HARDROCK GEOTECHNICAL
CONSULTING GEOTECHNICAL ENGINEERS

Geotechnical Site Investigation Report

RE: Proposed residential development at:

No. 261-263 Balwyn Road, Balwyn North

Client: Ding and Sam Australia
No. 3 Harrington Place
Doncaster East
Vic. 3109

Distribution: - Ding and Sam Australia
- FMG Engineering

File Number: 170334

Date: 14/03/2017

Introduction

A site investigation was conducted by an experienced geotechnical engineer at this site on the 9th of March, 2017. The purpose of the investigation was to provide foundation recommendations, geotechnical parameters and construction recommendations for the proposed new residential development. Construction is to be three level building over a single level basement. The basement is assumed to be cut to a maximum depth of 5.5m at the deepest corner and is to be close to and or abutting the property boundaries.

Site Description

The site comprises two adjoining residential allotments each with a single storey brick veneer residence. There is an inground swimming pool and garage to the rear of No. 261. There are no adjacent boundary footings. The site has a ground cover of pavements, grassed areas and garden beds. There are some small to large size trees close to the site boundaries. The existing structures are to be demolished and cleared to make way for the proposed development. The site has a moderate fall towards the front corner (south east) and has poor natural surface drainage.

Scope of the Investigation

The site investigation included:

- The drilling of 4 boreholes conducted with hand augers and a Toyota mounted drilling rig with 3 ½ inch solid flight augers, and
- Logging and bulk sampling of the subsurface profile.

Borehole logs and locations are shown on pages 12, 13 and 14 of this report.

Subsurface Conditions

Regional geology

The site is identified on the 'Geological Survey of Victoria' Ringwood Sheet (1:63,360) as being in the province of the Silurian 'Anderson Creek' formation and associated residual soils.

Subsurface profile

See borehole logs pages 12 and 13. The boreholes intersected:

- PAVING and FILL material to depths of between 0.08m and 0.20m, underlain by;
- Natural clayey SILT topsoils to depths of between 0.30m and 0.45m, underlain by;
- Stiff silty CLAY of moderate plasticity, underlain by;
- Distinctly weathered siltstone ROCK intersected at depths of between 0.60m and 0.90m.

The existing fill material can be considered the equivalent of rolled non sand fill in accordance with AS2870 -2011.

Soil moisture and groundwater

No groundwater was intersected in the boreholes. Filling and natural soils intersected were in a dry to moist condition, becoming moist with depth.

Earthquake - Site Sub-Soil Class

With reference to AS1170.4-2007, Section 2.4, a site sub-soil class of **CLASS B_e – Rock Site** is appropriate.

Site Classification

The site is classified as **CLASS M** in accordance with AS2870-2011.

Where the proposed development falls outside the scope of AS2870-2011 (clause 1.1) the design should be based on engineering principles.

Foundation Recommendations

Discussion:

The risk of differential movement between shallow and deep, soil and rock foundations is high. Potential differential movements of between 20mm and 40mm may occur, or greater if good foundation maintenance is not practiced.

To limit differential movement where the structure extends beyond the basement, we recommend all footings are founded in siltstone rock.

Non-structural footings (such as fences and any hard landscaping features) may be founded on conventional shallow foundations and/or a pier and beam foundation where reactivity induced movements may be critical.

Conventional Footings

Strip and pad footings

We advise that conventional strip and pad footings,

- Must penetrate any filling and natural soils,
- Should be founded at a minimum depth of 300mm below the bulk excavations,
- Must be founded in the weathered siltstone rock.
- As a guide only be proportioned to a CLASS A classification. The design should be based on engineering principles.

The depth to the rock can be estimated from the borehole logs which are relative to the surface levels at the time of the site investigation.

The footings can be proportioned for a maximum allowable bearing pressure of 700kPa. This pressure can be reviewed once the design pressures have been calculated.

Piles/Piers

Where required, we recommend the use of bored piers or equivalent.

All piles should penetrate through any filling and upper soils and be founded a minimum of 500mm into the underlying distinctly weathered rock. No minimum founding depths apply. Depth to rock can be estimated from the borehole logs.

Piles should be proportioned for an allowable end bearing pressure of 700kPa.

Alternatively, rock socketed bored piers founding a minimum of **three pile diameters within the distinctly weathered siltstone rock** can adopt a maximum allowable end bearing pressure of 1000kPa.

A skin friction of 50kPa can be adopted where within the distinctly weathered siltstone rock. No skin friction can be within the fill material or natural soils.

Bored piers must be clean of any fallen debris and saturated material. The piling contractor must provide means to ensure that a clean base to the pile is maintained.

Significant collapse of open bored piers may occur should the fill material and natural topsoils be saturated at the time of installation.

Excavation & Retaining Walls

Without engineered support the crest of any excavation should not be within 2m of any existing footings without written approval from this office.

Recommended safe batter slope angle for the soils on site are,

Soil/Rock Type	*Safe batter slope angles degrees (º)*	
	short term	long term
FILLING	30º	25-30º
clayey SILT	30º	25-30º
silty CLAY	55º	45º
SILTSTONE ROCK *	70º	45º

* Safe batter angles will depend on discontinuities (eg joints) in the rock mass. Safe batter angles should be confirmed prior to bulk excavation proceeding (where required).

Battering back of the basement excavation may be conducted where offsets/set-backs are sufficient as recommended below.

Where the off sets are not sufficient engineer designed will be required. Temporary support could be conducted by either installing a tied back/propped/cantilevered bored pier retaining wall. To insure the stability of the upper soils contiguous piles or soldier piles with structural shotcrete infill (top down construction) will be required.

Excavation Potential

It is expected that a medium to large sized conventional hydraulic excavator could excavate through the filling, natural soils and extremely weathered siltstone rock. Some difficulty may be encountered within the distinctly weathered siltstone rock due to the interbedded nature of the rock with softer and harder layers encountered.

The siltstone rock will increase in strength with depth. It is expected that rock breaking equipment and pre-loosening will be required within the distinctly weathered siltstone rock. The excavation potential of the rock will be dependent on the size of the excavator, the degree of weathering and jointing (orientation and condition). The excavation contractor will be more familiar with the capacity of their machine and local areas, and their advice should be sought as to the excavation potential of the site, and/or a trial pit conducted before large-scale cutting is proposed.

Battered Excavations

Excavation for the installation of the retaining walls should comply with the safe batter slope angles above. If the upper filling and top soils are wet at the time of excavation, they will collapse to their natural angle of repose.

Installation of the retaining walls should comply with the following:

- Installation of drainage and tanking behind the wall should be conducted if required. The clay at the foundation level will have a low hydraulic conductivity and for the purpose of drainage can be considered impermeable. The AG pipe should be covered with a geotextile filter to prevent silt and fines entering the pipe and the backfilling around the pipe be granular filling containing no fines. It is also recommended that these subsurface pipes are accessible and include provisions for ‘flush’ points. Drainage should discharge to the stormwater system.

- The backfilling against the wall should be comprised of **imported** free draining granular material with less than 5% fines. The material should be placed and not compacted, or the lateral pressures will change.

The final 15% of the total height of the wall of filling can comprise of on-site excavated soils which should be placed wet of optimum moisture content. Scoria is an excellent light weight backfilling material.

- The wall can then be designed for a triangular lateral earth pressure distribution using an average unit weight of γ = 18kN/m^3, ϕ'= 28º and c′= 0kPa for the fill material, and an adequate factor of safety applied. Yielding walls should be designed for an active earth pressure K_a, whereas non-yielding walls designed for an earth pressure 'at rest' K_o earth pressure. It is expected that the walls will be fix head and propped during construction and as such will need to be designed for an at rest pressure, K_o=1-sinϕ'.

- Checks for overturning should adopt the lateral pressures above and be resisted by a triangular passive earth pressure P_p. The passive pressure should be based on the estimated drained rock joint strength parameters adopting γ = 24kN/m^3, ϕ'= 25º and c′= 3kPa.

- Checks for sliding can adopt a K_a active earth pressure and resisted by a triangular passive earth pressure P_p, and frictional resistance along the base where $\tau = \sigma_n \mathrm{Tan}(\phi' + i)$ (i = surface roughness and σ_n= the normal stress under the footing, $\phi' + i = 70°$). The passive pressure and sliding should be based on the estimated drained rock joint strength parameters adopting γ = 24kN/m^3, ϕ'= 25º and c′= 3kPa.

- Any additional surcharges should be added to the lateral earth pressure. Note that AS4678-2002 recommends a minimum 5kPa surcharge loading to all walls.

- Should adequate drainage of the walls not be guaranteed water pressure should also be included in the lateral earth pressure, and the buoyant unit weight of the soils adopted for the lateral pressures.

- Should sloping backfill occur behind the proposed retaining walls the lateral earth pressure should be calculated accordingly.

Please note that trees may have deleterious effects on the retaining walls from the penetration of root systems, these may include increased loading on the structure and penetration of roots into joints or drainage systems. BS 8002 (1994) recommends that trees should not be permitted within a distance from the retaining wall equal to half the mature height of the mature height of the tree.

Engineered Walls

Where engineered walls are required contiguous piles or soldier piles with 'top down' structural shotcrete infill are recommended for this site. Solider piles can be designed to be cantilevered, propped or tied back.

Pile spacing

Pile spacing is generally dictated by the allowable pile deflections and the ability of the soils to naturally arch between piles. Where the capping beam does not exceed the depth of upper clayey silt and fill material, pile spacing may need to be reduced and/or contiguous/secant (touching) should the upper topsoils become saturated or, conversely, dry. Saturated or excessively dry topsoils may also necessitate the use of CFA methods.

It is important to note that ground conditions can change, and that during drier periods the groundwater may not be so much of an issue for construction.

Where the clayey silt is not saturated (wet) it may stand unsupported for short periods and it may be possible to undertake the construction using conventional methods without CFA techniques and space piles at greater centres.

It is recommended test pits are excavated to verify the stability of the natural clayey silt topsoils.

An experienced piling contractor should be contacted for further advice regarding pile installation in the conditions encountered on site.

General guidelines for pile spacing

The highest risk of instability for piled retaining systems is within the upper filling and loose clayey silt top soils. The natural silty clay and weathered rock will arch between piles up to 2.4m centres, noting pile spacing should be reduced where close to or adjacent to existing structures or were deflections are critical.

Good construction practices include:

(1) Leaving soils in place at the front of the piles until reinforcing and construction materials are on site and construction is immediately ready to proceed;
(2) Undertaking shotcrete infill wall construction as quickly as safely practicable with no delays once the infill soil is removed and reinforcing placed;
(3) Ensuring contingency plans are in place to immediately respond to any localised instability in consultation with the Structural Engineer (this could include shotcrete, or placement of bulk soil or crushed rock on the boundary);
(4) Continually monitor the bulk excavation and following any significant rainfall; and
(5) Undertake excavation with caution.

Please note where localized collapse occurs, adjacent ground may settle. The stability of adjacent land and buildings must be ensured.

Tied back/propped pile walls

A tied back pile wall may be installed utilising bored concrete piers and temporary tieback anchors. Tieback retaining walls should be designed incorporating full hydrostatic pressure, unless the wall can incorporate permanent drainage. Drainage could be strip drains nailed to the excavation face prior to shot creating.

The recommendations below are for a single top anchor/prop adopting a tied back wall ‘free earth support method’.

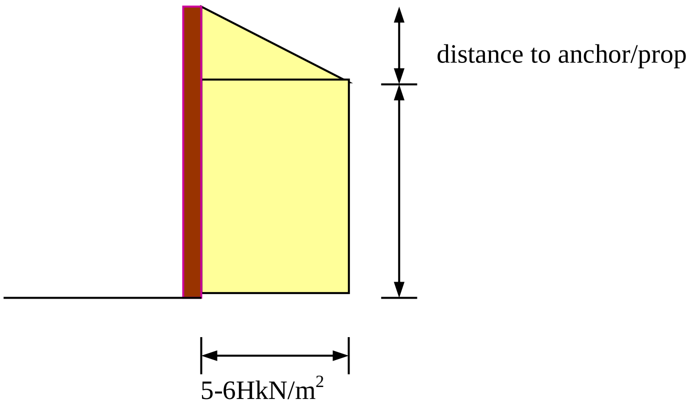
Should multiple pile anchors be used, which is unlikely for a single level basement a ‘brace cut’ earth pressure distribution should be adopted.

The embedment depth piles will be dependent on the passive pressure required to prevent kicking out of the base of the pile which should be calculated by the structural engineers. Bearing pressures are given above. Higher pressure may be available upon consultation with this office.

It is essential that the base of the bored piers is clean of any loose and fallen debris prior to pouring concrete.

The (non yielding) walls/piles should be designed for a triangular distribution down to the top anchor/prop and then adopt a uniform rectangular lateral earth pressure distribution using $P_0 = 5H$ kN/m^2 where H equals the height of the wall in meters. An adequate factor of safety should be applied. Passive resistance at the toe can be calculated by static geomechanics principles adopting the soil parameters in the table below.

Lateral earth pressure distribution for tie back walls*



*** Where tie-back, cantilevered or contiguous piles are used to support adjacent footings, lateral earth pressures should be increased to 6H kPa.**

Any additional surcharges should be added to the lateral earth pressure, i.e. hydrostatic, the line load from the existing building and surcharge loads. Note that AS4678-2002 recommends a minimum 5kPa surcharge loading to all walls.

A $K_{(s)}$ of 0.4 should be adopted for superimposed surcharge loading.

Anchors

Temporary anchor/piles should be installed to a depth such that the bonded length is beyond the active wedge of soil. Adopt an angle of 60° above horizontal from the base of the cut for the active wedge. The bonded length should be founded within the natural soil profile. Pile pull out tests must be conducted to ensure that the piles have adequate capacity as per the current piling code AS2159-1995. The piles/anchors may need to be tensioned to limit deflections. This will be dependent on the construction and excavation sequence, and should be reviewed by the Structural Engineer. Cable anchors should be installed by air rotary methods to ensure an adequate grout soil bond.

The allowable capacity for anchors must be determined by load tests. Advice from the structural engineer should be obtained for the maximum deflection acceptable.

The anchors are expected to be temporary until the retaining wall achieves a ‘fixed head’ by the ground and level floor.

Cantilevered soldier design

The piles should be designed for a triangular earth pressure distribution using the design parameters provide in Appendix A.

- K_0 parameters should be adopted where abutting or within a very close proximity to adjacent buildings, with suitable surcharge loads added accordingly;
- K_a parameters should be adopted elsewhere.

The embedment depth of bored piles for the support of a solider pile retaining wall will be dependent on the ultimate lateral resistance of the pile.

The lateral load capacity of the pile may be limited in three ways the shear capacity of the soil and structural capacity of the pile section and excessive deformation of the pile. Methods of calculating the ultimate lateral soil resistance include Brinch Hansen (1961) and Broms (1964) (simplification of the Broms method in AS 2159 – 1978).

Using one of the above mentioned methods the ultimate lateral capacity of the piles can be determined for differing embedment depths.

This office can be contacted where embedment depths appear excessive.

Contiguous piles

If contiguous piles are adopted the wall will act as a conventional retaining wall not as individual piles. The wall will need to retain the lateral earth pressure above as for the tie back walls. Drainage must be provided behind the wall or hydrostatic pressure added to the lateral earth pressure, i.e. strip drains nailed to the excavated face and allowed to drain to weep holes. The allowable bearing pressure beneath this wall can adopt the same pressure as for the basement strip footings.

Passive resistance at the toe can be calculated by static geomechanics principles as per basement retaining walls.

Retaining wall design notes

Earth pressure can be reduced to triangular Ka = 0.35 where the heads are not fixed eg down ramps provided that the minor movement at the head can occur to develop the active state. Movement required is generally 0.5% of the height which will develop the full active state.

Pavements

Sub-grade preparation

Outside the area of the basement
Preparation of pavements, down ramps and floor slab sub grades should consist of stripping of grass, root zone material and the surface fill material to expose the natural silty CLAY sub grade.

Areas within the proposed basement
Any loose, saturated and disturbed soils should be stripped to expose the natural silty CLAY or weathered ROCK sub-grade.

In both areas
The exposed surface should be proof rolled with the aim of achieving a dry density ratio of 98% as measured by standard compaction (AS1289 5.1.1). Any soft, wet or loose material which does not respond to compaction should be additionally excavated to expose a firm working base.

Depending on the moisture content of the sub grade at the time of construction, it may be necessary to add water or allow the sub grade to dry back to achieve satisfactory compaction.

Sub grade drainage

The sub grade should be provided with subsurface drainage to maintain any groundwater table to at least 300mm beneath the underside of the pavements, or a lower CBR value should be used in the design.

Pavements

Based on experience within the immediate area and the site investigation to date, it is recommended that pavements be designed using an estimated C.B.R value of:

- 4.5% for stiff silty CLAY and a long term Young's modulus E_{sl} of 20MPa and a correlation factor of 0.6 can be adopted as per the Cement and Concrete Association of Australia 'Industrial Floors and pavements' section 3 Design for strength.

- 15% for competent siltstone ROCK and a long term Young's modulus E_{sl} of 32MPa and a correlation factor of 0.9 can be adopted as per the Cement and Concrete Association of Australia 'Industrial Floors and pavements' section 3 Design for strength.

Earthworks

The use of on site filling and top soil material should be avoided and removed to spoil. The excavated silty clay and weathered rock should be suitable for structural filling.

Any imported filling used should comprise of clean, essentially of a granular nature, non-organic and have a plasticity index of less than 12%. Suitable material may include crushed scoria, nondescript crushed rock, mudstone or siltstone or equivalent. Fill material should have a nominal particle size of 75mm or less and as a guide to selecting the appropriate material would be,

P.I x %pass 0.425 (As sieve) < 600

Any filling should be placed in lifts not exceeding 250mm loose thickness. Each layer should be compacted to a dry density ratio of 98% measured by standard compaction (AS1289 5.1.1) using an appropriate medium weight vibratory roller. The recommended moisture content is within 2% of optimum moisture content under standard compaction.

Construction & Maintenance

Site Conditions

Excavation within fill material and natural top soils may experience short term instability (particularly if undertaken during the wetter months) and shoring and/or over excavation should be anticipated.

Disturbance of the filling and natural soils will result from demolition and existing footing removal. Disturbed natural soils will constitute fill material and deeper isolated areas of filling should therefore be anticipated.

Where footings/edge beams are to be additionally deepened, we recommend blinding concrete should first be poured in the base of the excavation upon which the footing/edge beam can be constructed.

Articulation

Articulation of pavements and floor slabs where they abut walls should be provide to allow for the differential movement between the foundations and the pavements.

Articulation of masonry walls should be provided as per details contained in reference (3) below. Spacing between articulation joints should:
- not exceed a maximum of 6.0m, and
- be provided at/or between points of high stress i.e. above door and window openings, changes in storey height, or above large spanning lintels.

Service trenches/easements

The presence of service trenches and easements is a common cause of unsatisfactory performance of foundations through either direct undermining or through the introduction of undesirable levels of soil moisture. For this reason, we recommend:
- Where footings are located in close proximity or adjacent to a backfilled service trench or easements, the footing must be deepened and founded at a depth of a minimum of 500mm below the level of plane of inclination of 45° above horizontal extending outwards from the base of the trench or filling (as illustrated by figure C6.1 AS 2870 2011). This includes service trenches which may be present on adjacent sites or on site prior to the current development.

In addition, and as a guide only we recommend:

- All service trenches should be sloped away from the building as per AS2870-2011 section 5.2.1 and be backfilled with non-permeable material as per AS2870-2011 section 6.6 (d).
- Backfill material should ideally comprise concrete, mortar or (preferably) cement stabilised soil, or clean adequately tamped/compacted clay placed marginally wet of optimum. Permeable or granular material such as sand, gravel, ¼ minus, or building rubble, should not be used to backfill service trenches in proximity to building foundations.

This will be less imperative for the foundations recommended above, but may assist in optimising the performance of pavements and/or hard landscaping features.

Construction

All contractors should be well briefed as to the requirements and specifications in this report. The sub grade preparation, compaction testing, and inspection of foundation excavations should be conducted to insure that they are in accordance with this report. It is recommended that fill material type is verified and that the compaction be tested during placement. Testing should be conducted in accordance with reference (6).

Any plumbing that is not accessible for repair should be flexible enough to tolerate differential movement between the foundation and surrounding ground.

This report is based on the assumptions that conditions revealed through selective sampling are indicative of the actual conditions throughout the site, i.e. correlation between boreholes. Variations between boreholes may exist due to previous land use or natural geologic processes. Additional deepening of the foundations, deeper than the minimum specified founding depths in this report, may be required. The actual subsurface conditions can be discerned only during earthworks when the subsurface profile can be directly observed.

For further information regarding geotechnical site investigation reports, refer to reference (7) below.

Inspection of all foundation excavations, site works and compaction must be conducted by a suitably qualified, experienced engineer, engineering geologist, building surveyor or similar to ensure that the founding material and site works are in accordance with this report. Should there be any doubt, this office should be immediately contacted.

Maintenance

Normal foundation maintenance requirements for reactive sites are not required for a foundation founded entirely on weathered rock.

Please do not hesitate to contact this office, should there be any further queries.

Yours Faithfully,
HardRock Geotechnical Pty Ltd

Harold McIntosh. B.E. (Civil)
(Geotechnical Engineer)

References:

(1) AS2870-2011. "Residential slabs and footings- Construction."
(2) "The Cement and Concrete Association of Australia", Technical note TN61.
(3) "Guide to home owners on foundation maintenance and footing performance", CSIRO sheet No. 10-91, August 1996.
(4) "Guidelines for the Provision of Geotechnical Information in Construction Contracts", published by the Institution of Engineers, Australia, l987.
(5) AS 3798-1996 "Guidelines on Earthworks for commercial and residential developments".
(6) AS1726-1993 "Geotechnical Site Investigations".
(7) AS2159-1995. "Piling – Design and Installation".
(8) AS2159 Supp1 - 1996. "Piling – Design and Installation Guidelines".
(9) Brinch Hansen, J (1961) " The ultimate resistance of rigid piles against transverse forces". -Danish Geotechnical Institute Bulletin no.12 pp5-9.
(10) Broms (1964a) 'The lateral resistance of piles in cohesive soils' Journal of the soil Mechanics and Foundations Division, American Society of Civil Engineer, vol. 90, no. SM3 pp 27-63.
(11) Broms (1964b) 'The lateral resistance of piles in cohesionless soils' Journal of the soil Mechanics and Foundations Division, American Society of Civil Engineer, vol. 90, no. SM3 pp 79-99.
(12) BS 8002-1994 "Earth Retaining Structures".
(13) AS 4678-2002 "Earth Retaining Structures".

HardRock Geotechnical P/L Consulting geotechnical engineers. **Borehole Logs**	**File**: 170334 **Date**: 09/03/2017 **Supervisor**: HM

Client: Ding and Sam Australia

Project: No. 261-263 Balwyn Road, Balwyn North

Borehole No. 1 **Drilling method**: A **Location:** see figure 1.

Depth (m)	Structure	Description	Cohesion/ density	Soil moisture/ groundwater	Testing:
	Pavement	concrete pavement			
0.08	SP	silty CLAY (CL), medium plasticity, orange/ brown/ grey grading to extremely weathered siltstone rock	ST	M	
0.60	weathered rock	distinctly weathered siltstone rock	D D	M M	
1.70		Refusal on distinctly weathered siltstone rock			

Borehole No. 2 **Drilling method**: HA **Location:** see figure 1.

Depth (m)	Structure	Description	Cohesion/ density	Soil moisture/ groundwater	Testing:
	Fill	clayey SILT/ gravel	L	M/D	
0.10	SP	clayey SILT (ML), low plasticity, grey	L	M/D	
0.40		silty CLAY (CL), medium plasticity, orange/ brown/ grey	D D	M M	
0.90		Refusal on distinctly weathered siltstone rock			

Legend:

Density	**Cohesion**	**Moisture**	**HA**-hand auger **A-** Flight auger drill rig.
VL-very Loose	Soft- Soft	W - wet	Unified soil Classification symbols: CL, SM, SW
L-Loose	F- Firm	M- moist	SP- Soil profile
MD- Medium Density	ST- stiff	D- dry	Some< 15%
D - dense	VST- Very Stiff		Trace< 5%

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Borehole Logs

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Borehole No. 3 **Drilling method**: HA **Location:** see figure 1.

Depth (m)	Structure	Description	Cohesion/ density	Soil moisture/ groundwater	Testing:
		clayey SILT (ML), low plasticity, grey	L	M/D	
0.30	SP	silty CLAY (CL), medium plasticity, orange/ brown/ grey grading to extremely weathered siltstone rock	ST	M	
0.70		Refusal on distinctly weathered siltstone rock			

Borehole No. 4 **Drilling method**: HA **Location:** see figure 1.

Depth (m)	Structure	Description	Cohesion/ density	Soil moisture/ groundwater	Testing:
	Fill	clayey SILT/ gravel	L	M	
0.20		clayey SILT (ML), low plasticity, grey	L	M	
0.45	SP	silty CLAY (CL), medium plasticity, orange/ brown/ grey grading to extremely weathered siltstone rock	ST	M	
0.80		Refusal on distinctly weathered siltstone rock			

Legend:

Density	Cohesion	Moisture	
VL-very Loose	Soft- Soft	W - wet	**HA**-hand auger **A-** Flight auger drill rig.
L-Loose	F- Firm	M- moist	Unified soil Classification symbols: CL, SM, SW
MD- Medium Density	ST- stiff	D- dry	SP- Soil profile
D - dense	VST- Very Stiff		Some< 15%
			Trace< 5%

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LOCATION PLAN

File: 170334
Date: 09/03/2017

Figure No. 1

Project:
No. 261-263 Balwyn Road, Balwyn North
Scale.
Not to Scale (sketch for borehole locations).

Legend:
⊕ Borehole
☐ Footing inspection

Appendix A – No. 261-263 Balwyn Road, Balwyn North

Material	Design Parameters						Poisson's Ratio	Young's Modulus (MPa)	K_0	K_p
	Drained		Undrained		Bulk Density γ (kN/m³)	Saturated Density γ (kN/m³)			$(1 - \sin\phi')$	$\frac{(1 + \sin\phi')}{(1 - \sin\phi')}$
	c´ (kPa)	ϕ´ (°)	C_u (kPa)	ϕ (°)						
FILL (loose)	0	28	0	28	17	20	0.1-0.2	1-5	0.53	2.76
clayey SILT (loose)	0	28	0	28	17	20	0.1-0.2	7-15	0.53	2.76
silty CLAY (stiff) including extremely weathered siltstone ROCK	3	25	100	0	18	18	0.2- 0.3	20-40	0.58	2.46
Distinctly weathered siltstone ROCK (high to moderately weathered)	3 (joint strength)	25 (joint strength)	200	0	24	24	0.2-0.3	150-500	0.58	2.46

Please note these parameters are difficult to measure and exhibit large natural variations. Sound engineering judgement is recommended in their use.