Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
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21 February 2011
Ref: 24711SYModellet

Beraci Pty Ltd
181-185 Parramatta Road
Granville NSW 2142

ATTENTION: Mr Arthur Maroon-Yacoub

PREDICTED GROUND MOVEMENTS
PROPOSED MIXED USE DEVELOPMENT
171-181 PARRAMATTA ROAD, GRANVILLE

This report presents the results of our finite element modelling of the proposed excavation and retention at 171-181 Parramatta Road, Granville. The modelling was commissioned by Arthur Maroon-Yacoub of Beraci Pty Ltd and was completed in accordance with our proposal (Ref: P333717SYemail, dated 16 December 2010).

The proposed development at 171-181 Parramatta Road consists of:

- Demolition of the existing buildings on site,
- Installation of a contiguous pile wall along the Duke Street frontage,
- Excavation to a basement bulk excavation level of RL1.8m, and
- Construction of a mixed use development incorporating two levels of basement carparking.

The purpose of the completed modelling is to predict the movements induced below the Main Western Railway Line (located to the west of the site on the other side of the Duke Street road reserve) as a result of the proposed excavation at 171-181 Parramatta Road, Granville.

Development of Geotechnical Model

To allow the impact of the proposed development on the Main Western Railway Line to be assessed a geotechnical model of the site and its surrounds was developed. This geotechnical model was then used in our numerical model to predict induced displacements below the railway line resulting from the proposed development.

A geological model was developed for one cross-section through the western site boundary. The location of this section is shown on the attached Figure 1. The detailed cross section is shown in Figure 2. The model is based on the subsurface results obtained from the boreholes completed during our investigation of the site which was presented in our report Ref: 18756SPrpt, dated 16 August 2004. Of this investigation, the only boreholes that extended to depths of greater than 1.5m were Boreholes 1, 6, 10, 11 and 13; these borehole logs have been attached to the rear of this report.

The model divides the subsurface profile into a number of soil and bedrock units. Geotechnical parameters were selected for each geological unit based on the borehole information, the results of field and laboratory strength testing and well established empirical correlations. We have completed no investigation of the rail embankment. In this regard it has been assumed that the rail embankment has been filled and has been moderately compacted. Consequently, typical soil parameters have been assumed for the fill.

This geotechnical model was then used as the basis for our numerical model. PLAXIS 2D, a two-dimensional finite element computer program was used to complete numerical analysis. Staged modelling was completed for each part of the excavation and retention sequence next to the boundary. The predicted cumulative displacements below the railway line as a result of the excavation and retention works at 171-181 Parramatta Road were calculated and are reported below. The movements of the retention system have also been provided.

Model Geometry

Cross Section 1 presents the model geometry and is shown in Figure 2. The surface levels were based on the reduced levels shown in the survey plan prepared by Gary Edwards and Associates Pty Ltd (Drawing Ref: 1618, Dated 12 July 2001) and the structural drawings prepared by HKMA Engineers (Drawing Number: 6070-SO2, 03 and 04, Issues: B, B and A respectively). .

Surcharge loads have been adopted for both the rail corridor and the Duke Street road reserve. In both cases a 10kPa uniformly distributed load has been adopted. In the case of the Duke Street road reserve the surcharge load extends from the top of the shoring system to the base of the existing retaining wall located on the boundary between the road reserve and the rail corridor. In rail corridor the surcharge load has been applied at the crest of the embankment where the railway tracks are located.

The geometry of the proposed retention system (ie anchor spacing, anchor level, anchor inclination and loads, the location of the retention system and the reduced level of the floor slabs) is based on the structural drawings prepared by HKMA Engineers as referenced above. These drawings have been attached in Appendix A.

Geotechnical Parameters

A small strain soil hardening model was used to model the behaviour of the soils while the shale bedrock was modelled using the Mohr-Coulomb model. The tables below detail the parameters adopted for soils and the shale bedrock respectively.

Geotechnical Parameters Adopted for Soils		
Parameter	Fill	Silty Clay Stiff - Very Stiff
Unsaturated Unit Weight (kN/m^3)	18	18
Saturated Unit Weight (kN/m^3)	21	21
Cohesion (c) (kPa)	0.5	2
Internal Angle of Friction (ϕ)	25	28
Modulus (E_{50}) (MPa)	10	15
Modulus (E_{oed}) (MPa)	5	7.5
Unload/Reload Modulus (E_{ur}) (MPa)	30	45
Shear Strain at $0.7G_0$	1.5×10^{-4}	1.5×10^{-4}
Reference Shear Modulus G_0^{ref}(MPa)	32	47

Geotechnical Parameters Adopted for Shale Bedrock					
Unit	*Unit Weight (kN/m^3)*	*Cohesion (c) (kPa)*	*Internal Angle of Friction (ϕ)*	*Youngs Modulus (E) (MPa)*	*Poissons Ratio*
Extremely Low Strength	23	20	28°	100	0.3
Low Strength or better	23	250	30°	500	0.25

Where soil or bedrock is in contact with structural elements, a reduction factor (R_{inter}) of 0.5 has been adopted. This is applied to the soil or bedrock strength parameters to model the reduction in shear strength between the two dissimilar materials.

Structural Parameters

The following structural parameters have been adopted for the structural elements

Structural Parameters Adopted					
Structural Element	*Bulk Unit Weight (kN/m^3)*	*Youngs Modulus (E) (kPa)*	*Second Moment of Inertia (I) per meter run (m^4/m)*	*Cross Sectional Area*	*Poissons Ratio*
Contiguous Pile Wall (0. 5m diameter piles)*	24	2.8×10^7	3.068×10^{-3}	$0.357m^2/m$ run	0.15
Floor Slabs	-	2.8×10^7	-	$0.2m^2/m$ run	-
Anchor – Bond Length	-	2.8×10^7	-	$7.85 \times 10^{-3}m^2$ per anchor	-
Anchor – Free Length	-	2.1×10^8	-	$4.28 \times 10^{-4}m^2$ per anchor	

* Assumes a 50mm gap is left between each pile

The values in the table above per meter run are based on an anchor spacing of 3m. The area of the free length of the anchors is based on 3 x 15.2mm strands.

The anchor and slab levels adopted in the model are presented below.

Reduced Level of Anchors and Slabs	
Anchor 1	6m
Slab 1 (FFL)	8.6m
Slab 2 (FFL)	5m
Slab 3 (FFL)	2m

Model Stages

The model was run through a number of stages in an attempt to simulate the history of the site. The stages are set out as follows:

1. Apply surcharge loads.
2. Install the contiguous pile wall.
3. Excavate to RL5.5m (ie 0.5m below the level of Anchor 1).
4. Install anchors at RL6m. These anchors have been prestressed to 400kN with an anchor spacing of 3m.
5. Excavate to RL1.8m, bulk excavation level (BEL). .
6. Install floor slabs at RL2m, RL5m and RL6.8m.
7. De-stress anchors.

Initial Stress State

The stress state in the model was developed by using the K_o method. A nil step was then run after the initial calculation stage. The purpose of this nil stage was to allow the stresses to re-orientate themselves to more accurately reflect the stress state that will occur where a non-horizontal surface exists.

Results

The analysis results for both sections are tabulated below. We note that on completion of analysis *Stage 1 Apply surcharge loads*, all displacements were reset to zero. This zeroing of movements allows only the movements induced by the excavation and retention at 171-181 Parramatta Road to be analysed. In the tables below we have provided results of the modelling for stages 3, 4, 5, and 7. The results summarised in these tables include both movements induced below the railway line and movements of the installed contiguous pile retaining wall itself. Figures 3 to 6 present graphical representations of the movements.

Maximum Cumulative Displacement		
Stage	Cumulative Displacement* below Railway Tracks (mm)	Cumulative Displacement* of Contiguous Pile Retaining Wall (mm)
3	2.1	30.8
4	2.1	21.0
5	3.7	28.5
7	3.9	28.6

*Displacements are the vector values. The horizontal and vertical components can be assessed from Figures 3 to 6

Based on the above results settlements induced below the alignment of the railway track as a result of the proposed excavation and retention are less than 5mm, and show only slight variation over the proposed construction stages. Nevertheless, we believe that these predicted movements are in themselves conservative. The soil parameters adopted are typically conservative. In addition, two dimensional analysis by its very nature is usually a more conservative tool than three dimensional analysis when predicting movements. Two dimensional modelling does not take into account three dimensional effects such as the plan geometry of the excavation and buttressing that occurs as a result of geometry that serves to limit deflections. In summary, the predicted movements are likely to be greater than those likely to occur in practice and probably provide an upper bound prediction of movements.

Factors of Safety (FOS) have been calculated at all temporary and permanent stages. The FOS for each stage has been calculated using the c-phi method, which progressively reduces the material parameters for the soils and bedrock until failure. Consequently, as the factor is not a lumped factor, but targets material properties and the uncertainties surrounding the material strengths, an acceptable factor of safety of 1.2 rather than 1.5 is generally adopted (Embedded Retaining Walls- Guidance For Economic Design, Ciria C580). The FOS was calculated be to greater than 1.2 in all permanent and temporary stages.

The proposed retention system consists of a contiguous pile wall with one row of anchors. Excavation to achieve BEL is likely to touch the top of the underlying shale bedrock. To allow for the possibility of some over excavation in front of the proposed wall we recommend that all piles have a minimum depth of embedment below the proposed BEL (including localised excavations for footings services etc.) of 1.5m with a socket length within shale bedrock of at least low strength of 1m.

The proposed excavation and construction will result in the generation of some behind-wall movements. Where services are located behind the wall, their integrity and ability to tolerate the proposed movements should be checked. Where they are unable to tolerate the movements, rectification works should be undertaken so that they have the required flexibility.

Summary and Conclusion

The modelling has shown that the effect of the proposed excavation and retention at 171-181 Parramatta Road will induce minor settlements of less than 5mm below the railway tracks. As discussed above, we believe that due to the limitations of two-dimensional modelling, and the parameters and modelling techniques adopted predicted settlements are probably conservative and higher than those that will be experienced during construction, however the extent is difficult to quantify.

General Comments

Plaxis 2D Version 9.0 has been used to model the effect of excavation and retention at 171-181 Parramatta Road on the Main Western Railway Line. Whilst all efforts have been made to check the reasonableness of the reported results the simulation of geotechnical problems by means of the finite element method implicitly involves some inevitable numerical approximations. Consequently, while results have been calculated to one decimal place, it is unlikely that their accuracy is to this order. Observation of displacements during the proposed stages of construction should be used to verify the accuracy of the analysis.

The modelling has been based on information available to us, which has been checked for accuracy to the extent reasonably possible. If additional information becomes available at any stage during the project which appears in conflict with current assumptions then we should immediately be notified and asked to review our analysis.

Should you require any further information regarding the above please do not hesitate to contact the undersigned.

Yours faithfully
For and on behalf of
JEFFERY AND KATAUSKAS PTY LTD

Woodie Theunissen
Associate

Reviewed by:

Paul Stubbs
Principal

Attached
Borehole Logs 1, 6, 10, 11 and 13 inclusive
Table A: Summary of Point Load Strength Index Test Results

Figure 1: Borehole Location Plan
Figure 2: Cross Section 1-1
Figure 3: Section 1 - Stage 3 Excavate to RL5.5m
Figure 4: Section 1 - Stage 4 Install 1st Row of Anchors at RL6m
Figure 5: Section 1 - Stage 5 Excavate to BEL RL1.8m
Figure 6: Section 2 - Stage 7 Destress 1st Row of Anchors

Appendix A: Structural Plans prepared by HKMA Engineers (Drawing Number: 6070-SO2, 03 and 04, Issues: B, B and A respectively

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SOIL TEST SERVICES

TABLE A
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S\,(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
13	9.24-9.27	0.7	14
	9.87-9.89	1.0	20
	10.25-10.28	0.6	12
	10.78-10.81	0.7	14
	11.16-11.19	0.6	12
	11.90-11.93	0.5	10

NOTES:

1. In the above table testing was completed in the Axial direction.
2. The above strength tests were completed at the 'as received' moisture content.
3. Test Method: RTA T223.
4. The Estimated Unconfined Compressive Strength was calculated from the point load Strength Index by the following approximate relationship and rounded off to the nearest whole number :
   U.C.S. $= 20\ I_{S\,(50)}$

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SOIL TEST SERVICES

TABLE A
SUMMARY OF POINT LOAD STRENGTH INDEX TEST RESULTS

BOREHOLE NUMBER	DEPTH m	$I_{S(50)}$ MPa	ESTIMATED UNCONFINED COMPRESSIVE STRENGTH (MPa)
1	10.18-10.22	0.6	12
	10.87-10.91	0.7	14
	11.17-11.21	0.8	16
	11.80-11.84	0.6	12
	12.16-12.20	0.4	8
	12.74-12.77	0.5	10
	13.00-13.06	0.5	10
6	9.35-9.38	1.0	20
	9.86-9.90	0.6	12
	10.32-10.35	0.5	10
	10.78-10.81	0.7	14
	11.16-11.20	0.8	16
	11.75-11.79	0.5	10
	12.18-12.21	0.7	14
10	9.08-9.12	0.7	14
	9.75-9.78	0.7	14
	10.18-10.22	0.5	10
	10.77-10.81	0.7	14
	11.16-11.19	0.6	12
	11.77-11.81	0.4	8
11	8.88-8.91	0.5	10
	9.16-9.20	1.2	24
	9.89-9.91	0.6	12
	10.24-10.27	0.9	18
	10.86-10.89	0.9	18
	11.26-11.29	0.6	12

NOTES: **SEE PAGE 2**

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BOREHOLE LOG

Borehole No. 1
1/3

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 28-7-04
Method: SPIRAL AUGER JK550
R.L. Surface:
Datum:
Logged/Checked by: A.H./PW

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
	ES		0			FILL: Gravelly clay, medium plasticity, brown, with concrete, brick and fibro fragments, timber and fine to coarse grained sand.	MC>PL			
	ES, DS	N = 18 5,8,10			CL	SILTY CLAY: medium plasticity, grey mottled orange brown and red brown.	MC<PL	H	- >600 >600	
			1			SILTY CLAY: low to medium plasticity, grey mottled orange brown and red brown.	MC>PL	VSt		
	DS	N = 14 6,6,8							250 420 300	
			2		CH	SILTY CLAY: high plasticity, grey mottled red brown and orange brown.				
ON COMPLETION OF CORING	DS	N = 13 4,6,7	3						360 250 360	
			4		CL	SILTY CLAY: medium plasticity, grey mottled red brown and orange brown.				
	DS	N = 18 5,8,10							320 310 250	
			5					St-VSt		
	DS	N = 6 2,3,3	6						100 120 250	
						as above, but with fine to coarse grained ironstone gravel bands.				
			7							

BOREHOLE LOG

Borehole No.
1

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 28-7-04
Method: SPIRAL AUGER JK550
Logged/Checked by: A.H./PW
R.L. Surface:
Datum:

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
				■	N = 22 8,10,12	8			SILTY CLAY: medium plasticity, grey mottled red brown and orange brown, with fine to coarse grained ironstone gravel bands.	MC>PL	St-VSt		
						9		-	SHALE: grey mottled orange brown.	XW	EL	-	
									SHALE: grey brown.	DW	L-M		LOW 'TC' BIT RESISTANCE
						10			SHALE: dark grey.	SW	M		LOW TO MODERATE RESISTANCE
						11 12 13 14			REFER TO CORED BOREHOLE LOG				

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Borehole No.
1

CORED BOREHOLE LOG

Client:	BERACI PTY LTD
Project:	PROPOSED RESIDENTIAL DEVELOPMENT
Location:	171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP	**Core Size:** NMLC	**R.L. Surface:**
Date: 28-7-04	**Inclination:** VERTICAL	**Datum:**
Drill Type: JK550	**Bearing:** -	**Logged/Checked by:** A.H./PW

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		9		START CORING AT 10.0m						
FULL RETURN		10		SHALE: dark grey, with thin light grey bands, bedded at 0°.	SW	M	×		- Be, 0°, Un, R - Be, 0°, Un, R - J, 20°, Un, R - Be, 0°, Un, R	
		11					× × ×		- Be, 0°, Un, R - Be, 0°, Un, R - Be, 0°, Un, R - Be, 0°, Un, R	
		12					× × ×		- Cr, 0°, 3mm.t - Cr, 0°, 5mm.t - J, 20°, Un, R - J, 80°, Un, R	
		13		END OF BOREHOLE AT 13.10m						
		14								
		15								

Jeffery and Katauskas Pty Ltd

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BOREHOLE LOG

Borehole No. **6**

1/3

Client: BERACI PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP **Method:** SPIRAL AUGER JK250 **R.L. Surface:**

Date: 27-7-04 **Datum:**

Logged/Checked by: A.H./PW

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			CONCRETE: 100mm.t				NO APPARENT REINFORCEMENT
	ES				-	FILL: Gravelly clay, medium plasticity, dark grey, fine to coarse grained igneous gravel, with slag and concrete fragments.	MC>PL	-	-	
	ES, DS	N = 7 3,3,4			CH	SILTY CLAY: high plasticity, grey mottled red brown and orange brown.	MC>PL	St	150 160 170	
			1					VSt		
	DS	N = 12 5,6,6							250 300 200	
			2					St		
ON COMPLETION OF CORING	DS	N = 10 3,5,5	3							
			4							
	DS	N = 14 4,5,9						VSt	150 200 210	
			5			as above, but with fine to coarse grained ironstone gravel bands.				
	DS	N > 18 11,18/ 150mm REFUSAL	6					H	450 450	
					-	SHALE: grey mottled orange brown.	XW	EL		
							DW	L		VERY LOW 'TC' BIT
			7							

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Borehole No. **6**

2/3

BOREHOLE LOG

Client: BERACI PTY LTD

Project: PROPOSED RESIDENTIAL DEVELOPMENT

Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP

Date: 27-7-04

Method: SPIRAL AUGER JK250

Logged/Checked by: A.H./PW

R.L. Surface:

Datum:

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SHALE: grey mottled orange brown.	DW	L		RESISTANCE
											M		LOW RESISTANCE
						8							
											M-H		MODERATE RESISTANCE
						9							
									REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

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CORED BOREHOLE LOG

Borehole No. 6

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP | **Core Size:** NMLC | **R.L. Surface:**
Date: 27-7-04 | **Inclination:** VERTICAL | **Datum:**
Drill Type: JK550 | **Bearing:** - | **Logged/Checked by:** A.H./PW

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION: Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ (EL VL L M H VH EH)	DEFECT SPACING (mm) (500 300 100 50 30 10)	DEFECT DETAILS – DESCRIPTION: Type, inclination, thickness, planarity, roughness, coating. Specific	General
		8								
		9		START CORING AT 9.19m						
FULL RET-URN		10 – 12		SHALE: dark grey, with thin light grey bands, bedded at 0°.	SW	M			- Cr, 0°, 3mm.t - J, 30°, Un, R - J, 60°, Un, R - Cr, 0°, 3mm.t - Cr, 0°, 5mm.t - Be, 0°, Un, R - J, 20°, Un, R - Cr, 60mm.t - Be, 0°, Un, R - Be, 0°, Un, R	
				END OF BOREHOLE AT 12.27m						
		13								
		14								

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Borehole No. **10**
1/3

BOREHOLE LOG

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 27-7-04
Method: SPIRAL AUGER JK250
R.L. Surface:
Datum:
Logged/Checked by: A.H./PW

Groundwater Record	SAMPLES (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			CONCRETE: 140mm.t				7mm DIAMTER REINFORCEMENT AT 100mm TOP COVER
	ES				-	FILL: Silty clay, high plasticity, brown, with fine to coarse grained igneous gravel and concrete fragments.	MC>PL	-	-	
	ES, DS	N = 5 1,2,3			CH	SILTY CLAY: high plasticity, grey mottled orange brown and red brown.	MC>PL	St	- 150 160 140	
			1					VSt		
	DS	N = 15 5,6,9							300 350 350	
			2							
ON COMPLETION OF CORING										
	DS	N = 19 6,8,11	3						200 200 320	
			4							
	DS	N = 18 5,7,11							350 380 300	
			5							
	DS	N = 13 4,6,7	6						350 300 250	
			7							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

BOREHOLE LOG

Borehole No. **10**

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 27-7-04
Method: SPIRAL AUGER JK250
R.L. Surface:
Datum:
Logged/Checked by: A.H./PW

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
								CH	SILTY CLAY: high plasticity, grey mottled orange brown and red brown.	MC>PL	VSt		
▶				■	N > 18 8,18/ 150mm REFUSAL			-	SHALE: grey mottled orange brown.	XW	EL	-	
						8			SHALE: grey brown.	DW	VL-L		VERY LOW 'TC' BIT RESISTANCE
											L-M		
						9			SHALE: dark grey, with high strength iron indurated bands.	SW			MODERATE RESISTANCE WITH HIGH BANDS
									REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

Jeffery and Katauskas Pty Ltd
CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS

CORED BOREHOLE LOG

Borehole No. 10
3/3

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP	**Core Size:** NMLC	**R.L. Surface:**
Date: 27-7-04	**Inclination:** VERTICAL	**Datum:**
Drill Type: JK550	**Bearing:** -	**Logged/Checked by:** A.H./PW

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		8		START CORING AT 8.95m						
FULL RETURN		9		SHALE: dark grey, with thin light grey bands, bedded at 0°.	SW	M			- J, 60°, Un, R - J, 50°, Un, R - Cr, 0°, 1mm.t - J, 40°, Un, R - J, 45°, Un, R - J, 50°, Un, R - Cr, 40mm.t	
		10								
		11								
		12		END OF BOREHOLE AT 12.03m						
		13								
		14								

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Borehole No. **11**
1/3

BOREHOLE LOG

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 26-7-04
Method: SPIRAL AUGER JK250
R.L. Surface:
Datum:
Logged/Checked by: A.H./PW

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			CONCRETE: 100mm.t				7mm DIAMETER REINFORCEMENT AT 100mm TOP COVER
					-	FILL: Sand, fine to medium grained, orange brown.	M	-	-	
					-	FILL: Sand, fine to medium grained, orange brown, with fine to coarse grained gravel and concrete fragments.	-	-	-	
					-	CONCRETE: 150mm.t	MC>PL	St	-	
			1		CH	FILL: Silty clay, medium to high plasticity, grey brown, with fine to coarse grained gravel.	MC>PL			
		N = 10 1,2,8				SILTY CLAY: high plasticity, grey mottled red brown.		VSt	100 350 450	
			2							
ON COMPLETION OF CORING										
		N = 10 3,4,6	3						220 250 260	
			4							
		N = 24 3,10,14							280 300 250	
			5							
			6							
					-	SHALE: grey brown, with low strength bands, iron indurated bands and clay bands.	XW	EL		VERY LOW 'TC' BIT RESISTANCE
			7							

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Borehole No. **11**
2/3

BOREHOLE LOG

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP **Method:** SPIRAL AUGER JK250 **R.L. Surface:**
Date: 26-7-04 **Datum:**
Logged/Checked by: A.H./PW

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SHALE: grey brown, with low strength bands, iron indurated bands and clay bands.	XW	EL		
▶										DW	L-M		
						8			SHALE: dark grey.		M		MODERATE RESISTANCE
						9			REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

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Borehole No. 11

3/3

CORED BOREHOLE LOG

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP	**Core Size:** NMLC	**R.L. Surface:**
Date: 26-7-04	**Inclination:** VERTICAL	**Datum:**
Drill Type: JK550	**Bearing:** -	**Logged/Checked by:** A.H./PW

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DETAILS DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		8		START CORING AT 8.45m						
FULL RET-URN		9, 10, 11		SHALE: dark grey, with thin light grey bands, bedded at 0°.	SW	M	× × × × × ×		- Cr, 60mm.t - XWS, 0°, 3mm.t - J, 75°, Un, R - J, 45°, Un, R - J, 85°, Un, R	
		12, 13, 14		END OF BOREHOLE AT 11.5m						

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Borehole No.
13

BOREHOLE LOG

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 26-7-04
Method: SPIRAL AUGER JK250
Logged/Checked by: A.H./PW
R.L. Surface:
Datum:

Groundwater Record	Samples (ES, U50, DB, DS)	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
			0			ASPHALTIC CONCRETE: 40mm.t				
						FILL: Gravelly sand, fine to coarse grained, brown, fine to coarse grained igneous gravel.	M	-	-	ROADBASE
		N = 3 1,1,2			CH	FILL: Gravelly sand, fine to coarse grained, brown, fine to coarse grained igneous gravel, with brick fragments and clay.	MC>PL	St	100 110 110	
			1			SILTY CLAY: high plasticity, orange brown.				
						SILTY CLAY: high plasticity, grey mottled red brown.		VSt		
		N = 15 3,6,9							320 390 360	
			2							
ON COMPLETION OF CORING										
		N = 14 7,7,7	3						320 400 350	
			4			as above, but with fine to coarse grained ironstone gravel bands.	MC<PL	H		
		N = 30 8,10,20							410 >600	
			5							
		N > 22 12,22/ 150mm REFUSAL	6		-	SHALE: grey mottled red brown, with iron indurated bands.	XW	EL	>600 >600	
			7							

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Borehole No. 13

BOREHOLE LOG

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP
Date: 26-7-04
Method: SPIRAL AUGER JK250
R.L. Surface:
Datum:
Logged/Checked by: A.H./PW

Groundwater Record	SAMPLES ES	U50	DB	DS	Field Tests	Depth (m)	Graphic Log	Unified Classification	DESCRIPTION	Moisture Condition/ Weathering	Strength/ Rel. Density	Hand Penetrometer Readings (kPa.)	Remarks
									SHALE: grey brown.	DW	L		VERY LOW 'TC' BIT RESISTANCE
						8							
▶									SHALE; dark grey.	SW	M		LOW RESISTANCE WITH MODERATE BANDS
						9							HIGH RESISTANCE
									REFER TO CORED BOREHOLE LOG				
						10							
						11							
						12							
						13							
						14							

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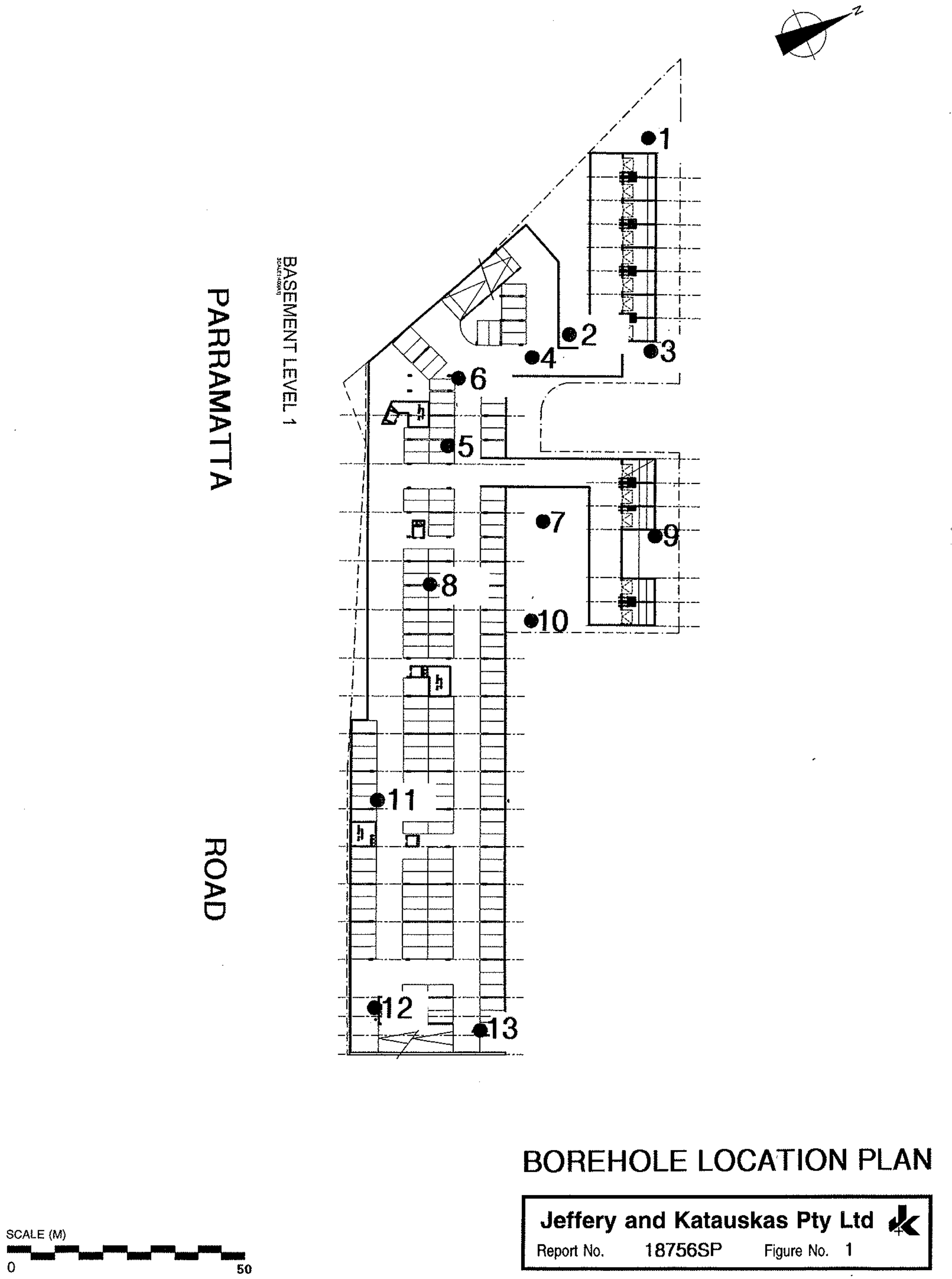
CORED BOREHOLE LOG

Borehole No. **13**
3/3

Client: BERACI PTY LTD
Project: PROPOSED RESIDENTIAL DEVELOPMENT
Location: 171-189 PARRAMATTA ROAD, GRANVILLE, NSW

Job No. 18756SP | **Core Size:** NMLC | **R.L. Surface:**
Date: 28-7-04 | **Inclination:** VERTICAL | **Datum:**
Drill Type: JK550 | **Bearing:** - | **Logged/Checked by:** A.H./PW

Water Loss/Level	Barrel Lift	Depth (m)	Graphic Log	CORE DESCRIPTION Rock Type, grain characteristics, colour, structure, minor components.	Weathering	Strength	POINT LOAD STRENGTH INDEX $I_s(50)$ EL VL L M H VH EH	DEFECT SPACING (mm) 500 300 100 50 30 10	DEFECT DESCRIPTION Type, inclination, thickness, planarity, roughness, coating. Specific	General
		8								
		9		START CORING AT 9.15m						
FULL RETURN				SHALE: dark grey with thin light grey bands, bedded at 0°.	SW	M	×		- Be, 0°, Un, R - 2 x Be, 0°, Un, R - Be, 0°, Un, R - Be, 0°, Un, R - Be, 0°, Un, R - 2 x Be, 0°, Un, R	
		10					× ×		- Be, 0°, Un, R - Be, 0°, Un, R	
		11					× ×		- Be, 0°, Un, R - Be, 0°, Un, R - Be, 0°, Un, R - Cr, 10mm.t	
		12		END OF BOREHOLE AT 12.1m			×			
		13								
		14								



BOREHOLE LOCATION PLAN

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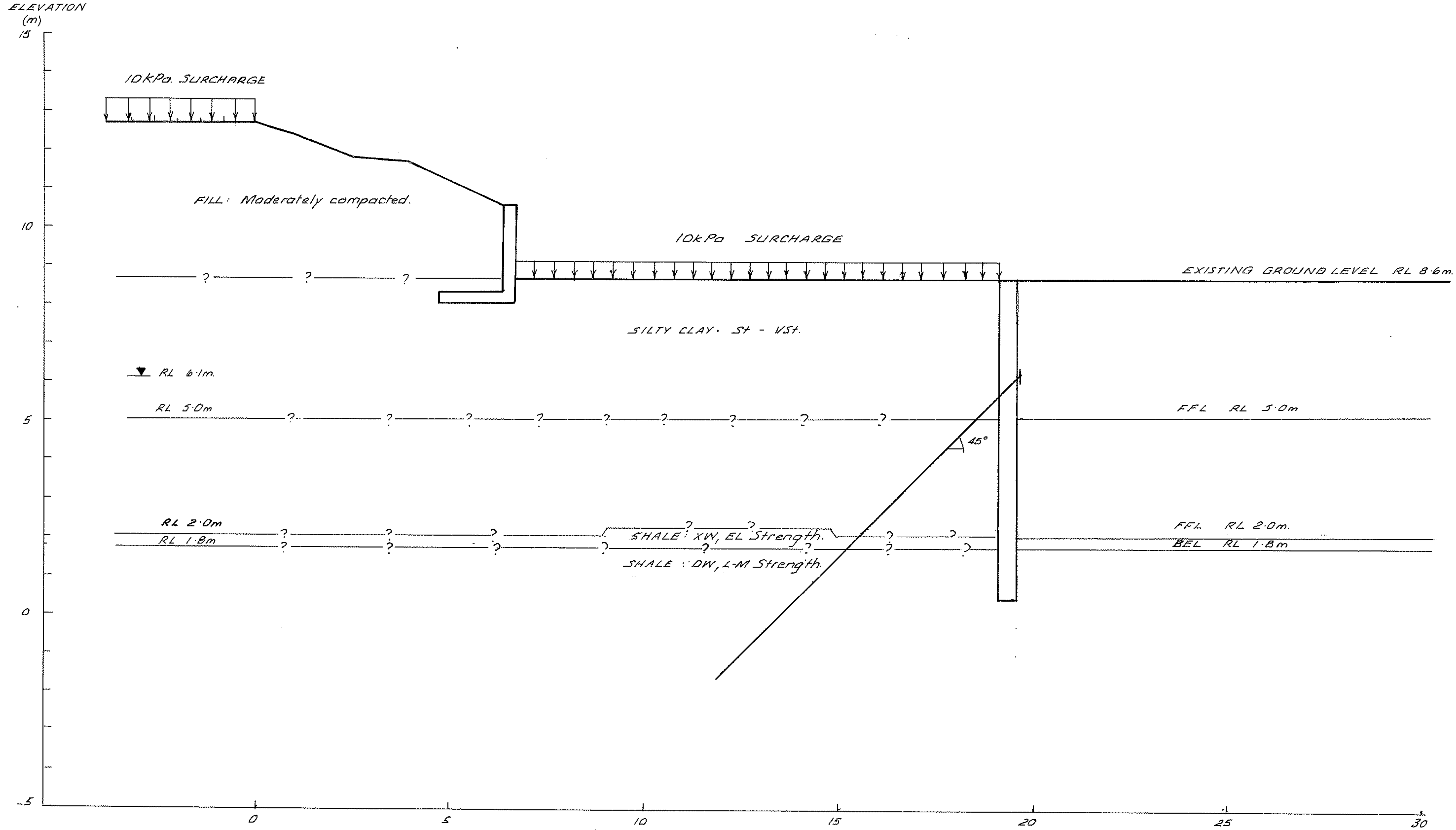
Report No. 18756SP Figure No. 1

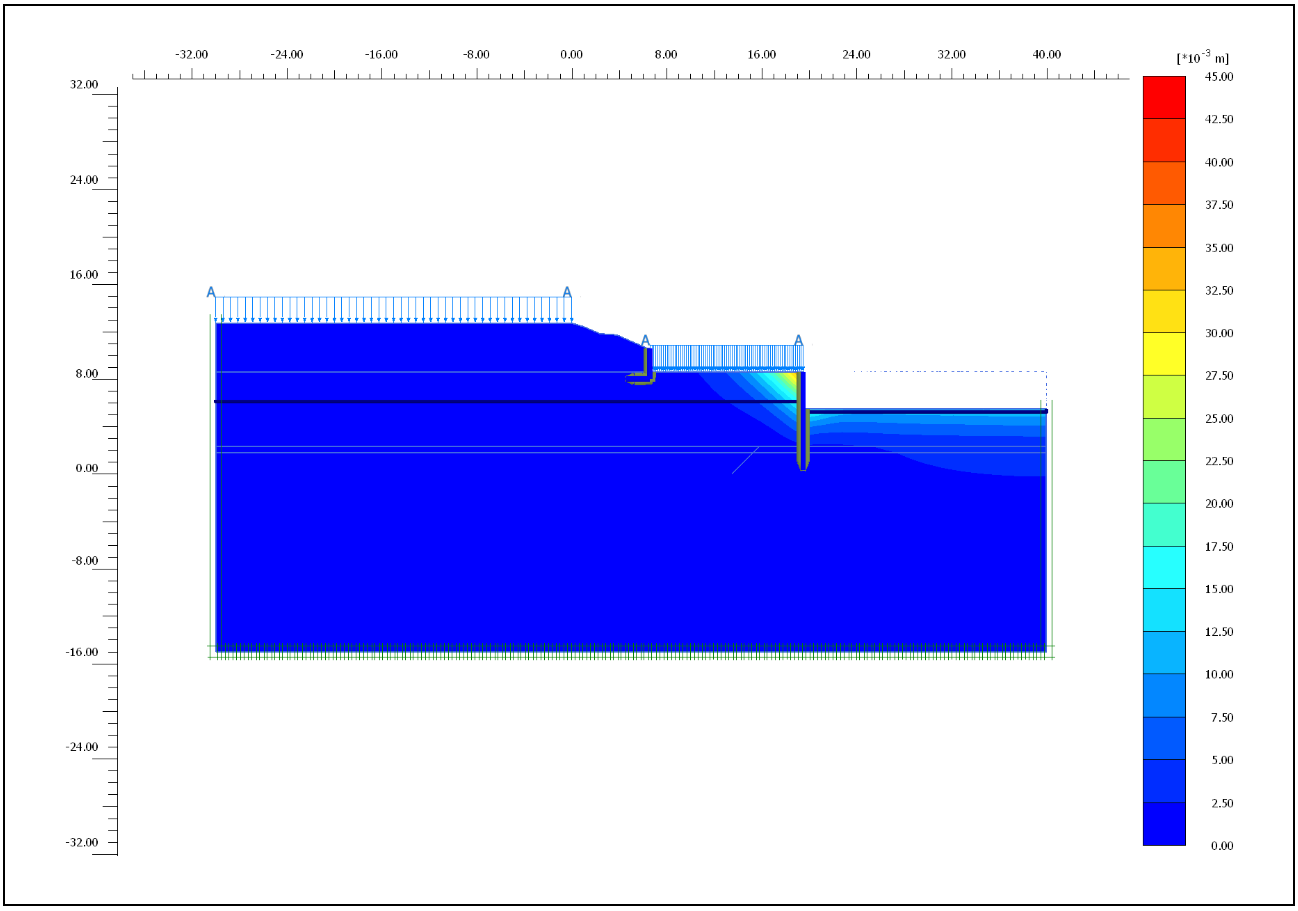


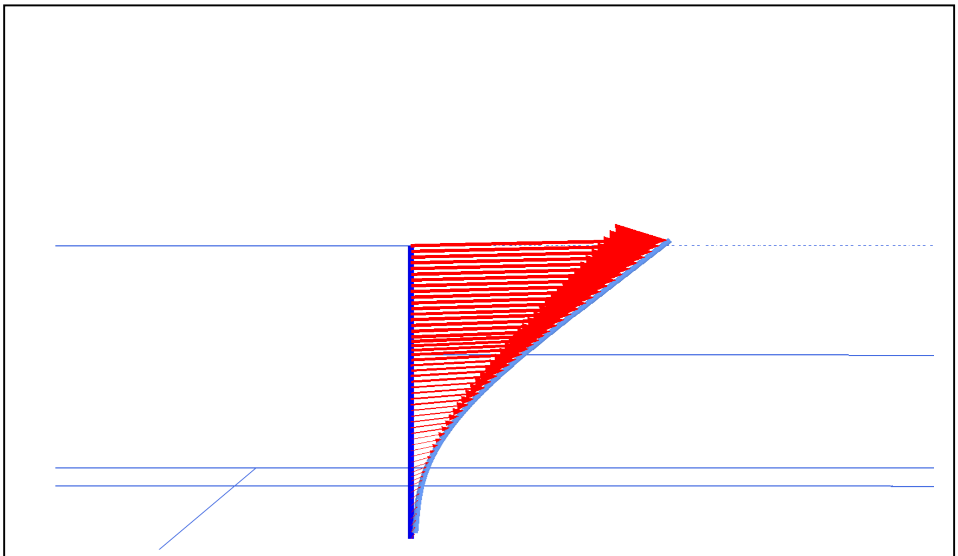
SECTION 1-1

SCALE (M)
0 10

Jeffery and Katauskas Pty Ltd
Report No. 24711SY Figure No. 2

Section 1 - Stage 3 Excavate to RL5.5m





Max Wall Displacement 33.3mm

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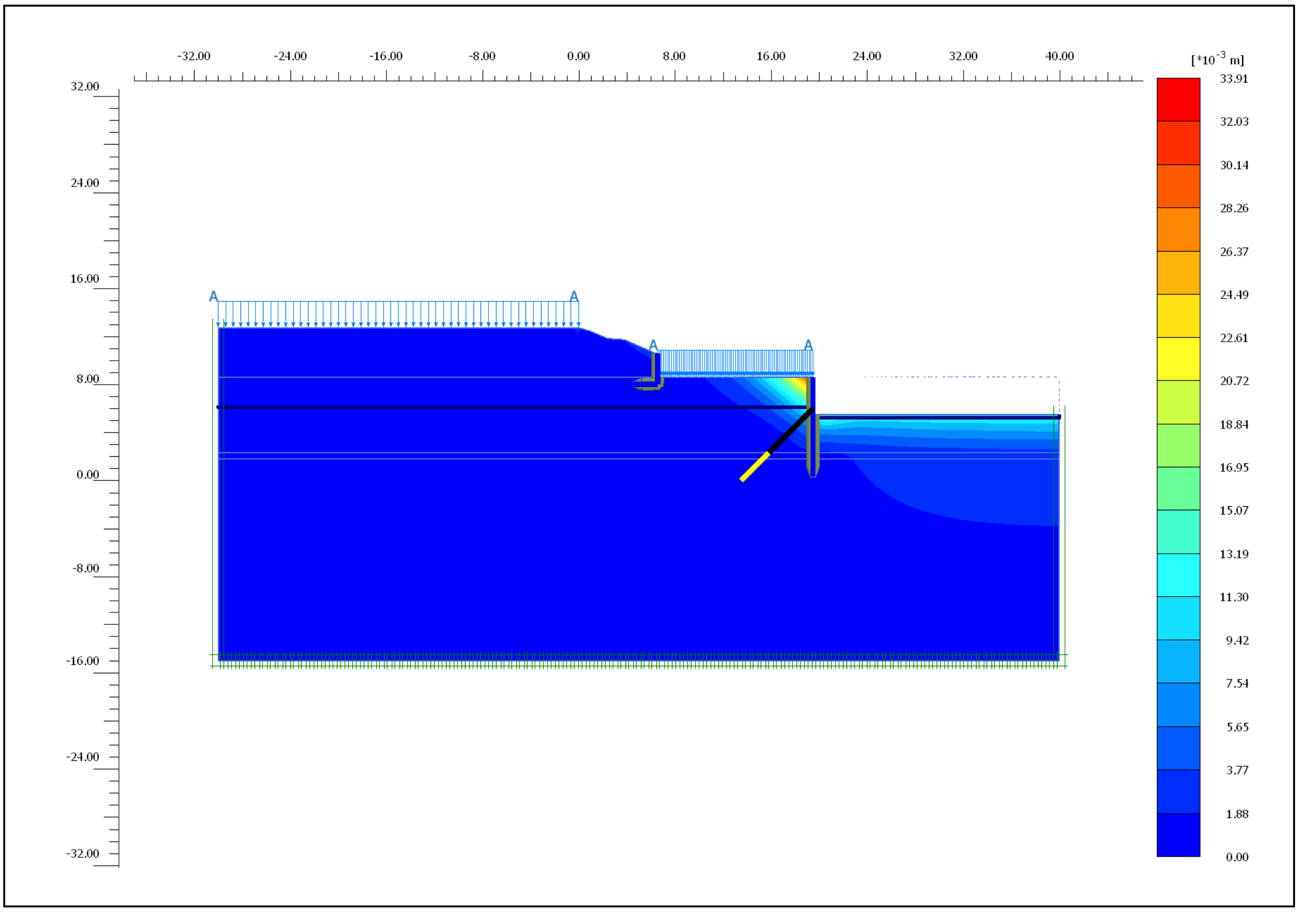
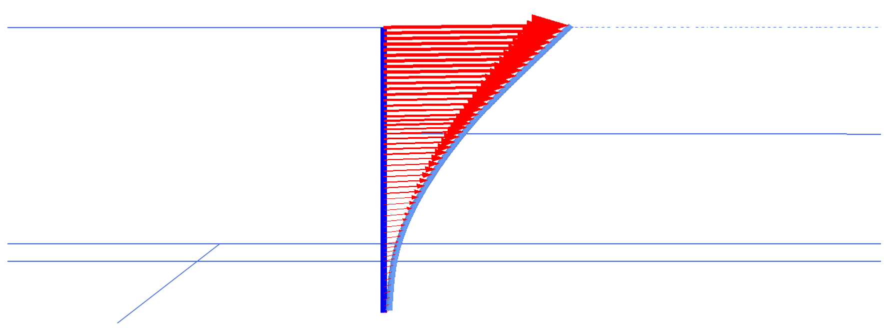
Report No. 24711SY **Figure No. 3**

Section 1 - Stage 4 Install 1st Row of Anchors at RL6m





Max Wall Displacement 23.4mm

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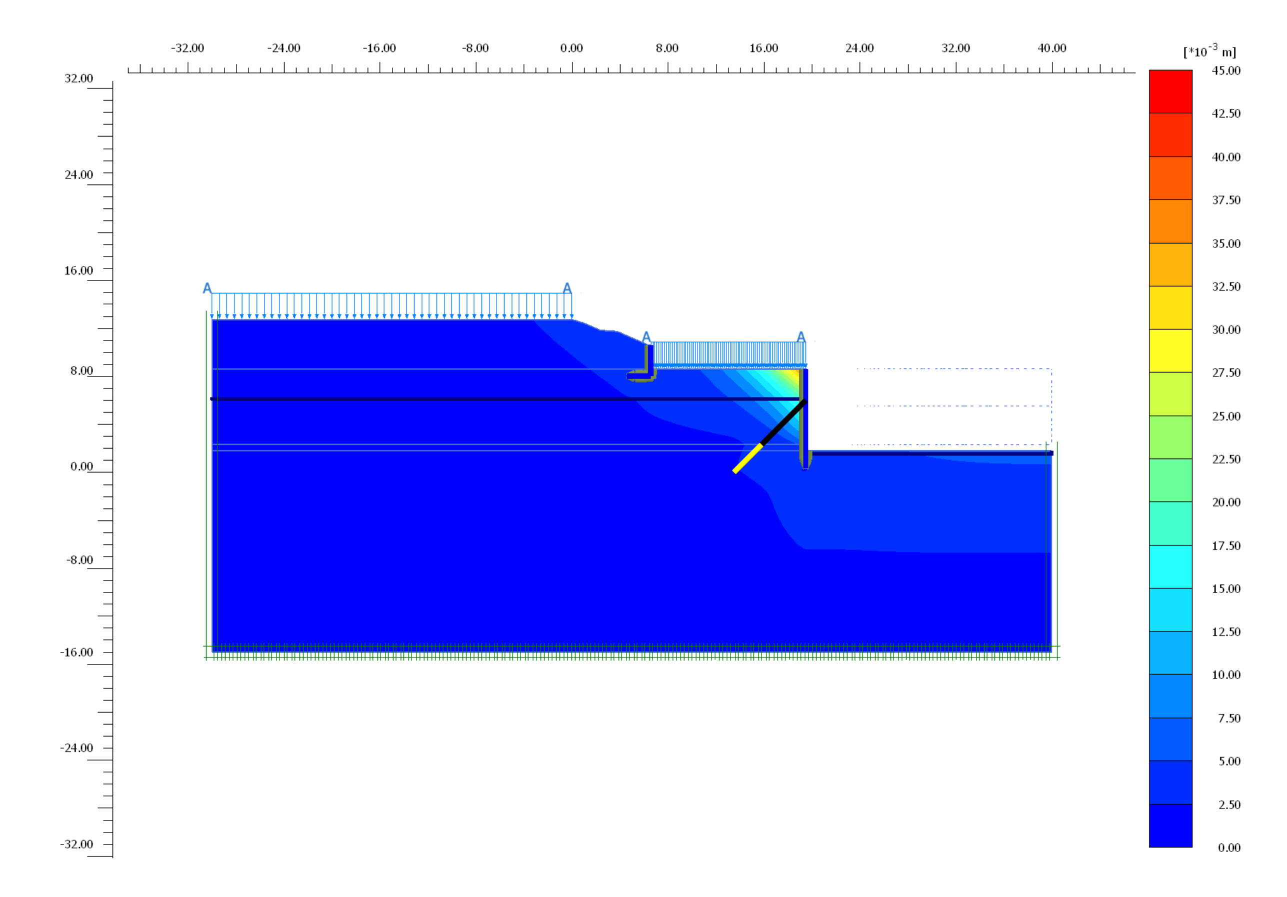
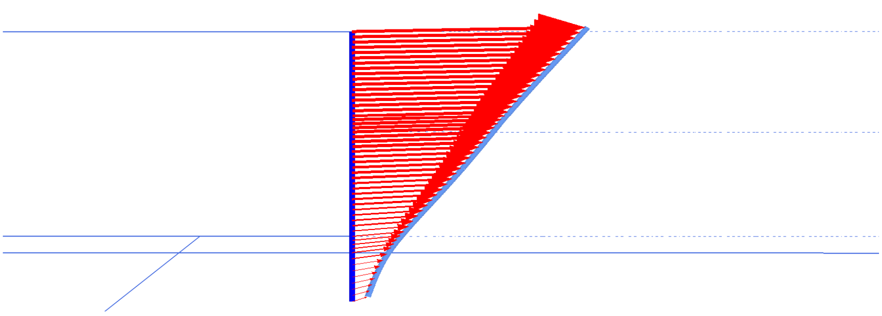
Report No. 24711SY **Figure No. 4**

Ref: 24711SYModellet

Section 1 - Stage 5 Excavate to BEL RL1.8m





Max Wall Displacement 34.6mm

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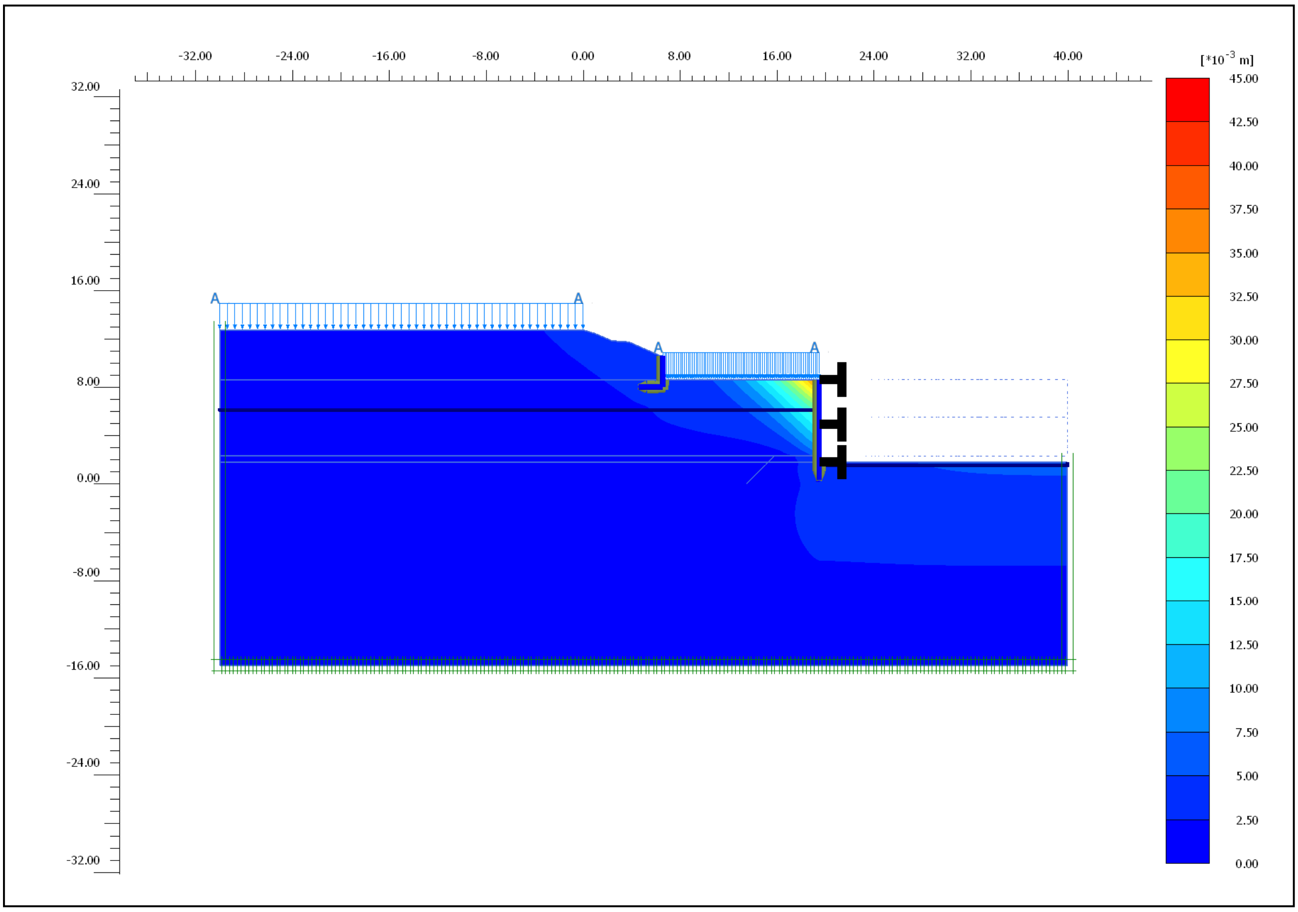
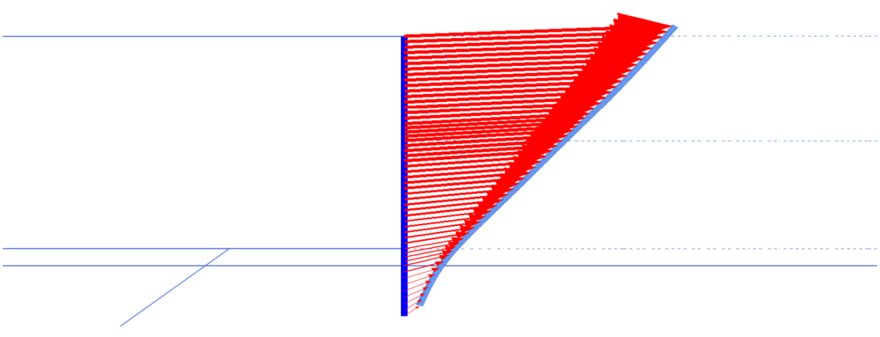
Report No. 24711SY **Figure No. 5**

Section 1 - Stage 7 Floor Slabs Installed Destress Anchor





Max Wall Displacement 28.6mm

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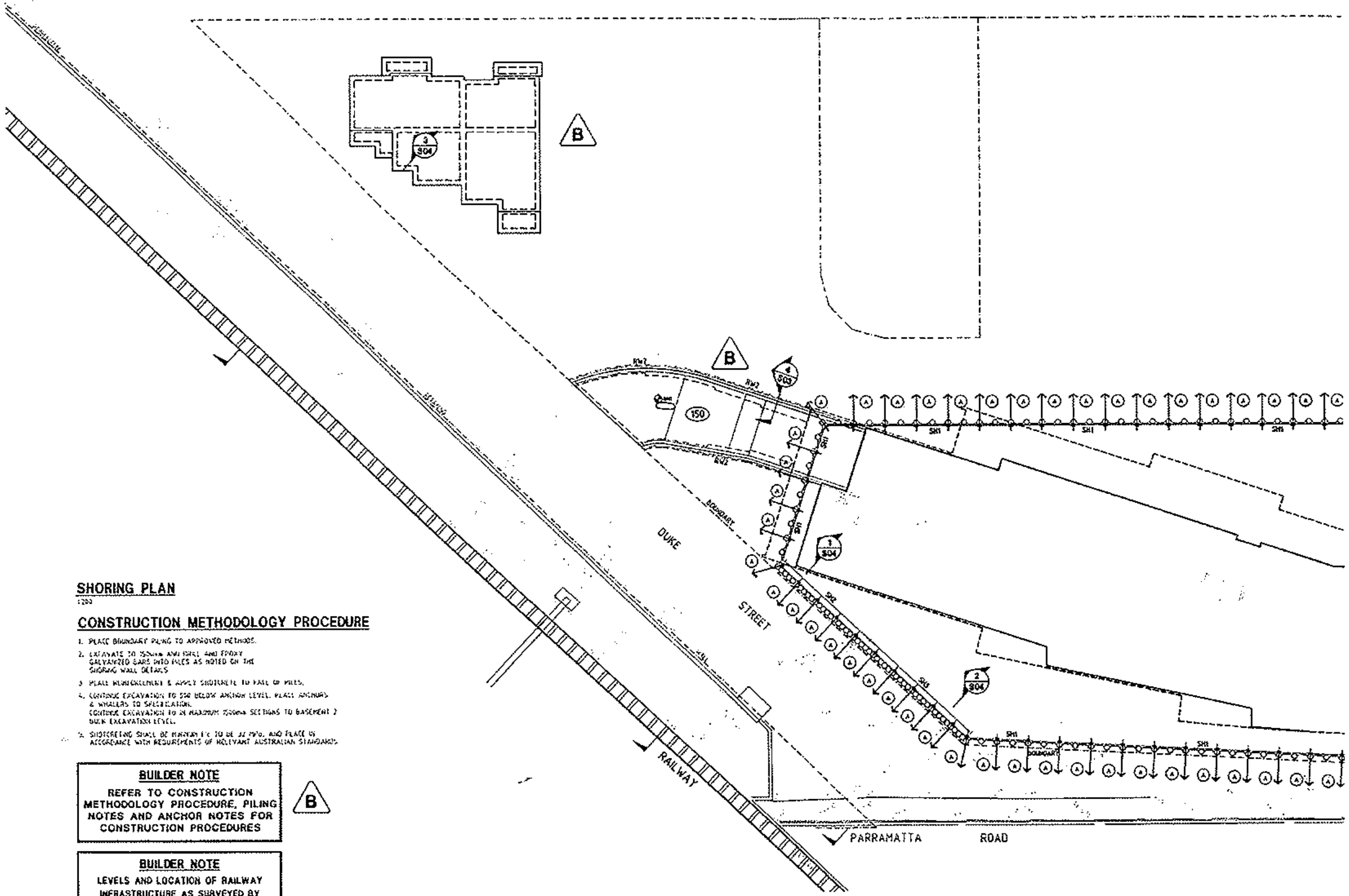
Report No. 24711SY **Figure No. 6**

APPENDIX A



PILING NOTES

1. REFER TO GEOTECHNICAL REPORT E10352/I-RPT DATED SEPTEMBER 2006 BY ENVIRONMENTAL INVESTIGATION SERVICES.
   THE CONTRACTOR IS TO FAMILIARISE HIMSELF WITH GROUND CONDITIONS PRIOR TO THE COMMENCEMENT OF ANY WORK. IF NECESSARY, THE CONTRACTOR IS TO FURTHER CONSULT THE GEOTECHNICAL ENGINEER.
2. PILING TO BE CARRIED OUT IN ACCORDANCE WITH AS2159 PILING CODE.
3. TOLERANCES, SETOUT AND STRAIGHTNESS TO BE IN ACCORDANCE WITH AS2159 PILING CODE.
4. ORIENTATION OF REINFORCEMENT CAGES TO ALLOW PLACEMENT OF ANCHORS WITHOUT CUTTING MAIN VERTICAL BARS.
5. SEWER LEVELS SHALL BE VERIFIED ON SITE PRIOR TO ANY ANCHOR PLACEMENT. THE ENGINEER IS TO BE ADVISED IF ANY CLASHES OCCUR.
6. ALL CONCRETE TO BE GRADE N32 (32 MPa). COVER TO TIES TO BE 60mm. ALL CONCRETE TO BE PLACED IN AN APPROVED MANNER TO PREVENT SEGREGATION DURING PLACEMENT.
7. THE PILING CONTRACTOR SHALL LOG ALL PILE INVERT LEVELS TO ENSURE MINIMUM INVERT LEVELS ARE ACHIEVED. THE GEOTECHNICAL ENGINEER SHALL VERIFY ALL BEARING MATERIALS.
8. THE CONTRACTOR SHALL ACCOUNT FOR ALL GROUND CONDITIONS AND WATER TABLE LEVELS REFERED TO IN THE GEOTECHNICAL ENGINEER'S REPORT. APPROPRIATE MEASURES SHALL BE TAKEN TO ENSURE PROPER PILE PLACEMENT.

ANCHOR NOTES

1. ANCHOR LOADS INDICATED ARE HORIZONTAL UNFACTORED SAFE WORKING LOADS.
2. THE CONTRACTOR SHALL TEST ANCHORS TO 150% OF SAFE WORKING LOAD. TEST RECORDS ARE TO BE MADE AVAILABLE TO H.K.M.A. ENGINEER.
3. THE CONTRACTOR IS TO INCREASE ANCHOR SAFE WORKING LOAD ACCORDING TO ANCHOR DECLINATION.
4. ANCHORS TO BE APPROVED SUPERSTRAND TENDONS, FULLY GROUTED OVER FULL BOND LENGTH IN APPROVED MATERIAL. REFER TO THE GEOTECHNICAL ENGINEER'S REPORT.
5. ANCHOR HEAD DETAILS, BEARING PLATES AND FIXING OF WALERS TO PILES TO BE APPROVED BY H.K.M.A. ENGINEER PRIOR TO FABRICATION.
6. ANCHORS TO BE DESTRESSED AND REMOVED IF DIRECTED BY CLIENT UPON ENGINEER'S APPROVAL TO DO SO.
7. THE CONTRACTOR IS TO ENSURE PERMISSION HAS BEEN OBTAINED PRIOR TO ANCHORING BEYOND BOUNDARY.
8. THE CONTRACTOR IS TO CARRY OUT A SERVICES SEARCH PRIOR TO COMMENCEMENT OF WORK. IF CLASHES OCCUR, THE CONTRACTOR IS TO NOTIFY THE ENGINEER IMMEDIATELY.

SHORING PLAN
1:200

CONSTRUCTION METHODOLOGY PROCEDURE

1. PLACE BOUNDARY PILING TO APPROVED METHODS.
2. EXCAVATE TO 1500mm AND DRILL AND EPOXY GALVANIZED BARS INTO PILES AS NOTED ON THE SHORING WALL DETAILS.
3. PLACE REINFORCEMENT & APPLY SHOTCRETE TO FACE OF PILES.
4. CONTINUE EXCAVATION TO 500 BELOW ANCHOR LEVEL. PLACE ANCHORS & WHALERS TO SPECIFICATION.
   CONTINUE EXCAVATION TO IN MAXIMUM 1500mm SECTIONS TO BASEMENT 2 BULK EXCAVATION LEVEL.
5. SHOTCRETING SHALL BE MINIMUM f'c TO BE 32 MPa, AND PLACE IN ACCORDANCE WITH REQUIREMENTS OF RELEVANT AUSTRALIAN STANDARDS.

BUILDER NOTE

REFER TO CONSTRUCTION METHODOLOGY PROCEDURE, PILING NOTES AND ANCHOR NOTES FOR CONSTRUCTION PROCEDURES

B

BUILDER NOTE

LEVELS AND LOCATION OF RAILWAY INFRASTRUCTURE AS SURVEYED BY GARY EDWARDS & ASSOCIATES PTY. LTD. DRAWING REFERENCE NO.1818

LEGEND

Ⓐ DENOTES 40t ANCHOR HORIZONTAL SAFE WORK LOAD, PLACED AND TESTED TO SPECIFICATIONS.

——— DENOTES BUILDING OUTLINE OF GROUND FLOOR

– – – – DENOTES BUILDING OUTLINE OF LEVELS 1-3

ISSUE FOR RAILCORP APPROVAL

ISSUE	DESCRIPTION	BY	DATE
B	REVISED AS NOTED	P.A.	02.12.10
A	ISSUE FOR RAILCORP APPROVAL	B.E.	[illegible]

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CHECKED BY: PHILIP MANCE 02.12.10

THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION UNLESS ENDORSED BELOW

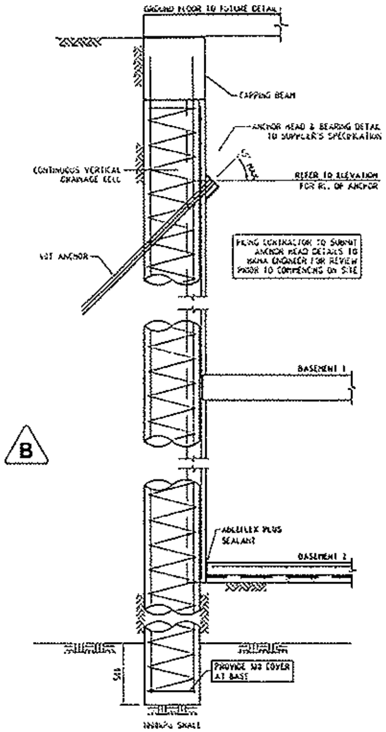
hkma

HKMA ENGINEERS
CONSULTING CIVIL & STRUCTURAL ENGINEERS
241-245 PENNANT HILLS ROAD, CARLINGFORD
PH. 9687 9222 FAX. 9687 9393

PROJECT: PROPOSED RESIDENTIAL DEVELOPMENT 171-181 PARRAMATTA ROAD, GRANVILLE

DRAWING TITLE: SHORING PLAN

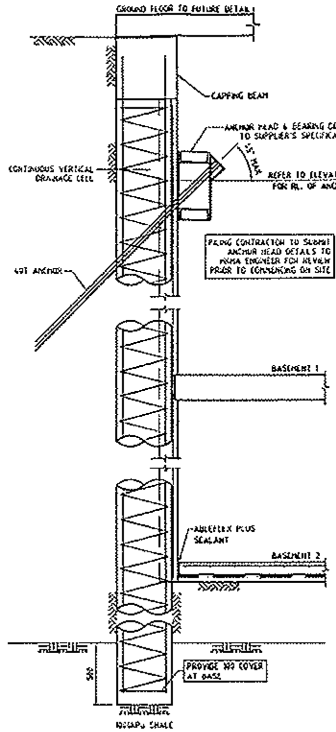
DESIGNED: P.M.
CHECKED: P.M.
DATUM:
SCALE: 1:200 1:20
DRAWING NUMBER: 6070-S02
ISSUE: B
SHEET: A1



SECTION OF SHORING WALL SH1

1:20

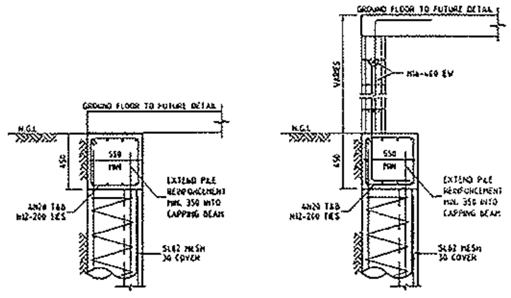
REFER SHORING ELEVATIONS FOR SPECIFIC ARRANGEMENTS



SECTION OF SHORING WALL SH2/SH3

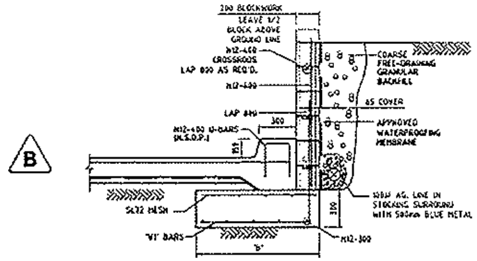
1:20

REFER SHORING ELEVATIONS FOR SPECIFIC ARRANGEMENTS



CAPPING BEAM DETAILS

1:20

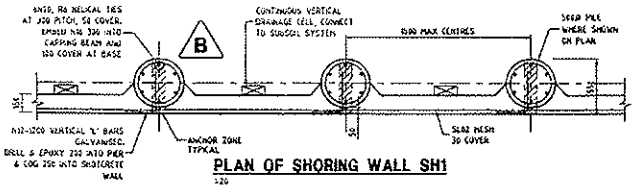


RW2/RAMP SECTION (4)

1:20

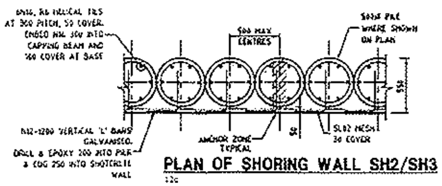
RETAINING WALL SCHEDULE			
"H"	"B"	"Y" BARS	"Y1" BARS
1000	850	N12-400	N12-400
1400	1150	N16-400	N16-400
1800	1550	N16-400	N16-400

ENGINEER TO CONFIRM RW SCHEDULE UPON COMPLETION OF BULK EXCAVATION



PLAN OF SHORING WALL SH1

1:20



PLAN OF SHORING WALL SH2/SH3

1:20

ISSUE FOR RAILCORP APPROVAL

B	REVISED AS NOTED		
A	ISSUE FOR RAILCORP APPROVAL		
ISSUE	DESCRIPTION	BY	DATE

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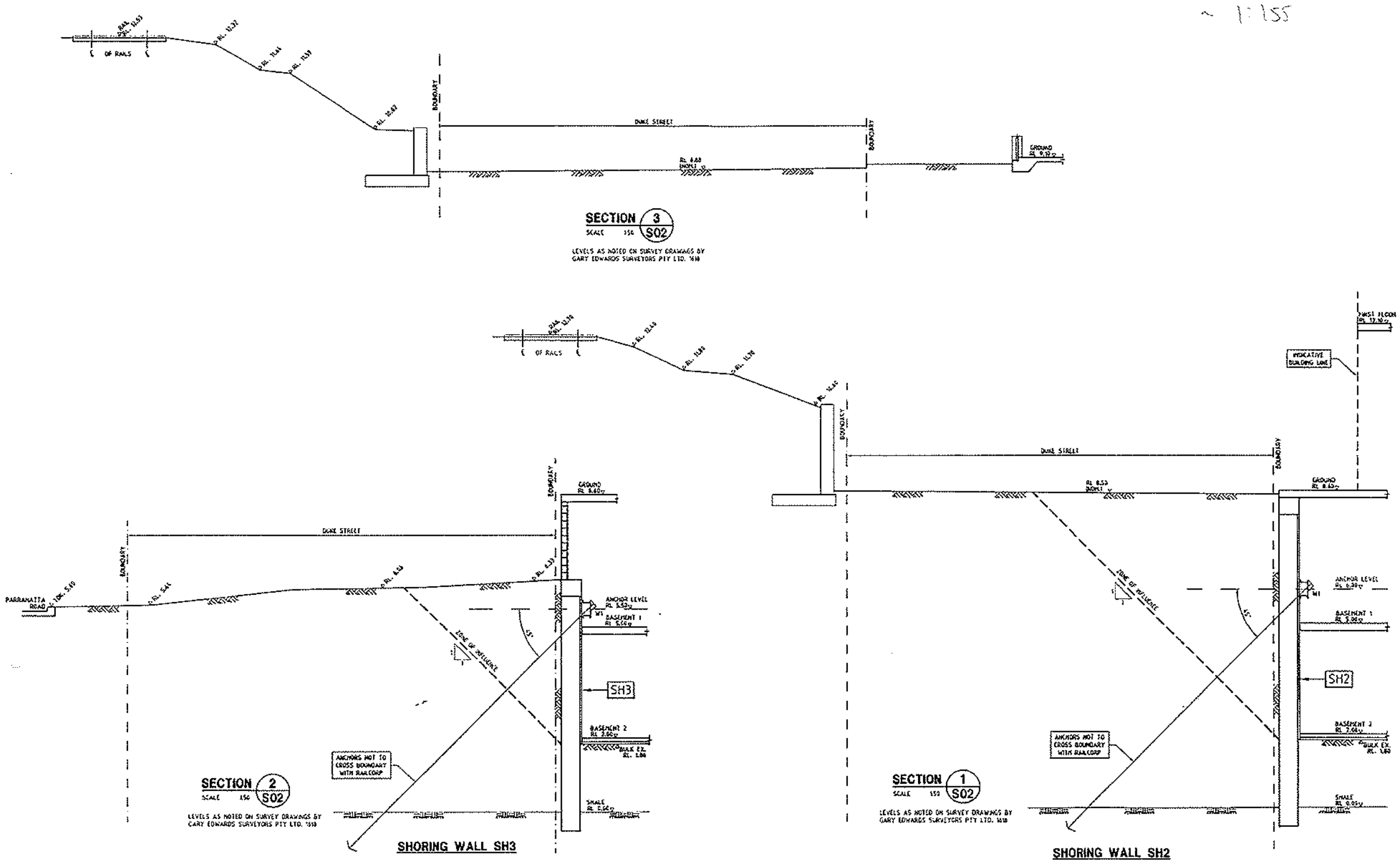
HKMA ENGINEERS
CONSULTING CIVIL & STRUCTURAL ENGINEERS
241-245 PENNANT HILLS ROAD, CARLINGFORD
PH. 9687 9292 FAX. 9687 1093

PROJECT: PROPOSED RESIDENTIAL DEVELOPMENT
171-181 PARRAMATTA ROAD,
GRANVILLE

DRAWING TITLE: SHORING PLAN
DETAILS & SECTIONS

DESIGNED: P.H | CHECKED: P.H | DRAWING NUMBER: 6070-S03 | ISSUE: B

SCALE 1:100 1:20 | SHEET A3



ISSUE FOR RAILCORP APPROVAL

A	ISSUE FOR RAILCORP APPROVAL
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PROJECT	DRAWING TITLE	DRAWING NUMBER	ISSUE
PROPOSED RESIDENTIAL DEVELOPMENT 171-181 PARRAMATTA ROAD, GRANVILLE	SHORING PLAN SECTIONS	6070-S04	A

SCALE 1:50 A1 SHEET A1

Jeffery and Katauskas Pty Ltd

CONSULTING GEOTECHNICAL AND ENVIRONMENTAL ENGINEERS
ABN 17 003 550 801

REPORT EXPLANATION NOTES

INTRODUCTION

These notes have been provided to amplify the geotechnical report in regard to classification methods, field procedures and certain matters relating to the Comments and Recommendations section. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited facts about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such facts obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the SAA Site Investigation Code. In general, descriptions cover the following properties – soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the predominating particle size and behaviour as set out in the attached Unified Soil Classification Table qualified by the grading of other particles present (eg sandy clay) as set out below:

Soil Classification	Particle Size
Clay	less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2mm
Gravel	2 to 60mm

Non-cohesive soils are classified on the basis of relative density, generally from the results of Standard Penetration Test (SPT) as below:

Relative Density	SPT 'N' Value (blows/300mm)
Very loose	less than 4
Loose	4 – 10
Medium dense	10 – 30
Dense	30 – 50
Very Dense	greater than 50

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Unconfined Compressive Strength kPa
Very Soft	less than 25
Soft	25 – 50
Firm	50 – 100
Stiff	100 – 200
Very Stiff	200 – 400
Hard	Greater than 400
Friable	Strength not attainable – soil crumbles

Rock types are classified by their geological names, together with descriptive terms regarding weathering, strength, defects, etc. Where relevant, further information regarding rock classification is given in the text of the report. In the Sydney Basin, 'Shale' is used to describe thinly bedded to laminated siltstone.

SAMPLING

Sampling is carried out during drilling or from other excavations to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon the degree of disturbance, some information on strength and structure. Bulk samples are similar but of greater volume required for some test procedures.

Undisturbed samples are taken by pushing a thin-walled sample tube, usually 50mm diameter (known as a U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application. All except test pits, hand auger drilling and portable dynamic cone penetrometers require the use of a mechanical drilling rig which is commonly mounted on a truck chassis.

Test Pits: These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling: A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Premature refusal of the hand augers can occur on a variety of materials such as hard clay, gravel or ironstone, and does not necessarily indicate rock level.

Continuous Spiral Flight Augers: The borehole is advanced using 75mm to 115mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling and insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the auger flights, but they can be very disturbed and layers may become mixed. Information from the auger sampling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability due to mixing or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table is of even lesser reliability than augering above the water table.

Rock Augering: Use can be made of a Tungsten Carbide (TC) bit for auger drilling into rock to indicate rock quality and continuity by variation in drilling resistance and from examination of recovered rock fragments. This method of investigation is quick and relatively inexpensive but provides only an indication of the likely rock strength and predicted values may be in error by a strength order. Where rock strengths may have a significant impact on construction feasibility or costs, then further investigation by means of cored boreholes may be warranted.

Wash Boring: The borehole is usually advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration.

Mud Stabilised Drilling: Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilise the borehole. The term 'mud' encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from intermittent intact sampling (eg from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling: A continuous core sample is obtained using a diamond tipped core barrel. Provided full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses are determined on site by the supervising engineer; where the location is uncertain, the loss is placed at the top end of the drill run.

Standard Penetration Tests: Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils as a means of indicating density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" – Test F3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube with a tapered shoe, under the impact of a 63kg hammer with a free fall of 760mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In the case where full penetration is obtained with successive blow counts for each 150mm of, say, 4, 6 and 7 blows, as

    N = 13
    4, 6, 7

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150mm and 30 blows for the next 40mm, as

    N>30
    15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, the test results are shown on the borehole logs in brackets.

A modification to the SPT test is where the same driving system is used with a solid 60° tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid Cone Penetration Test (SCPT) are shown as "N_c" on the borehole logs, together with the number of blows per 150mm penetration.

Static Cone Penetrometer Testing and Interpretation: Cone penetrometer testing (sometimes referred to as a Dutch Cone) described in this report has been carried out using an Electronic Friction Cone Penetrometer (EFCP). The test is described in Australian Standard 1289, Test F5.1.

In the tests, a 35mm diameter rod with a conical tip is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the frictional resistance on a separate 134mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are electrically connected by wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output as incremental digital records every 10mm. The results given in this report have been plotted from the digital data.

The information provided on the charts comprise:

- Cone resistance – the actual end bearing force divided by the cross sectional area of the cone – expressed in MPa.
- Sleeve friction – the frictional force on the sleeve divided by the surface area – expressed in kPa.
- Friction ratio – the ratio of sleeve friction to cone resistance, expressed as a percentage.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and occasionally very soft clays, rising to 4% to 10% in stiff clays and peats. Soil descriptions based on cone resistance and friction ratios are only inferred and must not be considered as exact.

Correlations between EFCP and SPT values can be developed for both sands and clays but may be site specific.

Interpretation of EFCP values can be made to empirically derive modulus or compressibility values to allow calculation of foundation settlements.

Stratification can be inferred from the cone and friction traces and from experience and information from nearby boreholes etc. Where shown, this information is presented for general guidance, but must be regarded as interpretive. The test method provides a continuous profile of engineering properties but, where precise information on soil classification is required, direct drilling and sampling may be preferable.

Portable Dynamic Cone Penetrometers: Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a sliding hammer and counting the blows for successive 100mm increments of penetration.

Two relatively similar tests are used:

- Cone penetrometer (commonly known as the Scala Penetrometer) – a 16mm rod with a 20mm diameter cone end is driven with a 9kg hammer dropping 510mm (AS1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various Road Authorities.
- Perth sand penetrometer – a 16mm diameter flat ended rod is driven with a 9kg hammer, dropping 600mm (AS1289, Test F3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.

LOGS

The borehole or test pit logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions, and their reliability will depend to some extent on the frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will enable the most reliable assessment, but is not always practicable or possible to justify on economic grounds. In any case, the boreholes or test pits represent only a very small sample of the total subsurface conditions.

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

Where groundwater levels are measured in boreholes, there are several potential problems:

- Although groundwater may be present, in low permeability soils it may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole or 'reverted' chemically if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read after stabilising at intervals ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (eg bricks, steel etc) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is of importance to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 *'Methods of Testing Soil for Engineering Purposes'*. Details of the test procedure used are given on the individual report forms.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (eg to a twenty storey building). If this happens, the company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions – the potential for this will be partially dependent on borehole spacing and sampling frequency as well as investigation technique.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of persons or contractors responding to commercial pressures.

If these occur, the company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed that at some later stage, well after the event.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document *'Guidelines for the Provision of Geotechnical Information in Tender Documents'*, published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Copyright in all documents (such as drawings, borehole or test pit logs, reports and specifications) provided by the Company shall remain the property of Jeffery and Katauskas Pty Ltd. Subject to the payment of all fees due, the Client alone shall have a licence to use the documents provided for the sole purpose of completing the project to which they relate. License to use the documents may be revoked without notice if the Client is in breach of any objection to make a payment to us.

REVIEW OF DESIGN

Where major civil or structural developments are proposed or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer.

SITE INSPECTION

The company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

Requirements could range from:

i) a site visit to confirm that conditions exposed are no worse than those interpreted, to
ii) a visit to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, or
iii) full time engineering presence on site.

GRAPHIC LOG SYMBOLS FOR SOILS AND ROCKS

SOIL

- FILL
- TOPSOIL
- CLAY (CL, CH)
- SILT (ML, MH)
- SAND (SP, SW)
- GRAVEL (GP, GW)
- SANDY CLAY (CL, CH)
- SILTY CLAY (CL, CH)
- CLAYEY SAND (SC)
- SILTY SAND (SM)
- GRAVELLY CLAY (CL, CH)
- CLAYEY GRAVEL (GC)
- SANDY SILT (ML)
- PEAT AND ORGANIC SOILS

ROCK

- CONGLOMERATE
- SANDSTONE
- SHALE
- SILTSTONE, MUDSTONE, CLAYSTONE
- LIMESTONE
- PHYLLITE, SCHIST
- TUFF
- GRANITE, GABBRO
- DOLERITE, DIORITE
- BASALT, ANDESITE
- QUARTZITE

DEFECTS AND INCLUSIONS

- CLAY SEAM
- SHEARED OR CRUSHED SEAM
- BRECCIATED OR SHATTERED SEAM/ZONE
- IRONSTONE GRAVEL
- ORGANIC MATERIAL

OTHER MATERIALS

- CONCRETE
- BITUMINOUS CONCRETE, COAL
- COLLUVIUM

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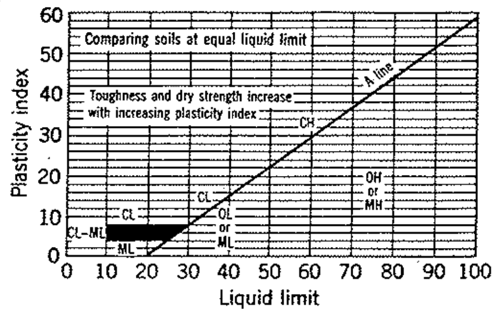
CONSULTING GEOTECHNICAL & ENVIRONMENTAL ENGINEERS

UNIFIED SOIL CLASSIFICATION TABLE

Field Identification Procedures (Excluding particles larger than 75 μm and basing fractions on estimated weights)				Group Symbols[a]	Typical Names	Information Required for Describing Soils	Laboratory Classification Criteria		
Coarse-grained soils More than half of material is *larger* than 75 μm sieve size[b] (The 75 μm sieve size is about the smallest particle visible to naked eye)	Gravels More than half of coarse fraction is larger than 4 mm sieve size	Clean gravels (little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	*GW*	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses	Use grain size curve in identifying the fractions as given under field identification. Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows: Less than 5% *GW, GP, SW, SP*; More than 12% *GM, GC, SM, SC*; 5% to 12% *Borderline* cases requiring use of dual symbols	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	*GP*	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for *GW*	
		Gravels with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures see *ML* below)	*GM*	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or *PI* less than 4	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*GC*	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics		Atterberg limits above "A" line, with *PI* greater than 7	
	Sands More than half of coarse fraction is smaller than 4 mm sieve size	Clean sands (little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	*SW*	Well graded sands, gravelly sands, little or no fines	Example: *Silty sand*, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (*SM*)		$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6; $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	*SP*	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for *SW*	
		Sands with fines (appreciable amount of fines)	Nonplastic fines (for identification procedures, see *ML* below)	*SM*	Silty sands, poorly graded sand-silt mixtures			Atterberg limits below "A" line or *PI* less than 5	Above "A" line with *PI* between 4 and 7 are *borderline* cases requiring use of dual symbols
			Plastic fines (for identification procedures, see *CL* below)	*SC*	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits below "A" line with *PI* greater than 7	

Identification Procedures on Fraction Smaller than 380 μm Sieve Size		Dry Strength (crushing characteristics)	Dilatancy (reaction to shaking)	Toughness (consistency near plastic limit)	Group Symbols	Typical Names	Information Required for Describing Soils
Fine-grained soils More than half of material is *smaller* than 75 μm sieve size	Silts and clays liquid limit less than 50	None to slight	Quick to slow	None	*ML*	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
		Medium to high	None to very slow	Medium	*CL*	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		Slight to medium	Slow	Slight	*OL*	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
	Silts and clays liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	*MH*	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		High to very high	None	High	*CH*	Inorganic clays of high plasticity, fat clays	Example: *Clayey silt*, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (*ML*)
		Medium to high	None to very slow	Slight to medium	*OH*	Organic clays of medium to high plasticity	
Highly Organic Soils		Readily identified by colour, odour, spongy feel and frequently by fibrous texture			*Pt*	Peat and other highly organic soils	



Plasticity chart
for laboratory classification of fine grained soils

NOTE: 1) Soils possessing characteristics of two groups are designated by combinations of group symbols (e.g. GW-GC, well graded gravel-sand mixture with clay fines).

2) Soils with liquid limits of the order of 35 to 50 may be visually classified as being of medium plasticity.

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LOG SYMBOLS

LOG COLUMN	SYMBOL	DEFINITION
Groundwater Record		Standing water level. Time delay following completion of drilling may be shown.
		Extent of borehole collapse shortly after drilling.
		Groundwater seepage into borehole or excavation noted during drilling or excavation.
Samples	ES	Soil sample taken over depth indicated, for environmental analysis.
	U50	Undisturbed 50mm diameter tube sample taken over depth indicated.
	DB	Bulk disturbed sample taken over depth indicated.
	DS	Small disturbed bag sample taken over depth indicated.
	ASB	Soil sample taken over depth indicated, for asbestos screening.
	ASS	Soil sample taken over depth indicated, for acid sulfate soil analysis.
	SAL	Soil sample taken over depth indicated, for salinity analysis.
Field Tests	N = 17 4, 7, 10	Standard Penetration Test (SPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration. 'R' as noted below.
	N_c = 5 7 3R	Solid Cone Penetration Test (SCPT) performed between depths indicated by lines. Individual figures show blows per 150mm penetration for 60 degree solid cone driven by SPT hammer. 'R' refers to apparent hammer refusal within the corresponding 150mm depth increment.
	VNS = 25	Vane shear reading in kPa of Undrained Shear Strength.
	PID = 100	Photoionisation detector reading in ppm (Soil sample headspace test).
Moisture Condition (Cohesive Soils)	MC>PL	Moisture content estimated to be greater than plastic limit.
	MC≈PL	Moisture content estimated to be approximately equal to plastic limit.
	MC<PL	Moisture content estimated to be less than plastic limit.
(Cohesionless Soils)	D	DRY - runs freely through fingers.
	M	MOIST - does not run freely but no free water visible on soil surface.
	W	WET - free water visible on soil surface.
Strength (Consistency) Cohesive Soils	VS	VERY SOFT - Unconfined compressive strength less than 25kPa
	S	SOFT - Unconfined compressive strength 25-50kPa
	F	FIRM - Unconfined compressive strength 50-100kPa
	St	STIFF - Unconfined compressive strength 100-200kPa
	VSt	VERY STIFF - Unconfined compressive strength 200-400kPa
	H	HARD - Unconfined compressive strength greater than 400kPa
	( )	Bracketed symbol indicates estimated consistency based on tactile examination or other tests.
Density Index/ Relative Density (Cohesionless Soils)		**Density Index (I_D) Range (%)** — **SPT 'N' Value Range (Blows/300mm)**
	VL	Very Loose — <15 — 0-4
	L	Loose — 15-35 — 4-10
	MD	Medium Dense — 35-65 — 10-30
	D	Dense — 65-85 — 30-50
	VD	Very Dense — >85 — >50
	( )	Bracketed symbol indicates estimated density based on ease of drilling or other tests.
Hand Penetrometer Readings	300 250	Numbers indicate individual test results in kPa on representative undisturbed material unless noted otherwise.
Remarks	'V' bit	Hardened steel 'V' shaped bit.
	'TC' bit	Tungsten carbide wing bit.
	T 60	Penetration of auger string in mm under static load of rig applied by drill head hydraulics without rotation of augers.

Ref: Standard Sheets/Log Symbols
November 2007

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LOG SYMBOLS

ROCK MATERIAL WEATHERING CLASSIFICATION

TERM	SYMBOL	DEFINITION
Residual Soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely weathered rock	XW	Rock is weathered to such an extent that it has "soil" properties, ie it either disintegrates or can be remoulded, in water.
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores.
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh rock	FR	Rock shows no sign of decomposition or staining.

ROCK STRENGTH

Rock strength is defined by the Point Load Strength Index (Is 50) and refers to the strength of the rock substance in the direction normal to the bedding. The test procedure is described by the International Journal of Rock Mechanics, Mining, Science and Geomechanics. Abstract Volume 22, No 2, 1985.

TERM	SYMBOL	Is (50) MPa	FIELD GUIDE
Extremely Low:	EL		Easily remoulded by hand to a material with soil properties.
		0.03	
Very Low:	VL		May be crumbled in the hand. Sandstone is "sugary" and friable.
		0.1	
Low:	L		A piece of core 150mm long x 50mm dia. may be broken by hand and easily scored with a knife. Sharp edges of core may be friable and break during handling.
		0.3	
Medium Strength:	M		A piece of core 150mm long x 50mm dia. can be broken by hand with difficulty. Readily scored with knife.
		1	
High:	H		A piece of core 150mm long x 50mm dia. core cannot be broken by hand, can be slightly scratched or scored with knife; rock rings under hammer.
		3	
Very High:	VH		A piece of core 150mm long x 50mm dia. may be broken with hand-held pick after more than one blow. Cannot be scratched with pen knife; rock rings under hammer.
		10	
Extremely High:	EH		A piece of core 150mm long x 50mm dia. is very difficult to break with hand-held hammer. Rings when struck with a hammer.

ABBREVIATIONS USED IN DEFECT DESCRIPTION

ABBREVIATION	DESCRIPTION	NOTES
Be	Bedding Plane Parting	Defect orientations measured relative to the normal to the long core axis (ie relative to horizontal for vertical holes)
CS	Clay Seam	
J	Joint	
P	Planar	
Un	Undulating	
S	Smooth	
R	Rough	
IS	Ironstained	
XWS	Extremely Weathered Seam	
Cr	Crushed Seam	
60t	Thickness of defect in millimetres	