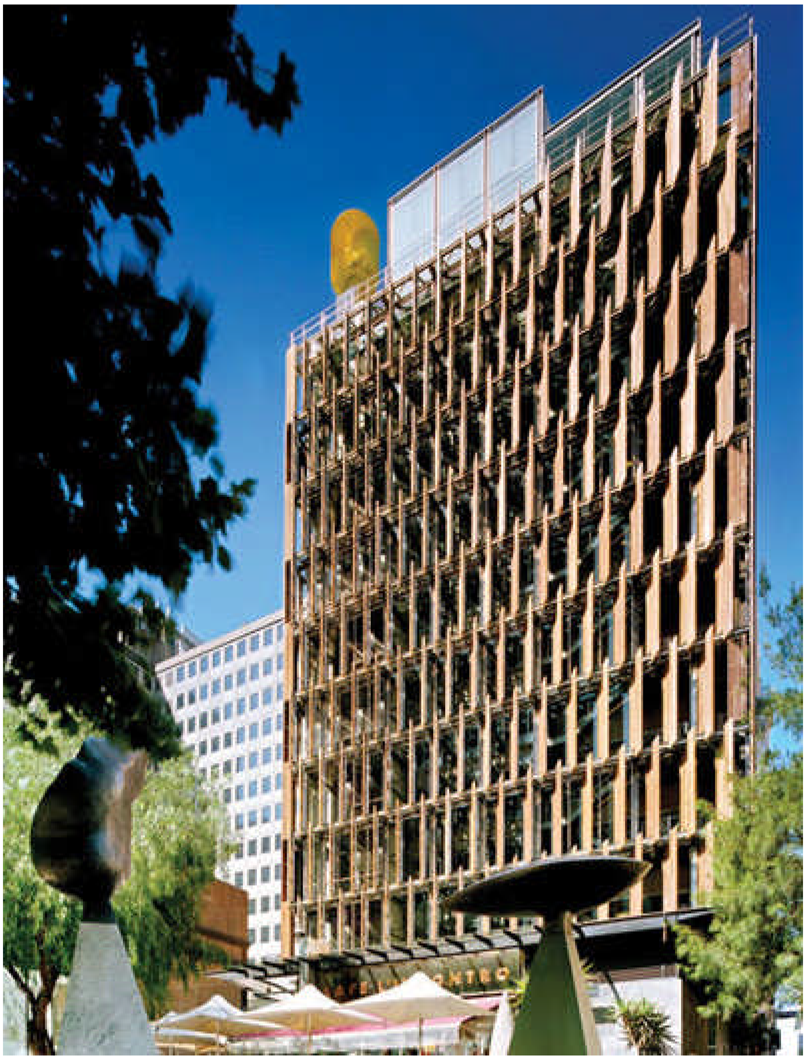
The Council House 2 (CH2) building



The collaboration between two Australian firms on Melbourne's new Council House 2 shows off the design possibilities for building-integrated HVAC.

The city of Melbourne intended CH2–the Council House 2 building, which opened in August 2006–to exemplify the best of high-performance, sustainable design as a model to other Australian cities. The 10-story, 135,000-square-foot city office building, which occupies a dense block adjacent to an existing city building in the heart of Melbourne, incorporates a number of radical strategies, like sewer mining for nonpotable water and the use of phase-changing materials in lieu of conventional chillers for cooling water. But it's the integration of these performance strategies–particularly in the building's mechanical systems–with the architecture that makes CH2 stand out as a case study, even for less ambitious projects and designers.

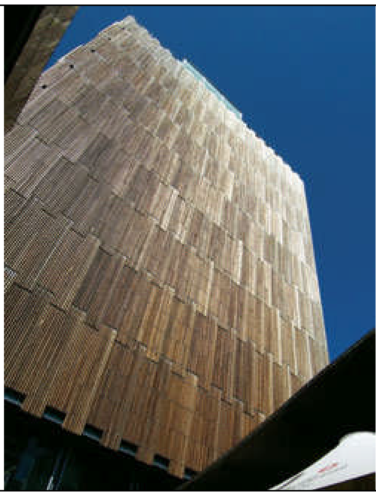
Melbourne has long been considered a hotbed of architectural experimentation, a distinction that is waning, much like the diminished visual shock of the landmark Federation Square designed by Lab Architecture Studios that opened in 2002 [record, June 2003, page 109]. This penchant for wackiness is lately being replaced by a more overt expression of sustainable design, such as in Grimshaw Architects' naturally ventilated Southern Cross rail station [record, May 2007, page 243] and, just as visibly, in CH2, designed as a collaboration between DesignInc's Melbourne office and Sydney-based engineers Lincolne Scott. It's as if the designers of the Southern Cross and CH2 projects sought to fuse the city's past obsession with form-making to a more recent concern: climate change.

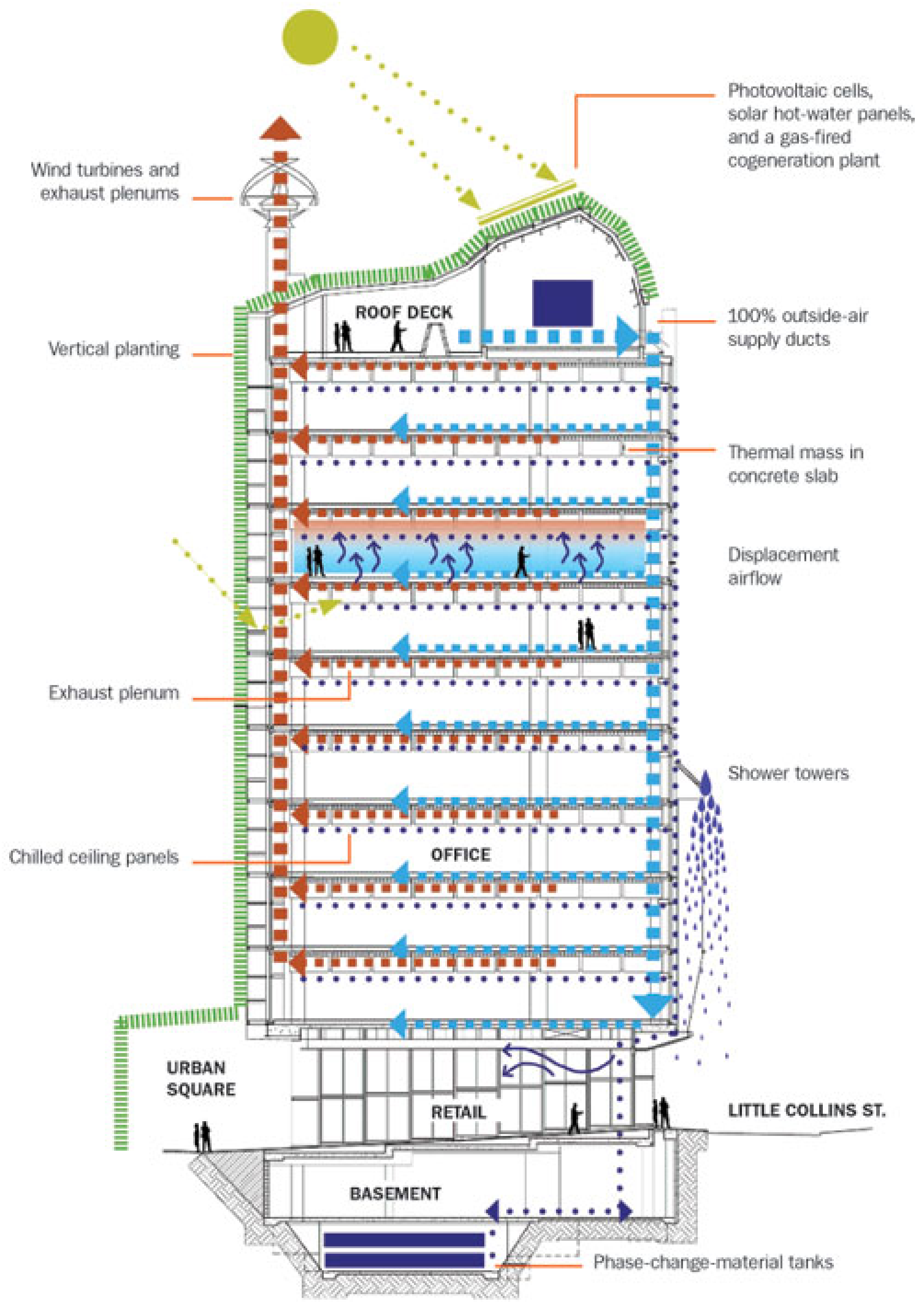
The Nature of Architecture

It's probably safe to say that the average architect doesn't think much about atmospheric pressure cells, let alone competing cells moving counterclockwise that can completely alter a city's weather in the course of half an hour. Melbourne architects complain that, due to such atmospheric conditions, the city experiences all four seasons in one day.

DesignInc's Mick Pearce saw opportunities in these circumstances for the design of CH2. Pearce has long adhered to a philosophy of biomimicry, whereby artificial systems–like those in a building–are designed to "mimic" the processes of nature. The biologist Janine Benyus, who Pearce knows well, documented such things in her book Biomimicry: Innovation Inspired by Nature (1997).

Pearce implemented the approach with his design for the 1996 Eastgate building in his native Harare, Zimbabwe–a building long-considered a landmark in sustainable design. That naturally ventilated office building relied on basement rock piles as thermal storage for free cooling in a building designed to mimic an African termite mound. "We're beginning to see a whole new science of biological design," says Pearce. "It's much closer to the thinking that goes into a zoo than an office environment." He connected with the CH2 project through his friend, Rob Adams, who, as Melbourne's director of city design and urban environment, is largely credited with championing the high-performance design goals of the building. And thanks to Adams's advocacy, CH2 is the Green Building Council of Australia's first Six Star office building, which is roughly equivalent to LEED Platinum.





As the sun drifts west, the timber panels slowly close. The phase-change-material tanks in the basement are part of the comprehensive HVAC strategy for the CH2 building.

The diagram developed by DesignInc illustrates how fresh air supplied from the roof circulates from the south side and down through the building before it exhausts through ducts integrated into the north side of the structure. A roof deck provides an up-close view of wind turbines. - Photos © Russell Fortmeyer

With CH2, Pearce and his colleagues at DesignInc sought to implement similar strategies employed at Eastgate, but within the requirements of Australia's version of a Class A office building. "Our climate analysis showed using thermal mass would work well, but Melbourne's pressure cells cause an interval of about three days between hot and cold periods," Pearce says, explaining that rock piles would have needed to be extremely large in order to store heat or cool long enough. "This three-day period is what we exploited with the design. The challenge was to go for serious thermal mass, as well as good thermal storage."

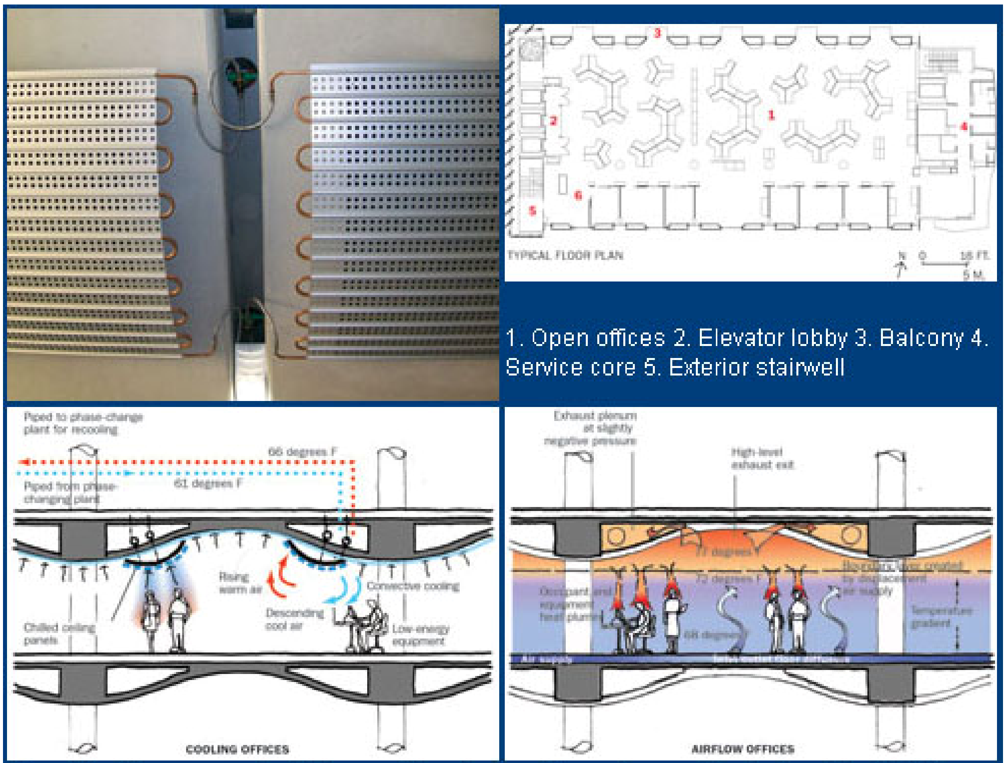
From the street, the three most public facades on CH2 actively convey this environmental message: hydraulically controlled recycled timber shutters on the west side automatically open and close depending on the sun's position; balconies with planter boxes on the north shield windows; and the south is defined by fresh-air shafts integrated from the roof down, set behind five so-called "shower towers" that act as exposed cooling towers for the mechanical system.

DesignInc had devised a preliminary scheme that called for tearing down an existing building adjacent to CH2's site, but they scrapped the idea based on the recommendation of the engineers at Lincolne Scott, who were brought in to help rethink the project. Over a three-week charrette in 2003, which included city representatives, architects, and engineers, among other interested parties, the team developed a schematic design incorporating many of the strategies eventually realized in CH2.

Ché Wall, managing director of Lincolne Scott and its Advanced Environmental Concepts group, says that "after the charrette, we had 85 percent of the engineering design done." But he adds that the more riskier items were isolated in the design so they could be replaced by conventional strategies in case they failed to perform as expected.

The original plan for CH2 called for a naturally ventilated building, but Wall says once it became clear that the building would need to meet the highest standards for occupant comfort when compared to commercial offices in the local market, they decided against natural ventilation because of noise and air-quality concerns in the busy central business district location.

Instead, to maintain 75 degrees Fahrenheit in the building, the designers embraced a combination of passive and active HVAC systems. This meant the floor plate–with a width of nearly 69 feet–was not as narrow as originally proposed (a narrow floor plate assists in cross-ventilation), but it also meant the designers needed to take a more holistic view of how the HVAC systems would be integrated into the structure and architecture.



1. Open offices 2. Elevator lobby 3. Balcony 4. Service core 5. Exterior stairwell

The chilled beams consist of copper tubes looped through a metal structure (top left). The tubes tie into chilled water supply and return lines running in the cavities behind the precast-concrete panels. The slot between the panels is also used for lighting cabling. In passive mode, fresh air is supplied from the floor only (bottom right). In active mode, the chilled beams operate and cool down the air supplied from the floor (bottom left).
Photos © Russell Fortmeyer

The Sum of All Parts

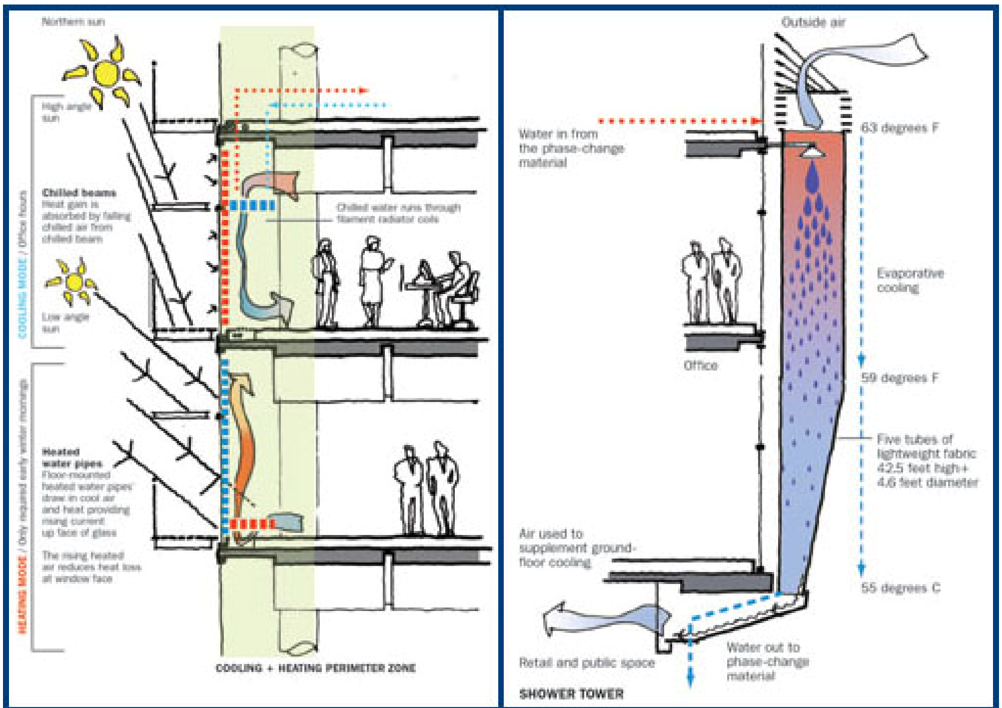
The success of that integration is felt every day. Consider an operational profile of the building on a warm day–Melbourne's temperatures average 80 degrees F in January–as experienced by an occupant sitting at her desk in the open office plan of the sixth floor. The building's concrete structure, poured with 30 percent fly ash, and its wavy, 7-inch-thick precast-concrete ceiling panels both cool down when windows automatically open from 1 to 6 a.m. to allow in night air.

This lowers the office's temperature 4 to 5 degrees and is directly responsible for a 14 percent energy savings for cooling. The ceiling is wavy for two reasons: first, to increase the surface area of thermal mass, and second, to create cavities used for exhaust air. Wall says they researched laser etching the concrete ceilings to double the surface area, but it proved too expensive (although, analysis showed it would have significantly improved the thermal properties). However, the ceilings are sandblasted, which does increase surface area.

Once the occupants arrive in the morning, air-handling units on the roof kick on and supply filtered, 100 percent outdoor air to cast-concrete ducts running down the building's south elevation. These ducts tie into the 6-inch, pressurized cavity of the raised floor on each level. "That's quite tight compared to most access floors," Wall says, a decision he says was made in order to preserve market-rate floor-to-floor heights of nearly 10 feet.

The air, which is treated for humidity depending on the wet-bulb temperature of the outdoor air, enters the space via floor-mounted, user-controlled "twist" diffusers at each workstation.

This cool air heats up and rises through the space and, induced by the stack effect, is pulled into slots along the ceiling panels and into cavities where it exhausts into shafts designed into the north elevation. These shafts exhaust through rooftop-mounted wind turbines. Matthew Jessup, a principal at Lincolne Scott, says computational fluid dynamic (CFD) modeling–and, now, postoccupancy studies–illustrate that this combination of night flushing, thermal mass, and mechanically supplied fresh air has been more than enough to keep occupants cool the entire morning and, on milder days, well into the afternoon.



In the winter, rooftop solar water heaters contribute hot water to the mechanical system?s perimeter heating units (bottom of left image). During warmer months, chilled beams integrated into perimeter light shelves cut down on heat gain from sunlight (top of left image). On the south side of the building, five ?shower towers? provide additional cooling to water for the mechanical system (right).
Photos © Russell Fortmeyer

During warm afternoons, however, the building shifts from a passive mode (where outside air is simply moved around) to an active mode that depends on mechanical cooling. The most novel aspect of CH2, in this respect, is the use of radiant panels attached to the underside of the precast-concrete ceiling units. Mechanical engineers like to call this a "chilled beam" or, in some cases, a "chilled ceiling." Long a solution embraced in Europe, chilled beams have yet to significantly catch on in the U.S. or Australia. For a conventional installation, the beams, which are basically metal tubes, are filled with chilled water supplied by a central chiller. "Using water as a medium for cooling is much more efficient than moving cold air around the building," says Wall.

At CH2, the beams are supplied with chilled water from two sources: an innovative phase-change-material-based storage tank in the basement and a more conventional rooftop central plant consisting of a gas-fired cogeneration plant. Phase-change materials (PCMs) are natural compounds, generally salt-based liquids, that collect and then release energy.

This typically occurs from a liquid to solid state and vice versa. PCMs are basically a more efficient version of ice storage, where engineers have taken advantage of cheap energy at night to make ice, which can then be melted during the day to provide chilled water to a building. And it’s much more efficient when compared to Pearce’s original concept of using rocks for thermal storage.

The chief benefit of PCMs is that they have a significantly higher freezing temperature (around 60 degrees F) than other substances, which means water returning in the loop system via evaporative cooling towers needs to be cooled less than usual. Although HVAC systems using PCMs have been installed in the U.S., they are relatively uncommon anywhere. At CH2, the 30,000 PCMs–they look like baseballs–divided among the basement’s three tanks can be used 80 percent of the year.

Otherwise, the chilled beams rely on the rooftop chiller and cooling towers during peak loading conditions in summertime, which is typically the last 2 hours of the work day. The architects supplemented the cooling towers with so-called “shower towers,” which act like public art anchored to the south elevation. The towers are 40-foot-high, 5-foot-diameter vertical shafts of ETFE material with a shower head installed at the top and a glass catchment basin at the bottom.

The towers provide chilled water to the mechanical system (cooling it nearly 10 degrees F), while also cooling the air for ground-floor retail spaces. Wall says the towers cool water much more efficiently than the CFD analysis originally indicated. At night they glow like five tubes along the column lines, while water cascades across the glass basins.

Pearce likes the way the towers add to the building’s dynamism–the moving wood panels on the west side, the spinning rooftop turbines, and the sway of the plants on the north side–all sustainable signposts meant to engage the city’s residents.

The sewer-mining system is one of CH2's more innovative sustainable strategies. Raw sewage is brought into the building directly from an adjacent sewage line (above left). From there, physical matter is filtered out and "flushed" back into the sewer system (above right). The water is then cleaned by a multistep process involving what amounts to a mini-sewage-treatment plant (bottom right). The cleaned, nonpotable water is then used throughout CH2 for flushing toilets, irrigating plants, and for make-up water in the mechanical system. Australian plumbing code, like its American counterpart, requires nonpotable water to be in lavender pipes (bottom left).
Photos © Russell Fortmeyer

The description of CH2's mechanical system can make it sound easy to accomplish, but many nuanced considerations and details are required to make it work. For one, Wall says they had to install chilled beams at windows to cut the heat load from sunlight but were able to incorporate the beams into light shelves that could be used to control daylighting.

A common concern regarding chilled beams and ceilings is condensation, a topic that raises Wall's ire. "As an engineer, I find this topic hugely annoying because we only have to maintain indoor humidity between 40 and 60 percent," he says. "In a museum, you need 45 to 50 percent humidity, so anyone saying you can't do a chilled beam in this city is saying you can't design a museum." Since CH2 isn't naturally ventilated, the facade was designed to be relatively airtight, helping to prevent condensation problems (the HVAC system also offsets high humidity when the windows open for night purging). All of this is monitored with the building management system through 2,500 probes and control points located throughout the structure. So far, the mechanical system hasn't had major problems.

By far, the most challenging aspect of the building's systems has been the unusual sewer-mining plant in the basement. This system draws nearly 12,000 gallons of raw sewage per day from the city's drains, filters out the physical waste, and then treats the water through a series of high-tech components. Coupled with a rainwater collection system, the mining plant supplies all of CH2's nonpotable water requirements, including the HVAC system. Eventually, it's hoped that the plant will feed nonpotable water back to the city for fountains and irrigation, as the system is designed to handle 26,000 gallons per day. "This system uses one-third the energy of a desalinization plant," Pearce says, in sly reference to political plans afoot for such a plant in the Melbourne area, a region long-plagued by drought.

From Energy to Occupancy

The designers and the client for CH2 all stress that while energy and water savings are worthy goals, the comfort of the occupants is the ultimate reason for the environmental strategies deployed in the building. Pearce says a hallmark of the Australian attitude toward sustainable design in offices is equity–thus, an occupant on the top floor would have a similar environmental quality as one on a lower floor. At CH2, windows narrow toward the upper floors and widen toward the lower, so intense daylight at the higher offices will appear similar to lower floors. To ensure equity, DesignInc and the city are working with the London-based postoccupancy expert Adrian Leaman, with the Usable Buildings Trust, on statistically gauging occupant satisfaction with the work environment in the next several years.

John Williams, a director in DesignInc's Melbourne office, says the city has invested so much into CH2 in hopes that it could influence the development of subsequent buildings, including housing, that involves city government. The city projected a 4.9 percent increase in effectiveness for the staff of 540 employed in the building, which translates into nearly $1 million in annual savings. Seeing those goals through was always Pearce's aim. He says he "likes to come to a place, build a building, and stay there afterward to make sure it works." He adds, "That's the only way you can find out about your own profession."

By **Russell Fortmeyer** (Architectural Record)