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Group

Structural Engineering Report One Sydney Harbour

Stage 1B Basement State Significant Development Application – SSD 6960

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1.0 Introduction

This report supports a State Significant Development Application (SSD 6960) submitted to the Minister for Planning pursuant to Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Development Application (DA) seeks approval for construction of the Stage 1B Basement and associated works at Barangaroo South as described in the Overview of Proposed Development section of this report.

1.1 Overview of Proposed Development

The Stage 1B Basement DA seeks approval for the construction of a four level basement to accommodate elements for the Stage 1B Residential Buildings (subject to separate SSD applications). The elements include the construction of common plant and services, loading docks, waste rooms and storage areas, and structural cores and associated building services for the Stage 1B Residential Buildings. The proposed development also includes above ground elements such as roads, car park ramps and risers, and temporary public domain and landscaping works.

It is noted that site preparation works, including demolition, remediation and excavation, are covered under SSD 5897.

1.2 Site Location

Barangaroo is located on the north western edge of the Sydney Central Business District, bounded by Sydney Harbour to the west and north, the historic precinct of Millers Point (for the northern half), The Rocks and the Sydney Harbour Bridge approach to the east; and bounded to the south by a range of new development dominated by large CBD commercial tenants.

The Barangaroo site has been divided into three distinct redevelopment areas (from north to south) – the Barangaroo Reserve, Barangaroo Central and Barangaroo South.

The Stage 1B Basement DA Site area is located within Barangaroo South as shown in Figure 1. The Development Application Site is located on land generally known and identified in the approved Concept Plan MP06_0162 (as modified) as Blocks 4A and 4B and part of the public domain area between those blocks and Block 5.

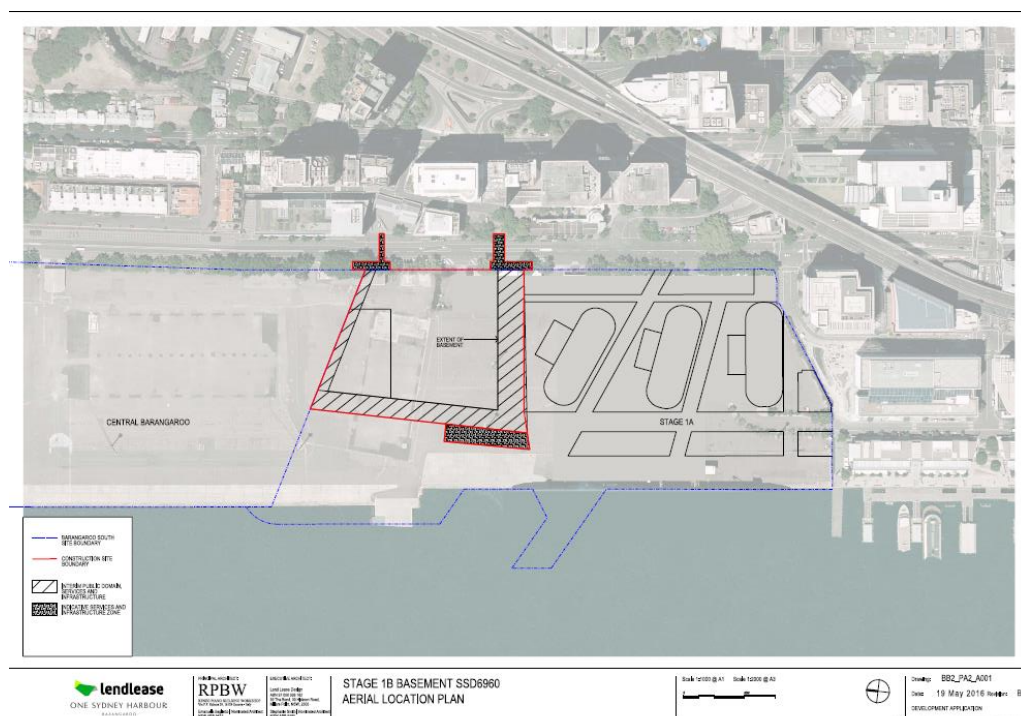


Figure 1: Stage 1B Basement Development Application (SSD 6960) Site Location Plan

1.3 Purpose of this Report

This report has been prepared to accompany the Development Application for the 1B Basement and associated works at Barangaroo South. It addresses the relevant Secretary's Environmental Assessment Requirements (SEAR's) for the project.

These SEAR's are discussed in the Environmental Assessment Report (EAR) that has been prepared to support the application.

1.4 Geotechnical Site Investigation

Reference is made to the Geotechnical Report for the Development Application (MP10_0026) by Coffey dated 9 December 2010. This report is based on existing information about the site and surroundings, which provides a description of the site history, geology, and ground conditions. The reports contain sufficient information to provide confidence that an adequate foundation solution can be developed.

Additional geotechnical investigations have been undertaken to provide specific foundation data for the foundation design and construction of the basement, as well as the interaction with neighbouring basements.

1.5 General Ground Conditions

The Sydney 1:100,000 Geological Sheet indicates that the site locality is underlain by Fill and Quaternary alluvium overlying Hawkesbury Sandstone. An igneous dyke (the Pittman LIV Dyke), is also shown in close proximity to the site. The depth to sandstone from existing surface level trending away from Hickson Road varies from 1m to 19m below ground across the site. A portion of the site is contaminated with hydrocarbons which will require remediation, which is addressed under SSD 5897 and approved and relevant remediation documentation.

1.6 Groundwater

Groundwater across the site is heavily influenced by tidal fluctuations of the adjacent Darling Harbour, as confirmed by Groundwater Monitoring done by Coffey between 13 and 19 December 2013. The existing Highest Astronomical Tide (HAT) of the site is 1.175m AHD.

A design ground water level of RL 2.335m AHD is adopted for the design of the basement which includes allowances for a 0.9m rise in sea levels as stated in the NSW Coastal Planning Guideline: Adapting to Sea Level Rise and an increase in water levels associated with a 1 in 100 year weather event of 0.36m.

2.0 The Structural Scheme

2.1 General Description of 1B Basement

Site 1B is proposed to have four basement levels with the lowest at approximately RL -11.2m top of structural slab level (SSL), lift pits to approximately RL-16.9 and piles below. A landscaped deck is proposed to extend over a large portion of Site 1B with a finished nominal level of RL 3.5m.

A portion of development site is shared with the approved Crown Hotel. The Crown portion of the site is approved to have only three basements. The Crown portion of the site is covered under a separate application. The approved Crown Hotel basement will be separated from the Lend Lease basement by a partition wall.

Robert Bird Group has reviewed and assessed the drawings and relevant documentation in respect of this project application as noted below:



Drawing No.	Revision	Drawing Title
BB2_PA2_A000	Rev B	TITLE SHEET
BB2_PA2_A001	Rev B	AERIAL LOCATION PLAN
BB2_PA2_A002	Rev B	SURVEY PLAN
BB2_PA2_A003	Rev B	DEMOLITION, EXCAVATION & SERVICES ZONE PLAN
BB2_PA2_A100	Rev B	BASEMENT PLAN LEVEL B0
BB2_PA2_A101	Rev B	BASEMENT PLAN LEVEL B1
BB2_PA2_A102	Rev B	BASEMENT PLAN LEVEL B2
BB2_PA2_A103	Rev B	BASEMENT PLAN LEVEL B3
BB2_PA2_A104	Rev B	BASEMENT PLAN LEVEL B4
BB2_PA2_A105	Rev B	BASEMENT PLAN LEVEL B5
BB2_PA2_A300	Rev B	SECTION 01
BB2_PA2_A301	Rev B	SECTION 02
BB2_PA2_A302	Rev B	SECTION 03
BB2_PA2_A303	Rev B	SECTION 04
BB2_PA2_A400	Rev B	BUILDING ELEMENTS – GROUND FLOOR
BB2_PA2_A401	Rev B	BUILDING ELEMENTS – PODIUM 1
BB2_PA2_A402	Rev B	BUILDING ELEMENTS – PODIUM 2
BB2_PA2_A501	Rev B	BUILDING ELEMENTS - ELEVATIONS

2.2 Substructure

Foundations

Due to the depth of the rock founding strata in relation to the lowest basement level, and to the high upwards hydrostatic loads on basement areas, bored piles are currently proposed for the foundations of the basement and buildings R4A, R4B, and R5. It is intended that the piles are founded within the sandstone providing bearing, with shaft adhesion generated through the rock for both compression and tension loading cases. The piled foundation will be installed as part of the basement construction.

The basement walls are proposed to be constructed of diaphragm walls on the western and majority of northern portions of the perimeter. They will be socketed into the rock and retain soil and hydrostatic loads, thereby utilising the principles of a fully tanked system. Soil anchors or another support system will be used in the temporary case as required and slab diaphragms will provide support for the walls in the permanent case. The final perimeter retention wall method will be subject to market advice.

On the eastern and eastern-most portion of the northern perimeter wall, rock is present very close to the ground floor level. A temporary secant pile, contiguous pile, sheet pile wall, or similar will be constructed and socketed into rock to retain the top portion of the excavation. As the site is excavated, this wall will be supported using ground anchors or similar in the temporary case, and the ground slab in the permanent case. The rock below this wall will be supported by ground anchors if required as per the geotechnical engineering report recommendations. The temporary walls required to complete remediation are also covered under SSD 5897.

The south boundary of the site is located approximately 10m north of the existing Stage 1A basement, which is already constructed with a wall down the length of the site. Stage 1A is two basements deep, so as the excavation proceeds below the lowest level the diaphragm wall will be supported using ground anchors in the temporary case and site 1B basement slabs in the permanent case.

The lowest basement slab will act as a hydrostatic raft slab to retain the uplift forces.

Vertical Structure

The vertical structure through the basement will consist typically of reinforced concrete columns or similar.



The structural design of the basement columns and walls will be coordinated with the reactions from the superstructure of buildings R4A, R4B, and R5 so as to ensure compliance with the relevant BCA and Code requirements for structural design.

Slabs

Basement slabs will be reinforced and / or post tensioned concrete band beam and slab construction.

The ground level slab will consist of multiple levels and set-downs to accommodate trunk services, road pavements, planters and landscaped areas, ramps, etc, and will need to accommodate multiple penetrations for plant access, intake and exhaust risers, etc.

The slabs will be designed to take the in plane forces required to prop the retention walls.

2.3 Stability

Soil, hydrostatic, robustness, wind, and seismic loading will be applied in accordance with the relevant sections of AS/NZS1170 and AS1170 Parts 0, 2 and 4. Structural stability will be provided by an arrangement of reinforced concrete shear walls and the perimeter diaphragm walls.

2.4 Waterproofing

All basement structures (other than the shoring walls), particularly the lowest level basement slabs in contact with the ground, must be watertight i.e. water and vapour proof and prevent the ingress of water. Joints within structural components need to maintain watertightness to the same degree as the adjacent structural components.

The lowest basement slabs are to have a waterproof membrane applied to achieve the above, as required.

2.5 Construction Staging

The building and structural components relating to each development stage should be structurally stable under all interterm conditions.

2.6 Green Star Initiatives

It is intended that Green Star initiatives relating to structure for the 1B basements include the following where appropriate:

- Use of cement replacement and/or recycled aggregate for concrete

3.0 Design Standards and Sources of Reference

3.1 General

The design and documentation of the basement and associated works shall comply with all relevant Australian Standards and the Building Code of Australia (BCA).

Standard Specifications or Codes of the British Standards Institute (BS) or the American Society for Testing and Materials (ASTM) are referenced only when a relevant Standards Australia publication does not exist.

Current editions of all codes and standards shall apply.

3.2 BCA Structural Provisions

The basement is classified as follows in accordance with Part B1 of the BCA.



Table 1: Classification

Australian Standard Table	Classification
AS 1170.0:2002 Table 3.1 Importance Level	3 – Buildings or structures that are designed to contain a large number of people
AS 1170.0:2002 Table 3.3 Design Events for Safety Wind Earthquake	Annual Probability of Exceedance 1:1000 1:1000

3.3 Codes and Standards

The following codes and standards will form the basis for the structural design:

Table 2: Codes and standards used in design

AS/NZS 1170.0	Structural design actions – General Principles
AS/NZS 1170.1	Structural design actions – Permanent, imposed, and other actions
AS/NZS 1170.2	Structural design actions – Wind actions
AS 1170.4	Structural design actions – Earthquake actions in Australia
AS 1720.1	Timber structures – Design Methods
AS 2121	Cold formed steel structures code
AS 2159	Piling – design and installation
AS/NZS 2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
AS 2327.1	Composite structures – Simply supported beams
AS 3600	Concrete structures
AS 3700	Masonry structures
AS 3735	Concrete structures retaining liquids
AS 4100	Steel structures
AS 4678	Earth-retaining structures
AS 5100	Bridge Design Set
BCA	Building Code of Australia
BS 5950-8	Structural use of steelwork in building – Code of practice for fire resistant design
BS 8102:1990	Code of practice for protection of structures against water from the ground
CIRIA	CIRIA Reports 139 & 140: Water Resisting Basements
CIRIA 0660	Early-age thermal crack control in concrete

4.0 Loads

4.1 Dead Loads

Dead loads are to be calculated on the basis of the following densities:

Reinforced concrete: 24.5 kN/m³

Steel: 78.5 kN/m³

4.2 Superimposed Dead Loads and Live Loads

Table 3: Superimposed dead loads and live loads used in design

Area	Superimposed Dead Load	Live Load
Car parking	0.5 kPa ceiling and services 1.0 kPa hobs and falls	3.0 kPa
Landscaping		As calculated for soil depth
Loading dock	2.0 kPa	As calculated for relevant use, 15 kPa minimum
Plant rooms	0.25 kPa ceilings 0.75 kPa floor finishes	7.5 kPa (minimum)
Retail	0.5 kPa moveable partitions 2.5 kPa finishes 0.5 kPa ceilings and finishes	5.0 kPa
Roads	5.0 kPa for road pavement and hard stand areas	25 kPa
Storage	0.25 kPa ceilings 0.75 kPa floor finishes	2.4 kPa per metre of storage height
Stairs	0.1 kPa services	4.0 kPa
Terraces (including trafficable roofs)	2.5 kPa finishes 0.25 kPa ceiling & services	4.0 kPa

4.3 Temporary Construction Loading

All areas located at ground level shall be designed for a temporary construction live load of 25 kPa. This may be relaxed in certain areas pending further coordination.

4.4 Wind Loads

For the structural design of components, wind loading applied to the structural elements will be assessed in accordance with AS1170 Part 2: Wind Actions. Terrain categories will be calculated based on the roughness length calculation.

The following design parameters have been assessed in accordance with AS1170.2:

Region: A2

Basic wind speeds:

Ultimate: $V_{1000} = 46$ m/s

Serviceability: $V_{25} = 37$ m/s

4.5 Seismic Loading

Earthquake loading applied to the structural elements and detailing of the seismic stability system will be in accordance with AS 1170.4: 2007: Earthquake actions in Australia.

Specific seismic data is summarised as:

Importance level: 3

Annual probability of exceedance: 1:1000



4.6 Earth Pressure Loading

The site-wide 1B Basement envelope has buildings R4A, R4B and R5 within it. Shear walls provided within the towers and diaphragm walls around the perimeter of the basement will resist earth pressures transferred through the permanent diaphragm slabs.

Earth retaining structures shall be designed in accordance with the recommendations in the geotechnical report.

4.7 Water Pressure Loading

The existing groundwater level relates directly to the adjacent tidal conditions. Resulting short term and long term water pressure conditions are to be applied to all submerged structures.

4.8 Vehicular Loads

Vehicular loads to public areas are to be designed in accordance with AS 5100.2

4.9 Barrier Loading

Barriers, upstands and perimeter containment walls within carparks, truck docks and access driveways are to be designed in accordance with AS 1170.1 Clause 3.6 and Table 3.3.

4.10 Balustrade Loads

Balustrades are to be designed in accordance with AS/NZS1170.1.

4.11 Anchor Stressing and De-Stressing

The design of the temporary anchoring systems used in the shoring walls are to accommodate the staged construction anticipated on the site. It is likely that the stressing and de-stressing sequences to be adopted will need to be staged.

4.12 Blast Forces

Generally the structures within the basements will be configured to allow for redundancy and progressive collapse of key components.

5.0 Serviceability

5.1 Design Life

The structure is intended to be designed for a nominal 50 year design life. The BCA and Standards Australia material standards will be used as the basis for the durability specification for the structure.

Reference should be made to the relevant material standard regarding maintenance assumptions that form the basis of the design code.

5.2 Deflection Limits

The deflection criteria specified in AS 3600 as AS 1170.0 and as specified below are appropriate for the basement:

Table 4: Deflection limits

Type of Member	Deflection to be considered	Deflection limit for spans	Deflection limit for cantilevers
Beams and slabs	Total deflection	1/250	1/125
Members supporting masonry partitions	The deflection that occurs after the addition or attachment of partitions	1/500 where provision is made to minimize the effect of movement, otherwise 1/1000	1/250 where provision is made to minimize the effect of movement, otherwise 1/500
Total deflection under wind loads	H/500	-	-
Inter-storey deflection under wind load	Floor to floor/500	-	-
Inter-storey drift under earthquake load	1.5% Floor to floor	-	-

5.3 Vibration Limits

Slabs and beams shall be designed to achieve the vibration criteria in AS 2670.2.

5.4 Construction Tolerances

Construction tolerances for structural components are to be as nominated in the relevant design codes and as required for the finishes applied over those structural components.

Refer to the Perimeter Earth Retention Systems Brief by Robert Bird Group for the tolerances relevant to these elements.

5.5 Concrete

Durability

The requirements of AS 3600 will be applied to all reinforced and post-tensioned concrete. For the foundations, the concrete mix and cover to reinforcement selected will be appropriate for the ground conditions.

Table 5: Concrete durability criteria

General	Exposure classification A1 to AS 3600
Pile caps and in-ground elements	Exposure classification A2 to AS 3600
Piles	In accordance with AS 2159 (Geotechnical engineer to confirm)
External elements	Exposure classification B1 to AS 5100

Crack Control

The degree of crack control to be provided in concrete elements will be in accordance with AS 3600.

5.6 Steelwork Corrosion Protection

The corrosion protection system for structural steelwork will be dependent on the location of the steel elements within the basement. Systems will be selected in accordance with AS/NZS 2312 as a minimum specification, and will be painted with a protective paint coating system.

5.7 Fire Resistance Levels for Structural Elements

Fire resistance levels for structural elements shall be determined in accordance with the BCA and fire engineered outcomes.

Concrete covers are to be in accordance with AS 3600 Section 5.

6.0 Structural Certification

A Registered Professional Engineer shall provide structural engineering certification in accordance with the relevant Authority requirements with NPER registration.

Certification for the design and inspection of all structural elements shall be provided at the completion of the project as well as interim staged certifications at agreed milestones during construction of the project as a whole.

7.0 Conclusion

This report has been prepared to inform and accompany the Stage 1B Basement Development Application (SSD 6960). It describes the structural scheme and summarises the structural design criteria at the time of the Development Application.

Our conclusion is that the project presented in the proposed 1B Basement Development Application can be designed and constructed utilising proven design and construction techniques and in accordance with the relevant codes and standards.



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