

DISCIPLINE CASE STUDY

Materials & Durability

OPPORTUNITIES
THROUGH
EXCELLENCE

bgeeng.com

BG
&E

Fort Nepean

MATERIALS CONDITION ASSESSMENT

PORTSEA, VIC, AUSTRALIA

CLIENT: PARKS VICTORIA



Located at the very tip of the Mornington Peninsula, Fort Nepean is one of the fortifications that protected Melbourne during World War I and II.

During the late 19th century, the government decided Victoria's rich goldfields needed protection.

Because of its strategic position, Fort Nepean became an important defence post. Numerous military fortifications were built, making Port Phillip one of Australia's most heavily defended harbours. In addition, the site has heritage cultural value, as the first British shot of World War I was fired from a gun emplacement at the site (Source: Parks Victoria).

BG&E were appointed as structural engineers and materials consultants, for the revitalisation of this heritage site.

The materials team completed an investigation of the current condition of the structures. Various non-destructive testing was completed on the heritage fabric of the structure, forming the basis on residual life assessments for various key elements. This formed the basis for an assessment of remediation options to provide the best benefit to Parks Victoria.

Port Kembla

MATERIALS CONDITION ASSESSMENT

PORT KEMBLA HARBOUR, NSW, AUSTRALIA

CLIENT: WGA AUSTRALIA



Port Kembla Harbour encountered a failure of hot rolled steel Z sheet piles. Specifically, a small number of these Z sheet piles became disconnected from the clutch shortly after installation. BG&E Materials was engaged to develop a methodology to test the steel and investigate the cause of this failure.

The works undertaken by our team included:

- The development of sampling and testing methodologies to confirm the properties of the steel and investigate the failure that had been reported.
- Hardness testing and micrographic examinations of steel to identify any differences in microstructure that may be indicative of changes in steel properties, confirmation of mechanical properties and chemical composition to confirm steel grade and properties, and assessment of welds.

- A macrographic examination of the sheet pile and clutch to confirm the profiles, as a part of the methodology.

The results of the testing were analysed by BG&E along with available information and drawings to confirm conformance of the steel to relevant ISO standards for hot rolled Z sheet piling, quality of the steel, and welding. The review also identified possible causes that may have contributed to the failure of the sheet piling that require further investigation.



Catherine Hill Bay Jetty

MATERIALS CONDITION ASSESSMENT

CATHERINE HILL BAY, NSW, AUSTRALIA

CLIENT: DEPARTMENT OF PLANNING & ENVIRONMENT

BG&E were engaged by the Department of Planning and Environment to conduct a thorough structural condition assessment of Catherine Hill Bay Jetty. The current concrete and steel structure, erected in 1974 to replace the historic timber jetty, has suffered neglect since 2009 when mining operations ceased. This assessment had two primary goals: evaluating adaptive reuse possibilities and considering demolition options.

BG&E, in collaboration with subcontractors, conducted a comprehensive structural engineering and durability assessment. This work involved extensive on-site works including:

- conducting reality modelling and high-resolution imaging via UAV,
- cleaning of steel piles in the tidal zone,
- thickness testing of steel elements, and
- strength and integrity testing of concrete elements.

Following the on-site data collection phase, extensive structural engineering modelling and calculations were undertaken to determine the current load capacity of the jetty and whether strengthening was required. Durability modelling, to determine if there was any remaining life of structural elements, was also conducted.



*Catherine Hill Bay Jetty –
Lake Macquarie, NSW, Australia.*

Three options were explored in this assessment:

1. Partial demolition over the land portion: based on the initial high-risk report, this option involved demolishing the heavily deteriorated landside jetty while retaining and maintaining the over-water portion.
2. Full demolition to the seabed: this option considered the complete removal of the jetty in manageable sections, utilising both landside and marine equipment.
3. Rectification of the full jetty: this extensive option involved the comprehensive remediation of both land and over-sea portions, including the demolition and replacement of various steel elements, such as landside columns, secondary steel framing, bracing, and multiple connections.

This structural assessment was delivered in 2023.



Albany Wharf

MATERIALS CONDITION ASSESSMENT

ALBANY, WA, AUSTRALIA

CLIENT: SOUTHERN PORTS AUTHORITY

To inform the master planning project, the Southern Ports Authority required an in-depth condition assessment following the Wharf Structures Condition Assessment Manual (WSCAM). BG&E undertook the site inspection, collection and testing of samples and non-destructive testing of concrete, steel, and timber elements.

The Port of Albany forms a part of the Southern Ports Authority, located in Western Australia. The Albany Port berths were showing signs of severe deterioration, including extensive cracking, spalling, timber rot and corrosion.

BG&E reviewed site inspection notes and documented the defects at the port. An assessment of suitable remedial options, including cost estimation and repair life, was then completed. This was then provided to the client to enable them to make informed decisions on asset management.

Plumbers Workshop

MATERIALS CONDITION ASSESSMENT

SYDNEY, NSW, AUSTRALIA

CLIENT: ROSE GROUP



Based in the Local Government Area (LGA) of Concord, the former Mortlake Gasworks operated from 1883 to 1990, during which time it provided the surrounding community with considerable employment. The heritage building has been retrofitted into a modern residential building that consists of 14 exceptional homes, designed to revere the buildings heritage and unique industrial style.

BG&E provided structural engineering and materials testing services, including investigation and existing structural assessments. Our team also contributed to the preliminary and detailed design, and the construction phase.

The key aspects of the works included:

- Repurposing the 1850's masonry structure.
- Installing new light-weight floors.
- Installing a new mansard roof.
- Seismic assessment of existing masonry elements, using in-situ test results.
- Strengthening of existing foundations.
- Verification of existing concrete floor.

This former gas fitters' workshop in Breakfast Point has been revitalised and certification of the redevelopment was achieved by applying a performance-based design approach.

The Doulton

MATERIALS CONDITION ASSESSMENT

LONDON, UNITED KINGDOM

CLIENT: THIRD.I GROUP



The historic 1980s Royal Doulton manufacturing site has been transformed by Third.i into The Doulton - a premium mixed-use building that boasts a health and wellness facility, private offices, three new storeys, and luxury apartments with floor-to-ceiling, double-height glass windows with views of the iconic London skyline.

BG&E provided materials, structural, and façade engineering services to the adaptive reuse heritage project - ensuring structural safety and performance enhancements while preserving 90% of the original building, resulting in a significantly reduced carbon footprint.

Due to limited information on the existing building, a key challenge of the project was understanding the structure's present behaviour and performance, in relation to the proposed design.

To combat this, BG&E's materials team combined destructive and non-destructive materials tests to ensure a comprehensive dataset for structural analysis. Using this data, our buildings team developed a Finite Element (FE) model that accurately replicated the behaviour of the existing building.



*The Doulton –
London, United Kingdom.*

The testing included:

- Electromagnetic cover scanning to identify embedded reinforcement location and cover.
- Rebound hammer survey as per BS EN 12504-2:2021.
- Ultrasonic testing using a Surfer Ultrasonic Tester UK 1401 as per BS EN 12504-4:2021.
- Concrete breakouts using a rotary hammer drill.
- Concrete core sampling to assess the compressive strength.
- Concrete core sampling to develop a durability model based on chloride diffusion and carbonation.

The buildings and façade team have been involved in The Doulton project since the concept stage, which facilitated the optimisation of the proposed design, innovative solutions to consultants' requests, and cost-effective proposals.

Notably, the façade team's material choices reduced loads on the existing structure, which eliminated the need for expensive strengthening works due to changes to imposed loads.

The building team optimised the structural layout, enhancing internal spaces for improved freedom and safety. A clever solution to maximise residential spaces involved transforming the north and south core walls into columns and strategically placing additional walls on residential floors from level two to level 17. A transfer floor was added at level one to restore the original load path on the substructure, avoiding intervention on the foundations.

Premier House & One Cathedral Square (1CS)

MATERIALS CONDITION ASSESSMENT

MANCHESTER, UNITED KINGDOM
CLIENT: PROPERTY ALLIANCE GROUP



The four-star Renaissance Hotel in Manchester has been closed since July 2020, in anticipation of an ambitious redevelopment by Property Alliance Group. Instead of taking the traditional demolish and rebuild route, the original hotel tower will be retained, undergoing restoration and upcycling.

The revamped 216-bedroom hotel, part of SH Hotels & Resorts, will operate under the 'Treehouse' brand. This project is a key component of the £181.6 million redevelopment plan for the Deansgate site, marking the second Treehouse Hotel in the United Kingdom, after the first in London.

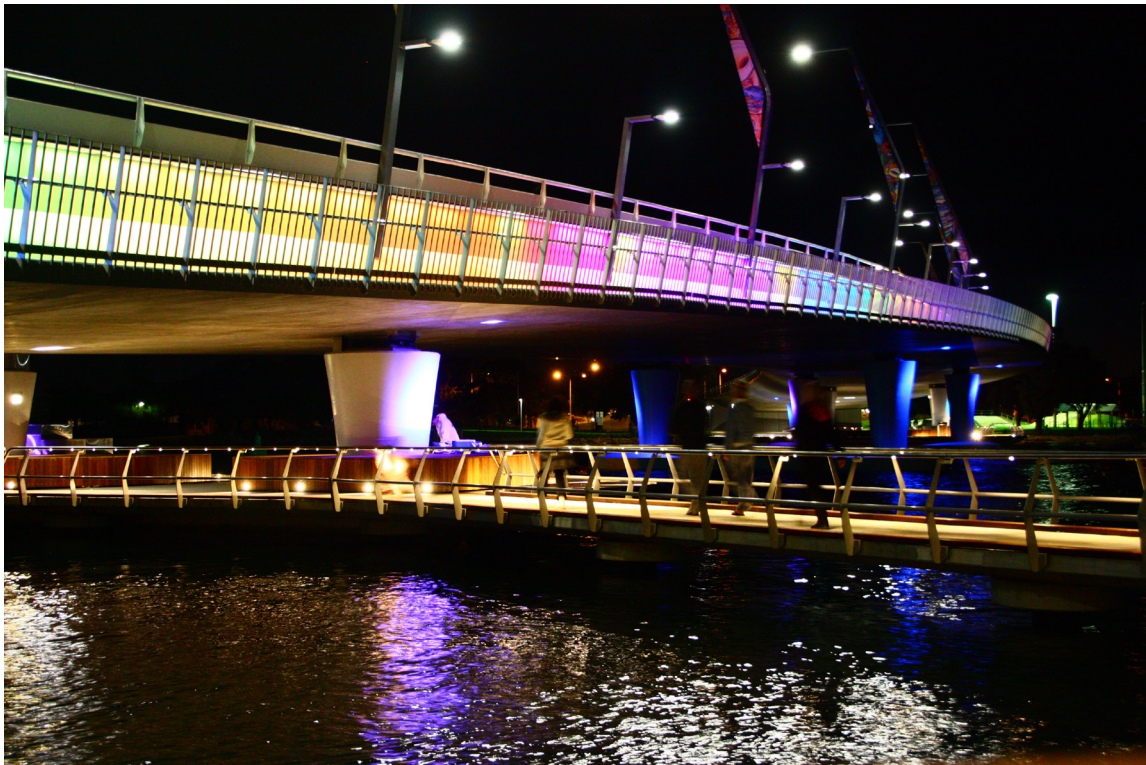
BG&E is providing structural engineering and materials services for the refurbishment project.

Our innovative technical solutions will significantly cut the development's embodied carbon emissions, facilitating owners and operators in achieving BREEAM Certification. The forecasted environmental benefits are substantial, projecting a remarkable 40% reduction in CO₂ compared to constructing a new hotel of the same size.

Mandurah Bridge Replacement

MATERIALS CONDITION ASSESSMENT

PERTH, WA, AUSTRALIA
CLIENT: MAIN ROADS WA



The \$51.8 million replacement of Mandurah Bridge was part of a scope of works that included the decommissioning of the existing bridge and the design and construction of a new bridge over the Mandurah Estuary, including associated roadworks, public amenities and infrastructure.



*Mandurah Bridge –
Perth, WA, Australia.*

Initiated in January 2016 and completed in March 2018, the new Mandurah Bridge serves to boost traffic capacity and stands as an iconic structure, offering improved amenities at the heart of the Mandurah for the community.

The existing structure was deteriorating and required an upgrade to expand capacity to two traffic lanes in each direction and improve safety for pedestrians and cyclists via separate and wider facilities over the bridge.

BG&E provided bridge design, civil and structural engineering, and flood modelling and hydrology services for replacement of the bridge, which runs over the Mandurah Estuary and into the surrounding marina precinct.

Our solution included adopting a unique curved soffit cross section constant along the full length of the 243 metre long bridge, resulting in a cost-effective landmark structure with a strong aesthetic appeal.

The bridge comprises six spans with 42 metre long internal spans and 37.6 metre long end spans. The post-tensioned superstructure is supported on elegant columns that are constructed on piled foundations. The new bridge includes lower-level wide shared paths which enable greatly improved pedestrian experiences, such as fishing platforms, public art and landscaping.

Banana Shire Council Water Reservoir

MATERIALS CONDITION ASSESSMENT

TAROOM, QLD, AUSTRALIA

CLIENT: BANANA SHIRE COUNCIL



The Taroom Clear Water Reservoir is a 0.45 ML concrete tank, located near the heart of the rural town. Built 52 year ago, the structure forms a critical part of the local community's drinking water supply.

The structure displayed signs of age, including cracking, spalling, and surface loss on the internal concrete face. The Banana Shire Council (BSC) required a condition assessment of the structure to determine remedial actions.

BG&E was engaged to undertake a detailed condition assessment of the external and internal face of the concrete reservoir. We determined that the surface loss on the internal concrete face did not pose as great of a durability concern as initially thought. However, our findings concluded that the concrete structure was nearing the end of its life, and remedial options were prepared.

Bridge #1056 - De Grey River

MATERIALS CONDITION ASSESSMENT

PILBARA REGION, WA, AUSTRALIA
CLIENT: MAIN ROADS WA



In the Pilbara region of Western Australia, Bridge #1056 spans the De Grey River along the Great Northern Highway.

BG&E was engaged to investigate the condition of the steel pile casings associated with the piers for Bridge #1056, including corrosion and section loss of the steel pile casings below, at and above the ground level.

The condition assessment of Bridge #1056 was completed in 2022, reporting varying amounts of corrosion in the pile casings with the greatest amount of section loss (up to 3.5 millimetres for a 12 millimetre thick pile casing) recorded at ground level. The report also confirmed complete loss of coating with no protection to the steel in the zones between the high-water and below ground level.

The project scope included:

- Preliminary works.
- Site investigation, including:
 - » Visual assessment to determine the condition of the casings and corrosion.
 - » Non-destructive testing, including ultrasonic thickness testing of the steel, ferrous dry film thickness gauge to determine coating thickness, coating adhesion testing using AS 3894.9, Method A, and completion of a hammer tap survey.
- Analysis of all site investigations and provision of a written report.

Quay Quarter Tower

**MATERIALS CONDITION ASSESSMENT,
REPAIR SPECIFICATION & REMEDIAL SUPERVISION**

SYDNEY, NSW, AUSTRALIA
CLIENT: MULTIPLEX



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.

Features:

- 52 storeys and five basement levels.
- 220 metres tall.
- Eight-metres floor to floor.
- Eight to 15 metre column grids.
- Composite columns (concrete filled steel tubes).
- Composite floor construction.
- Demolition of approximately one-third of existing floor plate over full height of building to allow significant floor plate extension works.
- Irregular/varying floor plate up the building – no ‘typical’ floors.
- Extension and strengthening of existing core for lateral stability.
- Raking columns forming part of complex transfer structures with columns being hung from the roof across 20+ floors.



*Quay Quarter Tower –
Sydney, NSW, Australia.*

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

The global recognition bestowed upon QQT is a testament to its remarkable achievement. Awards include:

- Council on Tall Buildings and Urban Habitat (CTBUH), winner: 2023 Award of Excellence - Best Tall Building 200-299 metres.
- World Architecture Festival (WAF) (Lisbon), winner: 2023 UK, Buildings - Office Award.
- German Architecture Museum (DAM) and DekaBank (Germany), winner: 2022/23 International High-Rise Award.
- International Association for Bridge and Structural Engineers (IABSE), winner: 2023 Gold Star Award & Rehabilitation Category.
- MIPIM Awards (Cannes), winner: Most Innovative Built & Natural Environment Consulting Firm.

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.



*Quay Quarter Tower –
Sydney, NSW, Australia.*

333 Kent Street

**MATERIALS CONDITION ASSESSMENT,
REPAIR SPECIFICATION & REMEDIAL SUPERVISION**

SYDNEY, NSW, AUSTRALIA
CLIENT: FDC

The revitalisation of a 1980's Sydney merchant house at 333 Kent Street has transformed this site into a state-of-the-art workplace designed for 2024 and beyond.

This \$400 million office tower redevelopment project seamlessly merges past and future, maintaining the integrity of the original superstructure - a nine-level building with a ground and mezzanine level, while implementing significant internal and external alterations – including seven additional storeys and a new commercial façade while retaining the heritage façade.

BG&E provided comprehensive material testing, construction engineering, and structural engineering services from concept to completion.

Our work involved in-situ testing and investigation and analysis of the existing building's concrete properties to preserve the original structural elements. A key challenge was strengthening the structure to meet the latest design code, and we ensured compliance through preparing performance solutions.

The project emphasised adaptive reuse and sustainability, delivering a carbon-efficient design solution while upcycling the iconic existing structure into an A-Grade commercial building in the heart of Sydney's CBD.

Focus Apartments

**MATERIALS CONDITION ASSESSMENT,
REPAIR SPECIFICATION & REMEDIAL SUPERVISION**

GOLD COAST, QLD, AUSTRALIA

CLIENT: FOCUS APARTMENT BODY CORPORATE



Focus Apartments, built between 1973 and 1976, is a 34 floor building located in Surfers Paradise on the Gold Coast.

The structure, home to 123 apartments, had severe reinforcement corrosion around the pool, resulting in spalling and delamination in the structure.

BG&E was engaged by the Focus Apartments Body Corporate to inspect and offer remedial advice on the repair of the pool area. Based on the advice provided, BG&E was then engaged to supervise the remedial works.

Sydney Metro City & Southwest (SMCSW)

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

SYDNEY, NSW, AUSTRALIA

CLIENT: JOHN HOLLAND, CPB, GHELLA JV

The Sydney Metro City & Southwest (SMCSW) project will extend the metro rail between Chatswood and Marrickville and will include a new tunnel beneath Sydney Harbour. Arcadis and BG&E in a joint venture (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, BG&E's 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 (TBMs) 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. It also includes 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.

The ABJV are 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, temporary works etc.).
- Design of temporary and permanent structures for all open box, shaft and dive sites (bored and CFA piling, shoring, steel platforms, deep excavation over 40m, drained and undrained structures, etc.).
- Building effects assessment.
- Project wide durability assessment.
- Earthing and Electrolysis assessment
- Project wide flooding assessment.
- Project wide CAD and BIM management.



*Sydney Metro City & Southwest (SMCSW) -
Sydney, NSW, Australia.*



Suburban Rail Loop

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

MELBOURNE, VIC, AUSTRALIA

CLIENT: CPB

The Suburban Rail Loop (SRL) was announced by the Victorian Government in August 2018 and is a city and state-shaping program of investments and policy initiatives (SRL Project) that will transform Victoria's public transport system, boost productivity, and deliver urban renewal outcomes for Greater Metropolitan Melbourne.

The SRL Project will deliver a 90 kilometre orbital rail line connecting every major railway line from the Frankston line to the Werribee line, with a connection to Melbourne Airport, and includes several new Stations, three new transport super hubs (at Clayton, Broadmeadows, and Sunshine) and integrated precinct developments associated with the new Stations.

BG&E was engaged to deliver Work Package C (WPC) - Tunnels and Civil - Cheltenham to Glen Waverley.

The BG&E Materials team:

- Developed a comprehensive durability report based on geological and hydraulic assessments, outlining the project's lifespan expectations and potential challenges.
- Integrated findings from geological and hydraulic assessments to forecast potential durability issues over the project's lifecycle including the impact of existing landfill location that posed additional risk to durability.
- Conducted a thorough assessment of deterioration mechanisms for both concrete and steel components involved in the project.
- Evaluated risks and opportunities throughout the design life of the project, considering factors such as material selection, construction methods, and environmental conditions.
- Performed detailed analyses of materials to ensure durability in various conditions, including atmospheric exposure and underground environments with varying soil aggressivity.
- Utilised scientific principles and engineering standards to select materials with appropriate properties for the project's specific requirements.
- Ensured compliance with relevant industry standards, codes, and regulations governing durability requirements including PS&TR requirements.
- Maintained detailed documentation of all design decisions, analyses, and assessments related to durability considerations.
- Provided a value for money report to identify opportunities, risks, and maintenance regimes.

*Suburban Rail Loop –
Melbourne, VIC, Australia.*



Thornlie Cockburn Link/ Yanchep Rail Extension

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

PERTH, WA, AUSTRALIA

CLIENT: NEWEST – NEWEST ALLIANCE



METRONET is the Government's long-term plan to merge transportation and land use planning in Western Australia, facilitating sustainable growth in greater metropolitan Perth over the next 50 to 100 years. It extends beyond rail infrastructure to influence the development of walkable communities around station areas.

The Yanchep Rail Extension and Thornlie-Cockburn Link are two in a series of METRONET projects aiming to expand Perth's public transport network. METRONET plans to add around 72 kilometres of new passenger rail and up to 18 stations, marking the largest investment in history into Perth's public transport.

BG&E provided engineering and design services for the following METRONET projects:

- Forrestfield-Airport Link.
- Yanchep Rail Extension.
- Thornlie-Cockburn Link.

THORNLIE-COCKBURN LINK

Scope of works include:

- Services relocation and protection.
- Approximately three kilometres of duplication of railway between Beckenham and Thornlie stations.
- Relocation of freight lines to create space for the electrified passenger railway.
- Approximately 14.5 kilometres of extension to connect Thornlie and Cockburn Central stations.
- Significant modifications at Thornlie to convert it into a through station that accommodates six-car trains.
- Cockburn Central to independently service the extension without impacting existing Mandurah Line services.
- Modified grade separations at Karel Avenue and Ranford Road.
- Stations, bus interchanges and parking facilities at Nicholson Road and Ranford Road.
- Noise and vibration mitigation measures.

BG&E carefully considered various factors such as rail freight operations, existing services, stakeholder and other project interfaces, staging of works, and environmental and heritage factors—including obtaining necessary environmental approvals. Additionally, we took into account specific elements like the Beckenham to Thornlie Station operational rail line, crossing the Canning River, the Glen Iris Tunnel and freeway interface, and the Ranford Road bridge.

YANCHEP RAIL EXTENSION

Scope of works include:

- Final alignment with rail infrastructure within a cutting (similar to the alignment between Clarkson and Butler stations).
- Grade separations at key road crossings and graded separated principal-shared paths.
- Stations, bus interchanges and parking facilities at Alkimos, Eglinton and Yanchep.
- Expansion of Butler Station's bus facilities.
- Noise and vibration mitigation measures.
- Significant stakeholder engagement.
- Alignment through nature reserve.
- Environmental concerns including dust, noise and vibration, and flora and fauna.
- Significant earthworks along the rail alignment.
- Relocation of existing services.
- Road access to the new rail alignment.

BG&E took into consideration various aspects, including adjacent developer interface and construction traffic, stakeholder and other project interfaces, earthworks and haulage, integration of principal shared paths, staging of works, locality, and environmental and heritage factors - including obtaining necessary environmental approvals.

METRONET Thornlie-Cockburn Link & Yanchep Rail Extension – Perth, WA, Australia.



New Fitzroy River Bridge

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

KIMBERLEY, WA, AUSTRALIA

CLIENT: MAIN ROADS WA

Flooding generated by Ex-Tropical Cyclone Ellie in December 2022 and January 2023 caused significant damage to the sections of Great Northern Highway at Willare Crossing and Fitzroy Crossing in the Kimberley.



At Fitzroy Crossing, the Fitzroy River Bridge was significantly damaged along with 500 metres of road - cutting access to Aboriginal communities east of the Fitzroy River as well as the East Kimberley and Northern Territory. Main Roads WA (MRWA) determined that a new bridge is required at the same location, with repairs to the existing bridge not considered feasible.

Given the critical importance of this bridge to the State and National Road network, MRWA were looking to have a new bridge structure and access roads completed within shortest practical timeframe and its elements that could be impacted by water flow completed before the next wet season.

BG&E provided bridge design services for the Fitzroy River Bridge replacement project, which included:

- A new two-lane traffic bridge over the Fitzroy River.
- Integrating a pedestrian pathway on the bridge.
- Reconstructing bridge approaches.
- Implementing flood and scour protection.
- Managing the protection and relocation of utility services.
- Flood modelling and hydrology.
- Temporary causeway and access road.

The new bridge is 100 metres longer than its predecessor at 270 metres long and twice as wide at 12.4 metres wide. The bridge is an eight-span continuous bridge with weathering steel-concrete composite deck construction, consisting of six welded steel beams made composite with concrete in-situ deck. The bridge superstructure was incrementally launched from the western abutment and completed in 32 days.

Blade wall piers with pile caps were installed and supported by 1200 millimetre diameter cased piles with concrete infill. The supporting piles of the bridge substructure were placed significantly deeper than the old piles to cater for scour in the riverbed during extreme flood events, reaching a maximum depth of 40 metres into the riverbed.

BG&E also delivered materials aspects of the bridge design, including provision of a durability plan, weathering steel detailing, concrete mixes, precast blade walls, and piles with permanent steel casing.

In December 2023 the New Fitzroy River Bridge in Western Australia's Kimberley region officially opened to traffic, more than six months ahead of schedule, marking the official reconnection of East and West Kimberley.

New Fitzroy River Bridge – Kimberley, WA, Australia.



Mandurah Road Footbridge

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

MANDURAH, WA, AUSTRALIA
CLIENT: MCCONNELL DOWELL



The Mandurah Road Footbridge crosses Mandurah Road and the PTA rail lines in Mandurah - to provide direct access to the Mandurah Rail Station from a nearby education campus. The bridge consists of two fabricated steel box girders that taper towards the crown of the arches. The structural steelwork is finished with a three coat Polysiloxane coating system that is required for both corrosion protection and appearance.

BG&E were requested to develop a methodology to investigate the condition of the coatings, defects and coating failures, and confirm if the defects are related to the coating application, exposure, or lack of maintenance.

The inspection methodology included:

- The use of drones and other camera technologies for visual inspection of inaccessible areas.
- Identification of sampling locations, destructive and non-destructive testing, and sample requirements for laboratory testing.



*Mandurah Bridge –
Perth, WA, Australia.*

- Testing requirements for coating adhesion, total dry film thicknesses and thicknesses of individual coats, assessment of surface preparation and analysis of coatings (laboratory methods).
- Consideration of access issues related to working over a busy four lane divided road and rail corridor, weight limits for access equipment on the footbridge and pedestrian traffic.

In addition to the inspection methodology, BG&E developed a coating specification suitable for undertaking site repairs to the protective coatings on the footbridge. The specification took into consideration:

- The existing coatings condition and compatibility with repair coats.
- Surface preparation methods suitable for site works.
- Specification of coatings compatible with the existing coatings, suitability for site application in limited time windows available, and a service life comparable to that of the existing coating systems.
- Maintaining the appearance of the bridge.



Coomera Connector (Stage 1)

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

NERANG, QLD, AUSTRALIA

CLIENT: ACCIONA GEORGIUO JOINT VENTURE

The Coomera Connector is a 45 kilometre north-south transport corridor connecting the Logan Motorway and Pacific Motorway interchange at Loganholme and Nerang-Broadbeach Road in Nerang.

The Department of Transport and Main Roads (DTMR) identified the 16 kilometre section between Coomera and Nerang (referred to as Stage 1 Coomera to Nerang) of the 45 kilometre long Coomera Connector project as having the highest demand for providing additional capacity between Loganholme and Nerang. The preferred arrangement has been identified as a new urban high-speed motorway having grade-separated interchanges which will provide an alternate route to the M1 for both the Coomera and Nerang river crossings.

BG&E was engaged to provide a holistic durability report for Coomera Connector Stage 1 North – Shipper Drive to Helensvale Road.

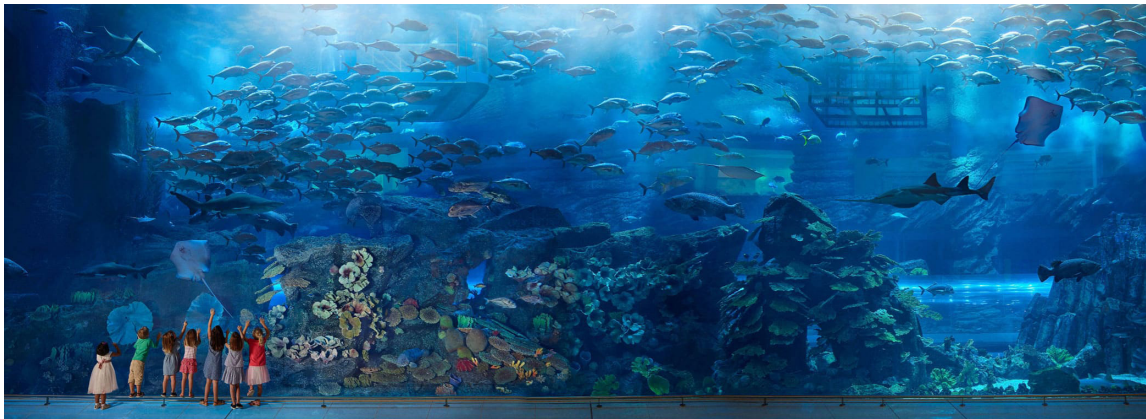
The report was constructed by assessing geological, hydrological, and atmospheric data, and providing durability recommendations to the specific site conditions for concrete, steel, and polymer technology. Inaccessible items were designed to withstand 100 years without maintenance and accessible assets were designed to minimise disruptions to serviceability and utilisation, recommending durable solutions and specific characteristics to fit the project location and intended use.

The durability report was completed in November 2022.

Marassi Aquarium & Underwater Zoo

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

DIYAR AL MUHARRAQ, BAHRAIN
CLIENT: BLACK & WHITE



BG&E collaborated with the globally acclaimed aquarium architect, James Hampton Design Partners, to carry out the structural design and documentation and to provide construction support services for the Marassi Aquarium and Underwater Zoo.

The project involved the construction of an aquarium within a shell and core tenancy space in the newly built Marassi Galleria mall in Bahrain. The aquarium will be the largest in Bahrain when complete, home to more than 200 species of fish, including sharks. Four different ecological zones have been created, with over 50 unique exhibits, including interactive digital displays.

BG&E carried out the design of the aquarium exhibit elements, including the extremely large reinforcing concrete shark tank,

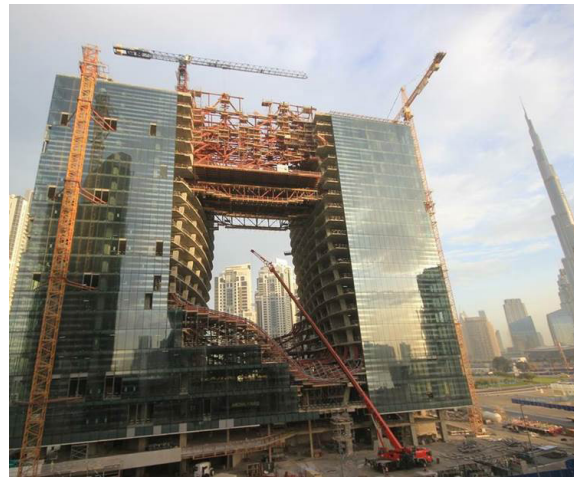
designed to resist intense water pressures while maintaining a watertight design and facilitating the installation of Perspex viewing panels.

Design of a new mezzanine floor using composite construction was carried out, as well as structural strengthening of the base build mall structure. Strengthening was designed to ensure the existing structure could support the heavy water loads imposed by the various exhibits and additional mezzanine floor.

The Opus

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

DUBAI, UNITED ARAB EMIRATES
CLIENT: MULTIPLEX



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

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

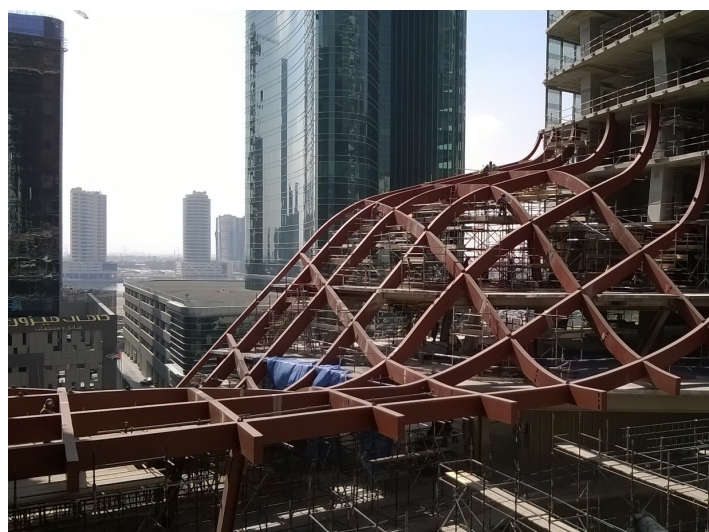
The groundbreaking segmental construction sequence for the bridge involved building main trusses and external façade grids bottom-up. Upon releasing temporary diagonal members, load paths transitioned from temporary to permanent, forming a 'top-hung' structure. This innovative approach

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:

- Saved three months in construction time by revising the footing design and removing 240 piles from beneath the tower footprints.

- Incorporated 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.



*The Opus –
Dubai, United Arab Emirates.*

Luxury Resort Island

DURABILITY ASSESSMENT & CONSTRUCTION SUPPORT

KINGDOM OF SAUDI ARABIA
CLIENT: UNDISCLOSED



This ambitious luxury resort island project for the Kingdom of Saudi Arabia (KSA) aims to reshape the region into a premier international tourist destination.

Designed by Foster and Partners architects, the project aims to turn the existing island into a luxurious resort destination that features an 800 metre diameter ring hotel with a central lagoon, over 550 luxury villas, and various amenity buildings, including beach clubs, restaurants, entertainment destinations, an 18-hole golf course, and associated amenities.

BG&E's role on the SAR 12 billion valued project involved:

- Design of 43 luxury villas, ranging from three to eight bedrooms, each with a unique architectural style and character.
- Design of nine different common amenity buildings, with two set to be constructed over the shallow waters just off the coast off the island.



*Luxury Resort Island -
Kingdom of Saudi Arabia.*

Our Designer's had to overcome several challenges to deliver the project, including:

- Ensuring durability of the structures in an extremely aggressive environment, including marine structures and timber elements.
- The projects very remote location and difficulty involved in transportation of labour and materials meant maximising the use of off-site manufacturing.

Preserving the project's architectural vision, BG&E collaborated with Timber Design Studios to incorporate extensive use of structural timber throughout. This included internal and external elements like pergolas, canopies, and roof structures. Notably, the use of exposed glulam timber beams and CLT panels in the Golf Clubhouse entrance achieved seven metre cantilevers, creating a memorable arrival experience for guests. The timber theme was seamlessly extended to each villa community to ensure the barefoot luxury feel of the island. BG&E and TDS worked closely with Fosters to ensure distinct architectural expressions for the four communities through specific framing methods and species selection.

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 1100 highly skilled people, in 15 offices across Australia, New Zealand, South East Asia, 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**

bgeeng.com

**BG
&E**