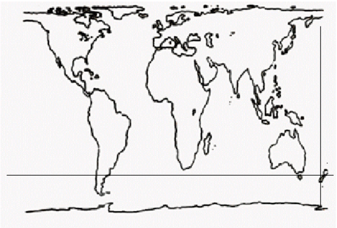
Case Study 13

Schools of Architecture and Design, Wellington

tertiary education institute, New Zealand



	Winter	Summer		
daylight	intermediate,	intermediate,	**climate**	temperate, oceanic

altitude 30m
heating degree days [18°C] °K*d — **cooling degree days [26°C]** 0°K*d
summer solstice [noon] 73° — **winter solstice [noon]** 25°

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
sun shine probability	%	53	55	51	49	40	40	38	42	49	47	49	48	49
sun shine hours	h	234	202	187	153	117	105	105	131	167	185	204	224	2014
sun altitude angle at noon														
temperature, average	°C	16.4	16.6	15.6	13.6	11.0	8.9	8.2	8.9	10.2	11.8	13.4	15.2	12.5
temperature, absol.max	°C	30.1	31.1	28.3	27.3	21.7	20.6	17.2	18.9	20.6	25.1	26.9	29.1	31.1
temperature, absol. min.	°C	4.1	4.7	3.9	2.1	-0.7	-1.2	-1.9	-1.6	-0.6	1.1	1.7	3.4	-1.9
precipitation	mm	81	81	85	100	122	125	139	122	100	106	88	91	1240
wind speed, average	m/s	7.1	6.69	7.22	6.97	7.36	6.86	6.85	6.98	7.61	8.07	7.74	7.68	7.26

Figure 1 Exterior view of the north glazing on the atrium

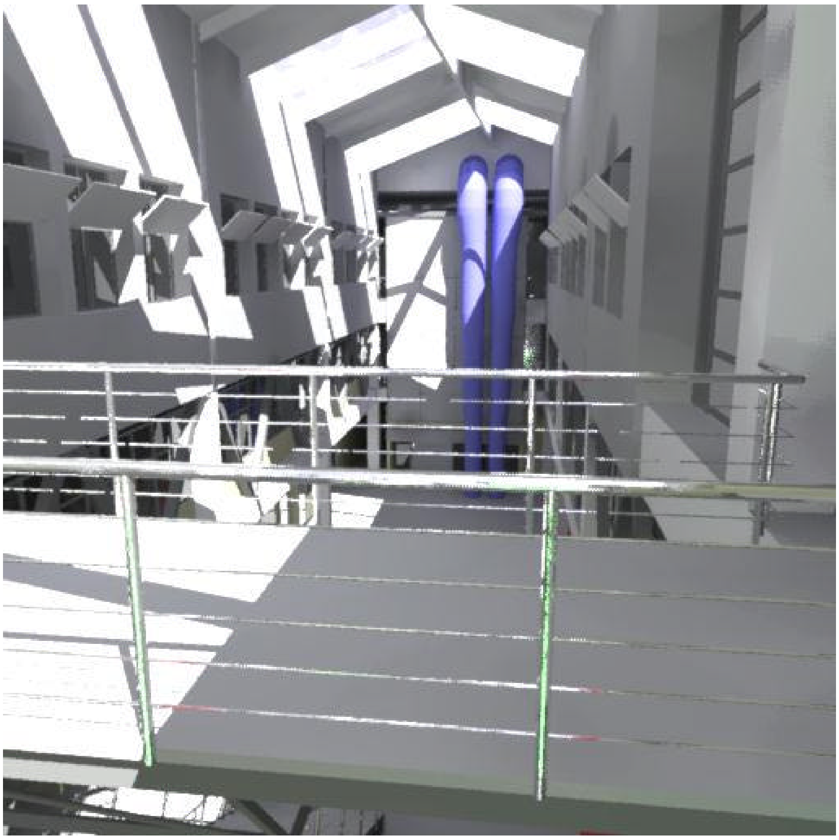


Figure 2 Radiance rendering of the atrium

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	**footprint/site area**	3600m²
floor area	14,300m²	**floor area ratio**	4

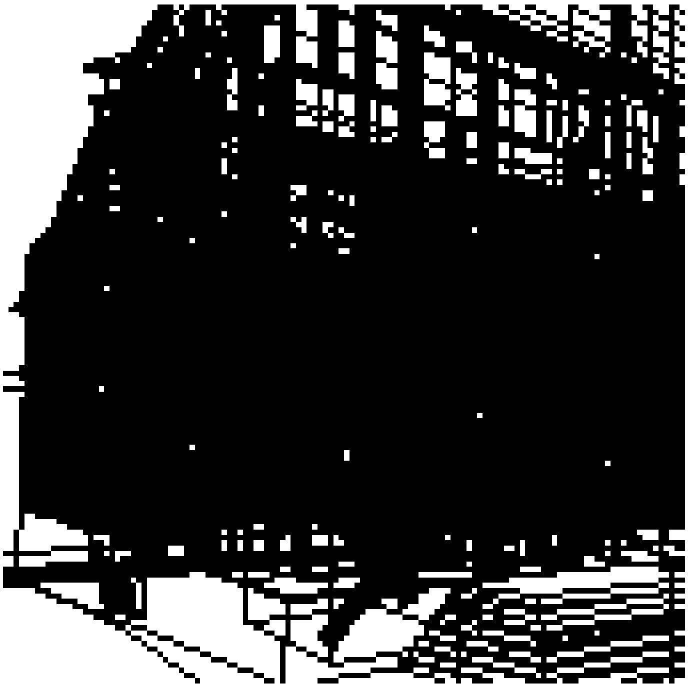


Figure 4 AutoCAD Drawing of front entry

File Contains Data for PostScript Printers Only

Figure 3 Plan; North is to the top of the page

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

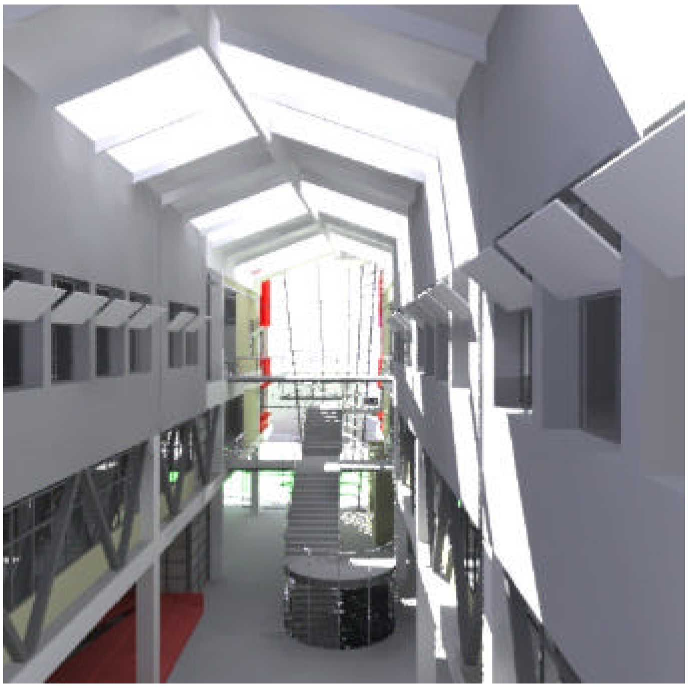


Figure 5 Radiance view of atrium, looking North

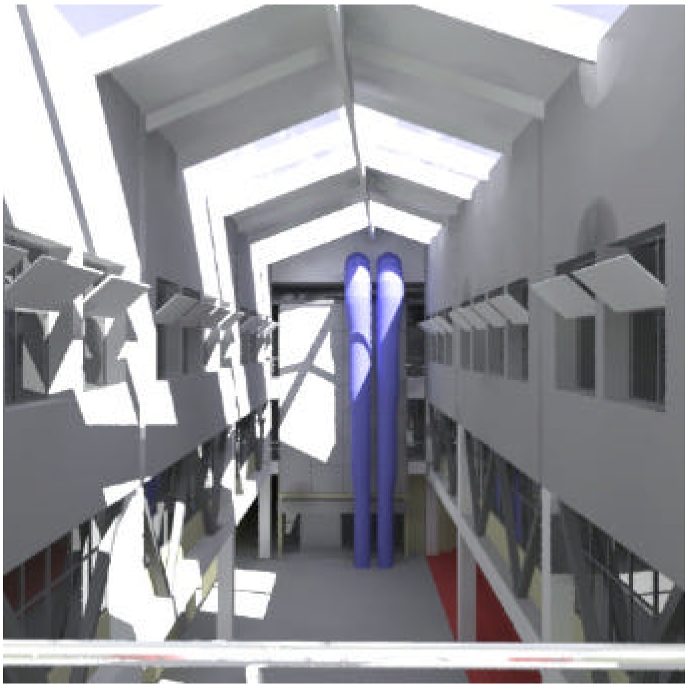


Figure 6 Radiance view of atrium, looking South

Figure 8 Photograph of atrium, facing North

Figure 7 Photograph of interior of atrium: October 1995 2pm

daylighting strategies

The central atrium is 39m long, 8m wide and 17m high. It has large double glazed "lights" which comprise approximately 50% (156m^2) 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:	
floor area of 4th year arch studio	250.0m^2
depth of studio	13.2m
width of studio	19.0m
floor to ceiling height [min/max]	3.0m/4.0m

window and glazing properties: 4th year arch studio:	
opening surface	m^2
glazed surface	28.5m^2
opening index	0.,58
corrected opening index	0.5
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 transmission of blind	24%

data for selected spaces:	
floor area of 5th year arch studio	350.0m^2
depth of studio	14.0m
width of studio	25.0m
floor to ceiling height [min/max]	3.6m/4.6m

window and glazing properties: 5th year arch studio:	
opening surface	m^2
glazed surface	35.7m^2
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 transmission 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 arefully internal and require artificial lighting all the time, except in the areas near the atrium.

classroom: atrium space (gallery):
lamp type fluorescent lamps **lamp type** halogen lamp, 100W / 91W
correlated color temperature 4000 °K **correlated color temperature** 2900°K / 3000°K
luminaire used THORN Mudulight 9507/158 **luminaire used** ERCO TM 77646 / 77671
installed power density 10 W/m^2 **installed power density** xx W/m^2
control strategy manual dimming & switching **control strategy** 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

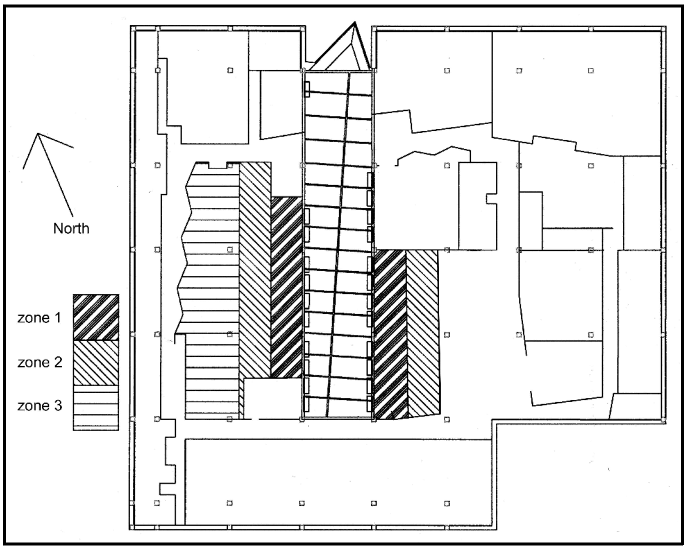


Figure 9 daylighting zones

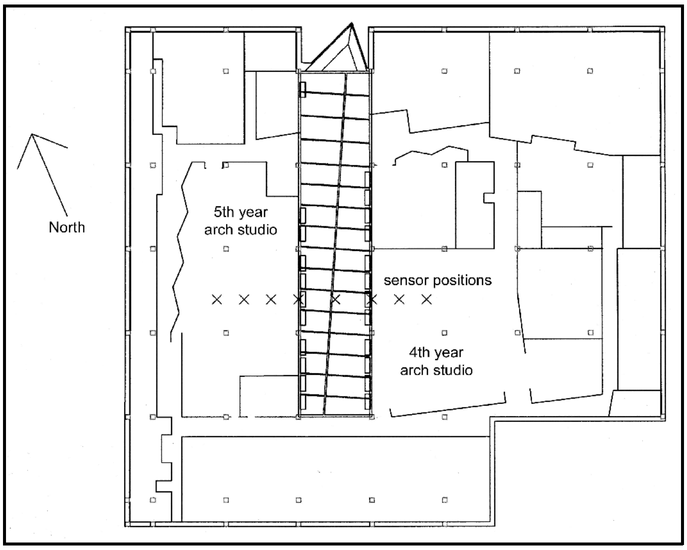


Figure 10 sensor positions

indoor and outdoor temperatures

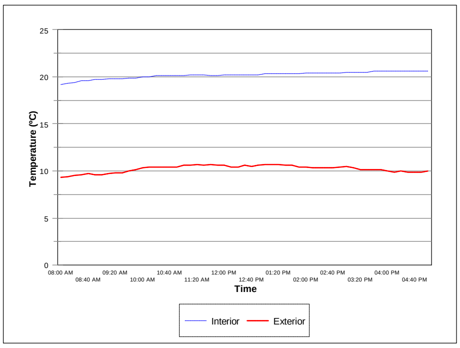


Figure 11 winter cloudy day (23/06/98)

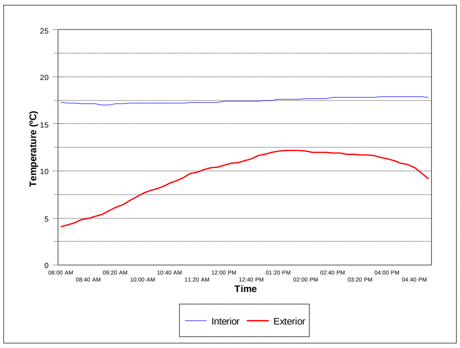


Figure 12 winter sunny day (20/06/98)

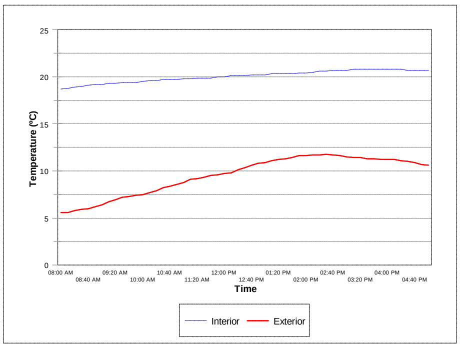


Figure 13 winter intermediate day (24/06/98)

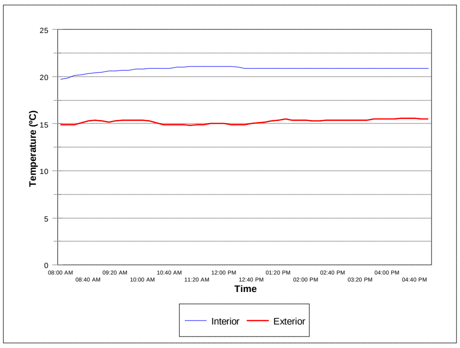


Figure 14 spring cloudy day (19/10/98)

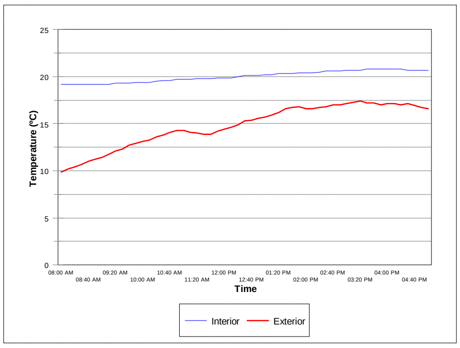


Figure 15 spring sunny day (17/10/98)

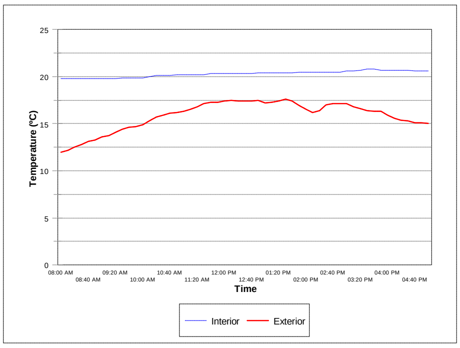


Figure 16 spring intermediate day (16/10/98)

winter, daylight and electric lighting energy use

discussion of winter monitoring results,

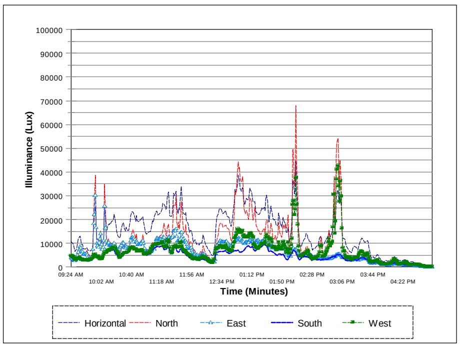


Figure 17 exterior cloudy day (23/06/98)

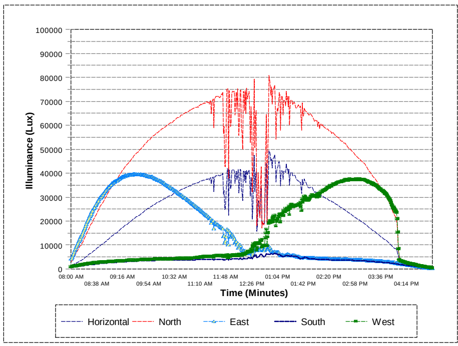


Figure 18 exterior sunny day (20/06/98)

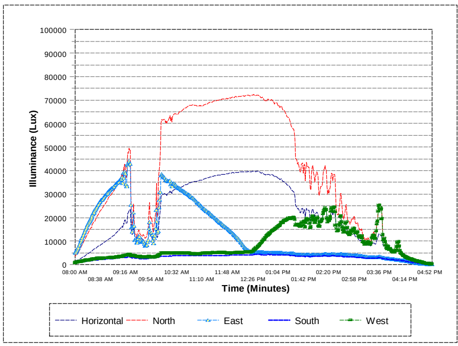


Figure 19 exterior intermediate day (24/06/98)

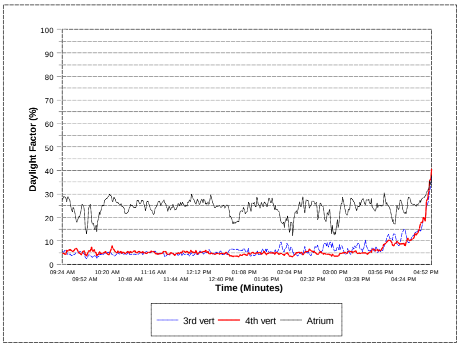


Figure 20 atrium cloudy day (23/06/98)

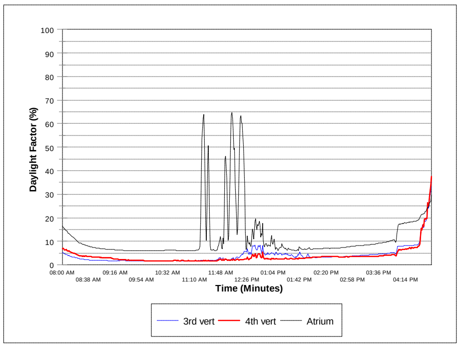


Figure 21 atrium sunny day (20/06/98)

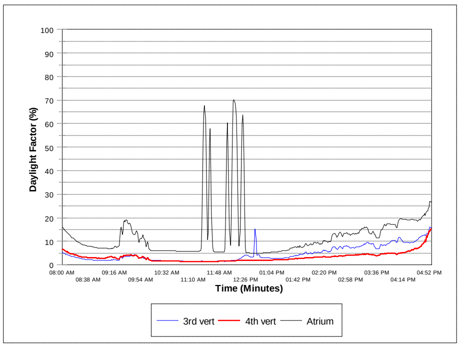


Figure 22 atrium intermediate day (24/06/98)

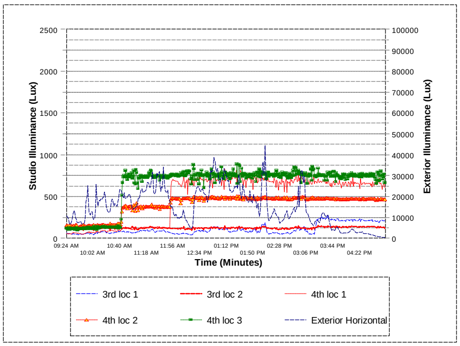


Figure 23 studios cloudy day (23/06/98)

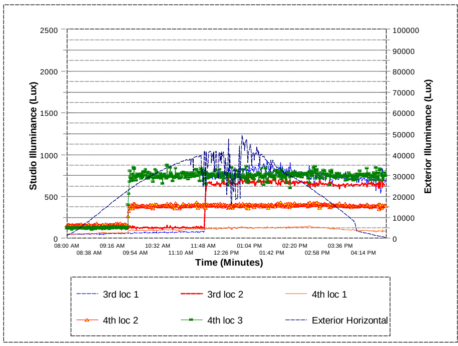


Figure 24 studios sunny day (20/06/98)

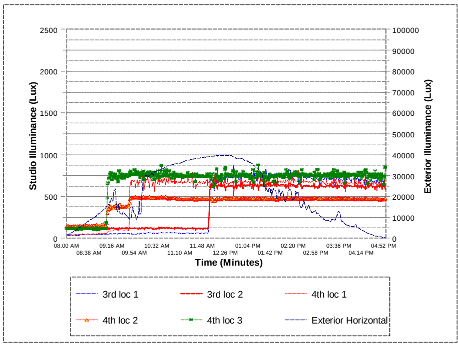


Figure 25 studios intermediate day (24/06/98)

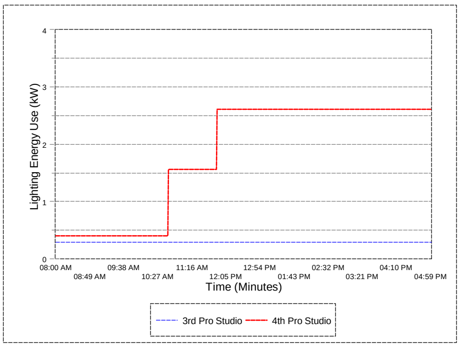


Figure 26 energy use cloudy day (23/06/98)

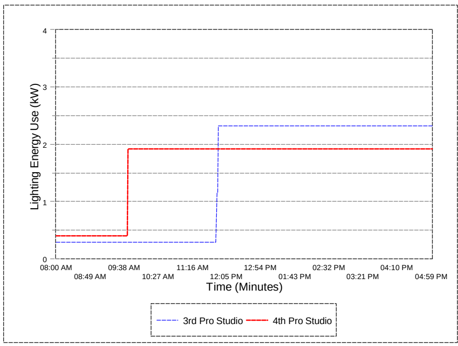


Figure 27 energy use sunny day (20/06/98)

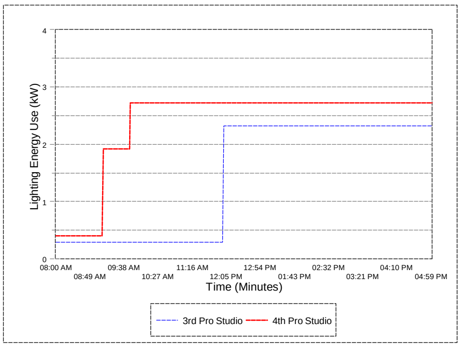


Figure 28 energy use intermediate day (23/06/98)

spring, daylight and electric lighting energy use

discussion of spring monitoring results,

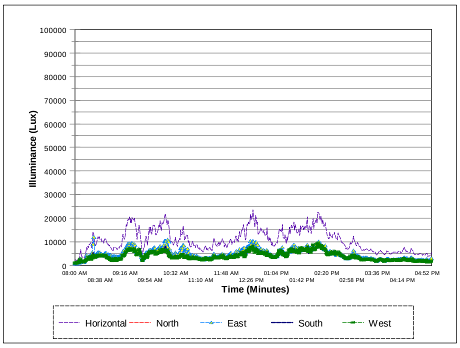


Figure 29 exterior cloudy day (19/10/98)

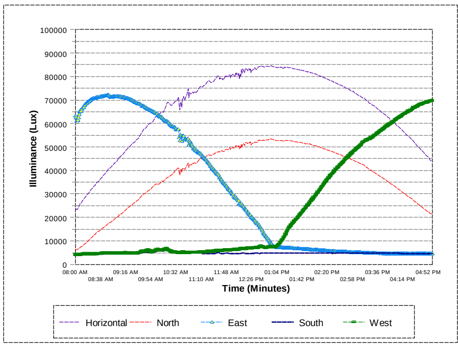


Figure 30 exterior sunny day (17/10/98)

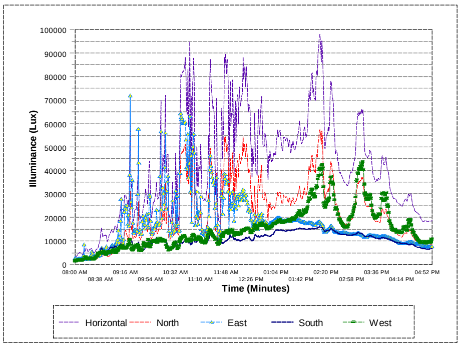


Figure 31 exterior intermediate day (16/10/98)

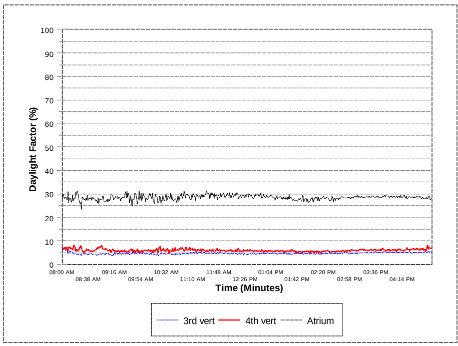


Figure 32 atrium cloudy day (19/10/98)

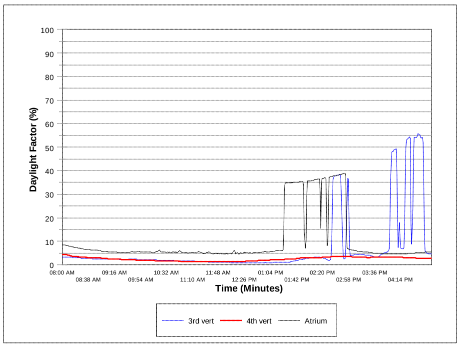


Figure 33 atrium sunny day (17/10/98)

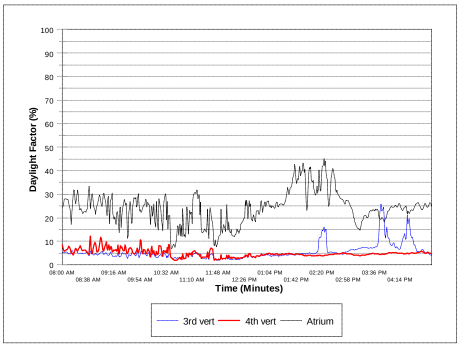


Figure 34 atrium intermediate day (16/10/98)

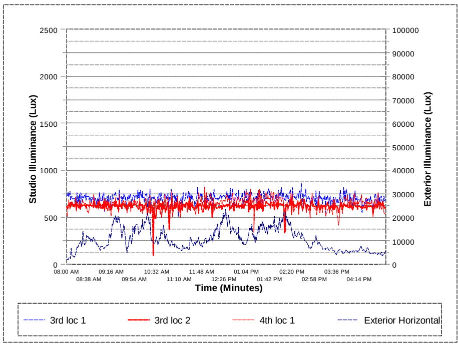


Figure 35 studios cloudy day (19/10/98)

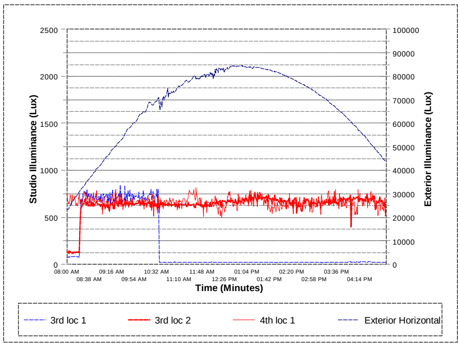


Figure 36 studios sunny day (17/10/98)

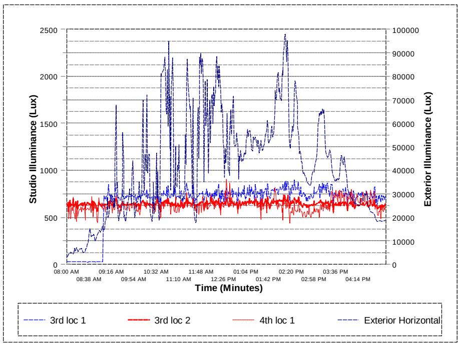


Figure 37 studios intermediate day (16/10/98)

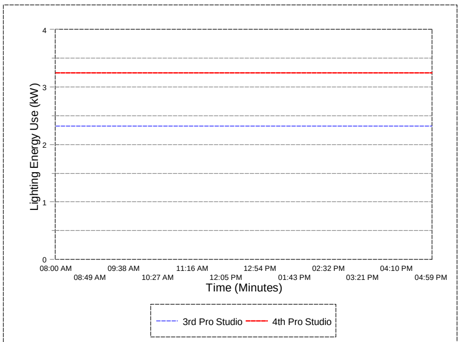


Figure 38 energy use cloudy day (19/10/98)

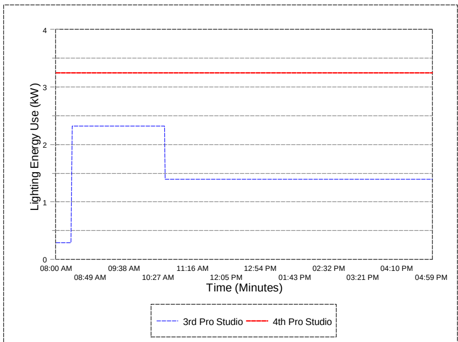


Figure 39 energy use sunny day (17/10/98)

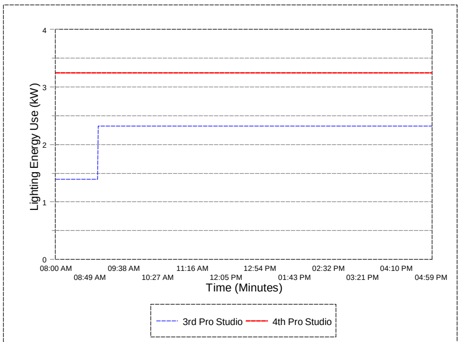


Figure 40 energy use intermediate day (16/10/98)

summer, daylight and electric lighting energy use

to be added to be added to be added
to be added
cloudy spring day [??.??.98]
to be added
sunny spring day [??.??.98]
to be added
intermediate spring day [??.??.98]
to be added
cloudy summer day [??.??.98]
to be added
sunny summer day [??.??.98]
to be added
intermediate summer day [??.??.98]
to be added to be added to be added

figure 18: spring monitoring results

figure 19: summer monitoring results

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

	Zone 1			Zone 2			Zone 3		
[%]	1	2	3	1	2	3	1	2	3
winter	70	60	40	60	50	30	50	40	20
spring	99	97	85	99	95	80	90	70	70
summer	100	100	100	100	100	95	100	95	90

table 3: percentage of time during one month between 08:00 and 17:00 when illuminance exceeds the bin illuminance value per daylit 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)