PENLEIGH + ESSENDON GRAMMAR SCHOOL

STEEL AWARDS 2012

WINNER CASE STUDY

AUSTRALIAN STEEL INSTITUTE

BUILDINGS - LARGE PROJECTS

STATE WINNER (VIC) 2012

ARCHITECTURAL MERIT

The Penleigh Essendon Grammar senior school is a $32M state of the art educational precinct for Years 11 and 12. The design was based on an 'infinity symbol', a shape that allows the facility to be structured around two protected courtyards. This in turn enhances the learning spaces' access to light, view and ventilation. At the heart of the infinity has been located the library and student learning centre.

The building has been programmed to be divided into eight functional zones, namely the arts school, history school, mathematics school, sciences school, student library and cafeteria, sports precinct and lecture theatre / performance space. Each precinct has its own unique quality and yet they are seamlessly connected to the next. The building aims to embody the journey of education, and the crossover between disciplines. This planning allows the building's circulation to constantly return to the library at its heart and in this way it physically echoes the educational ethos of the school.

> The steel frame became the single entity that set the geometry of the building, far beyond the function of a simple supporting sub frame.

The provision of significant courtyard spaces between the buildings required access to these spaces – this was achieved by the incorporation of two large "puncture points" through the face of the building, together with a central suspended library hub. These puncture points were formed using large spanning trusses that were incorporated into the façade framework. The trusses were curved both in plan and elevation.

The external façade consists of coloured glazed brickwork which forms sweeping planes both in plan and elevation – the brickwork extends 3-4m above the building line as a parapet structure. The choice of steelwork was critical to being able to deliver the sculptural parapet forms and brickwork cladding support elements of the building.

Another feature of the design is the large bay windows – these were designed from bespoke steel sections which formed Vierendeel trusses. Window bays up to 8.4m in length were required to support significant brickwork elements above. Window bay trusses were also curved in plan where geometry required this to be the case.

> 'Puncture points' connecting the interior and exterior were formed using large spanning trusses which were incorporated into the facade framework.

The roof forms an undulating plane which, in addition to being functional and capturing and shedding rain water, is sculptural in form. Piecemeal steelwork elements formed the basis of the design and construction of these areas, as warped and curvilinear surfaces were estimated using a ruled steelwork surface.

INNOVATION IN THE USE OF STEEL

The decision to use steel on this project became a driving force in decision making early in the design process. The steel frame became the single entity that set the geometry of the building, far beyond the function of a simple supporting sub frame.

The innovative use of steel was not just confined to its use in setting out the various brick courses and associated penetrations. The steelwork in this project was a real feature as well as structure. Each of the window and door frames were trimmed with steel plate and left exposed as a feature. The window frames were fully welded units that exactly matched the brickwork and cladding lines whether a flat or curved surface. Normally the window frames are hidden by flashing or other materials but in this project the structural steel frame is itself a dominant feature of the window framing.

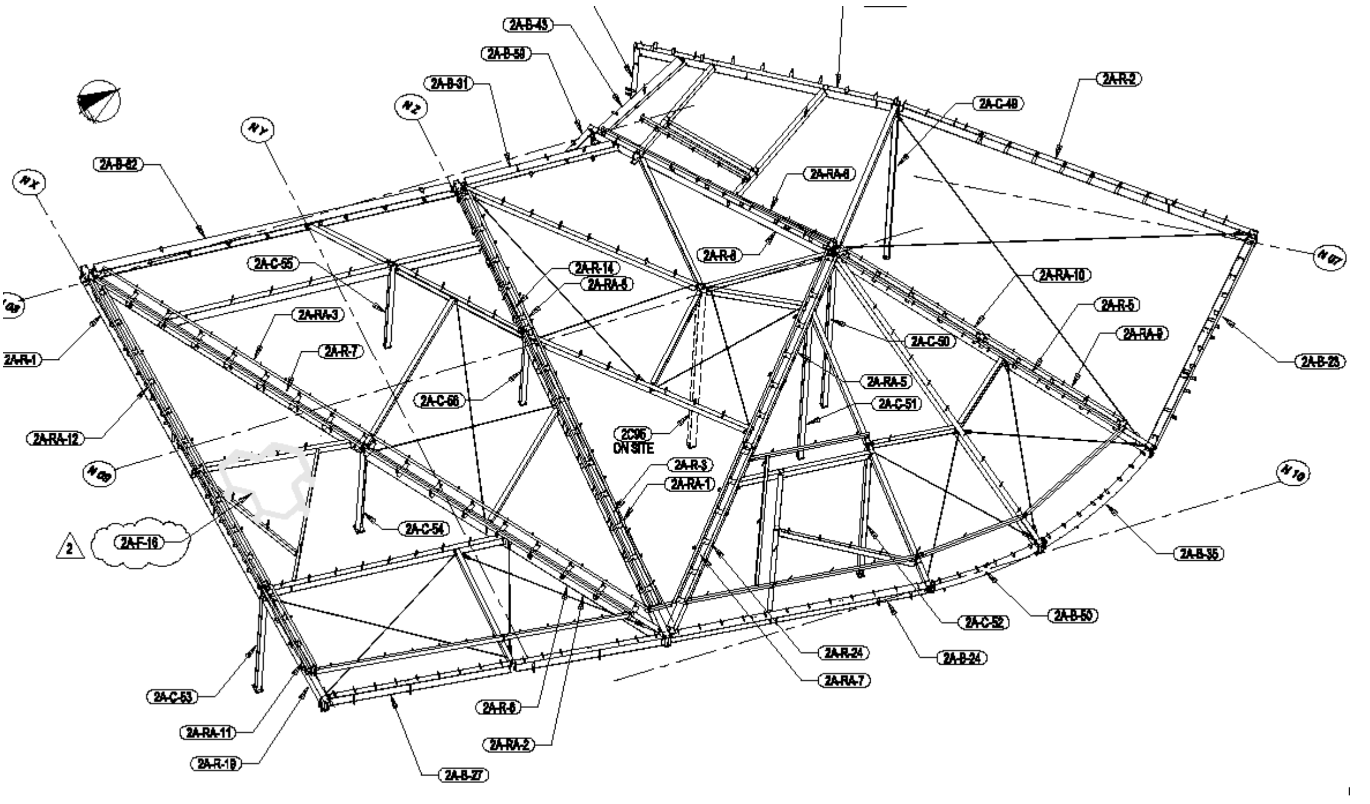
Another area of merit in regards to the structural steelwork is how well it worked in with the archways. The two archways located on the north west and south east faces of the structure are a demanding feature of the building. Rather than simply providing an entry and exit to the building they are a bold expression of the essence of the building itself. The use of steelwork in framing these areas was very innovative approach given the geometry involved. It provided a very quick construction timeline while leaving the site relatively clean and clear for the following trades. To construct these archways in a concrete form may well have been possible but the result from adopting steelwork was far more appropriate for the structure as a whole.

The use of steelwork in framing the two archways on north west and south east faces of the building was a very innovative approach given the geometry involved. It provided a very quick construction timeline while leaving the site relatively clean and clear for the following trades. To construct these archways in a concrete form may well have been possible but the relative speed, 'tidiness' and aesthetic effect of steelwork was far more appropriate to this build.

> The use of steel for the archways provided a quick construction timeline while leaving the site relatively clean and clear for following trades.

EFFICIENT USE OF STEEL

Steelwork was the key material of choice in enabling the construction of a complex curvilinear form. Much work was done in reducing complex curves into a series of ruled surfaces, such that the building could be built from a series of simple straight line steel components. Off site fabrication and prefabrication enabled the building to be erected in a manner similar to the construction of a meccano model set. Reducing a complex form into a simple set of rectilinear elements meant that the building could be tendered and constructed cost competitively,



(FOR MARKS NOT SHOWN SEE PLAN VIEW - MAIN ROOF)

AREA 2A - ISOMETRIC VIEW - MAIN ROOF

and that specialist trade contractors and the like were not required. This enabled the project to be delivered on time and under budget.

Prefabrication of the somewhat complex curvilinear trusses enabled for ease of delivery and erection on site without the requirement for any associated temporary staging works for these elements. The roof required a multi-tiered structure with run-off from one roof panel discharging onto an adjacent roof panel before finally discharging into a gutter system. The structural steel was used to establish a robust support frame rather than use a conventional flashing element.

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Resolution of the internal curvilinear façade skin into a simple series of vertical straight line support and cladding elements enabled for simple construction – all cladding panels were geometrically the same and therefore there was a high degree of repetition within the designed and built form.

The steelwork fabrication model was developed by Cocciardi both from the 2D design documentation and the design model provided by ARUP Melbourne. The role of Cocciardi was to utilise all available information and develop this into a 3D fabrication model suitable for the production of the steelwork fabrication details. The roof steelwork in particular involved meticulous coordination with the architectural and structural design teams, the structural steel fabricators, the cladding contractors, drainage systems, lighting systems and so on. The 3D construction model was subsequently provided to the main contractor as each area was completed so it could be utilised by various other trades as required.

By having the structural fabrication shop details completed by one drafting company independent of any particular fabricator, the detailer was able to source the supply of the structural steel from a number of sources. This allowed a significantly shorter supply timeline than would otherwise have been the case.

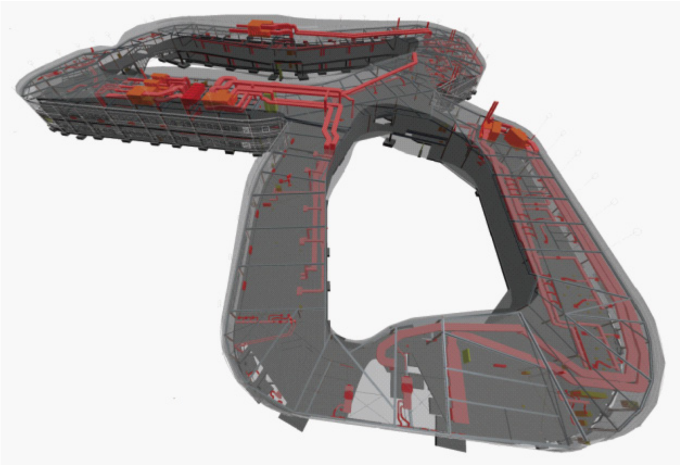
Very early in the process, Cocciardi realised it would be necessary to break the project into a number of different zones and then sub-areas within these zones. Cocciardi therefore submitted a breakdown of 9 zones broken into internal wall steelwork, external wall steelwork and roof steelwork within each zone.

The way in which the structure was designed allowed for separate areas to be developed and then issued for fabrication as separate packages and even sub-packages if required. Again this allowed for easier management of the fabrication and site storage of the steelwork.

ENVIRONMENTAL PERFORMANCE

> Steel was able to provide both durability in a semi-external environment and a light-weight response to a complex geometric form.

The fact that steel is a fully recyclable material was definitely a contributing factor to the selection of steel as a key building material on this project. There were several steel fabricators used on the project, but the majority of the steelwork was supplied by GVP Fabrications, which is a member of the ASI Environmental Sustainability Charter Group. Companies committing to this Charter are required to complete a declaration



Revit model including structure, services and architecture

to operate their businesses to reduce their environmental footprint and to increase the efficiency of resource use.

The built form was modelled and analyzed using digital design tools – the modeling used to describe the architecture was also developed to enable for structural analysis, design and documentation. The digital design approach enabled the efficient allocation of materials and structural steel beam sizes as appropriate.

Semi-clad spaces to the walkway courtyards were achieved using light-weight steel framing in combination with timber framing. The use of steel was important here, as steel was able to provide both durability in a semi-external environment (where resistance to corrosion is important) and a light-weight response to a complex geometric form, thus minimizing foundation sizes. The ability to provide a semi-clad space with the given materials meant that no additional money was expended for any form of mechanical heating, cooling or air exchange.

Natural daylight was provided to many of the internal teaching spaces through the incorporation of steel framed skylights. These elements were organic in geometry and were designed and fabricated as modular and light-weight units which lent themselves to embedment within the roof structural fabric without the requirement for local bespoke detailing changes.

The provision of light permeable façade elements was key to the provision of natural daylight into the building, and thus the catalyst for reduced power and artificial lighting requirements in the operation of the spaces.

> The use of a single digital design model ensured that any inconsistencies were identified prior to production of shop drawings, avoiding delays or problems on site.

BUILDABILITY

A key aspect in addressing buildability issues was the exchange of design and detail data between the architects, consultants and detailers. The built form was modelled and analyzed using digital design tools. A single digital design model was used as the basis to describe both architecture and engineering, and was also extensively used on engineering analysis. This ensured that any inconsistencies were identified prior to production of shop drawings, avoiding delays or problems on site. This modelling was then translated through to documentation – the model was also passed on to the steel fabricator for use for the purposes of quantity take off and shop drawing production. This

digitised approach enabled the simple rationalisation of a com plex curvilinear form.

The review process made possible by the use of a shared 3D model significantly streamlined the approval process both architecturally and structurally. The DXF files for fittings and the material lists provided at approval stage allowed the fabricator to secure stock and fully fabricate connections while the formal drawing approval was underway. This had a significant effect on delivery timelines.

> All steel elements were designed as part of a braced frame structure, so all connections were simply supported and there was no requirement for complex bolting or on site weld detailing.

Given the geometrically demanding shape of the project, the detailer followed the existing rationale of using a series of x,y & z cords referenced back to a nominated datum. This was critical in regard to the holding down bolts. The structure had numerous set downs combined with a demanding footprint. The holding down bolts were located in a 3 dimensional format. Marking plans were developed and issued utilising both 2D & 3D views.

All steel elements were designed as part of a braced frame structure – this meant that all connections were simply supported and that there was no requirement for complex bolting or on site weld detailing. All steelwork elements, including prefabricated truss elements and window frames, were delivered on the back of a truck to site and lifted in place or bolted together in situ on site – bolted connections were all snug tight (supporting shear force loads) so that there was no requirement for complex on site gunned connections. Throughout the steel erection works, there was no requirement for any staging works as frame elements were self supporting in their temporary state.

The requirement for strict document control was fundamental as the detailer Cocciardi was dealing directly with four separate fabricators, all making different elements of the project. Each fabricator had a unique approach to the production, depending on the size and complexity of their allocated section.

Connections were reviewed both from a fabrication and erectibility perspective. This was particularly pertinent with the two large archway structures, which required extensive connection development to ensure the proposed connections could ultimately be assembled in a safe and cost effective manner. The shop detailer worked closely with the architect, engineer and fabricators to establish splicing of the truss sections which would enable the elements to be easily transported to site and safely erected. Incorporation of 'as installed' data back into the 3D construction model improved efficiencies on site.

PROJECT TEAM

Architect:	McBride Charles Ryan
Structural Engineer:	Arup
Head Building Contractor:	Construction Engineering Australia
Steel Fabricators:	AJ Demuri DVP Engineering, GVP Fabricators, Jards + Co
Steel Detailer:	Cocciardi
Coatings Supplier:	Action Alliance