WESTERN GRANDSTAND, ADELAIDE OVAL

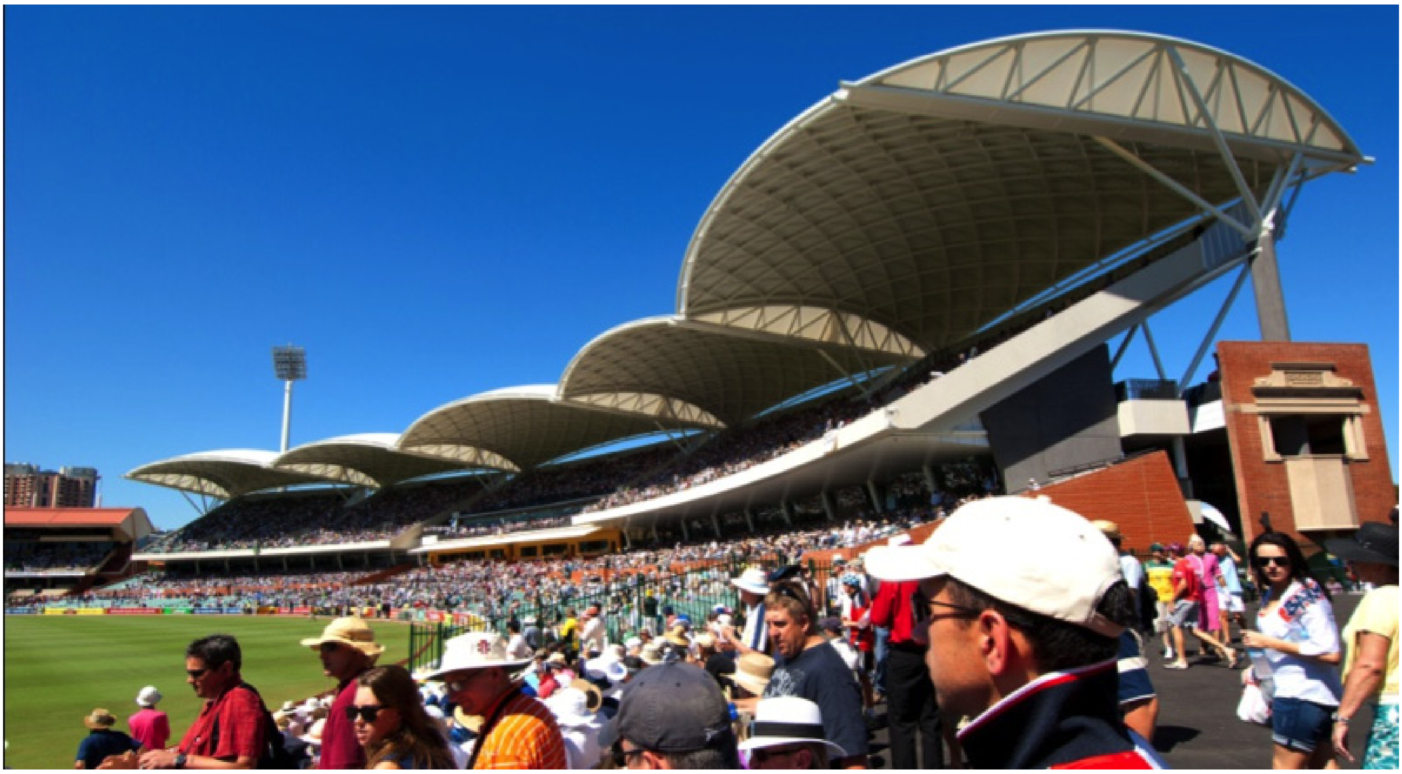
STEEL AWARDS 2012

WINNER CASE STUDY

AUSTRALIAN STEEL INSTITUTE

BUILDING - LARGE PROJECTS

NATIONAL WINNER 2012



ARCHITECTURAL MERIT

Adelaide Oval dates back over a century and is widely regarded as one of the most picturesque sporting grounds in the world. The Adelaide Oval Western Grandstand Redevelopment comprised the partial demolition and reconstruction of the existing Western members grandstand into a new $115 million, 14,000 seat grandstand.

The project delivers improved facilities and amenities to the ground for the South Australian Cricket Association (SACA) members and the public, has increased the member base and acts as a catalyst for the Riverbank Precinct Development that promises to shape Adelaide for generations to come.

The new grandstand meets the client brief by providing individual bucket seats with 80% shade by lunch and brings patrons up to 15m closer to the action. Within the central pavilion, a 600 seat dining room provides a first class function space coupled with panoramic views of the oval, cathedral and the surrounding parklands. The overall capacity of the iconic ground has been increased to 35,000. The key to the success of the Western Grandstand was that the final product must be iconic, it must be quintessentially Adelaide, and it must work in harmony with the existing fabric of the ground.

The diagrid roof forms the centrepiece of the new grandstand and is divided into five main sections with the central dome drawing the eye to the historic Giffen Stand – the oldest part of the existing fabric. The use of a diagrid for a stadia roof has seldom been undertaken in this way anywhere in the world and never in Australia. The roof uses curved 219CHS sections to achieve spans of up to 55m, leading to an elegant and exceptionally light (55kg/m^2) roof solution, making it one of the lightest roofs in Australia and globally. This support system provides patrons unobstructed views of the ground.

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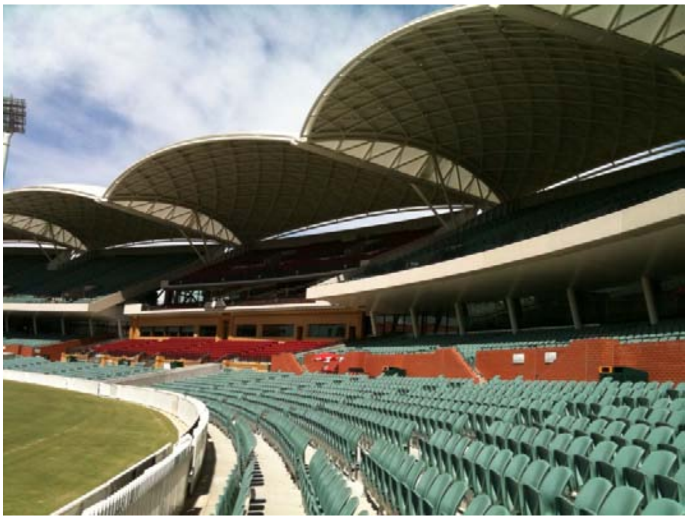
INNOVATION IN THE USE OF STEEL

Aurecon's services provided cutting edge design solutions including:

• Advanced analyses and design for the feature diagrid roof utilising finite element analyses, buckling analysis, plate stress design and extensive temporary and erection works design

• Wind tunnel testing to quantify design load pressures on the roof and reduce steel tonnage

• Fire engineering of the structural steel, reducing fire



protection measures with cost and programme benefits

• Long span steel rakers to support the seating tiers to a weight of 16 tonnes each.

• Facilitating the Safety in Design process to generate a safer facility long term and during construction.

• Long span dynamically sensitive floor design

• Retention of heritage elements

The diagrid roof forms the centrepiece of the new grandstand and is divided into five main sections with the central dome drawing the eye to the historic Giffen Stand – the oldest party of the existing fabric. The use of a diagrid for a stadium roof has seldom been undertaken as in the Western Grandstand solution anywhere in the world and never in Australia.

The roof design was optimised through sophisticated analysis and design including:

• Working with the design team Aurecon championed the early involvement of the steel subcontractor who was brought into the team at the completion of the schematic design. This allowed Aurecon to work directly with Built Environs and Samaras to ensure the roof solution could be built within appropriate tolerances and temporary staging.

• Aurecon undertook wind tunnel modelling allowing both a reduction in design wind pressures and design certainty for the roof to be pushed to the limit. The resulting roof is one of the lightest roofs ever constructed in Australia achieving the 7,000m^2 coverage with sophistication and elegance.

• The roof 3D model was used for shop detailing, imported into engineering analysis software and for architectural design.

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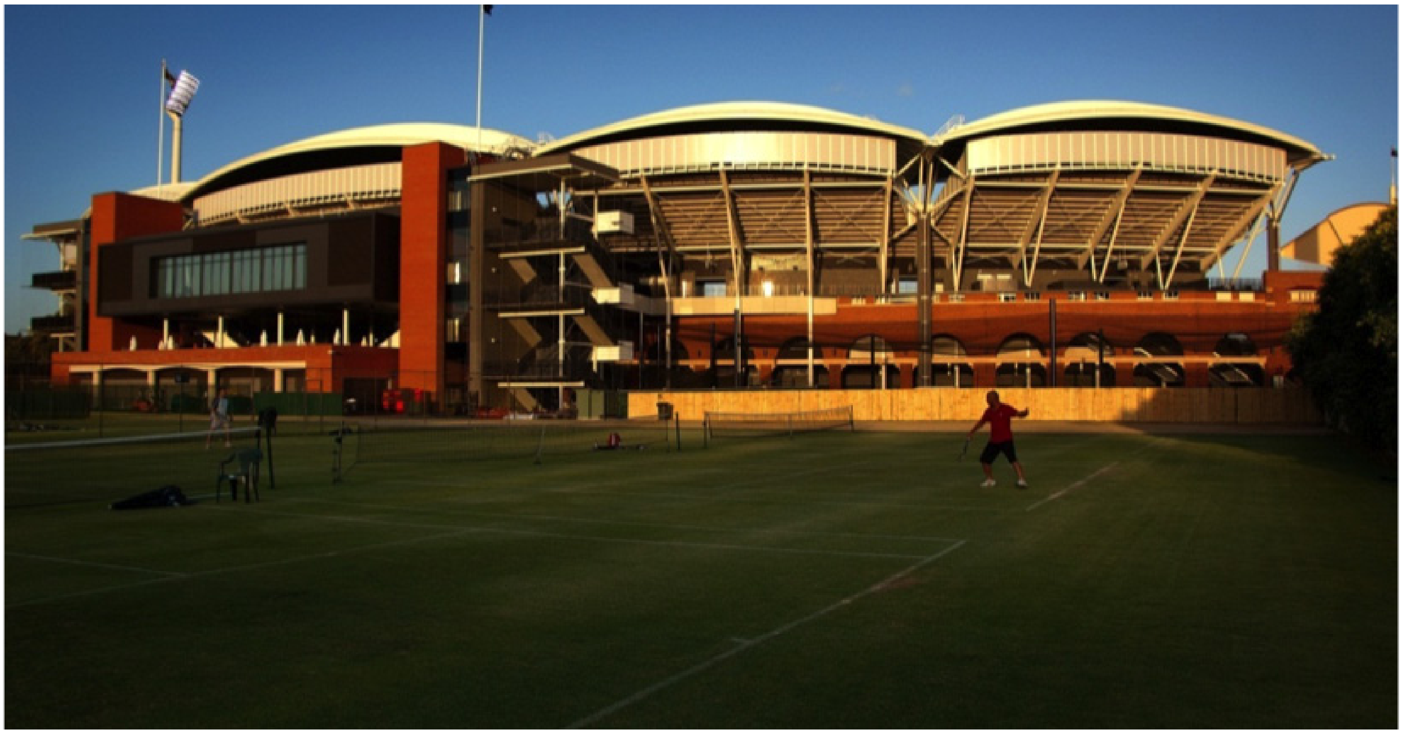
• Non-linear buckling analysis to determine the overall stability, erection sequencing and temporary works.

• Finite element analysis of the critical nodal connections that minimized the additional strengthening requirements of the thin walled lightweight members. Connection designs included design of the primary roof column node incorporating a 2 tonne solid steel billet.

• The roof was modelled dozens of times to allow, not only for the final case, but the temporary cases too, as the roof was delivered to site in 100 pieces and required to be erected cognisant of other site construction.

• Integration of lighting cables and services to maintain elegance of the design solution

• Efficient use of steel products



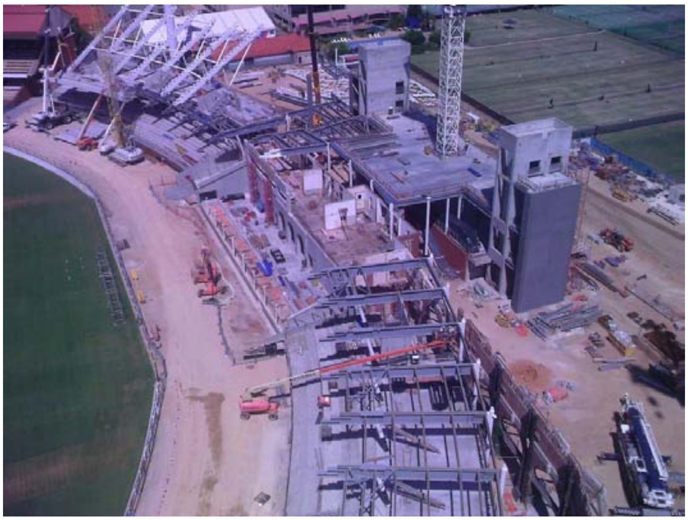
A critical component of improving patron amenity was improving the roof coverage from rain and for shading patrons from the sun. Coupled with this was an essential requirement for unobstructed views, necessitating a cantilevered steel roof solution. Aurecon undertook a multitude of design options to achieve these objectives.

The final roof solution comprises six roof trusses of circular hollow section construction arranged on a radial grid centred on the existing Giffen Stand. The steel roof is supported on feature precast concrete columns that weave through the retained heritage structure beneath, with the elegant diagrid shells between. The resulting roof cantilevers 30m from the rear seats proving drip line coverage for patrons in the mid and upper tiers. Detailed sun shade modelling also proved all patrons in the grandstand, including the lower tier, were in shade after the lunch break of the cricket test match. These improvements dramatically improve the viewing experience of the new grandstand which is the primary driver for patron attendances.

> The roof uses curved sections to achieve spans of up to 55m, leading to an elegant and exceptionally light (55kg/m^2) roof solution, one of the lightest roofs in Australia and globally.

The diagrid roof is formed using curved 219CHS sections to achieve spans up to 55m, leading to an elegant and exceptionally light (55kg/m^2) roof solution and comprises some 480 tonnes of steel for the 7,000m^2 roof area. Key to the structural system was the roof geometry with the shape generating the structural strength and aesthetic appeal.

Working closely with HASSELL and Cox architects the diagrid form was optimised based on iterations for the arch curvature resulting in curvatures span / 11.5 at the front and rear edges and span / 8.5 at the centre. The resulting diagrid form was generated in 3D creating a structurally efficient and visually

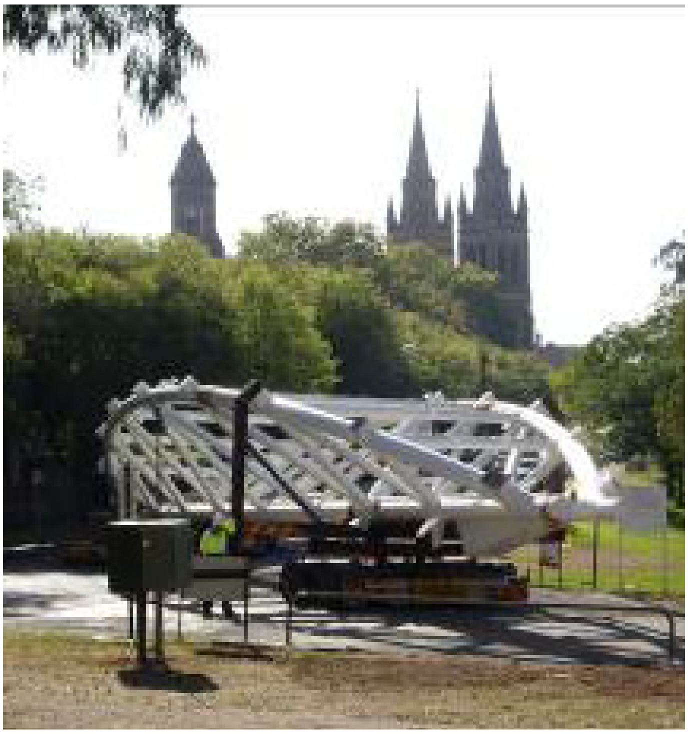


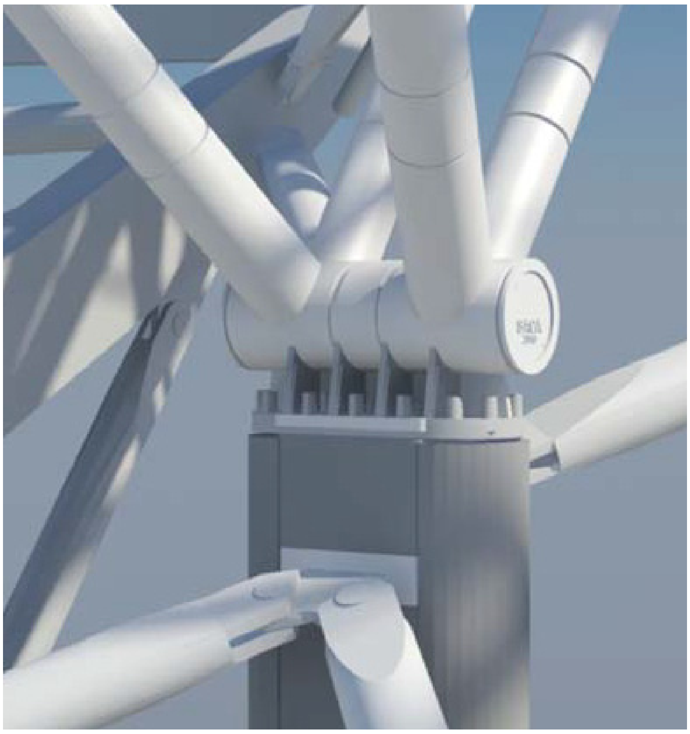
pleasing result.

Design loads were predominantly wind loading where Aurecon carried out cutting edge wind tunnel testing of the roof structure. The unusual curved form of the diagrid roof is not considered in the Australian Standards which provide inaccurate and conservative estimates of loads over this unique curved roof shape. The use of wind tunnel modelling resulted in wind loads being significantly reduced, with significant cost savings in structural steel and cladding. Other miscellaneous loads were considered for service loading for lighting and public address.

> Standard sections were used wherever possible to avoid material lead time, availability issues and reduce fabrication time and quantities.

The architectural vision and the engineering design were integrated from the outset and throughout the design. Intensive workshops were held in all engineering disciplines





and resulted in an optimised design while maintaining the client requirements.

EFFICIENT USE OF STEEL PRODUCTS

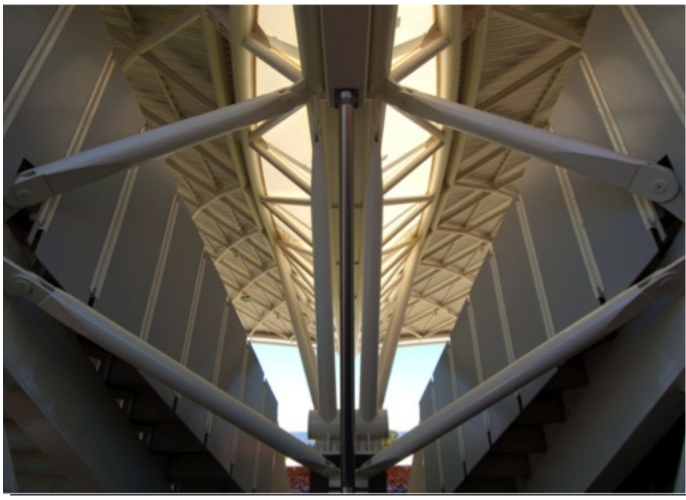
Standard steel CHS sections were predominantly used for the diagrid roof with standard universal beam and welded beam sections for the floor beams. Custom fabricated steel box rakers were designed and constructed to support the seating tiers. Design decisions were based on maintaining the use of standard sections in order to avoid material lead time and availability issues and reduce fabrication. This facilitated the order and use of extensive, readily available sections to achieve the design form.

The exception was in the connections where the open CHS sections were stiffened and gusseted for load transfer with some locations necessitating the use of solid steel billets for efficient load transfer and dramatic aesthetic appeal - with the roof column node a highlight. All the steel on the project was sourced from Australia.

The project construction period was a very tight 18 months coupled with a requirement for Adelaide Oval to remain operational for events. Aurecon worked with Built Environs and the design team to determine design solutions that allowed for rapid construction and for erection primarily from the western side, causing a natural boundary with the oval to the east.

Accordingly, structural steel and precast concrete formed the primary ingredients for the structural design. The building frame was structural steel for rapid erection, spandrels and retaining walls were precast concrete and KingFlor flooring was used to minimise formwork trades. These design solutions allowed for steel deliveries on site to be staged and planned to keep the construction progressing rapidly.

Early in the design a specialist steel detailer was invited to optimise the design, minimise the construction risks of the proposed solution and accelerate the detailing and construction planning taking place alongside design development.



Building services were prefabricated where possible following closely behind the structural erection. Around 1,450 tonnes of steel was used in the main frame, with around 480 tonnes used in the diagrid roof. Other major elements in the stand include around 200 precast wall panels and 430 seating plates, as well as precast stair risers and treads.

Collaboration was at the forefront of the delivery and documentation of the Western Grandstand Redevelopment. Intensive workshops were held throughout the project duration and resulted in an optimised design while maintaining the client requirements. Regular communication through the design team also focussed the documentation of the project with the 3D Revit model, providing design input to the Steel Subcontractor which was then advanced concurrently with the structural and architectural design. This approach saved considerable time and effort in the documentation phase.

Early in the design a specialist steelwork subcontractor was invited into the design team to work with the consultants and client to optimise the design, minimise the construction risks of the proposed solution and accelerate the programme with the shop detailing and construction planning undertaken concurrently with the completion of the design. This process facilitated the design process being undertaken concurrently with the fabrication, tolerance, erection and transportation aspects being considered into a single model. The net effect of this was a reduction in the design time pivotal to the on programme completion of the works.

Use of a common cross-discipline 3D model allowed the complexities to be worked through expediently in relation to design, fabrication, transportation and erection requirements.

ENVIRONMENTAL PERFORMANCE

Environmental initiatives and considerations included:

- wind tunnel testing to optimise the wind loads and reduce the amount of structural steel

- fire engineering of the structural steel to eliminate much of the fire protective coatings otherwise required to satisfy the Building Code of Australia

- the steelwork solution facilitated a lighter design, reducing the material requirements for foundations columns and walls and minimising concrete materials

- advanced design and analysis techniques resulted in material reductions throughout all disciplines

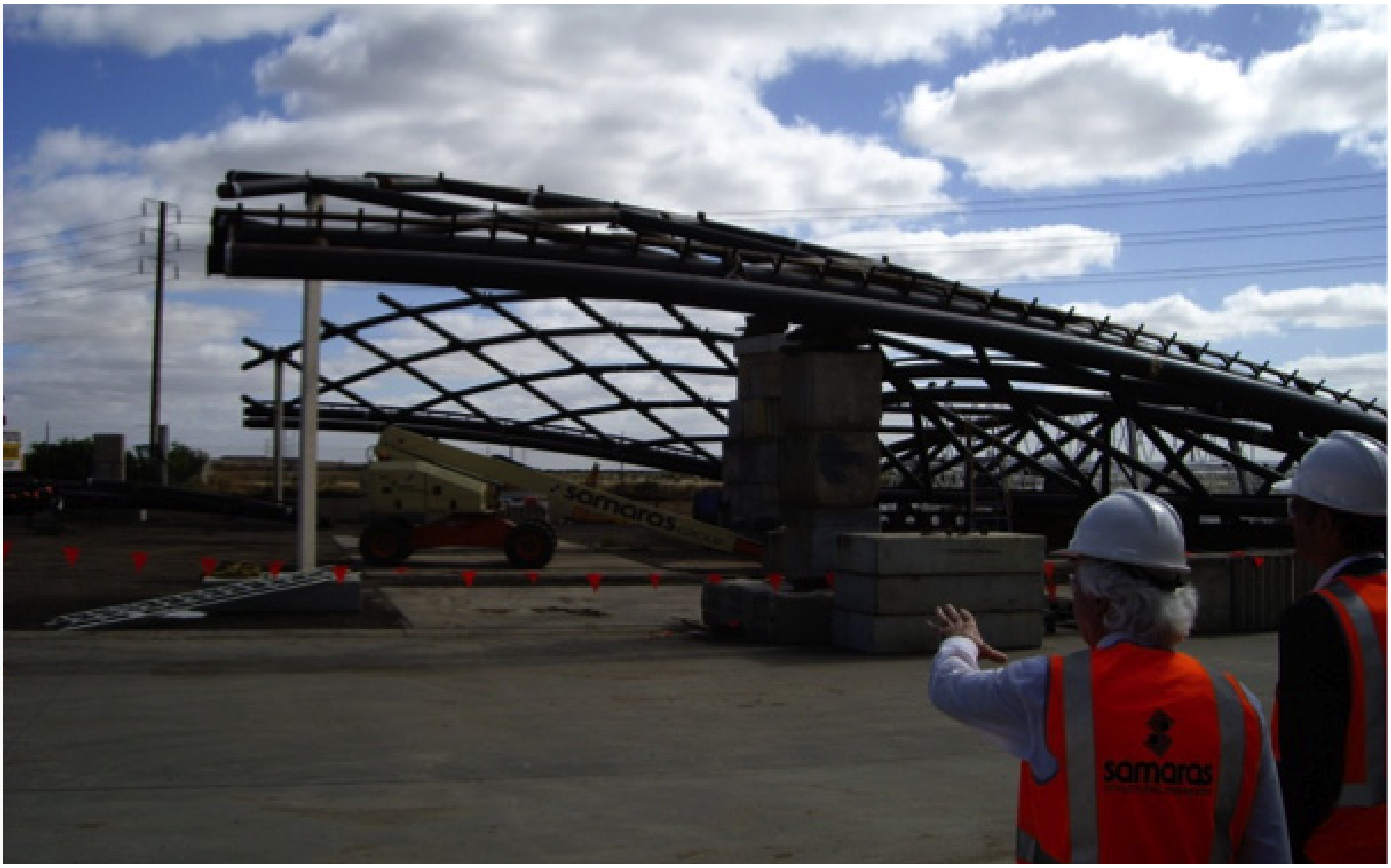
- the Safety in Design process considered the maintenance and operation of the facility as well as the demolition.

BUILDABILITY

Following the appointment of the steelwork subcontractor a series of design workshops were held where the preferred design was interrogated. At these sessions the issues of erection, transportation, fabrication, tolerance, temporary staging were entwined with the design aesthetics, structural performance, wind load resistance, servicing, and more to create a coordinated design solution.

In order to fast track the roof design and construction process and to guarantee the high degree of accuracy and quality required, the 3D modelling by the steel contractor occurred concurrently with the completion of the architectural and structural designs. This initiative allowed the complexities of the 3D design to be worked through in an expedient manner, satisfying the design, fabrication, transportation and erection requirements. It also facilitated the integration of the service provisions for the lighting cabling and guttering amongst the structure.

Connections in the diagrid were developed in careful consultation with Aurecon, the architects and steel subcontractor. The connections were developed to achieve the required load



transfer for the structural design for both the permanent and various temporary conditions. Close liaison with Built Environs and Samaras optimised the connections for position, tolerance and fabrication aims, while ultimately creating a connection of high visual appeal given the exposed nature of the feature roof.

To ensure the appropriate fit, on-site trial assembly was undertaken on each area of the roof in the steel contractor's yard where matching of connections was possible in a controlled environment. Subtle adjustments were made before completion of the fabrication and shop painting. This enabled the design solutions to cater for various load scenarios from the permanent condition with ultimate wind loads to the various temporary conditions as the 100 pieces of the roof were delivered, erected and clad insitu from south to north.

As the steelwork was delivered to site, Aurecon and the design team were on hand to witness primary lifts and assist with the erection engineering as the roof was surveyed and checked against the anticipated behaviour.

> To ensure the appropriate fit, trial assemblies were undertaken in the steel contractor's yard where matching of connections was possible in a controlled environment.

This process was required to be robust and involved Aurecon working closely with the Built Environs team to incorporate alternate construction methods for the roof as the programme changed to adapt into the overall project works as the Ashes deadline approached.

The collaborative process undertaken through all stages of the design and construction was pivotal in achieving a successful and on-time roof erection.

PROJECT TEAM

Architect:	Cox Architects + HASSELL
Structural Engineer:	Aurecon
Head Building Contractor:	Built Environs
ASI Manufacturer:	OneSteel
Fabricator:	Manuele Engineering, Samaras Structural Engineers
Steel Detailer:	Samaras, Universal Steel
Coatings Supplier:	International Paint, PPG Coatings
Coatings Contractors:	Samaras, Troisi Steel