



Fiona Stanley Hospital
Australian Construction Achievement Awards
Technical Paper



EXECUTIVE SUMMARY

The \$2 billion Fiona Stanley Hospital (FSH) in Perth is the centrepiece of the Western Australian government's newly revamped state's health system. It is the largest building infrastructure project ever undertaken by the State and provides 783 beds and twenty-four-hour acute care, together with teaching, research, medical and surgical services.

Brookfield Multiplex was responsible for full project management, design, construction, testing, commissioning and transition support under a Managing Contractor delivery model.

The innovative design response was conceived collaboratively, drawing from a consortium of experts across the health sector and design leadership from planners, architects, interior designers and health practitioners.

Drawing on principles of evidence-based design, the project vision responds to the derived patient and visitor experience, the environment and the natural landscape of the setting. The project team adopted a philosophy of openness which allowed the design to evolve within the constraints of a functionally driven brief and a highly structured building procurement process.

At the same time, they steadfastly upheld the integrity of the project vision. The landscape architecture is integral to the creation of a patient-centred health precinct, achieving a connection to the natural environment, light, outlook and space for social outdoor gatherings – all essential to patient, visitor and staff well-being. Integrated landscapes at ground and rooftop levels humanise the traditional clinical hospital environment.

FSH is a state-of-the-art health facility within a new mixed-use precinct contributing to the immediate site and the wider community.

THE HOSPITAL WAS DELIVERED ON DECEMBER 6 2013 - 17 DAYS AHEAD OF SCHEDULE AND WITHIN BUDGET.

“To Brookfield Multiplex, we couldn't have asked for a better partner. You have been absolutely thorough in everything you have done in relation to the construction of this building. You have been absolutely on time with your construction.”

Dr Kim Hames MLA
Deputy Premier and Minister for Health - December 2013

Fiona Stanley Hospital

by the numbers



10,000 cubic metres
concrete



860
toilet suites

36,000
light fittings



6,000
timber doors



1700
peak site
workforce



10 tower
cranes



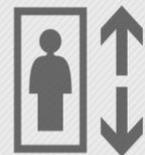
8 buildings
202,000
square metres

over
10m
manhours



382,000
cubic metres
painting

31
lifts



50,000
power outlets



2,200
kilometres
communications and power cable

Scope of project work

The hospital site covers the equivalent of four city blocks including 155,000sqm of floor space over seven main buildings and more than 8,000 rooms.

The hospital will provide a comprehensive suite of clinical services including:

- A full range of acute medical and surgical services
- The State burns service
- A 140-bed State rehabilitation service
- State-of-the-art emergency care
- Comprehensive cancer centre
- Renal dialysis and transplantation services
- Mental health unit
- Obstetrics and neonatology services
- Child and adolescent services
- A wide range of pathology services
- Diagnostic and interventional medical imaging services

Type of contract - Design and Construction of the Hospital.

The procurement model was a two stage Managing Contractor form of contract, based on a guaranteed maximum price with a shared savings regime to incentivise both Brookfield Multiplex and the State. Stage 1 was the equivalent of an Early Contractor Involvement (“ECI”), which facilitated a collaborative working environment where experienced personnel with particular skill sets from Brookfield Multiplex and the State were effectively combined to establish ‘One Team’ to develop best for project design solutions.

The transparent and ‘open book’ approach kept the State fully informed of the cost plan, programme and design development on a progressive basis through to the end of Stage One, by which time a minimum of 80% of the trade packages had to be designed, tendered and submitted for approval.

Once the Stage Two contract was awarded, Brookfield Multiplex assumed full responsibility for the design and delivery of the hospital including commissioning and readiness for services.

OHS&E Performance

With over 10 million man hours worked, the lost time injury frequency rate (LTIFR) achieved at the completion of the project was 4.9 - well below the industry’s standard of 13.7. We achieved 22 months LTI free between January 2013 and October 2014.

Over the course of the project more than 10,000 people attended site induction courses, the team reviewed more than 2,500 OHSE documents and the number of toolbox/OHS&E committee meetings and site inspections exceeded 4,000.

Brookfield Multiplex implemented a number of OHS&E innovations during the project including:

- Mates in Construction suicide awareness program directed at workers in the construction industry (won MBAWA Mark Allen Trust Lifesaver Award 2011)
- Safe Work – Incident Free Thinking initiative to create and maintain a behaviour-based safety culture
- Increase focus on lead indicators and declining trend in lag indicators
- Automated Site Safety Access System

- Doorminator system for installing more than 6,000 doors (finalist in Work Safety Awards WA 2012)
- Formwork jump form system designed to provide safe access to concrete core construction (won Federal Safety Commissioners Award for Outstanding Safety Solution 2011)
- Injury management presentations to entire workforce
- Robust mandatory training schedule covering a multitude of OHS&E courses for all staff including Certificate IV Occupational Health and Safety training for all site-based staff
- Spinal injury awareness program
- Mock site evacuations with state emergency services.

Time Performance

The State Government awarded the FSH contract to Brookfield Multiplex in February 2009. Construction started in September 2009 with the practical completion date set at 23 December 2013.

During the delivery phase some significant changes were made to the briefed requirements by the State including the introduction of neonatal/ obstetrics services, a new heart/lung transplant operating theatre and expansion of the emergency department.

Due to the efficient change management processes and collaborative efforts from team members, the project was still delivered ahead of schedule without any extensions of time.

One of the key drivers to delivering the project ahead of programme was to accelerate the structure to the main hospital building. This was on the critical path and enabled the services trades to commence installation work on multiple fronts.

We also brought forward construction of the State Rehabilitation and Mental Health buildings to de-risk the program by progressively completing the non-critical buildings.

One of the key successes was to consolidate this complex programme into a single page dash board to track and record progress across the hospital's nine buildings in a simplified format. The dash board provided accurate information for senior project managers to make informed decisions.

Cost

Brookfield Multiplex achieved significant cost savings during the ECI phase, whilst maintaining the integrity of the product delivered.

Stage One required the Managing Contractor to take over the coordination and delivery of the project design in consultation with the State's representatives and User Groups and meet the project brief and incorporate all of the reasonable requirements of the end users within the project budget.

This included providing cost and program advice on the various options and configurations being considered, in addition to contributing buildable, practical and cost effective solutions at the front end of the project, to enable an informed decision regarding design solutions to be taken by the State in a timely manner.

When the design documentation reached a stage that was sufficiently detailed to go to trade tender and had been approved by the State, the State's representatives were fully engaged in the procurement process including reviewing tender invitations and attending all tender openings and de-briefings, and ultimately receiving a detailed tender recommendation report for each package for their review and approval.

This was a transparent and ‘open book’ approach that kept the State fully informed of the cost plan, program and design development on a progressive basis through to the end of Stage One, by which time a minimum of 80% of the trade packages had to be design, tendered and submitted for approval.

Cost savings centred predominately on smarter, faster, more efficient solutions. Examples included modifying the services tunnel design to mitigate the potential impact of the high ground water table and acid sulphate soils, the foundation re-design to replace conventional pad footings with bored in situ piling to generate significant program savings, and change the design of the suspended slabs in the ward towers from conventional reinforced banded slab system to a 2-way post tensioned flat plate to achieve time and costs savings and create additional ceiling space for the services installation.

The overall cost outcome on the project was a significant share of savings pool that was shared by both parties under the contract and resulted in a project outcome that was beyond the parties expectations.

Quality

Delivering excellence in quality is paramount for any tertiary hospital and this was certainly achieved on Fiona Stanley. The careful selection of materials, high standard of workmanship and meticulous attention to detail is clearly evident in the finished product.



“The challenge is that we get a group of health professionals to work in this place who are as good as the people who built it. And, if you have that, you are going to have the best quality health care in the world.”

Professor Fiona Stanley, AO

Once interior finishes were completed within areas of the buildings, we also developed a forum between the State, consultants and ourselves to inspect and agree on the quality of the finished product. This established the benchmark standard that flowed through to the entire hospital.

Brookfield Multiplex’s goal was to achieve practical completion with a minimum number of defects, and zero impact on the tenant’s operations post-handover. To this end we:

- Deployed a new digital pen, web-based defect management system PenMatrix to record and issue project defects
- Utilised a cloud-based O&M manual system ZuTec to create a digital handover manual
- Developed a detailed custom QA operating system for the unique components of the project.

We conducted four separate inspections and re-inspections (pre-commissioning, post-commissioning, final inspection and compliance checking) with the State, consultants and the independent certifier to ensure all quality issues were addressed immediately and continuous improvement was achieved.

Environment, Heritage and Sustainability

A significant amount of time and money was invested in on-site conservation programmes and environmental initiatives including fauna relocation, flora and seed collection, top soil removal and reuse, and the preservation of natural bushland in two site conservation parks.

Trees on the 32 hectare site were salvaged and milled into timber for finishes and furnishings throughout the hospital. The site also includes five hectares of natural bush land, two conservation parks, underground infiltration tanks, three basins, internal gardens, courtyards, plazas, major landscaping and street scaping including the planting of more than 250,000 native plants.

Access to light, views and the outdoor environment achieve a positive experience for the patient, their families, staff and visitors with the goal of improving clinical outcomes.

Brookfield Multiplex identified a large volume of waste would be generated during construction, which led an education process to ensure approximately 10,000 workers over a four year period were kept informed of the waste minimisation strategies including the conversion of waste plasterboard into garden compost.

Brookfield Multiplex set a 75 per cent recyclable target rate by project's completion in December 2013. This target was easily achieved and more with a monthly average rate of 97 per cent recycled.

As recognition of our environmental initiatives on the project, we were successful at winning the following awards:

- 2013 Master Builders Association (WA) Excellence in Waste Management Award.
- 2012 BHP Billiton Best Specific Environmental Initiative - United Nations Association of Australia World Environment Day Awards World Environment Day (the award acknowledges innovative and outstanding environmental programs and initiatives from across Australia).

Green health care

The hospital sets a new standard in 'green' health care design. The project focused on achieving ecologically sustainable outcomes by designing all building services, systems, passive facade and other building elements within the hospital to minimise the energy footprint.

Specific ESD initiatives included:

- An increased use of natural light throughout the clinical and non-clinical spaces
- Sound building orientation and form incorporating effective solar passive design and solar shading.
- Metering and sub-metering of all major plant items and areas to enable energy usage to be accurately monitored and controlled.
- Highly efficient LED and compact fluorescent lighting systems comprising high frequency ballasts and occupancy sensor lighting control systems.

- Provision of low water use fixtures and the inclusion of water capture and re-use and recycling systems.
- Inclusion of indigenous plant species to minimise water usage and support native fauna.
- Precinct-wide end-of-trip facilities
- Precinct-wide public transport strategy
- Parklands and roof tops planted with local species for patient outlook and habitat and foraging for the protected Carnaby's Black Cockatoos
- Energy efficient systems including active chilled beams and low energy fixtures

To achieve energy efficiencies we designed a complementary tri-generation system (combined heat, power and cooling), providing 4 MVA of gas generated electrical power, 3.2 MW of cooling and 1.2 MW of heating. Heating provides the base load for the site wide generation of domestic hot water.

The hospital's Central Energy Plant (CEP) has two continuously running natural gas tri-generation sets and a single diesel generator (with space for a second).

An additional critical-to-life diesel generator was installed remotely to mitigate the risk of loss of the CEP. Individual loads are able to be added or shed to suit the power available.

Site load is matched to the available site power capacity based upon a pre-programmed matrix which can be manually overridden by an operator's control console. The system is controlled by hot-standby redundant PLCs with UPS backup.

The advantages include avoiding stopping operating procedures in the event of loss of supply authority power, provision of a high level of redundancy and reliability and more flexible load shedding capacity.

Stakeholder/Client Satisfaction

A key objective for Brookfield Multiplex was to establish from the start of the project an open and collaborative relationship with the State and other key stakeholders.

The following testimonials confirm our aim was achieved with aplomb:

'Working with Brookfield Multiplex has been a good experience for the State Government. They have been on time and on budget, and there have been no issues that we haven't been able to easily resolve.

All you have to do is go and look at Fiona Stanley Hospital to see what a successful company is involved in building that structure.

To Brookfield Multiplex, we couldn't have asked for a better partner. You have been absolutely thorough in everything you have done in relation to the construction of this building. You have been absolutely on time with your construction.

I would like to congratulate everyone involved with the project particularly Brookfield Multiplex."

Dr Kim Hames MLA
Deputy Premier and Minister for Health - December 2013

Health Planning and Architecture

The FSH project breaks new ground in hospital design, delivering the highest standards of care in a layout that can accommodate future expansion, new developments in clinical treatment and medical technologies.

The hospital is designed as a natural healing environment. Key circulation routes and other strategic zones of the buildings are flooded with natural light and designed to capture views of external courtyards and the natural landscape that surrounds the hospital.

The landscape and public domain is critical to the design, harmonising the precinct and connecting the different functions within the hospital.

The repetitive geometry and triangulated shading hoods on the building facades are inspired by the shapes, textures and colours of the fruit from the Banksia plant found in the surrounding woodlands.

The design of the hospital was driven by a number of key factors including:

- Efficient clinical planning
- Patient-centred care
- Respecting Aboriginal culture
- Clear intuitive wayfinding
- Evidence based design (EBD) techniques

A key feature of the hospital is the high proportion of single patient rooms which will contribute to improved infection control, fewer patient transfers, better privacy and confidentiality, better communication between patient and staff, and superior facilities for visitors. Single rooms account for 83 per cent of all patient rooms in the hospital.

Structural solutions

Structural responses to EBD initiatives proposed by the clinical planning team to the unique challenges posed by a hospital included:

- Provision of an appropriate level of future proofing and flexibility to be incorporated into the structural designs
- Structural framing to meet the demands of a highly serviced (electrical and mechanical) facility
- Floors within the imaging department, operating theatres, wards and laboratories required to meet relevant vibration acceptance criteria
- Structures to provide radiation shielding around oncology and nuclear medicine treatment rooms
- Structural detailing to support infection control, patient comfort and patient movement around the facility
- Incorporation of dedicated travel routes, to allow replacement of heavy clinical equipment in future
- The facility to provide a post-disaster function and survive a 1:500 year design event period for seismic events.

Logistics, Interfaces and Constraints

One of the project's main challenges was the concurrent construction of nine buildings, and the logistics and planning associated with ensuring that all of the buildings progressed without adversely impacting each other.

A typical example was the regular occurrence of multiple concurrent concrete pours on work faces on different buildings whilst ensuring the concrete plants, concrete trucks/pumps and cranes continued to be utilised efficiently.

Delivering this vast programme of works placed significant pressure on an already overstretched trade market, fuelled by the ongoing development boom that occurred within the resources sector at the time.

Constructing multiple buildings concurrently also meant a reliance on any one structural system or structural material was considered a project risk. A structural design was developed that provided alternate construction methods and materials to diversify the trade packages and enable multiple subcontractors to work on and contribute to the project.

Ten tower cranes operated during the peak of construction; it was essential the materials handling was efficiently managed to maintain high levels of production and achieve the tight construction programme.

Commissioning complexities

During the delivery of the hospital there were a number of complex commissioning challenges to ensure the energy infrastructure was developed to facilitate the commissioning of the interdependent buildings.

The nine-level main hospital building was divided into 56 construction/ fire zones and through detailed programming the works were scheduled to align with the commissioning activities.

Consequently, the Central Energy Plant commissioning plan had to integrate enabling packages whereby plant and equipment was 'set to work' initially, but fully commissioned and integrated later. Discussions with Western Power to describe the project's dependencies resulted in the acceleration of the permanent feeders being commissioned.

The hospital's IT infrastructure was developed and commissioned early to assist the commissioning and operation of the interdependent buildings intelligent systems. This required the installation of a temporary network and server facilities and resilience and continuity planning was conducted.

Unique risks to the project

The seven year duration of the design and construction phases presented a unique risk to the project. We needed to cater for ever-changing health technology, which we did by future-proofing the design, engaging in peer reviews with experienced health practitioners and carrying out global research to stay abreast of the latest developments in health facilities.

Due to the exacting standards required of a hospital and the criticality of providing a functional facility, Brookfield Multiplex constructed mock-ups for the repetitive and clinically significant rooms to ensure all quality and design issues were resolved early in the design phase.

This proved extremely successful in managing this risk, as it set the benchmark for the project and assisted clinicians and a large proportion of the 140 User Groups to physically view the rooms and test the functional and spatial requirements to suit their needs.

Another unique risk involved the management and coordination of State/FM supplied specialist equipment through 73 Specialist Equipment Rooms (SERs). The State/FM wanted to select medical equipment at the latest possible stage to ensure they procured the most current technology.

We established a team with specialist knowledge of the sophisticated medical equipment to 'future proof' the services and special requirements to accommodate the equipment selected through the SER process two years later.

Once the FM was subsequently appointed, a detailed FM alignment schedule was produced and regular meetings held to coordinate the selection, procurement and installation of all major medical equipment.

Specialist FFE coordination groups were established to develop a comprehensive schedule capturing equipment types, lead times, services requirements, environmental conditions, commissioning details etc. We held regular onsite meetings with equipment suppliers to review drawings, onsite conditions, monitor construction and address any interface issues in a timely manner.

In terms of unique construction risks, the structural design and construction of four oncology linear accelerator treatment bunkers required innovative research and extensive planning. Various structural alternatives and materials with higher shielding properties were considered and an in situ/hybrid steel/ concrete solution was chosen.

The solution comprised a hybrid 960 mm thick slab construct using heavy weight concrete with a minimum dry density of 3,500 kg/m³ over four 100 mm thick steel sheets to increase the shielding property of the bunker roof to the level required by the specification.

Community

Due to the size, complexity, location and nature of the project, there were a large number of stakeholders that required regular communication to be kept informed over the course of the construction period. These stakeholders included the State and its representatives, immediate and adjacent site neighbours and the broader neighbourhood.

The close proximity of neighbours that could be sensitive to noise emissions, vibration, dust and odour meant specific management plans and initiatives were put in place at the beginning of the project to ensure minimal disruption to our neighbours.

Leadership and Management of the project

Brookfield Multiplex takes pride in its project delivery approach and project leadership and management of projects is undertaken collaboratively and openly with clients. Understanding a client's key objectives and requirements and working with them to meet – or exceed – these targets was a key element of Brookfield Multiplex's approach with the State on FSH.

The willingness to be transparent and engender an open book approach fostered a genuine sense of cohesion and collaboration, which not only supported high performance delivery but also strengthened relationships between all project parties.

Relations between senior management at Brookfield Multiplex and the State were excellent and this became the foundation for good relationships all round. There were regular and open communications at senior level to ensure the project's objectives were always forefront of the team's thoughts and actions.

The quality and extent of the leadership and management delivered by Brookfield Multiplex throughout FSH is proven by the following:

- Zero contractual letters of dispute
- Zero extension of time claims
- Industry leading safety culture
- Up to \$30 million dollars' worth of additional works incorporated but delivered within original budget
- Delivery 17 days ahead of schedule.

Innovations generating a legacy for the construction industry

The successful delivery of the project through the previously untested two-stage Managing Contractor model has now gained broad endorsement all over Australia and is the preferred delivery model for a number of clients in the infrastructure market.

Brookfield Multiplex has also generated a legacy as the first organisation to implement the Mates in Construction suicide awareness program. The program is based on research that shows the suicide rate for young workers in the State's construction industry was three times higher than the national average for men.

Brookfield Multiplex led the move in Western Australia to embrace the program and the FSH site was the first to be accredited by the State Government.

Brookfield Multiplex introduced an education program to its workforce of more than 10,000 in order to become ambassadors for the program and to look after their colleagues. The initiative won the 2013 Master Builders Association Mark Allen Lifesaver Award and is now widely embraced throughout the industry.

Design Process

Upon award of contract, the incumbent major design consultants were novated to the Managing Contractor. The design starting points were a functional brief review, the concept precinct master planning options and schematic designs.

The key processes in achieving fully compliant design deliverables during Stage One included:

- User Group consultation
- Design development and review process
- Peer group reviews
- Establishment of technical and reference groups
- Construction of mock-up rooms to ensure functional and spatial requirements were met
- Submission of samples and prototypes to ensure the correct products and materials were selected
- Interior design presentations
- Standardisation reviews to ensure consistent and uniform design solutions for 'like' rooms were provided across the hospital precinct.

It was vitally important that the design and construction operations were aligned and coordinated, particularly given the complex nature of a hospital and the interdependencies of various services.

Using Revit 3D modelling software to create structural images to be shared with the site managers was a successful initiative. Updates to images were exchanged regularly, giving the construction team a better understanding of how the structure interfaced with services in real time. Further, 3D analysis of pipework and services routes in the Central Energy Plant and buildings proved to be invaluable for clash detection.

Occupational Health and Safety

Brookfield Multiplex's 'Safer by Design' strategy defines our approach to health and safety management, which is underpinned by a mature and disciplined culture driven by demonstrated senior management actions.

The four key objectives of the 'Safer by Design' strategy are to:

- Move control upstream through upfront design and planning
- Think long-term and focusing on reducing critical risks
- Demonstrate practices not just paperwork
- Practise disciplined reporting.

Brookfield Multiplex approached this complex project with a strong focus on upfront planning and risk management. This involved implementing a safety in design process that started at concept design stage and cascaded through the construction phase to the end user – the State.

Examples of this safety in design approach include:

- The fitting of sun screens to the panelised façade system prior to erection to eliminate the need to work at height
- Victaulic joints rather than welded joints were installed on the service tunnel pipework to avoid hot work in confined spaces, making it safer and faster to install and easier to replace and repair in the future.

Industrial relations

Brookfield Multiplex managed Industrial Relations through an open and continuous dialogue with all stakeholders.

Project and senior site managers were given the responsibility to manage industrial relations on a day-to-day basis. This ensured direct communications throughout the workforce and the mitigation of any potential issues before becoming real issues. As a result, only two days were lost to industrial action across the four-year construction life of the project.

Use and development of new technologies

Some of the new technologies introduced into the hospital include:

- Emerging patient-centric health facility model
- The first interventional theatres provided in WA
- Automated guided vehicles
- Active chilled beams for an environmentally efficient HVAC system
- IELVS automation network including integrated metering and energy profiling and management
- State-of-the-art AV system with live feeds from the operating theatres to the lecture theatre
- Electronic medical records
- Interactive patient entertainment system
- Consolidation points within the structured cabling design for simpler installation, less waste and increased future proofing via spare capacity.
- Blown fibre to support the communications services backbone infrastructure for easy installation and ease of replacement/upgrade.

Training, employment and development initiatives

Brookfield Multiplex established an Australian Industry Participation plan that supported the use of a local industry supply chain and workforce by actively seeking out local companies and providing opportunities and training to the local market. The success of the plan is reflected in the fact we engaged over 90% of our subcontractors from WA.

Brookfield Multiplex also implemented the Salvation Army's Employment Plus Programme with the support of our subcontractors to create job opportunities for those who have been out of work for a considerable period.

During the project approximately 70 trade apprentices and 15 consultant graduates were employed and trained. Brookfield Multiplex also employed an extra nine cadets and graduates.