Lend Lease (Millers Point) Pty Limited

Barangaroo Residential Buildings

Structural Engineering Report – Project Application

5 October 2012

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1 Introduction

This report supports a Project Application (MP11_0002) submitted to the Minister for Planning pursuant to Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act). The Application seeks approval for construction of two residential flat buildings (known as Buildings R8 and R9) 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 R8 and R9 Project Application seeks approval for the construction and use of two residential flat buildings comprising 161 apartments, ground floor retail, allocation of car parking spaces from the Bulk Excavation and basement Car Parking Project Application, and the construction of the surrounding ancillary temporary public domain and landscaping.

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 Headland Park, Barangaroo Central and Barangaroo South.

The R8 and R9 Project Application Site area is located within Barangaroo South.

1.3 Purpose of this Report

This report has been prepared to accompany the Project Application for the Residential R8 and R9 Buildings and associated works at Barangaroo South. It addresses the relevant Director-General Requirements for the project.

These Director-General Requirements 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 Project Application (MP10_0227) and to the Geotechnical Report prepared by Arup “Barangaroo South – R8 and R9 Residential Buildings Geotechnical Report – Project Application” dated 2 October 2012. Each report is a desktop study 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 comprising deep cored boreholes have been undertaken to provide specific foundation data for the foundation design and construction of Buildings R8 and R9 and the basement supporting these buildings.

1.5 General Ground Conditions

The Sydney Geological Map scale 1:100,000[1] and the Sydney Geological Map Scale 1:250,000[2] indicate that the site is underlain by the Hawkesbury Sandstone of the Wianamatta Group, which is overlain by Quaternary sediments and manmade fill.

A general description constitutes reclaimed land from the original shoreline approximating the Hickson Road alignment to the existing sea wall, comprising general fill overlying alluvial sediments overlying sandstone increasing in strength with depth. The depth to alluvium from existing surface level trending away from Hickson Road and the top of sandstone varies from 13m to 25m below ground under Buildings R8 and R9.

1.6 Groundwater

Groundwater across the site is heavily influenced by tidal fluctuations of the adjacent Darling Harbour, with daily tidal ranges of typically 0.5m to 1.5m AHD indicating that much of the site is subject to seawater flushing. Sydney Ports gives values for maximum high tide (Spring Tide) of 1.6m AHD, and minimum high tide (Neap Tide) of 1.3m AHD.

2 The Structural Scheme

2.1 General Description of Buildings R8 and R9

Building R9

The residential building R9 is a nine storey building with plant rooms at roof level. The structure of the building consists of a reinforced and post tensioned concrete frame laterally supported by lift and stair cores built over a basement which is constructed prior to Building R9. The vertical structure supporting Building R9 consists of reinforced concrete columns and reinforced concrete walls.

The residential component of the building is supported off a post tensioned concrete transfer structure transferring vertical loads to the basement and retail structural columns.

All foundations supporting building R9 are deep piled foundations to rock.

Building R8

The residential building R8 is a nine to eleven storey building with residential floors from level 1. The structure of the building consists of reinforced concrete and post-tensioned concrete floors laterally supported by lift and stair cores built over a basement constructed prior to the construction of building R8.

The vertical structure supporting the building is a combination of reinforced concrete columns, reinforced walls and fire rated steel columns.

The residential component of the building is supported off a post-tensioned concrete transfer structure transferring vertical loads to the retail structural columns and the basement columns under the podium.

2.2 Substructure

2.2.1 Foundations

Due to the depth of the rock founding strata in relation to the lowest basement level, bored piles are currently proposed for the foundations of the basement and buildings R8 and R9. It is intended that the piles are founded within the sandstone providing bearing, with shaft adhesion generated through the rock above toe level also utilised.

The piled foundation will be installed as part of the basement construction. The pile capacities will be capable of supporting the basement and the building superstructure of buildings R8 and R9.

2.2.2 Vertical Structure

The vertical structure through the basement will typically consist primarily of reinforced concrete columns and shear walls utilising medium and high strength concrete.

In some locations for building R8 the columns will consist of fabricated steel sections with appropriate fire rating to 90 min rating.

The structural design of the basement columns and walls will be coordinated with the reactions from the superstructure of Buildings R8 and R9 so as to ensure compliance with the relevant BCA and Code requirements for structural design.

2.2.3 The Basement and Ground Level

This structure is subject to a previous Project Application that has been designed and constructed to support the superstructure reactions for Buildings R8 and R9.

2.3 Superstructure

2.3.1 Vertical Structure

The vertical structure through the tower will typically consist primarily of reinforced concrete columns and shear walls utilising medium and high strength concrete.

Fire rated steel columns are proposed to support the northern end of building R8.

2.3.2 Transfer Level 1

The transfer structure at Level 1 is a deep post-tensioned beamed and slab structure transferring loads to suit the retail and basement column and wall arrangement.

2.3.3 Typical Floors

Typical floors will be of flat post-tensioned concrete slab construction.

2.3.4 Plant Levels

Plant levels will be of flat reinforced concrete and slab construction.

2.3.5 Fire Stairs

Fire stairs will be of reinforced concrete or structural steel construction with appropriate fire separation from the occupied spaces.

2.4 Stability

Robustness, wind, and seismic loading will be applied in accordance with the relevant sections of AS/NZS1170 and AS1170 Parts 0, 2 and 4, with additional wind load data based on the results of wind tunnel testing.

Structural stability will be provided by an arrangement of reinforced concrete shear walls. The stability system may be supplemented by outriggers, belt trusses or steel bracing at plant or other selected locations.

2.5 Green Star Initiatives

It is intended that Green Star initiatives relating to structure for Buildings R8 and R9 include the following where appropriate:

- Use of cement replacement and/or recycled aggregate for concrete; and
- Use of steel with recycled content.

3 Design Standards and Sources of Reference

3.1 General

The design and documentation of the building 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

Building C5 is classified as follows in accordance with Part B1 of the BCA.

Table 1: BCA Classification

BCA Table	Classification
AS1170.0-2002 Table 3.1 Importance Level of Building	2 – Apartments less than 15 storeys high
Table B1.2b – Design Events for Safety Wind Earthquake	Annual probability of Exceedance 1:500 1:500

3.3 Codes and Standards

The following codes and standards will form the basis for the structural 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 Code – Design Methods
AS 2121	Cold Formed Steel Structures Code
AS 2159	Piling code
AS/NZS 2312	Guide to the protection of structural steel against atmospheric corrosion

AS 2327.1	Composite structures – Simply supported beams
AS 3600	Concrete Structures Code
AS 3700	Masonry Code
AS 3735	Concrete Structures for Retaining Liquids
AS 4100	Steel Structures Code
AS 5100.6	Bridge design – Steel and composite construction
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
Eurocode 4	Design of composite steel and concrete structures
BCA	Building Code of Australia

4 Loads

4.1 Self Weight

Structural self weights are to be calculated on the basis of the following densities:

Reinforced concrete: 24.5 kN/m^3

Steel: 78.5 kN/m^3

4.2 Superimposed Dead Loads and Live Loads

Table 2: Design Loads

Area	Superimposed Dead Load	Live Load
Residential (General)	1.0 kPa moveable furnitures 0.5 kPa ceiling & services	1.5 kPa
Lift Lobbies / Vertical Villages	1.5 kPa finishes 0.5 kPa ceiling & services	4.0 kPa
Toilets	1.0 kPa finishes 2.0 kPa partitions 0.5 kPa ceilings & services	2.0 kPa
Foyer	2.0 kPa finishes 0.25 kPa ceiling & services	5.0 kPa 15 kPa temp. for construction staging
Residential Terraces (including trafficable roofs)	1 kPa finishes 0.5 kPa celing & services	2 kPa
Stairs and landings	1.5 kPa finishes 0.5 kPa balustrades	4.0 kPa
Plant Areas	3.5 kPa partitions & plinths 0.5 kPa ceiling & services	As calculated for relevant use: 5.0 kPa minimum.
Non-trafficable concrete roofs	2.5 kPa finishes 0.25 kPa ceiling & services	2.0 kPa BMU loads as provided by supplier
Lightweight roofs	As calculated	Generally 0.25 kPa Street awnings 1.0 kPa

Superimposed dead loads include floor finishes, ceiling, services, and partitions.

4.3 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 Part 2:

Region A2

Basic wind speeds:

Ultimate – V_{100} = 46 m/s

Serviceability – V_{20} = 37 m/s

4.4 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 (P) = 1:500

4.5 Earth Pressure Loading

Buildings R8 and R9 sit within a site-wide basement envelope. Shear walls provided within 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 interpretive geotechnical report which is being completed as part of design development.

4.6 Balustrade Loadings

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

4.7 Blast Forces

The building will not be designed for blast forces of any kind.

5 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 4100 and as specified below are appropriate for this building:

Table 3: Deflection Limits

Type of member	**Deflection to be considered**	**Deflection limitation (ΔL_{ef}) for spans**	**Deflection limitation (ΔL_{ef}) for cantilevers**
Beams and slabs	The total vertical deflection	1/250	1/125
Members supporting masonry partitions	The deflection which occurs after the addition or attachment of the partitions	1/500 where provision is made to minimise the effect of movement, otherwise 1/1000	1/250 where provision is made to minimise the effect of movement, otherwise 1/500
Storey drift under wind	H/500	-	-
Overall sway under wind/earthquake	H/500	-	-
Differential settlement between foundations	L/1000	-	-

5.3 Concrete

5.3.1 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.

Structural requirements for certain elements may increase concrete strengths above the minimum required for durability.

5.3.2 Crack Control

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

5.4 Steelwork Corrosion Protection

The corrosion protection system for structural steelwork will be dependent on the location of the steel elements within the building. Systems will be selected in accordance with AS/NZS 2312 as a minimum specification.

5.5 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 Conclusion

This report has been prepared to inform and accompany the R8 and R9 Residential Building Project Application. It describes the structural scheme and summarises the structural design criteria at the time of the Project Application.

Our conclusion is that the project presented in the proposed Residential Building Project Application can be designed and constructed utilising proven design and construction techniques.

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