ONE SHELLEY STREET, SYDNEY

ARCHITECTURAL STEEL DESIGN AWARD 2010 (NSW + ACT)

STRUCTURAL ENGINEERING STEEL DESIGN AWARD 2010 (NSW + ACT)

MULTI-LEVEL STEEL BUILDING DESIGN AWARD 2010 (NSW + ACT)

fitzpatrick+partners, Brookfield Multiplex and ARUP

Architectural merit

One Shelley Street is a 35 000 m², 11 storey commercial building with a striking combination of form, function and sustainability. The building features a unique interpretation of an external structural support system, the diagrid. This combined with a clear expression of the building's function, technology, construction methodology and a finer grain of detail, texture and finish defines the look of the building.

The design takes on the challenge of building over a partly constructed basement to create a structural support system unique to the location, and uses the opportunities of the harbour and site orientation to assist in achieving an energy efficient building.

The deliberate expression of the external steel diagonal structure wrapping the outside of the building is also done to minimise the internal structure and give maximum fitout and planning flexibility to building tenants. This element, designed in consultation with ARUP, creates an immediately identifiable landmark, where its definition, scale and detail create a richness and texture without the need for superfluous decoration.

Sustainability

ESD features, designed by Lincolne Scott, include passive chilled beam technology and harbour heat rejection to reduce energy required for cooling. Energy requirements are also reduced through daylight harvesting and using a performance coated double glazed façade with dot frit patterns to minimise solar heat gain whilst maximizing visible light penetration. Water efficient fixtures together with the harbour heat rejection system also significantly reduce potable water consumption.

The Green Building Council of Australia has awarded the building a 6 star green star "World Leader" v2 office design rating.

Innovation in the use of steel

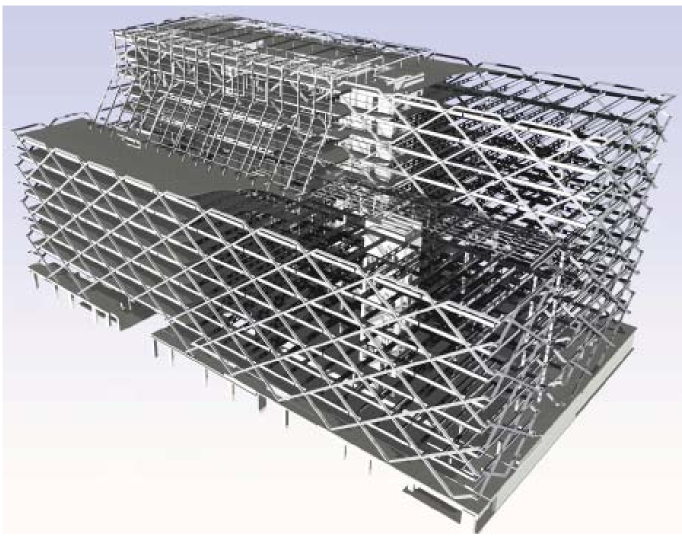
The externally expressed structure is an innovative use of steel establishing the building as having Australia's first external diagonal grid steel structural system with an integrated glass façade, eliminating the need for perimeter columns and maximizing internal floor space flexibility.

The external diamond pattern created by the diagrid is fully triangulated using the slab edge beam on the inside face of the facade. Stub connections cantilever inwards from the diagrid to transfer forces back to the edge beams. The unique diagrid enables the redistribution of vertical loads towards strong points in the existing basement, readily spanning across the bus ramps and minimising the basement strengthening works.

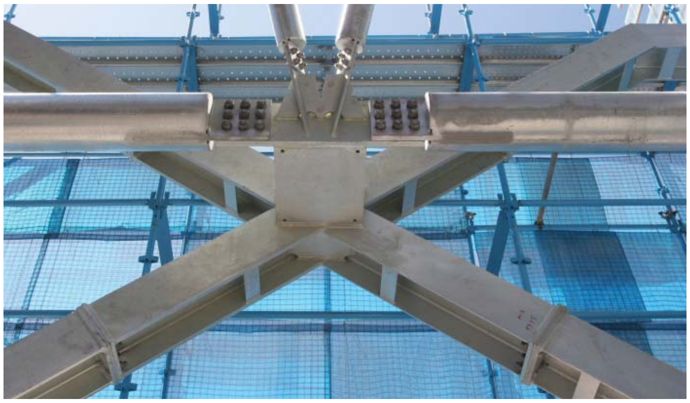
The connection between the diagrid and concrete ground floor structures was designed to transfer substantial vertical and lateral loads while minimising damage to the existing substructure. This was done using welded dowel pins on the underside of base plates. These were laid out to align where grout-filled core holes could be positioned in the ground floor slabs around existing post-tensioning ducts. Beneath this level, existing and new structures pick up the loads and transfer them through the basement levels.

The use of steel in the diagrid structure also allowed some extreme and innovative engineering in the form of hanging columns in the atrium void. The location of the bus parking and large open driveways in the basement prevented the placement of columns along the line of the atrium above. A pair of hanging columns was constructed to avoid these wide basement ramps.

During construction, temporary footings and temporary steel columns were constructed within the driveway areas from basement 5 to level 2 from which the final columns were constructed in a temporary load configuration. The vertical columns installed inside the atrium void were joined to the upper western diagrid structural frame, which formed a truss spanning over three grid bays (approximately 29m), to suspend this area from above. This is achieved with no apparent additional structure.



Following completion of the structure and removal of all building formwork the columns were then jacked up and bolted to the truss, which then withstood the permanent building load of six floors of the building. Following the completion of this the temporary columns were removed, reinstating full access to the basements.

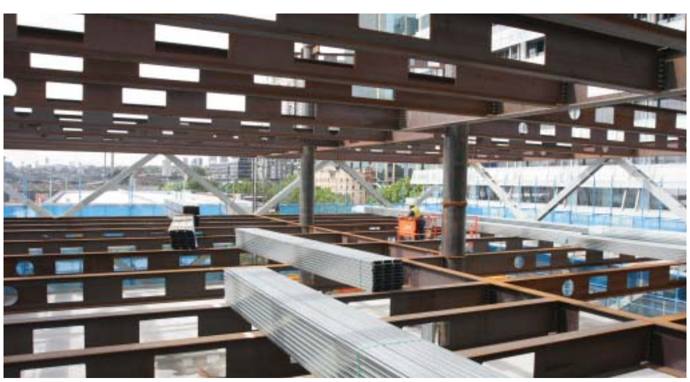


Efficient use of steel products

As the installation of steel work to the diagrid and floors was a critical path item, fitzpatrick+partners worked closely with Arup and Brookfield Multiplex and with the suppliers and installers, Bluescope Lysaght to develop steel design options for optimum performance and economy. Two structural options were investigated for the diagrid structure, taking into account steel tonnage, cost, repetition of structural elements, speed of erection and finish: fabricated box sections with applied protective paint finish, or off the shelf tube sections with simple bolt connections and profiled aluminium over-cladding. The latter was adopted, offering significant economies in its use of standard, off-the-shelf steel members and for its high quality finish.

The diagrid structure was designed for maximum duplication of structural steel elements and economy of means. A 9600mm structural grid was adopted, incorporating an industry standard 1200mm facade and ceiling module, to produce consistent and efficient floor plates. The external diagrid eliminates perimeter columns while the remotely located cores reduce on-floor columns to four, down the centre of high rise floor plates.

In the ceiling, relatively deep 610 Universal Beam sections are used complete with standardised unstiffened penetrations to accommodate all building services. These composite steel floor beams required no welding or painting and could therefore be delivered directly to site from the steel supplier,



once again saving time and cost. The composite beams are bolted to 610 Universal edge beams, connected to the external steel diagrid via steel stub connections, which penetrate through the façade at regular grid spacings.

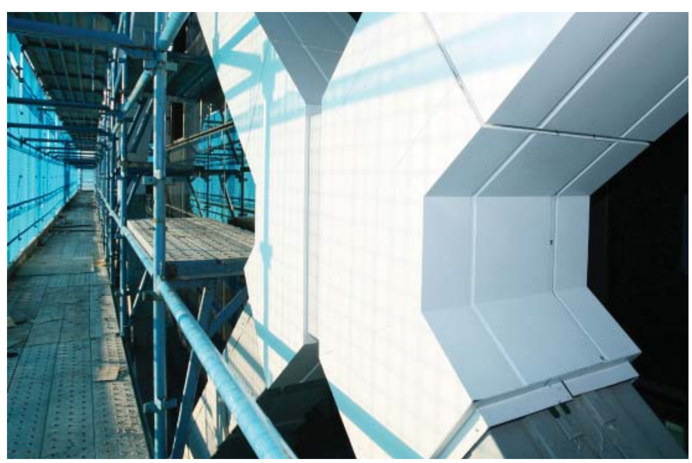
The resulting building offers large flexible floor plates, natural light, great amenities and a unique and safe work environment. This repetitive design allowed for quick construction, with the 11-storey main frame erected in approximately five months. The final structural design includes over 1,200 tonnes of diagrid steel and over 2,000 tonnes of steel floor beams. Over 450 diagrid nodes and 900 legs of steel were used, totalling in excess of 1,350 diagrid steel elements.

Practicality in fabrication and erection

The diagrid was originally conceived as perfectly finished steel box sections 400mm square, but it became apparent that it would be easier to clad a simpler, cheaper steel structure. The built diagrid is made from 310mm rolled universal column sections combined with heavier fabricated sections where the forces are greatest. The thickest plates in the diagrid are 70mm and the steel is of various strengths from 300MPa up to 450MPa. Each steel piece is precisely tuned to its location so that the overall steel usage is minimised.

Innovation was applied to the structural steel design in order to achieve the architectural vision while using mostly simple parts to keep cost down. This was achieved by ensuring most of the complexity was localised in just the diagrid nodes, ensuring the remainder of the structure was as simple as possible.

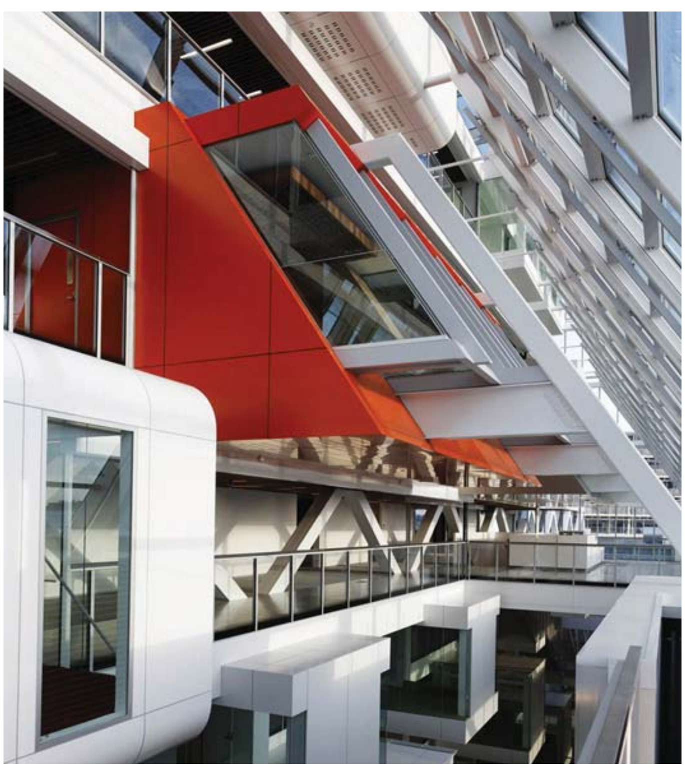
Working closely with the contractors, the diagrid was designed to be made from pieces that had repetitive geometry and were of a size that could be readily handled in the shop. After galvanising, the subassemblies were simply bolted together on site, encased with fire protecting board, and clad with purpose made aluminium extrusions that kept the overall size to 420mm square.



The pre-assembled framing elements allowed for quick construction, while other time and cost saving methods included the use of standard UB sections that didn't require welding or paining and therefore could be supplied directly from the supplier to the site.

With the difficulty of constructing the diagrid, post construction jacking and unpredictable settlements, a unique survey regime was developed to regularly review and monitor the diagrid as it was installed. Arup completed a detailed settlement analysis for Brookfield Multiplex to benchmark achievable deflections. Significant surveying of the node points was undertaken following installation, again following placement of concrete, then on removal of back propping and again on completion of the structure to ensure installation and construction was within the designed tolerance. With the building being 100m long, node points had to be checked for alignment vertically, horizontally and to the grid line offset, making sure they did not step in and out in the vertical and horizontal planes. This intensive survey approach to identify structural movement was critical to ensure a weather proof building.

In addition, the facade required complex interface design where structure penetrated the façade to accommodate variable deflections. A subsill drainage system was developed around the node points capable of taking movements of up to 35mm to allow for the installation tolerances and settlements of the diagrid.



Steel framed cantilevered meeting pods and bridges were incorporated into the base building package late in the design process. Brookfield Multiplex, Arup and fitzpatrick+partners worked closely with fitout designers Clive Wilkinson Architects and Woods Bagot on placement of these elements to limit the impact on the diagrid structure being erected. The initial construction and design methodology was revised and design of the pods was modified to enable the structure of the pods to be pre-fabricated and lifted into place as one element.

Steel framing to external and internal lifts allowed the lift structure to be prefabricated off site and delivered prefinished to site which ensured quick erection times and a high quality finish to architectural grade steelwork at the building entry.

Aesthetics and detail

Externally, the diagrid cladding and façade glazing are key visible elements. After exploring various options, the final solution was to overclad the corrosion and fire protected diagrid steelwork with powdercoated aluminium cladding profiles to achieve a sleek, high quality finish. Significant effort was put into refining the cladding and glazing details, which are highly visible at ground level and through the façade itself.

Testing included the production of design and prototype models to scrutinize performance issues including erection, fixings, finish, maintenance, water proofing, deflection tolerances, safety issues and durability.

As atrium steelwork is highly visible, it had to reflect the same fine level of texture and detail. The same rigour was applied in detailing well resolved, uncomplicated junctions that were easy to construct. The use of 3-dimensional software was critical for clash detection and in the resolution of complex junctions, particularly where multiple elevated elements join from different directions in space. These atrium façade structural systems consist of expressed architectural grade steelwork, incorporating diagonal structural connections to continue the conceptual approach from the diagrid.

High rise atrium steelwork was designed with alternate structural steel bays having sleeved and bolted steel connections, while intermediate bays were welded and prefinished off site to reduce high level work and ensure a high quality of finish. A similar approach was adopted in the low rise atrium roof structure, where primary elements were welded and prefinished off site, with sleeved and bolted secondary elements.

Pre-fabrication of the steel framework and the off-site application of fire retardant intumescent paint to the cantilevered atrium pods ensured a greater control over the quality of welded junctions and surface finish to architectural grade steelwork.

At ground level the curtain wall extends down alongside the double height retail footpath as a glass “skirt” structurally supported by exposed diagonal architectural grade steel struts. Significant time was spent on site sanding and painting these and atrium pod steel members to obtain a high quality finish.

Corrosion protection

In response to the highly corrosive exterior environment the diagrid steelwork was hot-dip galvanized to protect against corrosion. Due to the potential long term risk of fire spray eroding and leeching through the diagrid cladding joints, which are not completely water sealed, there was a decision to use Promat fire resistant board, constructed around the steelwork. The promat board was then sealed with a water-proof membrane, with the combined end result being a highly moisture resistant, multi-layered corrosion protection system.

Project team

Architect:	fitzpatrick+partners
Structural engineer:	Arup
Head building contractor:	Brookfield Multiplex
ASI manufacturer:	BlueScope Lysaght, OneSteel
Steel distributor:	Southern Steel
Steel fabricator:	Cullen Steel Fabrication, Strongest Link S+L Steel Fabrication Southern Steel Supplies
Steel detailer:	BlueScope Lysaght
Coatings:	Industrial Galvanisers

Summary

Through the use of the external steel frame, One Shelley Street creates a strong architectural presence through the amalgamation of optimal design, engineering and construction. The diagrid structure, integral both as a powerful visual element and structural solution, provides a flexible interior space which is economical in terms of cost and construction. The highly detailed and refined steel structural system both defines the striking aesthetic of the building and utilises standard sized and prefabricated steel elements to create an elegant and efficient design solution.