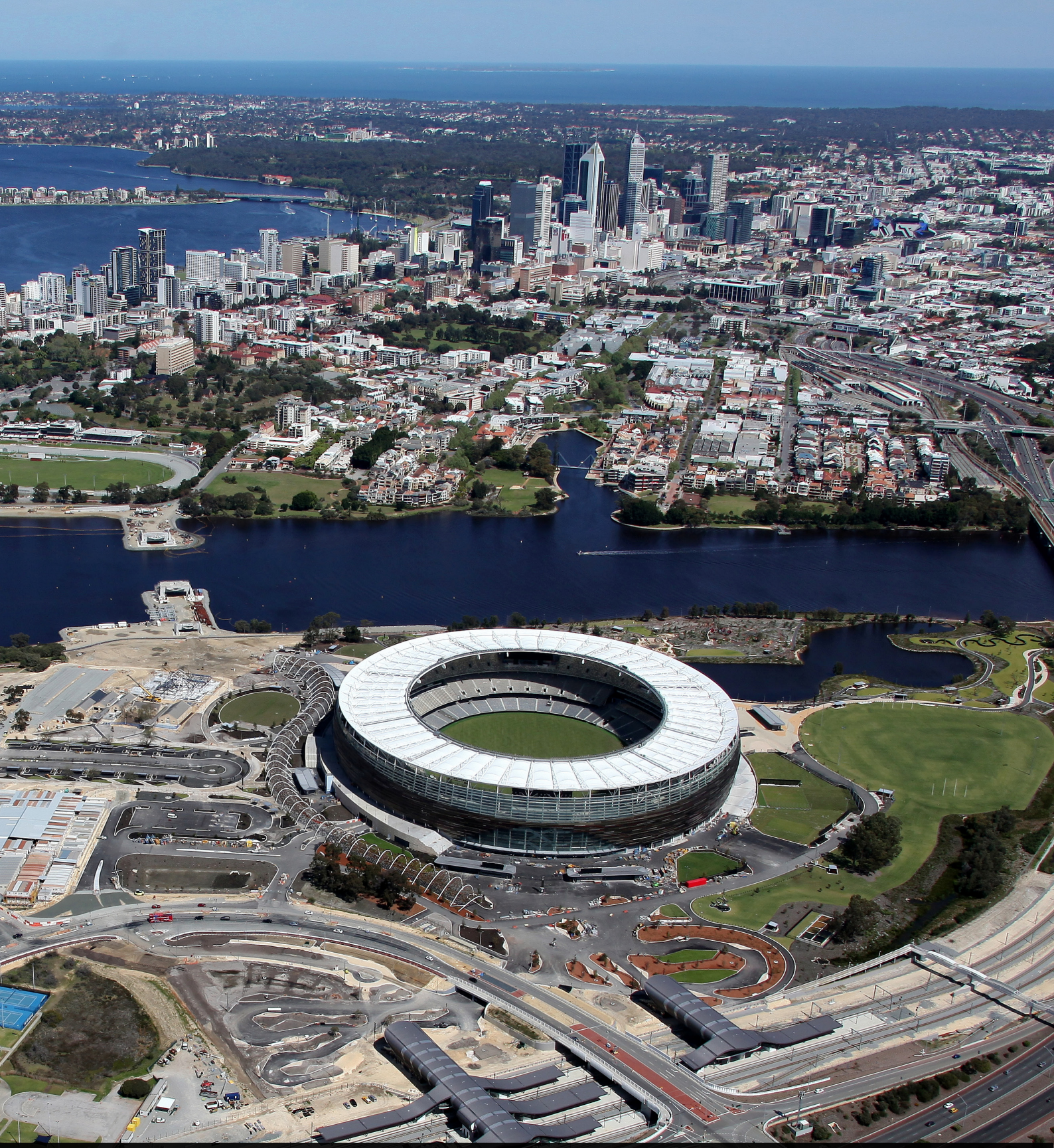


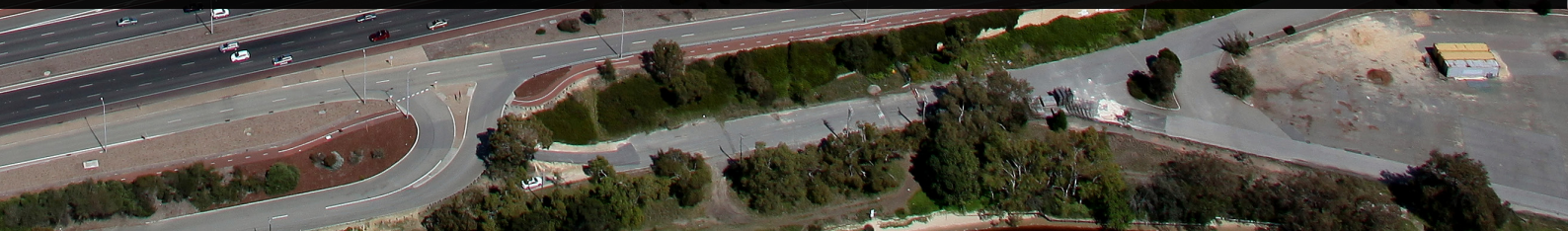
AUSTRALIAN CONSTRUCTION ACHIEVEMENT AWARD

MULTIPLEX

Built to outperform.

TECHNICAL PAPER

OPTUS STADIUM AND STADIUM PARK



Abstract

In the construction of Optus Stadium and the surrounding Stadium Park, Multiplex has delivered a truly world-class venue for Western Australia.

Located on the Burswood Peninsula, the 60,000 seat multi-purpose Stadium can host a variety of sports and entertainment events including Australian Football League, cricket, soccer, rugby and concerts.

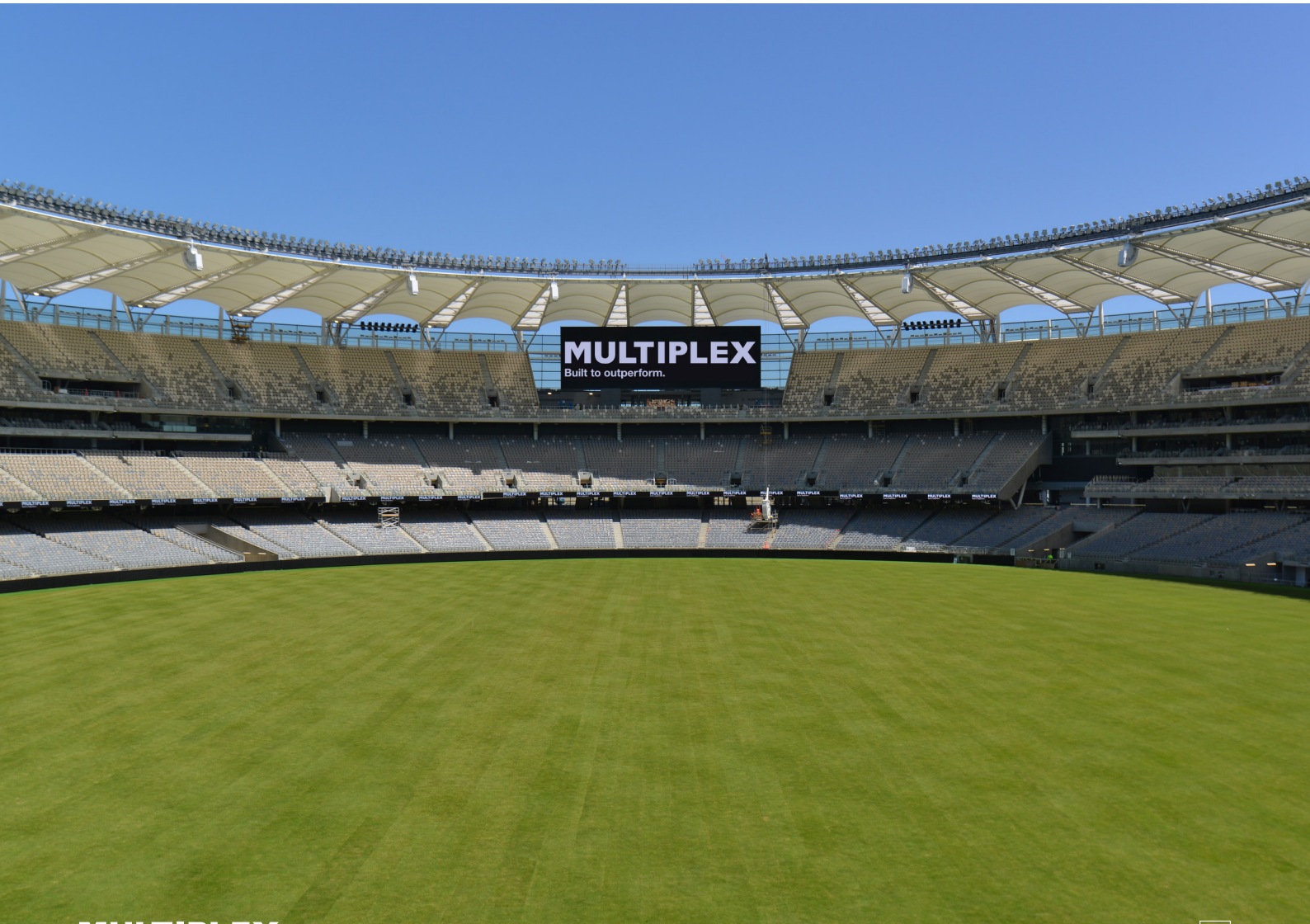
The surrounding Stadium Park provides year-round access for visitors of all ages, with facilities including nature playgrounds in the Chevron Parkland, the BHP Boardwalk and Amphitheatre, picnic and barbeque areas, public art, recreational facilities and bars and restaurants.

Multiplex was responsible for the design and construction of the Stadium and surrounding precinct as part of the Westadium Consortium, appointed in 2014 to design, build, partially finance and facilities manage the Stadium.

A 'one team' approach was taken from the outset, with the Multiplex and Client teams co-located on site to foster a collaborative working relationship. All team members were energised to work toward the project's shared vision of delivering a world-class stadium in an activated sports and entertainment precinct.

The result is an innovative design which ensures an exceptional event atmosphere and home ground advantage.

Construction of Optus Stadium and Stadium Park was delivered over three weeks ahead of schedule. It is owned by the Western Australian State Government and opened to the public on January 21, 2018.



1. Scope of Work

Multiplex was responsible for managing a design team consisting of three architects and 20 consultants, as well as engaging more than 130 subcontractors and suppliers to deliver the full range of trades and services.

The Stadium itself is a six-level steel and concrete structure with a colosseum seating bowl of 60,000 seats, designed with the potential to increase to 70,000 seats within the existing structure. A lightweight fabric roof covers 85% of seats and creates a suspended 'halo' effect.

The structure is clad with a striking anodised aluminium façade reflecting WA's unique geology and incorporating LED lighting displaying team colours. Over 50 food and beverage options are provided including restaurants, cafes and other outlets. The Stadium also hosts 17 distinct premium product areas, the largest variety of any stadium in Australia.

With a vision of a 'Stadium within a park', the scope of work also consisted of hard and soft landscaping over an area of 41 hectares, including the design and construction of nature play areas, a boardwalk and amphitheatre, a community arbour and a number of cycle and pedestrian pathways connecting the precinct.

Multiplex managed and coordinated the design consultant team to interpret the brief and develop a compliant and coordinated design solution with buildability input.

Key challenges included overcoming poor ground conditions and implementing a delayed design and procurement process without impacting on-time delivery of the project.

2. Type of Contract

Optus Stadium and Stadium Park was procured through a Public Private Partnership using a Design-Build-Finance-Maintain (DBFM) procurement model.

The Westadium consortium was awarded the DBFM contract in August 2014, which includes a 25 year maintenance period.

The consortium comprises John Laing (equity investor and asset manager), Multiplex (lead design and construction contractor), BGIS (facilities manager leading the maintenance and services delivery), and Brookfield Financial (financial adviser).

The State of Western Australia funded 60 per cent of the design and construction (paid during the three year design and construction phase) and Westadium is responsible for financing the remaining 40 per cent of the infrastructure.

3. Rehabilitation of the Burswood Peninsula

Previous land use of the Burswood Peninsula meant that at project commencement, the site was registered as 'possibly contaminated – investigation required' under the Contaminated Sites Act 2003 (WA).

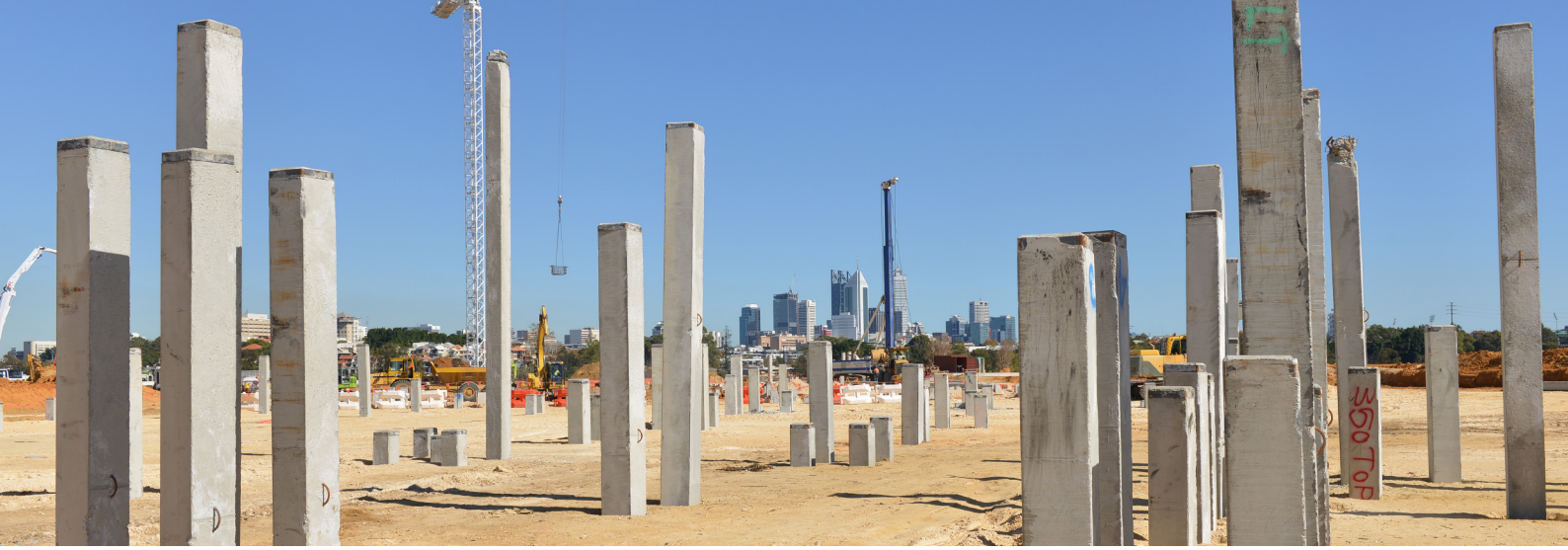
Additionally, the site is located adjacent to the protected Swan River and interconnected with the river via an onsite river fed tidal lake.

As a result, the ground conditions for the project were particularly challenging. Site investigations found that the upper eight metres of ground consisted of fill including concrete, fly ash, car bodies and household appliances.

Beneath this fill, the estuarine sediment known as the Swan River Alluvium was found to depths of 25 metres, overlying stiffer clays and sandstone.

Environmental challenges included management of potential impacts to ground and surface water, contaminated soils, and ground gases. Site specific management plans and procedures were developed and implemented to manage these risks and included:

- Developing a soil capping strategy involving warning layers and importing over 40,000 cubic metres of high quality top soil
- Implementing a comprehensive ground and surface water monitoring system
- Requirement for a ground gas membrane to the satisfaction of an impartial Contaminated Site Auditor



Multiplex's target was the reclassification of the site's contamination status to enable it to be utilised for its intended purpose as a Stadium and precinct.

This was successfully achieved with the Independent Auditor and Government Environmental agencies endorsing the targeted reclassification for the site. It was also achieved ahead of the targeted date, being the first public event being held at the Stadium.

4. Ground Improvement

A number of different ground improvement techniques were used to counter the conditions. A 20,000m^2 area within the Stadium Park underwent dynamic compaction and surcharge loading to collapse large voids, like those created by car bodies or similar items located within the fill.

Over 8,000m^2 of vertical drains were installed to the Bus Hub area. Due to objects in the fill blocking the installation of the drains, over 50% of the area was required to be pre-punched to clear obstructions.

Over 10,000 Controlled Modulus Columns (CMCs) were used to improve ground conditions across a 60,000m^2 area of the Stadium Park adjacent to the Swan River and river-fed lake.

CMCs are a relatively new technology to Western Australia and the Stadium was one of the first projects to utilise CMCs to this extent. As opposed to pre-loading this area, which may have pushed contaminants into the Swan River and river-fed lake, CMCs work by improving the characteristics of compressible ground by use of rigid inclusions.

This successfully improved the ground for key areas of the precinct including the Chevron Parkland and BHP Amphitheatre and Boardwalk, while meeting stringent environmental requirements for the site.

Over 2,700m^2 of sheet piling was also installed to further prevent any contaminants migrating into the Swan River.

The Stadium structure itself is supported by over 2,600 piles to depths of 36 metres. In total over 30,000m^3 of concrete was used for the ground improvement works, representing nearly a third of the concrete used on the Stadium structure in total.

5. Ground Gas Mitigation

A further common environmental impact from landfill sites is the presence of ground gases such as methane and carbon dioxide in the soil. Additionally the Swan River Alluvium is known to produce ground gases due to the organic content within the soil.

Initial testing of the site identified the presence of gases including methane and carbon dioxide. In a 'worse case' scenario, gases could enter the building once constructed and pose a hazard to human health or create a potentially explosive atmosphere.

As such, gas mitigation was identified as a requirement to remediate the site for its intended use.

There is no set standard for gas mitigation in Western Australia. A compound known as 'Golden Boot' is commonly used in Melbourne, however this was identified as being sensitive to heat and therefore not suitable for use in Perth's warm climate.

Multiplex instead employed the innovative use of an existing product - utilising the Enviro HP1600 water proofing membrane as a gas membrane. This had recently been used by Multiplex on the adjacent Crown Towers development on a much smaller scale (the first time it had been used for this purpose in Western Australia).

The Stadium is the first time Enviro HP1600 has been successfully implemented on such a large footprint and has proven meet the stringent specifications for a ground gas mitigation solution.

6. Logistics, Interfaces and Constraints

On-site logistics required careful consideration due to the large volume of traffic movement in and around site, with multiple work fronts under construction. At peak 18 cranes were operating on the site, including eight tower cranes.

This was managed by dedicated logistics team coordinating day-to-day works and upcoming major deliveries, including road closures to deliver 50 steel roof trusses.

With a limited laydown area available, a Just in Time (JIT) delivery system was established peaking at 500 vehicles per day and averaging three vehicles per minute during peak times. All deliveries were booked and managed through a specialised and dedicated Multiplex Site Logistics team.

The project had several external interfaces with independent contractors adjacent or within the project site including the Stadium Operator, Swan River Pedestrian Bridge, Public Transport Authority train station development and Victoria Park Drive road realignment.

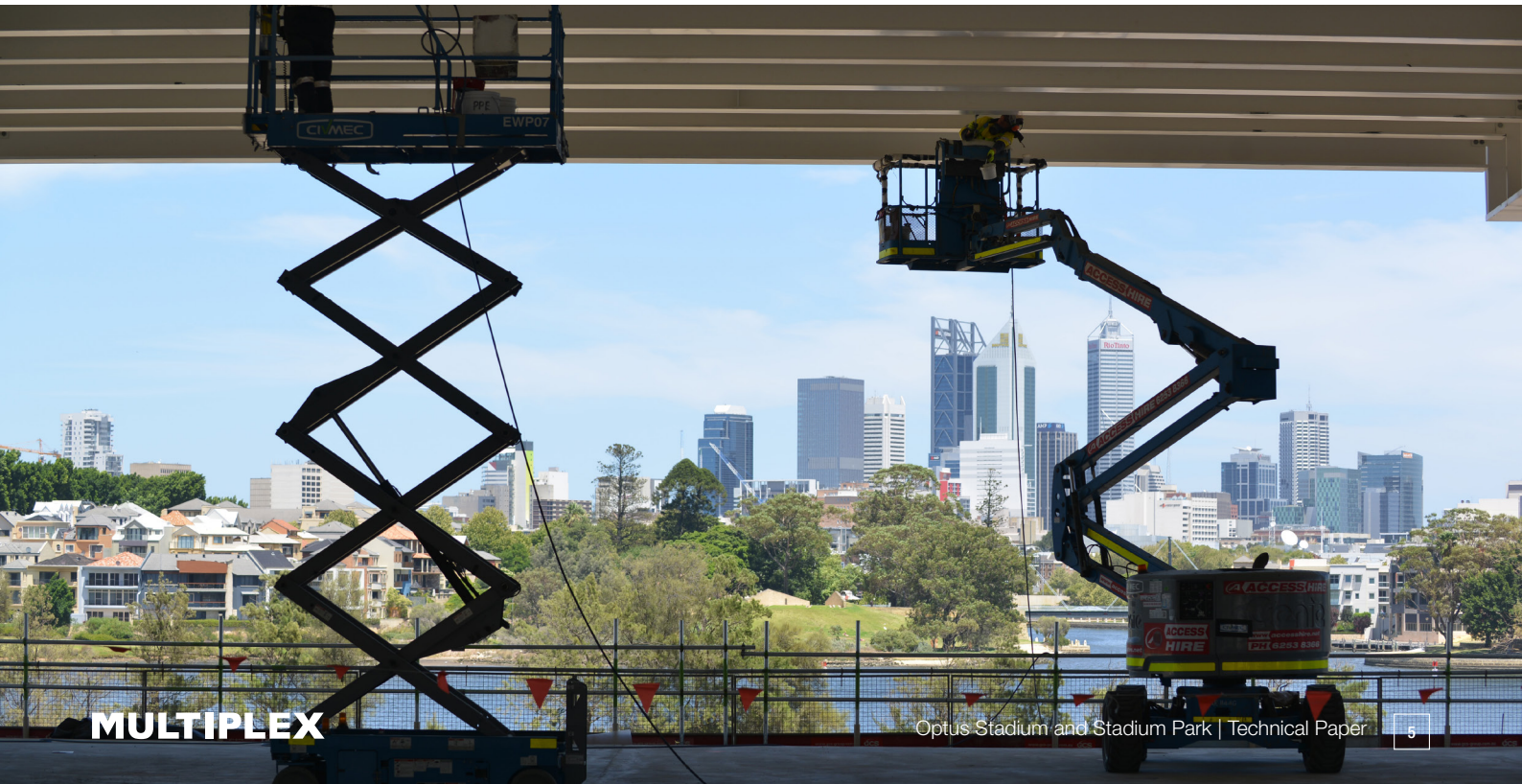
Other interfaces included State utilities upgrading water, communications and power provisions to site.

All interfaces were successfully managed by Multiplex as the lead contractor for the precinct, with regular interface meetings held to maintain dialogue and transparency.

With the site classified as ‘potentially contaminated’ the site team also carefully managed all civil works and tracked all civil earthwork movements, minimising disruption, re-using spoil where possible and avoiding cross-contamination.

A peak workforce of around 1,350 people also meant there were significant logistics considerations around the movement and accommodation of workers on site.

Amenities were provided on-site for all workers, with parking and shuttle bus facilities established at the nearby Belmont Park to ensure ease of access to the project and reduce traffic congestion on surrounding infrastructure.



7. Technology-focused Stadium

Ensuring the latest technology was available at the Stadium opening was a key focus for the project. Multiplex developed a delayed design and procurement process for the AV and ICT systems to allow the most current technology to be installed without affecting the on-time delivery of the project.

Technology features include:

- The world's largest LED integrated sports lighting system including sport lights, halo roof canopy lights and 7km of lighting in the Stadium's anodised aluminium façade.
- High density Wi-Fi allowing fans to simultaneously access and view streaming video and other content services, with over 1,400 wireless access points installed throughout the venue.
- Two 340m^2 mega screens, the largest screens in a sporting facility in the southern hemisphere.
- Over 1,000 screens across the venue that are independently addressable from the Event Control Room, enabling full flexibility on the content that can be shown.
- High level CCTV security using Siemens' integrated security management platform - a first for an Australian stadium.

8. Building Information Modelling (BIM)

Technology was also a focus in the design and construction process, with Perth Stadium one of the first projects in Australia to deliver Building Information Management (BIM) to Level of Development (LOD) 500.

This means an entire 'as-built' model of the Stadium and Stadium Park was delivered to the client to be utilised throughout the 25-year maintenance period.

All assets within the Stadium are tagged and coded back to the BIM model and its database via QR codes, providing a powerful asset management tool for both the FM provider and the Operator.

BIM was also used extensively throughout the design and construction process. Documentation reviews and clash detection were carried out in the model, which had particular value during the incorporation of the delayed design and procurement works, where the time between the completion of the design and installation became particularly short.

BIM was also used for progress tracking on site using QR code scanning systems for the primary structure and all FF&E, with weekly status images captured directly from the model.

The fast paced programme for the project forced an overlap of design and construction, compressing design. To adapt to this, a central BIM server was set up on site with all subcontractors having live access to each other's models. Combined with cloud based model synchronisation for interstate and overseas modellers, the continual flow of information allowed everyone to access the most up to date data at all times.

The delayed design portion of the stadium utilised this along with in-house architectural drafters to design, coordinate and model all 100+ catering spaces in a staged sequence tailored to site progress.

FF&E was managed using QR Codes generated through Google Sheets application programming interfaces (APIs), connected to a customised phone app that integrated Aconex Field QR IDs, allowing FF&E install and issue tracking live from site and mapped against design.

Laser scanning was utilised to asses steel deformation/deflection tolerances and ensure that integration with the façade was seamless.

Cloud-based issue tracking software system JIRA was used to track client comments and sign-off brief compliance. These were linked directly to Aconex documents and correspondence through custom coding and back-end APIs.

The industry-leading use of BIM also provided the opportunity to train and upskill not just Multiplex's own staff, but also client, subcontractor and supplier teams in the use of BIM and its associated programs.

To get off the ground running, Multiplex engaged experienced BIM consultants PDC in a

knowledge-share contract to train the project team. A number of mid-project training sessions were held, ranging from small classes of four to one-on-one sessions with both Multiplex and client staff.

Toward the end of the job, the operator and facilities management staff were trained in the use of the model post-handover.

Custom video tutorials and project specific training guides were also produced to support these face-to-face training sessions.

Training and knowledge sharing sessions with subcontractors were also chaired by Multiplex BIM staff, upskilling those where possible in Revit, Navisworks and even plugins like Dynamo. The collaborative atmosphere between the various subcontractor modellers also fostered a great environment of peer-to-peer knowledge sharing.

10. Stadium Roof Trusses

With roofing dominating the aesthetics of any stadium design, the design of the Perth Stadium roof was particularly complex - constructed to appear as if it is floating above ground.

Central to the design was the engineering of an innovative roof truss, developed using a high load pin connection to support the structure.

This involved removing the concrete structural elements holding the concrete plats up and replacing them with steel V-props.

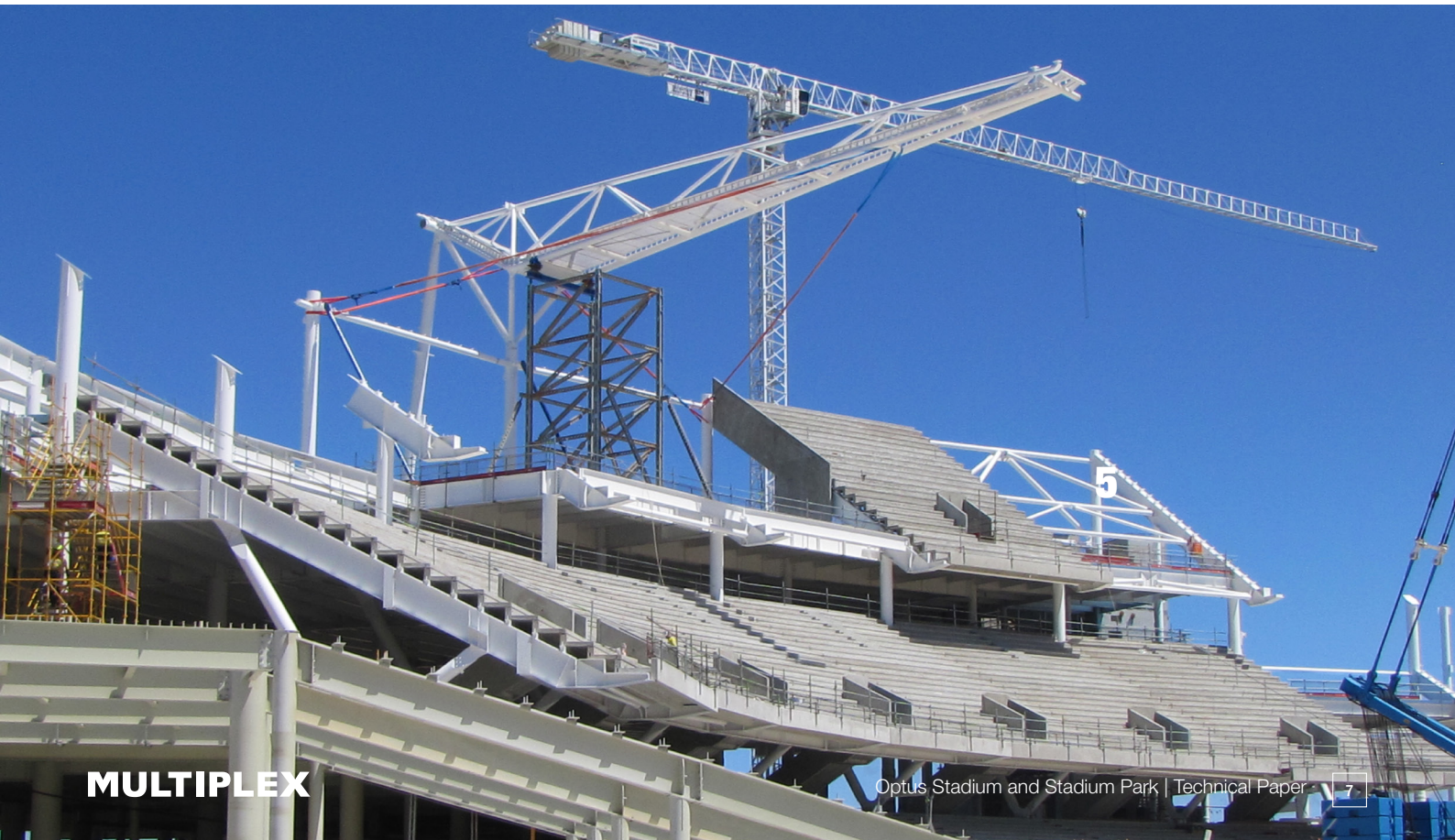
The design was inspired by the swing arm of Marc Marquez's 2012 Moto2 World Championship-winning motorcycle. By turning the arm upside down, the roof's design took shape.

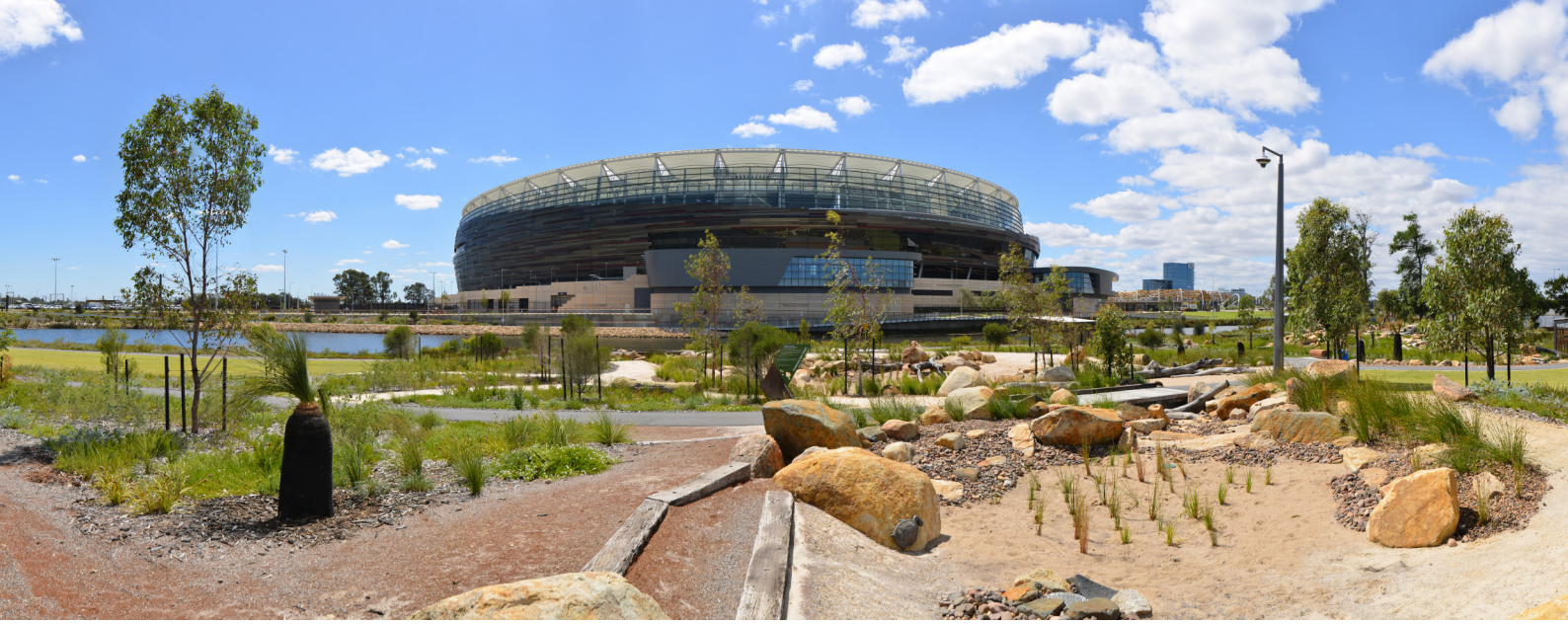
The efficient use of steel provided an opportunity to remove much of the material mass from the roof structure.

Importantly, it also minimised working at heights. This was identified early in the project as a key risk, with the original truss design requiring a large amount of work to be carried out on the trusses at height.

In a highly collaborative and best-for-project approach, the structural engineers, architects, subcontractor and Multiplex design team worked with the Multiplex Engineering Innovations Group to redevelop the truss design into a single steel truss that could be fabricated, transported, dressed and lifted as one piece.

This minimised the need to work at the Stadium roof height where use of low order hierarchical controls such as harnesses and static lines would normally be required.





11. Safer by Design

Multiplex's approach to health and safety on the project was underpinned by its 'Safer by Design' strategy, which is based on growing a mature culture, driven by senior management actions and embedding safety in the business process and decision making.

Safety was at the core of project planning from commencement. Wherever possible, critical construction risks were engineered out during the design process, with the aim to achieve the highest order hierarchical controls possible - focusing on the more effective and robust controls and striving to eliminate the need for people to be exposed to high risk work activities. An example of this is the roof truss design, discussed above.

Accountability for safety outcomes was clearly defined and applied across the management team, Multiplex's employees and subcontractors. Performance indicators were established to continuously measure the status of health and safety.

This included but was not limited to participating in risk workshops, re-enforcing our safety and health policy, completing regular workplace audits and inspections, monitoring work practices, attending and contributing to safety meetings, reviewing safe work methodology and ensuring all persons working on the site were appropriately inducted and trained.

A safety leadership group was established comprising senior management representatives from each discipline including project and site management, services, logistics, precinct/ civil and HSE and regional management representatives.

Meeting on a weekly basis, the group focused on the project critical health and safety risks, defining controls and establishing hold points. Senior leaders were allocated with responsibility to manage specific risks.

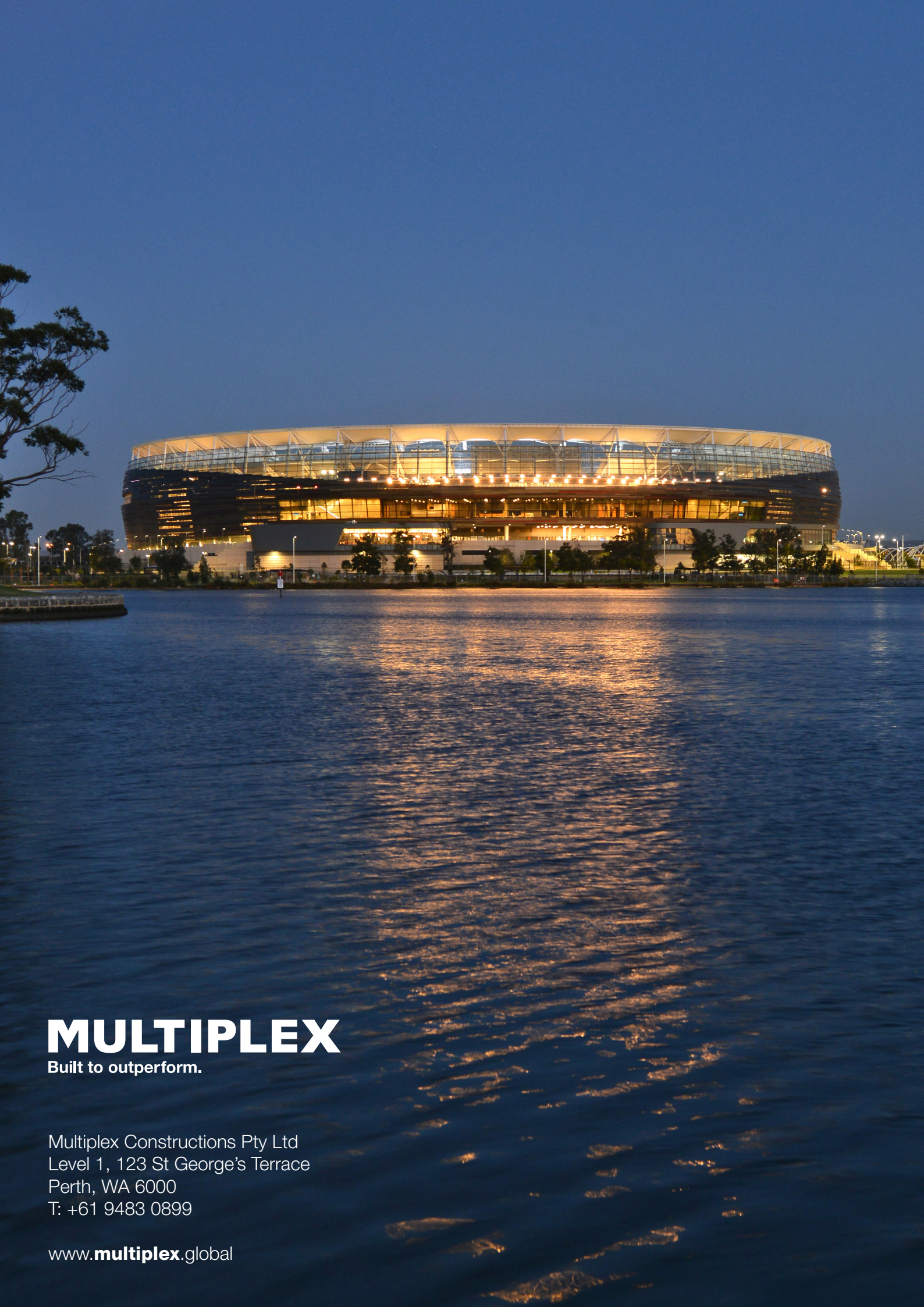
Supplementary to the safety leadership group meetings, an open forum construction team meeting was held weekly led by the Senior Site Manager. Safety and health was the first agenda item.

The construction team members were able to raise any health and safety issue and worked collaboratively to determine practical solutions – these conversations were the biggest priority, not just making sure the paperwork was complete.

Regional management representatives conducted regular unannounced workplace inspections, focusing on the 'infield' work practices and questioning the approach being taken to manage the safety critical project risks.

In addition to standard reporting requirements, the workforce was strongly encouraged to report near misses. Near misses were thoroughly investigated and any lessons learnt shared throughout the organisation.

Multiplex's approach delivered a safe working environment for over 8,000 people who completed over 4.2 million man hours on site.



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