Structural
Civil
Traffic
Façade

Liverpool Health and Academic Precinct

State Significant Development – Structural Statement

Prepared for Health Infrastructure

03 March 2020

181052

Rev 05

Taylor Thomson Whitting (NSW) Pty Ltd (ABN 81 113 578 377)
as trustee for the Taylor Thomson Whitting NSW Trust
(ABN 59 514 956 558) I Consulting Engineers
Level 3, 48 Chandos Street, St Leonards NSW 2065

Your Partner in Engineering

Table of Context

1 Background

Liverpool Hospital is located within the Liverpool Central Business District (CBD), on the corner of Elizabeth Street and Goulburn Street, Liverpool. The Hospital includes land east and west of the Main Southern Railway, which forms an eastern and western campus. The proposed works are located in the western portion of the western hospital campus. The site is legally described as Lot 501 in DP1165217.

The application seeks consent for the construction and operation of a new multi-storey Integrated Services Building providing new treatment and support services that will integrated with the existing hospital. The works also include the refurbishment of certain existing hospital facilities. For a detailed project description refer to the EIS prepared by Ethos Urban.

Stage 1 would involve the demolition of the existing Education Building back to the interface of the existing Old CSB and construction of a new basement and 4 storey building. This building is planned to accommodate Education, Retail, Health, Birthing and Pathology.

Stage 2 would involve demolition of the existing Oncology, Pathology and Alex Grimson Buildings for the construction of a new basement and 7 storey building. This building is planned to accommodate Cancer Clinics, Retail, Heamatology, General Clinics, Women's Ambulatory Care, Paediatrics Consultants & New IPU's for Oncology, Haematology, Postnatal, Antenatal, Paediatric & Palliative Care.

Construction will occur with a new building on the current Education Building site (Goulburn Street Frontage) as Stage 1, followed by a new building on the current pathology, oncology and Alex Grimson site as Stage 2 and refurbishment works as Stage 3.

The staging of the works has been planned to minimise disruption to the site, with key constraints being the location of the main substations on the Alex Grimson building, and the majority of the hospital being serviced through the current services tunnel that runs from the central energy plant on the Eastern Campus. Proposed Stage 1 and 2 works will require new services to be installed, prior to the removal of Alex Grimson and the services tunnel.

New structures are likely to be reinforced concrete framed buildings with post-tensioned slabs. In order to reduce weight where constructing over the existing bunkers, steel framed and prefabricated options will be investigated.

In order to keep the existing bunker facilities operating during the construction of Stages 1 and 2, it is proposed to construct the new structure over the bunkers using steel trusses to span the current bunkers, as the current pier footings for the bunkers do not have excess capacity. This new truss structure can be incorporated into the planning of future buildings.

Options were assessed to move the bunkers, with cost and disruption to operations being the reasons for the decision to keep the bunkers in their current location. Structurally it is feasible to either construct over the bunkers, or to relocate them. Radiation shielding was assessed by a specialist consultant, we note that concrete roof slabs up to 2m thick are in place, which will provide a significant level of shielding, that is similar to the shielding provided by the wall construction. Additional shielding where required, can be installed on top of the existing slab.

1.1 The Site

Liverpool Hospital is located within the Liverpool Central Business District (CBD), on the corner of Elizabeth Street and Goulburn Street, Liverpool. The Hospital includes land east and west of the Main Southern Railway, which forms an eastern and western campus. The proposed works are located in the western portion of the western hospital campus. The site is legally described as Lot 501 in DP1165217.

Figure 1. Site Plan.

1.2 Existing Buildings

The Liverpool Hospital site has been continually developed and modified for more than 100 years.

The majority of buildings on the site have been developed since the 1980's.

Major developments include –

Building – Western Campus	**Approximate Year of Development**
New Clinical Services Block	2011
Old Clinical Services Block /Education	1993
Alex Grimson	1978
Caroline Chisholm	1992
Cancer Therapy	1993
Pathology	1992
Don Everett	1994
Brain Injury	1992
P2 Carpark	1993
Mental Health	2004
Ron Dunbier House	1980's (assumed)

Building Eastern Campus	**Approximate Year of Development**
Multi Deck Staff Carpark	2010
Central Energy	1993
Ngara Health	2013
Computer Centre - ISD	2004
Misc Older Buildings	Pre 1990

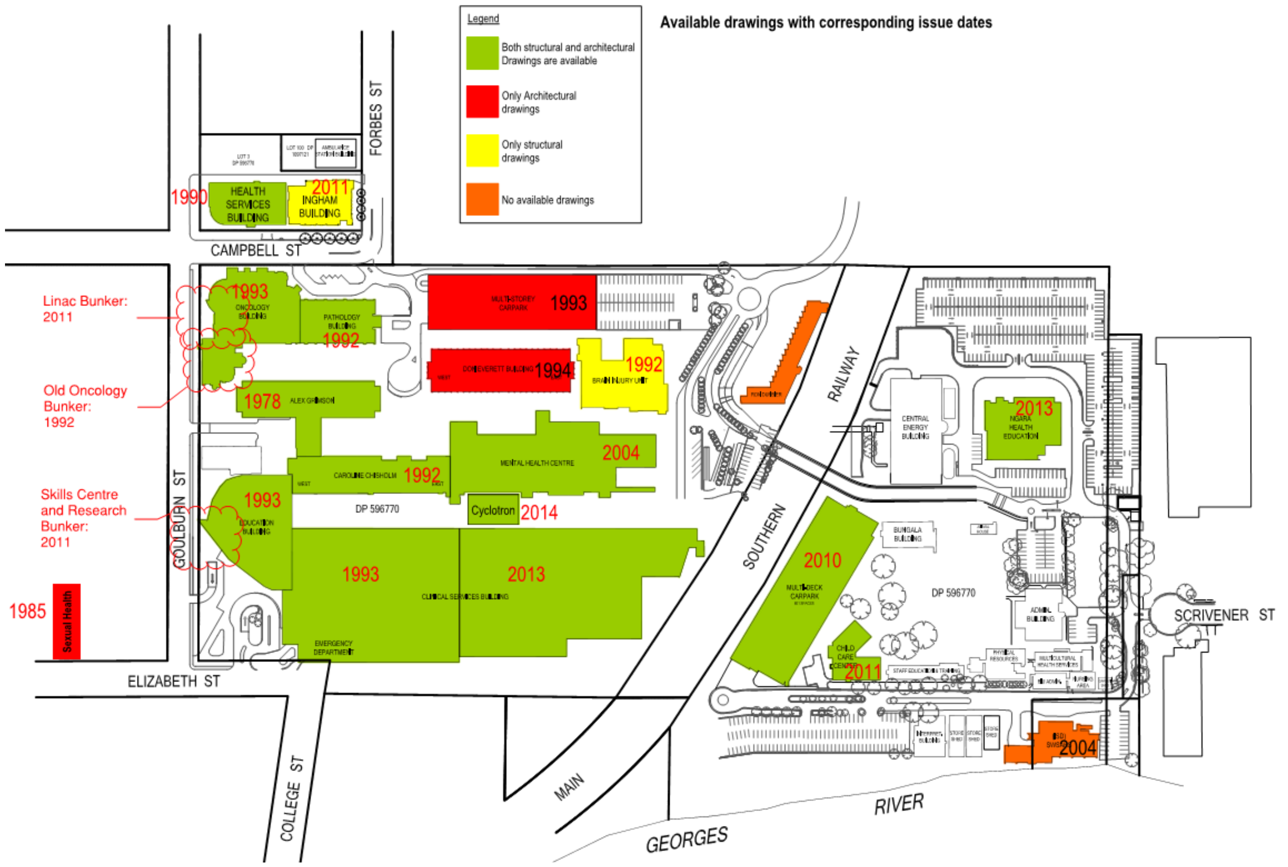

Figure 2 shows the general building layout and age

Building structures are typically reinforced concrete framed buildings, founded on piers or piles on bedrock.

The new CSB is a post-tensioned floor slab system, with reinforced concrete columns and shear walls.

The current P2 carpark is steel framed with a precast concrete slab structure.

In general, the building structures appear in reasonable condition considering their relative ages.

1.3 Site Constraints

The major constraints identified include –

Main Southern Railway

- The main Southern Railway line divides the site to create the East and Western Campuses. It is a major part of the Sydney Trains Network, and any redevelopment within 25m of the train lines will require consultation and potential approval of Sydney Trains, and specific design for train derailment loadings.

Current Services Tunnel

- The current service tunnel is a concrete structure with precast elements, that allows services from the Central Energy Building (CEB) on the Eastern Campus to run beneath the railway line and connect to the Western Campus, ending at the Alex Grimson building. A walk through of the tunnel indicated it is in good condition, with no structural issues noted.

Constrained Site – Western Campus

- The site on the Western Campus is effectively fully built on the west side. In order to construct new buildings with appropriate clinical linkages, the Concept Design has been developed incorporating a decanting and staging strategy.

Eastern Campus

- While the Eastern Campus is relatively lightly developed, the railway line provides a barrier to integration with the main clinical buildings.

- Flood levels due to the Georges River will also have a greater impact on the Eastern Campus, with any new clinical buildings to be located above the PMF for habitable areas.

2 Geotechnical Conditions

Geotechnical investigations have been carried out over a number of years for the overall site. A recent geotechnical assessment has been carried out by JK Geotechnics (ref: 32837Arpt dated 17 February 2020). This included additional investigation works and desktop review of 6 previous reports dating back to 1991.

2.1 Western Campus

The ground conditions generally comprise fill overlying alluvial soils over the majority of the site, with fill overlying residual soils in the NW corner, then siltstone at variable depths.

Fill comprises variably compacted clay and sand to a maximum depth of 3.5m. Alluvial soils are predominantly silty clays, of medium to high plasticity. Rock levels are higher in the NW corner, varying from 2m to 13m depth over the site.

Building foundations are likely to be piers founded on medium / high strength bedrock for all new multi-storey structures.

2.1.1 Proposed ISB

The proposed ISB building is located on the western side of the site and is expected to be founded on piers in the Class II/I siltstone. Due to the dipping nature of the rock towards the east, it is anticipated piers will be of the order of 6-8m long.

3 Concept Design

The complex nature of construction on the site has resulted in the project being split into a number of stages.

The project is proposed to be split into the following works packages as summarised below.

Works Package	Scope
Main Works Stage 1 & Stage 2 New Build	New Build (including interface linkages between the existing Clinical Services Building, Caroline Chisolm and construction over the existing radiation oncology bunkers): Stage 1: • Decant Engineering, Education, Kitchen and Mortuary into the refurbed CSB and temporary Education Building. • Temporary public connections to CSB. • Demolish existing main entrance and Education building back to the interface with the Old CSB. • Stage 1 ISB construction and handover. • Decant to new Stage 1 ISB. Stage 2: • Demolish Pathology, Oncology and Alex Grimson. • Stage 2 ISB Construction & New Forbes Street Entrance. • Decant to new Stage 1 ISB and complete temporary facilities.
Main Works Stage 3 Refurbishment Works	Refurbishment - Emergency Department, Operating Theatres and ICU.

Figure 3 – Stage 1 & 2 Main Works

3.1 Stage 1-Main Build

The Stage 1 Main Build works will begin the construction of the new Integrated Services Building (ISB). It is understood that a temporary new entry / drop off will be located at the north east corner of the New CSB during the main construction works. Subsequently demolition of the existing main entrance & Education building can occur to create the construction zone for Stage 1.

3.1.1 Stage 1 - Main Build

Key issues include –

- Development of temporary main access to the building to replace the main entry.
- Construction of new building at the current main entry will require maintenance of or relocation of existing plant/services area below in the basement. Column locations to suit potential foundations coordinated during schematic design. Potential structural options will include post tensioned slabs and concrete frame, similar to the adjacent Old CSB to facilitate interface of the new structure with the existing.
- Defining the demolition cut line between Education Building and the Old CSB needs to be assessed to provide an optimum solution for both the demolition and construction stages.

- There is a small zone of structure between CSB and Caroline Chisholm which is to be maintained facilitate existing Services and access during Stage 1. Lateral stability of this remaining zone will require review and assessment.

- Works adjacent to ED will require staging consideration.

- Construction of stage 1 of ISB will accommodate new plant/ substations, to enable demolition of the Alex Grimson building in Stage 2.

3.2 Stage 2 – Main Build

Initial works will require the co-ordination and reticulation of existing plant/services between the Oncology and Alex Grimson buildings.

The current ground levels and basement of Alex Grimson will reduce required excavation for this zone of the Stage 2 works, as the new levels will be integrated with the new works.

Key issues include -

- Existing services in the new drop-off area to be confirmed, and potentially relocated.

- Existing link bridge to pathology to remain until the existing services are replaced for Oncology and the bunkers.

- New entry / drop off from Forbes Street to be excavated to create plant area and ramp below. Coordination with landscape requirements will be required.

- Construction over the bunkers will be required while operations are to be maintained.

- The building structure will be required to bridge over the Existing Bunker building with piles to be installed in the zone between existing building and the western boundary. The position of existing services adjacent to this zone will need to be accurately positioned and surveyed in co-ordination with facilitating installation of the piles supporting the new building structural over. Relocation of an existing stormwater line will be required.

- Refurbishment of Caroline Chisholm will occur following the relocation of Women's and Children services to the new ISB.

- Demolition of the existing carpark could occur as part of this stage.

- The link bridge for to the Ingham building is proposed to connect through the existing lobby. Modifications will be required to the existing glazing support steelwork.

3.2.1 Construction over the Bunkers

Options have been reviewed to retain the existing bunkers or relocate them to part of the new build works. The team has agreed to retain the bunkers in the current location, requiring construction to occur over them for Stage 2 buildings.

Existing structural drawings of the bunkers have been reviewed. Roof structures consist of concrete depths between 300mm – 2000mm for shielding requirements. These depths will allow for overhead protection loadings (10kPa) as live loads during construction. Radiation shielding is being assessed by a specialist consultant, but we note that concrete roof slabs will provide a significant level of shielding, that is similar to the shielding provided by the wall construction. Where additional shielding is required, it can be installed on top of the existing slab.

The foundations for the bunkers are piled, however, the weight of the bunkers fully utilises the foundation capacity, meaning new structures will need to span over them.

Bored piers may be constructed adjacent to the existing bunkers, and the current proposal is to construct a steel trussed deck at Level 2, to form at construction deck.

Spans of approximately 25m will be required.

3.3 Stage 3 – Refurbishment Works

Refurbishment works including completion of ED, theatre and ICU extensions and Medical Imaging will occur.

Structural reviews have confirmed proposed loadings for these works are feasible.

In the current MAU, ICU pendants exist which may be reused.

Support framing will be required in the ceiling zone for bariatric patient lifters a required. This will comprise angle frames bolted to the concrete slab over.

No change to the structure is proposed for the Caroline Chisolm building, and less critical administration will be housed there.

4 Stage 1 & 2 - Main Building Typical Construction

4.1 Suspended Slab Options

An 8.4 x 8.4m column grid has been adopted to provide flexibility to floor layouts. A post tensioned structural system has been proposed. This is a combination of Post- tensioned banded slab with a post tensioned flat plate for the internal spans.

Option 1 - Post Tensioned Concrete Banded Slab

The post-tensioned banded slab will consist typically of 2200 wide band beams which are 400 deep with slabs 240 deep for the typical floors (inclusive of 40mm topping). The bands would run on grid, primarily in the north-south direction.

Option 2 – Post Tensioned flat plate

With its flat soffit, this option has the advantage of the simplest formwork of the options considered. The flat soffit also has advantages for services reticulation by minimising obstructions. The disadvantages of this system include the requirement for a significantly thicker slab. The flat plate option is also post-tensioned in both orthogonal directions.

This option will require studrails or equivalent at every column to maintain the slab integrity in punching shear.

The vertical penetration arrangement for interior columns and a zone for future penetrations will also been checked for the flat plate slab option. Refer to sketch below for the penetration arrangement at internal columns.

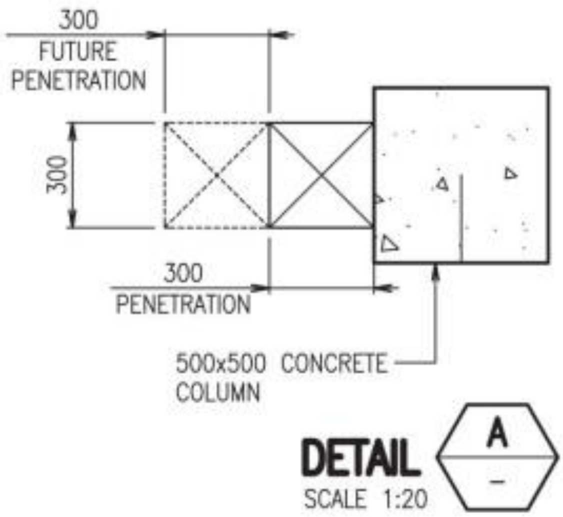

Figure 2: Typical penetration arrangement adjacent to columns and zone for future penetrations (DGN 01)

4.2 Slab on Ground

The Basement level slab will be constructed partially on grade with a free draining subbase and zones of suspended slabs subject to the location.

4.3 Roof Structure

The building is to be designed typically with a post-tensioned concrete roof. The upper roof structure will house various plant equipment which is to be contained within steel framed enclosures.

Roof slabs to Level will contain falls to drains and overflows.

4.4 Foundations

Foundations below columns at basement level are to be piles into the rock.

Piles located under the lift cores and stair wells will be tied together with a base to transfer loads from columns through to piles. Piles are socketed into the siltstone with larger socket lengths for piles in tension. The Geotechnical Investigation conducted by JK Geotechnics notes an allowable end bearing pressure of 3500kPa for piles in the Class II/I siltstone.

4.5 Vertical Structure and Stability

Floor to floor height in the new build will typically vary between 5m (in the basement) to 4.5m (for the typical upper floors).

Transfer structures will be minimised by the use of a simple grid. The new buildings will have stair and lift cores and shear walls. The cores may require extension to include the large service risers adjacent. These cores and shear walls will provide the primary stability to the building against lateral loads. Additional concrete shear walls will be added in the basement, where required, to assist the building with resisting lateral load.

4.6 Vibration

The vibration criteria being adopted will be similar to that being used in the design of other major NSW public hospitals (as per Design Guidance Note 1 Rev A). New building areas which are required to support operating theatres and other sensitive areas such as medical imaging equipment are to comply with RF1 (Response Factor 1). This is a British Standards term that relates to a multiplying factor of 1 on the vibration base curve in AS 2670.2-1990 and ISO 10137-2007.
Other areas of the building not containing medical imaging equipment or Intensive Care Units are to be designed for RF2 (Response Factor 2).

4.7 Fire strategy

The fire protection strategy is being developed in coordination with the BCA consultant, architect and fire engineer. A number of options utilise a combination of fire walls, drenching sprinklers and design of structural members to comply with the required FRL of 120/120/120.

5 Safety in Design

Safety in design reviews on all aspects of the structure will be undertaken using a structural risks and solutions register. This will be completed at the following millstones during the Hospital project:

- Prior to structural trade packages for tender
- Prior to issue of structural drawings for Construction

6 Design Parameters

6.1 Loads

In general, all loads and load combinations shall comply with AS/NZS 1170 Parts 0 to 4 structural Design Actions. Live load reductions will be applied as permitted by AS/NZS 1170.1. Generally, the design loads are:

6.1.1 Permanent Actions – Dead Loads

Dead load shall be considered as the self-weight of the structure plus an allowance for services, toppings, walls and ceilings which vary significantly throughout the site.
The additional dead loads should not be less than the following:

Area	Services, ceilings, partitions etc.
Hospital floors and office areas	1.8 kPa (excludes 40mm sacrificial topping)
Car Park Areas	0.5 kPa
Concrete roof areas	4.9 kPa (Includes 70mm ave falls +60mm pebbles+ services under)
courtyards	2.8 kPa (Includes 70mm ave falls + services under)

No façade or masonry wall loading is included in the above loads. We will allow for a façade loading of 1 kPa which equates to approximately 5 kN/m depending on the floor to floor heights. This will need to be confirmed once the façade type and extent is developed.

It is assumed that all internal partitions will be of lightweight stud construction and specific allowance will be made for masonry partitions if required. In particular, masonry walls will most likely be required around services risers and additional band beams will be required around the major risers.

6.1.2 Imposed Actions – Live Loads

Area	Uniformly Distributed Actions	Concentrated Actions
General Hospital Floors	3.0 kPa	2.7 kN
Theatres / X-Ray Rooms / Laboratories	3.0 kPa	4.5 kN
Stair and Corridors	4.0 kPa	4.5 kN
Office Areas	3.0 kPa	2.7 kN
Car Parking	2.5 kPa	13 kN
Ambulance Parking	15 kPa	-
Plant and Utility Areas	Plant loads or 5.0 kPa (minimum)	4.5 kN (minimum)
General Store Rooms	2.4 kPa for each metre of storage height (max 2.1m)	7.0 kN
Compactus	4.0 kPa for each metre of storage height. Locations to be confirmed	To be calculated
Trafficable Roof/ Courtyard	4 kPa	1.8 kN
Non-trafficable Concrete Roof	1.5 kPa	1.4 kN

Pattern loading will be considered when determining worst case scenarios for strength and serviceability where required by AS1170. Live load reductions will be considered for columns, walls and footing design in accordance with AS1170.1. No live load reductions are to be applied to any floor system elements.

Loads in plant areas are to be confirmed by services engineers once layouts are known. Higher loading will be required for large pieces of plant or tanks.

6.1.3 Wind Loads

Wind loads are in accordance with AS1170.2 and based on the following parameters:

New Hospital:

Region:	A2
Importance Level (BCA Table B1.2a):	4
Annual probability of exceeding (BCA Table B1.2b):	1:2000 (ultimate)
	1:25 (serviceability)
Regional Wind Speed: Ultimate limit states -	V_{2000} = 48 m/s
Serviceability limit states -	V_{25} = 37 m/s
Terrain Category (all directions):	3

6.1.4 Earthquake Loads

Earthquake loadings shall be in accordance with AS1170.4 – 2007 (Earthquake actions in Australia) and AS/NZS1170.0 – 2002.

Hazard Factor (Z):	0.1

Site Sub-Soil Class:	Ce (Shallow Soil)
Importance Level (BCA Table B1.2a):	4
Annual probability of exceeding	1:1500
(BCA Table B1.2b):	
Earthquake Design Category:	III

6.1.5 Barriers

Barriers including parapets, balustrades and railings are to be designed in accordance with Table 3.3 of AS/NZS 1170.1.

6.2 Serviceability

6.2.1 Deflection Limits

Deflection limits for the concrete structures are generally as follows;

	Maximum floor deflection			
	Dead	**Incremental**	**Live**	**DL + LL**
Floors supporting masonry walls	Span/360	Span/1000[1]	Span/500	Span/300 (25mm max)
Compactus areas	N/A	Span/750[2]	N/A	25mm max
Other floor areas	Span/360 (20mm max)	N/A	Span/500	Span/300 (25mm max)

1. Areas supporting normal weight masonry partitions.
2. Incremental deflection after compactus installed.

Note: For transfer structure the floor total long term deflection is to be limited to 10mm maximum.

6.2.2 Durability

For concrete elements this will be achieved by specifying all elements in accordance with section 4 of AS 3600 which sets out requirements for plain, reinforced and post tensioned concrete structures and members with a design life of 40 to 60 years. Exposure classifications are as follows;

Exposure Classification	**Elements**
A2	Internal
B1	External
A2 – To be confirmed by Geotechnical Engineer	In Ground

Protective coatings to structural steel elements shall comply with AS/NZS 2312 and ISO 2063 for the long-term protection category.

6.2.3 Occupant Perception of Motion

As outlined in section 3.6, the new building will be designed to an RF2 response factor where there are no operating theatres and other sensitive areas.
Areas that contain sensitive imaging equipment or pendants which require a greater restriction on vibrations experienced by the occupants will be designed for an RF1 response factor.

6.2.4 Fire Resistance Levels

The BCA type of construction required for this building will be type A. Fire Resistance Levels (FRL) for the structural elements will need to be in accordance with Specification C1.1 of the BCA. Typically, the FRL (minutes) for concrete structural elements is 120/120/120.

6.2.5 Design Standards

The structural design will be in accordance with the latest revision of all relevant Australian Design Standards, the Building Code of Australia and other statutory requirements. As a minimum requirement, the design shall be based on, but not limited to;

Number	Edition	Title
AS/NZS 1170.0	2002	Structural design actions Part 0: General Principles
AS/NZS 1170.1	2002	Structural design actions Part 1: Permanent, imposed and other actions
AS/NZS 1170.2	2011	Structural design actions Part 2: Wind Actions
AS 1170.4	2007	Structural design actions Part 4: Earthquake loads
AS 2159	2009	Piling – Design and installation
AS 3600	2018	Concrete Structures
AS 3700	2001	Masonry Structures
AS 4100	1998	Steel Structures
HI Design Guidance Note 1	Rev A 22 Oct 2012	Structural Design Criteria Guidelines
HI Design Guidance Note 24	Rev B 30 May 2018	Building Importance Levels for NSW Health Projects

7 Certification

Design certification will be issued on completion of the detailed design and documentation.

A Site Inspection Certificate will be issued after construction.

Prepared by:
TAYLOR THOMSON WHITTING (NSW) PTY LTD
in its capacity as trustee for the
TAYLOR THOMSON WHITTING NSW TRUST

MARK SHERLOCK
Senior Engineer

Authorised by:
TAYLOR THOMSON WHITTING (NSW) PTY LTD
in its capacity as trustee for the
TAYLOR THOMSON WHITTING NSW TRUST

ROBERT MACKELLAR
Managing Director