

# **MILLENNIUM ARTS AT THE QUEENSLAND CULTURAL CENTRE ACAA TECHNICAL CONFERENCE PAPER**

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## **ABSTRACT**

At the turn of the Millennium the Queensland Government through its Department, Arts Queensland completed master planning of the Millennium Arts at Queensland Cultural Centre (MAP). The project objectives were to provide public facilities with inherently flexible spatial standards and the embodiment of current best practice in art museum and library design, suggesting and encouraging interaction and openness between the cultural institutions and the general public.

The master planning took 5 years and involved the relocation of existing entities and completion of separate International Design Competitions for both the Gallery of Modern Art (GoMA) and State Library Redevelopment (MLP). The successful consultants were then engaged to conduct schematic design which was completed in December of 2002.

Specific project challenges would include; delivering a project with multiple stake holders on time and on budget, maintaining certain services and collections within the existing Library during construction and to allowing controlled access to SLQ staff to critical areas, maintaining services of existing central energy plant at the Queensland Cultural Centre, maintaining single lane egress on an existing public road within the building site and sourcing recycled materials and maximising waste recycling.

## **KEY WORDS**

ACAA, Millennium Arts Project, Bovis Lend Lease,

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## **INTRODUCTION**

In June of 2003 after an intensive tender and assessment period the Department of Public Works Major Projects Division acting on behalf of Arts Queensland awarded Bovis Lend Lease the Managing Contractor Role for the Millennium Arts Project. During the post tender workshop assessments, Bovis Lend Lease demonstrated certainty in delivery, value for money and an ability to manage and work with the project's multiple stake holders.

The project included the design and construction of a new 26,000m<sup>2</sup> stand-alone Gallery of Modern Art (GoMA), the redevelopment of the State Library of Queensland (doubling the size to 28,000m<sup>2</sup>) and Site Infrastructure Works between the existing and new buildings. At a cost of \$291.3 million, it was the largest ever investment in Arts infrastructure in the State.

This technical paper will describe the project, its key challenges and the innovative solutions and delivery achievements of the project. The Bovis Lend Lease journey on the Millennium Arts Project has been nearly four years to date, however the stakeholders commenced work in the mid 90's, hence the reason for the project name. Bovis Lend Lease feel privileged to have been selected as Managing Contractor and proud of the fact that the project was completed on time, under budget with a satisfied client and stakeholders.

## **PROJECT SCOPE**

Project scope included design, authority approval, procurement, construction and commissioning of activities including;

- Managing and meeting the needs of multiple stakeholders
- Managing and co-ordinating separate consultants for each building
- Pre-characterisation and removal of 24,000 m<sup>3</sup> of contaminated material
- Cultural heritage training and monitoring of all excavation in natural ground
- 0.5km of public road relocated complete with high voltage electrical, gas, water and communications infrastructure services.
- 44,163 m<sup>3</sup> of site materials recycled. Equates to 80% of waste material.
- 25 kilometres of pre-cast driven piles
- 30,000 m<sup>3</sup> of concrete poured with a peak of 1,500 m<sup>3</sup> in one week
- 3,000 tonnes of reinforcement
- 1,300 tonnes of roof structural steel including up to 18m overhang
- 17,000 m<sup>2</sup> of roof sheeting
- 65 air handling units
- 10.5 Mega watts chilled water capacity added
- 3 No 1.4 mega watt generators
- 30 mega watt plate heat exchangers added in lieu of cooling towers
- 4 km of chilled, condenser and hot water infrastructure pipe work
- Dismantling and removal of 5 mega watts of cooling towers
- 3,500 tonnes of scaffolding
- 90m culvert inlet diverting Brisbane River to a site storage well at a 1000 l/sec
- In excess of 30,000 lights
- 80,000 m<sup>2</sup> of plasterboard
- 6,000 m<sup>2</sup> of polished timber floor using recycled or plantation timber
- 1,300 m of balustrade
- 15,000 m<sup>2</sup> of façade
- 1,500 m<sup>2</sup> of fire rated R4 insulated sandwich panel façade
- 1300 m of man made copper and fibreglass solar screens
- 40,000 m<sup>2</sup> of new building floor space completely fitted out
- 14,000 m<sup>2</sup> of refurbished building space completely fitted out

- 2,400 m<sup>2</sup> of repository storage with 15 kPa live load capacity
- Compactus storage of 17.5 km of restricted access literature
- 3.5 hectares of external public space with 40 different elements
- 45,000 native plants including
- 4,500 m<sup>2</sup> of turf
- Management and delivery of Public Art
- Food and beverage fit out

## **KEY CHALLENGES AND INNOVATION TO OVERCOME**

### **CLIENT AND DESIGN MANAGEMENT**

The major challenge of this project was to manage the multiple stakeholders to deliver the largest investment in Arts infrastructure on time and on budget whilst meeting the objectives of the architectural design selected from an international competition. The tender documents required Bovis Lend Lease as managing contractor to take control of design after schematic design and complete design development and construction documentation.

Two of the three areas required the schematic design to re-commence due to budget and brief changes. Alterations to one area would often have consequences in the next so a collaborative approach was fundamental to a successful outcome. Bovis Lend Lease were able to mitigate delays to the project program by overlapping schematic design and design development and cost plan progressively.

Bovis Lend Lease staffed the project specifically aligned with the multiple stake holders. Each building and relevant design consultant team was allocated to a separate design and construction team within Bovis Lend Lease with a Senior Site Manager and Senior Construction Manager across the entire project.

### **CONSULTANT COORDINATION**

Separate design consultants existed on each building with the Library consultants also had responsibility for the Site Infrastructure Works. The tender documentation reflected schematic design by each Architect on the basis of each of their design competition winning schemes. Bovis Lend Lease recognised at time of tender that there was significant co-ordination work to be done interfacing between the buildings and that each Architect was of course passionate about their respective concept. Design working sessions facilitated by Bovis Lend Lease senior project personnel, were held with both architectural consultants and the client where a shared outcome was achieved whilst maintaining program.

Approximately 10 months prior to practical completion Bovis Lend Lease received a variation to complete the new entry to the existing Queensland Gallery. This introduced a third architectural consultant and another interface.

### **SITE REMEDIATION (DECONTAMINATION)**

Bovis Lend Lease found numerous latent conditions when completing the decontamination. The quantity of contaminated material increased significantly as did the severity or classification of contamination. The high end contaminated material required stockpiling on site whilst awaiting interstate laboratory tests to verify types of contaminants and hence suitable disposal methods. Bovis Lend Lease were able to micro manage the positioning of stockpiles and propose alternative on site classification where possible permitting following activities to commence on schedule. Through these initiatives the forecast remediation period of 58 days was actually reduced by 2 days despite the significant increase in volumes and material types.

## **DIFFERENTIAL SETTLEMENT**

With different structural engineers in each building with unique client requirements, foundation solutions varied throughout. The building and major structural elements were all piled, however the basement ground slab solutions varied. Basement levels were above and below 1 in 100 year flood levels. Some areas had to be designed to relieve uplift pressure in the event of flooding; others were required to resist water ingress at all times. What was difficult was tying these areas together and being able to warrant the water proofing and a uniform surface level. Bovis Lend Lease engineered these risks out by adopted the use of transition slabs and careful selection of flexible pavement finishes.

A differential settlement challenge existed in the surface finishes. The specific remediation of the existing site meant bulk excavation cut levels varied in depth. The depth of imported fill between existing and final surface levels varied by up to 5m in a horizontal distance of 10m. The Geotechnical report identified a soft compressible layer approximately 10m deep that could have a variable reaction to the dead loads imposed by the fill. In addition the engineered fill would contain critical in ground services pipe work that was susceptible to differential settlement. The under ground service tunnel required perimeter backfill to a depth of 6 m yet contained services that traversed through the tunnel supported by piles and then through engineered fill. This criteria was not identified during tender, but Bovis Lend Lease commissioned the project civil consultant to conduct a settlement analysis which recommended pre-loading the site during construction. Bovis Lend Lease rescheduled the construction logic and prioritised the problem areas thus providing maximum pre-load time during construction. Settlement pits and expansion bellows over and above that of the tender design, were also adopted in the critical in-ground services as added insurance.

## **BASEMENT WATERPROOFING**

Certain basement areas and lift pits contained suspended waterproofed ground slabs with sub grades that expected long term settlement. Bovis Lend Lease utilised their in house Certainty in Design team (CiD), who review projects nationally and identify repetitive defects and gather information on the success of certain high risk elements including waterproofing. The CiD team assisted the project architects in establishing suitable waterproofing systems and ensured that building design criteria matched warranty conditions of all products used. Bovis Lend Lease organised technical orientations by waterproofing manufacturers to the site staff so that project specific Inspection and Test Plans could be developed and ensure that warranty conditions were all satisfied. Lift pits were actually not waterproofed on the underside for fear of leaks occurring at the junction of the precast pile to the structure. Instead the team adopted concrete mixes with low shrinkage, strict water content and increased design thickness. This methodology benefited the program particularly in the GoMA building as it contained large lift pits for the Art lifts.

## **RESOURCE AVAILABILITY AND CONTINUITY OF WORK**

Bovis Lend Lease identified that due to the irregular building structure, providing continuity of work to set resource numbers would be difficult. Each of the two main buildings warranted separate resources to achieve the best possible completion date. Bovis Lend Lease identified that the Library building critical path did not actually run

through the structure of the new extension, but rather the staged refurbishment of the existing. Bovis Lend Lease constructed both the GoMA and Library buildings with the one formwork company and used the two buildings for efficiency in resource levelling. Bovis Lend Lease also identified opportunities within the reinforced concrete structure to substitute composite steel and concrete structure thus reducing demand on formwork resources. Furthermore the formwork company agreed to substitute conventional framing on high soffits with scaffold erected by separate resources. This not only alleviated resources of the critical structure trade, it also provided a safer working platform for the formwork to soffits as high as 10m.

### **POLISHED IN-SITU STRUCTURE**

The entrance level galleries to GoMA contain polished concrete floors. The original intent was for these floors to be topped and then polished, however budget determined that topping to certain areas be deleted and the polish be applied to the structural slab. Bovis Lend Lease agreed to this cost saving item for the benefit of the project, however it actually increased their risk profile as Managing Contractor. Protection of the floor prior to the polishing period was the concern. A detailed comparison of options led to a decision to apply a burnished finish to the in situ structure effectively providing a industrial floor like surface that would resist damage. This increased the time and cost to grind and polish the floor as it was significantly harder, however the resistance to damage the floor displayed during construction proved worthwhile and the justification is in the finished product.

### **RETENTION OF EXISTING MATURE TREES**

The site area contained multiple existing mature trees that were deemed significant. By far the most significant was an existing Poinciana tree located on the eastern or riverside face of the Library. Bovis Lend Lease engaged an arbourist to provide a dilapidation and ongoing report on this tree. The Poinciana tree was estimated at 80 to 100 years of age with an expected life span of 130 years. The existing Library had already been built in close proximity of the existing root system. The redeveloped Library would require new foundations and building façade 3m closer than the existing. The tree was considered an engineering feat in that it cantilevered more than 25m out over the river bank and had not fallen over despite the proximity of the original Library foundations. It was this feature that received recognition in university lectures by Horticultural Professors as far as Germany. Bovis Lend Lease considered this tree and its survival as one of the top three project risks.

The trees uniqueness soon became widely respected and appreciated by all on site and Bovis Lend Lease found willingness by all to comply with the innovative solutions which included;

- Exposing and mapping the existing roots using compressed air to remove surface soil
- Adjacent pile caps were designed as above ground to avoid excavation
- Utilising steel 75 SHS steel pile sections driven by a low height piling rig lifted up over the existing building via the tower crane that would not interfere with the

trees branches, but more importantly allowed piles to be located in between the exposed root system

- A high level façade screen consisting of steel and glass was redesigned to allow the glass to be applied off site and 12m long steel trusses installed with rigging access on the opposite side to the tree. The original design tendered to Bovis Lend Lease would have required a scaffold founded off ground level located in the centre of the Poinciana tree.

## **NOISE AND VIBRATION MITIGATION**

25 kilometres of piles were driven at Millennium Arts Project. A significant amount of these were within the vicinity of buildings occupied by people and equipment. Bovis Lend Lease applied noise and vibration levels performance criteria at time of tender and paid a premium to obtain specific equipment that minimised both noise and vibration. The times when piles were driven against buildings were co-ordinated with occupants where possible. Vibration was benchmarked beforehand and monitored during piling for critical equipment including IT server rooms. Bovis Lend Lease manufactured vibration isolation platforms for critical IT equipment that could not be turned off. The platforms dissipated the vibrations transferred through the existing concrete structure.

## **MOVEMENT CRITERIA BETWEEN EXISTING AND NEW AT THE LIBRARY**

The tender documents identified that where the existing and new Library structures adjoined a building joint would be required. A proprietary product was nominated by the Architect for the floor, wall and ceiling of the openings that occurred at this demarcation line. It was not until design development that the structural engineers were able to predict the full range of movement due to differential and structural deflection, wind, building shrinkage, thermal expansion and finally seismic. If you exclude seismic the predicted movement is +/- 20mm in three directions. The seismic movement graduates from +/- 10mm to +/- 50mm in two directions, increasing as you go up the five floor levels.

The design criteria adopted was all services and finishes would accommodate the +/- 20mm. Essential life saving services and fire rating only would accommodate the seismic movement. Once the design criteria was established and accepted by authorities the challenge was to implement it. The services solution was achieved simply enough by introducing expansion bellows. The fire proofing between floors proved harder. Bovis Lend Lease were able to source a hybrid product that satisfied the building certifier. The product would accommodate the +/- 20mm movement and be able to expand the 50mm should the catastrophic event of a fire start during an earthquake.

## **GOMA ROOF**

850 tonnes, 7000 pieces and up to 18m of overhang! Post tender Bovis Lend Lease engaged an independent engineer to conduct wind analysis studies and predict the pressure co-efficient that the roof would be subjected to. This was then modelled by the structural engineer and a deflection predicted. Bovis Lend Lease took the predicted deflection and applied their own safety factor and made these the criteria for the securing of the soffit cladding. This was Bovis Lend Lease identifying design criteria that can sometimes be missed as it often stretches over more than one consultant and multiple trades. That was the theory. The practical test involved a sample roof corner being

erected off site and deflection measured. The result was minor additional bolts added, but also confirmation of the correct erection procedure. A second test was applied on site at completion of steel erection and prior to roof or cladding where Bovis Lend Lease used the tower crane to lift up the corner of the roof and record the deflection, duration and pitch. All corners passed the site test before cladding was allowed to commence.

#### **MAINTAINING CONDITIONS AND ACCESS IN EXISTING LIBRARY**

\$28 million worth of books were left in the Library building and staff required safe and controlled access four times a day for one hour intervals. The existing IT server room had to remain live and accessible at all times. Environmental conditions specifically air-conditioning had to be maintained. The levels containing the books were to receive a full refurbishment, realignment of the eastern façade and have new openings cut into the western load bearing façade. The construction methodology was dictated specifically by this requirement. Bovis Lend Lease had the option based on the tender documents to have the books stored on one floor at a time which when including the final reposition back to both floors, would have required the library to relocate the books three times.

Instead Bovis Lend Lease requested the books remain in their original position which was against the western façade. Hoardings were installed on each floor down the middle of the building separating the western façade and the existing books from the eastern façade. Mechanical plant and ductwork serving that floor was modified and re-balanced such that positive air pressure was achieved on the book side of the hoarding. Bovis Lend Lease carried out works on the eastern side including the façade re-alignment and floor plate expansion including the feature red box clearly visible from the riverside and the new level 5 over the entire existing building. At the same time the structure for the expansion that butted against the existing west façade was completed. The new final shelving was then installed and a majority of the books were then relocated to their final location.

Once the books were relocated to the eastern side Bovis Lend Lease were able to then refurbish the western side. The existing mechanical plant was again modified and re-balanced to provide positive pressure on the book side. Works to the west side included extensive penetrations through the existing structural façade. However because the structure of the new expansion was complete access was available both sides of the wall. It was safer and faster to complete the 800 m of saw cutting, 700 No core holes and removal of 100 tonne of reinforced concrete wall.

#### **RIVER COOLING HEAT EXCHANGE SYSTEM**

Due to the need for space in the existing central energy plant and the opportunity to reduce water consumption, a new river cooling system to replace two existing cooling towers was a requirement of the tender documents. Bovis Lend Lease supported the initiative, but identified difficulties in what was being asked at the time. The original scheme included modifying an existing building to house the heat exchange plates and pumps and piping the water from the river. There was no overhead structure proposed to suspend the pipes projecting out to the river. Bovis Lend Lease's structural engineers raised concern about the stability of the river bank and what impact this would have on the foundation to the pipes. The existing building proposed to house the exchange plates had insufficient head height and contained commercial space on the floor above, hence acoustic and vibration separation was a risk. Finally the condenser water pipe route

between that building and the existing chillers required extensive excavation in the existing Peel Street which had a project requirement to maintain at least one lane at all times to permit vehicle exit for patrons using the Art Gallery or Museum carpark.

Bovis Lend Lease proposed an alternative location and methodology to obtain the river water. The new location between the Library and GoMA permitted a culvert construction to obtain river water ingress to a storage well within site. The culvert was supported by piles and was designed to accommodate long term shifts in the river bank. Water was then piped back to the river, but this pipe used the culvert as structural support. Furthermore the greenfield space allowed construction of a plant room space with double the head height and sufficient safe access for maintenance.

### **UPGRADE TO EXISTING CENTRAL ENERGY PLANT**

The existing central energy plant is split into 2 buildings. One contains existing chillers and High Voltage Switchgear, the second contained the existing emergency generators and cooling towers. The challenge for Bovis Lend Lease was mainly in the second building where the generators were being replaced and two out of four cooling towers removed to make space for three new chillers and a roof enclosure. The existing generators provided emergency power supply to the entire cultural centre including the existing gallery, museum and playhouse theatre. To replace these Bovis Lend Lease set up temporary portable generators the size of ship containers at each of these buildings and run temporary cable feeds to existing essential main switch boards.

The removal of the cooling towers was originally scheduled to occur after the river cooling system was commissioned. The logic was lift the cooling towers out, lower the new chillers in and then install a new roof over. The final river cooling system required construction of 80m of culvert which delayed the original commissioning date. Bovis Lend Lease had to re-sequence the works in the central energy plant. The revised scheme meant installing the chillers before the cooling towers were removed. Bovis Lend Lease lowered the level of the new roof and utilised the existing steel that supported the cooling towers. The roof was installed in two stages actually using the existing cooling towers as part of the roof whilst the chillers were installed beneath. A gantry beam with a lifting capacity of 6 tonne was installed to allow the new chillers to be lifted from below and horizontally dragged into the building. Once the cooling towers were removed the roof required the final in fills where the towers previously sat and then commissioning of the chillers could commence. Bovis Lend Lease estimates the program saving of this scheme was approximately four months.

## **DELIVERY ACHIEVEMENTS**

### **SAFETY**

Greater than 10,000 people inducted to project. 2.5 million man hours recorded. Measuring the frequency of lost time injuries per 200,000 man hours of construction, Bovis Lend Lease achieved a Lost Time Injury frequency Rate (LTIFR) of 1.5. This bettered the project target of 2 and is considered a fantastic result.

### **PROGRAM**

The project was delivered on time. The scope was varied significantly and Bovis Lend Lease were able to reprogram and re-sequence to accommodate.

### **WORKFORCE**

Two year presence on site generated 2.5 million man hours. Peak workforce of 950 lasted for six straight months. 2600 jobs generated by the project.

### **TRAINING**

In excess of 200,000 hours of training provided. 270 apprentices and trainees contributed 91% of this. This number of apprentices or trainees is regarded as exceptional within the industry.

### **INDUSTRIAL**

No lost time occurred due to project related industrial issues.

### **PUBLIC AWARENESS OF CONSTRUCTION**

This project is located in prime river front land at the heart of Brisbane City. Public commuting to work by vehicle, train, bus or ferry all observed daily the progress of the project. Media coverage was constantly positive. The buildings were not only complex to build; they actually looked complex to the general public. The industry was being recognised for the skill and commitment necessary to achieve such iconic buildings. To continue this beyond the construction period Bovis Lend Lease in conjunction with the client engaged a professional photographer to record the construction process and characterise the individuals who make construction of a project like Millennium Arts possible. The photos are currently on display in the Library building and many of the 10,000 strong workforce have been able to bring family members back to not only see the finished product, but also gain an insight into the construction process.

Bovis Lend Lease feel that this project legacy was essential for the construction industry.

## **CONCLUSION**

The Millennium Arts Project is considered a successful project delivered on time and on budget. The Queensland construction market has been overheated given the state of the economy and demand of migration numbers never seen before in this State. Bovis Lend Lease met their contractual obligations despite incurring 3 years of this overheated market and limited industry resources.

Bovis Lend Lease believe that the project thrived on innovation as the complexity of the project made it a daily requirement. The project challenges and innovations are certainly worth noting however the true achievement of the project was the collaboration and commitment of Bovis Lend Lease, design consultants and the workforce to make this project happen.

Bovis Lend Lease ensured the workplace benefited by organising training and providing safe working conditions. An appreciation for this projects contribution to culture was inherent throughout the project site. A spirit of achievement by the workforce was fostered and constantly acknowledged by Bovis Lend Lease. This acknowledgement was culminated in the selection of a carpenter from the workforce to formally hand over the electronic access card to Premier of Queensland the Honourable Peter Beattie at Project Completion.

## **ACKNOWLEDGEMENTS**

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