New Western Sydney University Bankstown City Campus

Structural Design Report

Revision: 4

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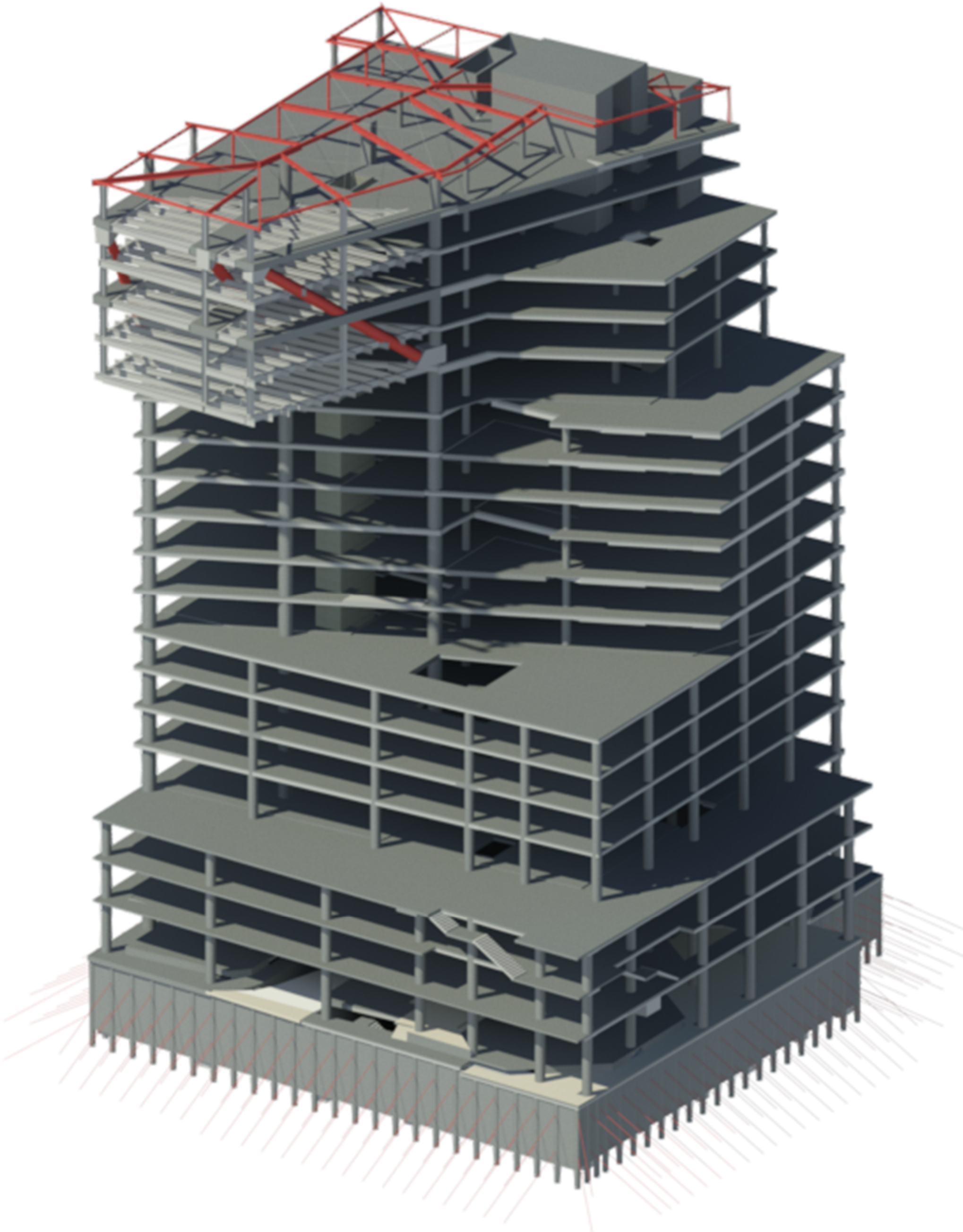
Project No.:	10979	***Issued For:***	Detailed Design
Date:	23 August 2019		



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Report Amendment Register

Rev. No.	Section & Page No.	Issue/Amendment	Author/ Initials		Reviewer/ Initials		Date
1		Schematuc Design - Client Review	Vivien Chen	VC	Ruba Georges	RG	12/03/2019
2		Detailed Design - SEAR	Vivien Chen	VC	Ruba Georges	RG	21/06/2019
3		Detailed Design	Vivien Chen	VC	Ruba Georges	RG	19/07/2019
4		Detailed Design	Vivien Chen	VC	Ruba Georges	RG	23/08/2019

FINAL DRAFT ACCEPTED BY: AUTHOR: REVIEWER:

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1.0 SUMMARY

Bonacci Group NSW Pty Ltd has been appointed as the structural design consultant for the new Western Sydney University (WSU) Bankstown City Campus (BCC) project at 74 Rickard Road along with a portion of 375 Chapel Road, Bankstown. This project is a proposed new development which will host up to 2000 students on any one day across am and pm when built by 2021.

The total site area is approximately 3678 square metres. The 83 m high tower has 19 stories including ground floor together with 2-story of under ground carpark, and also a 22 m cantilever from level 14 up. The building consists of a foundation system of pad-footings sitting on rock and a 600mm dia soldier pile shoring system. The core located at the mid-eastern side of the building, consists of 8 lift cores and two stair cores that is joined together by header beams. The floor plates are prestressed concrete one-way slabs and band beams except for the cantilevered slab on levels 14-18 which consists of composite slabs supported by steel beams and inclined concrete-filled-steel-tube (CFST) columns jointing with prestressed tie beams and diaphragms in the slab system on levels 14,16 & 18.

The roof structure will be a light-weight non-trafficable steel roof.

The construction of this building will be conventional except for the cantilevered section. The construction methodology and sequence for the cantilevered section is detailed in section 13 of this report.

An Early Works Development Application will be submitted to Canterbury Bankstown Council for site preparation works including bulk excavation, shoring and temporary wall anchors.

2.0 SCOPE

The scope of this report is to summarise the following analysis and design aspects:

Analysis:

1. Outline building mathematical model with relevant assumptions, simplifications, adjustments, and factors as required;
2. Generate summaries of the analysis outputs, structural behavior and performances;
3. Building redundancy and disproportional collapse.

Design:

1. Foundations such as pad footings, spring stiffness, long term deformations, etc – subject to Early Works DA;
2. Shoring wall design and temporary wall anchors – subject to Early Works DA;
3. Structural steel and composite structures:

- Steel & CFST columns;
- Steel & Composite Beams;
- Steel to Steel Connections;
- Steel to Concrete Connections;
- Fire Protection (by others).

4. Concrete Structures:
    - Concrete Columns;
    - Concrete Walls in terms of compression, tension, flexure, shear, and header beams;
    - PT slab design;
    - Stairs.
5. Composite slabs.
6. Tie floor design as separate from composite or PT slab design.
7. Transfer Structures as separate from material categories.

3.0 REFERENCE DOCUMENTS

The following Australian Standards have been used in the detail design phase:

AS 1170.0-2002 Structural design actions Part 0: General principles

AS 1170.1-2002 Structural design actions Part 1: Permanent, imposed and other actions

AS 1170.2-2011 Structural design actions Part 2: Wind actions

AS 1170.4-2007 Structural design actions Part 4: Earthquake actions in Australia

AS 3600-2018 Concrete structures

AS 4100-1998 Steel Structures

AS 2327.1-2017 Composite structures

Consultant Reports

Geotechnical report: 86462.00.R.002.Rev0 Geotechnical Investigation August 2018 by Douglas Partners

4.0 LOADING

The structural design loads used for the design of the building are in accordance with AS/NZS 1170 Part 1, "Structural Design Action: Permanent, Imposed and Other Actions".

The building is designed to importance level 3 in accordance with the BCA.

4.1. Superimposed Dead (SDL) and Live Loads (LL):

Basement Car Park SDL 0.5 kPa LL 2.5 kPa

Ground (general) SDL 2.0 kPa LL 4.0 kPa

Retail SDL 3.0 kPa LL 5.0 kPa

Lift Lobby SDL 2 kPa LL 4 kPa

Truck Access SDL 0.5 kPa LL 15 kPa

Multi-purpos Space SDL 5.0 kPa LL 5.0 kPa

Commercial SDL 1.5 kPa LL 3.0 kPa

Terrace (with deep planter) SDL 18.3 kPa LL 2.5 kPa

Terrace General SDL 2.5 kPa LL 4 kPa

Plant SDL 5.0 kPa LL 7.5 kPa

Substation SDL 5 kPa LL 10 kPa

Roof SDL 2.0 kPa LL 0.25 kPa

Roof Access Platform LL 2.5 kPa

Façade General SDL 3 kN/m

Green Edge SDL 10 kPa

4.2. Seismic:

To Australian code AS 1170.4-2007:

μ= 1.0

Sp=0.77

kt=0.05

kp=1.3

Z=0.08

Subsoil class= Ce

Mass source: G+0.3Q

Earthquake design category Ⅲ

4.3. Wind loads:

To Australian code AS 1170.2-2011:

Region A2

Ultimate V_R=46 m/s

Service V_R=37 m/s

Terrain category 3

4.4. Robustness:

The building is designed with an inherent level of robustness. In accordance with the requirements of AS1170.0-2002, the robustness load is taken as 1.0% of the gravity load (G+ΨcQ). Ψc is taken as 0.4.

5.0 GEOTECHNICAL INVESTIGATION

The site is located in gently undulating terrain where natural surface slopes are estimated to be about 5% towards the south. The surface contours in the area of the site indicate that the site is located within a slight drainage depression into which surface waters from the north and north-east drain.

The subsurface profile is summarised in the geotechnical report as below:

- Filling and residual clays overlying extremely low and very low strength rock to depths between 4.2 m and 6.8 m, below which depth the rock becomes quite variable in strength between test locations, underlain by;
- Generally low to medium strength with significant thicknesses of very low to low and medium to high strength layers then;
- Medium and high to very high strength siltstone and sandstone which extends below depths between 12.2 m and 14.8 m.

Groundwater depths have been measured within the rock from monitoring wells on the site with depths ranging from 7.9 m to 8.9 m (RL 14.9 m to RL 16.4 m).

6.0 PROPOSED DEVELOPMENT

6.1. Foundations

Depending on the depth of the excavation the material exposed at the bulk excavation level is likely to be very low strength shale or better. Typical design bearing capacities for the different rock strengths are summarised in Table 9 in the geotechnical report.

Foundation Stratum	Maximum Allowable Pressure		Maximum Ultimate Pressure	
	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)	End Bearing (kPa)	Shaft Adhesion (Compression) (kPa)
Extremely low strength rock	700	70	2,500	100
Very low to low strength rock	1,500	150	5,000	200
Medium strength rock	3,500	350	20,000	1,000
Medium to high strength rock	8,000	800	100,000	2,500

The foundations for the columns/walls will be pad footings proportioned based on the allowable bearing pressure in this Table.

6.2. Basement Slab

In summary, the geotechnical engineer has confirmed that the long term design water table is near the base of the lowest basement slab. Further they have confirmed that the basement slab does not need to be designed for long term hydrostatic pressures provided that a drainage system is installed under the slab to relieve any hydrostatic pressure buildups.

Therefore, the basement B2 slab has been designed as a slab on grade, however, we would recommend the addition of hydrostatic pressure relief valves or stand pipes at regular centres throughout the slab.

The project Hydraulic Engineer should seek advice from Douglas on likely inflow rates for the design of the sub-soil drainage system.

6.3. Shoring Walls

In combination with the above DP advise, Bonacci have internally reviewed the choice of site retention system.

Previously we were assuming that a secant pile wall would be required to prevent above basement water ingress, however with the DP advice provided secant piles now appear not to be required. We are therefore proposing to alter the retention system to a more cost effective solutions consisting of a drained Ø600 mm soldier pile wall.

Soldier pile walls are quite common in Sydney where major long term hydrostatic pressures are not present. They are probably the most cost effective site retention system used as the number of piles is dramatically reduced in favour of shotcrete infill panels. At each shotcrete panel a vertical strip drain is placed that links to the sub soil drainage system so that in the event of localised hydrostatic pressure buildups behind the wall, the strip drain provides the pressure relief.

It should be noted that soldier pile walls may appear wet due to localised water penetration and it is recommended that a dry wall be placed in front of the soldier pile with an appropriate dish drain at each slab level to collect any water seepage.

The temporarily lateral reatrain to the shoring walls will be provided by two rows of ground anchors. The SWL of ground anchors is specified on the DD shoring elevations.

In addition there is a portion of the shoring wall next to the ramp along the east boundary has no restrain from the slab and they will have to be replaced by the Ø600 mm contiguous piles which can span vertically without any lateral restrain within the span. Please refer shoring elevations for details.

Shoring wall and temporary wall anchors will be included within the Early Works DA and not subject to this SSD.

6.4. PT Slabs

PT slabs will be designed by D & C subcontractors.
Please refer structural detail design drawings for GAs for each level and the schedule on the first page of the drawings for reinforcement and PT rates.

6.5. Cantilevered Slab

The cantilevered slabs from level 14-18 consist of composite slabs supported by steel beams and inclined concrete-filled-steel-tube (CFST) columns jointing with prestressed tie beams and diaphragms in the slab system on levels 14, 16 & 18. Please refer to structural detail design drawings for GA arrangement of floor elements and diagonal struts (CFST) and the schedule on the first page of the drawings for reinforcement and PT rates.

6.6. Roof

The current roof system is light-weight structural steel roof supporting the solar panels. The access platform load has been allowed in the detail design and the support system for the mechanical fans will be added if required.

The design of the BMU track supporting system and the canopies are to be further developped.

7.0 ANALYSIS INPUT PARAMETERS

7.1. Material Properties

Concrete material properties adopted are as per AS 3600-2018.

Reinforcement is 500 MPa N grade as per AS/NZS 4671.

Concrete core walls: 65 MPa

Concrete columns:

B2-L4: 90 MPa

L4-L8: 80 MPa

L8-Roof: 65 MPa

CFST tube: 250 Grade

7.2. Model analysis parameters

The building has been modelled in ETABs to determined the overall building movements and for the design of the lateral elements. The adopted analysis parameters used for this stage of analysis are as per the below:

7.2.1 Element stiffness modifiers

Element	SLS		ULS
Columns	1.0		0.8
Beams	0.6		0.3
Headers	0.9		0.6
Slab (Bending)	0.3		0.3
Slab (Diaphragm)	0.6		0.6
Walls (Shear)	1.0		1.0

7.2.2 Other analysis parameters

- High tension stiffness modifiers **not included** in ULS or SLS analysis.
- P delta effects **accounted for** in both ULS & SLS analysis.
- **Semi rigid** diaphragms were modeled.
- Construction sequence **applied.**
- Creep and shrinkage analysis **not applied**.
- Foundations modelled as **springs**.
- Founding strata elastic modulus **2,000 MPa.**

8.0 MODEL GEOMETRY

The building structure has been modelled and analysed with Etabs.

The model geometry complies with the architectural schematic design Revit model submitted on 18th June 2019 and the structural detail design drawings due to issue on 28th June 2019.

- Floors are modelled as shells and meshed with auto mesh of 1.0m squares.
- Wall meshing is modelled with auto mesh of 1.5m squares.
- Header beams are 1.2m deep over corridors and 1.7 m deep at lift/stair doors.
- Transfers: Transfer beams are located on level 1 and 13.
- Outriggers: None

9.0 ANALYSIS OUTPUT AND STRUCTURAL PERFORMANCE

Modes – ULS analysis model reference

Case	Mode	Period sec	Frequency cyc/sec	Circular Frequency rad/sec	Eigenvalue rad^2/sec^2
Modal	1	2.924	0.342	2.149	4.6183
Modal	2	2.286	0.438	2.7491	7.5575
Modal	3	0.947	1.056	6.6358	44.0339

Modes – SLS analysis model reference

Case	Mode	Period sec	Frequency cyc/sec	Circular Frequency rad/sec	Eigenvalue rad^2/sec^2
Modal	1	2.595	0.385	2.4213	5.8628
Modal	2	2.077	0.481	3.0252	9.1518
Modal	3	0.887	1.127	7.0819	50.153

Structural performance and building movements has been discussed in a separate Movement & Tolerance Return Brief issued on 28th May 2019 and is attached as Appendix C in this report.

10.0 SERVICEABILITY

10.1. General

The design of the building addresses the serviceability and durability requirements of all relevant Australian Standards. In addition the design shall contain deflections within the limits of the relevant Australian Standard.

The structural floor components shall be designed and constructed to contain any deflections under service loads within limits for structural integrity, visual appearance, avoidance of excessive floor slopes, prevention of cracking in floors, walls and ceilings, proper installation and operation of machinery and equipment, traffic or the building occupants, and avoidance of ponding.

10.2. Building Sway due to Wind Loads

Building sways (Deflection) subject to service wind loads shall satisfy:

- Total lateral deflection to not exceed height/500.
- Inter-storey deflection to not exceed inter-storey/500 or 12mm, whichever is lesser.

10.3. Building Movements due to Gravity Loads

Building movements under gravity loads (lateral and vertical movements) caused by the large building cantilevers and inclined columns will be assessed by Bonacci in a separate Gravity Movement Report. This report will detail an assessment of these movements and the implications on façade elements and other non-load bearing walls and fitments will need detailed consideration by all the design team during the DD phase.

Building movements are used to determine construction pre-setting (vertically and horizontally) of the building to limit the long term movements to acceptable levels. Floor slopes within the building are going vary over time due to creep and shrinkage effects. This risk can be mitigated via pre-setting the floor levels at the cantilevered edge and provide additional topping to the required floor levels to satisfy the relevant acceptable Australian Standard requirements. It is recommended that the gravity movement criteria causing changes to floor slopes should be explained in detail in the Project Brief, so that the end user is aware of the movements that may occur over the building life.

10.4. Concrete Floor Slab and Beam Deflection Criteria

The joints between the floor slabs need to be considered carefully. Changes of levels between slabs as a result of differential settlement are not permitted.

All concrete floor elements and their associated composite structural steel beam components are to be designed such that their long-term deflection does not exceed the span/250 with incremental deflection limited to span/500. The long-term deflection of any structure supporting rigid partition walls without regularly spaced movement joints shall not exceed span/500 with incremental deflection limited to span/1000.

10.5. Steel Roof Deflection Criteria

The design criteria for vertical deflections of structural steel rafters and beams are as follows:

Total Deflection (after pre-cambers)

Self Weight and Dead load:	Span/360 or 20mm
Self Weight, Dead Load and short term Live Load:	Span/300

Incremental Deflection

Short term Live Load or Wind load:	Span/200 or 30mm
Ceiling Dead Load only:	Span/500

Notes:

- Incremental and total deflection criteria are based on AS1170.0:2002 Table C1 for rippling, sagging and cracking limit requirements for hung ceilings.
- Incremental deflections to rafters and primary beams can be additional and consideration of suitable deflection heads to walls is required.
- It is assumed that appropriate movement and expansion joints are installed into brittle ceiling finishes and fixtures to assist in controlling cracking from the roof deflections described above.
- For cantilever beams and rafters the deflection limit at the ends of the cantilevers are based on the above limits but with the span being equivalent to twice the distance from the support to the end of the cantilever.

10.6. Crack control in Slabs

Generally, all internal suspended slabs have been designed for a moderate degree of crack control. For post-tensioned slabs, this will result in a minimum post-tension stress of 1.4 MPa and 2.0 MPa for moderate and strong degree of crack control, respectively.

Diaphragm slabs that connect tie beams to core elements have been designed for high degree of crack control and in accordance with the strut and tie requirements of AS3600.

Pour strips or Temporary Movement Joints (TMJs) will be introduced where appropriate to minimise the long-term creep ans shrinkage effect of the concrete and these will be co-ordinated with the builder’s construction programme.

10.7. Blast or Impact loads

Vertical structural elements subjest to heavy impact (e.g. loading dock etc) shall be designed to withstand impact and abrasion where they cannot be passively protected (e.g. through the use of bollards and crash walls).

This building generally is not designed for any blast loads imparted from vehicular or personnel improvised explosive devices, external fuel storage facilities (fixed or mofile) or from vehicular borne loads. Explosive loads from nearby substations will be desogned for as per standard substation design guidelines.

11.0 FIRE RATING

According to BCA code (2019) please refer to below tables for fire rating requirements:

Building Element – Offices, Carpark and Assembly Areas	FRL (Class 5, 7a and 9b - Type A Construction)
External Walls (Load Bearing)	120/120/120
External Columns	120/-/-
Load Bearing Fire Walls	120/120/120
Shafts (Non-load Bearing)	-/120/120
Other Load Bearing Walls, Beams, Trusses, Columns	120/-/-
Floors	120/120/120
Roofs	120/60/30*

Building Element – Retail Areas	FRL (Class 6 – Type A Construction)
External Walls (Load Bearing)	120/120/120*
External Columns	120/-/-*
Load Bearing Fire Walls	120/120/120*
Shafts (Non-load Bearing)	-/120/120
Other Load Bearing Walls, Beams, Trusses, Columns	120/-/-*
Floors	120/120/120*
Roofs	120/60/30*

*To be advised by BCA consultant.

12.0 CONSTRUCTION SEQUENCE (LEVEL 14-18)

Please refer to Appendix B for construction sequence of cantilevered slab from level 14-18.

13.0 FUTURE COORDINATION AND STRUCTURAL CONSIDERATIONS

Items to be further coordinated in the design development phase are listed below:

1. Ground floor slab along Appian Way side to be coordinated between architect, landscape consultants and civil engineers.
2. The connection details for the cantilevered composite structure to be further developped from level 14 to 18.

14.0 SAFETY IN DESIGN

Work Health and Safety (WHS) is important to all stages of the project and all stakeholders. Safety in Design (SiD), is the method of identifying design solutions to minimise hazards, not only to improve WHS outcomes, but to also potentially reduce associated costs.

The following summarises the most relevant Work Health and Safety Acts and Regulations:

- Work Health and Safety Act 2011 – Sect 22: Duties of persons conducting business or undertakings that design plant, substance or structures; describes the requirements for the designer to ensure, so far as is reasonably practicable, that the structure is designed without risks to the health and safety of persons. This section also describes the requirements for risk assessment and communication of the risk assessment results.

- Work Health and Safety Act 2011 – Sect 46: Duty to consult with other duty holders; highlights that the designer has a duty, so far as is reasonably practicable, to consult, co-operate and coordinate with other persons who have a duty to the same matter.

- Work Health and Safety Regulation 2017 – Reg 36: Hierarchy of control measures; describes the process if it is not reasonably practicable for the designer to eliminate the risks to health and safety. It is the designer's responsibility to minimize the risk, as far as practicable, by providing mitigation measures and giving rise to a hazard with a lesser risk.

Refer to Appendix A for Bonacci Groups current Risk Register, highlighting potential health and safety hazards relating to the design services provided by Bonacci Group, associated with the project during its construction, operational life, maintenance, and de-commissioning.

Bonacci Group has also been involved with an additional project wide Safety in Design workshop that required input from each of the designers.

APPENDIX A SAFETY IN DESIGN REGISTER

BONACCI

SAFETY IN DESIGN RISK REGISTER

Revision No.: B

Date: 22/08/2019

PROJECT NAME: Western Sydney University - Bankstown City Campus

PROJECT No.: 10979

						Initial Risk Rating						Residual Risk Rating		
ID	Phase	Hazard Description	Cause of Risk and Outcomes	Existing Control Measures	Responsible	Likelihood (Drop Down Menu)	Consequence (Drop Down Menu)	Risk Rating (Auto Populated)	Additional Control Measures	Responsible	Progress and Status	Likelihood (Drop Down Menu)	Consequence (Drop Down Menu)	Risk Rating (Auto Populated)
1 Structural Items														
SV1	Construction Excavation	Ground conditions contaminated/unstable	Ground conditions not fit for purpose or serviceability. Settlement of footings, damage to superstructure, ongoing maintenance issues.	Procure geotechnical, geochemical/environmental investigation and design footings in accordance with geotechnical recommendations	Design Team	3 - Possible	3 - Moderate	**Medium**	Ensure ongoing monitoring during construction and inspection of footing trenches are carried out by relevant geotechnical engineer.	Contractor		4 - Unlikely	3 - Moderate	**Medium**
SV2	Construction Excavation	Steep batters	Collapse/sliding failure of batter. Uncontrolled collapse of batter slope. Damage to property, physical injury.	Procure geotechnical report and design associated batters in accordance with geotechnical recommendations	Design Team	3 - Possible	4 - Minor	**Medium**	Construct slope in accordance with geotechnical engineer recommendations	Contractor		4 - Unlikely	4 - Minor	**Low**
SV3	Construction	Working in confined spaces	Asphyxiation. Personal Injury.	Personnel to have appropriate certification.	Contractor	3 - Possible	2 - Major	**High**	Provide suitable ventilation. Engage a spotter	Contractor		3 - Possible	4 - Minor	**Medium**
SV4	Construction Excavation	Contamination from soils and Hazardous Materials	Handling and disposal of contaminated soils known to exist in the area.	Procure a Geotechnical & Geochemical/Environmental investigation	Contractor	3 - Possible	2 - Major	**High**	Use of specialist sub-contractor with appropriate certification.	Contractor		3 - Possible	4 - Minor	**Medium**
SV5	Construction	Lifting steelwork and heavy equipment	Uncontrolled failure of the lifting equipment and panel. Personal injury, property damage.	Equipment to have adequate integral lifting points.	Contractor	3 - Possible	4 - Minor	**Medium**	Provide adequate access and minimise reach. Do not lift in adverse conditions. Use only licensed contractors.	Contractor		4 - Unlikely	4 - Minor	**Low**
SV6	Design Construction	Temporary propping	Failure of temporary props leading to uncurled collapse of structural elements. Personal injury, property damage.	Provide non-trafficable zone along edge where necessary. Temporary propping to be professionally designed and installed / maintained by licensed contractor.	Contractor	4 - Unlikely	4 - Minor	**Low**	Processes to be implemented by Contractor to prevent overstressing and/or structural collapse. Contractor to engage a temporary works engineer.	Contractor		4 - Unlikely	4 - Minor	**Low**
SV7	Design Construction	Welding	Heat damage to surrounding work, interfaces, fire, personal injury.	Where possible, use bolted connections for structural work. Provide temporary welding shields and fire extinguishers close to welding. Ensure "Hot Work" permits are in place.	Contractor	3 - Possible	2 - Major	**High**	Personnel to have appropriate certification.	Contractor		4 - Unlikely	3 - Moderate	**Medium**
SV8	Design Construction	Serviceability and deterioration of concrete	Corrosion of structural reinforcement. Ongoing property maintenance.	Provision of concrete grades and cover to reinforcement consistent with concrete exposure standard relevant to Australian Standards	Design Team	3 - Possible	4 - Minor	**Medium**	Reinforcement to be transported, stored and installed in safe manner. Damaged reinforcement not to be accepted. Construct structural system in accordance with design documentation.	Contractor		4 - Unlikely	4 - Minor	**Low**
SV9	Design Construction	Serviceability and deterioration of structural steelwork	Corrosion of structural steelwork. Ongoing property maintenance.	Provision of steelwork protective coatings to suit the exposure classification relevant to Australian Standards	Design Team	3 - Possible	4 - Minor	**Medium**	Steelwork to be transported, stored and installed in safe manner. Damaged Steelwork and coatings not to be accepted. Construct structural system in accordance with design documentation.	Contractor		4 - Unlikely	4 - Minor	**Low**
SV10	Design Construction	Users injuries from tripping	Protrusions of items from walls, floors etc.	Review of structure to ensure all potential tripping hazards are mitigated.	Architect	3 - Possible	4 - Minor	**Medium**	Site inspections to identify and mitigate potential tripping hazards.	Contractor		4 - Unlikely	4 - Minor	**Low**

BONACCI

SAFETY IN DESIGN RISK REGISTER

Revision No.: B **PROJECT NAME:** Western Sydney University - Bankstown City Campus

Date: 22/08/2019 **PROJECT No.:** 10979

							Initial Risk Rating						Residual Risk Rating	
SV11	Design Maintenance	Personnel fall from building during cleaning and maintenance causing possible fatality	No anchorage points for harness and/or BMU.	Details of anchorage points and/or BMU and/or similar items to be provided for review of impacts onto structural design.	Architect Contractor Cleaning Consultant	3 - Possible	2 - Major	**High**	Personnel to have appropriate certification.	Cleaning Contractor		4 - Unlikely	2 - Major	**High**
SV12	Design	Overloading of structures from heavy services	Structural design has not allowed for sufficient services loadings.	Bonacci have allowed for design loads as per AS1170.1 and specific loads provided, whichever is larger.	Bonacci Design Team	3 - Possible	2 - Major	**High**	Items exceeding design loads must be submitted to Bonacci for review.	Services Engineer Architect Contractor		4 - Unlikely	2 - Major	**High**
SV13	Design Construction	Collapse of structure during construction	Structure being overloaded in temporary condition.	Structural documentation specifies that the Contractor is responsible for the Design, Implementation and Certification of All Temporary Works, Propping, Needling, False Work, Bracing, Back Propping, and so forth, necessary to complete the Works.	Bonacci Contractor	3 - Possible	1 - Catastrophic	**Extreme**	Processes to be implemented by Contractor to prevent overstressing and/or structural collapse. contractor to engage a temporary works engineer.	Contractor		5 - Rare	1 - Catastrophic	**High**
SV14	Design Construction	Structure does not achieve intended load carrying capacity	Construction does not comply with certified IFC documentation, Consultant Advice, Site Inspection Reports or other relevant advices	Periodic site inspections by Bonacci. Contractor's QA and processes to ensure construction compliance with documentation.	Bonacci Contractor	3 - Possible	1 - Catastrophic	**Extreme**	Contractor to confirm the structure has been constructed as documented.	Contractor		5 - Rare	1 - Catastrophic	**High**
SV15	Construction Excavation	Deep footings/trenches	Slips / falls - trip hazards. Falling objects from height. Collapse while working in excavation. Uncontrolled failure of the excavation, leading to physical damage and personal injury.	Limit depth of open excavation.	Design Team	3 - Possible	4 - Minor	**Medium**	Use shields, safe management practices by contractor. Provide non-trafficable zone along edge of trenches/excavations where necessary. Limit time that excavation is open.	Contractor		4 - Unlikely	4 - Minor	**Low**
SV16	Construction	Working at heights	Falling from height, Fall, risk to personal injury/death, physical damage.	Maximise off site fabrication	Design Team Contractor	3 - Possible	4 - Minor	**Medium**	Provide temporary/permanent walkways and handrails and/or fall arrest systems	Contractor		4 - Unlikely	4 - Minor	**Low**
SV17	Construction	Temporary penetrations	Falling from height. Fall, risk to personal injury/death, physical damage.	Minimise penetrations in high traffic zones.	Design Team Contractor	3 - Possible	4 - Minor	**Medium**	Provide temporary handrails/hoardings. Provide non-trafficable zone along edge	Contractor		4 - Unlikely	4 - Minor	**Low**
SV18	Construction	Lifting precast panels	Uncontrolled failure of the lifting equipment and panel. Personal injury, property damage.	Limit size and tonnage of panels.	Design Team Contractor	3 - Possible	4 - Minor	**Medium**	Provide adequate access and minimise reach. Do not lift in adverse conditions. Use only licensed contractors.	Contractor		4 - Unlikely	4 - Minor	**Low**
SV19	Construction	Dust	Nuisance to residential neighbours, possible health risks. Personal injury, public relations.	Minimise via wetting down as appropriate.	Contractor	2 - Likely	5 - Negligible	**Low**	Ensure site is kept clean and safe at all times.	Contractor		2 - Likely	5 - Negligible	**Low**
SV20	Design Construction	Building damage or collapse due to environmental event	Building damage or collapse due to earthquake or wind event. Property damage, personal injury.	Building designed with bracing system using ductile reinforced concrete bracing cores, shear walls and frame action. Design of new structure to relevant Australian Standards.	Design Team	4 - Unlikely	2 - Major	**High**	Construct structural system in accordance with design documentation. Ensure safe transportation, storage and installation of structural elements.	Contractor		5 - Rare	2 - Major	**Medium**
SV21	Design Construction	Building damage or collapse due to fire event	Building damage or collapse due to fire event. Property damage, personal injury.	Building designed with fire protection to structural elements in compliance with NCC requirements. Design of new structure to relevant Australian Standards.	Design Team	4 - Unlikely	2 - Major	**High**	Construct structural elements in accordance with design documentation. Ensure safe transportation, storage and installation of structural elements.	Contractor		5 - Rare	2 - Major	**Medium**

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SAFETY IN DESIGN RISK REGISTER

Revision No.: B **PROJECT NAME:** Western Sydney University - Bankstown City Campus

Date: 22/08/2019 **PROJECT No.:** 10979

							Initial Risk Rating						Residual Risk Rating	
SV22	Temporary Works Construction	Load paths are very sensitive to construction sequence. Altering construction sequence without reviewing temporary works may cause structure instability	Possible personal injury or fatality, structure collapse.			3 - Possible	1 - Catastrophic	Extreme	Ensure construction be carried out as outlined in the Construction Sequence Report to be prepared by the contractors temporary works engineer. Any proposed alterations to the construction sequence shall be assessed and approved prior to commencement. Construction methodology diagrams to be readily available on site. Contractor to ensure that all site inductions include the construction methodology. All changes to the erection, propping and de-propping sequence shall be approved by a suitably qualified engineer with knowledge of the construction methodology.	Contractor Temporary Works Engineer		3 - Possible	1 - Catastrophic	Extreme
SV23	Temporary Works Construction	Temporary works to be designed for specific sequence of pouring. The sequence of concrete pouring may cause imbalanced loading to the structure, hence causing structure instability.	Possible personal injury or fatality, structure collapse.			3 - Possible	1 - Catastrophic	Extreme	Ensure concrete pouring be carried out as outlined per proposed program and as outlined in the Construction Sequence Report to be prepared by the contractors temporary works engineer. Any proposed alterations to the pouring sequence shall be assessed and approved prior to commencement. Construction methodology diagrams to be readily available on site. Contractor to ensure that all site inductions include the construction methodology. All changes to the erection, propping and de-propping sequence shall be approved by a suitably qualified engineer with knowledge of the construction methodology.	Contractor Temporary Works Engineer		3 - Possible	1 - Catastrophic	Extreme
SV24	Temporary Works Construction	Temporary works to be designed to be engaged in certain stages. Removal of temporary propping before the designated removal stage may cause structure instability.	Possible personal injury or fatality, structure collapse.			3 - Possible	1 - Catastrophic	Extreme	Ensure temporary props are removed after a complete load path is achieved. Refer to temporary works drawings and construction sequence report for removal of temporary props (de-propping sequence). Construction methodology diagrams to be readily available on site. Contractor to ensure that all site inductions include the construction methodology. All changes to the erection, propping and de-propping sequence shall be approved by a suitably qualified engineer with knowledge of the construction methodology.	Contractor Temporary Works Engineer		3 - Possible	1 - Catastrophic	Extreme

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SAFETY IN DESIGN RISK REGISTER

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							Initial Risk Rating						Residual Risk Rating	
SV25	Temporary Works Construction	Unaccounted construction loads applied during erection or during construction may cause failure of structural members.	Possible personal injury or fatality, structure collapse.	Design documents to include construction loads that have been designed for.	Design Team	3 - Possible	1 - Catastrophic	**Extreme**	Contractor to ensure no greater loads are imposed on the structure. The contractor shall place signs in appropriate prominent places indicating all loading limitations for each part of floors and other elements.	Contractor		4 - Unlikely	1 - Catastrophic	**High**
SV26	Construction	Floor are stressed prior to achieving capacity leading to failure of structure	Possible personal injury or fatality, structure collapse.			4 - Unlikely	2 - Major	**High**	Ensure concrete has reached the required strength as noted on the PT contractors drawings prior to stressing.	Contractor		4 - Unlikely	2 - Major	**High**
SV27	Design Construction	Building damage or collapse due to removal of hanging columns	Possible personal injury or fatality, structure collapse.	Design documents to clearly highlight any hanging columns/structure	Design Team	5 - Rare	5 - Negligible	**Low**	Contractor to include any hanging columns/structure on as-built drawings and operations manuals	Contractor		5 - Rare	5 - Negligible	**Low**
SV28						5 - Rare	5 - Negligible	**Low**				5 - Rare	5 - Negligible	**Low**
SV29						5 - Rare	5 - Negligible	**Low**				5 - Rare	5 - Negligible	**Low**
SV30						5 - Rare	5 - Negligible	**Low**				5 - Rare	5 - Negligible	**Low**
2 Civil Items														
CV1	Design Construction	Grates	Tripping hazard on wrongly specified grate sizes	BCA/Architect to advise on grate specifications	Design Team	3 - Possible	3 - Moderate	**Medium**	Civil contractor to ensure correct grates are installed	Contractor		4 - Unlikely	3 - Moderate	**Medium**
CV2	Design Construction	Appian Way Grading	Flat grading can cause ponding and stagnant water	Grading to be designed to ensure falls/slopes are efficient	Design Team	3 - Possible	3 - Moderate	**Medium**	Civil contractor to construct grades in accordance with design documents.	Contractor		4 - Unlikely	3 - Moderate	**Medium**
CV3	Design Construction	Interface between levels (e.g. paving and lawn; building and footpath, etc.)	Slips / falls - trip hazards due to level change.	BCA/Architect to advise on grades and steps	Design Team	2 - Likely	3 - Moderate	**High**	Civil contractor to construct grades in accordance with design documents.	Contractor		4 - Unlikely	3 - Moderate	**Medium**
CV4	Design Construction	Sediment Collection. Contaminated water.	Sediments can collect and block pits, and pipe drainage causing system surcharge. Contaminated water leaves the site during construction.	Sediment erosion control measures to be designed to relevant standards and current practices.	Design Team	3 - Possible	4 - Minor	**Medium**	Civil contractor to install sediment erosion control measures in accordance with design documents. Strict compliance with the Soil and Water Management Plan. Ensure all site staff are aware of the responsibilities (particularly site supervisor)	Contractor		4 - Unlikely	4 - Minor	**Low**
CV5	Construction Maintenance	Working in confined spaces	Asphyxiation. Personal Injury.	Personnel to have appropriate certification.	Contractor	3 - Possible	2 - Major	**High**	Provide suitable ventilation. Engage a spotter. Provide maintenance adequate signage.	Contractor Maintenance		3 - Possible	4 - Minor	**Medium**
CV6	Design Construction	Pooling of water in landscaped Appian Way area	Slip/Fall and Drowning hazard	Depth of water to be assessed and provisions to control blockages in drainage outlets considered as part of landscape design. Natural grading of landscaped areas promoted	Bonacci Landscape Architect	3 - Possible	2 - Major	**High**	Civil contractor to construct grades in accordance with design documents. Regular maintenance of drainage infrastructure and control public access where no other solution	Contractor Maintenance		5 - Rare	2 - Major	**Medium**
CV7	Design Construction	Pit/Drain/Sub-surface drain maintenance	Maintenance hazard	Ensure structure for access to pits etc is located away from busy vehicular traffic. Ensure pits have appropriate safe access requirements	Bonacci Architect	3 - Possible	2 - Major	**High**	Civil contractor to construct pits in accordance with design documents.	Contractor Maintenance		5 - Rare	2 - Major	**Medium**

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							Initial Risk Rating						Residual Risk Rating	
CV8	Design Construction	Vehicular Impact damage into public spaces	Vehicular impact through accidental acts	Design road and roadside furniture in accordance with AustRoad guidelines, RMS and any applicable Council guides. Design impact resistant bollards if required or other control measures such as speed limiting devices, control measures and frangible objects adjacent to road. Note this does not include deliberate vehicular impact acts such as terrorism type "Ram Raid" events. If a building is deemed by the owner to have potential risks with such events then a separate threat assessment needs to be undertaken and specialist measures designed by others to limit the acts.	Bonacci Architect	4 - Unlikely	3 - Moderate	**Medium**	Civil contractor to construct road and roadside furniture in accordance with design documents.	Contractor		5 - Rare	3 - Moderate	**Medium**
CV9	Design Construction	Trenching	Collapse of excavation	Limit depths of excavations where possible	Design Team	3 - Possible	2 - Major	**High**	Subcontractor to confirm temporary batters / shoring. SWMS required. Consultant verification or certification where required. Deep trench and excavation procedure. Provide exclusion zone. Provide hoarding and bunting installation	Contractor		4 - Unlikely	2 - Major	**High**
CV10	Design Construction	Trees	Tree roots damage the structural footings and pavements	Ensure high reactive soils are not influenced by excessive irrigation. Specify suitable trees and position (Install root barrier if necessary)	Landscape	3 - Possible	2 - Major	**High**	Contractor to install landscaping to design documents.	Contractor		4 - Unlikely	3 - Moderate	**Medium**
CV11	Design Construction	Overland Flow Paths - Appian Way	Safe conveyance of stormwater during construction	Provision of pit and pipe systems and overland flow paths that limit overland flow velocities and prevent danger to both public and construction personnel.	Design Team	2 - Likely	4 - Minor	**Medium**	Civil contractor to construct grades, pits and pipes in accordance with design documents.	Contractor		3 - Possible	4 - Minor	**Medium**
CV12	Design Construction	Flooding	Adverse flooding impact to other properties. Flood inundation of proposed building. Increased flood hazard.	Appian way grading and minimising any obstructions on Appian way to reduce flood impact to other properties. Design finish floor level to allow 500mm freeboard above 1% flood. Provide flood hazard warning signage	Design Team	3 - Possible	2 - Major	**High**	Civil contractor to construct grades, pits and pipes in accordance with design documents. Provide flood hazard warning signage	Contractor		4 - Unlikely	2 - Major	**High**
CV13	Construction	Noise	Damage to hearing			4 - Unlikely	4 - Minor	**Low**	Hearing protection to be used by site personnel	Contractor		4 - Unlikely	4 - Minor	**Low**
CV14	Construction	Dust	Respiratory issues			4 - Unlikely	4 - Minor	**Low**	Appropriate dust masks to be worn. Wet ground surface when disturbing soil	Contractor		4 - Unlikely	4 - Minor	**Low**
CV15	Design Maintenance	On Site Detention Tank	Failure of OSD leading to uncontrolled stormwater runoff	Enable emergency overland flow from OSD	Design Team	3 - Possible	3 - Moderate	**Medium**	Regular maintenance, cleaning of OSD	Maintenance		4 - Unlikely	4 - Minor	**Low**
CV16	Operation Maintenance	Water Quality	Stormfilter failure causing increased pollutant runoff			4 - Unlikely	4 - Minor	**Low**	Regular maintenance of stormfilter	Facilities Management		4 - Unlikely	4 - Minor	**Low**
CV17	Design Construction	Vehicular Impact damage into excavation	Vehicular impact through accidental acts	Design impact resistant bollards if required or other control measures such as speed limiting devices, control measures and frangible objects adjacent to road. Note this does not include deliberate vehicular impact acts such as terrorism type "Ram Raid" events. If a building is deemed by the owner to have potential risks with such events then a separate threat assessment needs to be undertaken and specialist measures designed by others to limit the acts.	Bonacci Architect	4 - Unlikely	2 - Major	**High**	Contractor to provide traffic management plan	Contractor		5 - Rare	2 - Major	**Medium**

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SAFETY IN DESIGN RISK REGISTER

Revision No.:	**B**	**PROJECT NAME:**	**Western Sydney University - Bankstown City Campus**
Date:	**22/08/2019**	**PROJECT No.:**	**10979**

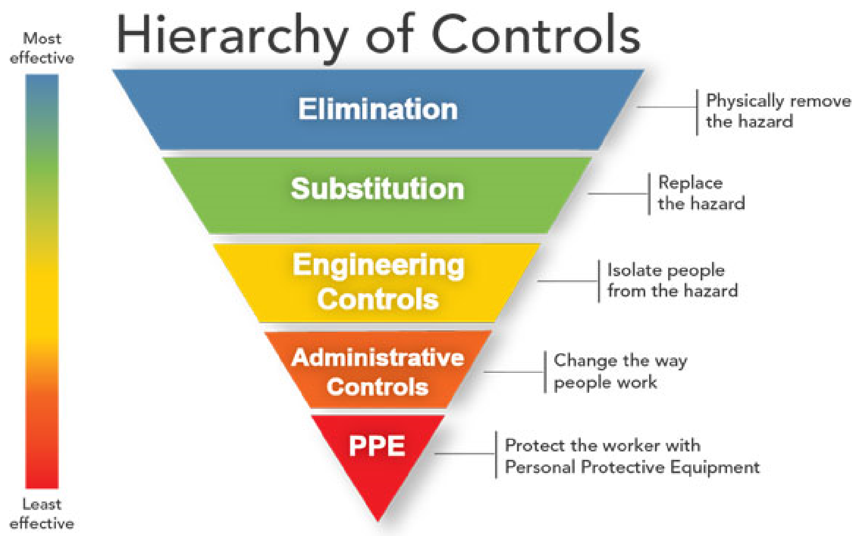
							Initial Risk Rating						**Residual Risk Rating**	
CV18	Construction	Flooding	Personnel swept into excavation zone.	Provide emergency evacuation protocols.	Design Team	5 - Rare	5 - Negligible	Low	Implement emergency evacuation protocols	Contractor		5 - Rare	5 - Negligible	Low
CV19						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV20						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV21						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV22						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV23						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV24						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV25						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV26						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV27						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV28						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV29						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low
CV30						5 - Rare	5 - Negligible	Low				5 - Rare	5 - Negligible	Low

Risk Matrix

	Likelihood				
	1 - Almost Certain	**2 - Likely**	**3 - Possible**	**4 - Unlikely**	**5 - Rare**
	Possibility of Repeated Incidents	Possibility of isolated incidents	Possibility of occurring sometime	Not likely to occur	Practically impossible
Consequences					
1 - Catastrophic	Extreme	Extreme	Extreme	High	High
2 - Major	Extreme	Extreme	High	High	Medium
3 - Moderate	Extreme	High	Medium	Medium	Medium
4 - Minor	High	Medium	Medium	Low	Low
5 - Negligible	Medium	Low	Low	Low	Low

Extreme	Intolerable, engineering required to reduce risk level
High	Tolerable, with safeguards, monitor and proactively try to reduce risk wherever possible
Medium	Tolerable, with safeguards, monitor and review to reduce risk
Low	Acceptable, manage with procedures, continuous improvement

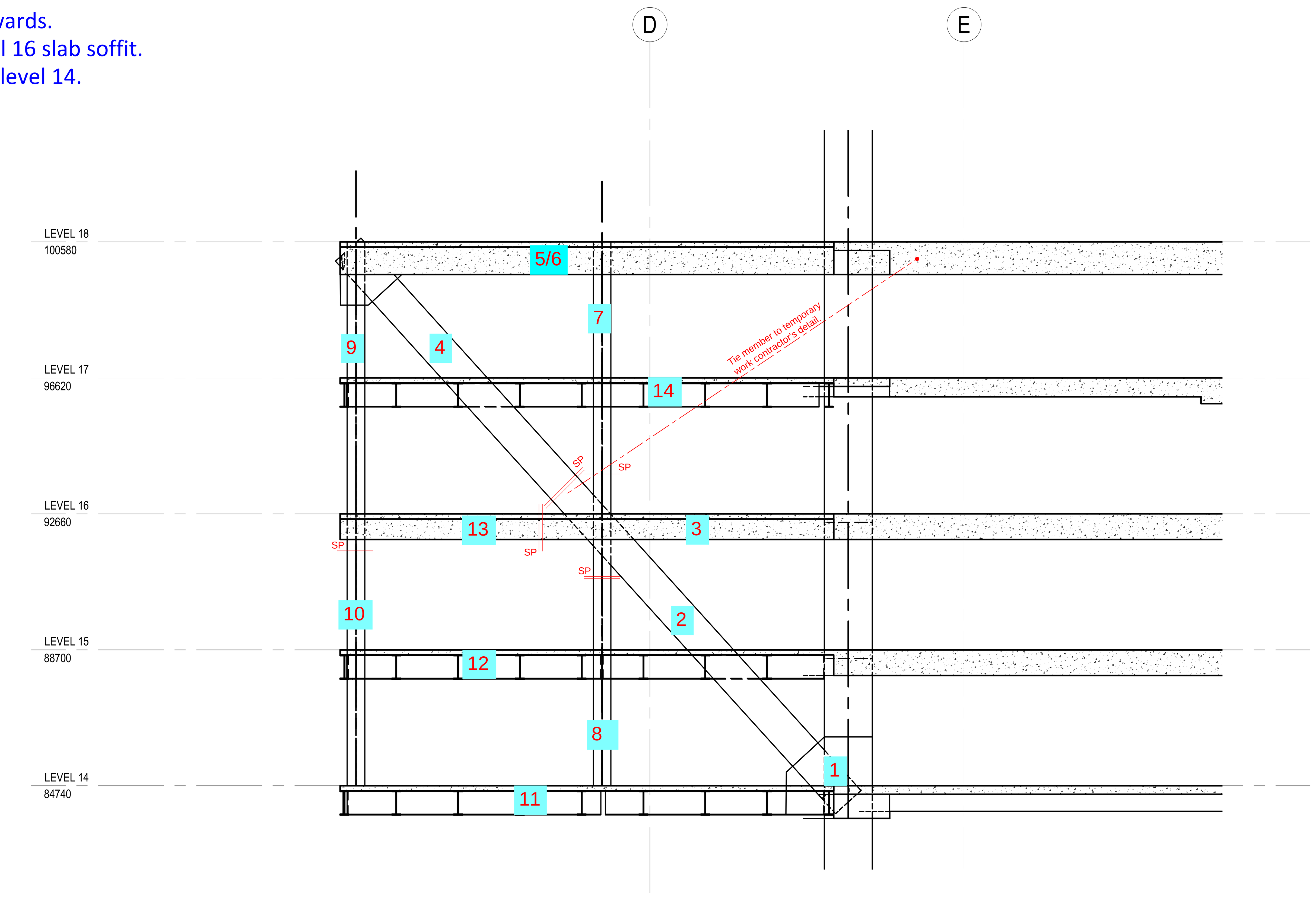
	Health & Safety	**Assets**	**Reputation**	**Financial**	**Environmental**
1 - Catastrophic	Many Fatalities	$10 Million	International Media	Corporate	Large Community
2 - Major	Single Fatality	$1 Million	National Media	Region / Affiliate	Small Community
3 - Moderate	Many Injuries	$100 thousand	Local Media	Division / Site	Minor
4 - Minor	Single Injury	$10 thousand	Some Media	Other	Minimal to None
5 - Negligible	LTI	$1 thousand	No Media	Negligible	None



APPENDIX B CONSTRUCTION SEQUENCE FOR LEVEL 14-18 CANTILEVERED SLAB

<u>Proposed construction sequence for level 14-18 cantilevered slab (rev 2):</u>

1. Construct the concrete plinth at the lower end of the raking columns.
2. Install the lower half of the diagonal struts with temporary bracing tie back to L18 slabs / beams.
3. Install the tie beams on level 16 from the splice location inwards. Form up the slab in between.
4. Install the upper half of the diagonal struts.
5. Install all three primary (tie) beams on level 18 and pour the concrete in the steel tubes.
6. Form up the composite slabs between the beams on level 18.
7. Install the inner droppers from level 18 down and splice connect to the outriggers welded to the diagonals.
8. Install the inner droppers from level 16 downwards.
9. Install the external droppers to just below level 16 slab soffit.
10. Install the external droppers from level 16 to level 14.
11. Construct level 14 slabs.
12. Construct level 15 slabs.
13. Construct the rest of the level 16 slabs.
14. Construct the level 17 slabs.



<u>Note:</u>
SP = Denotes full contact bolted splice to AS4100.

APPENDIX C MOVEMENT & TOLERANCE CRITERIA RETURN BRIEF

BONACCI

Western Sydney University

Movement & Tolerance Return Brief

Project Ref: 10979
Revision: 01
Date: 28 May 2019

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Document Status Note:

Revision	Date Issued	Prepared by	Reviewed by	Title
01	28/05/2019	GS / VC	TH / RG	

Prepared by: Vivien Chen

Date: 28/05/19

Project Name: Western Sydney University

BG Project No: 10979

Discipline: Structural

1.0 Details of structural movement limits

The following sets out the structural deflection limits for both short term and long term of different structural conditions. For each condition, the actions (loads) considered in reference to these limits shall be those required for the relevant serviceability limit state (working loads) and may be reduced where appropriate in accordance with AS 1170, AS3600 and AS4100.

2.0 Vertical Deflection of the Floor Structure under Dead and Live Load

The suspended floors have been designed in accordance with the deflection limits AS 1170 & AS 3600. The deflection is assessed relative to supports. A negative number represents a sag, and a positive number represents a hog.

Type	**Loads Applied**	**Deflection Limit**
Initial Deflection *(Prior to installation of cladding, partitions & finishes)*	Self Weight of structure	+5mm -15mm
Incremental Deflection: *(Long Term additional deflection after installation of cladding, partitions , finishes and long term imposed loads + short term imposed loads)*	Quasi Permanent Loads+ Imposed (live) Loads	+ 10mm - 25mm or Span / 500 (the lesser of)
Total Long Term Deflection *(combination of short term + incremental)*	Quasi Permanent Loads + Imposed (live) Loads	+ 15mm - 30mm or Span / 250 (the lesser of)

Table 1: Slab Deflection Criteria

Note: Quasi Permanent Loads include all dead loads, superimposed dead loads plus a proportion of the imposed load considered as permanent. This proportion varies according to the proposed usage of the space but is typically 40% for residential use.

These deflections exclude any differential movements between adjacent points of support from either foundation settlement or column shortening effects.

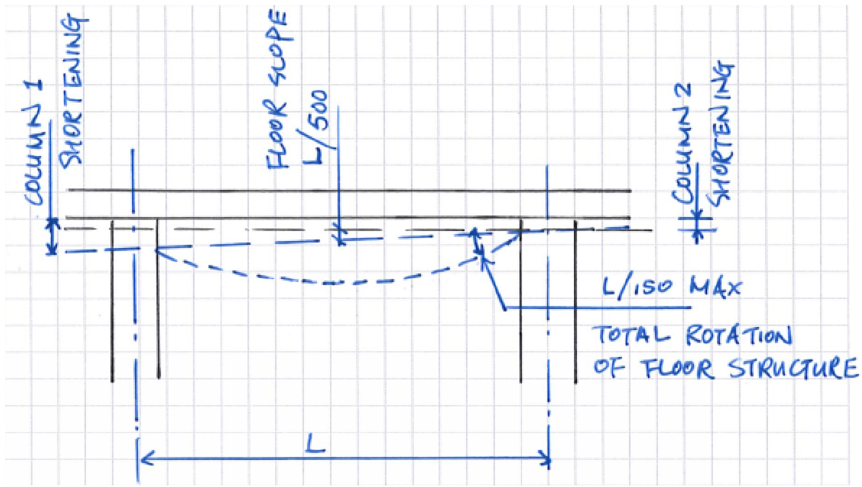
2.1 Vertical Foundation Settlement criteria

For the purpose of the building performance analysis, the anticipated settlement of the foundations is in the range of 10 – 30 mm under the structure and in the range of 0 to 10mm under podium only. Anticipated differential settlements at the base of pads under working loads are assumed in line with the following:

- At the base of the pad – Differential settlement between adjacent columns< 15mm or L/500
- At the base of the pad – Differential settlement between the core and adjacent columns < 15mm or L/500

3.0 Column Differential (Axial) Shortening

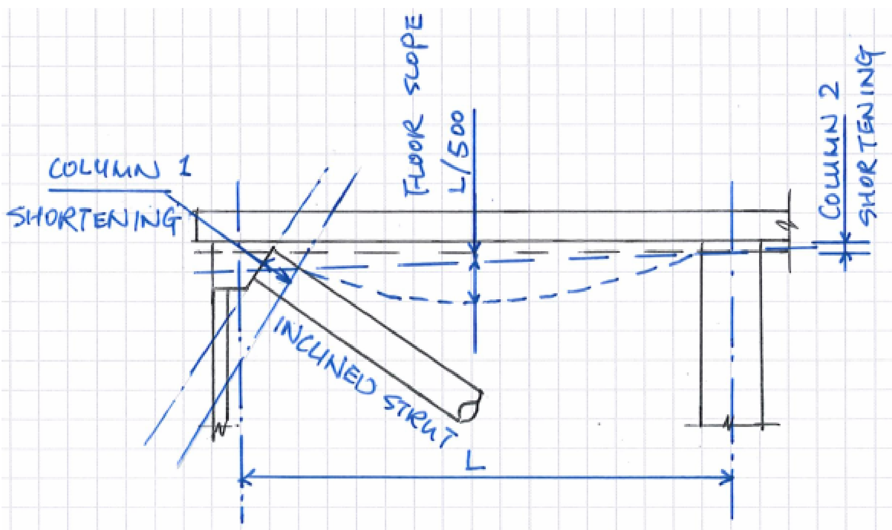
Axial shortening in load-bearing concrete columns, occurs as a result of elastic shortening and creep & shrinkage effects, can be expressed as the summation of elastic strain caused by load application, shrinkage strain caused by drying of concrete and creep strain induced by sustained stress over a long-term period. The differential shortening between the columns / walls will induce additional forces in slabs and beams, causing the slab to rotate and slope, developing potential damage to floor finishes, services, non-load bearing masonry works, etc. Thus a limitation needs to apply to the long term differential shortening in the columns. Please refer to the diagram below:



Column Differential Shortening Criteria

4.0 Cantilever Slab Vertical Movements

Similar criteria should apply to the cantilever end of the slab. The aiming for this limitation is to achieve a flat slab at the end of the construction. However there is 20% tolerance for material property as specified in the code (AS 3600:2018) that needs to be considered.



5.0 Global Horizontal Deflection of Structure

5.1 Horizontal Movement of the Completed Structure Subject to Wind Loading

The primary structure will deflect laterally under wind loading. Wind loads are based on peak gusts lasting for a short period.

Based on these assumptions, the horizontal sway under wind loading will be limited to the value given in Table 2 below.

Condition	Deflection Limit
Deflection of a single storey Total building deflection	h/250 (where h=storey height) h/500 (where h=building height)

Table 2: Horizontal Movement Criteria

It is recommended that all follow on trades and structural interfaces are designed based on the deflection limits set out in Table 2. This limit is based on preliminary information and will be developed in conjunction with the contractor and design team.

5.2 Global Horizontal Movement of the Completed Structure Subject to Gravity Loading

When the centre of a buildings weight does not coincide with the centre of a buildings vertical stiffness, the structure will deflect horizontally under its own self weight. This structure incorporates several large cantilevering floors at the top which further exacerbate these effects.

The structural design aims to limit this movement and to limit the permanent lateral action this applies to the core; however, some movement is inevitable.

As the cantilevering floors are constructed, they will induce a clockwise twist to the core. This twist will increase over time.

The lateral design movement limits are set out in Table 3 below.

Condition	Deflection Limit
Deflection due to structural self-weight	H/500 (where H=storey height)
Deflection due to total dead and long term imposed loads (DL+SDL+0.3LL)	H/500 (where H = storey height)

Table 3: Allowable lateral deflections due to gravity loads

This limit is based on preliminary information and will be developed in conjunction with the contractor and design team.

6.0 Inter-story Drifting under Earth Quake Load

According to the code AS 1170.4 – 2007 Clause 5.4.4, "*The inter-story drift at the ultimate limit state calculated from the forces determined in Clause 5.4.2 shall not exceed 1.5% of* the *story height for each level*", that is about 60 mm based on the floor to floor height of 3.960 m typically.

The seismic design coefficients are listed in the **190312-10979-WSU structural schematic design report-Rev 1** section 4.2.

7.0 Building Presets

Whilst not considered at Schematic Design phase, the long term movements of the building under gravity loads may result in floor slopes that are greater than the client's expectations. Therefore it may be prudent to consider presetting the cantilever section upward above the level plane to deal with long term movement effects. If the lateral movements of the building are unacceptable then the core can also be preset laterally to compensate for long term gravity induced sways.