

A NEW DAWN FOR THE SOUTHERN CROSS

A massive urban renewal project in Melbourne celebrates the golden age of rail and heralds the rebirth of public transport with a grand piece of infrastructure.

By Jason Bryce



Photo courtesy of John Gollings

Design and build a massive, unique and iconic civic structure over an urban transport hub and do it while 940 trains and 50,000 people travel through your work site every day.

That is the boiled down essence of the brief for Melbourne's Southern Cross Station project.

Oh, and did we mention that we need it quickly? We're hosting the Commonwealth Games and

thousands of visitors will start arriving around about the time of completion.

By the way, we are using that controversial public infrastructure funding framework called the "public-private partnership" (PPP) so expect plenty of attention from all sorts of media.

You'll need to source plenty of skilled labour during a severe skill shortage caused by Australia's resources boom while dealing with the friendly

comrades from the railway unions as well as the CFMEU (building workers).

And just for your information, it is a historic site that has been used continuously for 150 years.

We don't know much about what lies underneath it, or even where the electrical wiring, plumbing and other utility services actually are in the existing structure.

Despite all the complexities, and many of those issues led to significant delays and cost overruns, there can be no denying that from the urban decay that was Spencer Street Station has risen a modern architectural and engineering masterpiece.

In less than four years, the renamed station has become an airport-style transport hub celebrating the excitement of the golden age of rail.

For visitors to Melbourne, Southern Cross Station is now an appropriately memorable gateway to the city long recognised as Australia's cultural and sporting capital.

Background

The site has been the terminus of the state's suburban and regional rail network and the administrative headquarters of public transport in Victoria since 1859. It links the train system to the metropolitan tram and bus networks, but divides the CBD from the adjacent Docklands.

Originally named Batman's Hill Station, the station sits adjacent to the site of the original homestead of John Batman, founder of the city of Melbourne. A major development in the early 1890s was the completion of a railway viaduct

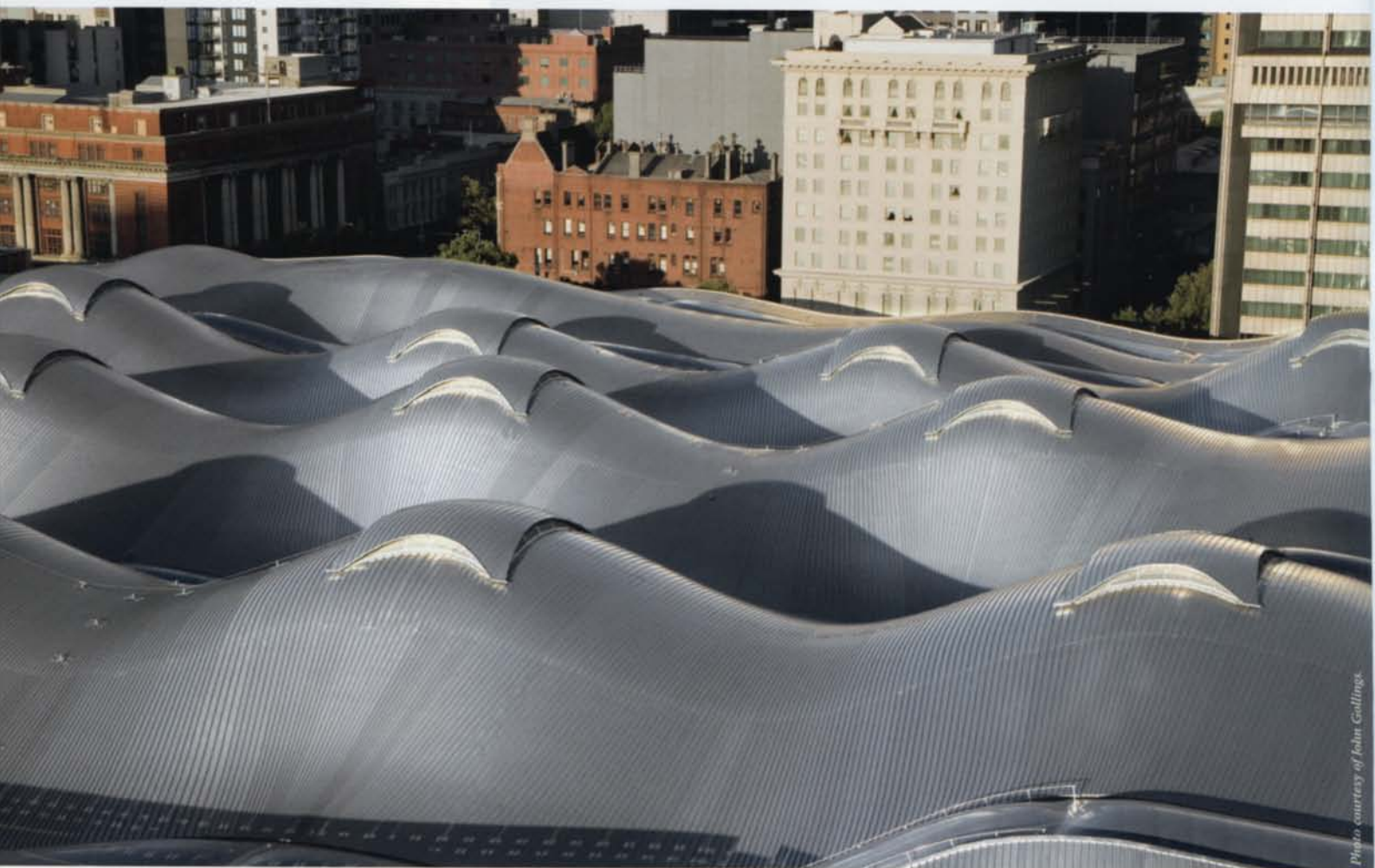


Photo courtesy of John Gullings

linking Spencer Street and Flinders Street Stations.

In 1915, with the electrification of the Melbourne metropolitan rail system, the viaduct was duplicated providing four tracks between Spencer Street and Flinders Street.

Over time the station fell into a state of neglect as the private car took centre stage in the transport system of the city. The last redevelopment of the site in the 1960s simply hid the tracks and platforms behind an unimaginative (even ugly) office block.

The station, the viaduct and the track easement was an effective barrier between the CBD and Docklands, from the northern bank of the Yarra River. As a result, the urban environments on both sides had suffered.

Nevertheless the station is an integral part of the Victorian and Australian rail network and part of the heritage of the nation. Any development on the site not only had to cater for huge expected population growth, but capture and add to this history. The government also wanted the site to link the city to the Docklands and river as it invested in a massive urban renewal project for Docklands.

When it first opened on 13 January 1859, citizens were granted a public holiday to watch the first train depart for Williamstown. When the redeveloped Southern Cross was completed the current government made almost as big a fuss.

Covering 13.5 hectares, featuring Australia's largest undercover concourse and costing upwards of \$700 million this was a major project in every sense of the word.

"Everybody who worked on this project will always look back at Southern Cross Station with an enormous sense of achievement and pride," Mark Scorer, Leighton Contractors' General Manager, Southern Region told the media in 2006. "What they created in the face of enormous challenges was exceptional."

Concept and design

The main feature of the new station is its spectacular wave-form roof, comprising a series of 'moguls' that reach up to 24 metres above platform level. The roof covers an area of 37,000

square metres, including 7000 square metres of flexible skylights.

That giant hall is largely enclosed by massive glass façades. At either end of the platforms are raised concourses that align with Bourke and Collins Sts. Those concourses provide pedestrians with straight through access, over the tracks, from the city to the Docklands.

"It was a conscious decision that the roof form should be subservient to the city grid as it moves westwards across towards Docklands," said Keith Brewis, architect and director of Grimshaw and Project Director of the Southern Cross Station project.

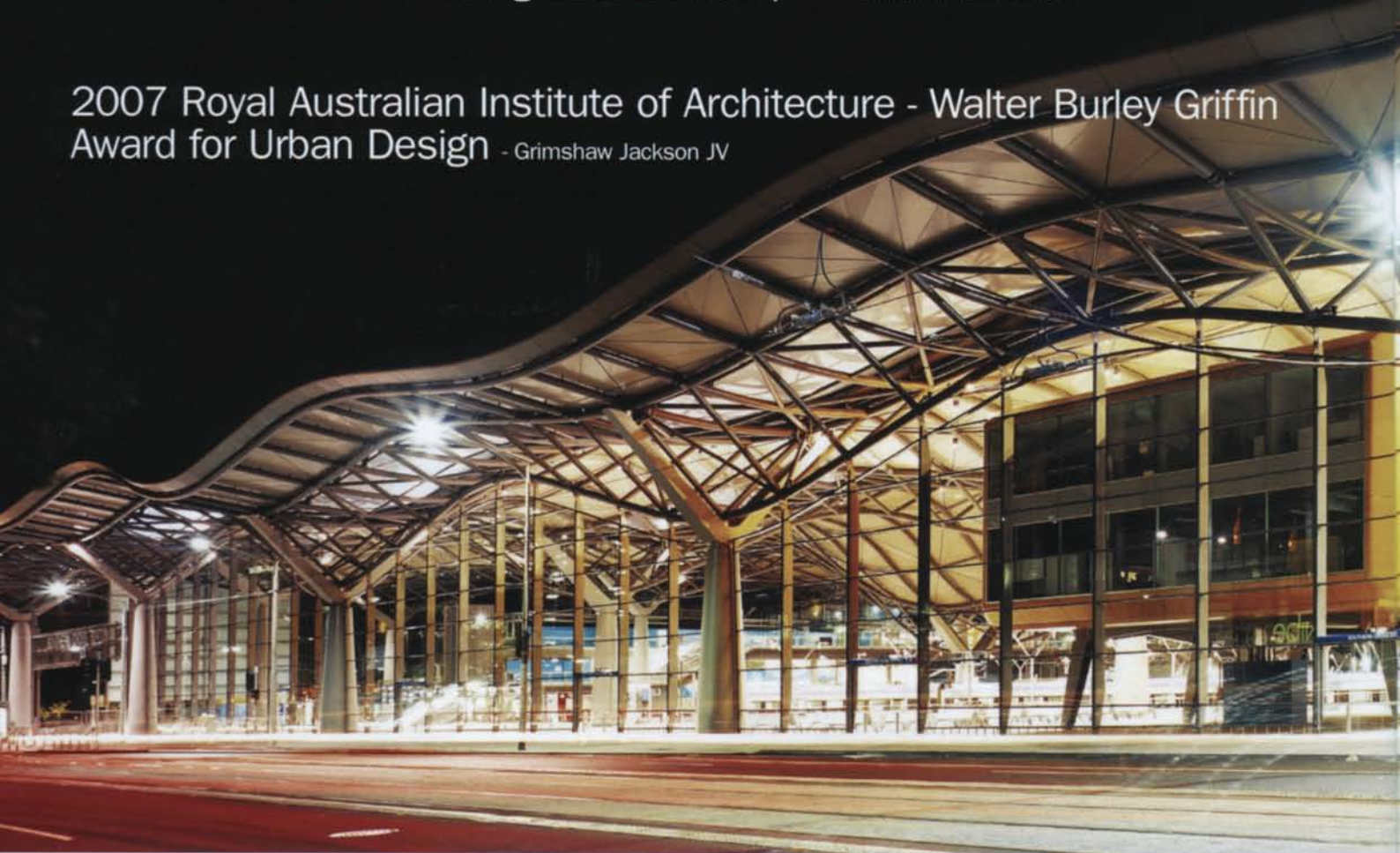
The architectural design work was a joint venture between British firm Grimshaw, which was fresh from redeveloping London's Waterloo

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This powerful conflation of old and new, people and trains, structure and light make the Southern Cross station a worthy winner of this year's Lubetkin Prize - RIBA

2007 Royal Institute of British Architects – Lubetkin
Award “Best new building outside Europe” - Grimshaw Jackson JV

2007 Royal Australian Institute of Architecture - Walter Burley Griffin
Award for Urban Design - Grimshaw Jackson JV



“ The new Southern Cross Station in central Melbourne shows how successful urban design can contribute significantly to the public and civic realm of a city. The project had to respond to the functional, operational and logistic needs of the station, but it was also critical to linking Melbourne’s central city grid with the rapidly expanding Docklands precinct. – RIBA Jury

International station to cater for the cross channel railway, and Melbourne firm Daryl Jackson.

Jackson was largely responsible for the development north of Bourke St, comprising the bus station, car park and retail mall, while Grimshaw led on the main railway hall featuring the wavy roof.

However the roof was not the first design feature decided upon. The Victorian state government demanded a transport interchange that could grow with the city over the next 50 – 100 years. Brewis said that is achieved largely by dispersing commuters to the outer edges of the site, rather than funneling them into congested tunnels or internal pathways as the old station did.

“It can make sense to congest people for clarity or for retail purposes but in this kind of application it is better to disperse them,” said Brewis “That is really just good practice.”

“Once we had persuaded the client to rework some of the platforms, we could quite easily develop the raised concourses and the street level concourse along Spencer St which really aids this disbursement,” he adds.

“A by-product of that disbursement is that it brings activity to the areas surrounding the site.”



Photo courtesy of Shannon McGrath.

The concrete filled steel pillars that support the roof structure are spaced about forty metres apart in both east-west and north-south directions. Those large distances give flexibility to change track alignments and platform configurations underneath the roof relatively easily.

The concourses sit just on top of the electric lines above the tracks, with the roof eight metres above that. The height of the roof, upon entering from the raised concourses, give the building a sense of grandeur, said Brewis.

Upon entering from street level on Spencer Street, the traveller is presented with a giant concourse that extends the length of the structure and through to the regional train platforms.

"Along Spencer Street we really tried to blur the difference between in and out extremely," said Brewis "So the movement from the pavement to the concourse is almost unperceivable, other than you pass through a glazed screen.

"The same concept was used at the Collins St and Bourke St ends, except they are on the raised concourse level."

At the southern Collins St end, a low rise commercial office block is planned to sit on the concourse level. That project will begin in 2008.

At the northern end is the bus terminal, car

park and retail mall. That northern development was part of the Southern Cross project and joins almost seamlessly to the northern concourse, but is very different in appearance and user experience to the main railway hall under the wavy roof.

It would be fair to say, as some bloggers on design websites have, that travelers arriving by bus to Southern Cross don't get the grand and inviting architectural greeting that train commuters get. Buses arrive into a cement cavern largely removed from daylight and the surrounding environment.

Most buses coming into Southern Cross come directly from the airport and arrive approximately every 10 minutes, so there are significant numbers of visitors missing out on Melbourne's grand new gateway.

However that will change in the future, as two extra platforms have been added to provide for a future rail link to Tullamarine airport.

The roof itself was born from the architects' vision of a grand, open railway hall in the nineteenth century European tradition. Stations such as Paddington and Kings Cross in London provide views across the site and, according to Brewis,

give commuters a feeling of calmness, community and safety.

"Coming into the station, you know intuitively where you need to get to," said Brewis "so you hardly need signage, and raising people above and into the daylight makes people calm."

That European railway tradition is typically realised with huge barrel shaped halls ventilated at the apex to remove polluted air. The problem with that concept was that the architects had previously decided upon the disbursement strategy using large open concourses on three sides connecting seamlessly with the surrounding built environment.

"The barrel vault forms of the European railways work well if there is a single concourse at one end, and they obviously worked very successfully to remove the smoke and soot from the steam trains as prevailing winds swept over the top, sucking out fumes.

"But what we would end up with if we used that form at Spencer St was trapped diesel fumes going up to the roof form, tracking longitudinally along the top of the barrel, then cooling and dumping down onto the concourses at the ends."



“The roof trusses were a three dimensional shape with curves on all three axes. It was a challenge to fit up all the pipe to pipe connections with some nodes having up to six elements connecting together all fully welded and, at the same time, maintain the overall dimensions of each truss unit. A series of complex jigs were designed to provide accurate assembly as each completed truss needed to fit exactly into the required position. It should be noted that the ramifications of an incorrectly fitting unit would have been catastrophic – ASI

The other consideration was that the government had requested that commuters and railway administrators be given a comfortable air conditioned space.

Brewis said the architectural team, that numbered about 30 at the peak of the design phase, decided that pumping large volumes of air into a huge sealed hall was environmentally inappropriate and wanted to build a naturally ventilated structure.

“So we had to adjust and modify the nineteenth century railway roof form to a three dimensional series of elongated domes which hold the hot contaminated air in a reservoir high above the passengers.

“Then we used both thermal gradient, (ie: hot air rises) and differences in air pressure to push air out of the station.”

That process is aided by the prevailing south westerly and north westerly winds creating pressure differences over the roof and sucking the air out.

The roof is comprised of three layers and in between the external roof and the ceiling panels visible from below is the reservoir of polluted air.

Compact pods within the main structure house the administration offices and are air conditioned.

The surrounding built environment also demanded respect said Brewis. That was achieved by developing the roof in a plane 16 – 24 metres above street level.



“In delivering the biggest railway upgrade in Victoria in 120 years, Leighton Contractors and the Southern Cross project team had accomplished a complex and difficult feat that will be applauded for many years to come.

– Master Builders Executive Director, Brian Welch

“The beauty of that is it works really well with the old civic character of the Spencer St area, particularly the Savoy and Grand Hotels. Those kind of buildings had a civic façade of four or five storeys, say 15 to 16 metres in scale, and the roof respects that.”

Perhaps unfortunately, some of the older buildings in the immediate vicinity of the station have subsequently been taken down as the area regenerates, but the Savoy and the Grand remain.

In awarding the Lubetkin Prize for Architecture to Grimshaw, the Royal Institute of Architects wrote:

“These roof elevations are often private fantasies for the architect, but here, surrounded by high-rise buildings, the upper surface becomes a topography that is visible to everyone. The view down on to it is lovely.

“Grimshaw made a strong façade to the existing city and pushed high level access fingers out into the new zone. He worked around the existing tracks to make a big, rangy urban space.”

Photo courtesy of John Gollings.

“2007 Royal Australian Institute of Architects (RAIA) Victorian Architecture Awards - Architecture Award for Urban Design

– Grimshaw Jackson JV

Build and construction

After the concept had been finalised, the roof had to be designed with the operational needs of the station firmly in mind. The government had decided that the major platforms would not be realigned and that the station would remain open for business while the work was underway.



Photo courtesy of John Gollings

Therefore roof design had to address four crucial requirements:

- 1) The roof had to be erected in sections during short down periods and at night.
- 2) Each erected section had to be rigid and stable without using temporary props, especially over track areas.
- 3) Each section had to allow the construction teams to demobilise quickly at the end of a shutdown period and remobilise again at the start of the next period.
- 4) Platform space used by construction activities had to be minimised.

Daily co-ordination with the railway operators was therefore critical to Leightons, the lead builders, and did lead to delays.

"It was apparent as soon as we got on to the project that there was no real arrangements in place between government, the train company and our team to facilitate easy access," said McCutcheon. "All that had to be negotiated on an ongoing basis from start to finish."

To minimise disruptive crane lifts, sections were prefabricated into the largest practicable sections possible.

There are 29 columns supporting the roof. The major spines of the structure are supported by Y shaped columns fabricated from steel plates and filled with concrete. They sit in the middle of alternate platforms and cradle the spine trusses in the ears of the Y shape.

Each major column had to be independently rigid enough to withstand lateral forces along the truss direction and transverse to it before the entire structure was connected together.

Wind tunnel testing on a 1:400 scale model of the roof was carried out at Melbourne University, producing averaged and localised pressure distributions. Engineers from Winward Structures used those results to design the final structure.

Connecting the spine truss in the saddle point of the columns was complex and problematic. The original concept was a three point pin connection, one at the crutch of the Y and two at the top of the column ears.

Lining up the three pins within holes oversized by just 2mm proved impossible due to fabrication

tolerances, deformation during transport and erection and thermal movement.

An architectural pin connection was used instead. This involved large steel billets being shaped and fitted to the spine trusses, then welded to the column arm on site.

The columns rest on a fixed base in the form of a rigid pile cap supported by a group of piles.

Andrew McCutcheon said excavation for those piles led to more problems area early on in the construction phase.

"There were unforeseen contamination issues on the site," explains McCutcheon. "I mean as soon as you start digging in those environments there is a lot of contamination built up over the hundred and fifty years the station had been operating."

Because of that contamination issue and the problems with access, the builders were granted time extensions and completed the project within the revised contract time frame.

Rumours that the full final cost of the project reached as high as one billion Aussie dollars persist, but as the Civic Nexus consortium bore the cost overruns,

2007 Royal Institute of British Architects - International Award

— Grimshaw Jackson JV

2007 Master Builders Association of Australia - National Commercial Builder of the Year

— Leightons for Southern Cross Station

2006 Australian Steel Institute (Victoria/Tasmania) Steel Awards

— Architectural Steel Design Award —
(Large Project)

the final figure may never be made public.

The continued operation of the suburban electric train lines meant the main spine trusses were installed in large sections to minimise working time above working tracks.

That structure consists of structural steel tube, mostly 356mm outside diameter circular hollow section. Tube wall thickness varied between 6.4mm and 23.8mm on some of the flatter arches.

The sections were fabricated off site and transported by barge to Port Melbourne, 5 km away from the station. They were then transported by road at night and lifted directly into position using one of Australia's few 600 tonne crawler cranes.

The working window for these operations was tight. The last train departs the station at 12.30am and the first train the next morning departs at about 5am. Allowing for mobilisation and demobilisation, there was just a two and half hour window each night for the installation of these massive structures.

The sections of spine truss were fabricated in 20 metre lengths. A truss section was installed firstly over each column, then 20 metre infill truss sections lowered into place and bolted in.

The large roof modules that sit on the trusses were constructed in the median strip of Wurundjeri Way, the dual carriage roadway that runs behind the site. The crawler crane was then used to lift these large units directly into position.

Over other parts of the station, where access was not limited to that night time window, the primary arches spanning from truss to truss were installed first, followed by the secondary and diagonal members.

Running along each spine truss and above each platform is a clear skylight made of Teflon derived tensioned fabric technology known as EFTE. The skylights are inflated cushions that provide for thermal movement in the rest of the roof structure.

What followed was installation of the 6 500 unique triangular ceiling panels. These were shipped into the site in 180 containers and each one fitted perfectly into its unique position without any problems recorded.

"The ceiling system was developed so that people could actually work over the operating station," said Stephen Rancic, Director of Unison Design & Construct.

"Rather than lightweight panels, the ceiling panels were made to be trafficable, so people could walk on them, materials and tools stored on them etcetera."

"These were designed, detailed and manufactured in China then put up onto the steelwork," explains Rancic "All the gaps were sealed so that things couldn't fall between them and that created a working platform for the sheet installation of the roof."

The combination of the working deck and a twin rope access system was judged to be very successful from a safety perspective. Leightons report that there were just three very minor OH&S incidents at the roof level that required basic first aid.

It was Unison's expertise with an innovative aluminium based product from Corus Bausysteme (with the propriety name Kalzip) that brought them into the project, said Rancic. Unison, along with specialist roof installers Barden Steeldeck, were responsible for both the roof and the ceiling underneath.

At the peak of the work there were 23 riggers and "about six others" manufacturing the individual pieces from sheets supplied by Corus.

"Why Kalzip got the job was because you can roll, cut taper sheets to suit while most of the other products you generally have to bend and crinkle and it doesn't look very good," said Stephen Rancic.

That flexibility allowed the 10,000 individual roof sheets to create desired curves of the domes and valleys of the roof.

"Nothing is screwed down," said Rancic "the roof is held down by the clamping effect of the small clips."

Over 100,000 clips had to be located precisely in 3 directions enabling the roof sheets to fit and to slide due to temperature effects.

The sheets were cut and detailed next to the site as they were required.

"In this project you have some sections with double curvatures," said Rancic.

"Those kind of issues really made it complicated to manufacture and to install."

While other large projects have included curved roof structures, notably Madrid Airport, there is arguably no other large roof that has the complex design features of Southern Cross Station.

Many of the individual panels are curved in opposite directions.

The complexity of the roof design also created structural issues. The structural system of two offset arch systems rotated in plan by about 45 degrees with the ceiling panels fitted in between is believed to be unique to this project.

Structurally the roof is curved in two nearly orthogonal directions meaning that load transfer was not simply axial in the classic arch action. The steel members were required to support large bending moments as well.

Every bump and curve is different and no part of the roof repeats. Specially created software was used on site to model each piece which because of the pitch and curvatures could not fit anywhere except in its own precise location.

"This roof has every type of problematic issue that you can have in the one job," said Rancic

"From the experience of these past projects where the curves got more complicated and more elaborate I think they have learnt the lessons of the sheets locking up and also how to physically model it."

Another complicating factor was that significant displacements of the supporting members occurred during construction. These displacements threatened to create large differential movements at the connection points between the panels and the grid of main arches and perpendicular members.

The work-around for that problem was specially designed connections that allowed these differential movements to occur without inducing large stresses in the panels.

The roof panels are not painted and will dull slightly with time, but they are expected to well exceed the 25-year warranty required by the client.

For the next thirty years, the station will be managed by the private sector concessionaire ABN Amro which will receive annual payments from the government which started at \$35million in 2006. The concessionaire also benefits from the retail facility at the northern end of the site.

The project's successful completion and its obvious improvements to the commuter experience have given the PPP model of financing and developing major public infrastructure a good deal of credibility. However some in the urban design community continue to question whether the PPP model limited the project's innovative design to the railway hall, leaving the bus station and retail development looking pretty bland by comparison.

That northern development does not feature the wavy roof and does not blend seamlessly with the surrounding streetscape like the main station south of Bourke St. "I would have done that differently," said the architect Keith Brewis bluntly.

Critics argue that the PPP model imposed budget constraints on the private sector consortium that left the northern half of the project looking and feeling a bit cheap next to the grand station hall.

Leightons say that compared with the traditional public sector approach, the Southern Cross PPP has led to a higher quality of design and better facility management.

For his part, Stephen Rancic from Unison is pleased that Australia is building things with imagination.

"The shape and design is quite radical. Generally here it's all bottom line and we slap things up pretty cheaply and quickly. Here they have made an effort to create a unique structure that will be talked about for a long time."

The architect, Keith Brewis said the client kept mentioning the word "icon" and he thinks they have more than delivered on that requirement.

"When we arrived the area around Spencer St was quite forlorn, now it has really started to come alive and I think loved a lot more by the people of Melbourne.

"Five years ago the CBD seemed to work as far down as King St, then it faded away down to Spencer St, now it carries on through a lot more and that will continue to grow."

Brewis said the building shows off the engineering and geometry of how the building operates in the tradition of 19th century British architect Isambard Brunel, the brains behind London's Paddington station.

"Major railway stations are very ambitious things," said Brewis. "They have to deal with an awful lot of functional elements. They simply have to work every day."

Southern Cross Station does work and not just at the functional level. It has created that icon demanded by the government whilst creating a welcoming urban space protected from the elements.

Perhaps most significantly, the new station seems to proudly announce that public transport is back in business after generations of neglect. **A**

2006 Australian Steel Institute (Victoria/Tasmania) Steel Awards

- Steel Fabricators Award for Southern Cross Station

2006 Australian Steel Institute (Victoria/Tasmania) Steel Awards

- Steel Detailers Award

“The design of Southern Cross Station sought to resolve the many complex and competing elements of the brief at both an urban and architectural level, as well as meeting the programmatic demands of a major transport interchange. Central to the concept of the station was a ‘breathing roof’ that enabled natural ventilation to the whole station. The entire interchange is enclosed under this single undulating ‘wave form’. To create the unique wave form roof, steel was the only sensible structural choice. The roof is a significant structural and architectural achievement.

- ASI

SOUTHERN CROSS STATION



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Active Pedestrian Information System

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