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AUSTRALIAN CONSTRUCTION ACHIEVEMENT AWARDS

NEW MUSEUM FOR WA

Executive Summary

With eight new galleries, a 1,000 square metre special exhibitions gallery, and dynamic and activated public spaces, the New Museum for WA is set to become a landmark building for the State of Western Australia.

The existing WA Museum site included four heritage buildings with its oldest, the Old Gaol, dating back to the mid-1800s. The redevelopment has combined the heritage with an innovative new build that connects all four heritage buildings for the first time in the Museum's history.

The project team faced numerous challenges in the delivery of the New Museum, from working in and amongst heritage buildings, to delivering an ambitious engineering design including an innovative structural steel roof.

Through a one team approach, the project was delivered on time and on budget, and to the exceptional standard expected for a building of such civic significance.

Scope of Work

A redevelopment of the existing WA Museum, the project included:

- the Design and Construction of a new building that integrates with the existing heritage buildings
- heritage restoration works to the Old Gaol, Jubilee, Beaufort and Hackett Hall buildings
- A Central Energy Plant (CEP) servicing the Perth Cultural Centre, expected to reduce energy use and CO2 emissions by around 30% in the year after the New Museum is operational.

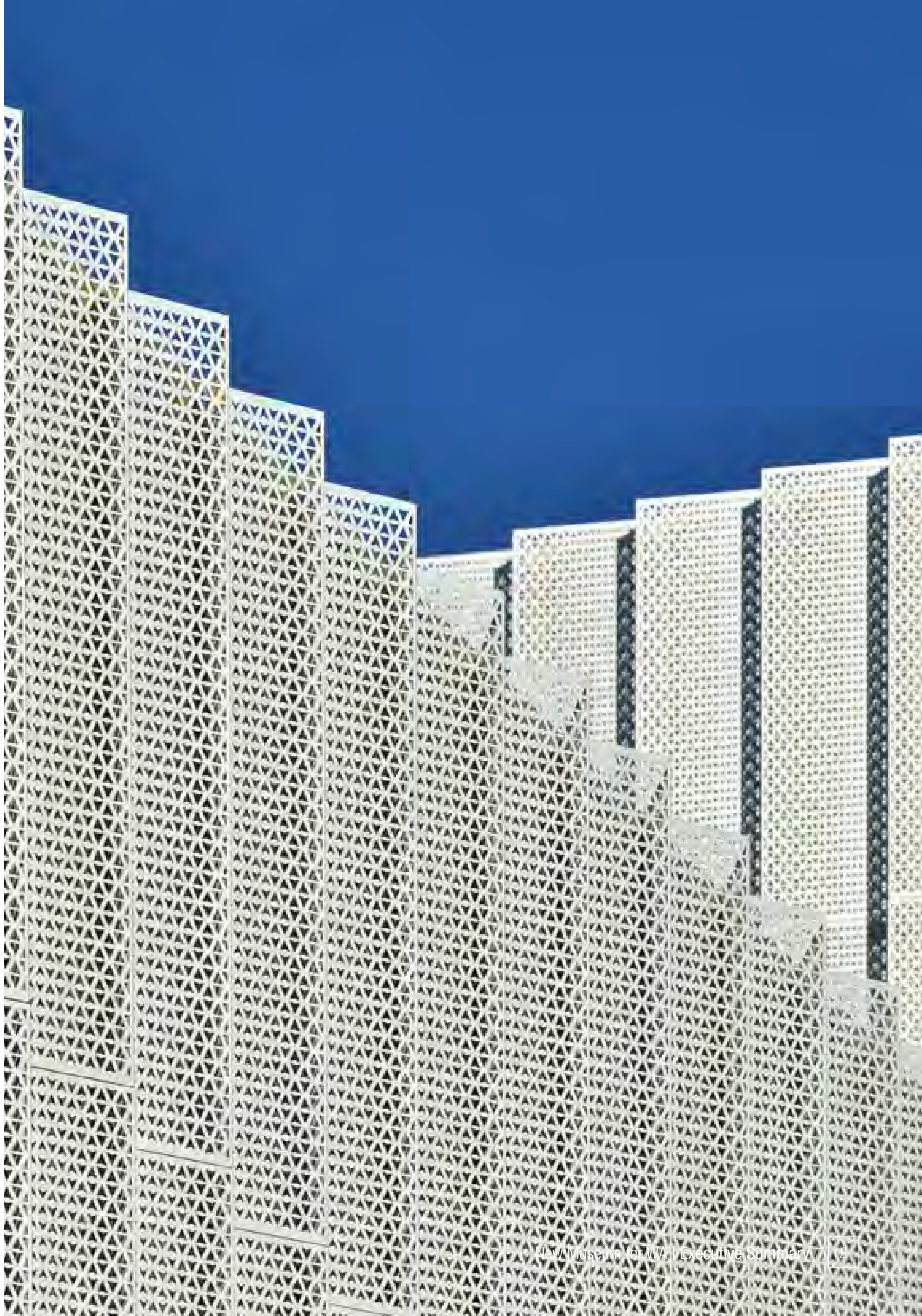
The New Museum for WA is more than three times the size of the previous Museum and includes eight new galleries, a 1,000 square metre special exhibitions gallery, multipurpose spaces for programs, learning studios, cafe and food and beverage tenancies, and stunning spaces for gathering, meeting and special events.

The interior of the Museum is organised through two primary circulation loops – one horizontal and one vertical – that bring together the heritage and new buildings to allow visitors to experience the Museum in a number of ways.

As Managing Contractor, Multiplex was responsible for managing the project's design team, including architects Hassell + OMA, as well as over 130 consultants, suppliers and subcontractors engaged to deliver the project.

Type of Contract

Multiplex delivered the New Museum for WA under a Managing Contractor arrangement, awarded by the WA State Government under a two-stage contract in July 2016. Stage 1 encompassed detailed design and enabling works for the site including demolition. Stage 2 of the contract commenced in January 2018 encompassing the main construction works.

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1.1 Innovative Approaches to Project Issues and the Use and Development of New Technologies

Structural Steel

The Museum's striking structure elevates over 38 metres above ground level, and cantilevers for 17 metres over the existing heritage-listed Hackett Hall building. The primary horizontal spanning structure is made up of high-strength steel trusses which span 54 metres in length between two cores. The requirement for column-free spaces to exhibition galleries as well as to the main entry known as the 'City Room' meant minimal vertical support elements, while achieving floor loading of up to 8kPa live load with minimal deflection limits. To maintain the site's foundation integrity, the cores were required to be designed to carry the equivalent of a 30-storey building.

This presented numerous challenges to the design and construction of the steelwork. The cantilever steel trusses had to be lifted into place above the existing heritage building. In addition, an innovative approach was required to maintain access through the site, while completing significant temporary works at ground level.

During the early stages of the design, various options were reviewed to achieve the support requirements and evaluated against safety, cost, duration and functional requirements. One notable design change was to use Grade 450 steel for the project, delivering a 25% weight reduction compared to standard grade steel and a 15% cost saving. Prior to commencing fabrication and installation of the structural steel, a detailed erection sequence was developed through an enhanced visualisation model to identify potential problems, clashes or issues. The issues were then resolved by Multiplex and the design team, including the involvement of the structural steel installer, before being presented to relevant stakeholders including heritage authorities.

A single crane serviced the site therefore construction sequencing was critical. The inner-city location of the site also meant the logistics of transportation and delivery were a major consideration. To overcome these challenges, the steel trusses were designed as individual segments to be assembled and lifted on site. Each segment was sized in weight and length based on its specific distance from the crane location.

A stick build approach was determined where the welded truss elements were prefabricated and connected by a large number of bolts at the splice location. This allowed steelwork to be delivered by standard semi-trailers without curfews, with each section of steel designed to ensure the tower crane could unload and install into its designed position. The constraints of the site did not afford the luxury of utilising a mobile crane to unload.

Cantilever Steel erection

The cantilever on the south side of Hackett Hall is the most visually stunning element of the structure, but the western section also created some engineering challenges. The external truss on the western elevation predominantly cantilevers off another truss supported by and spanning between the north and south cores, which is some 17 metres in length. The fully-assembled outside truss is an impressive 84 metres long, with a complicated support network provided by multiple nodes in the other adjacent trusses, including more cantilevers. As part of the erection sequence, the series of temporary engineering calculations had to be performed to ensure the safe lifting and installation of the structural steelwork. For instance, truss 5, spanning east to west, was utilised as the primary propping truss to temporarily support the structure as it was being built. Tower crane sections were utilised to support the truss with hydraulic jacks to set the final level of the truss.

The overall structure is an amazing feat of engineering, and the erection of the western truss was the most challenging from an installation point of view, as the middle section had to be installed when the remaining sections were in place. With very little tolerance and using two mobile 300 tonne cranes, the truss section was installed by a dual crane lift with the tower crane in a supporting role. The activity commenced at 6am and the truss was finally in place by 11.30pm that night. A credit to all the structural steel workers and engineers involved in the operation that it was carried out safely to precise tolerances.

Installation of the structural steel roof

The completed cantilever above Hackett Hall

BASWA ceilings

Design and installation of a ceiling that provided both the aesthetic and acoustic properties required for the New Museum took significant effort. The Museum has many large, voluminous front-of-house spaces to make it more welcoming for visitors and allow flexible use into the future. The architectural design includes many hard, reflective surfaces including glass, terrazzo tile and metal finishes, and a functional requirement to reduce the acoustic reverberation. This required detailed research and exploration of innovative ceiling finishes.

The resultant analysis and studies determined the use of a BASWA ceiling, consisting of an insulation panel with a plaster look facing. With no Australian suppliers or distributors, Multiplex was required to direct source from the manufacturer, BASWA Acoustic, based in Switzerland.

By absorbing sound waves, the BASWA acoustic ceiling system reduces reverberation time making conversations clearer even with the hard surfaces in the vicinity. It works by converting the sound energy into heat energy by dissipation and absorption.

Installation consists of gluing the panel to the plasterboard ceiling which is then grouted. Completing the installation includes sanding the substrate and spraying the BASWA final layer. This can only be carried out using a birdcage scaffold as the installers have to rule off the spray. Considering that all the front-of-house areas have a BASWA ceiling, this required multiple high-level scaffolds to be erected and dismantled throughout a virtually finished building. The risk of collateral damage was high. With careful planning with the subcontractor on this high risk activity, Multiplex completed the work safely and took ultimate care not to cause any damage.

BASWA Ceiling

Roborigger

As part of Multiplex's continued focus on safety and exploration of new technologies, the project engaged in the first commercial trial of wireless load controlling system, Roborigger. Roborigger helps minimise workers' exposure to high risk activities by being able to remotely hold a crane load steady in any given direction, without the use of a tagline.

The Roborigger device uses inertial forces to accurately rotate and orient crane loads, eliminating the need for workers to be in close proximity to the load during the lifting and lowering phases.

TENSA has been developing the Roborigger technology since 2016 and Multiplex has supported this as an industry partner since 2017, coordinating Roborigger trials on commercial sites and providing user feedback. The successful first pilot of Roborigger on the New Museum project saw the device awarded Best Solution to a Work Health and Safety Risk at the 2019 WA Work Health and Safety Excellence Awards.

Roborigger in action on the New Museum project

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Hackett Hall and City Room scaffold

Due to the limited site footprint a unique scaffolding system was developed for the construction around Hackett Hall and the City Room, consisting of a main support frame with ring system scaffolding and a honeycombed base. This enabled 6m wide x 6m high passageways throughout the base of the scaffold, facilitating traffic for heavy machinery and personnel.

The scaffold included runway beams installed on top of its one decked level to support three independent ring system rolling towers, facilitating the installation of ceiling panels and associated trades.

The base scaffold was built in thirds, progressively being re-installed as the finishing works progressed. The upper level scaffolds were simply pushed across the top of the shore below. As such, the top of the scaffold did not require dismantling and re-erecting, nor was it necessary to fill the whole area with a birdcage.

Running beams were deployed to enable works to continue beneath this scaffold. Traditionally, this would have required a large birdcage scaffold that would have restricted access to trades working under. However, use of running beams was primarily utilised as a means by which to reduce loads into the heritage floor by redirecting loads into the structural columns below.

The design significantly improved access below the scaffold and reduced the volume of scaffolding in the area by 60% compared to a full birdcage. The reduction in equipment being installed at height also greatly reduced the potential for falls, dropped objects and worker fatigue.

Craneable scaffold

In an effort to reduce the risks of falling from heights, falling objects and manual handling, Multiplex utilised craneable scaffold modules extensively at the New Museum project. Large scaffold modules were either lifted up into position, or lifted down to ground level to be dismantled, or lifted into another elevation of the building for use.

With the New Museum façade system requiring a full perimeter scaffold, the site had over 1,000 tonnes of scaffold at peak. The ability to modularise and crane lift large portions of scaffold at once resulted in considerable improvements to tower crane efficiency and made it much safer for those involved. By prefabricating scaffold modules at ground level, scaffolders could build the modules with components at hand in a dedicated area onsite in lieu of carrying components up into position – which carries with it an increased risk of manual handling injuries, falling objects and falling from height. With the use of Roborigger, large scaffolds could also be lifted in tight locations (for example, between the tower crane and east elevation of the building) without the risk of the scaffold spinning and coming in contact with the crane and/or tower crane.

Scaffolding system in place for the City Room construction

Interlayer mesh glass

The overall architectural scheme for the New Museum relies upon a grand statement that includes the use of bold planes and a language of materials that effectively "wrap" around the heritage buildings. Further to the technical requirements above, the interlayer mesh in the glazed façade provides the architectural intent of having an expressed gold band to the external of the building whilst maintaining a neutral colour within the internal space.

Extensive environmental studies and modelling was done to ensure the building was well insulated from external environments and to optimally maintain thermal comfort for Museum patrons. A number of glazing options (such as ceramic frit and tinting) and shading alternatives were carefully considered for this location against these key design criteria. As an outcome of this process, the gold mesh interlayer glazing is considered the option most capable of delivering a building that is both coherent with the overall architectural language, while providing adequate levels of translucency throughout the day to promote activation of the building.

The mesh interlayer glazing is variable in its levels of transparency and translucency throughout the day and night. During the day, when direct light does not fall onto the glass, it provides visibility to the building within. When direct light falls on the glass during the afternoon, the glazing becomes less transparent and the overall effect is "golden" in colour. At night, the glazing becomes more transparent when the retail space is lit internally, providing a strong level of permeability and activation.

The light responsive nature of the gold mesh glazing offers an effective means of addressing variable sunlight and solar heat gain conditions while supporting the overall architectural intent without resorting to applied shading alternatives.

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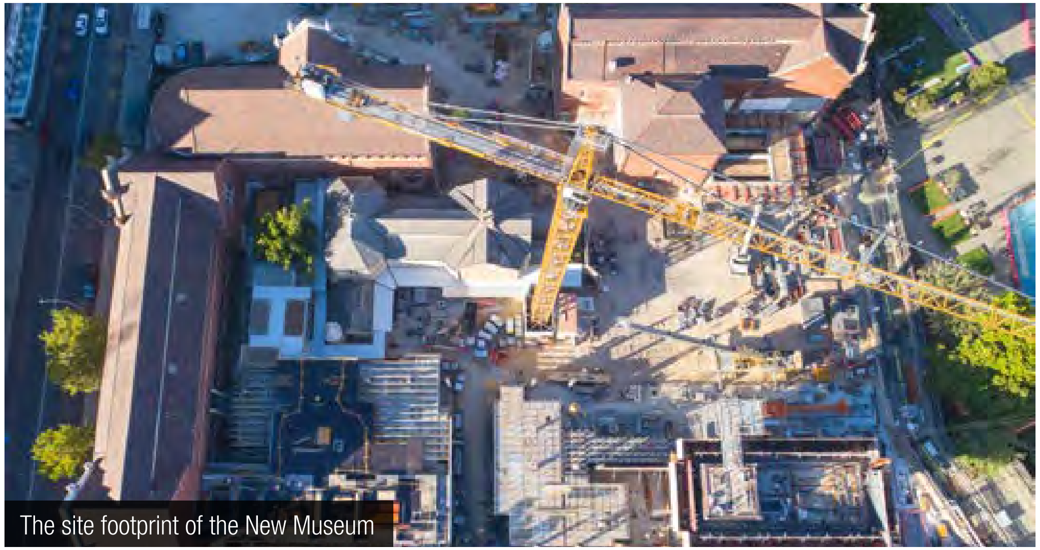
2. Complexity, Difficulty and Optimisation of the Construction Task

2.1 Logistics



The site footprint of the New Museum

Logistically, the New Museum project was particularly challenging. Bordered by busy city roads and pedestrian thoroughfares and with a limited site footprint, there was little lay down area available.

A single tower crane serviced the site, making its location critical to the efficient construction of the building. It was also critical that the location of the piles supporting the crane did not interfere or cause any damage to in-ground archaeology around the heritage Old Gaol building.

With the only available lay down space utilised for crane unloading, the site was required to operate on a just-in-time delivery basis. Each delivery was planned down to the specific time and duration required to allow work to flow smoothly. To enable this, a logistics meeting was held at 2pm each day with all contractors to coordinate every delivery and pick-up.

To provide a level of flexibility, Multiplex installed an additional number of gates on the north and south elevations capable of accommodating reticulating semi-trailers, depending on the stage of the project and the accessibility constraints.

2.2 Interfaces

The site had a number of key interfaces due to its position within the busy Perth Cultural Centre (PCC). The public interface was constant, with the site bordered by pedestrian thoroughfares which had to be maintained throughout construction. A secure 2.4 metre high hoarding was erected around the site perimeter to minimise the risk of construction dust from escaping the site and protect the public from ongoing construction.

There were also a number of interfaces with the surrounding buildings within the PCC, particularly the State Library of WA. A diaphragm wall retaining structure existed on the western side of the site, bordering the State Library, which stood alone and was soil anchored by stressing cables into the ground on the eastern side. West of the diaphragm wall, a double storey underground car park exists with a plant room and plenum running the entire way.

The piling design of the New Museum consisted of a mixture of contiguous and bored piling. In order to accommodate this, the State Library diaphragm wall soil anchors had to be de-stressed.

In the first instance, the diaphragm wall had to be propped. Structural steel wasn't an option due to limited access, so a scaffold tube design was developed where the scaffold tubes were bolted to the diaphragm wall back to the existing structure. Scaffolding provided the flexibility required due to the limited plant and space available.

On completion of the propping, the anchors were de-stressed, then removed or cut to accommodate the contiguous piling and bored piling. It was determined after exploratory survey that the first row of anchors would be removed by excavating six metres along the line of the wall and physically "pulling" them out. The lower anchors fouling the piles were cut by bore piling through. This is fraught with risk, as if the anchor cable is not sheared straight through, the stressing cable could get caught in the piling auger and cause a void in the elevation of the pile. This could result in a large concrete protuberance, requiring it to be removed during top down construction and delaying the process. Due to the planning undertaken and the experience of the piling contractor, this risk was successfully mitigated.

2.3 Constraints

Constructing amongst four heritage buildings posed some unique constraints:

- Construction on top of and adjacent to heritage buildings, with some innovative methodologies used to overcome those constraints.
- Conservation and protection of archaeological features and artefacts, including the provision of archaeological monitoring.
- Planning the location of project offices and worker amenities was critical to avoid utilising essential laydown area. By installing false floors and building stand-alone walls, Multiplex secured approval to house offices and amenities in the heritage Jubilee building, accommodating up to 300 personnel.

Beaufort Building

An example of the complexity due to the heritage buildings is found in the Beaufort Building, which features one of the world's best quality casts of the Parthenon Frieze on its walls, dating back to 1908.

The seismic upgrade to the heritage buildings entailed creating a steelwork exoskeleton within the building where structural steel columns were either installed in the wall (such as was required in the Beaufort Building) or external to the wall (as is the case in Hackett Hall).

In order to complete the seismic works, approximately 30 Parthenon Frieze (PF) panels required removal to allow structural steel columns to be embedded within the walls. The prising of the PF panels off the wall entailed significant investigation by the master plastering contractor, who had many years of experience in plaster mouldings. As luck would have it, one of the operatives working on these panels had a brother who had previously worked on the northern panels in 1970 that became loose post the Meckering earthquake in 1968.

To ensure the integrity of the panels, silicon moulds were made in situ of the panels to be removed in case damage occurred during the removal process. Prior to cutting the slots in the existing walls, Helifix bars were drilled through the brickwork to connect the inner and outer leaves of the heritage brickwork.

The cutting of the vertical slot for the embedded columns (using a saw running up and down the wall on a fixed rail) required a deal of patience and precision to avoid any vibrational impact on the adjacent panels. The slots were wet cut to avoid silica dust issues. On completion of the cutting of the vertical slots, the brick sections were removed by inserting a steel flat bar into the slot and cranking to break point.

The embedded columns were craned into position through localised roof openings and carefully fed down into position. Once the columns were in position, the remaining roof bracing steel work was installed through roof openings. This was no mean feat as the steelwork had to be fed through the existing rafters. The team had to be cognisant of the weather conditions to ensure no rain damage occurred to the heritage fabric.

Hackett Hall North Wall modification

The modification of the north wall of Hackett Hall to accommodate new openings on four levels required a large amount of planning and sequential work to ensure the heritage fabric was not damaged and the safety of personnel carrying out the work was maintained.

Removal of the Hackett Hall north wall could only commence on completion of the Level Four wrap above, to ensure the building remained water tight. Prior to commencement, micro fine injection grouting was carried out underneath the existing strip footing. The non-heritage external non-load bearing leaf of brickwork was removed to accommodate the new footing for the outer portal frame which was then bolted to the existing brickwork. To ensure the internal of Hackett Hall was protected from water ingress and dust contamination, a full height scaffold was built internally and sheeted with plywood. The balconies within Hackett Hall are supported by existing 200x150 wide beams, which in turn are built into the wall. The work to create the openings was carried sequentially from top to bottom, ensuring that the remaining parts of the wall at roof level and at each individual balcony was supported to avoid collapse of the wall. The internal scaffold was also used to support the cantilevered section of the balcony.

The horizontal member of the portal frame supported a downward right-angle structural steel member, which penetrated the outer brickwork to support the inner and outer leaf. The inner leaf of brickwork then was bolted to the PFC to support the wall and allow the window opening to progress. This work was carried out floor by floor to accommodate the creation of a spandrel panel of brickwork that supported the internal balconies. This was a very challenging piece of work, with both demolition and structural steel installation being carried out concurrently. Creating the openings at the existing floor levels while supporting the existing balconies and avoiding damage to the heritage fabric is a testament to the trades and site management involved.

Seismic Upgrades


Structural steel works to support the blue whale installation

The heritage buildings required significant seismic upgrades to meet project brief requirements facilitating life safety in the event of an earthquake. This work involved the addition of structural steel to floors, walls and roof structures. Roof and soffit access was required to implement much of the work. In some cases, removal of heritage ceilings and/or floor coverings was required. Installing bulky structural steel members within an existing heritage building created a number of challenges, however utilising modern technology, the team limited re-work and reduced unnecessary risk to workers and heritage fabric.

Multiplex engaged a specialised access subcontractor to install static lines and gang ways within the roof space. This safety system was installed prior to any works commencing. All workers entering the roof space were then connected to this system, eliminating the risk of fall injuries. Multiplex then engaged a licensed contractor to vacuum clean all roof spaces prior to any works commencing. Primarily for worker health and safety, this also reduced the amount of loose debris and dust within the roof space that could fuel a stray spark, creating a catastrophic roof fire. Following cleaning, 3D scanning was undertaken to accurately and thoroughly model the existing heritage roof structure.

Seismic steel was designed with intricate connections and a large number of bracing members. Scanning identified significant variance within the existing timber roof structures from building to building, and within each building itself. With this information at hand, accurate shop drawings could be developed and the structural design tweaked to suit existing conditions. Scanning ensured accurate fabrication, minimising site rework, ad-hoc design changes and site modifications.

Fire is a major risk with any building but in particular heritage buildings. Implementation of 3D scanning (along with roof cleaning) significantly reduced the amount of on-site cutting and welding and hence reduced the fire risk.

The New Museum is also home to 'Otto' the blue whale. Thie whale skeleton is hung within existing heritage building, Hackett Hall , weighing almost 5 tonne including the steel armature and skeleton. The roof structure required significant upgrades to support the weight of the display, and to incorporate seismic steel upgrades. Five structural steel beams were installed to create fixing points for the whale armature. Otto is now held in place by inconspicuous steel members seamlessly integrated into the heritage fabric above, creating one of the Museum's most spectacular exhibits.

Re-Roofing

Multiplex was awarded a major variation mid-project which involved a full re-roofing of all four heritage buildings. Existing non-heritage roof tiles, made of clay and asbestos, were removed and the roofs were returned to their former glory with installation of slate roof tiles and timber she-oak shingles.

This process created a number of challenges for the construction team. Firstly, removal of asbestos roof tiles from the circia-1856 Old Gaol posed asbestos exposure risks to workers, and the public. To eliminate the risk of exposure, these works were undertaken over a site-wide Christmas shut down period.

A full perimeter screened scaffold was erected around the Old Gaol as well as seven overhead scaffold beams to support static lines. Workers were permanently fixed to static lines when removing roof tiles and re-roofing. The overhead life safety scaffold system was fabricated on ground in craneable sections (minimising working at heights) and engineered to be lifted into place. Once in place, static lines were slung and inertia reels connected. Workers could then safely walk on the roof structure while removing and re-laying tiles. Should a worker slip and fall, the inertia reel would jam and the worker could be winched to safety.

The remaining heritage buildings utilised a similar system. A full perimeter scaffold was installed, allowing workers to safely access the work front. Due to the span and pitch of the heritage roofs, it was decided a static line with recovery system be employed rather than overhead beams, as well as installation of roof safety mesh. Static lines run over the roof at various locations allowed workers to harness onto the line in order to access the roof and remove tiles, however, having the lines at foot level does not allow the use of a inertia reel. Should the worker fall, they will fall through the roof or ceiling before the inertia reel engages.

Multiplex recognised this challenge and installed rescue scaffolds and/or scissor lifts within the building space below. Should a worker fall, the static line system would ensure the worker does not reach the floor below. The worker can then be rescued using the scaffolds/scissors in the room below. Once roof tiles were removed, the first item installed over existing rafters was conventional roof safety mesh. Mesh was laid over and fixed to existing rafters. Once installed, mesh acted as an additional layer of protection for workers in the event of a slip or fall.


Completed re-roofing on the Old Gaol building

Needling
A vast portion of the demolition works on the Museum (heritage portion) required structural needling, a process where steel or timber beams are installed through a brick or concrete wall. The needles are propped down to sound footing and jacked upward to take up load. Needles are spaced in a way that allows the wall below to be demolished while the upper wall remains supported. Generally, the remaining wall above the opening is required to remain in situ.

In one particular instance on the New Museum, Multiplex was required to remove a large triple skin load bearing wall. This wall was supporting the roof structure, two balconies and a level one slab. The roof, balconies and slab required substantial propping and temporary support prior to any works commencing. An outer (architectural) skin was removed first, allowing visible access to the balcony support steelwork cantilevered within the remaining wall. New footings were poured and a structural steel portal frame installed against the outer heritage wall. The portal frame was welded to each balcony support beam which allowed partial removal of brickwork above that balcony only.

This process continued while balcony propping remained to the outer edge of each balcony (removing the cantilever effect of the balcony). Welding was progressively completed and brickwork progressively removed. Once the newly installed portal frame was strapped back to the heritage building and all balcony support beams welded to the frame, propping could then be removed and façade installation commenced. This process required complex staging and interface between numerous trades to facilitate the works.


Structural needling work underway

2.4 Community

The busy city location meant there was a number of important stakeholders in close proximity to the project, including residents near the construction site. Multiplex worked to an approved Traffic Management Plan and Noise Management Plan which dictated the control of traffic entering and leaving the site and the operational hours of the site. Dust, noise and vibration monitoring was implemented on the perimeter of the site to ensure compliance. As a result, Multiplex received no formal complaints over the course of the project, particularly impressive given the adjacent building is the State Library of WA.

The Perth Cultural Centre is well used by pedestrian traffic and is a focal point for minor and major festivals. With this in mind, the planned methodology for servicing the project elevation, with the remaining 30% being operated from the James Street side. There was also the interaction with numerous festivals in the Perth Cultural Centre, such as Fringe World where Multiplex provided support and coordinated access. The Traffic Management Plan also took into account the large number of buses travelling north on Beaufort Street, ensuring public transport and other vehicles were not inconvenienced during the construction.

A point to note is that Multiplex employed its own Construction Workers (CWs) as traffic mangers/gate persons on the Francis and James Street gates. The CWs were chosen for their traffic management expertise, but also for their personality in dealing with the public interface. Considering that James Street is a pedestrian zone frequented daily by a large number of pedestrians, the Multiplex gate persons became the public face of Multiplex and the project and as such developed a friendly and hospitable environment for passers-by.

2.5 Unique Risks

The heritage buildings posed many unique risks and unknowns, particularly the archaeological risk and findings. A number of protected items were also located within the site, including a heritage grapevine (circa 1850s) that had to be maintained throughout the build.

Collaboration with all stakeholders is fundamental to Multiplex's risk management approach. Ahead of starting on the project, every trade engaged in a Trade Risk Workshop (TRW) to ensure works were planned to minimise any risks associated with the heritage buildings. For subcontractors with high risk activities identified, a Construction Risk Assessment Workshop (CRAW) was conducted to clearly identify the high risk activities, current controls proposed and additional controls required. In total, 38 TRWs, 20 CRAWs and 30 project risk workshops were carried out.

The buildings were assessed for compliance with current codes and, as a result, seismic strengthening was incorporated into the fabric of the buildings.

Careful planning and collaboration with all parties on site ensured that the project was successfully delivered without any impact to the heritage structures.

Lantern

The lantern mid-way through installation

One of the most striking elements of the build is the re-use of the Hackett Hall lantern. Deemed to have significant heritage value, the lantern is a raised portion of the Hackett Hall roof which required removal in order to construct the new build above.

To ensure the heritage value was kept and appropriately recognised within the new build, the lantern portion of the roof was removed and raised to become part of the floor above. A trafficable glass top has been installed in its place, allowing patrons to look down into (and even walk over) the Hackett Hall building beneath.

The construction of the lantern carried some unique risks, given it required cutting through the fragile heritage roof. A number of risk workshops were held to plan the works to ensure it was carried out without damaging the heritage structure.

To avoid inclement weather impacting Hackett Hall during the works, the building was sealed before the roof tiles and rafters were initially removed and structural steel installed to stabilise the lantern. The lantern section itself was additionally braced to accommodate saw cutting the juncture between the lantern ceiling and the timber glazing frame. The condition of the timber frame and glazing was poor and a number of panels had to be replaced. Once it was loose enough to lift, cleats were welded on and the lantern was lifted into place using four block and tackles in 50mm increments to avoid any buckling or twisting of the unit.

Due to the careful planning, the installation was completed smoothly with no damage to the lantern. The lantern is now a stunning example of heritage and new build coming together, allowing the building itself to become one of the Museum's exhibits.

Heritage Grapevine

Nestled in the centre of the New Museum site adjacent to the old Gaol are two heritage grapevines that were planted in the 1850s. The grapevines are of the old Muscat of Alexandria variety and are believed to be the oldest in Western Australia. Multiplex design and subsequent construction work needed to be carefully planned and executed around the grapevines to ensure that the health of these fragile vines was not compromised. Multiplex worked closely with the Museum's viticulturist, Ian Cameron (who has voluntarily maintained the vines for the past 50 years!) throughout construction to upkeep the watering, fertilising and pruning regimes. A tree protection zone around the vines was established to ensure no storage of materials and tools, nor excavation undertaken in the vicinity. It was a great success story that the grapevines still remain healthy and fruitful after two and a half years of heavy construction.

2.6 Sustainability and conservation

The sustainability and services strategy for the New Museum had to be carefully integrated with the architectural design. With a focus on delivering a high level of environmental quality, simple key initiatives took advantage of existing assets of the site and the locale to produce low impact, cost effective solutions. Re-use of the heritage buildings was integral to the New Museum concept with 100% of the existing façade and 85% of the structure retained.

The envelope of the New Museum is designed to minimise energy consumption, while providing user comfort with a weather-proof inner skin and perforated outer veil stabilising the building's inner conditioned environment.

The New Museum design provides a natural airlock to the exhibition spaces to passively protect the environmental condition of these sensitive spaces. The highly controlled conditioned spaces for exhibition utilise the public front-of-house circulation and gathering spaces to mediate between the exterior public spaces and the highly controlled exhibition spaces.

Sustainability was also considered throughout the construction process, with over 90% of construction waste recycled and diverted from landfill.

Central Energy Plant

The New Museum is sited within the Perth Cultural Precinct (PCC), which has a common ownership structure. This allowed the opportunity to deliver a Central Energy Plant, termed the Energy Thermal System (ETS), that enables all of the buildings within the precinct to be more energy and CO2 efficient.

The ETS is designed to rationalise the utility services to the PCC and reduce consumption to the individual buildings within the PCC, particularly electricity and gas.
Overall, the project team upgraded the existing mechanical and electrical services that service the Art Gallery of Western Australia, State Library of WA, Perth Institute of Contemporary Arts, State Theatre and Blue Room and amalgamated many of the services in the PCC. Multiplex installed a 6MW cooling thermal plant including associated cooling towers and a 3MW heating water thermal plant at the Art Gallery and State Library. These centrally located plants were then reticulated through the busy PCC landscaping whilst minimising the impact to the public, the institutions and the retail outlets within the PCC.

The individual buildings all had different infrastructure needs, a wide variety of bespoke systems as well as significantly aged plant. Each building was individually investigated and assessed to allow for a centrally operated system to provide the necessary heating and cooling to match with the individual buildings existing systems.

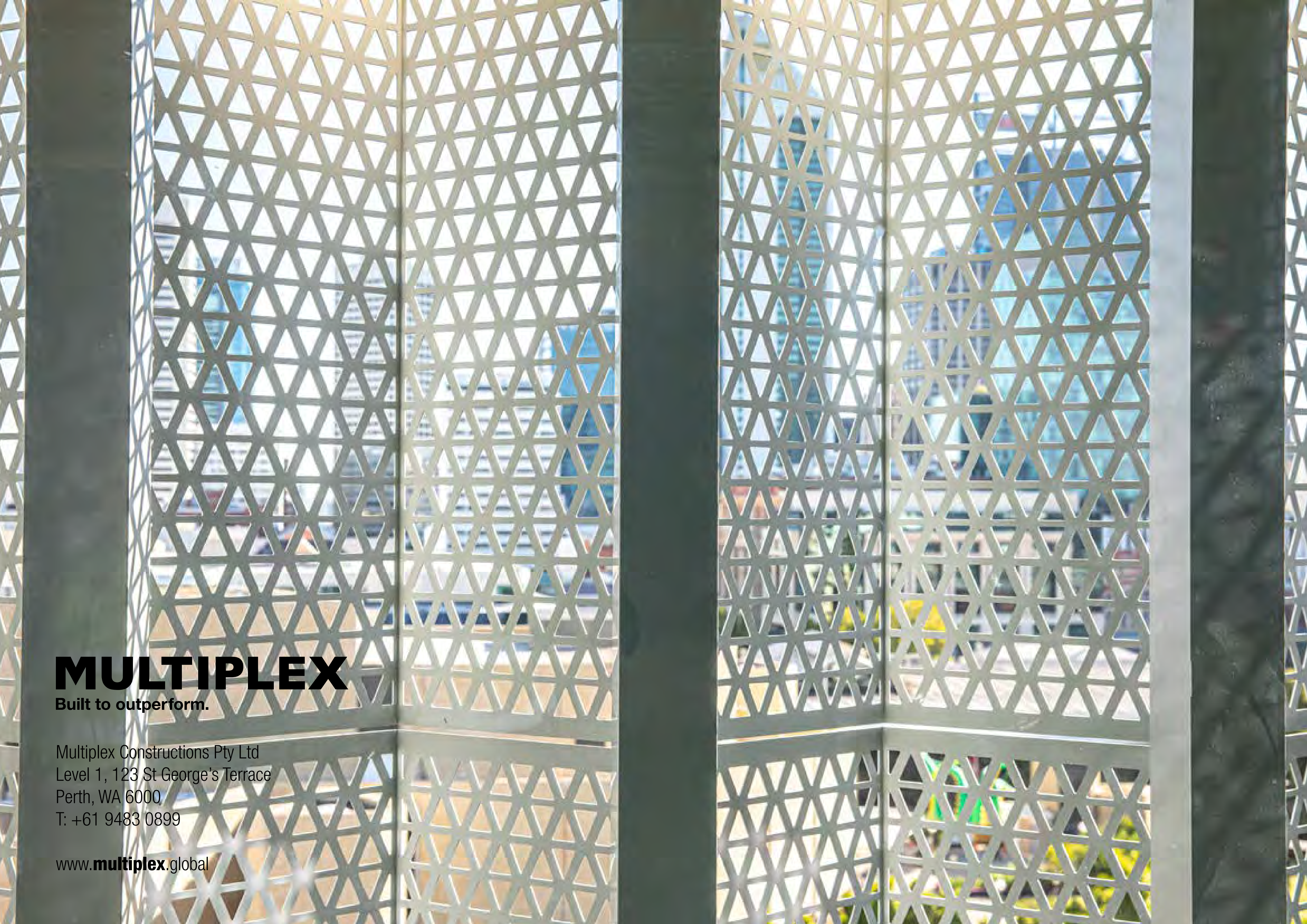
The project also upgraded the precinct's electrical infrastructure including a high voltage ring main arrangement, transformers and switchgears and built two intake switch rooms to facilitate the redundancy of the Western Power 11 kV connections.

The plant started supplying power to the PCC in late 2017 with the Museum to be connected prior to opening. The Museum has its own air handling units but uses the cooling towers and chillers from the precinct (installed in the Art Gallery and Library) to provide the necessary heating and cooling.

In addition to the detailed design requirements, significant engagement was required with the institutions to ensure no risk to their operations, including ensuring no damage to sensitive art works within the Art Gallery which are reliant on air-conditioned spaces. Therefore, the planning was detailed with tight timeframes. The installation and commissioning works were successfully completed the satisfaction of all operators.

Additional benefits of the ETS included:

- Centralised plant and a centrally accessible building management system via a tablet which operators can use interrogate and run the systems, allowing for a reduction in operational effort across the PCC
- Major savings are expected to be realised after 2020 when the museum has been running and open to the public, with the aim of a 30% reduction in CO2 emissions and reduction in energy costs.
- Redundant substations can now be removed, freeing up valuable CBD land within the PCC for civic purposes
- The redundancy provided as part of the ETS allowed the deletion of a Museum-specific generator, negating the need for the associated extra diesel and operation costs.



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Multiplex Constructions Pty Ltd
Level 1, 123 St George's Terrace
Perth, WA 6000
T: +61 9483 0899

www.**multiplex**.global