STRUCTURAL SERVICES

NEWCASTLE GRAMMAR SCHOOL – PARK CAMPUS STAGE 1

Client: Newcastle Grammar School c/o APP Corporation Pty Limited
Project: Newcastle Grammar School Park Campus – Stage 1
Project No: 00016194
Report: 16194-LD-RP-S-0001

Member of:
CONSULT AUSTRALIA

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REV	DATE	DESCRIPTION	AUTHOR	REVIEWER
A	24/09/2021	For Review	PF	
B	13/10/2021	SSD Issue	PF	TD

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1 Scope and Introduction

1.1 Report Scope

This report describes the design solutions proposed for the development and identifies the relevant site constraints imposed on the structural design.

The background and context to the design assumptions are discussed and addressed within this Report to detail how each will guide the Structural Engineering design. Additionally, this report should be read in conjunction with the following documentation:

- Geotechnical Assessment Report by Tetra Tech / Coffey, Ref: 754-NTLGE282007-AD dated 19 February 2021.
- Mine Subsidence Desktop Assessment Report by Tetra Tech / Coffey, Ref: 754-NTLGE282007-AB dated 2 February 2021.
- Mine Subsidence Investigation and Assessment by Tetra Tech / Coffey, Ref: 754-NTLGE282007-01-AI Dated: 30 July 2021
- Architectural drawings by SHAC Architects, Ref: 4293.

1.2 Description of Development

The Subject Site currently features an existing pre-school and houses grades K-4 through six main buildings. The school has recently approved a masterplan prepared SHAC Architects to support the continued development of the school.

The Stage 1 structural works include the following:

- Demolition or part-demolition of existing Admin Building.
- Refurbishment of Block B to accommodate a new central Administration and relocation of other school functions.
- Construction of a new 3-storey building features the following structural elements:
    - Ground floor open air space / COLA and extension of adjacent play area.
    - Levels 1 and 2 to house 16 learning spaces.
    - Roof top terrace/outdoor play area.
    - Lift access.

The Stage 1 works will be delivered by a team of consultants engaged by NGS with the coordination of APP as the Project Manager. The Architectural Masterplan was endorsed by the NGS Board in late 2019 and forms the basis for the Stage 1 project.

2 Structural Design Criteria

The principal design criteria are:

- **Post Disaster Function**. The building will not be designed for post disaster function, adopting a Building Importance Level of 3.
- Annual probability of exceedance for seismic activity (1 in 1000 year earthquake)
- Annual probability of exceedance for wind (1 in 1000 year wind)

  The design has made no allowance for blast/explosion, vehicular or aircraft impact, etc on the building structures.

- **Strength** and ductility of the building and all its components shall be adequate to resist the load combinations in accordance with AS1170.0:2002 and the relevant current code limit state provisions.
- **Stability** of the building and in particular the stability of the individual primary lateral load resisting structural elements when subjected to wind and/or seismic loading, using the code load combinations, shall be maintained in accordance with AS1170.0:2002 Dead and Live Loads and Load Combinations
- **Deflection** of the building as a whole and inter-storey height deflections when subjected to serviceability limit state wind loads and/or seismic loading shall comply with the following:

  Total lateral deflection shall not exceed height/500 for wind loads

  Inter-storey drift shall not exceed 1.5% of the storey height under Ultimate Limit State earthquake.

- **Floor Deflections** calculated to AS3600/AS2327.1 or AS4100 as appropriate and limited to span/250 total long-term deflection or maximum 25mm and span/500 incremental for lightweight partitions and well-articulated masonry walls.
- **Durability** to be to AS3600:2018/AS4100:1998 provisions

The School is to confirm their requirements, however, in general structural elements should achieve the following:

– Building structure - concrete elements	50 years
– Structural steelwork	50 years
– Corrosion Protection Systems	15 years

- **Fire rating** to AS3600:2018/AS3700:2018/AS4100:1998 as appropriate and the Building Code of Australia.

- **Natural Frequency of floor elements.** Floor vibration design response to occupant activity to generally comply with recommendations of AS2670.
- **Adaptability, Flexibility and Expandability.** The School is to confirm the requirements of future proofing, however the following will be adhered to:
  - The building structural system and grid will optimise functionality and future adaptability and expansion limiting internal shear walls where possible.
  - The use of post-tensioned concrete will not limit future flexibility in regard to placement of penetrations, etc relative to any other structural system.

Set Downs. Areas requiring set-downs will be identified by the architect and the floor designed appropriately.

3 National Construction Code

3.1 Building Code of Australia

The structure is to be designed in accordance with the relevant parts of the Building Code of Australia (BCA). Based on our understanding, the following items are deemed to be appropriate for the structural design;

Description	**Specification**
Importance Level	3
Annual Probability of Exceedance for Wind (Area A2; non cyclonic)	1:1000
Annual Probability of Exceedance for Seismic	1:1000
Main Building (Fire Rating)	To be confirmed by BCA Consultant

3.2 Australian Standards

The structural design of the development shall be carried out in accordance with the provisions of the relevant Australian Standards, Council Standards and the Building Code of Australia, and in accordance with the accepted practice and principles of structural engineering.

Where there is no relevant Australian Standard or Code, use may be made of appropriate overseas standards or recognised method of analysis, design or testing.

The following Australian Standards have been identified as relevant:

- AS1170.0: 2002 – Structural Design Actions : General principles
- AS1170.1: 2002 – Structural Design Actions : Permanent , imposed and other actions

- AS1170.2: 2011 – Structural Design Actions : Wind actions
- AS1170.3: 2003 – Structural Design Actions : Snow and ice actions
- AS1170.4: 2007 – Structural Design Actions : Earthquake Actions
- AS2159: 2009 – Piling: Design and Installation
- AS3600: 2018 – Concrete Structures
- AS3700: 2018 – Masonry Structures
- AS4100: 1998 – Steel Structures
- AS4600: 2005 – Cold Formed Steel Structures

4 Design Loads / Actions

4.1 Dead Loads

Dead loads shall be calculated as provided for in the latest version of AS1170.1:2002 Dead and Live Loads. The major dead loads to be used in design include the following:

Material Density

- Reinforced concrete generally 25kN/m3.
- Soil (in planters) 18kN/m3-
- Glazed panels (windows, doors) 25kN/m3.
- Structural Steel 78kN/m3.
- Timber
  - Softwood 6kN/m³ min
  - Hardwoods, nominally KDH 10kN/m min
- Tiling and grout Not less than 20kN/m³

4.2 Superimposed Dead Loads

Generally, a superimposed dead load allowance of 1.0 to1.5kPa will be applied throughout the structure to account for partitions, ceilings, services, fixtures and other items fixed to the slabs.

- Partition walls 0.5kPa minimum
- Ceilings and misc. dead load 0.25kPa. minimum

▪ Services Ducts, Lighting etc.	0.25kPa. minimum
▪ Applied toppings - Balconies	1.5kPa minimum. Actual loads are to be calculated
▪ Applied toppings - Internal	1.5kPa minimum. Actual loads are to be calculated
▪ Ovals over suspended slabs	12.5kPa (600mm soil zone + toppings for falls)
▪ Roof – Covered Play	Subject to detailed design but including: • Trafficable Wearing Slab • Insulation • Drainage Layer • Screed to falls and membrane

4.3 Live Loads

Live loads shall be calculated as provided for by the latest version of AS1170.1:2002 – Permanent, Imposed and other Actions. The major live loads to be used in design include the following (distributed loads shown - point loads as per code or lift/plant manufacturer):

▪ Classrooms	3.0kPa
▪ Storage	5.0kPa, based on 2.1m of maximum storage height
▪ Corridors and Lift lobbies	4.0 - 5.0kPa
▪ Balconies and Terraces	Equal to area providing access but net less than 4.0kPa
▪ Plant Room	5.0kPa min (actual plant loading will be used if greater than 5.0 kPa as per architectural drawings and suppliers loading requirements)
▪ Public and Fire Stairs	4.0kPa
▪ Roof Non-trafficable	0.25kPa minimum.
▪ Roof – Trafficable / Covered Play	4.0 kPa
▪ For other areas not defined	refer to AS1170.1

Live load reduction will be applied to vertical elements in accordance with AS1170.1:2002.

Live load reduction will not be applied to slab/ beam elements in accordance with AS1170.1:2002.

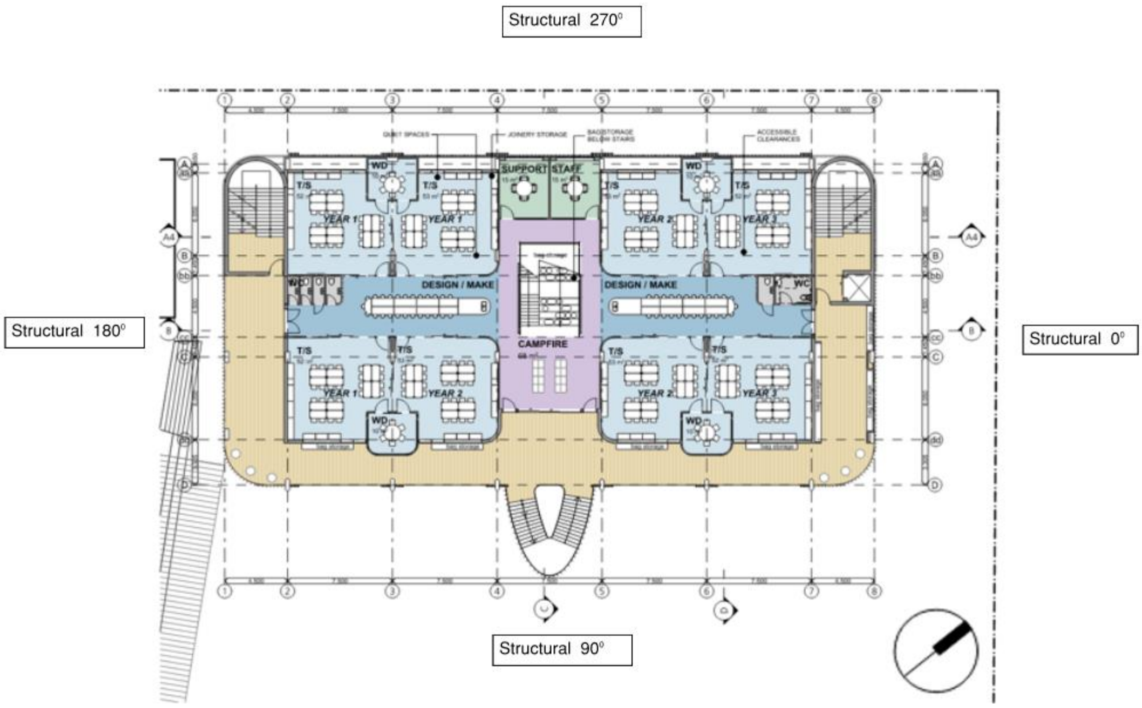
4.4 Limit State Wind Loads

The wind pressures will be calculated using the following parameters:

Regional Wind Speed Parameters		
Code	AS1170.2:2011	
Location	Region A2	
VR (ULS)	46m/s	1:1000 Annual Probability of Exceedance
VR (SLS)	37 m/s	
Ms	1.0	
Mt	1.0	
Md	0.8 to 1	Refer AS 1170.2
Terrain Category	2 to 3	Refer AS 1170.2
M(Z,cat)	Varies with height	Refer AS1170.2
General Pressure coefficients		
Cp,eW	+0.8	Refer AS1170.2
Cp,eL	-0.5	Refer AS1170.2
Cp,eS	-0.65	Refer AS1170.2
Ka	1 Max	Refer AS1170.2
Kc	0.9 Max	Refer AS1170.2
Kl	1.0 to 3.0	Refer AS1170.2
Kp	1.0	Refer AS1170.2
Cp,i	-0.3 or 0.0	Refer AS1170.2

Design Wind Speeds

Site Wind Speed:								
	N	NE	E	SE	S	SW	W	NW
Terrain Category	2	3	3	3	3	3	3	2
M_z,cat	1.056	0.9	0.9	0.9	0.9	0.9	0.9	1.056
Md	0.8	0.8	0.8	0.95	0.9	0.95	1	0.95
Ms	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
Site Wind Speed (ULS) (m/s)	38.9	33.1	33.1	39.3	37.3	39.3	41.4	46.1
Site Wind Speed (ULS) (m/s)	31.3	26.6	26.6	31.6	30.0	31.6	33.3	37.1
Structure	θ = 0°	θ = 90°	θ = 180°	θ = 270°				
Design Wind Speeds (ULS) (m/s)	38.86	39.33	41.40	46.15				
Design Wind Speeds (SLS) (m/s)	31.26	31.64	33.30	37.12				



4.5 Earthquake Loads

Code	AS1170.4:2007	
Structure Classification	Importance Level	III
	Annual Probability of Exceedance	1:1000
	Location	Newcastle

	Probability Factor	Kp =1.3
	Hazard Factor	Z=0.11
	Founded	Class Ee
	Structure height	H>12m, H<50m
Earthquake Design Category		EDC II

5 Materials

5.1 Concrete

Reinforced and prestressed concrete, including elements reinforced with permanent steel formwork and plain concrete, shall comply with the provisions of AS3600:2018 and the standards referenced therein, in terms of analysis, design, and specification of constituent materials including reinforcement.

5.2 Structural Steel

Structural steel, including steel used in composite construction and connections, shall comply with the provision of AS4100 and standards referenced therein, in terms of analysis, design and the specification of constituent materials.

5.3 Masonry

Masonry structures shall comply with the provisions of AS3700:2018 and the standards referenced therein, in terms of analysis, design and the specification of constituent materials.

6 Geotechnical

6.1 Ground Conditions

Topographically the site is located within a former estuarine floodplain in the historical location of Cottage Creek. Historical maps (including Plan of Port of Newcastle 1887, Map of the Newcastle. District showing the Colliery Holdings 1932) have the area as a “swamp”. Since the 1900s, the area has been raised with fill creating a near-level plain, with Cottage Creek realigned to Parkway Avenue south of the site. Newcastle Harbour is located 1km to the north.

Based on the 1:100,000 scale Newcastle Coalfield Geology map, the site is underlain by Quaternary deposits comprising gravel, sand, silt and clay. Underling this unit is the late Permian aged Lambton Subgroup of the Newcastle Coal Measures comprising interbedded and interlaminated siltstone, sandstone and coal. The mined Borehole Seam forms the floor of the Lambton Subgroup, which also contains the Yard Seam not present at the site.

Unit number	Unit	Description	Approximate Base Depth (m)
1	Fill	Sandy CLAY\CLAY/ SAND/Sandy GRAVEL	3 to 4
2	Estuarine clay	Clay soft to firm consistency	9 to 10
3	Estuarine sand	Interbedded sand and clay, firm consistency and medium dense sands	16 to 19
4	Residual clay	Clay stiff to very stiff consistency	22 to 25
5	Interbedded siltstone and sandstone	Highly weathered to moderately weathered, very low strength to at least 30m	58*
6	Borehole Seam	Mined Seam. Lower 16' 5.25" (5m) to 17' (5.2m) being grouped together with the upper 1' 4.5" (0.4m) to 20" (0.5m) of poor quality unsuitable for mining.	63.5*
7	Waratah Sandstone	High to very high strength sandstone	From 63.5*

*Note * Depths estimated from historical drilling in the area.*

Figure 1 – Ground Stratigraphy (Coffey / Tetra Tech, 745-NTLGE282007-AB)

6.2 Mine Subsidence

6.2.1 Desk Top Study

SA NSW Merit Assessment Policy requires a Desktop Assessment for the property. This assessment has been prepared by Coffey / Tetra Tech. The desk top study provided the following assessment:

- Uncertainty Factor (confidence in the existing data on the workings): High uncertainty.
- Factor of Safety (subsidence event): Less than 2.1

In reference to the SANSW Merit Policy, the building should be designed to be safe serviceable and any damage limited to "very slight" in accordance with AS2870's damage classification for the following parameters:

- Tilt up to 20mm/m.
- Tensile and compressive strains of 6.5mm/m
- Radius of curvature of 1.5km.

In accordance with the SA NSW Merit Assessment Policy, the site cannot have a high uncertainty and additional investigations of the workings was required.

6.2.2 Additional Mine Investigations

Further geotechnical investigations of the mines has been undertaken by Coffey / Tetra Tech. The fieldwork completed at the site comprised the:

- Drilling of four additional boreholes to a depth of up to 65m
- Geophysics through the drilling string of three locations to assist in the verification of the coal seam and mined heights.
- Acoustic Televiewer of three locations to assist in identifying defects within the rock
- Downhole Sonar imaging of the voids encountered.
- Camera inspection of boreholes with voids.

This investigation generally showed the mine plan to be a good representation of the mine workings present. Voids generally ranged from 2.3m to 2.85m in height with a total pillar height of 6.1m including rubble.

The development will need to be designed to remain safe serviceable and repairable for the potential subsidence at the site including:

- Maximum surface subsidence of 770mm.
- Maximum tilt for the building of 25mm/m.
- Maximum tensile strains of 5.5mm/m with a radius of curvature of 1.8km.
- Maximum compressive strains of 6.5mm/m with a radius of curvature of 1.5km.
- Point of inflection 20m from limit of support which is the barrier beneath Union Street.

The additional information gained from this investigation reduces the uncertainty from high to moderate. However, as the width to height ratio is less than 4 the mine workings do not meet the minimum required to be considered long term stable and as such the building will need to accommodate the subsidence described above.

6.2.3 SA NSW Merit Assessment Policy

SA NSW Merit Policy provides the following conditions for approval for Trough Subsidence Risk.

(1) Submit plans prior to construction with a letter from a qualified structural engineer that the improvement will remain “safe, serviceable and any damage from mine subsidence shall be limited to ‘very slight’ in accordance with AS2870 (Damage Classification), and readily repairable”. The subsidence impact parameters should be clearly stated.

(2) Either (a) submit a proposal to remove the risk of mine subsidence by a suitable means, such as grouting or (b) demonstrate that the improvement can be designed to remain “safe, serviceable and any damage from mine subsidence shall be limited to ‘very slight’ damage in accordance with AS2870 (Damage Classification), and readily

repairable". If grouting option chosen, submit for acceptance by Subsidence Advisory NSW prior to commencing work: a. Grout Design, including grout locations (dimensioned in plan and elevation), and design parameters for any residual mine subsidence. b. Grout Implementation Plan; including a site plan (showing property boundaries within 200m of the site), grout locations (dimensioned in plan and elevation), proposed bore locations, and grout designers endorsement. c. Grout Verification Plan; showing the location of verification holes and the grout designer's endorsement. Any assumptions applied to the numerical modelling shall be subject to verification (using empirical or analytical methods) and a sensitivity analysis. Arrange for an independent peer review of the grouting design and implementation plan by a suitably qualified engineer acceptable to the Subsidence Advisory NSW. On completion of grouting submit a Grout Verification Output Report endorsed by the grout designer and site verification engineers for compliance with the accepted Grouting Plan.

(3) Submit an "Engineering Impact Statement" prior to commencement of detailed design for acceptance by SANSW, which shall identify the: a. Mine subsidence parameters used for the design. b. Main building elements and materials. c. Risk of damage due to mine subsidence d. Design measures proposed to control the risks. e. Comment on the likely building damage in the event of mine subsidence and sensitivity of the design to greater levels of mine subsidence.

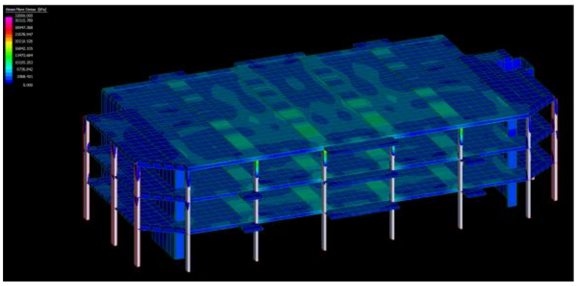
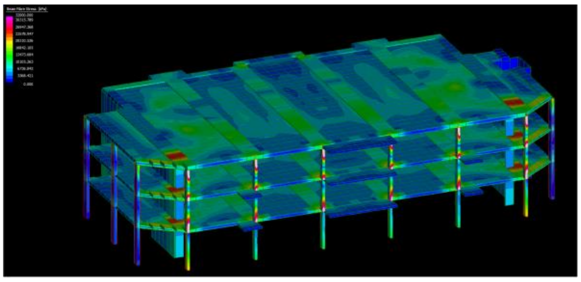
(4) Submit detailed design drawings prior to commencement construction with the design measures proposed to control the mine subsidence risk clearly highlighted and the design subsidence parameters clearly marked on the plan.

(5) A number of permanent survey marks to AHD will be required so that building movement can be monitored should mine subsidence occur. survey marks need to be initially surveyed and all details are to be forwarded to Subsidence Advisory NSW. (6) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.

6.3 Mine Subsidence Management Assessment

A concept design for the building structure has been prepared to consider a design solution that would limit damage to "very slight'. In accordance with AS 2870:2011 App C very slight would limit cracking to structural and non-structural elements to less than 1mm.

A 3D finite element model for the building was prepared using Strand 7 and ground subsidence movements were imposed onto the structure reflecting the settlement and curvature profiles identified from the mine subsidence study. Stress distributions and strength demands where then determined for the structural elements with and without subsidence.

	
No Subsidence Dead and Live Load Stress Plot	Subsidence Dead and Live Load Stress Plot

General Findings:

- Strength demand increased typically in the order of 40% to 60% in some elements however the building structure is generally capable of being designed to achieve compliance with SA NSW
- Ground strains will heavily impact the foundation system and design
- Materials Selection
  - Eliminate the use of brittle finishes and materials including tiles, masonry
  - Allowance for damage and replacement to some materials
- Tilts
  - Should the subsidence halt part way through the site then building could be left out of level in the order of 500mm across the short direction.
  - Tilts in the order 25mm per metre would disrupt / prevent the use of the building due to impact on floors and drainage
  - Structure would need to accommodate a system or strategy to relevel the building
- Detailing and Jointing
  - Additional jointing and articulation to finishes, materials and fixtures would be required to accommodate movement.
  - Windows and doors likely require repair and adjustment

The damage to finishes and the potential out of level of the building after a subsidence event was considered not to achieve the very slight damage condition required under the SA NSW Merit policy. On this basis a mine grouting solution has been proposed.

7 Flood Impact

To satisfy the management of risk to life the building is required to be withstand the hydraulic forces associated with the Probably Maximum Flood event.

Flood Design Actions:

- Flood Depth (RL 4.8m AHD)
- Velocity: 1.8 m/s
- Velocity x Depth Product: 1.4 m^2/s

8 Design Solutions

8.1 Lateral Loading System

Th Generally, in order to provide future flexibility to buildings, stability will be provided by walls contained within lift cores, stair cores etc and column to beam connection stiffness. The use of shear walls remote from cores will be minimised to optimise future flexibility of structure.

8.2 Structural Form

The general building form has been determined by functional and architectural planning requirements. A description of the likely structural solutions for each of the key building areas is noted below.

8.3 Union St Learning Building

The main teaching and learning building is a four storey building consisting of:

- Ground Floor – Soft play area
- Level 1 and 2 – Class room and learning areas
- Level 3 – Covered roof top external play

The three suspended floors are supported on a regular column grid with no transfers. A concept level design has been prepared for this structure and includes

- post tensioned banded slab is considered the most appropriate to minimise the structural zone and provide adequate clearance for building services.
- Reinforced concrete columns and walls

8.4 Modifications to Existing Block B

The existing building structure consists of the following:

- Raft foundation slab including banded beams across column grids with an infill waffle type slab between bands
- Reinforced concrete columns
- First Floor - Suspended banded slab (conventionally reinforced)
- Roof – Steel bearer and timber trusses and timber purlins
- Brick Veneer and non load bearing steel studs

Part of the project scope includes the modification to existing Block B building. Refurbishments and modifications generally include mostly fitout changes to non-loadbearing partitions and finishes, however there are some structural parts to be assessed.

Ground Floor:

- New wet area rooms will require new falls and drainage to be introduced. Detailed design for these areas will need to consider local steps or ramps to build up above slab surfaces instead of cutting into the existing
- New wall penetrations through brickwork requiring new lintels.

First Floor

- Enclose balconies
- Likely new minor service penetrations that require review of the existing slabs to ensure it does not impact on the slab adequacy.

8.5 Foundations

The foundations will be designed in accordance with the recommendations provided in the Geotechnical Report prepared. A concept design for a pile foundation to the residual clays or weathered rock has been considered. This solution is subject to the need to grout the mine workings due to the implications for ground compression and tension strains on the piles and particularly differential strains over the height of the piles.

An alternative solution is also being considered (incomplete at time of report) to provide ground improvements to increase the stiffness and bearing capacity of the upper soft materials and then construct a high-level raft slab. This design requires an interactive approach with the geotechnical engineer to assess ground settlements and to design the extent of ground improvement works.

8.6 Lateral Stability

The building will be required to resist lateral loads due to wind and earthquake actions. From the form and shape of the building, earthquake and wind loading will be determined to ensure the most severe lateral load imposed on the building is analysed and resolved in the design.

In order to resist these lateral loads a braced reinforced wall system has been adopted.

8.7 Lift and Stair Walls

It is proposed that these walls will be designed as reinforced concrete walls to provide vertical support to the adjacent slab areas as well as the stairs.

These walls will also be used to provide lateral stability to the building frame to optimise the building system and maximise the flexibility of the structure and its ability to accommodate changes in the future by limiting the use of internal shear walls within the building and functional space.

8.8 External Façade

At the time of preparing this report the façade design had not yet been finalised. The system will include structural steel primary support elements. Infill screens are subject to further development with the architect.