Solar angles

Lindsay Johnston investigates the positives and negatives of solar gain in a Melbourne educational and office building.

There is, perhaps, a romantic notion among ‘green’ architects that the epitome of sustainability and user satisfaction in an office building is working spaces with opening windows and fresh air. This was exemplified in Europe by Ton Albers’ NMB Bank headquarters in Amsterdam, completed in the 1980s. The converse is a perception, among people like me, that in Australia and other hot climates, an unprotected and sealed glass-walled building, with no physical sun control and no openings, is a ‘no, no’.

Post-occupancy evaluation research currently in progress at the University of Newcastle questions whether non air-conditioned office spaces, with purely natural ventilation via user-operated opening windows, are a realistic and acceptable proposition in the moderately hot and humid climates of the Sydney region. The indications are, through preliminary results using PROBE user surveys, that user satisfaction is not being met in buildings that do not have summer air conditioning, even though they demonstrate best current practice in the design of natural passive ventilation and cooling.

It is, therefore, interesting to examine the design and subsequent performance of this building in Melbourne, the recent recipient of the 2002 RAIA Victorian Chapter ‘Sustainable Architecture Award’, which, at a preliminary glance, manifests a quite uncompromising north facing all-glass wall, with no hint of sun control devices.

Born perhaps under controversial planning circumstances, Building A of the University of Melbourne, designed by Metier 3 Architects, is in Carlton a few kilometres north of the Melbourne CBD. It is one of three major new buildings that, along with the new landscaped piazza over a subterranean car park, form University Square. Across the street to the north is the university campus, to the west there are large hospital buildings, and on the east side are four two-storey period terrace houses which have been retained, restored and integrated into the development. This facility has been unoccupied since its completion and, at time of writing, was still awaiting occupation by the university.

Building A is another example of an innovative building for a university client. [The majority of *ar* ESD case studies have been on educational buildings.] The view is that universities are long-term building owners and operators, interested in the life cycle operation of their buildings, in contrast to city commercial developers who are focused on short-term financial return. The good news is that ‘smart’ clients, developers and investors are now recognising that energy efficiency and ‘green’ branding are marketing advantages – ‘doing well by doing good’.

The building was developed by Equiset on behalf of the University of Melbourne. The brief required a combined teaching facility, with high quality office space incorporating key elements of environmentally sustainable design, within the defined budget. The building area of 17,200 square metres is on nine levels and consists of lecture theatres and teaching spaces on the ground and first floor, with six levels of office space plus a plant room over, and a basement level with services and access to a new car park under, the adjoining pedestrian plaza – also designed by Metier 3.

Building A, University Square.
University of Melbourne, Carlton VIC
Metier 3. Architects

Lindsay Johnston. Review
Tim Griffith, Aaron Pocock.
Photography

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Climate: At latitude 37.8˚S, Melbourne has a temperate coastal climate with warm dry summers and cool wet winters. Winter mean dry bulb temperatures in July are 9.6˚C with maximum of 16.2˚C and minimum of about 0˚C. Summer mean dry bulb temperatures in January are 20.3˚C with minimum 11.7˚C and maximum a high 38.1˚C. Temperatures in the 30s are experienced from December through to March. Annual rainfall averages 650mm per year, with between eight and 14 rainy days per month.

Orientation: The visually powerful architecture of Building A is responsive to orientation. The building is broader on the east–west axis, presenting a long northern facade to Grattan Street. This north facade bends back at the top plant room level and accommodates photovoltaic panels facing north at 27˚ to the vertical. This functionally derived formal strategy drives the strong visual dynamic of the east and west gable elevations. The latter respond to their respective orientations. The east facade picks up the rhythm of the retained terrace houses in an external shading grid and a secondary core is located to the west, contributing to the beneficial reduction in west-facing glazing.

Sun control: On the uncompromising all-glass north facade, which returns onto the west and east elevations, there are no external sun control devices above podium level. Retained mature deciduous trees at street level protect the lower levels of the north elevation. Their shade is supplemented by fixed external horizontal blades at ground and first floor levels. The hot west facade is closed down through large areas of externally insulated solid wall and reduced window areas, with one deep inset multi-level balcony recess screened to some extent by a feature projecting vertical blade. The east facade is layered with a large framed grid of blades and ledges sitting outside the glass curtain wall and this, along with deep recesses, gives some shading from hot morning summer sun. The south elevation, above podium level, continues the large blade and ledge grid on a smaller scale and reduces unwanted penetration of early morning and late evening summer sun. The key questions are whether the high performance glass in the north facade can do the work and whether a physical sun control system that could have eliminated perhaps 50 percent of the heat gain on the north elevation would have been a more effective option?

Insulation: Keeping heat in an office building in Australia is not as critical as it is in cold climates, as the solar gains and heat emanating from users, lighting and electronic equipment gives inherent internal warmth. Interestingly, however, energy demand modelling done for this building by Arup showed that there will be a higher energy demand through the winter months than in summer months. Wall and roof terrace insulation is provided at R1.5 (the same as a normal house) and main metal roof insulation is provided at R2.5. Particular emphasis was also given to the air-tightness of the external facade system and air-locks have been incorporated at all entrances. The double-glazed facade reduces heat loss achieving R0.55 to R0.63, particularly beneficial on the south elevation in winter (normal single glazing is a negligible R0.17). Double glazing, in itself, has little beneficial effect on summer heat gain due to radiation from outside – it is the heat-rejecting glass that does the work (see below).

Thermal mass: This multi-level structure with concrete frame, core and floors, has good levels of thermal mass that can, if used effectively, moderate the fluctuations in internal temperatures relative to diurnal external temperatures. Active night purging of the structure in summer, using cool outside night temperatures to chill down the thermal mass, is a desirable option if this is built into the routine HVAC program. Externally derived winter heat gain, beneficial in residential buildings, is more difficult to control in an office building due to problems of local solar heat and glare in perimeter locations where people still have to sit at work. Big areas of thermal mass in west-facing walls are partially shaded by horizontal shelves and form part of the secondary core, allowing dissipation of unwanted summer afternoon heat into staircases and ducts.

01 Detail of the photovoltaic panels in the upper levels of the north-facing facade.

02 The new building has a dramatic presence on the university campus, though dwarfing the existing terrace houses on the east.


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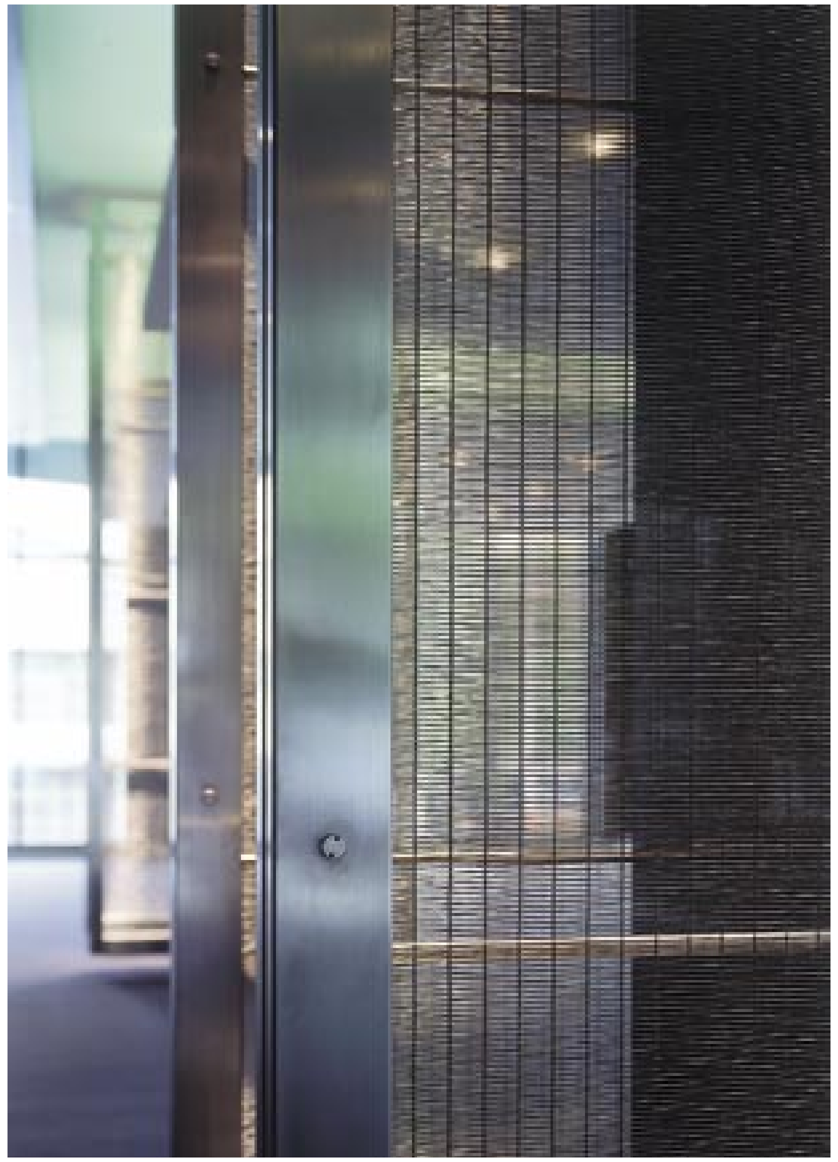
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Glazing: The thermal, energy and, ultimately, greenhouse emissions performance of this building is largely down to the performance of the glass and its relative impact on energy required for lighting and cooling. The glass and double glazing is of two types: higher performing ‘Glaverbel Stopray Ocean’ to the north facade and the wraparound sections of the east and west facades, and ‘Glaverbel Stopray Elite’ to the rest. These glasses are known as ‘low E’ (low emissivity) as they reflect long wave radiation and ‘emit’ low levels of radiated heat into the building. Glazing cavities are air filled (not argon filled). With glass selection, the crucial relationship is between admission of desirable daylight and exclusion of undesirable solar heat gain – a difficult balancing act. Clear single glazing has a VLT (visible light transmitted index) of 0.88, letting in 88 percent daylight, and an SC (shading coefficient) of 0.95, which lets in 95 percent of solar thermal heat gain. Reflective double glazing can cut the SC down to levels as low as 0.10 (eliminating 90 percent of heat gain), but in turn can reduce the VLT, admitting only 10 percent daylight, thus necessitating high artificial lighting demand and associated energy consumption. The ‘Stopray Ocean’ glass has an SC of 0.23 (admitting only 23 percent of solar heat gain) and a VLT of 0.34 (admitting 34 percent of daylight). The ‘Stopray Elite’ glass has an SC of 0.44 and a VLT of 0.67. This strategy allows more daylight into these shaded or south-facing areas while improving insulation.

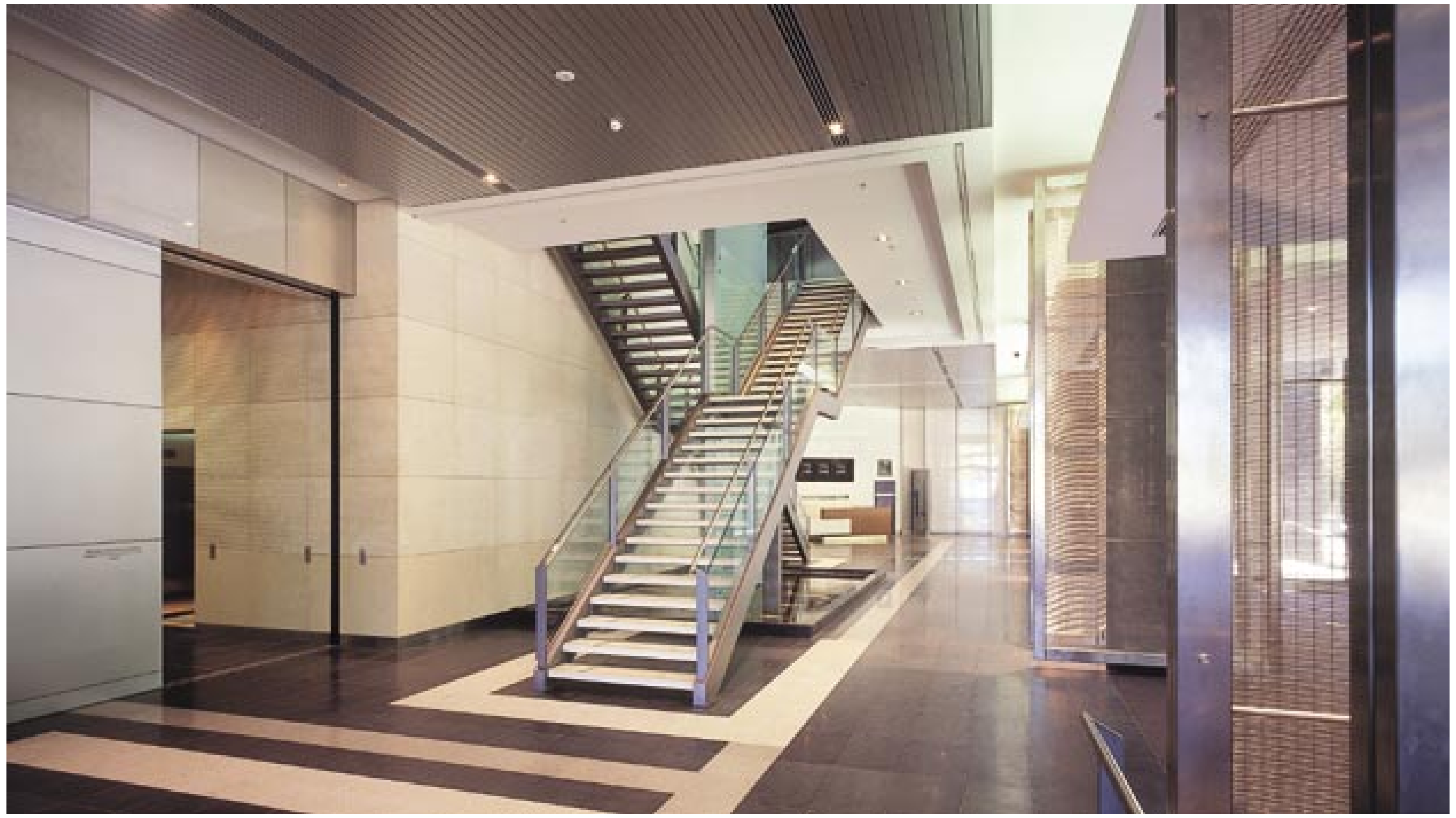
Lighting: A high performance T5 lighting system throughout the building, with low loss, continuously dimmable electronic ballasts, allows automatic fine-tuning control using photocell sensors that dim or switch off lighting to maintain a working 350 lux as daylight levels fluctuate. Separate perimeter circuits allow this lighting to respond differently to perimeter and deep locations within the office floors. Light output from fluorescent tubes falls over time, and this system of sensors allows initial light levels to be automatically cut back over the first year or more of use. The building management system has movement sensors in all the teaching areas, which switch off the lights after a period of non-activity. All these strategies have significant benefits in reducing energy consumption and cost.

Heating and cooling: The HVAC is a low-pressure system that incorporates outside air economy and variable speed drives – all of which is standard in a building of this type. Depending on the internal load of people and equipment, it is estimated that conditions are available in Melbourne to allow the system to run 25-30 weeks of the year on untreated outside air, with another 20 weeks with partial benefit. The HVAC system is on occupancy sensors, which switch off areas not in use. Teaching areas have CO2 sensors that cut in fresh air when CO2 levels rise (and students start nodding off to sleep).

Water: With an average annual rainfall of 650mm, it is estimated that about 600,000 litres of rainwater per year can be harvested from the roof area of 1053 square metres and used for toilet flushing, giving about 200,000 flushes from dual flush cisterns. Rainwater storage capacity is 5500 litres in two corrugated copper tanks in the roof plant room, with a total capacity of about 11,000 litres, half of which is kept topped up with town water.

03 The glass-clad north facade defies all accepted ESD principles.
04 The east elevation with University Square in the foreground.

05 Material selection does not necessarily reflect attention to embodied energy.



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Materials: Attention to issues of embodied energy in materials selection (energy required to extract, make, transport and place materials) does not appear to have been a priority and materials are largely as you would find in any commercial building, including some imported luxurious marble veneers. Low embodied energy wool carpet, with no off-gassing concerns, has been selected in preference to synthetic, but potentially recyclable, options.

Energy consumption: Arup was engaged during the design stage as ESD advisers and conducted a comparative assessment of two design and specification options, which looked at variables such as glazing specification, lighting design, insulation levels and some other relevant features. This analysis considered 'whole of building' (owner and occupant) energy demand under a range of assumptions and idealised conditions. A potential 25 to 30 percent annual energy and cost saving was identified by implementing key environmental efficiency strategies. Simpson Kotzman, services consultants, indicate that the cost of upgrade of the facade to 'low E' double glazing was paid for by reduction in the capital cost of the plant and associated equipment. It is not possible to correlate the energy and GGE (greenhouse gas emissions) performance of this building to the new ABGRS (Australian Building Greenhouse Rating Scheme) which is, of course, only for office buildings. My 'back-of-the-envelope' calculations, based on idealised figures prepared by the design team, suggest energy consumption and resultant GGE levels would be at the low end of the spectrum at 150-170kgCO2e/sq.m/year – that would probably gain the office component of the project a four to five star rating under the ABGRS bands for Victoria. As the building has been unoccupied, there is no real data yet available to validate its performance. It should be noted that these performance 'guestimates' are derived from the design and specification characteristics of the building before the on-site energy production from the integrated photovoltaics is considered.

Solar energy production: A major feature of the building is the inclusion of 426 square metres of photovoltaic panels located in the sloping top two levels of the north-facing facade. This was 50 percent funded by a grant from the Australia Greenhouse Office. Using a standard facade fixing system, polycrystalline solar cells have been laminated into heat-strengthened glass panels and integrated into the cladding. These can be seen from, and admit light into, the roof plant room. The angle from the horizontal of 63˚ is not ideal – 38˚ would be ideal for Melbourne – this reduces their output effectiveness by about 10 percent. It is significant to note that the output from these PVs represents only about 2.5 percent of the total estimated building demand. Annual production from these panels is projected by Arup at 40,000kWh (about 0.24kWh/sq.m of panel/day), which I calculate would save about 50tonnesCO2e/annum, equating to the emissions from six average Australian homes or the planting of about 5000 young trees.

Conclusion: Is this building a 'green' building and worthy of the accolade of the Sustainable Architecture Award? It appears that the building will perform at a 'best practice' level relative to city commercial buildings, and should deliver a high level of user comfort to its eventual occupants in a 'no compromises' controlled environment. Its main positive features are its reasonable response to orientation, its high performance facade, its efficient services systems, its integral inclusion of a large area of photovoltaic panels and its collection of roof water for toilet flushing. On the question, 'Is an all-glass, sealed, no sun control, north facade acceptable?' – the balance of expert opinion is that, under current energy cost conditions, that are almost certainly not paying the true environmental cost of their production, the 'no external sun-shading' option is the most cost/energy effective in the Melbourne context at this time – loathe as I am to say – and the building will probably perform at a four to five star emissions rating level with regard to GGE. However, as Barney Foran, author of the very important recent CSIRO report 'Future Dilemmas: Options to 2050 for Australia's Population, Technology, Resources and Environment', has stated, we may now need to be considering 10 star buildings for the future. Perhaps future RAIA Sustainable Architecture Awards should be pushing harder for more radical solutions?

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06 The entrance foyer.

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