

One one one Eagle Street



LOCATION:

Brisbane, Australia

SUBMITTING FIRM:

Arup

FIDIC MEMBER:

Consult Australia



One One One Eagle Street, a new 50 storey commercial office tower located within the Brisbane's Riverside precinct, has been heralded as one of Australia's best new office buildings – setting new benchmarks in innovation, quality and sustainability.

Project synopsis

Designed by Cox Rayner and Arup and constructed by Leighton Contractors, the 199.7m tall building features an unprecedented, organic vertical structure inspired by nature. It is also arguably the world's first high rise built using the principles of biomimicry inspired by the way plants grow upwards towards the light. It comprises 56 levels including 44 typical office floors, two plant rooms, roof level, a six-level basement, as well as a foyer bistro and an espresso bar at the podium level.

No two office floors are the same due to the shifting geometry and striking perimeter raking columns. The edges of the tower floors are supported by a seemingly random collection of slender inclined columns that grow from the base of the tower, branching and tapering as they rise. Clever integration of the building's design and construction overcame the many logistical and technical challenges of building a major tower with a deep basement within a busy commercial, retail and residential precinct.

Cox Rayner and Arup's concept for the building was selected through a design competition. The GPT Group, as both developer and owner, was impressed with the sustainable fig tree design, with the fig trees being celebrated in the completed tower as the centrepiece of a captivating lighting installation.

The engineering design of this truly unique building draws on the strengths and experience of Arup's best engineers with Arup providing structural, civil, façade, fire and maritime engineering services.

The successful completion and leasing of one of the few major towers to be constructed in the midst of the global financial crisis is a testament to the vision of The GPT Group and their design and sustainability aspirations, and to the value of the collaborative and integrated approach adopted by the entire project team. Completed in June 2012, the building delivered more than 63,385m² of Property Council of Australia Premium Grade rated Net Lettable Area (NLA) to the local office market.

At practical completion, One One One Eagle Street had successfully leased 83% to blue chip tenants, exceeding its 40% target. The outcomes of the project are a direct result of the client's strong vision, cutting-edge design, and innovative construction techniques.

Innovation, quality, and professional excellence

Site location, unprecedented design, ambitious architectural and client aspirations, and a tight program, presented numerous design and construction constraints. These challenges led to a high degree of technical excellence and innovation solutions, delivered to an exceptional quality.

The site selected for The GPT Group's new premium grade six star Green Star commercial office tower is perfectly located in the heart of the prestigious 'Golden Triangle' riverfront precinct in Brisbane's CBD. Proximity to river views, public transport and the Riverside dining and retail facilities all offer outstanding amenity to building users, and the generous and transparent foyer of the new building dramatically improves public circulation and views at ground level.

The site selected for the new tower did however present major technical and aesthetic challenges for the building's designers and builders:

- The 50 storey office tower with six basement levels and a plan footprint of approximately 40m x 40m had to be built on a site area only half the area of the tower, with minimal disruption to the existing Riverside properties and users, and within the same timeframe as a conventional tower with an unimpeded site.
- To take best advantage of the outstanding river views, the tower's service core should ideally be pushed to the buildings southwest corner, the tower's perimeter columns should be smaller than conventional towers, and the ceiling heights around the perimeter of the office floors should be higher than normal. To achieve the higher than normal ceiling heights without increasing the floor to floor heights meant devising a new 'thin edge' detail for the office floors.
- The proximity of the building to the river meant difficult ground conditions, with soft marine clay soils and a high water table. The challenge posed by the ground conditions was magnified by the proximity of the existing Riverside and Riparian towers, and the need to ensure that the development of the new tower would not affect these buildings or their foundations.
- The site for the new building was flanked by two existing towers designed by renowned architect Harry Seidler. The new tower needed to respect the presence of the existing towers while carving out its own unique identity.

Arup worked closely with the architect and contractor to develop a unique and innovative high-rise building design concept that cleverly addressed these challenges. This concept not only offered a way of building the new tower on its restricted site without disrupting the operations of the precinct, but it incorporated a unique hybrid tower design that provided a powerful identity for the building as well as allowed the building's core to be offset and producing unrivalled view transparency for building users through slender inclined perimeter columns and shallow edge beams.

The 'organic' tower perimeter structure was devised as a way of transferring loads gradually down around and through the existing facilities to land at ground points where basement columns and footings could be located without disruption to the busy office and retail precinct.

Arup developed a parametric design model that enabled hundreds of column patterns to be rapidly generated using random number generators governed by a defined set of structural rules including maximum and minimum column angles, maximum column loads, and zero sum of angles at each floor to ensure overall stability. The resulting patterns were then reviewed with the architect to select the optimum architectural solution.

The organic nature of the pattern is not accidental – one of the algorithms used to generate the hundreds of patterns considered during the initial design phase was derived from a seed germination and 'growing towards the light' algorithm. This application of biomimicry not only resulted in an impressive visual presence but also provided a number of key structural advantages.

The randomly inclined geometry of the columns allows them to be 'gathered together' at the base to land on support points positioned to clear the existing operational loading dock and existing substation, thus avoiding the expensive and time-consuming transfer structures that would otherwise be required.

The fig tree frame by its nature also provides a substantially higher degree of redundancy and resistance to accidental or deliberate damage, than would be provided by a conventional façade with vertical columns. The partial triangulation that exists within the fig tree frame provides an inherent lateral stiffness that supplements the lateral and torsional stiffness of the tower core. This extra stiffness gained from the perimeter column framing allowed the central concrete core structure to be offset to the south-west corner of the tower floor plate and substantially reduced in size in the top half of the tower, thus providing valuable additional net lettable floor area for The GPT Group.

The use of concrete filled steel box sections (ranging from 800sq to 300sq) for the fig tree columns ensured that the perimeter columns would be substantially more slender than conventional reinforced concrete columns, resulting in an unprecedented degree of transparency and access to views for building occupants.

Innovative 'Brisbane-first' construction sequence

While the fig tree columns are the most obvious innovation on the project, the manner in which the deep basement below the tower was constructed in parallel with the tower construction also represented a significant innovation. The new seven level basement is positioned in poor ground on the bank of the Brisbane River (and in part below the existing two storey Riverside Centre basement).

Arup developed a construction method with Leighton Contractors that utilised a perimeter diaphragm wall and large prefabricated steel columns that were installed from ground level and plunged into large diameter piles founded in rock below the future basement. The plunge columns were designed to support the tower construction while the basement was being excavated.

This approach allowed construction to proceed up and down simultaneously and minimised the impact on patrons and businesses using the existing riverside precinct. This innovative construction methodology was a first for Brisbane and resulted in construction duration savings of between six and 12 months when compared with the conventional approach of tower construction following excavation and basement completion.

The principles of transparency and integrity

Every aspect of the project, from construction to completion, has embraced global best practice in sustainability, pushing design, aesthetics and construction boundaries.

With the building now close to fully occupied with many prestigious national and international tenants our client The GPT Group have said that the development has exceeded their expectations. The office tower has set the benchmark for premium grade office space within Brisbane and has become a sought-after address in the city by selling the excellence of the design and the user experience. The tenants have expressed their appreciation of the unique design and sustainable initiatives this tower provides for their workplace.

Transparency and integrity to overcome engineering challenges

Other significant engineering challenges that had to be overcome included major internal column transfers at the lobby level that are required to achieve the high degree of transparency at ground level that is so important in the integration of the new tower with the precinct.

In order to transfer the 8,000t internal column loads through to the basement carpark below the structural team developed an innovative system of prefabricated structural steel sections embedded into the concrete walls that did not require increases in wall thicknesses. Large diameter multistrand tendons were then used to tie these transfer elements back to the main core.

One One One Eagle Street's most significant innovation is its organic vertical structure which has created a legacy for the engineering and construction industry. In what is believed to be the world's first high rise tower built using the principles of biomimicry, it shifts tower design to a bold new possibilities. The unprecedented design not only defines the architecture, it equally defines the interior office space.

The clever structure evolved as a method of transferring the building loads to the edge of the site, due to the existence of the shared loading dock and carpark entrance directly under the northern half of the site, and the planned carpark under the southern side of the site. The design, development, fabrication and installation of a system of angled perimeter structural columns into an irregular geodesic grid was unprecedented design and presented challenges and risks to cost and programme.

A computer program (specifically written by Arup for the project) facilitated and enabled the development of these irregular geodesic grid of perimeter angled columns generating the column angle, spacing and size in unison with the structural requirements of the building core.

The learnings of design and constructing the building's structure has, and will continue to be captured within industry awards, technical papers and industry conferences, to benefit the wider industry. This includes, but is not limited to, the new knowledge gained in relation to differential shortening and fire engineering to sustain the structure's fire performance while incorporating the fig tree lighting and artworks requirements.

The positive feedback from the building owner (The GPT Group) describing the extraordinary success they have had with tenanting this building is a testament to the economic viability of this development. Our client believes this is directly attributable to the unique design and visual presence of the building.

Sustainability and respect for the environment

More than any other tower in the subtropical band around the world, One One One Eagle Street captures the spirit of the subtropics with its unique abstracted organic structure and commitment to sustainability, a distinctive and evocative response to its context at the scale of broad urban geography and at that of its immediate urban context.

The GPT Group has a strong corporate commitment to sustainability, and challenged the project team to achieve world's best practice standards in sustainable design and construction. The team enthusiastically embraced and met this challenge, with the project awarded the highest star rating available from Australia's Green Building Council – a 6 star Green Star Design (v2) rating. More recently, the building has also achieved a 6 star Green Star As-built (v2) rating.

Energy usage was minimised through the use of:

- a bespoke façade system that incorporates high efficiency glass, automated motorized blinds and integral shading louvers to reduce solar gain
- high efficiency HVAC systems
- onsite electricity generation via a gas-fired Tri-generation plant that can provide 25% of the buildings peak energy demand, which reduces demand on the city grid
- electrical and tenancy sub/metering
- high efficiency lighting, which together with high levels of natural daylight from highly transparent glass and reflection from integrated light shelves, and individual control of all light fittings via a DALI (Digitally Addressable Lighting Interface) result in very low energy usage for office lighting.

Indoor environment quality was optimised by incorporation of:

- ventilation rates more than 50% above the rates required by the relevant Australian Standards together with automated CO₂ monitoring
- a high level of ACE (Air change effectiveness) by reduced mixing of supply air with recirculated air
- excellent indoor air quality through the use of low VOC materials
- high frequency lighting ballasts to all the low energy lighting to eliminate perceptible flicker and enhance occupant comfort
- very low ambient noise levels within all office areas of 40 – 45 dB LAeqT
- a high degree of daylight penetration in to the office floor areas coupled with high efficiency glare control through high ceilings and fixed light deflectors in the perimeter zone and sensor activated automatic blinds
- spectacular river views from all tenant levels, with floor plates configured to ensure that more than 60% of the lettable area is within 8m of the highly transparent façade.

Management practices were tailored to minimise waste throughout the life cycle of the building's construction and operation, including:

- construction waste management which ensure that over 90% of the construction waste generated during site clearing and construction was diverted from traditional landfill and recycled
- dedicated occupant recycling facilities are provided in the completed building to allow tenants to separate, collect and recycle office consumables.

Water usage was minimised through:

- use of high efficiency fittings and fixtures
- provision of a recycling plant to process grey water to Grade A level for use in toilet flushing and irrigation
- water metering including automatic leak detection
- all landscape irrigation from recycled or captured water.

Materials sustainability was maximised through:

- cement replacement by flyash – an industrial waste product with substantially lower embodied energy than cement
- PVC minimisation by use of alternative materials for services reticulation
- All timber used within the base building and fitout obtained from certified sustainable sources.
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Harmful emissions were reduced through:

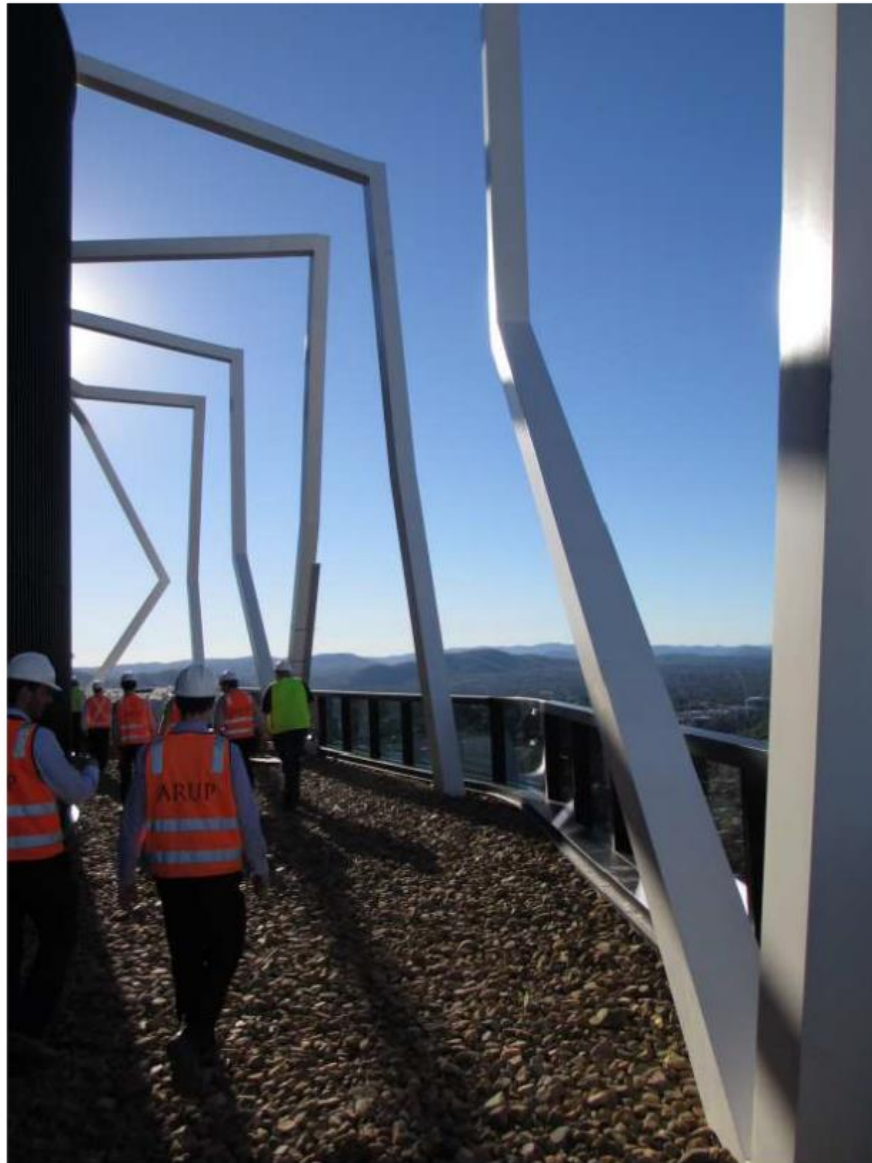
- minimising the Ozone Depletion Potential (ODP) of refrigerants through careful design and selection of the HVAC chillers
- external lighting was designed to reduced unnecessary dispersion of light into the night sky to reduce light pollution
- CO₂ emissions were reduced through the energy savings achieved and the excellent public transport linkages and facilities provided.

Out of the ordinary

On January 11 2011, Brisbane City was inundated with water due to river flood levels well above previous Q100 flood levels. The Riverside Centre basement filled completely with flood water as did the lower carpark level of 123 Eagle Street (Riverside Centre). An estimated 20 million litres of contaminated water was removed taking approximately 10 days of continuous pumping. Significant damage was sustained, far greater than initially estimated by team. There were limitations to the clean-up as the basement was unable to be fully cleaned until the adjacent basement car park was cleaned. There was one final basement concrete pour to perform prior to the flooding – occurring 11 weeks after the flood. Construction optimisation occurred through a flood remediation plan detailing strategies and procedures, and daily reporting. The team helped develop a recovery plan, and voluntarily provided project management, procurement, pricing, supplier negotiation and onsite works supervision.

The high standard of engineering design in this building is evident in the inherent environmental sustainability achievements of minimising the material necessary to support a tall building while achieving such a unique office tower with striking visual identity and distinctive organic architecture.

Arup believes One One One Eagle Street is a major breakthrough in tall tower design on an international scale, with the synergistic relationship between architecture and structure generating a regionalist architecture which is a refreshing departure from the 'could be anywhere' nature of so many tower designs.



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