 4th year arch studio:

- Opening Surface:  m²
- Glazed Surface:  28.5m²
- Opening Index:  0.58
- Visible Transmittance:  75%
- Energy Transmittance:  ??% in atrium,

material, colour, reflectance: 4th year arch studio:

- Side Walls:  Paint, White, 89%
- Rear Wall:  Paint, Blue, 23%
- Ceiling:  Corrugated Iron, Silver, 85%
- Door:  Paint, Blue, 23%
- Blind (Interior):  %
- Light Transmittance of Blind:  24%

data for selected spaces:

<table>
<thead>
<tr>
<th>Space Type</th>
<th>Floor Area</th>
<th>Depth of Studio</th>
<th>Width of Studio</th>
<th>Floor to Ceiling Height [min/max]</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th year arch studio</td>
<td>350.0m²</td>
<td>14.0m</td>
<td>25.0m</td>
<td>3.6m/4.6m</td>
</tr>
</tbody>
</table>

window and glazing properties: 5th year arch studio:

- Opening Surface:  m²
- Glazed Surface:  35.7m²
- Opening Index:  0.58
- Corrected Opening Index:  0.5
- Visible Transmittance:  75%
- Energy Transmittance:  ??% in atrium,

material, colour, reflectance: 5th year arch studio:

- Side Walls:  Paint, White, 89%
- Rear Wall:  Paint, Blue, 23%
- Ceiling:  Corrugated Iron, Silver, 85%
- Door:  Paint, Blue, 23%
- Blind (Interior):  %
- Light Transmittance of Blind:  24%

artificial lighting

There is no daylight responsive control system in any studio or office. The larger area studios have pull cord controls for local area switching of the single tube fluorescent luminaires. These luminaires have locally-designed profile 3M silver-coated reflectors, and no diffusers. Circulation lighting in the building is a combination of double compact fluorescent downlights and HID area lighting.

The artificial lighting in the building comprises a broad range of the lamp types currently available: there are tungsten halogen uplighters (1-2kW!) In some admin offices; HID down lights in the entry foyer and atrium; double compact fluorescent downlights and single lamp CFL bulkhead fittings in stairways and upstairs internal circulation areas; large HID lamps in industrial fittings in the general circulation corridors; standard GLS tungsten lamps on dimmers in the two lecture theatres; and a grid of single lamp, bare battens with attached sharp cut-off silver reflectors.

For most of the external offices, and the perimeter areas of the external studios, no artificial lighting is needed during the day. However, all the circulation corridors are fully internal and require artificial lighting all the time, except in the areas near the atrium.

classroom: atrium space (gallery):

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Fluorescent Lamps</th>
<th>Halogen Lamp, 100W / 91W</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlated Color Temperature</td>
<td>2900°K / 3000°K</td>
<td></td>
</tr>
<tr>
<td>Luminaire Used</td>
<td>THORN Mudulight 9507/158</td>
<td></td>
</tr>
<tr>
<td>Luminaire Used</td>
<td>ERCO TM 77646 / 77671</td>
<td></td>
</tr>
<tr>
<td>Installed Power Density</td>
<td>10 W/m²</td>
<td></td>
</tr>
<tr>
<td>Control Strategy</td>
<td>Manual Dimming &amp; Switching</td>
<td></td>
</tr>
</tbody>
</table>

manual switching
monitoring, measured performance

The daylight monitoring system in the School of Architecture Building records simultaneous measurements of illuminance levels (in lux), at one minute intervals, outside with the sensor positioned on the roof, and inside with sensors being positioned in the atrium, and the 4th (3rd professional) and 5th year (4th professional) architecture studios.

Five sensors are positioned on the roof, measuring the horizontal, and North, East, South, and West vertical exterior illuminance. Three sensors are positioned in the atrium, one on the horizontal, located beneath the atrium roof glazing, and two on the vertical, positioned on the windows facing into the atrium from each studio. These sensors are used to determine the percentage of exterior illuminance available for use in the two architecture studios (daylight factor). A further five sensors are positioned in the centre of the daylighting zones in the two architecture studios (figure 9), two in the 4th year and three in the 5th year studio (figure 10). Each of the sensors located in the two architecture studios were fixed at a height of 1 metre and 3 metres apart.

Monitoring:
Winter monitoring period: 19/06/98 - 30/07/98
Spring monitoring period: 14/10/98 - 30/10/98
Summer monitoring period: N/A

Thermal load analyses: SunCODE computational thermal loads
POE studies:
Experimental changes: During the spring monitoring period only two sensors were able to be used in the 5th year architecture studio

Figure 9 daylighting zones

Figure 10 sensor positions
indoor and outdoor temperatures

Figure 11 winter cloudy day (23/06/98)

Figure 12 winter sunny day (20/06/98)

Figure 13 winter intermediate day (24/06/98)

Figure 14 spring cloudy day (19/10/98)

Figure 15 spring sunny day (17/10/98)

Figure 16 spring intermediate day (16/10/98)
winter, daylight and electric lighting energy use

discussion of winter monitoring results,

Figure 17 exterior cloudy day (23/06/98)
Figure 18 exterior sunny day (20/06/98)
Figure 19 exterior intermediate day (24/06/98)

Figure 20 atrium cloudy day (23/06/98)
Figure 21 atrium sunny day (20/06/98)
Figure 22 atrium intermediate day (24/06/98)

Figure 23 studio cloudy day (23/06/98)
Figure 24 studio sunny day (20/06/98)
Figure 25 studio intermediate day (24/06/98)

Figure 26 energy use cloudy day (23/06/98)
Figure 27 energy use sunny day (20/06/98)
Figure 28 energy use intermediate day (23/06/98)
spring, daylight and electric lighting energy use
discussion of spring monitoring results,

Figure 29 exterior cloudy day (19/10/98)

Figure 30 exterior sunny day (17/10/98)

Figure 31 exterior intermediate day (16/10/98)

Figure 32 atrium cloudy day (19/10/98)

Figure 33 atrium sunny day (17/10/98)

Figure 34 atrium intermediate day (16/10/98)

Figure 35 studios cloudy day (19/10/98)

Figure 36 studios sunny day (17/10/98)

Figure 37 studios intermediate day (16/10/98)

Figure 38 energy use cloudy day (19/10/98)

Figure 39 energy use sunny day (17/10/98)

Figure 40 energy use intermediate day (16/10/98)

summer, daylight and electric lighting energy use
discussion of summer monitoring results,

**Performance Data**

discussion of performance data,

real performance no daylight rel. savings

[kwh/month] 0 - 24 h 8 - 17 h 8 - 17h 8 - 17 h

winter 118.9 79.5 104.4 60%
spring 41.0 12.8 104.4 89%
summer 27.8 3.1 104.4 97%

Table 2: Artificial lighting energy consumption of the selected space during one month

<table>
<thead>
<tr>
<th>Zone</th>
<th>Zone 1</th>
<th>Zone 2</th>
<th>Zone 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>winter</td>
<td>70</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>spring</td>
<td>99</td>
<td>97</td>
<td>85</td>
</tr>
<tr>
<td>summer</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 3: Percentage of time during one month between 08:00 and 17:00 when illuminance exceeds the bin illuminance value per daylight zone, for a bin illuminance of 1) 300 lx, 2) 500 lx 3) 1000 lx

Results of step 14 and step 15 to implement protocols; computation of the annual daylighting performance of the space; computation of the daylighting performance of the space for the monitoring phase; (optional)

Table 4: Annual artificial lighting energy savings

Results of step 16 to implement protocols; computation of thermal loads with daylighting and with lights on; (optional)

Table 5: Thermal loads
post occupancy evaluation
presentation of results, 2 pages (only for Green on the Grand, Götz Building, Bayer Building, Wellington School of Architecture)

discussion of the daylighting strategy
this section reflects the opinion of the monitoring team on the daylighting performance of the case study. The following aspect might be discussed:
- attractiveness of the space
- cost/benefit of strategy/measures/devices
- building construction and design issues
- user feedback
- HVAC interaction with daylighting
- application/can it be generalized?
- recommendations (last paragraph): how do we design if we have to do it again?; commission and calibration of the system; how should we run the system
discussion of the daylighting strategy,

figure 20: fisheye photograph of the selected space under sunny sky conditions on june, 21, 12:00
figure 21: fisheye photograph of the selected space under cloudy sky conditions on march, 21, 12:00

persons responsible for monitoring:
name of person(s)
name of institution
address of institution
phone, fax
e-mail
References (if any)
1) auther(s); title; place; year; page(s)
2) auther(s); title; name of periodical; (volume); (number);date of issue; page(s)