DISCIPLINE CASE STUDY

Construction Engineering

OPPORTUNITIES THROUGH EXCELLENCE

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BG&E

Sydney Metro City & Southwest (SMCSW)

SYDNEY, NSW, AUSTRALIA
CLIENT: JOHN HOLLAND, CPB CONTRACTORS & GHELLA JV

The Sydney Metro City and Southwest (SMCSW) project will extend the metro rail between Chatswood and Marrickville and will include a new tunnel beneath Sydney Harbour.

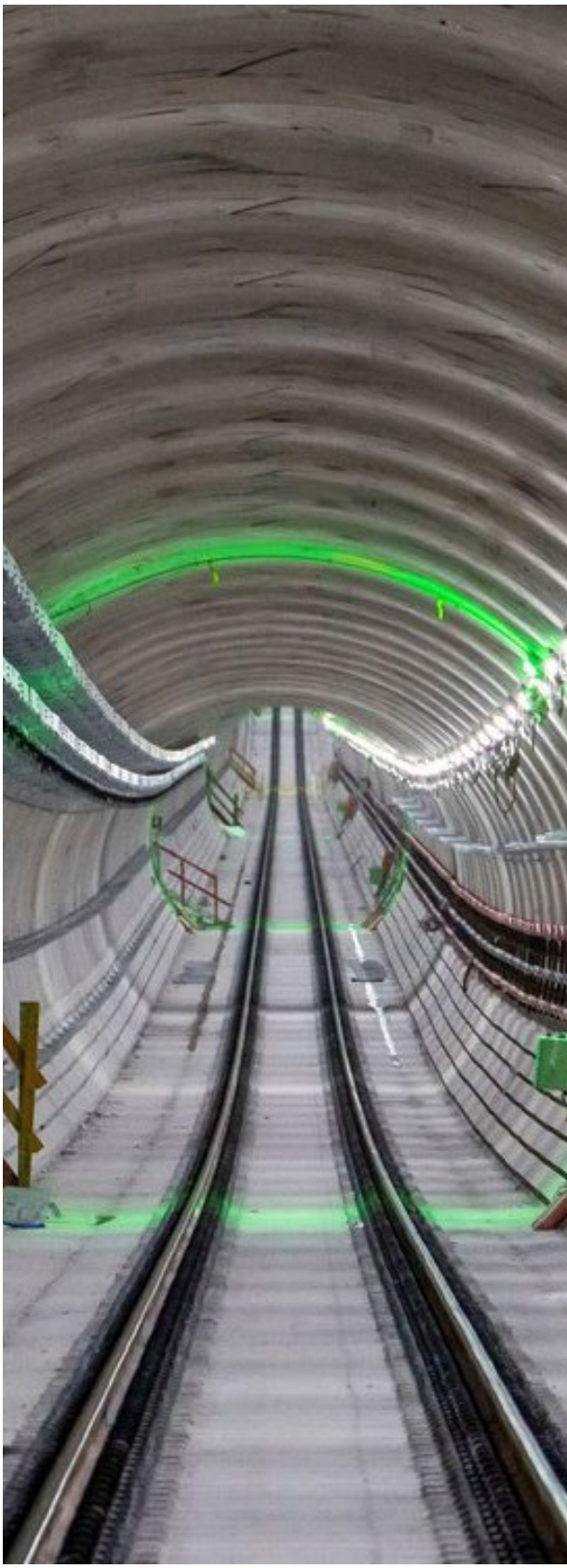
The ABJV was responsible for following scope of works for the TSE design:

- Design of temporary and permanent civil works (roadworks, drainage, temporary and permanent storm water diversion, flood modelling, utility coordination, road safety audit, traffic modelling, traffic staging, and temporary works).
- Design of temporary and permanent structures for all open box, shaft and dive sites (bored and CFA piling, shoring, steel platforms, deep excavation over 40 metres, and drained and undrained structures).
- Building effects assessment.
- Project wide durability assessment.
- Earthing and electrolysis assessment.
- Project wide flooding assessment.
- Project wide CAD and BIM management.

Arcadis and BG&E in a JV (ABJV) were engaged to do the tunnel station excavations, surface civil works and selected permanent and temporary works structures. In addition to the original scope of work, the BG&E team of engineers have provided construction engineering assistance and temporary work design.

The SMCSW is a 15.5 kilometre project, spanning from Chatswood to the Marrickville area, including a crossing beneath Sydney Harbour. The project includes:

- Constructing running tunnels with waterproofing using tunnel boring machines for dry tunnels, mined cross passages, a cavern for a rail crossover at Barangaroo, tunnelling below Central Station, and creating mined station caverns with adits for new stations at Victoria Cross, Martin Place, and Pitt Street, including a connection to the existing Martin Place Station on the Sydney Trains Eastern Suburbs Line.
- Demolition, excavation, and concrete structures for dives in Chatswood and Marrickville, as well as for new stations in Crows Nest, Victoria Cross, Barangaroo, Martin Place, Pitt Street, and Waterloo.
- Installing a permanent concrete lining in all tunnels, caverns, adits, cross passages, and underground openings to accommodate future track bed and rail and station services.
- Constructing the primary concrete structure at the new Barangaroo station and ensuring safe personnel access to underground spaces with temporary support services, including maintaining site facilities for handover to follow-on contractors upon completion.
- Removal of all temporary work and site facilities not otherwise required for handover to follow-on contractors.



Sydney Metro City & Southwest - Sydney, NSW, Australia.

Barangaroo Station Excavation & Hickson Temporary Road Bridge

SYDNEY, NSW, AUSTRALIA
CLIENT: JOHN HOLLAND, CPB CONTRACTORS & GHELLA JV

As part of the $2.8 billion Sydney Metro City and Southwestern (SMCS) Tunnels and Station Excavation Works contract (TSE), BG&E was appointed by JHCPBGJV to undertake the detailed design of the Barangaroo Station Excavation and Hickson Temporary Road Bridge.

Following this, BG&E were appointed by JHCPBGJV to design the stations' permanent structure.

BG&E's third contract on the project was awarded by Besix Watpac - providing temporary works and construction advice during the commissioning and fitout of the station and construction of the permanent surface works and roads.

Barangaroo Station Excavation & Hickson Temporary Road Bridge – Sydney, NSW, Australia.

PROJECT DETAILS

The station excavation is typically rectangular in plan with proposed bulk excavation level to be at approximately RL – 24.5 metres.

The retention system is comprised of soldier pile walls, with the inclusion of jet grouting between piles, and anchors for the western retaining wall and headwalls. A shotcrete face will be constructed in front of the soldier piles.

The shotcrete wall is connected to the piles with dowels. The soldier piled solution is intended to provide a tanked solution for the structure sitting above the sandstone bedrock. A blinding layer will be provided at the base of the excavation, with a longitudinal fall to facilitate drainage.

To allow the station excavation and construction activities to continue, a temporary acoustic roof and steel bridge structure for public access were provided. To maintain public access to the Station along the Hickson Road heritage retaining wall, a two lane suspended public access bridge was built over the full length of the box excavation. The public access bridge was supported on temporary piles and steel girders traversing the excavation.

At a later stage, the temporary bridge steel girders were extended to provide construction access alongside the western retaining wall, and two future bridge crossings over the excavation were also required for construction access.

In the scope for Besix Watpac, the temporary bridge had to be partially demolished while the new road over the station was built, with the road then being rediverted to be supported over the station box.

Quay Quarter Tower

SYDNEY, NSW, AUSTRALIA
CLIENT: AMP CAPITAL

BG&E provided structural and construction engineering services (including permanent and temporary works) and materials testing services (including highly complex modelling and analysis) to Quay Quarter Tower (QQT) - a highly sustainable commercial vertical village that is recognised as the largest adaptive reuse project in the world.

In a construction world-first, one side of the tower was demolished and reconstructed, while the other side of the tower was retained and refurbished simultaneously – enabling significant environmental and operational efficiencies.

During the upcycle of the existing building, around two-thirds of the towers original core were retained – conserving approximately 12,000 tonnes of embodied carbon.

The upcycled QQT now boasts doubled usable area and user accommodations, compared to the original tower – from 45,000 to 102,000 square metres of usable area, and from 2,500 to 9,000 square metres of user accommodations, respectively.

The global recognition bestowed upon QQT is a testament to its remarkable achievement. It was awarded the 'World Building of the Year' at the 2022 World Architecture Festival (WAF) in Lisbon and received the prestigious 2022/23 International High-Rise Award. These accolades highlight the extraordinary transformation and sustainability of the project, setting a new global standard in adaptive reuse.

The upcycle of the existing AMP centre tower into QQT has set a new global standard in adaptive reuse, bearing testament to an ambitious team, innovative design, and technical engineering excellence – with the result being a saving of over 12,000 tonnes of embodied carbon when compared to the traditional demolish and rebuild route.

Western Harbour Tunnel

SYDNEY, NSW, AUSTRALIA
CLIENT: ACCIONA

The Western Harbour Tunnel is a major transport infrastructure project that will make it easier, faster and safer to get around Sydney.

Extending from the Rozelle Interchange to the Warringah Freeway, the creation of a western bypass of the Sydney CBD will take pressure off the Sydney Harbour Bridge, Sydney Harbour Tunnel, Anzac Bridge and Western Distributor corridors to improve transport capacity in and around Sydney Harbour.

BG&E was engaged by Acciona to provide structural, civil, geotechnical, construction engineering (temporary works), façade and waterproofing design services across three different sites in Sydney - Cammeray, Rozelle and Berrys Bay.

Key aspects of the design services provided by BG&E include:

- Temporary works design including civil and pavement design to facilitate site establishment, structural steel site shed design, gantry crane design and other miscellaneous temporary works.
- Four gate design process, similar to other major TfNSW infrastructure projects (DCD, SDD, FDD, IFC).
- Frequent interfacing workshops with other disciplines including Architecture, Tunnels, Monitoring and Evaluation (M&E), Fire Engineering, Durability and Construction.
- 100 year design life for all permanent concrete structures (including fixings) and any elements unable to be replaced or maintained.
- Design of partially suspended RC slabs supporting large water deluge tanks above a decommissioned underground decline structure.
- Extensive Architectural and M&E coordination for the Cammeray site to enable construction and tunnel commissioning at the Interim and Ultimate phases.
- Spaceproofing and excavation coordination interface with below-ground ventilation tunnels and adjacent infrastructure assets at Cammeray.
- Design of the ventilation outlet in a restricted triangular site allowing for construction with live traffic on the Warringah Freeway.
- Bespoke assessment of elements to be demolished and modified to existing Rozelle interchange maintenance buildings.
- Consideration of M&E space, loading and fire resistance requirements for permanent fit out structures in the existing Rozelle tunnel network.
- Reviewing documentation of Rozelle and Southern Tunnel packages to assess the impact of WHT works on existing structures.
- Given the space constraints at the Cammeray site, along with the complexities of underground tunnels and multi-discipline interfaces, careful consideration was required for construction staging and coordination with the tunnel and WFU design elements.

Western Harbour Tunnel - Sydney, NSW, Australia.

Eastern Tunneling Package

SYDNEY, NSW, AUSTRALIA
CLIENT: JOHN HOLLAND, CPB CONTRACTORS & GHELLA JV (JCG)

The Sydney Metro West project is a new 24 kilometre underground metro railway that will double rail capacity between Parramatta and the Sydney CBD, transforming Sydney for generations to come.

John Holland CPB Contractors Ghella JV (JCGJV) has been awarded the contract to design and build the tunnels for the Sydney Metro West – Eastern Tunnelling Package (ETP).

The ETP works include the construction of 3.5 kilometre tunnels under Sydney Harbour between The Bays and Sydney CBD and the excavation of Pyrmont and Hunter Street stations.

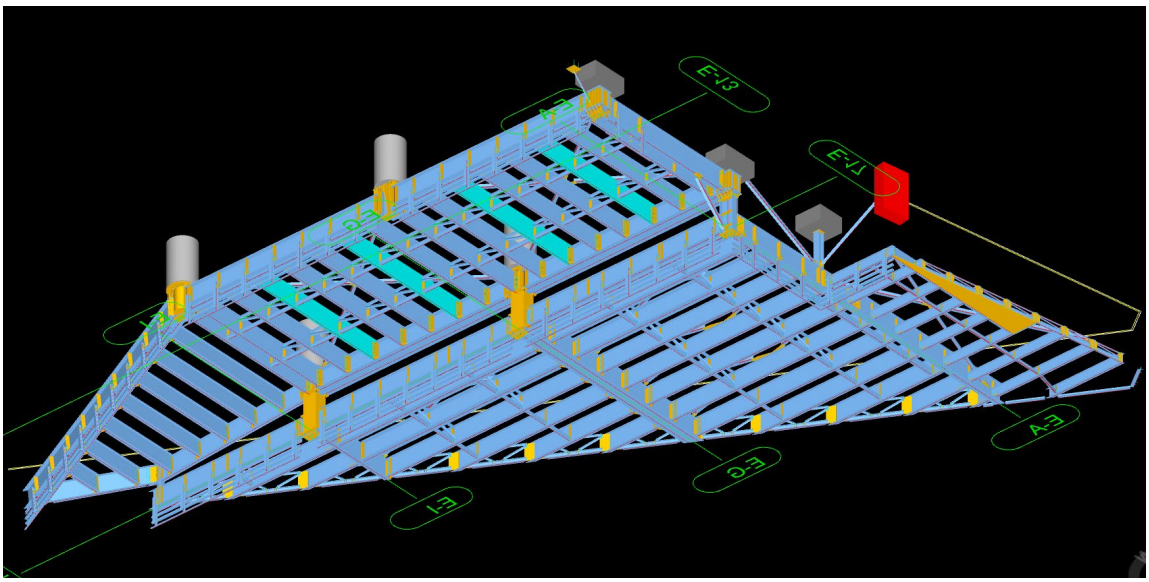
Starting at The Bays, tunnel boring machines will cross the harbour near the Anzac Bridge, before heading to the new Pyrmont Station and then under Darling Harbour before reaching Hunter Street Station in the heart of the CBD.

This once-in-a-century infrastructure investment is Australia's biggest public transport project and will provide fast, reliable, turn-up-and-go metro services with fully accessible stations, link new communities to rail services and support employment growth and housing supply.

BG&E, in JV with Arcadis, was engaged by JCGJV to provide structural, civil, geotechnical, temporary works and construction phase services associated with the station excavations works and enabling works for the TBM operations.

This included design of steel working platforms over the station excavation at both Pyrmont and Hunter Street along with complex construction and demolition staging design adjacent to existing heritage buildings. The design of temporary structures to facilitate TBM launching at The Bays, such as segment and spoil shed structures, grout and water treatment plant structures and significant temporary civil works to facilitate construction activities.

ETP Platform Model, Eastern Tunneling Package - Sydney, NSW, Australia.



Sydney Football Stadium

SYDNEY, NSW, AUSTRALIA
CLIENT: JOHN HOLLAND

The Sydney Football Stadium (SFS), now known as Allianz Stadium, is a $828 million, state-of-the-art stadium near Sydney's CBD that was funded by the NSW Government and reopened to the public in 2022.

BG&E was engaged to undertake temporary works for the fabrication, transportation, and erection of the steel roof for SFS. These works included:

- Erection staging of the major roof elements, including a staged FEA model for each roof element, with temporary supports on the pitch to control the local soil bearing and overturning.
- Review of lift studies and design of temporary supports for out-of-plane lifting induced loading.
- Design of the temporary support jigs and mechanisms to allow movement in the stressing stages and lifting of the radial arches.

The new stadium was built to meet the future safety and access requirements and boost growth in the Sydney visitor economy.

Fortitude Valley School

BRISBANE, QLD, AUSTRALIA
CLIENT: QLD DEPARTMENT OF EDUCATION

BG&E provided construction engineering services for the sports centre of the College, which was a part of the $98.7 million redevelopment.

Fortitude Valley State Secondary College is the first school to open in inner-city Brisbane in over 50 years. This innovative educational facility embraces its urban surroundings and utilises the subtropical climate, fostering a vibrant learning environment that engages with the local community.

Designed by Cox Architecture, with Thomson Adsett delivering the final architectural design, the school features a blend of traditional classrooms and contemporary collaborative and workshop spaces spread across multiple levels.

BG&E provided comprehensive civil, structural, flood, and traffic engineering services. The early works, valued at $81 million, facilitated the integration of flood modelling with civil and structural designs, ensuring a seamless approach to the project. Constructed by Hutchinson Builders, the project was completed ahead of the initial schedule, showcasing exceptional project management and execution.

The sports centre, part of a broader $98.7 million redevelopment, further extends the innovative design.

BG&E provided construction engineering services, including managing the structural design for a 23 metre concrete floor spans over twin basketball courts. The proximity to a rail line required careful consideration of rail impact loads and partial collapse criteria, with the entire structure built using precast elements.

BG&E's scope also covered the erection sequencing of precast components to assess their strength at various stages and the design of all temporary works to ensure stability. The team produced 4D-rendered animations, aiding communication of the construction sequence to on-site trades.

Fortitude Valley School - Brisbane, QLD, Australia.

Sapphire by The Gardens

MELBOURNE, VIC, AUSTRALIA
CLIENT: MULTIPLEX

BG&E was engaged by the builder, Multiplex, to provide construction engineering and temporary works services to Sapphire by The Gardens, a development that comprises two concrete towers - a 59 storey hotel named Shangri-La by The Gardens, and a 57 storey residential tower called Sapphire by the Gardens. Notably, these luxury towers are interconnected by an innovative sky bridge located on the 46th floor.

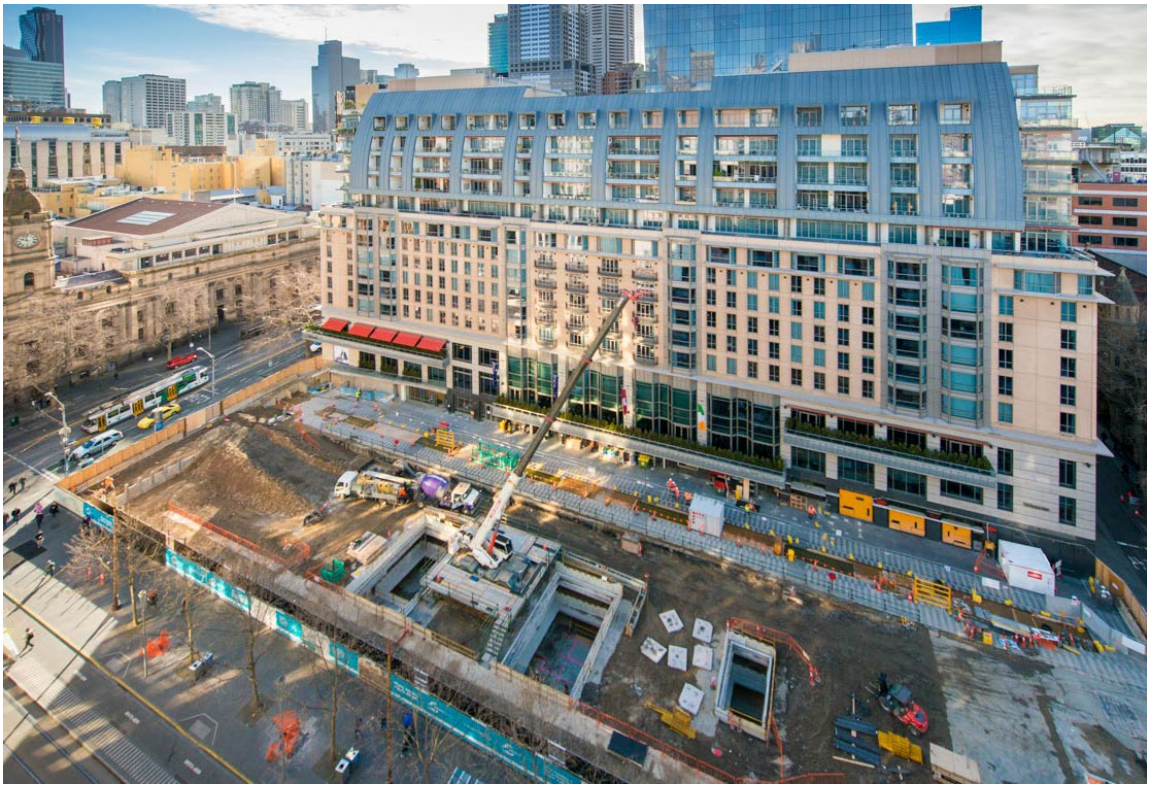
We provided a full range of construction engineering and temporary works services to the residential and hotel mixed-use development – including tower cranes, temporary propping, shoring of Alimak, man and materials hoists, and construction logistics at roof level.

A noteworthy side project that stemmed from the development was the crane lift of a three million dollar McLaren supercar to its new home in the 54th floor penthouse of Sapphire by the Gardens.

BG&E was asked to conduct a peer review and proof engineer for the proposed crane lift of the supercar - a delicate operation that involved meticulous review of the car's rigging arrangement to ensure a secure and level operation. Upon assessing the proposal, our team identified that the clearance under the McLaren was only 60 millimetres, prompting us to propose crucial modifications to facilitate the successful crane lift of the McLaren.

Melbourne Metro

MELBOURNE, VIC, AUSTRALIA
CLIENT: CROSS YARRA PARTNERSHIP



The Melbourne Metro project stands as a pivotal transformation for the city of Melbourne, encompassing a nine kilometre tunnel beneath the CBD to connect the West and East, with an estimated cost of approximately $11 billion.

The Melbourne Metro serves as an economic stimulus and significantly contributes to employment opportunities in the vibrant capital of Victoria. The Melbourne Metro will substantially enhance commuter capacity and trip frequency upon its completion.

As of October 2023, BG&E has successfully delivered close to 200 packages of work, including temporary works design and a range of other services. The major phases of this project were completed in 2022, marking a significant milestone in our commitment to contributing to the success of the Melbourne Metro.

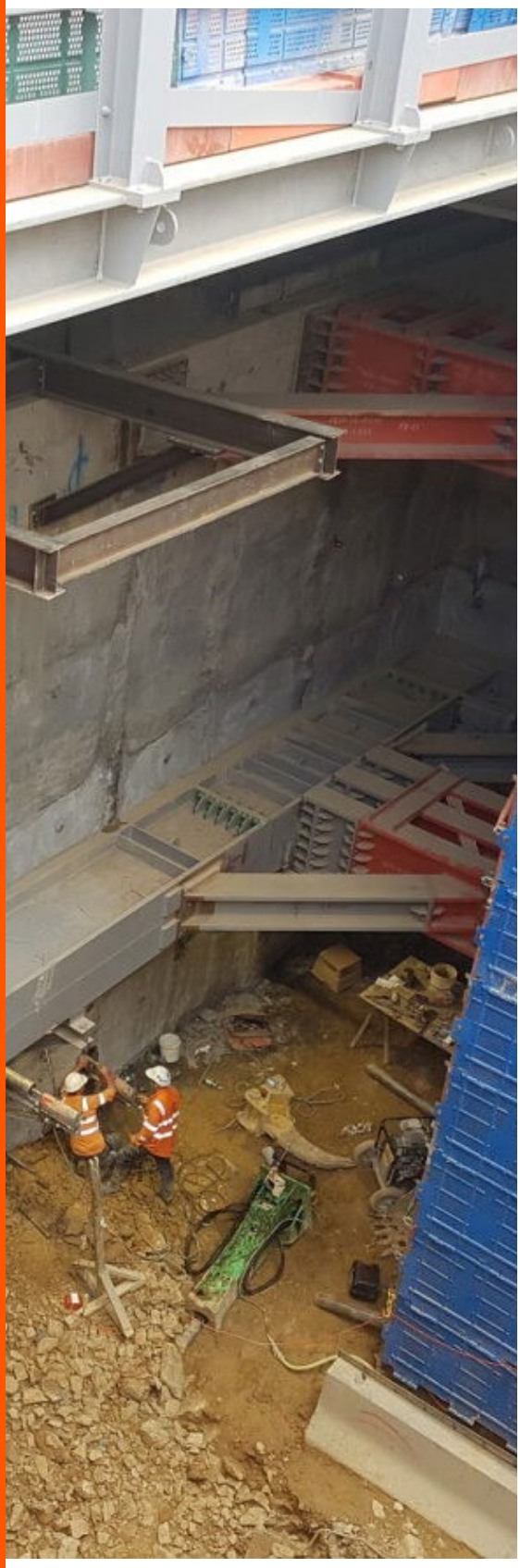
MELBOURNE METRO – TOWN HALL STATION

BG&E has been responsible for designing and documenting numerous significant packages of work to enable the excavation and construction of the Town Hall Station. We have undertaken works at all three of the access shaft sites, inside the station cavern and as part of the works to tie into Flinders Street Station.

Work packages included:

- Assessment of the existing Federation Square structure for the temporary construction arrangement, including demolition of significant lateral stability elements and replacement with temporary propping, to enable construction of an access shaft into the station cavern.
- BG&E also undertook construction staging analysis to optimise the build out of the main Federation Square shaft in conjunction with the adjacent secondary shaft, which will hold the escalators.
- Temporary retention walls and strutting of a 40 metre long and 5.6 metre wide trench in the roadway of Flinders Street, were required to construct a permanent reinforced concrete pedestrian tunnel linking the station cavern with Flinders Street Station. Maintaining these temporary supports throughout various stages of the construction process through coordination with other stakeholders and careful staged construction sequencing.
- Two tower crane gantries sitting over the public footpath on Swanston Street to enable removal of the temporary shed and heavy deck at the City Square shaft and construction of the permanent structure. Crane foundations were constrained on one side by the station works and on the other by numerous services running below the footpath and roadway, requiring close coordination with the construction team, Melbourne City Council and the asset owners.

Melbourne Metro – Town Hall Station - Melbourne, VIC, Australia.



Melbourne Metro – Town Hall Station - Melbourne, VIC, Australia.

- A large platform spanning over the City Square access shaft, which supported ventilation and scrubber units to ensure clean, fresh air for the teams working in the tunnel. Space constraints from the shaft retention system resulted in the deck having a unique doubly hung arrangement, with the primary beams hanging down from the capping beam on each side of the shaft and the secondary beams hanging from the primaries. This arrangement required exploration of custom sections and connection detailing with the client and steel shop detailer, along with construction and demolition sequencing.
- Construction staging analysis of the top-down construction at the Flinders Over Site Development (OSD) site to fast-track completion of the substation to allow trains to start running through the tunnel for testing – a key milestone for the project. The assessment also optimised the sequence for removal of the temporary plunge columns, which supported the upper floors of the station until the columns and liner wall had been completed.
- Temporary shafts in each of the platforms of Flinders Street station to access construction of lift shafts running from platform level to the underpass below. These works have ensured DDA access between the platforms of Town Hall and Flinders Street Stations.
- Each shaft was tightly constrained by the heritage listed platform structures, which remained operational throughout, and were further complicated by highly adverse ground conditions.
- Construction sequencing and loading assessments of each concourse slab within the station cavern at both Town Hall and State Library Stations to avoid temporary propping of these slabs, allowing train testing to start while construction continued. The construction team's requirements for these slabs were highly dynamic, but BG&E's responsive and engaged team ensured the construction programme remained on track.

MELBOURNE METRO - STATE LIBRARY STATION

Construction of the new State Library Station was highly complex, with five separate access shafts, along with the station cavern sitting under Swanston Street.

Construction sequencing between the main rail tunnel and adjacent station box was such that the tunnel boring machines for the main tunnels would pass the station box prior to its construction.

For safety reasons, a connecting adit between the tunnels and station box needed to be completed prior to the TBM's passage. To enable construction of the adit, a 26 metre deep 'D' shaped temporary shaft was constructed.

The temporary shaft, designed by BG&E, was constructed using concrete soldier piles and shotcrete infill panels, with a top capping beam and intermediate ring beams to provide lateral support to the piles.

Control of settlement and ground movement was a key design constraint to protect adjacent tall buildings and other surrounding infrastructure. Strain gauges and other monitoring devices were installed to provide real time feedback of actual movements with alarm states activated if detected movements exceeded predicted movements. Once the adit was completed, the shaft was backfilled and then progressively demolished as the permanent shaft, within which it sits, was excavated.

Melbourne Metro – State Library Station - Melbourne, VIC, Australia.

OTHER MELBOURNE METRO SITES

BG&E's participation in the Melbourne Metro Temporary Works project extended to all the metro sites, including:

- Steel bumper beams at Arden Station to prevent impact being precast concrete arch pieces and the adjacent completed structure during arch installation.
- Brackets to support the large, temporary steel struts and walers retaining the walls of various shafts, including at Parkville. BG&E's proposed connection details incorporated allowances for construction tolerances - such as piles installed out of position and allowing these brackets to be fixed to the shotcrete wall instead of the piles, to avoid clashing with heavy reinforcement within the piles.
- Polymer fibre reinforced shotcrete infill walls spanning between the shaft piles, where the rock was good quality to remove the requirement for steel mesh reinforcement, allowing faster excavation.
- Steel-framed concrete hoppers and concrete pipe restraints at Anzac Station and the Eastern Portal sites, to allow improved delivery of concrete from street level to the base of the shafts.

Melbourne Metro -
Melbourne, VIC, Australia.

North East Link

MELBOURNE, VIC, AUSTRALIA
CLIENT: SPARK CONSORTIA

The North East Link represents a significant investment in Melbourne's North East, aiming to transform transportation in the city and serve as the missing link in the freeway network.

Spark Consortia (Spark) consists of Salini Impregilo, GS Engineering and Construction, China Construction Oceania, Broadspectrum Australia, Capella Capital, John Laing Investments, and advisors Lendlease.

Delivered as a Public Private Partnership, Spark will construct twin three lane tunnels and interchanges that will protect homes and sensitive environmental areas - including the Yarra River, Banyule Flats, and Warringal Parklands.

BG&E is providing the primary package tender design - including road design, traffic modelling, and civil and dive structures design. Our scope of work also includes the design of four crane pile caps and piles at two different sites, Lower Plenty Road and Manningham.

This project will include the following elements:

- A massive upgrade to the Eastern Freeway.
- Completion of the M80 Ring Road.
- Melbourne's first dedicated busway.
- A new park and ride in Bulleen.
- More than 25 kilometres of new and upgraded walking and cycling paths.

Slated to be completed in 2028, the project includes the construction of tunnels to address a crucial freeway network gap, removing 15,000 trucks from local roads daily and reducing travel times by up to 35 minutes. Additionally, it will involve the completion of the Ring Road in Greensborough, a revamp of the Eastern Freeway, the establishment of Melbourne's first dedicated busway, and the creation of the North EastTrail, offering over 34 kilometres of pedestrian and cycling paths.

Optus Stadium

PERTH, WA, AUSTRALIA
CLIENT: ARUP

Formerly known as New Perth Stadium, Optus Stadium was completed in 2018 and accommodates permanent seating for up to 60,000 patrons, with the potential for expansion to accommodate up to 70,000 seats. The stadium forms a permanent centerpiece for the wider sports and entertainment precinct on the Burswood Peninsula, overlooking the Swan River.

Procured and delivered through a Design & Construct Managing Contract, BG&E was engaged as a subconsultant to Arup to provide both civil and structural engineering services for the stadium and wider precinct development.

For the structural component of the project, BG&E provided detailed structural engineering design, modelling, and documentation for the stadium substructure components.

Due to the presence of underlying soft alluvial soil materials with high consolidation settlement characteristics, a piled foundation system was adopted to found the steel-framed stadium structure and the event level concourse ground slab. Driven concrete piles were selected to avoid handling, treatment, and management of the contaminated soils.

Coordinating with the super-structure team, BG&E developed pile layouts, designed all pile-caps, and the suspended event level slab. Due to the high soil settlements below, slab services were integrated into the slab using thickenings or in suspended service trenches.

In addition, BG&E designed and documented the external ticketing gates structures and external landscaping structures, and assisted the contractor with temporary works designs for components of the superstructure.

Taking the lead for the civil design, BG&E's team focused on addressing the existing land conditions of the 73 hectare precinct. The civil works and stormwater design philosophy was to provide a sustainable and environmentally considerate design solution integrated with the interfaces of the surrounding State Transport Infrastructure and the landscaping vision and design for the sports precinct.

Given the soft underlying soil materials, our Civil team had to work to the existing ground levels, as significant fill would trigger long-term consolidation settlement. This approach was adopted to avoid ongoing maintenance of the pavements, roads, in-ground services, and key landscaped areas such as the community oval.

This was undertaken over the asset's design life while minimising the impact of the design and construction on the surrounding important ecological features, such as the Swan River and river-fed lake.

The Swan River Foreshore is a significant existing public realm resource, and the project provides an important opportunity to ensure that this resource is maintained and enhanced from environmental, infrastructure, health and safety, and ecological perspectives.

Optus Stadium - Perth, WA, Australia.

Opus Building

DUBAI, UAE
CLIENT: BROOKFIELD MULTIPLEX

BG&E provided structural engineering services to the Opus, a mirrored glass building designed by the late architectural legend, Dame Zaha Hadid. It consists of two 21 storey towers connected at roof level by a six storey deep composite sky bridge and six basement levels.

Due to the unusual shape of the building, an innovative construction methodology was developed for the bridge assembly, podium, and temporary platform on the bridges underside that enabled façade installation.

The groundbreaking segmental construction sequence for the bridge involved building main trusses and external façade grids bottom-up.

Upon releasing temporary diagonal members, load paths transitioned from temporary to permanent, forming a 'top-hung' structure. This innovative approach enabled simultaneous work in various locations across the site, allowed the use of lower-capacity cranes, reduced steel segment tonnage, and minimised construction time and overall construction cost.

Other innovative design outcomes achieved by BG&E include:

- Saving three months in construction time by revising the footing design and removing 240 piles from beneath the tower footprints.
- Incorporating an isolation strip in the hydrostatic slab to prevent differential settlement stress, reducing reinforcement needs by 30% at the junction between the hydrostatic slab and raft and saving over 60 tonnes
- Designing flat floor slabs that eliminated the need for edge and cross beams, improving constructability and reducing program time. Podium and link bridge complexities were removed from the critical path by shifting to composite steel construction. Opening three simultaneous construction fronts expedited tower completion.
- The segmentally launched sky bridge didn't require propping, enabling uninterrupted work on the podium below. Optimised construction sequencing minimised temporary diaphragm actions, ensuring an efficient and buildable structure. Innovative connection details facilitated bottom-up construction with a significant portion hanging in the permanent case.
- Façade installation utilised a temporary steel bridge platform beneath the permanent sky bridge. Innovative construction methods minimised module weights with temporary fixed cantilevered conditions, transitioned to a permanent pin-roller condition, almost halving the platform's weight, and allowed dismantling with a bridge above it after façade installation.

Opus Building - Dubai, UAE.

One Za'abeel

DUBAI, UAE
CLIENT: ALEC ENGINEERING & CONTRACTING

The Magnificent One Za'abeel is a prestigious mixed-used development located between the old and new business districts in bustling Dubai. Its scale is as complex as it is enormous, with two beautifully designed towers standing at 304 metres and 241 metres, sitting over the top of an operational six lane carriageway. The development also features seven basements 28 metres below ground level.

Above ground, the One Za'abeel towers sit on podiums A and B, connected by a 125 metre tall (in the air) and 225 metre horizontal steel and glass structure - the world's longest cantilever.

BG&E'S ROLE & EXPERTISE

BG&E was appointed as the contractor's third-party engineer, tasked with verifying the structural calculations and drawings of the link bridge, which were provided by the steelworks contractor. BG&E's team also designed the necessary temporary works for the construction and erection of the link bridge, ensuring that all project phases met the strict architectural and serviceability criteria.

SAFE INSTALLATION & MONITORING

A critical aspect of BG&E's role involved monitoring the stresses and deformations in the towers during the entire construction program, including the erection of the link. This was essential to ensure the safe installation of the bridge, which needed to meet stringent serviceability requirements.

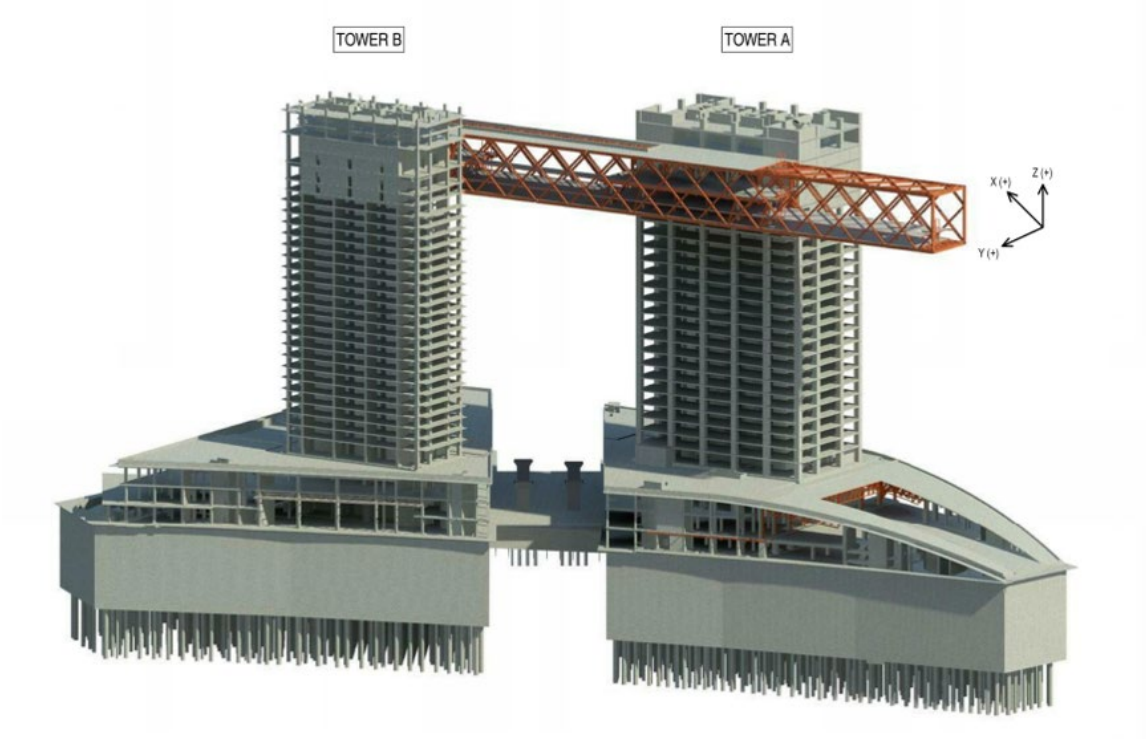
The cores and columns of the towers were pre-set out of plumb to accommodate expected movements during the link's construction. The link bridge was fabricated on a temporary steel structure over Podium A and Podium B, with both podiums partially strengthened to support the bridge's incremental launch.

INNOVATIVE CANTILEVER & LAUNCH SOLUTIONS

BG&E devised an innovative cantilever solution that allowed the 225 metre long link bridge to be launched incrementally across a live highway, eliminating the need for intermediate supports. This approach reduced highway closure time, eliminated the need for additional foundation structures, and minimised disruption to traffic.

The link bridge was lifted in two segments - one weighing 7,500 tonnes and the other 2,500 tonnes. This staged lifting ensured that deformations in the cantilevered end did not impede the structure's welding to the towers. BG&E also ensured that the construction program avoided the need for a second lift to be placed on the critical path by allowing tower construction to continue in parallel.

One Za'abeel - Dubai, UAE.



SIMULTANEOUS TOWER CONSTRUCTION

Initially, the construction of the towers was expected to halt until the link bridge was fully welded to both towers. However, through detailed sensitivity analysis, BG&E demonstrated that tower construction could continue up to certain levels during the lifting and fixing of the link bridge. This allowed the project to remove tower construction from the critical path, reducing overall construction time and cost.

LIFTING & STRENGTHENING SOLUTIONS

During the lifting process, highly high loads were vvtransferred to the towers. BG&E worked closely with the steelworks and lifting contractors to provide multiple design options for the lifting gantries and developed solutions for strengthening the towers. This included using the existing permanent steelwork to reinforce the towers, which reduced the need for additional embedded steel elements to be constructed on-site.

BASEMENT STRUCTURE COORDINATION

The close proximity of the two plots required significant retaining structures, such as soil anchors and walling beams, during the shoring stage. BG&E coordinated these basement works to avoid conflicts with the permanent basement structure. By optimising the construction staging and reducing the extent of retaining structures, BG&E minimised the time additional contractors were required on-site, further improving efficiency.

One Za'abeel -
Dubai, UAE.

Qatar National Library

DOHA, QATAR
CLIENT: QATAR FOUNDATION FOR EDUCATION, SCIENCE & COMMUNITY DEVELOPMENT

BG&E was engaged by the Brookfield Multiplex Medgulf JV to provide construction engineering, value engineering and temporary works design for the construction of the Qatar National Library (QNL).

The QNL is spread over three stories with raking stadium-like terracing plus a basement level for book storage to create a structural form similar to an open book at a scale of 140 metres by 140 metres.

The OMA designed building's façade panels are hung from the roof and have been created from a unique curved glass profile, utilising the depth of the curve in the glass to provide structural strength and avoid the use of any mullions.

To model the roof and façade integrally, BG&E developed a staged analysis model to determine the displacements at each stage of the installation and designed the fixings to suit these tolerances during the installation of the 27 metre high hung façade elements.

A 3D Tekla modeling for the analysis of the roof structure for the design of the structural elements was undertaken and sent straight to fabrication. BG&E also engineered an alternative design for the raft foundation to limit excavation, increase pour sizes and enable trafficability of the crawler crane on the slab during the construction.

Te Kaha Stadium

CHRISTCHURCH, NEW ZEALAND
CLIENT: JINGGONG STEEL INTERNATIONAL

BG&E is providing construction engineering and temporary works services for the $683 million project, including design review of temporary propping, lifting lug assessment, truss construction jigs, temporary stability of roof trusses, and access platforms.

The Te Kaha Stadium is a state-of-the-art addition to Christchurch, set to accommodate 30,000 for sports and 36,000 for music events. The stadium promises to invigorate the city centre, spur development, and reestablish Christchurch as a sports and cultural hub - drawing visitors from around New Zealand and the world.

With the project set to span from 2023 to 2025, the design review for Te Kaha Stadium presents challenges involving coordination with overseas designers and a Mandarin-speaking team, as well as addressing the designer's unfamiliarity with local codes.

Effective management of critical factors such as logistics, crane availability, and tight project timeframes and time constraints is essential.

Our technical team will apply their robust earthquake engineering knowledge, 3D FEM modelling skillset, expertise in legislative requirements and local design codes, and multilingual capacity to ensure the project's success.

21 Moorfields

LONDON, UK
CLIENT: MULTIPLEX CONSTRUCTION EUROPE

The completion of Crossrail in 2019 is triggering a regeneration of the Moorgate area, and 21 Moorfields – located directly above an existing London Underground station and a future Crossrail ticket hall – offers a major commercial opportunity.

BG&E was commissioned by Multiplex during tender to devise a complete construction engineering solution. Temporary works on site were minimised by fabricating larger pieces in the factory and transporting to site. Future hold points were removed by erecting the arches first before the floors were installed.

The development covers approximately 564,000ft² and will become the new London headquarters for Deutsche Bank, incorporating high-quality retail and commercial office space.

Data Centres

	LOCATION	MW	STORIES	BG&E ENGINEERING SERVICES	TYPE
AUSTRALASIA	ACT, Australia	20	1	Structural, Civil & Traffic Engineering	Colocation
	Auckland, New Zealand	12	2	Const. Support | Temporary Works	Colocation
	Auckland, New Zealand	12	2	Const. Support | Temporary Works	Colocation
	Auckland, New Zealand	12	5	Structural Engineering	Hyperscale
	NSW, Australia	35	6	Structural Engineering	Colocation
	NSW, Australia	48	3	Structural Engineering	Hyperscale
ASIA	Cavite, Philippines	24	3	Structural & Civil Engineering	Colocation
	Fairview, Philippines	124	5	Structural & Civil Engineering	Hyperscale
	Hyderabad, India	48	5	Structural & Civil Engineering	Hyperscale
	Johor, Malaysia	54	2	Structural Engineering	Hyperscale
	Kuala Lumpur, Malaysia	54	2	Structural Engineering	Hyperscale
	Kyoto, Japan	100	4	Site Due Diligence	Hyperscale
	Manila, Philippines	36	3	Structural & Civil Engineering	Hyperscale
	Manila, Philippines	22	4	Structural & Civil Engineering	Colocation
	Manila, Philippines	16	3	Structural & Civil Engineering	Colocation
	Osaka, Japan	32	4	Structural Peer Review	Hyperscale
	Pune, India	96	2	Structural & Civil Engineering	Hyperscale
	Saitama, Japan	48	5	Structural Peer Review	Hyperscale
	Singapore	16	6	Structural & Civil Engineering	Colocation
MIDDLE EAST	Abu Dhabi, UAE	60	3	Structural & Civil Engineering	Hyperscale
	Bahrain	48	2	Structural & Civil Engineering	Hyperscale
	Dubai, UAE	20	3	Structural & Civil Engineering	Colocation
	Dubai, UAE	20	3	Subject Matter Expert | Technical Advisor	Colocation
	Dubai, UAE	7.2	3	Structural & Civil Engineering	Colocation
	Israel	60	2	Structural & Civil Engineering	Hyperscale
	Israel	51	2	Structural & Civil Engineering	Hyperscale
	Israel	51	2	Structural & Civil Engineering	Hyperscale
	Israel	51	2	Structural & Civil Engineering	Hyperscale
EUROPE	Berlin, Germany	16	2	Const. Support Temporary Works	Colocation
	Dublin, Ireland	4	2	Structural & Civil Engineering	Owner Occupier
	London, UK	96	5	Const. Engineering | Sequencing	Hyperscale
	Madrid, Spain	4.8	1	Structural & Civil Engineering | Const. Support	Colocation
	Vienna, Austria	4.8	1	Structural & Civil Engineering | Const. Support	Colocation

At BG&E, we are united by a common purpose – we believe that truly great engineering takes curiosity, bravery and trust, and is the key to creating extraordinary built environments.

Our team of more than 700 highly skilled people, in offices across Australia, New Zealand, Singapore, the United Kingdom and Middle East, design and deliver engineering solutions for clients in the Property, Transport, Ports and Marine, Water, Defence, Energy and Resources sectors.

OPPORTUNITIES THROUGH EXCELLENCE

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