

# Structural Report

## Sandstone Precinct – Lands Building and Education Building

Prepared for Pontiac Land Group / 21 October 2016

151903

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## 1.0 Introduction

This structural report has been prepared for Pontiac Land Group for the redevelopment of the Lands and Education Buildings. The report will outline the following:

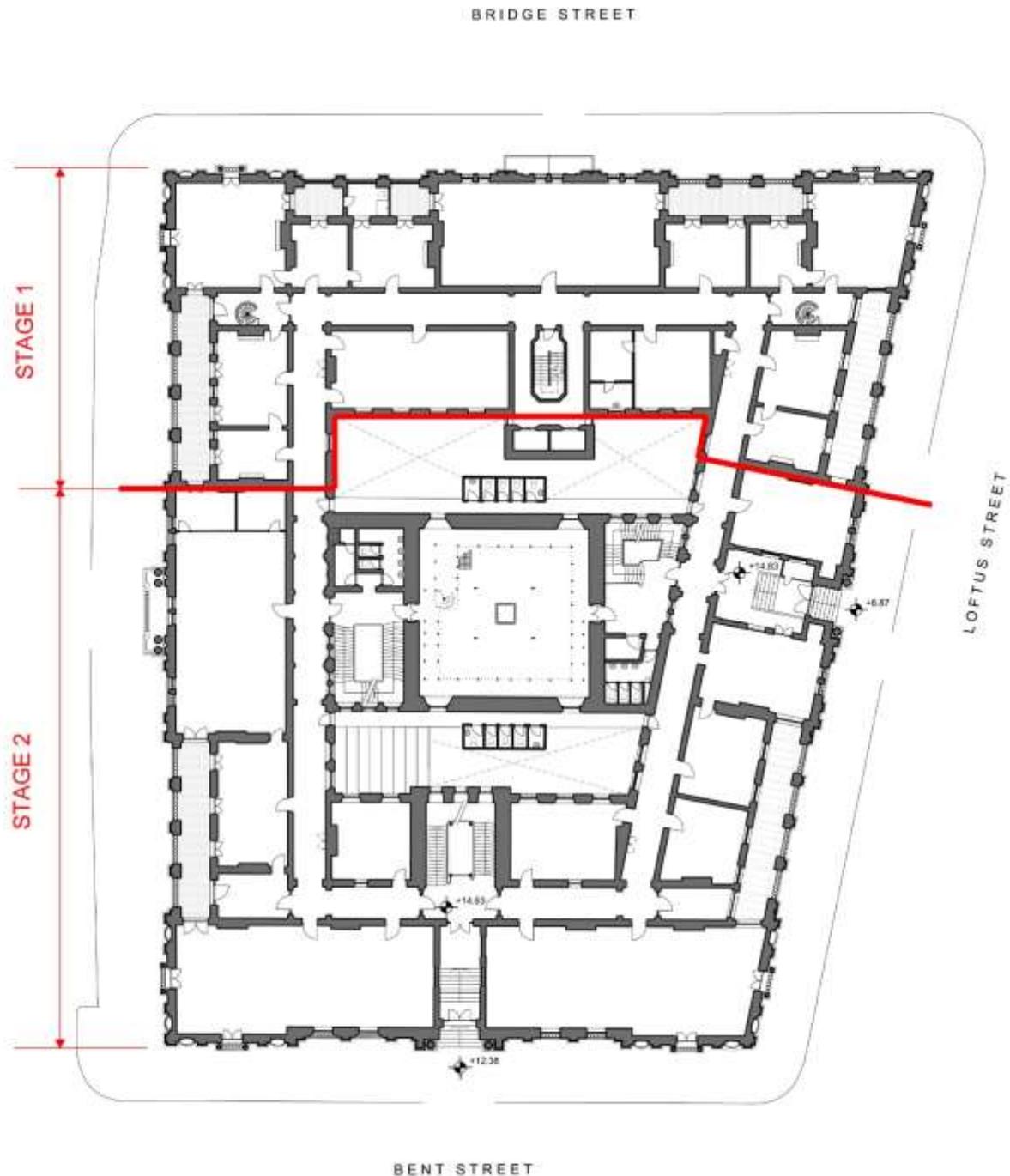
- Existing structural framing
- Geotechnical conditions
- Proposed structural modifications
- Proposed strengthening of structure to support building modifications and change of use
- Proposed strengthening of structure for earthquake resistance
- Construction of underground tunnel link between the lands and education building
- Fire-rating of structure

## 2.0 Lands Building

### 2.1 Existing Structure

The Lands Building was built in 2 stages (refer Fig. 1)

- Stage 1: northern sector constructed in 1881
- Stage 2: southern sector constructed in 1891

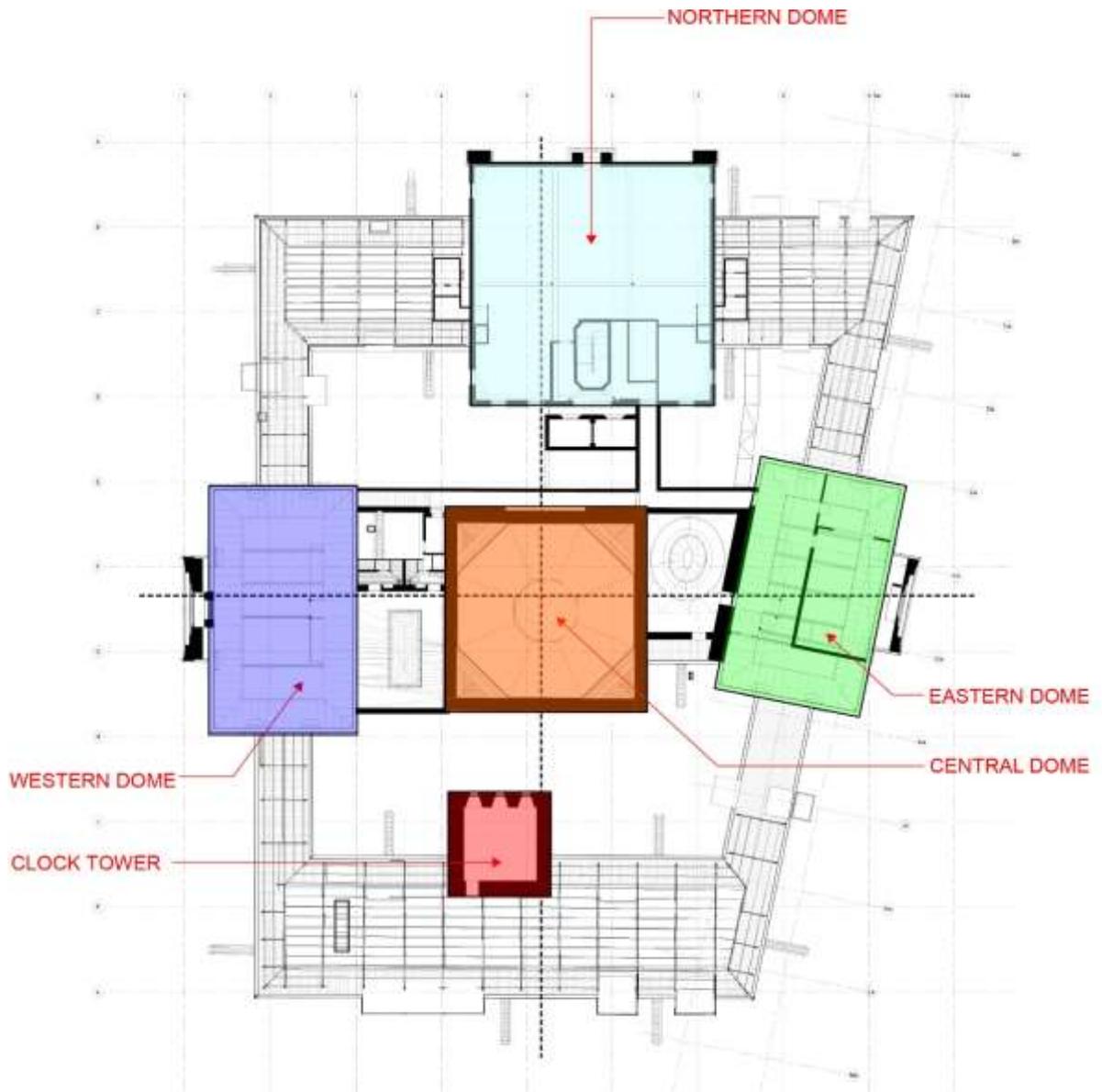


**Fig. 1 – Lands Building Staging**

Structural drawings of the building do not exist, only architectural plans and sections are available for review. The building structure can be categorised into the following sections (refer Fig. 2):

- Main Building
- Northern dome

- East dome
- West dome
- Central dome block
- Clock tower
- Foundations
- Wall and Floor Structure



**Fig. 2 – Lands Building**

### 2.1.1 Main Building

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The external walls of the building are sandstone walls of varying thickness up to 1077mm. The type of construction of the external walls i.e. solid sandstone or rubble core is unknown but it is expected to be solid sandstone based on the architectural sections. The internal walls are masonry brick walls of varying thickness up to 460mm. It is unknown if the internal courtyard walls are solid or cavity construction.

The floor construction is as follows:

- Large rooms: fabricated steel girders supported by the sandstone and brick walls, timber floor joists spanning between the steel girders and load bearing walls. The girders are fabricated from steel plates riveted together.
- Smaller rooms: timber floor joists spanning between load bearing walls
- Internal circulation corridor: brick arching floors spanning between brick walls
- Perimeter balconies: Brick arching floors spanning between sandstone walls
- The roof construction: Arching brick/concrete mortar spanning between steel girders. The girders are supported by the masonry walls and cast steel columns  
  
Steel roof trusses fabricated from angles spanning between masonry and sandstone walls

### 2.1.2 Northern Dome

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The construction of the northern dome is a combination of masonry and steel frame. The floors are timber joists supported by steel girders. The roof structure is a steel framed dome that is mounted on steel ball bearings to allow the dome to rotate.

Further investigation to determine the exact framing of the dome will be carried out once access is available.

### 2.1.3 East and Western Dome

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The east and western dome is a combination of masonry and steel frame. The floors are timber joists supported by steel girders. The roof structure is a steel trussed roof.

Further investigation to determine the exact framing of the dome will be carried out once access is available.

### 2.1.4 Central Dome block

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The central dome block is a load bearing masonry structure. The floors are steel joists supported by steel beams and cast steel columns. The central atrium void was infilled around 1954 at each floor with a steel beam and column and concrete floor construction.

Further investigation of the stair flights and landings will be carried out once access is provided.

### **2.1.5 Clocktower**

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The clocktower is a solid masonry structure that is a combination of solid masonry walls and columns from levels ground to roof level and sandstone walls and columns from roof level to the spire. The clocktower has intermediate floors framed from timber floor joists and steel beams.

## **2.2 Geotechnical Conditions**

A Desktop Study has been carried out by PSM dated 10 October 2016.

It is expected that the geological profile is natural clays (1m to 2m) overlaying weak sandstone. The weak sandstone should transition to high strength sandstone with increasing depth.

Geological maps indicate that the site could be located within the G.P.O Fault Zone. The fault zone comprises of sub vertical joints running parallel to the faulting. The sandstone weathering down below the faulting is a 'sugary' sandstone down to about 25m.

The original architectural drawings indicate the sandstone and brick walls are supported by wider brick foundations below ground level. The foundations are expected to be founded on the sandstone.

## **2.3 Proposed Structural Modifications**

### **2.3.1 Timber Floors**

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The timber floors will need to be lowered in local areas to provide adequate setdowns for the new bathrooms. This will be achieved by removing the floor boards and cutting down the floor joist depth from the top. Additional floor joists will be added adjacent to the modified floor joist to re-establish the floor live load capacity.

### **2.3.2 New Roof Structure**

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The existing steel roof trusses will be removed at level 3 and replaced with a steel framed gridshell roof. A new steel framed lightweight floor system comprising of steel beams and steel floor joists will be constructed above the existing steel and brick arch ceiling of level 2. The new steel floor system will also support the loads imposed by the new steel roof.

### **2.3.3 New Openings to Northern, Western and Eastern Dome**

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New door openings are proposed at level 3 from the external roof spaces into the internal areas of the domes. The structural framing of the domes requires further survey to establish the steel column and beam locations. The final location of the openings will need to be modified to miss the structural framing of the domes.

A large floor penetration is proposed in the centre of the Northern dome floor at level 5 and 6. The void is to facilitate a new stair from level 3 up to level 6. The openings will need to miss the steel floor beams at levels 5 and 6. Once a detailed survey of the floor system has been carried out the floor penetrations will need to be modified to suit the existing structure.

## 2.4 Earthquake Strengthening of Building

The strategy for the earthquake strengthening of the Lands Building is consistent with the recommendations summarised in a report by the Government Architects Office titles Lands Department Building Assessment of Building Structure under Earthquake loading dated September 2008. The options for the earthquake strengthening are

1. Full compliance to AS 1170.4-2007 Structural design actions Part 4: Earthquake actions in Australia.

This document is referenced by the Building Code of Australia and outlines the requirements for designing structures for earthquake loads.

2. Compliance to meet the requirements of AS 3826-1998 strengthening existing buildings for earthquake.

This document is not referenced by the Building Code of Australia. The document sets out the minimum earthquake requirements to assess and analyse an existing building. This document was produced acknowledging that it is economically impractical to update an existing building to meet the full earthquake loading as specified in AS 1170.4 .

The intent of the standard is to minimise the risk of loss of life and injury.

3. Hybrid solution adopting AS 3826-1998 as a minimum standard and meeting full compliance to AS 1170.4 for critical sections of the structure.
4. This option allows for earthquake strengthening of the building generally to the lesser standard AS 3826 whilst strengthening higher public risk areas to achieve full compliance to AS 1170.4. This option will minimise public risk and not compromise the high heritage nature of the building

It is recommended to adopt option 3 as the earthquake strengthening strategy for the Lands building. This approach is consistent with the recommendations by the Government Architects Office report September 2008.

A finite element earthquake model of the Lands Building is currently being set up. The model is created using the data obtained from the point cloud survey. Additional investigation to determine the make-up of the structure will need to be carried out. This will involve the removal of floor boards and non-heritage linings to measure beam and columns sizes. Access to begin the structural investigation is expected in 2017.

The earthquake forces as specified from both standards as outlined in Options 1 and 2 will be applied to the structure to understand how the building will behave. The analysis will confirm which areas of the structure will perform well or poorly under earthquake loads. The following areas of structure will be interrogated to ensure they have partial or full resistance to earthquake loading:

- public egress paths
- perimeter façade

- Pediments (including statues) and perimeter balustrades
- central clock tower
- northern dome
- east and west dome

The floors diaphragms will be reinforced by removal of the floor boards and supplemented with a structural ply diaphragm. The floor boards need to be removed to allow the floor system to be fire rated and to allow the acoustic performance of the floor to be enhanced. A new acoustically isolated floor board system will be replaced over the ply diaphragm.

The steel floor beams and the timber joists will be mechanically fixed to the sandstone and brick walls.

The central circulation corridor floor is a brick arch structure. The arch will require restraining from spreading by the addition of tie rods.

It is expected that the earthquake analysis can be completed by early 2017 after the structural investigation works can be completed.

## 2.5 Firerating of structure

The current fire strategy of the Lands Building is unknown. The building is currently sprinkled but the timber floors and steel girders are not fire protected.

The proposal is to provide a 60/60/60 FRL to the typical floors and a 120/120/120 FRL to specific areas of the public/service areas at level Lower ground.

### 2.5.1 Firerating of floors

The firerating of the floors is to be achieved without removal of the existing heritage ceilings.

A number of options to achieve the firerating are currently being considered. These options will require further development with the product suppliers and fire testing with bodies such as the CSIRO are being considered by the product suppliers to ensure full certification of the system can be achieved.

The followings systems are being investigated:

#### a. Timber Floor where the Heritage Ceiling is Fixed Directly to the Floor Joist

- Option 1. Promatec

This system requires the floor boards to be removed and a layered system of Promatec board is installed between the floor joists. The system relies on the capacity of the floor joists to support the floor structure whilst undergoing charring. The system will need to be developed further as the Lands building 260x60mm timber joists require the Promatec boards to be installed at the base of the joist and not 70mm up from the base of the joist. This is required to ensure adequate structural capacity is maintained and an adequate acoustic and services zone is provided above the Promatec board.

Promatec have an in-house fire testing facility in Melbourne and Adelaide to enable further product development and testing.

- **Option 2 Vermitex**

This system requires the floor boards to be removed. A mesh reinforcing system is fixed between the base of the floor joists and a wet Vermitex material is sprayed in between the floor joists. The Vermitex material can be supplied in a number of densities ranging up to 600kg/m<sup>3</sup>. The higher density materials are preferred by the acoustic consultant but still do not provide adequate mass to meet the theoretical acoustic requirements.

It is recommended to carry out a series of fire and acoustic tests with the Vermitex product to determine the actual acoustic performance. Vermitex use the certifying body CSIRO to carry out all their acoustic and fire testing. They are prepared to commission CSIRO to carry out further testing to confirm compliance for this project.

The steel beams supporting the timber floor joists will need to be fire protected with a fire spray. The sides and top of the beams can be sprayed from above the floor. Access to the bottom flanges of the steel beams will require the heritage ceiling to be carefully removed and replaced by specialist contractors.

**b. Ceiling Void Between Floor Joists and Ceiling**

In this situation the floor boards are to be removed and a firerated board is to be installed to the underside of the timber joists. The method of installing the firerated board from above the floor joist is difficult and requires advice from specialist contractors

**c. Central Circulation Corridor**

The central circulation corridor floor structure is constructed from brickwork built as an arch to span the corridor. The actual make-up of the floor system requires further investigation to determine the brick arch thickness and the mortar thickness on top of the arch.

The firerating performance of the brick floor system will then be able to be investigated. The floor system may require the firerating performance to be enhanced by additional linings if the system cannot achieve the 60min rating.

### **2.5.2 North, West and Eastern Domes**

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The domes are a constructed from a composite of steel frames, masonry walls and a timber floor system. The steel columns and floor beams and the timber floor joists will require to be rated using a firerating board system lined on the inside of the structure.

### **2.5.3 Sandstone Walls**

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The façade of the building comprises of load bearing sandstone. Further investigation is required to ascertain the fire rating performance of the sandstone. Fire testing of the sandstone may be required if adequate data on the sandstone performance cannot be attained.

### **2.5.4 Brick Walls**

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The internal load bearing brick walls will be assessed for fire performance to meet AS 3700 2011 Masonry structures. It is expected that due to the thickness of the brick walls that the walls will satisfy the 60 min rating.

### **2.5.5 Roof Structure**

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The roof structure is a composite structure of steel roof trusses with a steel framed and brick arch structure located directly below the trusses. It is proposed for the steel trusses to be removed.

The steel frame located under the trusses will need to be fire rated by

1. Intumescent paint to the bottom flange of the beam  
and
2. Firespray to the webs and top flange

The arch infills between the steel beams are believed to be brickwork. The brickwork will need to be assessed for performance under a fire.

An alternate approach could be to consider the steel frame and brick arch as a ceiling system that does not require rating and provide a fire separation with the new roof floor system (steel beams and steel joists).

The cast iron columns that support the steel beams will require fire rating with intumescent paint.

## 3.0 Education Building

### 3.1 Existing Structure

The building was built in 2 stages. The first stage was completed in 1915 and the second stage completed in 1930.

Stage 1 is a 7 storey steel and reinforced concrete building. The columns are structural steel I sections reinforced with plates that are concrete encased. The external facade is load bearing brickwork with a sandstone ashlar facing. The floor system is a system of steel beams supporting a ribbed reinforced concrete slab. The exact details of the slab is to be confirmed once a detailed inspection of the structure can be carried out.

Limited structural drawings are available for this stage of the building. The framing layout of steel columns, beams has been identified off a few structural drawings but member sizes cannot be identified from the drawings.

It is noted in the Conservation Management Plan dated March 2015 that the steel frame was designed as a rigid steel frame which implies that the lateral stability is achieved by frame action of the steel floor beams and columns.

Stage 2 is a 7 storey steel and reinforced concrete building. The columns are fabricated steel sections that are concrete encased. The floor system is a steel beam and ribbed reinforced concrete slab. The ribs are 150mm wide by 318mm deep at 600mm centres. The slab is 63mm thick.

According to the Conservation Management Plan dated March 2015 all the walls including the exterior stonework are supported off the concrete encased steel framework. The building is braced laterally by masonry shear walls. The limitation placed by using masonry shear walls that is resulted in somewhat less flexibility in the interior planning of each floor.

Limited structural drawings by Structural engineer Charles A Reed are available for review. The exact details of the structure is to be confirmed once a detailed inspection of the structure can be carried out.

The foundation system is expected to be reinforced pad foundations bearing on sandstone.

### 3.2 Geotechnical profile

The geotechnical profile is expected to be natural clays overlaying sandstone. There is a possibility that the sandstone could be heavily jointed. The proposed geotechnical investigation has allowed for 4 boreholes and 8 cored testpits.

A Desktop Study has been carried out by PSM dated 10 October 2016.

### 3.3 Fire rating of the structure

An FRL of 90/90/90 is required for this building. The current resistance levels are as follows:

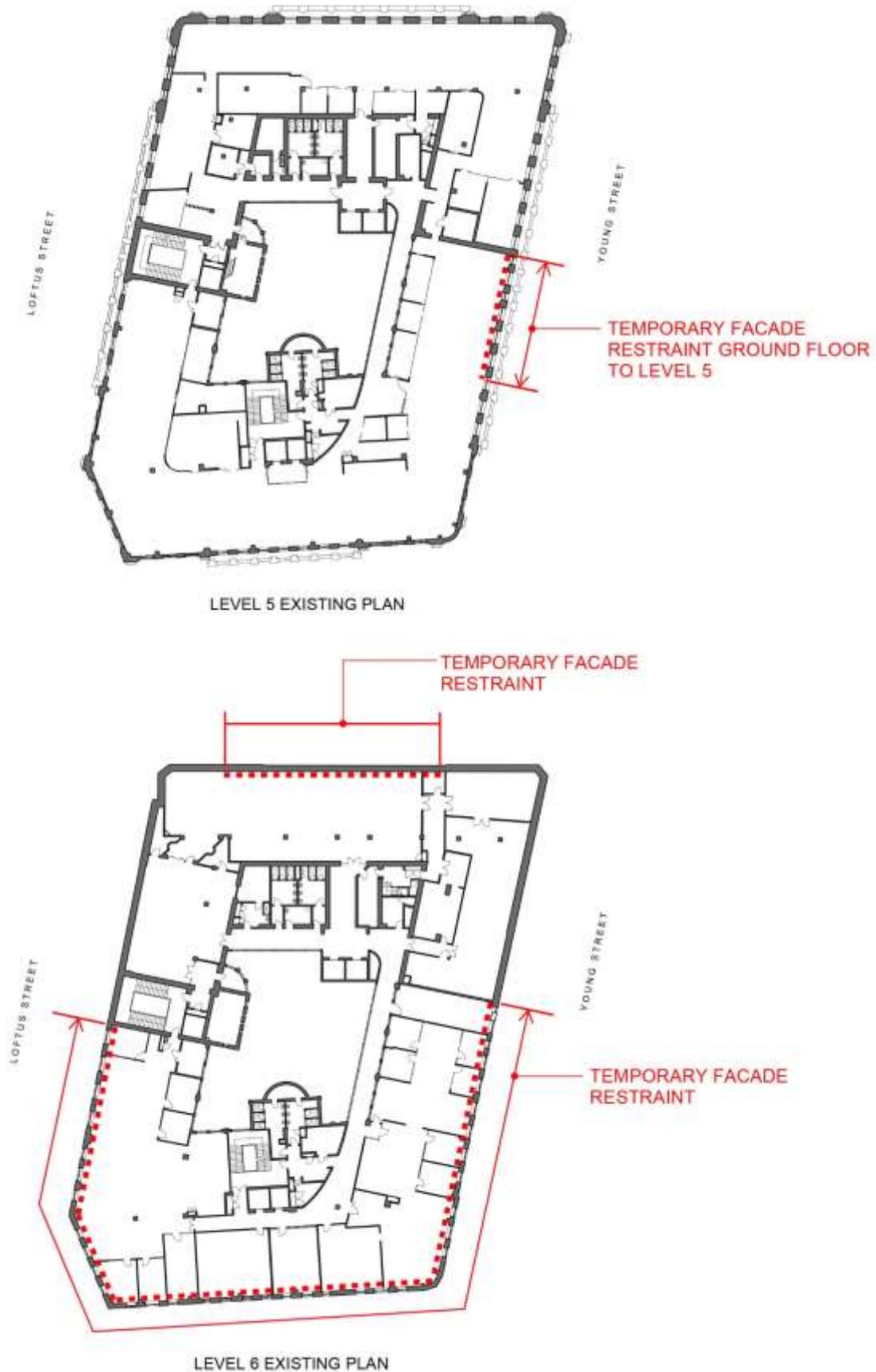
- **63mm thick floor slabs:** The cover to the reinforcement is unknown and will need to be confirmed. Based on a 20mm cover to reinforcement the 63mm thick slab will only achieve an FRL of 60/60/30. A fire protecting soffit lining will be required to enhance the FRL of the slab. The slabs are supported by 150mm ribs at 600mm centres, based on a 20mm cover to reinforcement the ribs will have an FRL of 30/30/30. The slab system will require a fire lining to achieve the 90/90/90 rating.
- **Steel columns:** The steel columns are concrete encased. The thickness of the encasement and the existence of fire reinforcement in the encasement is unknown and must be confirmed. A detailed investigation is required to confirm the extent and thickness of encasement in all areas. A fire protecting lining may be required if the encasement is inadequate or fire reinforcement is non-existent.
- **Steel floor beams:** The steel floor beams are concrete encased. A detailed investigation is required to confirm the extent and thickness of the encasement and the existence of a fire reinforcing mesh. A fire protecting lining may be required if the encasement is inadequate or the fire reinforcement is non-existent.

### 3.4 Proposed Development

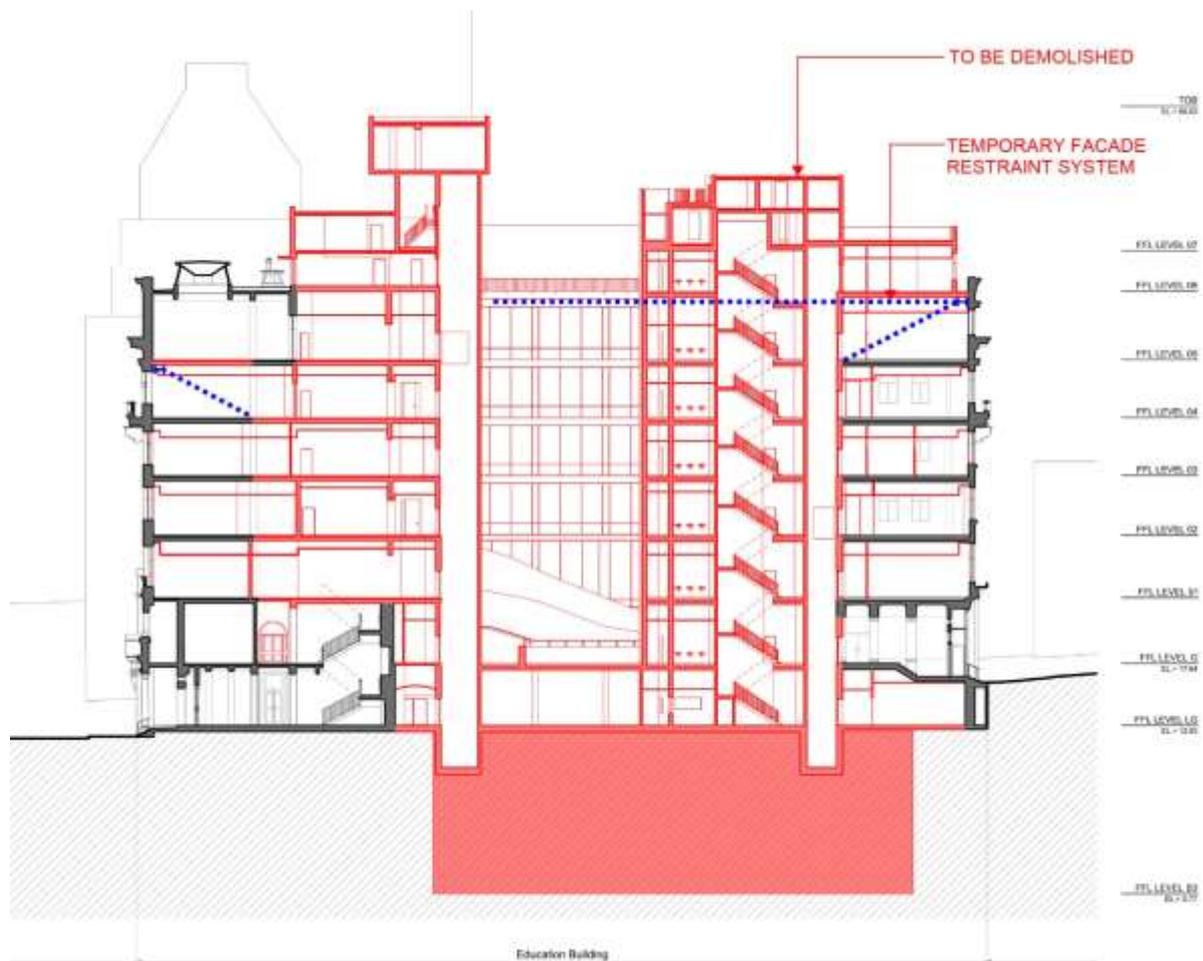
The proposed development involves:

- Partial demolition of existing structure and strengthening of existing structure
- Excavation of 3 basements
- Addition of new floors at levels 6,7,8,9 and roof
- Addition of new stair and lift shafts
- Provision of a pool at level 5
- Excavation of a link tunnel between the Education and Lands building
- Partial demolition and strengthening of existing structure

The extent of demolition is indicated on architectural plans by Make drawing Nos SP-DA-G-2295 to 2309. The demolition of the eastern section of slab at levels ground to level 6 to allow for the construction of the new stair and lift cores will require a section of the eastern facade to be temporarily stabilised with structural steel walers and braces. The construction of the new pool at level 5 will require a section of the northern façade to be temporarily stabilized by steel walers and braces. Refer Fig. 3 and Fig. 4. If the new structure can be constructed through the existing slabs prior to demolition of the affected slabs, sections of the retention steelwork could be deleted.



**Fig. 3 – Temporary Façade Retention**



**Fig. 4 – Temporary Façade Retention**

The remaining concrete floor slabs will provide temporary lateral stability to the building. In specific areas additional temporary structural steel bracing will be provided to enhance the system.

The additional load to the existing columns and foundations created by the addition of the new floors will require the steel columns and foundations to be strengthened. The final detail of strengthening cannot be determined until the existing columns and foundations have been fully investigated for steel and concrete strength and sizing.

It is envisaged that the columns will be strengthened with additional steel plates and encasing the columns with a high strength concrete. The foundations will require enlargement.

### 3.5 New Structure

The new structure is proposed to be reinforced concrete floors and columns. The new foundations will be pad footings bearing on sandstone.

A brief description of the new works are as follows:

- Foundations: Concrete pad footings
- Basement retaining walls : Reinforced concrete walls
- Basement 1 to basement : Reinforced concrete structure
- Lift and stair shafts : Reinforced concrete
- Columns: Reinforced concrete
- Infill slabs levels Reinforced concrete slabs and steel beams
- New slab levels Reinforced concrete flat plates
- Roofs : Reinforced concrete and light weight steel framed roofs

The new slabs will be tied into the existing floor plates to allow the building to behave as a single structure.

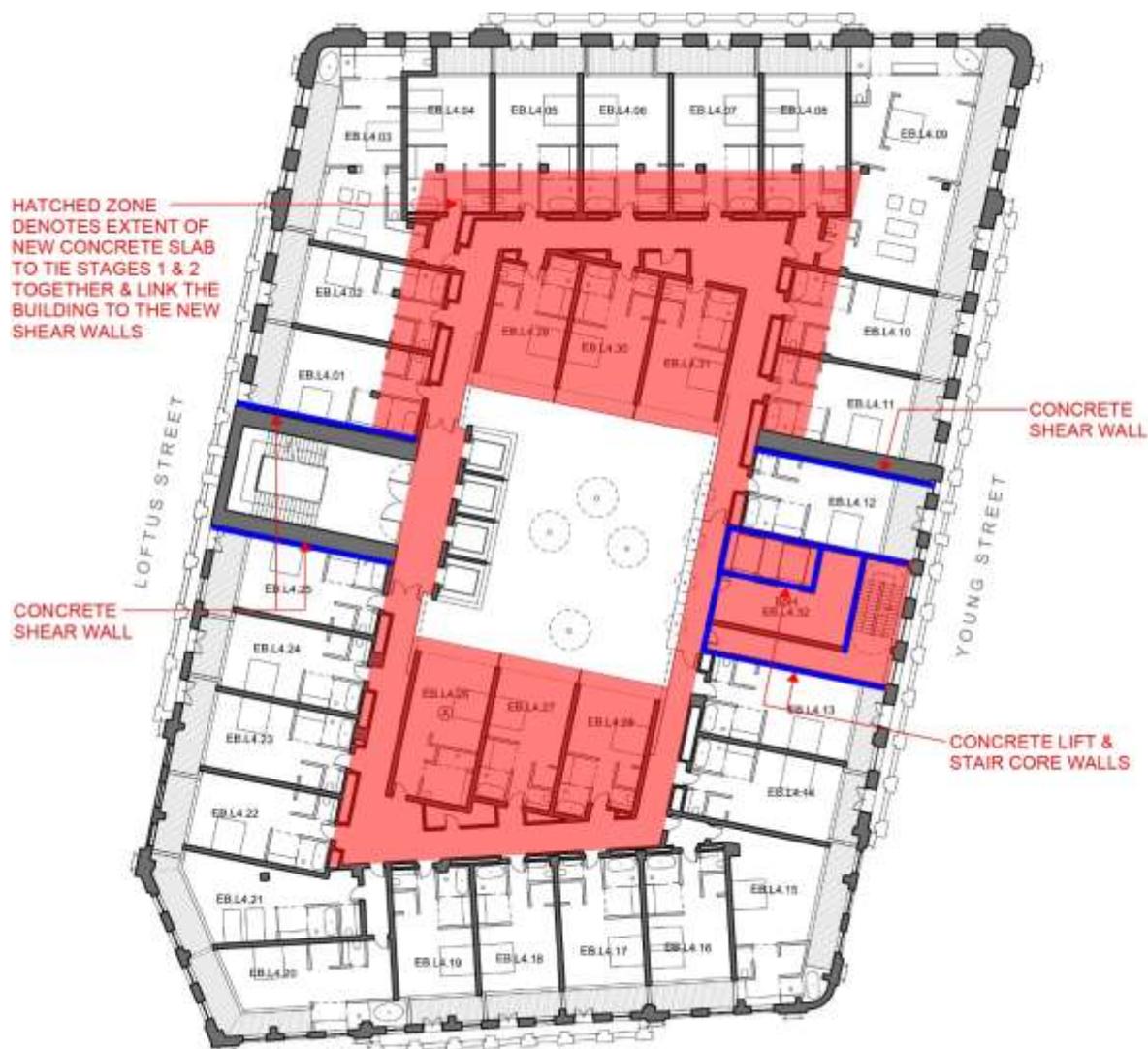
### 3.6 Upgrading the Building to Resist Wind and Earthquake Loading

The existing structure relies on the masonry walls to provide lateral stability to the building. The building would not comply with the requirement to resist earthquake loading as specified in AS1170.4 Earthquake Loads.

The lateral stability of the building has a different structural approach in stage 1 and 2. The Conservation management Plan dated March 2015 outlines how the stage 1 structure relies on the perimeter walls and rigid steel beam and column connections for lateral stability where the stage 2 structure relies on internal masonry walls for lateral stability.

The proposed works involves the provision of additional floors which will change the mass and stiffness of the building. It is required under the BCA to upgrade the building to meet AS 1170.4 Earthquake Loads and AS 1170.2 Wind Loads.

To enhance the lateral stiffness of the building new concrete lift and stair shafts and shear walls have been provided. A section of existing concrete slab has been removed from around the internal atrium and a new insitu concrete floor slab in the shape of a ring has been re-established around the inner atrium to tie the 2 stages of construction together and link the building to the new shear walls refer Fig. 5.



**Fig. 5 – Education Building Lateral Stability Strategy**

The facade fixings to the concrete structure will need to be investigated and upgraded if required to meet the earthquake and wind load requirement.

### **3.7 Excavation of Basements**

The final methodology of how to excavate the basements will be dependent upon the quality of the sandstone bedrock and advice from the excavation contractor, demolition contractor and main building contractor.

The final selection of excavation equipment sand shoring system will be based on the quality of the sandstone. Strict guidelines will be set to limit excavation vibrations to ensure damage to the sandstone fabric does not occur.

### **3.8 Pool Structure**

The level 5 existing structure located under the proposed pool will be locally demolished and rebuilt in steel and reinforced concrete to allow for a drop in floor level to accommodate the pool base.

The new pool will be either a reinforced concrete or steel system that is vibration isolated on bearings from the main building. Options on the pool structure are currently being investigated and will be assessed on weight, buildability and long term serviceability.

### **3.9 Service Tunnel**

The service tunnel is a 4m wide corridor located approximately 7m below street level.

The confirmation of the existence of the G.P.O Fault Zone will dictate the construction methodology used to tunnel under the building foundations and across the road. Upon completion of the geotechnical investigation tunnelling options will be investigated.

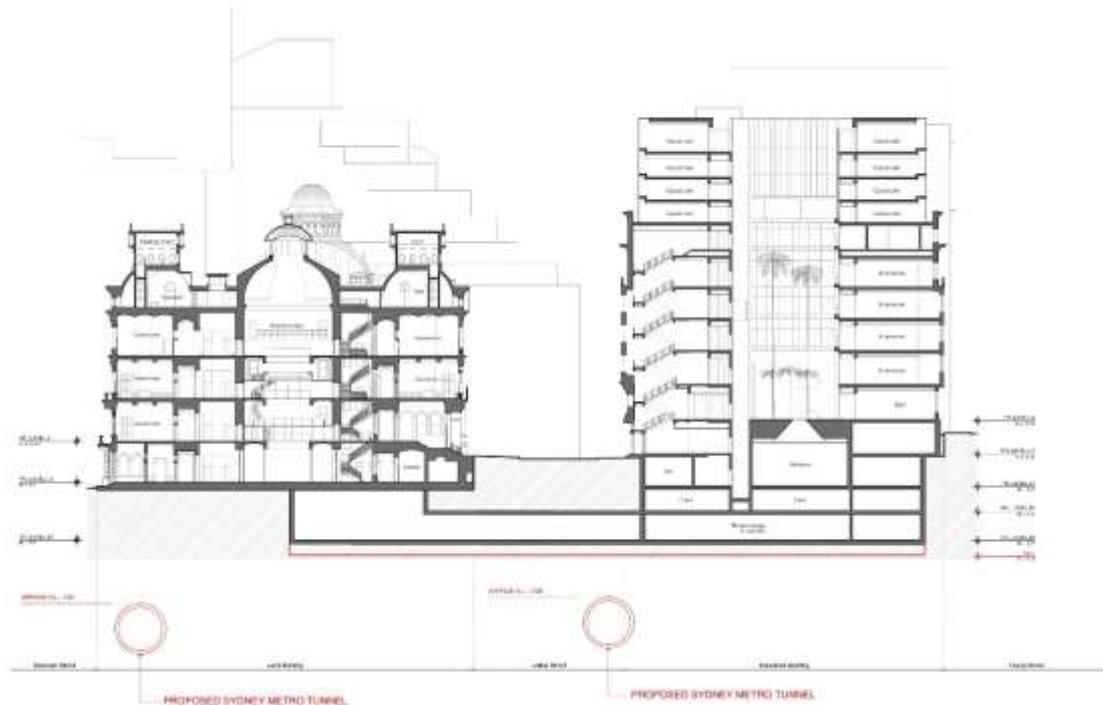
## 4.0 South West and City Metro Rail Tunnels

The proposed South West and City Metro rail tunnel alignment runs directly under both the Lands and Education building. Refer Fig 6. The top of the tunnel is located approximately 7m below the proposed basement and link tunnel RL of -0.23. The eastern of the two tunnels run under the south western corner of the Education building. Coordination will need to be carried out with the Sydney Metro engineers to discuss the proposed new foundations that will influence the design of the tunnel lining.



**Fig. 6 – Sydney Metro Tunnel Alignment**

Preliminary discussions have been held with Brendan Baker (Principal Manager Customer and Product, City and Southwest Sydney Metro, Transport for NSW). Initial discussions with Mr Baker and Ridley Co confirm that Transport for NSW acknowledge that we are proposing an excavation and a tunnel link. They have confirmed and that there is approximately a 7m separation between the metro tunnels and the proposed Education building basement excavation Refer Fig 7. Mr Baker has indicated that this clearance should be acceptable. He had requested that further consultation be carried out once our design has progressed to understand excavation methods etc.



**Fig. 7 – Sydney Metro Tunnel Cross Section**

Recent discussions with Mr Baker and TTW confirm that the detailed design of the Metro tunnel is underway. TTW are in the process of organising meetings with Transport for NSW to seek approval of our proposed works. Key items to discuss and seek approval include:

- excavation level of tunnel link and Education building basement
- new pad footings from Education Building imposing load onto Metro Tunnel
- excavation methodology for new link
- stray currents
- vibration and acoustic issues from the train network.

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