Appendix D: Foundation Laboratory Testing

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Annexure DC	Direct Simple Shear Tests - Fugro
Annexure DD	Direct Shear Tests - TriLabs
Annexure DE	CIU Triaxial Tests - Golders
Annexure DF	CIU Triaxial Tests – Trilabs
Annexure DG	Oedometer Consolidation Tests
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Annexure DI	Miscellaneous Tests
Annexure DJ	Laboratory Test Procedures

D1. Introduction

This appendix provides details on the engineering properties of the foundation and fill materials described in Appendix C. The engineering properties are largely based on the results of laboratory tests undertaken as part of the ITRB investigations, supplemented by other testing which includes:

- Previous laboratory investigations;
- Laboratory investigations undertaken in parallel to the ITRB investigations; and
- Limited field testing.

The scope of testing and a summary of the results of the testing are provided in the following sections while details of test procedures and test certificates are provided in the annexures to this appendix.

D2. ITRB Laboratory Testing

D2.1 Overview

ITRB investigations for the Cadia NTSF embankment failure are discussed in Appendix C. Samples collected as part of these investigations included:

- Disturbed samples;
- Undisturbed block samples;
- Thin walled undisturbed samples, 63mm diameter; and
- Lexan undisturbed samples, 100mm diameter.

Testing of selected samples of foundation and construction materials from these investigations was undertaken by:

- Trilab Brisbane, Qld
- Golder Perth, WA
- Fugro Perth, WA
- Microanalysis Perth, WA
- Hensel Geosciences Mudgeeraba, Qld
- Consultant Palynological Services Canberra, ACT

The type and number of tests completed by each organization is shown in Table D2-1.

Test	Trilab - Brisbane	Golder - Perth	Fugro - Perth	Microanalysis - Perth	Hensel Geoscience	Palynological Services
Atterberg Limits	25	8	4			
Linear Shrinkage	23	8	4			
Hydrometer / PSD	22	8	3			
Specific Gravity	13	9	3			
Bulk Density	4	2				
Standard Compaction		1				
Oedometer Consolidation	3		3			
Constant Rate of Strain Consolidation		6				
Direct Shear Test	7					
Ring Shear - Remoulded	1					
Direct Simple Shear (DSS) - Undisturbed		17	9			
DSS - Remoulded		3				
CIU Triaxial – Single Stage	9	3				
CIU Triaxial – Multi Stage						
X-Ray Diffraction – Semi Quantitative				6		
Petrographic Analysis					6	
Age Determination by Palynology						2

Table D2-1: Type and number of tests completed by laboratory

Table D2-2 provides a breakdown of tests according to material type.

Table D2-2:	Type and number	of tests completed	according to material type
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Test	Residual Basalt	Paleo Alluvium	Unit A – Forest Reef Volcanics	Unit B – Forest Reef Volcanics	Forest Reef Volcanics Bedrock
Atterberg Limits	4	8	13	12	
Linear Shrinkage	4	8	13	10	
Hydrometer / PSD	4	5	14	10	
Specific Gravity	3	4	13	5	
Bulk Density	1		3	2	
Organic Content (Loss on Ignition)		1			
Standard Compaction			1		
Oedometer Consolidation	1	3		2	
Constant Rate of Strain Consolidation	1	1	2	2	
Direct Shear Test			4	3	
Direct Simple Shear (DSS) - Undisturbed	6	5	9	6	
DSS - Remoulded			3		
CIU Triaxial – Single Stage					
CIU Triaxial – Multi Stage		2	3	2	
X-Ray Diffraction – Semi Quantitative	1		3	2	
Petrographic Analysis					6
Age Determination by Palynology		2			

D2.2 Test Details

D2.2.1 Test Methods

Where available, tests were completed to Australian Standards (AS) and these are listed below.

- Moisture Content AS1289.2.1.1
- Atterberg Limits AS1289.3.1.1, .3.2.1, .3.3.1
- Linear shrinkage AS1289.3.4.1
- Particle size distribution by wash sieving AS1289.3.6.1
- Particle size distribution by hydrometer AS1289.3.6.3
- Specific gravity AS1289.3.5.2
- Bulk density AS1289.6.4.1
- Standard Compaction AS1289.5.1.1
- Oedometer consolidation AS1289.6.6.1
- Direct Shear AS1289.6.2.2
- Isotropically Consolidated Undrained (CIU) TriaxialAS1289.6.4.2

Procedures adopted for advanced testing of foundation materials are included in Annexure DJ. The procedures adopted were often specific to the laboratory undertaking the testing but were generally in accordance with the American Society for Testing and Materials (ASTM). Applicable ASTM standards are:

- D4767 Consolidated undrained triaxial compression (CIU)
- D6528 Consolidated undrained direct simple shear (DSS)
- D4186 Controlled Strain Loading Oedometer (CRS)
- D6467 Torsional Ring Shear (RS)

Standards were not used for petrographic analysis or age determination by palynology.

D2.2.2 Test Certificates

Certificates for various tests undertaken by the ITRB are provided in annexures to this report.

D3. Other Laboratory Testing

D3.1 Pre- Construction Testing

Prior to the construction of the NTSF, laboratory testing of soil samples from the investigations was limited and included the following:

- Atterberg Limits;
- Particle Size Distributions;
- Emerson Class;
- Moisture density tests (Standard Compaction);
- Consolidated undrained (CIU) triaxial tests on 4 re-compacted samples; and
- Constant head permeability tests on 4 samples.

Three CIU triaxial tests, completed on re-compacted specimens from the 2000 investigations for the STSF, were subsequently incorporated into the NTSF data base.

Results of the pre-construction testing are included in references 1995-001, 1997-001 and 1997-002. (Appendix J)

D3.2 Construction Testing

During construction, soil index tests and compaction tests were undertaken on low permeability materials as part of the Quality Assurance (QA) for the various stages of the NTSF. Particle size distribution tests were also completed on Stage 1 filter materials. No QA testing was completed on rockfill materials.

In general, only summaries of these data are provided in construction reports. Results for Stages 1 and 2 of the NTSF are included in references 1998-001, 2000-002, 2002-001 and 2003-001 (Appendix K).

D3.3 Supplementary Testing

D3.3.1 ATC Williams

ATC Williams (ATCW) recovered undisturbed samples of foundation materials at five (5) locations around the perimeter of the NTSF and STSF (reference 2018-005, Appendix K). Although the samples were taken in mid-February 2018, results of laboratory testing was not available until July 2018.

The testing included:

- Atterberg Limits;
- Particle size distribution (by hydrometer);
- Oedometer consolidation tests on 3 samples; and
- Anisotropically consolidated triaxial compression tests (CAU) on 4 samples.

D3.3.2 GHD

Following the NTSF embankment failure, GHD were engaged by Newcrest to assist CVO in minimizing the impacts of the failure (containment) and resuming production through a resumption in tailings emplacement in the STSF. As part of these activities GHD drilled nineteen (19) investigation holes and undertook laboratory testing that included:

- Atterberg Limits;
- Particle Size Distributions;
- Emerson Class;
- Consolidated undrained (CIU) triaxial tests;
- Unconsolidated undrained (UU) triaxial tests;
- Direct shear tests, and
- Oedometer consolidation tests.

D3.4 Test Certificates

Test certificates for the previous and supplementary testing are included in the relevant references and are not reproduced in this appendix. Results are incorporated in the following sections where they are deemed to be both relevant and of an appropriate quality.

D4. Foundation Properties

D4.1 Foundation Materials

The geological units intersected in the immediate vicinity of the NTSF slump are highlighted on Figure D4-1. The field characteristics of these units are discussed in Appendix C, while the engineering properties will be presented in the following sections.

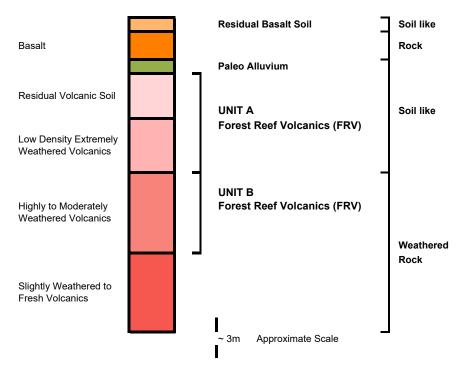


Figure D4-1: Geological units intersected at NTSF slump

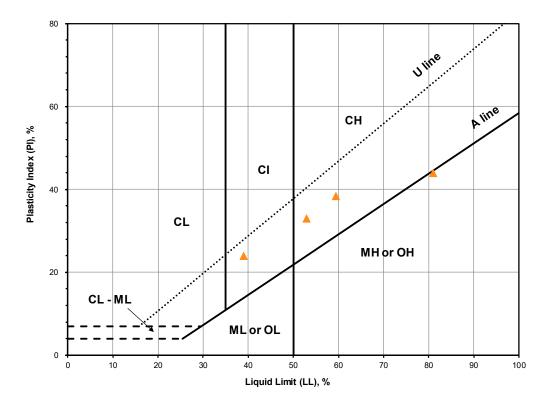
D4.2 Residual Basalt

D4.2.1 Index Tests

Atterberg Limit and index tests completed on four samples of residual basaltic soil are summarised in Table D4-1. Atterberg Limits are plotted on Figure D4-2.

Table D4-1:	Residual Basalt -	Atterberg	Limits and Index Tests
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Hole	Depth Range (m)		Atterberg Limits			inear rinkage (%)	Moisture (%)	r Density (t/m3)	c Gravity
No.	From	То	LL	PL	PI	Li Shri	Field N (Dry [(t	Specific
CE411	3.00	3.45	59	21	38	15.0	30.3	1.52	2.79
CE412	39.50	39.72	81	37	44	1.5	48.5		2.55
CE413	53.50	53.80	39	15	24	12.5	20.1		
TP401	0.70	1.00	53	20	33	14.5	21.7	1.76	2.80





D4.2.2 Direct Simple Shear Tests

Direct simple shear tests were completed on two samples of residual basaltic soil. These test results are summarized in Table D4-2.

Osmula	Dauth	Consol. Stress (kPa)	Dry	Shear Strength		SS F	Test					
Sample No	Depth (m)							Density (kN/m3)	Peak (kPa)	Post Peak (kPa)	Peak	Post Peak
		400	1.76	270	270	0.68	0.68	G/DSS				
TP401	0.70 – 1.00	800	1.76	277	219	0.35	0.27	G/DSS				
		1200	1.77	408	372	0.34	0.31	G/DSS				
		400	1.52	114	110	0.29	0.28	F/DSS				
CE411	3.00 - 3.45	800	1.50	209	198	0.26	0.25	F/DSS				
		1200	1.54	332	306	0.28	0.26	F/DSS				

Table D4-2: Residual Basalt – Undrained shear strength data

The peak mobilized friction (ϕ m') from the DSS tests was 15.2° and 16.5° for CE411A and TP401 respectively, while the post peak mobilized friction at 25% strain ranged between 14.4° and 15.9°.

Shear stress versus vertical effective stress determined from the two DSS tests is plotted on Figure D4-3.

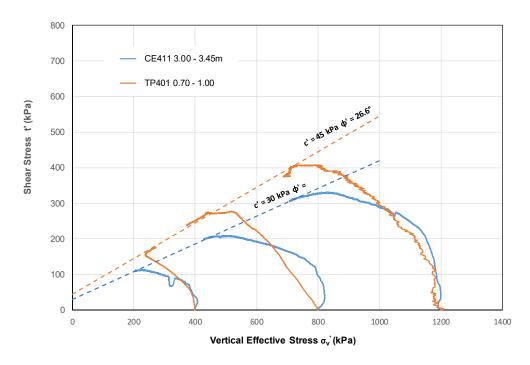
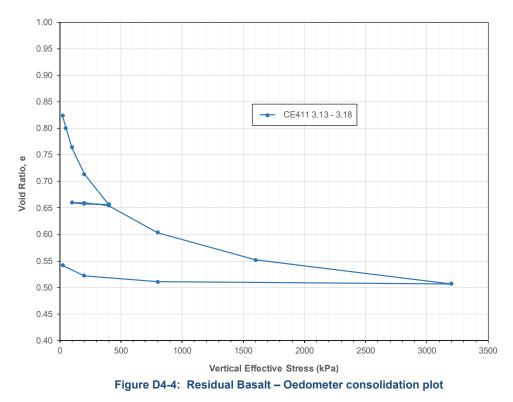


Figure D4-3: Residual Basalt – Shear stress versus vertical effective stress

D4.2.3 Consolidation Tests

One oedometer consolidation test was completed on residual basalt. The sample was loaded to 400kPa, unloaded to 100kPa, reloaded to 3200kPa, then unloaded to 25kPa. The results are presented in Figure D4-4 as a void ratio / vertical effective stress plot and summarized in Table D4-3.



ID	Depth	RL	γd (t/m3)	w (%)	60	Cr	Cc	σ'p
CE411	3.13 – 3.18	686.89	1.52	26.2	0.824	0.021	0.180	70

The apparent pre-consolidation pressure (σ_p) indicated in Table D4-3 was calculated using the Casagrande Method.

D4.3 Paleo Alluvium

D4.3.1 Index Tests

Atterberg Limit and index tests completed on nine samples of paleo alluvium are summarised in Table D4-4.

Samples CE417 18.50 to 19.00 and 19.50 to 20.00, were described as high plasticity, black CLAY with some organic matter. The organic content of CE417 18.50 to 19.00 was determined as 7.1% based on Loss on Ignition

Atterberg Limits are plotted on Figure D4-5.



Hole No.		Range n)	Atte	erberg Lii	nits	Linear Shrinkage (%)	_inear rinkage (%)	_inear rinkage (%)	Moisture (%)	Dry Density (t/m3)	Specific Gravity
	From	То	LL	PL	PI	lus L	Field	Dry	Speci		
CE406	18.40	18.50	71	24	47	19.0	27.5		2.70		
CE411A	12.50	12.95	53	27	26	12.0	25.8	1.52	2.87		
CE411A	14.50	15.00	53	25	28	12.0	25.7	1.64	2.70		
CE411A	15.00	15.35	54	27	27	11.5	28.4	1.58			
CE416	21.85	21.90	87	27	60	22.0	34.1				
CE417	16.50	16.86	61	24	36	12.5	27.4	1.59	2.74		
CE417	18.50	19.00	80	32	48	19.0	42.3	1.31	2.49		
CE417	19.50	20.00	58	22	36	13.0	34.9	1.46			
CE417	20.80	20.85	48	19	29	13.0	26.3				

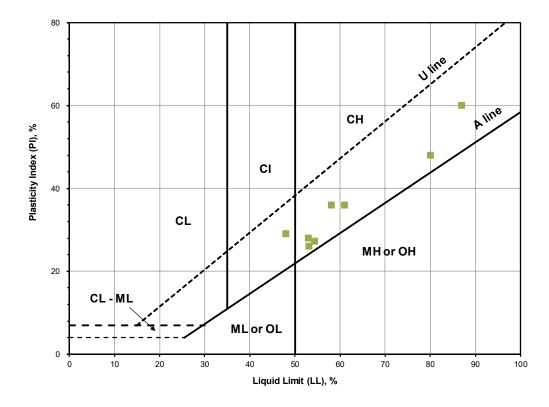


Figure D4-5: Paleo Alluvium – Plasticity Chart

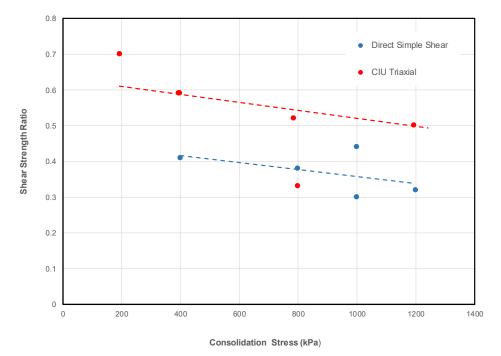
D4.3.2 Strength Data

Direct simple shear tests and CIU triaxial tests were completed on five samples of paleo alluvium. Undrained shear strength data are summarized in Table D4-5.

		Osmaal	Dry	Shear Strength		SS Ratio			
Sample No	Depth (m)	Consol. Stress (kPa)	Dry Density (kN/m3)	Peak (kPa)	Post Peak (kPa)	Peak	Post Peak	Test Type	
		398		234		0.59			
CE411A	14.50 – 15.00	786	1.64	412		0.52		T/CIU M	
		1194		595	387	0.50	0.32		
		400	1.58	162	161	0.41	0.40	F/DSS	
CE411A	15.00 – 15.35	800	1.52	301	297	0.38	0.37	F/DSS	
		1200	1.63	389	376	0.32	0.31	F/DSS	
CE417	16.50 - 16.86	1000	1.49	438	425	0.44	0.43	G/DSS	
		194	1.22	135		0.70		T/CIU	
CE417	18.50 – 19.00	394	1.22	198	105	0.59	0.27	М	
		799	1.31	260	119	0.33	0.15	T/CIU	
CE417	19.50 – 20.00	1000	1.46	302	300	0.30	0.30	G/DSS	

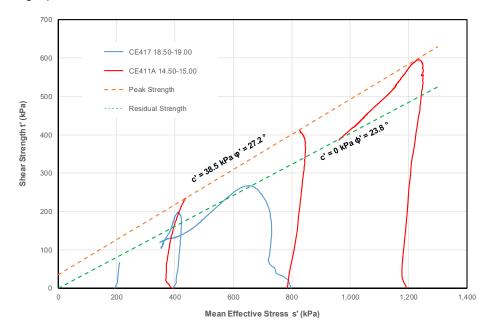
Table D4-5: Paleo Alluvium – Undrained shear strength data

The data in Table D4-5 indicates a minimal reduction in post peak strength for DSS tests, while triaxial tests in both the inorganic and organic paleo alluvium exhibit a substantial reduction in post peak strength. A plot of undrained shear strength ratio vs consolidation stress provided as Figure D4-6 indicates the undrained shear strength ratio in DSS tests is approximately 70% of that measured in triaxial tests.





MIT stress paths for CIU triaxial tests are graphed on Figure D4-7, together with effective stress, strength parameters calculated for the triaxial tests.





D4.3.3 Consolidation Tests

Three oedometer consolidation tests were completed on undisturbed samples of paleo- alluvium. The samples were loaded to 400kPa, unloaded to 100kPa, reloaded to 3200kPa, then, in the case of one sample, unloaded to 25kPa. The results are presented in Figure D4-8 as a void ratio / p' plot and summarized in Table D4-6.

The void ratio and compression index of the organic clay (CE417 18.50 - 19.00) is substantially higher than that of the two 'remaining samples.

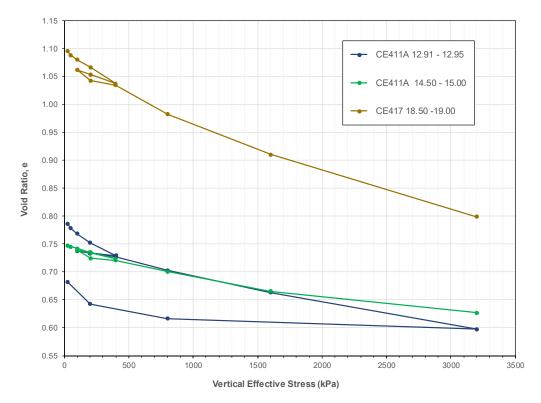


Figure D4-8: Paleo Alluvium – Oedometer consolidation plots

ID	Depth	RL	γd (t/m3)	₩ (%)	eo	Cr	Cc	σ'p
CE411A	12.91 – 12.95	677.09	1.52	25.8	0.786(1)	0.040	0.210	580
CE411A	14.50 – 15.00	675.00	1.56	26.0	0.732	0.030	0.125	425
CE417	18.50 – 19.00	681.58	1.20	45.5	1.077	0.045	0.380	675

Table D4-6: Paleo Alluvium -Summary of consolidation test data

The apparent pre-consolidation pressure (σ_p) indicated in Table D4-6 was calculated using the Casagrande Method.

D4.4 Unit A - Forest Reef Volcanics

D4.4.1 Index Tests

Atterberg Limit and index tests completed on eleven samples of Unit A of the Forest Reef Volcanics (FRV) are summarised in Table D4-7.

Shrinkage Field Moisture (%) Gravity / Density (t/m3) **Depth Range Atterberg Limits** (m) Hole (%) Specific No. Dry inear From То LL PL PI CE411A 16.00 16.50 61 31 30 12.5 37.7 1.28 2.58 CE415 4.12 4.30 52 33 19 8.5 38.4 CE415 6.00 6.50 56 31 25 9.0 43.8 1.28 2.89 CE416 23.00 1.59 23.50 59 28 31 12.0 27.7 2.77 CE416 24.00 24.33 63 26 37 11.5 25.6 1.59 2.85 CE416 24.50 25.00 73 33 40 13.0 34 1.4 2.66 CE416 25.50 32 14.0 25.00 67 35 39.3 1.41 2.72 CE416 25.50 25.95 60 29 31 11.0 38.7 1.33 2.66 CE416 30 26.50 27.00 64 34 14.5 38.4 1.41 2.62 CE416 27.00 27.45 67 25 41 13.0 37.9 1.36 2.9 CE417 24.00 24.30 55 28 27 10.5 35.9 1.29 2.85 CE417 25.90 30 24 26.00 54 9.0 36 PL01 0.00 0.50 51 25 26 13.5 33.5 1.38 2.78

Table D4-7: Unit A FRV - Atterberg Limits and Index Tests

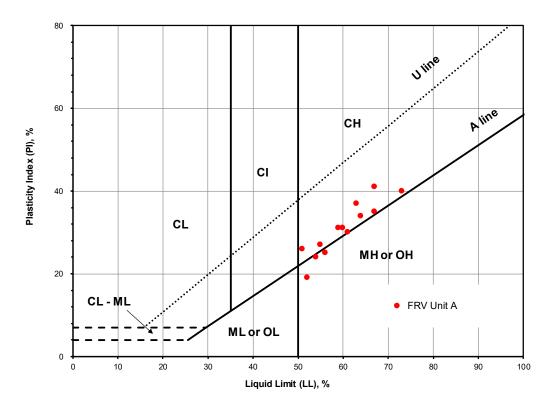
The following graphs are provided for the various index tests.

Atterberg Limits are plotted on Figure D4-9.

Particle size distributions are plotted on Figure D4-10

Figure D4-11 is a graph of the initial dry density of Unit A samples with depth. The dry density of Unit A samples is typically below 1.40t/m³ although there are some isolated samples with higher values.

Figure D4-12 is a graph of the initial void ratio of Unit A samples (open circles) and 'as tested' void ratio (closed circles) against confining stress.





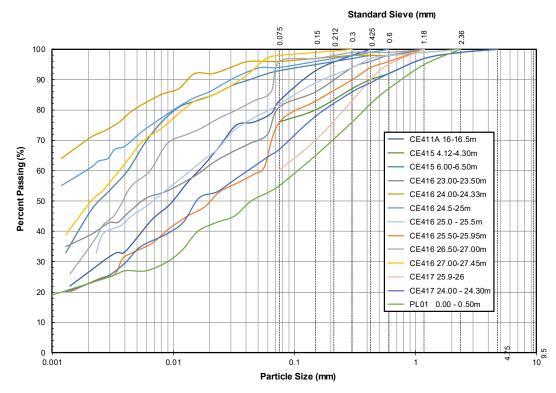


Figure D4-10: Unit A FRV – Particle Size Distributions

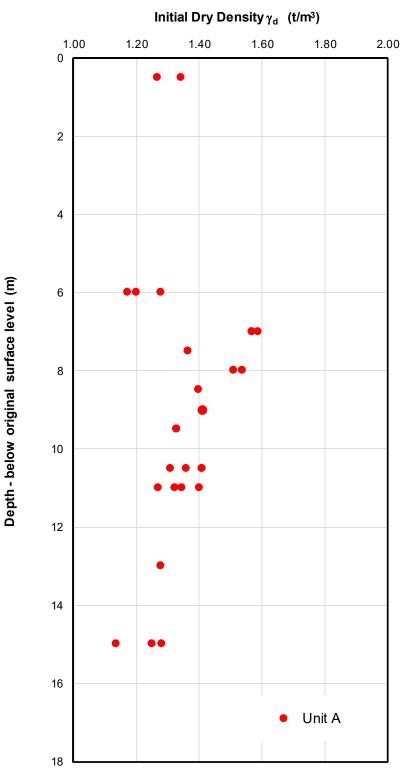
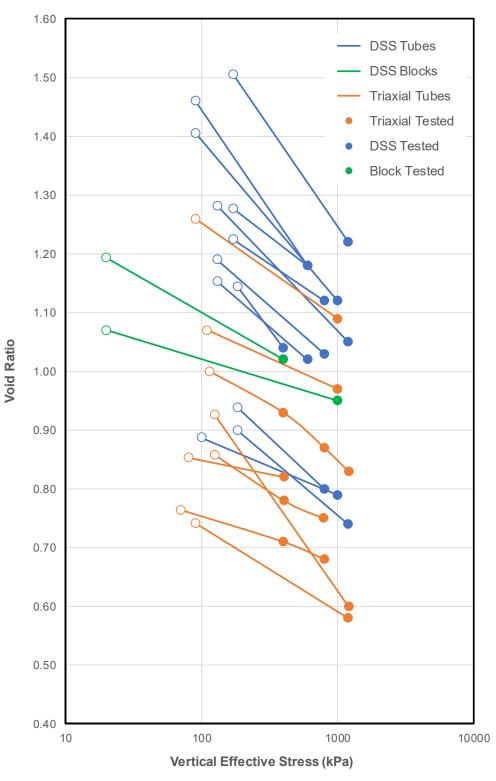


Figure D4-11: Unit A FRV – Initial dry density vs depth





D4.4.2 Strength Data

Direct simple shear tests and CIU triaxial tests were completed on eight samples of FRV Unit A while direct shear tests and one ring shear test were completed on a remoulded sample of FRV Unit A.

Undrained shear strength data is summarized in Table D4-8.

Table D4-8: Unit A FRV– Undrained shear strength data

			Dry	Shear S	Strength	SS I	Ratio		
Sample No		Consol. Stress (kPa)	Density (kN/m3)	Peak (kPa)	Post Peak (kPa)	Peak	Post Peak	Test Type	
		600	1.33	225	200	0.38	0.33	G/DSS	
CE415	6.00 - 6.50	1000	1.36	275	195	0.28	0.20	G/DSS	
		1000	1.28	395	223	0.40	0.22	G/CIU	
		400	1.57	222		0.56		T/CIU	
CE416	23.00 – 23.50	801	1.57	347	164	0.43	0.20	М	
		1199	1.59	490	242	0.41	0.20	T/CIU	
CE416	24.00 – 24.33	1000	1.59	340	320	0.34	0.32	G/DSS	
		400		260		0.65		T/CIU	
CE416	25.50 – 25.95	799	1.33	379		0.47		М	
		1203		491	86	0.41	0.07	T/CIU	
		403	4.44	240		0.60		T/CIU	
CE416	26.50 – 27.00	791	1.41	380	0.48	0.48		М	
		1204	1.36	342	77	0.28	0.06	T/CIU	
CE416	27.00 - 27.45	1200	1.41	315	252	0.26	0.21	G/DSS	
CE410	27.00 - 27.43	1000	1.33	347	257	0.35	0.26	G/CIU	
		600	1.31	334	316	0.56	0.53	G/DSS	
CE417	24.00 - 24.30	800	1.35	385	385	0.48	0.48	G/DSS	
		1200	1.29	362	287	0.30	0.24	G/DSS	
PL1	0.00 – 0.50	400	1.36	204	204	0.51	0.51	G/DSS	
	0.00 - 0.50	1000	1.43	390	235	0.39	0.24	G/DSS	
		250	1.46	244	244	0.98	0.98	G/DSS	
PL1	0.00 – 0.50 Remoulded	500	1.48	319	312	0.62	0.62	G/DSS	
		1000	1.49	396	359	0.40	0.36	G/DSS	

A plot of undrained shear strength ratio vs consolidation stress is provided as Figure D4-13. Equations defining the trend lines indicated on Figure D4-13 are:

- Peak triaxial strength $Su/p' = 0.72 0.000300 \sigma v'$
- Peak DSS strength $Su/p' = 0.66 0.000300 \sigma v'$
- Post Peak DSS strength Su/p' = 0.45 0.000200 σv'

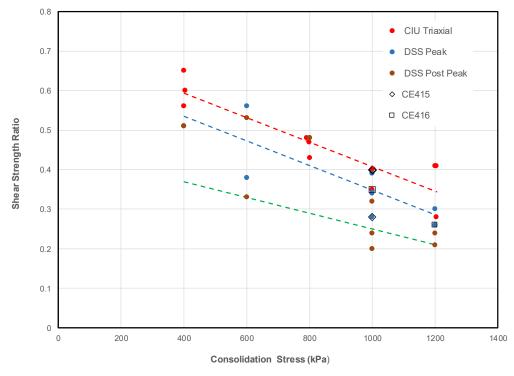


Figure D4-13: Unit A FRV - Shear stress ratio vs consolidation stress

MIT stress paths for representative CIU triaxial tests are graphed on Figure D4-14, together with effective stress, strength parameters calculated for these tests.

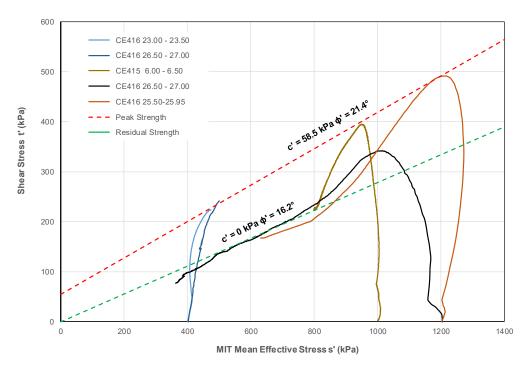
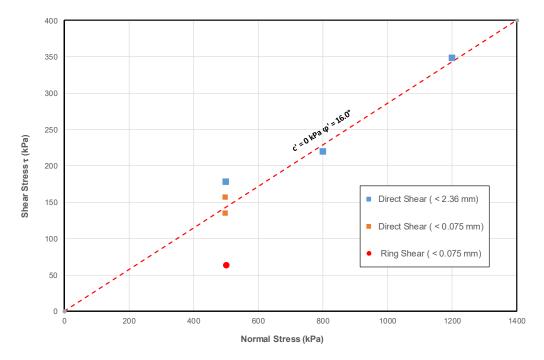


Figure D4-14: Unit A FRV – MIT stress paths & effective stress strength parameters

A ring shear test and direct shear tests were undertaken on a single sample of FRV Unit A (CE416 24.5 – 25.0) remoulded at its insitu moisture content and dry density (~34% & ~1.40t/m³).

Due to equipment limitations the ring shear test was completed at one normal pressure (500kPa) on material passing 75 µm. The direct shear test was completed at three normal pressures on material as received (passing 2.36 mm). In order to provide a direct comparison with the ring shear test, an additional direct shear test was completed on < 75 µm material and a normal pressure of 500 KPa. Residual values (after 4 to 5 reversal cycles) are plotted on Figure D4-15 indicate an average mobilised friction ϕ'_m = 16° at normal stresses above 800kPa.





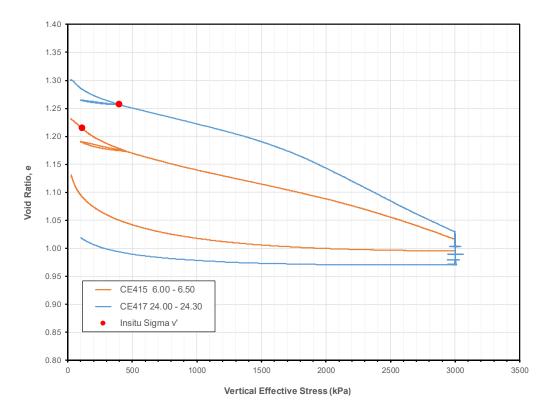
D4.4.3 Consolidation Tests

Two constant rate of strain (CRS) consolidation tests were completed on undisturbed samples of Unit A. The samples were loaded to 400kPa, unloaded to 100kPa, reloaded to 3200kPa, then, unloaded to 25kPa. The results are presented in Figure D4-16 as void ratio / vertical effective stress and in Figure D4-17 as Coefficient of Consolidation / log p'. Results are summarized in Table D4-9.

ID	Depth	RL	γd (t/m3)	w (%)	eo	Cr	Сс	σ'ρ
CE415	6.00 - 6.50	680.20	1.28	41.5	1.25	0.025	0.095	170
CE417	24.00 -24.30	676.08	1.23	37.1	1.32	0.013	0.075	130

Table D4-9: Unit A FRV - Summary of CRS consolidation test data

The apparent pre-consolidation pressure (σ_p) indicated in Table D4-9 was calculated using the Casagrande Method.





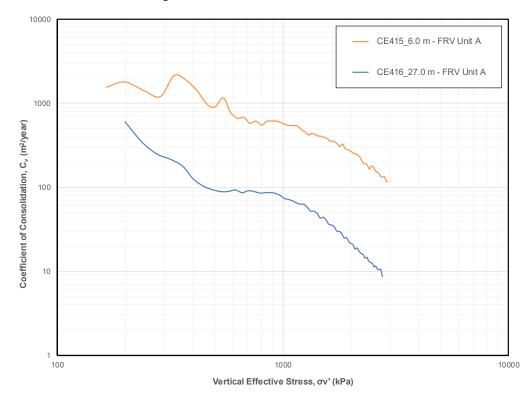
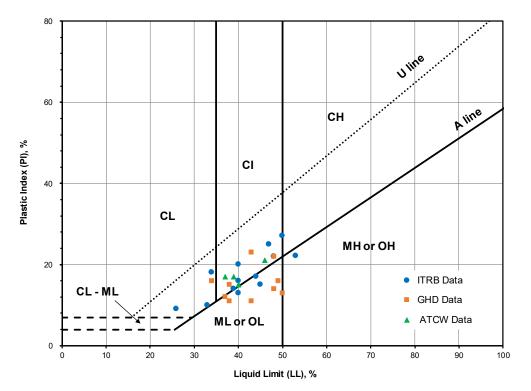


Figure D4-17: Unit A FRV – CRS Coefficient of Consolidation

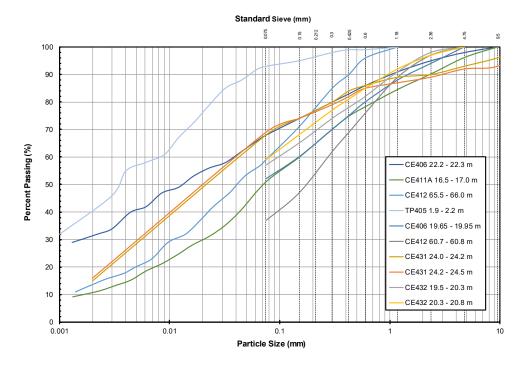
D4.5 Unit B – Forest Reef Volcanics

D4.5.1 Index Tests

Table D4-10 provides a summary of Atterberg Limit and index tests completed on ITRB, GHD and ATCW samples taken from Unit B FRV. Atterberg Limits and particle size distributions are plotted on Figure D4-18 and Figure D4-19 respectively.









Hole No. (refer	Depth (n		Att	erberg Lir	nits	Linear Shrinkage (%)	Field Moisture (%)	Dry Density (t/m3)	Specific Gravity
notes)	From	То	LL	PL	PI	us 1	Fielc	ĥ	Speci
CE406	19.65	19.95	33	23	10	6.0	22.3	1.54	
CE406	22.20	22.30	40	20	20	8.0	19.8	1.75	2.82
CE411A	16.50	16.95	53	31	22	12.5	37.4	1.46	2.83
CE412	62.15	62.20	47	22	25	12.5	23.3		
CE412	65.50	66.00	50	23	27	11.5	25.5	1.50	2.64
CE432	19.80	20.30	40	27	13	8.0	24.2	1.61	
CE432	20.30	20.80	40	24	16	6.5	28.2	1.52	2.63
CE432	23.50	24.0					26.4	1.58	2.70
CE433	33.80	33.80	26	17	9	6.0	28.2		
TP405	1.90	2.20	48	26	22	12.0	28.6	1.58	2.75
CE382	0.45	0.90	37	25	12	9.00	17.7	1.80	
CE382	1.50	1.95	38	23	15	10.0	14.1	1.83	
CE383	1.00	1.45	48	34	14		31.8	1.85	
CE383	2.00	2.45	50	37	13		37.4	1.68	
CE383	3.00	3.45	43	32	11		34.8	1.78	
CE383	4.00	4.41	48	26	22		30.5	1.90	
CE383	5.00	5.35	49	33	16		28.1	1.91	
CE384	2.00	2.25	38	27	11	9.0	14.6	1.73	
CE392	2.00	2.45	43	20	23	12.0	17.2	1.83	
CE392	3.50	3.66	34	18	16	9.5	11.3	1.97	
BH2A	0.22	0.52	37	20	17		24.1	1.63	2.75
BH2B	1.30	1.50	46	25	21		19.0		
BH2B	1.50	1.90						1.64	
BH2B	2.00	2.0	40	25	15		15.0		
BH2B	3.00	3.40	39	22	17		11.5		
BH3	1.00	1.50	40	25	15		18.0		

Table D4-10: Unit B FRV - Atterberg Limits and Index Tests

Notes

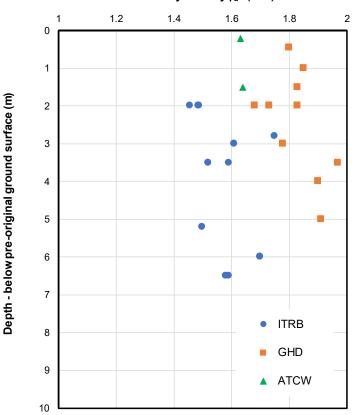
Sample

ITRB

GHD

ATCW

The initial dry density of Unit B samples is plotted against depth on Figure D4-20. The dry density of these samples is typically above 1.40t/m³.



Initial Dry Density γ_d (t/m³)



The initial void ratio of Unit B ITRB samples (open circles) and 'as tested' void ratios (closed circles) are plotted against confining stress on Figure D4-21.

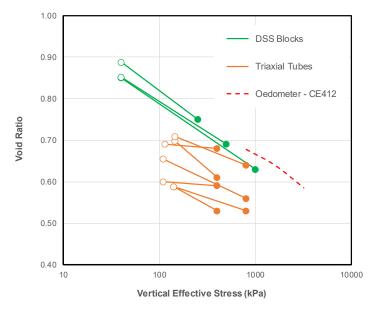


Figure D4-21: Unit B FRV – Initial & tested void ratio vs vertical stress

D4.5.2 Strength Data

Direct simple shear tests and CIU triaxial tests were completed on six samples of Unit B of the Forest Reef Volcanics. Undrained shear strength data is summarized in Table D4-11.

Comple	Depth	Consol. Stress (kPa)	Dry	Shear S	Strength	SS Ratio		Test
Sample No			Density (kN/m3)	Peak (kPa)	Post Peak (kPa)	Peak	Post Peak	Туре
		400	1.32	263	260	0.66	0.65	F/DSS
CE411A	16.50 – 16.95	800	1.46	504	501	0.63	0.63	F/DSS
		1200	1.49	529	527	0.44	0.44	F/DSS
		202 20.30 400	1.61	234		1.16		T/CIU
CE432	CE432 19.80 - 20.30		1.01	390	296	0.98	0.74	М
		795	1.59	511	158	0.64	0.20	T/CIU
CE432	20.30 - 20.80	204	1.52	203	186	1.00	0.92	T/CIU
66432	20.30 – 20.80	398	1.52	361	255	0.91	0.64	T/CIU
CE432	22.80 – 23.20	400	1.70	468	410	1.17	1.03	T/CIU
CE432	22.80 - 23.20	800	1.70	718	472	0.90	0.59	T/CIU
CE432	23.50 - 24.00	400	1.58	321	221	0.80	0.55	T/CIU
CE432	23.30 - 24.00	796	1.59	624	253	0.78	0.32	T/CIU
		250	1.58	90	90	0.36	0.36	G/DSS
TP405	1.90 – 2.20	500	1.63	165	162	0.33	0.32	G/DSS
		1000	1.69	278	260	0.28	0.26	G/DSS

Table D4-11: Unit B FRV – Undrained shear strength data

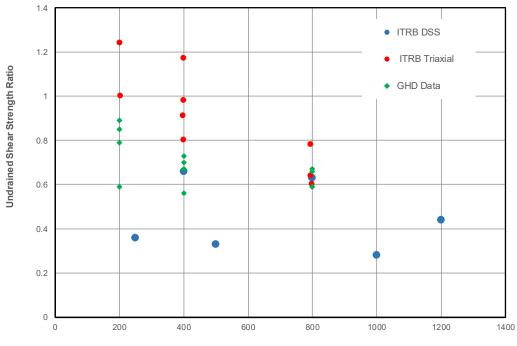
Results for tests on the above samples have been plotted on the following figures.

Figure D4-22 Undrained shear strength ratio vs consolidation stress for both DSS and CIU.

Figure D4-23. Shear stress versus vertical effective stress from DSS tests.

Figure D4-24. Stress paths for ITRB CIU triaxial tests.

Figure D4-25. MIT plot of shear strength at peak stress ratio for both ITRB and GHD data.



Consolidation Stress (kPa)



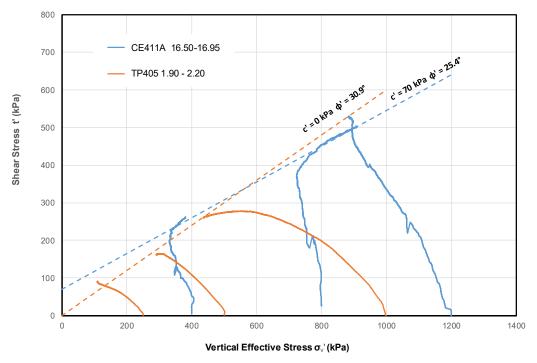


Figure D4-23: Unit B FRV – Shear stress versus vertical effective stress from DSS tests

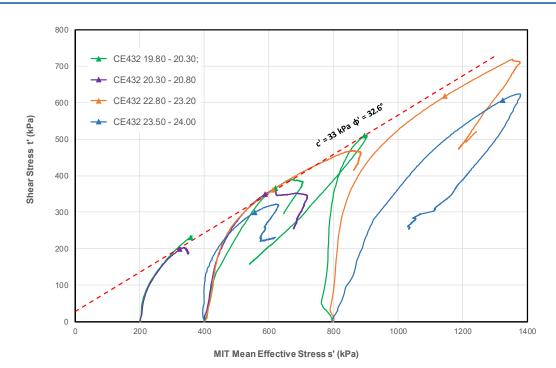


Figure D4-24: Unit B FRV - Stress paths for ITRB CIU triaxial tests

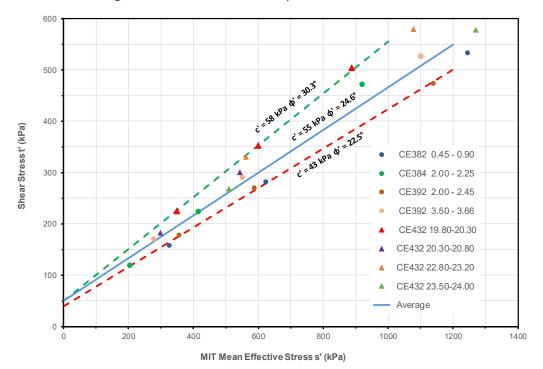


Figure D4-25: Unit FRV – MIT plot of shear strength at peak stress ratio

One direct shear test was completed on a section of FRV Unit B sonic core from CE406. Residual shear stress values are plotted on Figure D4-26.

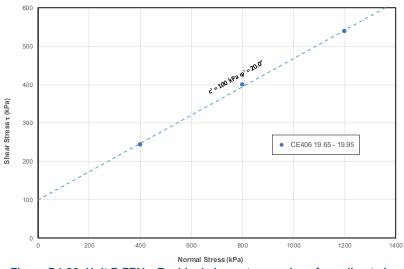


Figure D4-26: Unit B FRV – Residual shear stress values from direct shear

D4.5.3 Consolidation Tests

Two oedometer consolidation tests were completed on undisturbed samples of Unit B from Forest Reef Volcanics. The samples were loaded to 400kPa, unloaded to 100kPa, reloaded to 3200kPa, then, in the case of one sample, unloaded to 25kPa. The results are presented in Figure D4-27 as a plot of void ratio vs vertical effective stress and summarized in Table D4-12. The apparent pre-consolidation pressure (σ_p) indicated in Table D4-12 was calculated using the Casagrande Method.

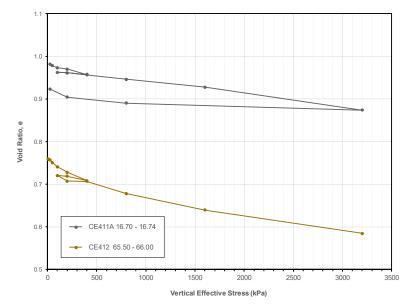


Figure D4-27: Unit B FRV – Oedometer consolidation plots

Table D4-12: Unit B FRV - Summary of consolidation test data

ID	Depth	RL	γd (t/m3)	w (%)	eo	Cr	Сс	σ'p
CE411A	16.70 – 16.74	673.3	1.44	30.9	0.982(1)	0.023	0.18	1000
CE412	65.50 - 66.00	666.6	1.50	26.1	0.758	0.022	0.18	400

Notes:

(1) Void ratio at initial loading stage

D5. Fill Materials and Nomenclature

D5.1 Embankment Zoning

The construction of the NTSF has been undertaken in ten (10) stages. The internal zoning and nomenclature has changed over the years and this is tracked in the following section.

The Stage 1 embankment had the following internal configuration;

- Zone A A 5m wide sloping clay core, thickening to 12m at the base,
- Zone B Upstream rockfill shoulder with a slope of 1.5H:1V,
- Zone D Downstream rockfill shoulder with a slope of 1.5H:1V,
- Zone C1 A 15m wide transition rockfill between the clay core and downstream rockfill shoulder of the embankment, and
- Zone C3 A secondary 5 m wide transition rockfill between Zone C1 and Zone A up to an elevation of 670 m,

The Stage 2A embankment, a 7m high zoned earth and rockfill downstream raise had the following internal configuration;

- Zone A A 5m wide sloping clay core,
- Zone B Rockfill shoulders with upstream and downstream slopes of 1.5H:1V,
- Zone B1 Downstream Rockfill platform with a slope of 1.5H:1V
- Zone C4 A 3 m wide transition rockfill between the clay core and downstream rockfill shoulder of the embankment, and
- Zone F A secondary 1 m wide filter between Zone C4 and Zone A,

The Stage 2B embankment was also designed as a 7m downstream raise with zoning identical to Stage 2A, however Stage 2B was constructed in two separate lifts, each of 3.5m height. At this stage the nomenclature for the zones was changed from alphabetical to numerical. The Stage 2B dam had the following internal configuration;

- Zone 1 A 5m wide sloping clay core,
- Zone 3B Rockfill shoulders with upstream and downstream slopes of 1.5H:1V
- Zone 3A A 3 m wide transition rockfill between the clay core and downstream rockfill shoulder of the embankment, and
- Zone 2A A secondary 1 m wide filter between Zone C4 and Zone A,

The Stage 3 embankment was designed as a 4.5 m central raise with the upstream shell founded on the Stage 2 tailings beach. The embankment has upstream and downstream slopes of 2H:IV and 1.5H:IV respectively, and a 9 m crest width. The Stage 3 dam had the following internal configuration;

- Zone 1 A 3m wide vertical clay core with a 3m wide cap
- Zone 3B or 3A Rockfill shoulders with an upstream slope of 2H:1V and downstream slope of 1.5H:1V
- Zone 3A A 3 m wide transition rockfill between the clay core and downstream rockfill shoulder of the embankment, and
- Zone 3D A working platform between the embankment and the tailings beach

Stages 4 through to 10 were designed as upstream raises of varying heights with upstream and downstream slopes of 2H:1V and 9m crests. These lifts had the following internal configurations;

- Zone 1 A 4 m wide downstream sloping clay core with a 0.8 m horizontal clay blanket spanning the stage 3 Crest
- Zone 3B or 3A Rockfill downstream shoulder with a slope of 2H:1V
- Zone 3A A 3 m wide transition rockfill between the clay core and downstream rockfill shoulder of the embankment with a 0.6 m thick layer between the clay blanket and downstream rockfill, and
- Zone 3D A working platform between the embankment and the tailings beach.

Table D5-1 provides a summary of the zone types for both Stage 1 / Stage 2A and Stage 2B.

	Embankr	ment Zones	
Fill Type	Stage 1/ Stage 2A	Stage 2B and Later	Notes
Clay Fill	Zone A	Zone 1	Placed in 200 mm lifts
	Zone B	Zone 3B	Monzonite Rockfill with a maximum Particle size of 600 mm, placed in 1.25 m lifts
	Zone D	Not Used	Silurian sedimentary Rockfill with a maximum particle size of 300 mm, placed in 650 mm lifts
	Zone B1	Not Used	Monzonite Rockfill with a maximum particle size of 1000 mm, end dumped in 5 m lifts.
Rockfill	Not Used	Zone 3C	Monzonite Rockfill with a maximum Particle size of 1000 mm, placed in 5 m lifts
	Zone C4	Not Used	Monzonite Rockfill with a maximum Particle size of 300 mm, placed in 300 m lifts
	Not Used	Zone 3A	Monzonite Rockfill with a maximum Particle size of 300 mm, placed in 600 m lifts
	Not Used	Zone 3D	Well Graded Fresh Overburden from Mining Operations, Maximum Particle size of 300 mm
	Zone C1	Not Used	Silurian Sedimentary Rockfill, Placed in 300 mm lifts
Filters	Zone C3	Not Used	Silurian Sedimentary Rockfill, Placed in 300 mm lifts
	Zone F	Not Used	Placed in 300 mm lifts
	Not Used	Zone 2A	Placed in 300 mm lifts

Table D5-1: Summary of Stage 1 and 2 embankment zoning

D5.2 Clay Fill

D5.2.1 Previous Investigations

Prior to construction, two rounds of tests were conducted on the clayey soils within the reservoir area and within the foundation footprint for the purpose of clay borrow investigations. The first was by Woodward-Clyde as part of the Cadia Mine Feasibility Study (1995-001) and the second by Pells Sullivan Meynink (1997-001) as part of a supplementary site investigation for detailed design. The samples taken by Pells Sullivan Meynink (PSM) were combined to create bulk samples as follows;

- TP100 to TP104 upper right abutment, above RL705 m
- TP105 to TP107 plateau area on right abutment at RL 705 m
- TP108 to TP112 central right abutment
- TP113 to TP115 lower right abutment, below about RL686 m
- TP118 to TP121 left abutment (all residual andesite)

Effective stress strength parameters were determined on three Woodward Clyde and one PSM sample compacted to 98% of Standard Maximum Dry Density. The results of these tests are summarized in Table D5-2, together with the results of three similar tests completed by Woodward Clyde in 2000 (2000-003) on samples from Lower Rodds Creek (LRC) TSF, now the STSF. An MIT plot of these tests, together with three tests completed for Upper Rodds Creek (URC) dam or presented as Figure D5-1.

Test Pit	Depth (m)	MC (%)	γd (kN/m3)	c' (kPa)	ϕ ' (degrees)			
Woodward-Clyde Investigation (1995)								
TS12	0.3 - 0.6	19.3	1.71	18	30			
TS6	0.2 - 1.4	19.8	1.71	79	22			
TD38	1.9 - 4.1	18.4	1.71	32	25			
Pells Sullivan Meyninl	k Investigation	(1997)						
TP100 +TP107	Combined	27.2	1.48	6	24			
Woodward-Clyde Inve	stigation (2000)						
TP4	0.6 - 1.5	16.0	-	20	26.5			
TP6	0.6	17.1	-	15	27			
TP26	1.0	19.4	-	20	22.5			

Table D5-2: Results of preconstruction triaxial strength tests

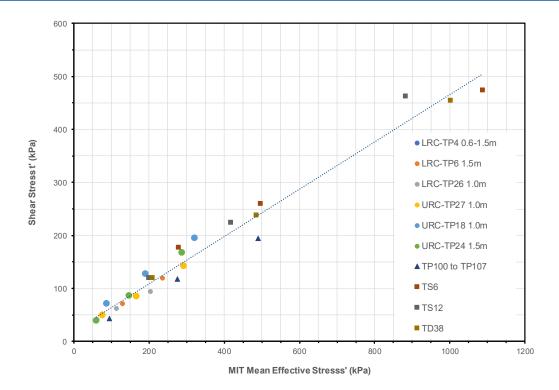


Figure D5-1: MIT plot of preconstruction and 2000 triaxial tests

D5.2.2 Construction

The specifications for Zone A/1 are provided in Table D5-3 and Table D5-4.

	Percent F	Passing (%)
Grain size (mm)	Min	Max
37.5	100	100
19	95	100
4.75	85	100
1.18	65	100
0.425	50	100
0.25	35	95
0.075	20	90
0.002	8	80
0.001	0	0

Table D5-3: Zone A/1 - Gradation specification

Table D5-4: Zone A/1 - Atterberg Limit Specification

Atterberg Limits	
Liquid Limit (%)	25-80
Plasticity Index (%)	10-50
Linear Shrinkage (%)	<20

Atterberg limits from Quality Assurance (QA) testing of Stage 1 and Stage 2A clay core materials, presented on Figure D5-2 and Figure D5-3 respectively, show that tested materials generally conformed to the construction specification

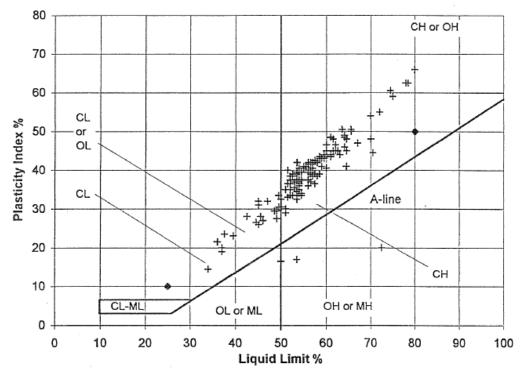
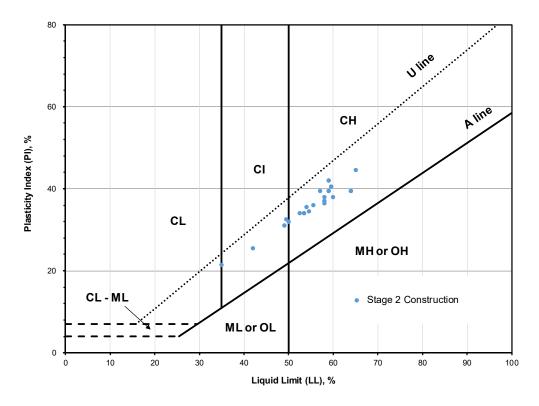


Figure D5-2: Stage 1 – Atterberg Limits from construction QA





D5.2.3 ITRB Investigation Data

As part of the ITRB investigation program, one drill hole (CE407) was completed specifically to intersect and sample the Stage 1 embankment clay core. The clay core intersected, over a depth of 3.5m, was high plasticity brown clay and three undisturbed samples were recovered. Two CIU tests and one oedometer consolidation test were completed on these samples.

Undrained shear strength data from the two CIU tests are summarized in Table D5-5, while the undrained shear strength ratio for these and the pre-construction tests (Table D5-2) are plotted in Figure D5-4. As could be expected the post peak mobilized friction shows only a minimal post peak reduction.

An MIT plot of effective stress strength results for the ITRB and previous tests is presented as Figure D5-5, while consolidation test results are presented in Figure D5-6 and Table D5-6.

				Shear S	trength	Stress	Ratio	
Sample No	Depth (m)	Consol. Stress (kPa)	Dry Density (kN/m³)	Peak (kPa)	Post Peak (kPa)	Peak	Post Peak	Test Type
CE407	50.00 - 50.50	613	1.73	207	-	0.34	-	CIU
CE407	50.00 - 50.50	812	1.73	294	-	0.36	-	CIU
CE407	50.00 - 50.50	1203	1.73	396	345	0.33	0.29	CIU
CE407	51.00 - 51.50	1202	1.77	456	445	0.38	0.37	CIU

 Table D5-5: Clay Core – Undrained shear strength data

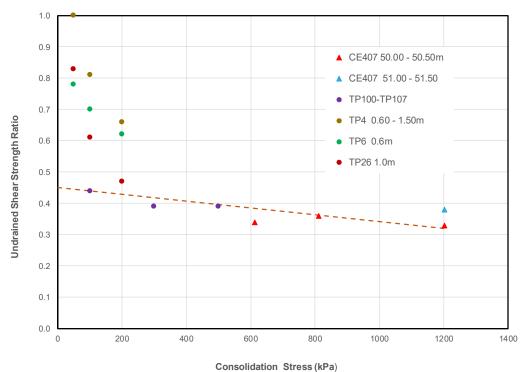
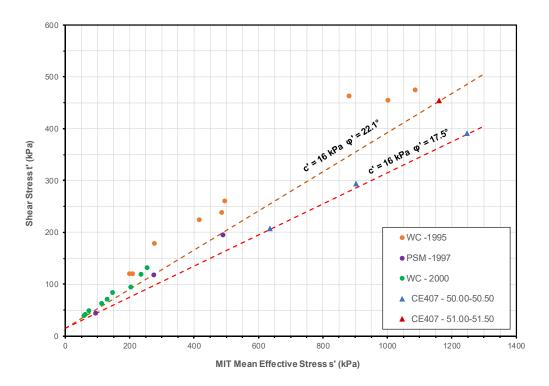


Figure D5-4: Clay Core – Undrained shear strength ratio results.





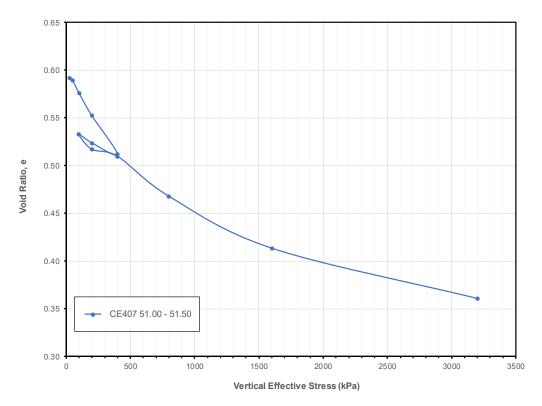


Figure D5-6: Clay Core – Oedometer consolidation test result

Table D5-6:	Clay Core -	- Summary of	consolidation test data
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ID	Depth	RL	γd (t/m3)	w (%)	eo	Cr	Сс	σ'p
CE407	51.00 – 51.50	680.5	1.63	22.2	0.578	0.038	0.175	180

D5.3 Rockfill

D5.3.1 Construction

Rockfill (both Monzonite, and Silurian Sedimentary rock), was sourced from the initial stripping and mining operations for the open pit. The various specifications for these materials are summarised in Table D5-7.

Zone	Maximum Particle Size (mm)	Maximum Lift Thickness (m)	Compaction Requirements	Rock Type
B/3B	600	1.25	5 passes of a 10-tonne static weight vibrating roller	Fresh Monzonite Rock
B1	1000	10	End-dumped	Fresh Monzonite Rock
C4	300	0.3	2 passes of a 3-tonne static weight vibrating roller	Fresh Monzonite Rock
D	300	0.65	5 passes of a 10-tonne static weight vibrating roller	Silurian Sedimentary Rock
ЗA	300	0.6	5 passes of a 5-tonne static weight vibrating roller	Fresh Monzonite Rock
3C	1000	5	Trafficking of Haul Trucks with High Energy Impact Compaction.	Fresh Monzonite Rock

Table D5-7: Rockfill – Type and construction specification.

During construction of Stage 1, it became apparent that the volume of monzonite rock for Zone B was limited, and placement was constrained by double handling. As a consequence, the upstream shoulder was retained as Zone B (monzonite) while the downstream shoulder was changed to Silurian sedimentary rock (Zone D), compacted in the same manner as Zone B.

The Silurian sedimentary rockfill, designated as Zone D, was initially considered inferior to the igneous rock (Zone B) and as a consequence, the Stage 1 design was modified to incorporate a downstream waste rock berm (Zone B1), with a crest width of 32m at RL690m, and a downstream slope of 1.35H:1V. Zone B1 consisted of monzonite directly hauled from the open pit. Subsequently, direct shear tests on Zone D material indicated that it met the requirements of the original design, and placement of Zone B1 was postponed even though it formed part of the Stage 2 embankment. The direct shear tests on Zone D material are not reported in the construction documentation.

No quality control testing was completed on any of the rockfill zones.

D5.3.2 Design Shear Strength

Due to the difficulty (particle size and variability) and cost of performing large-scale tests on rockfill, no strength tests were completed for design nor insitu density tests during construction.

The bulk density used in design for the rockfill ranged between 19 kN/m³ and 20 kN/m³, while drained strength parameters of c' = 0kPa and ϕ ' = 40° were adopted for rockfill and c' = 0kPa and ϕ ' = 42° were adopted for the finer transition zone.

The rockfill strength parameters adopted for design were checked using Leps (1985) assembled published laboratory test data on rockfill strength and reported the friction angle as a function of normal pressures, as deduced from the Mohr diagram. A shortfall of the Leps data set is a lack of information at normal pressures below 70kPa. Lepps also acknowledges that this data only provides a rough estimate of the effects of relative density, gradation, and the effect of crushing, and that there is no evaluation of particle shape or degree of saturation influence

The Leps data set was subsequently been screened to include only fine grained igneous rocks similar to that which was used in the NTSF. This data is reproduced in Figure D5-7 and indicates that a friction angle of 40° to 42° is appropriate for a normal stress of 1000 to 2000 kPa.

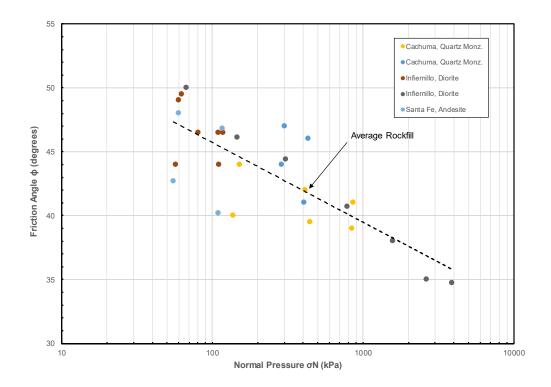


Figure D5-7: Leps (metric version) including fine grained igneous rocks

The reduction in shearing strength with confining pressure observed in triaxial tests on rockfill can also be described by the equation:

$$\tau = A (\sigma_n)^{b}$$

Where:

 τ = rockfill shear strength σ_n = normal stress A & b are constants. Haselsteiner et. al. (2016) have looked at a more recent database of rockfill testing (2009) and have proposed four rock fill strength classes using the A b parameters as indicated in Figure D5-8.

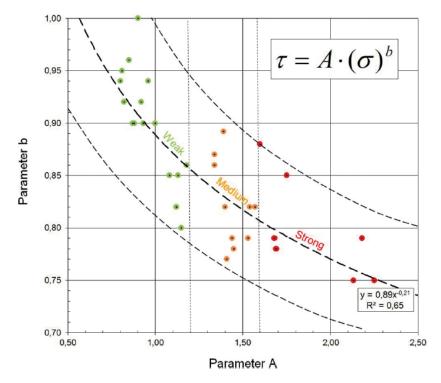


Figure D5-8: Rockfill strength parameters (Haselsteiner et al.)

Parameters A = 0.90, b = 0.97 provide a reasonable approximation to the lower bound strength in Lepps, while parameters of A = 1.9, b= 0.85 provide a reasonable approximation of the average rockfill strength for fine grained igneous rock shown in Figure D5-7.

D5.3.3 Deformation Modulus

The modulus of compressibility (E) of the rockfill is dependent on the rock type, strength, shape and gradation of rock sizes in the rockfill and layer thickness. It is also dependent on the roller size and type, number of passes, whether water is added during compaction, the confining stresses on the rockfill and also the duration of loading, i.e. there is a creep component.

Hunter and Fell (2002) developed a method for estimating the secant modulus of rockfill during construction (Erc) and pseudo modulus on first filling (Erf) based on analysis of monitoring data, mostly for concrete faced rockfill dams. Hunter and Fell recommend determining the representative secant modulus at the end of construction Erc using the D80 of the rockfill for rockfill of various strength as indicated in Figure D5-9.

In the case of the NTSF, with only the maximum particle size specified for the rockfill, a coefficient of uniformity (CU) of 7.5 (used to prevent gap-graded filters) can be used to determine the D80. For the three rockfills specified above, the secant modulus can be estimated as an average of 75 MPa.

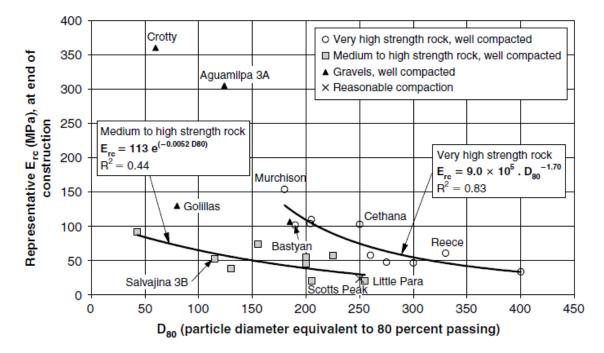


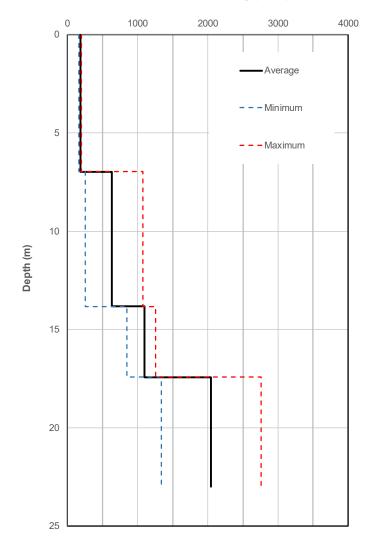
Figure D5-9: Representative secant modulus versus particle size and UCS

D5.3.4 Dynamic Shear Modulus

GHD were engaged by Newcrest to complete a geophysical investigation in the vicinity of the NTSF and STSF which comprised six ERI traverses and twelve Seismic Refraction Tomography (SRT) traverses.

Seismic refraction traverse Line 7 was located along the toe of the NTSF southern embankment. The traverse was approximately 1650m long and commenced on the eastern abutment of the NTSF and terminated on the partially constructed Stage 2 Buttress at approximately CH2500. As part of the seismic refraction traverse, Multi-channel Analysis of Surface Wave (MASW) soundings were completed at 18m intervals along the traverse. The output of the MASW soundings is a profile of shear wave velocity with depth which in turn can be interpreted as a profile of the dynamic shear modulus with depth.

A selection of MASW soundings completed along the Stage 2 Buttress were analysed to assess the dynamic shear modulus of the embankment rockfill. The results from nine MASW soundings are plotted on Figure D5-10 as the minimum, average and maximum shear wave velocity against the average thickness of the respective layers.



Shear Wave Velocity (m/sec)

Figure D5-10: Stage 2 Buttress Rockfill – Shear wave velocity ranges

Due to the variable thickness of the rockfill at the toe of the southern embankment, the dynamic shear modulus calculated from specific soundings was compared with materials intersected in adjacent drillholes. In the case of drillholes CE403 and CE404, the midpoints of the soundings were located within 10m of the drillholes, while the nearest sounding to CE405 was located 100m to the east. The results for these three soundings are shown on Figure D5-11.

Taking into consideration possible errors in the layer thicknesses calculated from the MASW sounding, Table D5-8 provides a comparison of material type, shear wave velocity and dynamic shear modulus based on drillholes CE403, CE404 and CE405.

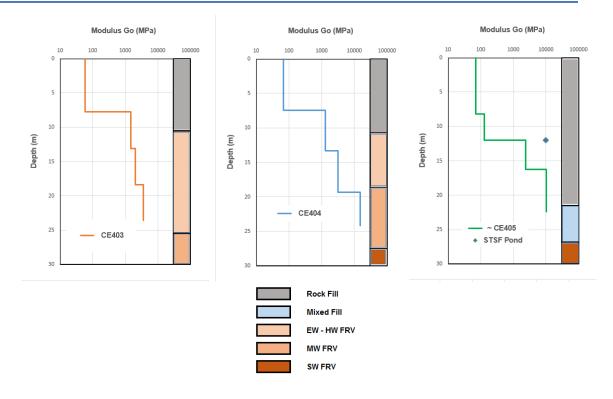


Figure D5-11: Stage 2 Buttress Rockfill – Comparison of MASW soundings and drillholes

Material Type	Shear Wave Velocity (m/sec)	Dynamic Shear Modulus (MPa)		
Rockfill	170 - 260	60 - 130		
EW – HW Volcanics	810 – 1,090	1,310 – 2,390		
MW Volcanics	1,250 – 1,340	3,140 – 3,580		
SW- Fresh Volcanics	2,260 - 3,080	10,190 – 20,870		

Table D5-8: Comparison of shear wave velocity, dynamic shear modulus and material

D5.4 Filters

D5.4.1 Construction

As Stages 1 and 2 of the NTSF were design as water retaining structures, filters were provided between the clay core and the downstream rockfill. The specification for these materials are summarised in Table D5-9.

Particle Size (mm)	Zone C1	Zone C3	Zone F
300	100-100		
200	96-100		
160	87-100		
80		100-100	
75	83-100	83-100	100-100
63	80-100	80-100	-
53	77-100	77-100	-
37.5	72-100	72-100	94-100
26.5	66-100	66-100	-
19.0	60-98	60-98	90-100
13.2	54-92	54-92	-
9.5	50-87	50-87	74-100
6.7	43-80	43-80	-
4.75	38-75	38-75	60-100
2.36	28-62	28-62	44-100
1.18	19-50	19-50	28-85
0.60	13-42	13-42	10-65
0.425	9-36	9-36	-
0.30	6-32	6-32	0-45
0.15	2-22	2-22	0-20
0.075	0-13	0-13	0-10
0.050	0-12	0-12	
0.001	0-0	0-0	

Table D	5-9: F	ilter Sp	ecification
---------	--------	----------	-------------

A major change to the design during the construction, was the inclusion of transition, Zone C3, as an L shaped zone at the base of Zone C1 and between Zone C1 and the core. Whereas Zone C1 was < 300mm Silurian sedimentary rock visually selected in the open pit, Zone C3 was crushed to < 80mm, placed in 300mm loose layers and compacted with 1 pass of a 10 tonne static weight vibrating roller. The base leg of Zone C3 was 10m wide and extended up the abutments to RL695 as a 1m thick layer, while the upstand leg was 5m wide and extended full height to RL670 and then 3m height between RL670 and RL680.

Excavation beneath the clay core and transition/ filter was undertaken to expose hard residual soil or extremely weathered rock. Where potentially permeable material was identified in the downstream side of the core trench, the core trench was widened (on the downstream side by 6m and blanketed with Zone A. Zone C3 filter was then extended over the widened section of core trench.

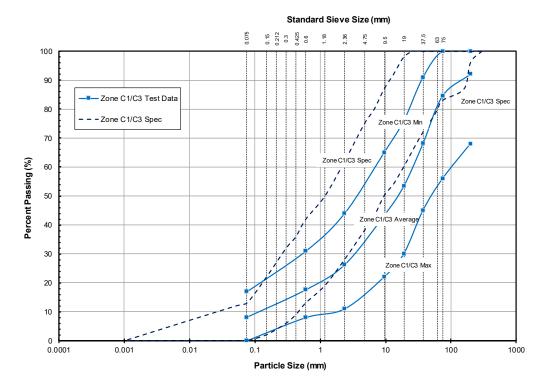
D5.4.2 Quality Control

Apart from the Clay Core, Zones C1 and C3 were the only materials that were tested regularly as part of the QA. The summarised results for Stage 1 QA on Zone C1 and C3 are shown in Figure D5-12, however the tests did not distinguish between Zone C1 and Zone C3, even though they had separate specifications.

During construction, concerns were raised regarding the particle size distribution of Zone C1, as the contractor consistently had difficulties in achieving the specified material grading. Test excavations in this material indicated that voids were filled. It was also decided to complete a large scale slot test to assess the potential for piping.

The test was completed in a 44-gallon drum and Zone C1 and Zone A materials were compacted in layers. An 8 mm cable, embedded into the Zone A material, was pulled out to create an artificial crack. The test confirmed, that under a significant head, the artificial crack in the did not propagate.

There exists no documentation for the QA/QC testing on Zone F, however the Stage 2A construction report states that "After some initial teething problems and plant modifications, a sand/gravel product meeting the specification requirements was consistently produced".



The average QA/QC data for Zone 2A is reproduced in Figure D5-13.

Figure D5-12: QA/QC Data for Zones C1/C3

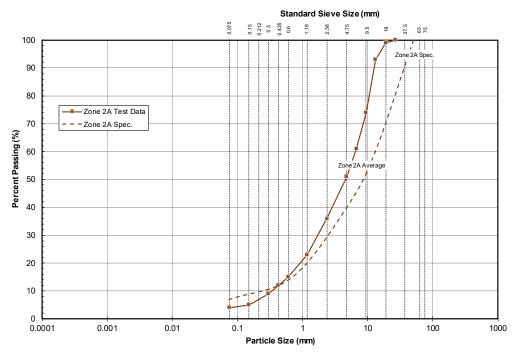


Figure D5-13: QA/QC Data for Zone 2A

D5.4.3 Filter Design Criteria

A filter criteria analysis was completed to assess the suitability of Zone C1/C3 to act as a critical filter for Zone 2A. This analysis, based on Chapter 26 of the National Engineering Handbook (1994), assesses filtering criteria, permeability criteria, prevention of gap-graded filters, and segregation criteria. As shown in Figure D5-14, Zone C1/C3 complies with the permeability and filter criteria at the D15 size. However, it becomes too coarse and well graded to comply with gap-graded prevention and segregation criteria. Zone 2A complies with all criteria except for gap-graded prevention at the D60 size.

A second analysis was completed to determine the internal stability of both filters using the Kenny and Lau (1985) method. The Zone C1/C3 filters fall well within the unstable zone while the Zone 2A filter falls just outside of the zone.

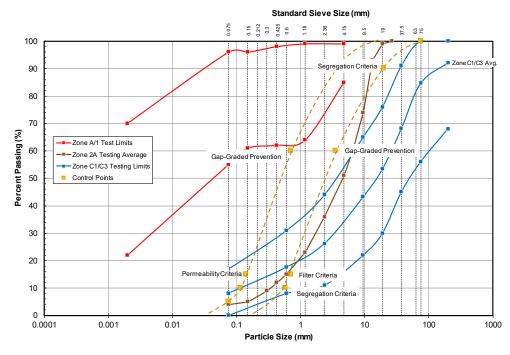


Figure D5-14: Filter Criteria for Zone A/1 with Zone C1/C3 and Zone 2A

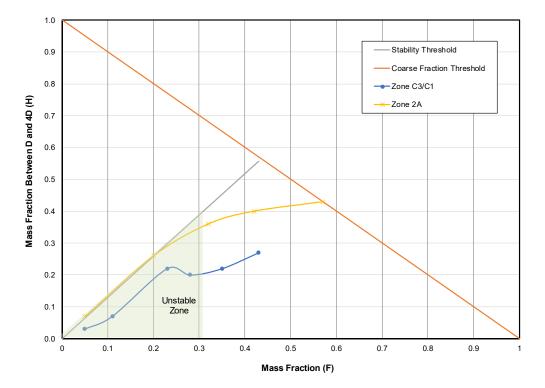


Figure D5-15: Internal stability analysis for Zone C1/C3 and Zone 2A

D6. References

Hunter, G., & Fell, R. (2002). The Deformation Behaviour of Rockfill. UNICIV Report No. R405, School of Civil and Environmental Engineering, The University of New South Wales.

- Kenny, T., & Lau, D. (1985). Internal stability of granular filters. Candian Geotechnical Journal. Leps, T. (1970). Review of Shearing Strength of Rockfill. Journal of the Soil Mechanics and Foundations Division, 1159-1171.
- National Engineering Handbook. (1994). *Gradation Design of Sand and Gravel Filters*. United States Department of Agriculture Natural Resources Conservation Service .

Annexure DA Index Tests



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley Operations

IPO Number: 2018-017 Sample ID: Refer to Table Borehole ID: Refer to Table

Tested By:	KM	Checked By:	RC
Date:	Refer to Table	Date:	26/09/2018

ATTERBERG LIMITS Test Method: AS1289.3.9.1, AS1289.3.2.1 and AS1289.3.3.2

Borehole				Depth (m)		W _L *	W _P *	l _P *		LS*
ID	Sample No.	Sample ID	Date Tested	-		(%)	(%)	чР	(%)	mode*
				From	То	((/		(/	
CE411	PT1	2018-017-005	25/09/2018	3.00	3.45	59	21	38	15.0	Cracking
CE411A	PT2	2018-017-007	18/09/2018	12.50	12.95	53	27	26	12.0	Curling
CE411A	PT4	2018-017-011	25/09/2018	15.00	15.35	54	27	27	11.5	Curling
CE411A	PT5	2018-017-016	25/09/2018	16.50	16.95	53	31	22	12.5	Curling

* W_L = Liquid Limit, W_P = Plastic Limit, I_P = Plasticity Index, NP = Non Plastic, LS = Linear Shrinkage Method of preparation : Dry sieved, History of sample : Oven dried at 50[°]c mode = condition after drying

node - condition after drying

Cadia NTSF Failure - Laboratory Testing Atterberg Limits

Figure A2-1

Job No.LAB127730

N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\03 Classification\04 Atterberg Limits\03 FinalRev 0\For Client\2018-017 AL.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT1

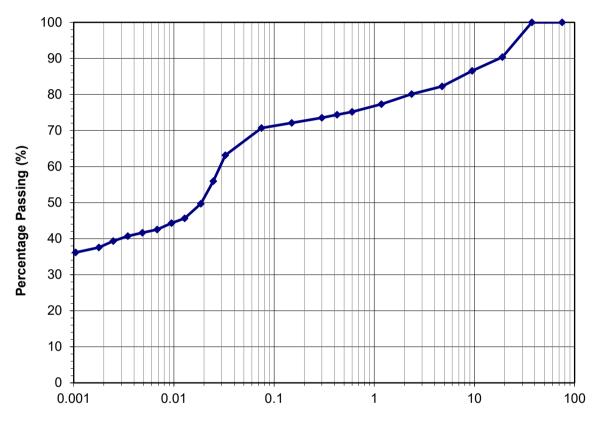
 IPO Number:
 2018-017

 Sample ID:
 2018-017-005

 Borehole ID:
 CE411

 Depth:
 3.00 m to 3.45 m

Tested By:	KM	Checked By:	RC
Date:	26/09/2018	Date:	28/09/2018



PARTICLE SIZE DISTRIBUTION Test Method: AS1289.3.6.1 & AS1289.3.6.3

Particle Size (mm)

Sieve Analysis						
Particle size (mm)	% passing	Particle size (mm)	% passing		Pai	
75	100	1.18	77			
37.5	100	0.600	75			
19	90	0.425	74			
9.5	87	0.300	74			
4.75	82	0.150	72			
2.36	80	0.075	71			

Hydrometer Analysis							
Particle size (mm)	% passing	Particle size (mm)	% passing				
0.0326	63	0.0049	42				
0.0248	56	0.0035	41				
0.0186	50	0.0025	39				
0.0128	46	0.0018	38				
0.0095	44	0.0010	36				
0.0068	43						

Project Particle Size Distribution

Figure A1-1

Job No.LAB127730

N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\03 Classification\03 PSD\03 Final\Rev 0\For Client\2018-017-005 PSD.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT2

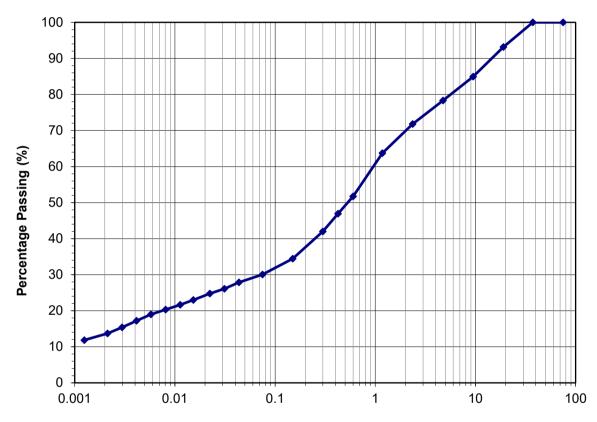
 IPO Number:
 2018-017

 Sample ID:
 2018-017-007

 Borehole ID:
 CE411A

 Depth:
 12.50 m to 12.95 m

Tested By:	SL/KM	Checked By:	RC
Date:	20/09/2018	Date:	28/09/2018



PARTICLE SIZE DISTRIBUTION Test Method: AS1289.3.6.1 & AS1289.3.6.3

Particle Size (mm)

Sieve Analysis				
Particle size (mm)	% passing	Particle size (mm)	% passing	
75	100	1.18	64	
37.5	100	0.600	52	
19	93	0.425	47	
9.5	85	0.300	42	
4.75	78	0.150	34	
2.36	72	0.075	30	

Hydrometer Analysis				
Particle size (mm)	% passing	Particle size (mm)	% passing	
0.0436	28	0.0058	19	
0.0312	26	0.0041	17	
0.0223	25	0.0030	15	
0.0153	23	0.0021	14	
0.0113	22	0.0012	12	
0.0081	20			

Project Particle Size Distribution

Figure A1-2

Job No.LAB127730

N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\03 Classification\03 PSD\03 Final\Rev 0\For Client\2018-017-007 PSD.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT5

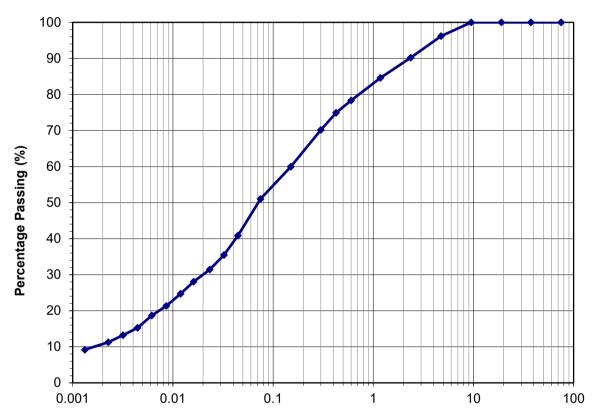
 IPO Number:
 2018-017

 Sample ID:
 2018-017-016

 Borehole ID:
 CE411A

 Depth:
 16.50 m to 16.95 m

Tested By:	SL/KM	Checked By:	RC
Date:	25/09/2018	Date:	28/09/2018



PARTICLE SIZE DISTRIBUTION Test Method: AS1289.3.6.1 & AS1289.3.6.3

Particle Size (mm)

Sieve Analysis				
Particle size (mm)	% passing	Particle size (mm)	% passing	
75	100	1.18	85	
37.5	100	0.600	78	
19	100	0.425	75	
9.5	100	0.300	70	
4.75	96	0.150	60	
2.36	90	0.075	51	

Hydrometer Analysis				
Particle size (mm)	% passing	Particle size (mm)	% passing	
0.0445	41	0.0062	19	
0.0323	35	0.0044	15	
0.0233	31	0.0032	13	
0.0161	28	0.0023	11	
0.0120	25	0.0013	9	
0.0086	21			

Cadia NTSF Failure - Laboratory Testing Particle Size Distribution

Figure A1-3

N:lagLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\03 Classification\03 PSD\03 Final\Rev 0\For Client\2018-017-016 PSD.xlsm

Job No.LAB127730



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley Operations

IPO Number: 2018-017 Sample ID: Refer to Table Borehole ID: Refer to Table

Tested By:	KM	Checked By:	RC
Date:	Refer to Table	Date:	28/09/2018

SOIL PARTICLE DENSITY OF FRACTION PASSING THE 2.36 mm SIEVE Test Method: AS1289.3.5.1

Borehole ID	Sample No.	Sample ID	Date Tested	Dept	h (m)	Soil Particle Density
	NO.			From	То	(g/cm³)
CE411	PT1	2018-017-005	26/09/2018	3.13	3.18	2.79
CE411A	PT2	2018-017-007	26/09/2018	12.91	12.95	2.87
CE411A	PT5	2018-017-016	26/09/2018	16.70	16.74	2.83

Cadia NTSF Failure - Laboratory Testing Soil Particle Density

Figure A3-1



Sean Lenihan - Senior Laboratory Technician

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Client:	Hatch Pty Ltd				
	61 Petrie Terrace Brisbane QLD 4000				
Project:	NTSF Embankment Failure ITRB		Date:	22/06/18	
Location:	Cadia Mine		Project No.:	18101980	
Test procedu	ure: AS 1289.2.1.1,AS 1289 3.9.1, AS 1289.3.2	2.1, AS 1289.3.3.2 & A	S 1289.3.4.1		
	Laboratory Reference Number		180721		
	Sample Identification		18005 TP401 0.	.7-1.0m	
	oumple identification		Block sam	ple	
	Sample Description		CLAY (with sand, tra	ce of gravel)	
	Liquid Limit (%)		53		
Plastic Limit (%)			20		
	Plasticity Index (%)		33		
	Linear Shrinkage (%)		14.5		
	Moisture Content (%)	ND			
	Sample History		Air Dried		
	Method of Preparation	Dry Sieved		d	
	Length of Shrinkage Mould (mm)	125			
	Cracking, Curling or Crumbling		Yes		
N.D	. = Not Determined N.O. = Not	ot Obtainable	N.P. =	= Non Plastic	
Notes:					
Tested as rece	vived			PLF1-041 RL0 21/11/17	
Certificate Re	eference: 18101980_180721_TR-180090_PI_	Rev0			
	NATA Accreditation No: 1961	Perth	Sean	Centhan	
NATA	Accredited for compliance with ISO,	/IEC 17025			

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Notes:



Sean Lenihan - Senior Laboratory Technician

Perth Laboratory 84 Guthrie Street Osborne Park Perth WA 6017 P: +61 8 9441 0700 F: +61 8 9441 0701 www.golder.com perthlab@golder.com.au Client: Hatch 61 Petrie Terrace, Brisbane Project: NTSF Embankment Failure ITRB Date: 29/06/18 Location: Cadia Mine Project No.: 18101980 Test procedure: AS 1289.2.1.1, AS 1289 3.9.1, AS 1289.3.2.1, AS 1289.3.3.2 & AS 1289.3.4.1 Laboratory Reference Number 180788 18006 TP405 Block Sample Sample Identification 1.9-2.2m **Sample Description** CLAY (trace of sand) Liquid Limit (%) 48 Plastic Limit (%) 26 Plasticity Index (%) 22 Linear Shrinkage (%) 12.0 **Moisture Content (%)** ND Air Dried **Sample History** Method of Preparation Dry Sieved Length of Shrinkage Mould (mm) 125 Cracking, Curling or Crumbling No N.O. = Not Obtainable N.D. = Not Determined N.P. = Non Plastic PLF1-041 RL0 21/11/17 Tested as received **Certificate Reference:** 18101980_180788_TR-180102_PI_Rev0 Sean Lenihan NATA Accreditation No: 1961 Perth NATA Accredited for compliance with ISO/IEC 17025

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N.C	Length of Shrinkage Mould (mm) Cracking, Curling or Crumbling D. = Not Determined	N.O. = Not Obtainable	125 No N.P. = Non Plastic		
	Method of Preparation		Dry Sieved		
	Sample History		Air Dried		
	Moisture Content (%)		ND		
	Linear Shrinkage (%) 11.5		11.5		
Plasticity Index (%)			37		
Plastic Limit (%)			26		
	Liquid Limit (%) 63		63		
	Sample Description CLAY		CLAY		
	Sample Identification		18027 CE416 PT2 24.0-24.33m		
	Laboratory Reference Number		181314		
	ure: AS 1289.2.1.1,AS 1289 3.9.1, AS		•		
Project: .ocation:	NTSF Embankment Failure ITRB Cadia Mine	Dat	e: 25/09/18 ject No.: 18101980		
	61 Petrie Terrace, Brisbane	_			
Client:	Hatch		84 Guthrie Street Osborne Park Perth WA 6017 P: +61 8 9441 0700 F: +61 8 9441 0701 www.golder.com perthlab@golder.com.au		

Sean Lenihan NATA Accreditation No: 1961 Perth ΝΑΤΑ Accredited for compliance with ISO/IEC 17025-Testing THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL Sean Lenihan - Senior Laboratory Technician

Client:

Project:

Location:

Test procedure:



•				84 Gu P: +61 8 9	Perth Laboratory uthrie Street Osborne Park Perth WA 6017 9441 0700 F: +61 8 9441 0701 www.golder.com erthlab@golder.com.au
	Hatch				
	61 Petrie Terrace, Brisbane				
	NTSF Embankment Failure ITRB			Date:	25/09/18
n:	Cadia Mine			Project No.:	18101980
ocedu	re: AS 1289.2.1.1,AS 1289 3.9.1, AS	S 1289.3.2.1,	AS 1289.3.3.2 & A	S 1289.3.4.1	
	Laboratory Reference Number			1813	13
	Comula Identification			18026 CE4	17 PT4
Sample Identification				24.0-24	4.3m
	Sample Description			CLA	Y
	Liquid Limit (%)			55	
	Plastic Limit (%)			28	
	Plasticity Index (%)			27	
	Linear Shrinkage (%)			10.9	5
	Moisture Content (%)			ND)
	Sample History			Air Dr	ied
	Method of Preparation			Dry Sie	eved
	Length of Shrinkage Mould (mm)			125	5
	Cracking, Curling or Crumbling			No	,
N.D.	= Not Determined	N.O. = Not Ob	otainable	N.I	P. = Non Plastic

Notes:

 Tested as received
 PLF1-041 RL1 14/09/18

 Certificate Reference:
 18101980_181313_TR-180150_PI_Rev0

 NATA Accreditation No: 1961 Perth
 Second Condition

 Accredited for compliance with ISO/IEC 17025-Testing
 Second Condition

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 Secon Laboratory Technician

61 Petrie Terrace, Brisbane

NTSF Embankment Failure ITRB

Client:

Project:

Location:

Hatch

Cadia Mine



Perth Laboratory 84 Guthrie Street Osborne Park Perth WA 6017 P: +61 8 9441 0700 F: +61 8 9441 0701 www.golder.com perthlab@golder.com.au Date: 25/09/18 Project No.: 18101980 Test procedure: AS 1289.2.1.1, AS 1289 3.9.1, AS 1289.3.2.1, AS 1289.3.3.2 & AS 1289.3.4.1

Labor	atory Reference Number	181312		
s	ample Identification	18025 CE417 PT2 19.5-20.0m		
	Sample Description		CLAY	
	Liquid Limit (%)		58	
	Plastic Limit (%)		22	
	Plasticity Index (%)	36		
L	inear Shrinkage (%)	13.0		
Moisture Content (%)		ND		
Sample History		Air Dried		
м	ethod of Preparation	Dry Sieved		
Length	of Shrinkage Mould (mm)	125		
Cracki	ng, Curling or Crumbling	Yes		
N.D. = Not Determined N.O. = Not		t Obtainable N.P. = Non Plastic		
Notes:				
Tested as received			PLF1-041 RL1 14/09/1	
Certificate Reference:	18101980_181312_TR-180150_PI_R	ev0		
	NATA Accreditation No: 1961 P	erth	Sean Lenihan	
NATA A	ccredited for compliance with ISO/IEC 1	7025-Testing	- 14	

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•		P	Perth Laboratory 84 Guthrie Street Osborne Park Perth WA 6017 P: +61 8 9441 0700 F: +61 8 9441 0701 www.golder.com perthlab@golder.com.au					
Client:	Hatch							
	61 Petrie Terrace, Brisbane							
Project:	NTSF Embankment Failure ITRB	Date:		2/10/18				
Location:	Cadia Mine	Project	No.:	18101980				
Test proced	ure: AS 1289.2.1.1,AS 1289 3.9.1, AS 1289.3.2.	1, AS 1289.3.3.2 & AS 1289.	3.4.1					
	Laboratory Reference Number		181204					
		180	024 CE416 P	Γ4				
	Sample Identification		27.0-27.45m					
	Sample Description		CLAY					
	Liquid Limit (%)	67						
	Plastic Limit (%)		25					
	Plasticity Index (%)		41					
	Linear Shrinkage (%)		13.0					
	Moisture Content (%)	ND						
	Sample History	Air Dried						
	Method of Preparation		Dry Sieved					
	Length of Shrinkage Mould (mm)		125					
	Cracking, Curling or Crumbling		Yes					
N.D	D. = Not Determined N.O. = Not	l Obtainable	N.P. = N	Ion Plastic				
Notes:								
Tested as rece	eived			PLF1-041 RL1 14/09/18				
Certificate Re		ev0						
	NATA Accreditation No: 1961 P		ean	Lenihan				
>								

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125

Yes

Plasticity Index Test Report

Length of Shrinkage Mould (mm)

Cracking, Curling or Crumbling

Client:

Project:

Location:

Hatch

Cadia Mine



Perth Laboratory 84 Guthrie Street Osborne Park Perth WA 6017 P: +61 8 9441 0700 F: +61 8 9441 0701 www.golder.com perthlab@golder.com.au 61 Petrie Terrace, Brisbane NTSF Embankment Failure ITRB Date: 26/09/18 Project No.: 18101980 Test procedure: AS 1289.2.1.1, AS 1289 3.9.1, AS 1289.3.2.1, AS 1289.3.3.2 & AS 1289.3.4.1 Laboratory Reference Number 181203 18023 CE417 PT1 Sample Identification 16.5-16.86m CLAY **Sample Description** 61 Liquid Limit (%) Plastic Limit (%) 24 Plasticity Index (%) 36 Linear Shrinkage (%) 12.5 **Moisture Content (%)** ND Air Dried **Sample History** Method of Preparation Dry Sieved

N.O. = Not Obtainable N.D. = Not Determined N.P. = Non Plastic Notes: PLF1-041 RL1 14/09/18 Tested as received Certificate Reference: 18101980_181203_TR-180139_PI_Rev0 Sean Lenihan NATA Accreditation No: 1961 Perth NATA Accredited for compliance with ISO/IEC 17025-Testing THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL Sean Lenihan - Senior Laboratory Technician



Client:	Hatch		· ·						
	61 Petrie Terrace, Brisbane								
Project:	NTSF Embankment Failure ITRB		Date:	26/09/18					
Location:	Cadia Mine		Project No.:	18101980					
	lure: AS 1289.2.1.1,AS 1289 3.9.1, AS 1289.3.	2.1, AS 1289.3.3.2 &							
	Laboratory Reference Number		181205						
	Sample Identification		18022 CE415	PT1					
			6.0-6.5m						
	Sample Description		SILT						
	Liquid Limit (%)		56						
	Plastic Limit (%)		31						
	Plasticity Index (%)		25						
	Linear Shrinkage (%)		9.0						
	Moisture Content (%)		ND						
	Sample History		Air Dried						
	Method of Preparation		Dry Sieved						
	Length of Shrinkage Mould (mm)		125						
	Cracking, Curling or Crumbling		No						
N.I	D. = Not Determined N.O. = N	ot Obtainable	N.P. =	Non Plastic					
Notes:									
Tested as rec	ceived			PLF1-041 RL1 14/09/18					
Certificate R				1					
	NATA Accreditation No: 1961		Perth Sean Ceni						
NATA	Accredited for compliance with ISO/IEC								
	THIS DOCUMENT SHALL ONLY BE REPRO	DUCED IN FULL	Sean Lenihan	- Senior Laboratory Technician					

Particle Size Distribution, Hydrometer & Plasticity Index Test Report

ら GOLDER

Project: Location:	61 Petrie	e Terrace										
Location:		1011400										
Location:	Foundat	ion Laborato	ory Testing		Date:	23/05/18						
	Queensl		, J		Project No.:	18101981						
Lab Reference			180609	Sample Identification:	Foundation Material							
		-		•								
Laboratory Sp	ecimen D	escription:	Sar	ndy CLAY								
AS1726 - Soil (=	CH									
Particle Size Dis				Plasticity Index and Moistu	re Content							
AS 1289 3.	6.1	AS 128	39 3.6.3									
Sieve Size %	Passing	Sieve Size	% Passing	Test	Method	Result Spe	ec.					
150.0 mm	100	0.062 mm	53	Liquid Limit %	AS 1289.3.1.1	51						
75.0 mm	100	0.044 mm	50	Plastic Limit %	AS 1289 3.2.1	25						
53.0 mm	100	0.032 mm	45	Plasticity Index %	AS 1289 3.3.1	26						
37.5 mm	100	0.023 mm	43	Linear Shrinkage %	AS 1289 3.4.1	13.5						
26.5 mm	100	0.016 mm	40	Moisture Content %	AS 1289 2.1.1	33.5						
19.0 mm	100	0.012 mm	34	Sample History:		Air Dried						
9.5 mm	100	0.009 mm	30	Preparation Method: Dry Sieved								
4.75 mm	100	0.006 mm	27	Cracking/Crumbling/Curling of lin	near shrinkage	No						
2.36 mm	100	0.004 mm	27	Linear shrinkage mould length (mm): 125								
1.18 mm	95	0.003 mm	25	ND = not determined NO = not obtainable NP = non plastic								
0.600 mm	87	0.001 mm	19	Notes	on Hydrometer	test						
0.425 mm	82			Pretreatment Omitted	Measured Parti	cle Density - 2.78 g/cn	m³					
0.300 mm	76			Type of Hydrometer - ASTM	Type of dispers	ion - Mechanica	cal					
0.150 mm	65											
0.075 mm	55											
			75 1	Particle Size Distribution 50 300 425 600 1.18 2.36 4.75	9.5 19 26.5 37.5 53	75 150 A.S. Sieves						
100												
90												
80												
70												
<u>p</u> 60												
20 60												
a 40												
30												
20												
10												
0 +		0.01	0.1	<u> </u>	10	100 100	00					
		-		Particle Size (mm)			-					
Notes:												
	Tested as received PLF1-020 RL0 12/12/1											
ested as receiv	red				Certificate Reference: 18101981_180609_TR-180078_HYD_Rev0							
Fested as receiv Certificate Refe		18101981_	180609_TR-	180078_HYD_Rev0		10 1 10						
				180078_HYD_Rev0 No: 1961 Perth	Step	on Alle						
	erence:	NATA A	ccreditation		Hef	la Ally						

Particle Size Distribution, Hydrometer & Plasticity Index Test Report

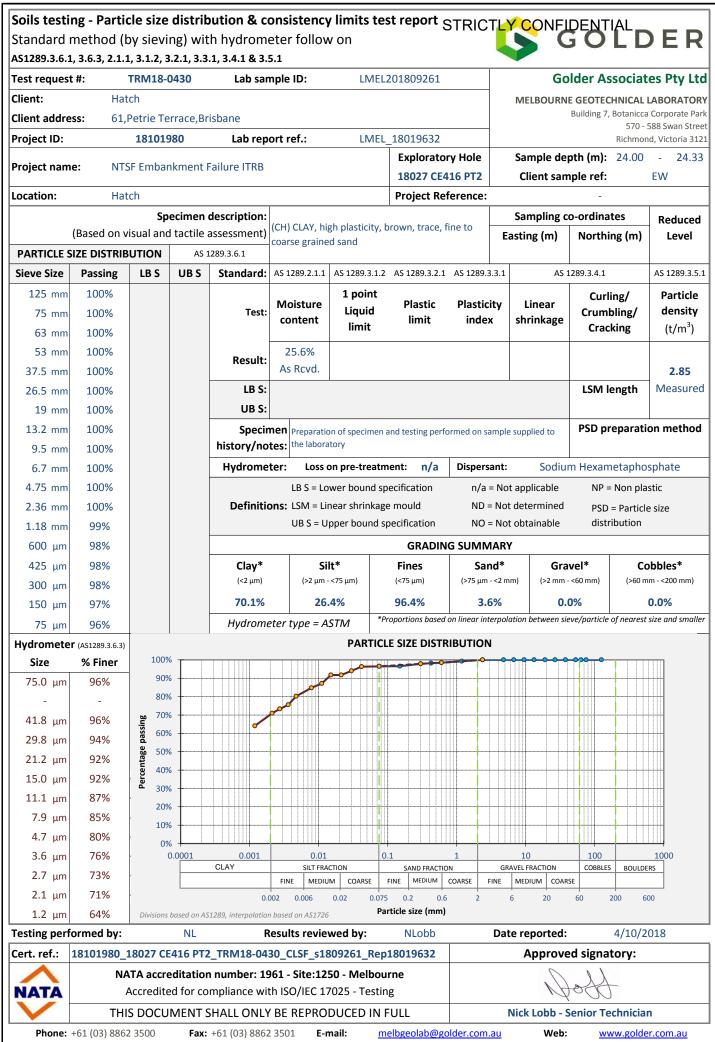
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lient:	-								
ment.	Hatch P	'ty Ltd							
	61 Petri	ie Terrace Br	isbane QLD	4000					
roject:	NTSF E	Embankment	Failure ITR	3	Date:	22/06/1	8		
ocation:	Cadia M	line			Project No.: 18101980				
	ence Numb		180721	Sample Identification:	18005 TP401 0.		.00		
			100721			.7-1.000			
				Block sample					
-	-	Description:		AY (with sand, trace of gravel)					
	oil Classific	-	CH						
Particle Size		-	meter	Plasticity Index and Moistu	re Content				
AS 128		AS 128					-		
Sieve Size	% Passing	Sieve Size	% Passing	Test	Method	Result	Spec.		
150.0 mm	100	0.056 mm	82	Liquid Limit %	AS 1289.3.1.2	ND			
75.0 mm	100	0.040 mm	80	Plastic Limit %	AS 1289 3.2.1	ND			
53.0 mm	100	0.029 mm	75	Plasticity Index %	AS 1289 3.3.1	ND			
37.5 mm	100	0.021 mm	71	Linear Shrinkage %	AS 1289 3.4.1	ND			
26.5 mm	100	0.015 mm	68	Moisture Content %	AS 1289 2.1.1	21.2			
19.0 mm	100	0.011 mm	64	Sample History:		Air Dried			
9.5 mm	100	0.008 mm	62	Preparation Method:		Dry Sieved			
4.75 mm	98	0.006 mm	59	Cracking/Crumbling/Curling of li					
2.36 mm	96	0.004 mm	55	Linear shrinkage mould length (mm):					
1.18 mm	94	0.003 mm	52	ND = not determined			on plastic		
0.600 mm	92	0.001 mm	44		on Hydrometer				
.425 mm	91			Pretreatment Omitted	Measured Parti		2.80 g/cm3		
.300 mm	91			Type of Hydrometer - ASTM	Type of dispers	ion -	Mechanical		
0.150 mm	89								
0.075 mm	87								
100			75 1	Particle Size Distribution 50 300 425 600 1.18 2.36 4.75	9.5 19 26.5 37.5 53	75 150	A.S. Sieves		
90									
80									
70									
60									
50									
60 50 40									
30									
20									
10									
0		0.01	0.1	1	10	100	1000		
				Particle Size (mm)					
0		0.01	0.1	•	10	100			

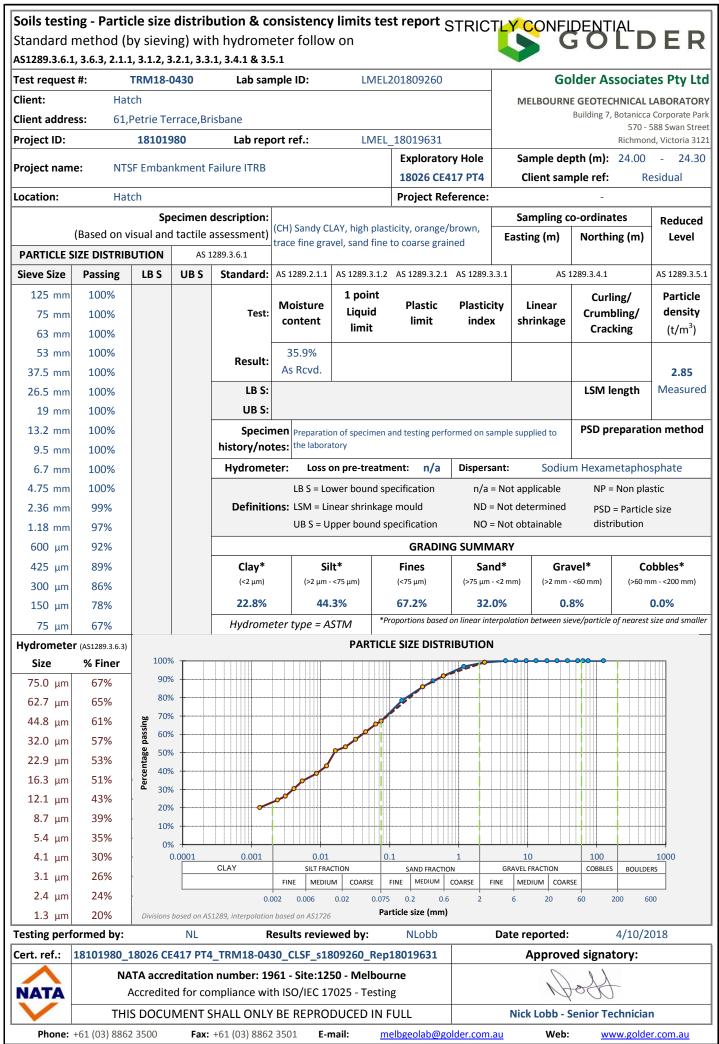
Particle Size Distribution, Hydrometer & Plasticity Index Test Report

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Client: Project:	Hatch								
-									
-	61 Petrie	e Terrace, B	risbane						
-	NTSF E	mbankment	Failure ITR	3	Date:	29/06/18	3		
_ocation:	Cadia M				Project No.:	1810198			
_ab Referen			180788	Sample Identification:	18006 TP405 B				
			100700			lock Sample			
					1.9-2.2m				
_aboratory Sp		-	CL	AY (trace of sand)					
AS1726 - Soil	Classifica	ation:	CI						
Particle Size Di	stribution	Hydro	meter	Plasticity Index and Moist	ure Content				
AS 1289 3	3.6.1	AS 128	9 3.6.3						
Sieve Size %	% Passing	Sieve Size	% Passing	Test	Method	Result	Spec.		
150.0 mm	100	0.063 mm	92	Liquid Limit %	AS 1289.3.1.2	ND			
75.0 mm	100	0.045 mm	88	Plastic Limit %	AS 1289 3.2.1	ND			
53.0 mm	100	0.032 mm	85	Plasticity Index %	AS 1289 3.3.1	ND			
37.5 mm	100	0.023 mm	79	Linear Shrinkage %	AS 1289 3.4.1	ND			
26.5 mm	100	0.017 mm	73	Moisture Content %	AS 1289 2.1.1	28.6			
19.0 mm	100	0.012 mm	67	Sample History:		Air Dried			
9.5 mm	100	0.009 mm	61	Preparation Method:		Dry Sieved			
4.75 mm	100	0.006 mm	58	Cracking/Crumbling/Curling of linear shrinkage					
2.36 mm	100	0.004 mm	55	Linear shrinkage mould length (mm):					
1.18 mm	100	0.003 mm	46	ND = not determined NO = not obtainable NP = non plastic					
0.600 mm	99	0.001 mm	32	Note	s on Hydrometer	test			
0.425 mm	99			Pretreatment Omitted	Measured Parti	icle Density -	2.75 g/cm ³		
0.300 mm	98			Type of Hydrometer - ASTM	Type of dispers	ion -	Mechanical		
0.150 mm	95								
0.075 mm	93								
			75 4	Particle Size Distribution		75 450	A.S. Sieves		
100			75 1	50 300 425 600 1.18 2.36 4.75	9.5 19 26.5 37.5 53	75 150			
90									
80									
70									
g 60									
bercent passing 50 40									
L SU									
ة 40 40									
30									
20									
10		++							
0									
0.001		0.01	0.1	1 Particle Size (mm)	10	100	1000		
Notes:				· · ·					
10100.									
ested as recei	ved					PLF1	-020 RL1 22/05		
		18101980_1	L80788_TR-	180102_HYD_Rev0	11 M		-020 RL1 22/05/		
				180102_HYD_Rev0 1 No: 1961 Perth	Helle	PLF1	-020 RL1 22/05/		
Tested as recei	ference:	NATA A	ccreditation		Hefler		-020 RL1 22/05/		



These tests were carried out in accordance with the Australian standards identified in this certificate.



These tests were carried out in accordance with the Australian standards identified in this certificate.

Standard r	oils testing - Particle size distribution & consistency limits test report tandard method (by sieving) with hydrometer follow on \$1289.3.6.1, 3.6.3, 2.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.5.1									CTL	Y CON	FIDE		ER
Test request	: #:	TRM18-0	0407	Lab sar	nple ID:	LIV	IEL201	809106			G	older A	ssociat	es Pty Ltd
Client:	Hat	ch									MELBOURN		CHNICAL	LABORATORY
Client addre	ss: 61,I	Petrie Te	rrace,Bri	sbane						Building 7, Botanicca Corporate Park				
Project ID:		181019	980	Lab rep	ort ref.:	LME	L_180	19421_7						588 Swan Street Id, Victoria 3121
		r ruha					E	xplorato	ry Hole		Sample de	oth (m):	27.00	- 27.45
Project nam	e: NTS	NTSF Embankment Failure ITRB					18024 C	CE416 Client sample ref: PT4			PT4			
Location:	Cad	lia Mine					Р	roject Re	ference:			-		
		Sp	ecimen	description:							Sampling co	o-ordina	tes	Reduced
	(Based on v	visual and	d tactile	assessment)	(CH)CLAY, hig	h plasticity	,red bro	own		Eas	ting (m)	Northi	ng (m)	Level
PARTICLE S	SIZE DISTRIB	UTION	AS 1	289.3.6.1										
Sieve Size	Passing	LB S	UB S	Standard:	AS 1289.2.1.1	AS 1289.3.	1.2 AS	1289.3.2.1	AS 1289.3	3.3.1	AS 1	289.3.4.1		AS 1289.3.5.1
125 mm	100%				Moisture	1 poin		Plastic	Plastic	itv	Linear	Curl	•	Particle
75 mm	100%			Test:	content	Liquid limit		limit	inde	-	shrinkage	Crum	•	density
63 mm	100%											Crac	king	(t/m ³)
53 mm	100%			Result:	37.7%									
37.5 mm	100%				As Rcvd.									2.90
26.5 mm	100%			LB S:								LSM I	ength	Measured
19 mm	100%			UB S:								000		
13.2 mm	100%			Specir history/no	nen Preparatio		en and t	esting perfo	rmed on sa	mple su	pplied to the	PSD pr	eparatio	on method
9.5 mm	100%								Diamana		Codiu		ataabaa	whete
6.7 mm	100%			Hydrome		on pre-tre			Dispers			m Hexam		
4.75 mm	100%			Dofiniti	LB S = Lo Dns: LSM = Lir	wer bound	•				pplicable etermined		Non plas	
2.36 mm	100%			Dennitio		pper bound	•				btainable		= Particle ibution	size
1.18 mm	100%				0000	pper bound	a speen				btumubic	aisti		
600 μm	100%			Clau*	c:	lt*			G SUMN		Crea	*		
425 μm	100%			Clay* (<2 μm)	-	ι τ * <75 μm)		ines 75 μm)		1d* - <2 mm)	Gra (>2 mm -			bbles* m - <200 mm)
300 μm 150 μm	100% 99%			48.2%	49	.5%	97	7.8%	2	2%	0.0	1%		0.0%
130 μm 75 μm	98%				eter type = A									size and smaller
Hydromete				nyuroni	ier type in	1	ICLE SI	ZE DISTRI	BUTION					_
Size	% Finer	100%	6 T				0++0	<u></u>			, <mark>9 • • •</mark> •	• • ••	1 1 1 1 1	
75.0 μm	98%	90%	6										-	
58.4 μm	97%	80%	6											
41.8 μm	92%	100 709	6		- p									
29.9 μm	88%	Dercentage passing					•							
21.3 µm	85%	ntage 20%			*									
15.1 μm	83%						Î							
11.2 μm	79%	• 30% 20%												
8.0 μm	74%	. 10%												
5.7 μm	70%	· 09												
4.1 μm	63%		0.0001	0.001	0.01	CTION	0.1		1		10	100		1000
2.7 μm	54%	,		CLAY	SILT FRA	1	FINE	SAND FRACTIO			EL FRACTION	COBBLES	BOULDER	15
2.1 μm	50%	c		0.0	002 0.006	0.02 0		0.2 0.6	2	6	20	60 2	200 60	10
1.3 µm	39%	Divisions	based on AS	1289, interpolation	based on AS1726		Particle	e size (mm)						
Testing perf	-		LM		Results revie				ara	Date	reported:		2/10/20)18
Cert. ref.:				/18-0407_Cl				1			Approve		tory:	
				n number: 19						1	Sar			
NATA				mpliance wit				1	Course	-	a albumb	Conte	l ok evet	om. Exertise -
				SHALL ONLY					-					ory Engineer
Phone:	+61 (03) 8862	3500	Fax:	+61 (03) 8862	3501 E-r	nail:	melb	geolab@gc	older.com.	au	Web:	<u>w</u>	ww.golde	er.com.au

These tests were carried out in accordance with the Australian standards identified in this certificate.

Rep Combined PSD Hydro - RL18

Standard i	oils testing - Particle size distribution & consistency limits test report tandard method (by sieving) with hydrometer follow on \$1289.3.6.1, 3.6.3, 2.1.1, 3.1.2, 3.2.1, 3.3.1, 3.4.1 & 3.5.1										FIDE		ER
Test request	t #:	TRM18-0	0407	Lab sar	nple ID:	LM	EL201809105			G	older A	ssociat	es Pty Ltd
Client:	Hat	ch							MELBOURNE GEOTECHNICAL LABORATOR				
Client addre	ess: 61,	Petrie Te	rrace,Bri	sbane				Building 7, Botanicca Corporate 570 - 588 Swan Si					
Project ID:		181019	80	Lab rep	ort ref.:	LME	L_18019420_6	6					d, Victoria 3121
Project nam	e: NTS	SF Emban	kment F	ailure ITRB			Explorate	ory Hole	S	Sample de	pth (m):	16.50	- 16.86
			ener				18023 (CE417		Client sam	ple ref:		PT1
Location:	Cac	lia Mine					Project R	eference:			-		
	Specimen description			•	(CH) CLAY.hig	h plasticity.	grey,trace sand		S	ampling c	o-ordina	tes	Reduced
	•			assessment)	(- , - , 0	1	5 - <i>//</i>		East	ting (m)	North	ing (m)	Level
	SIZE DISTRIB			289.3.6.1									
Sieve Size	Passing 100%	LB S	UB S	Standard:	AS 1289.2.1.1	AS 1289.3.1 1 point	2 AS 1289.3.2.1	1 AS 1289.3	3.3.1	AS 1	289.3.4.1		AS 1289.3.5.1
75 mm	100%			Test:	Moisture	Liquid	Plastic	Plastic	ity	Linear		ling/ bling/	Particle density
63 mm	100%			Test.	content	limit	limit	inde	x s	hrinkage		king	(t/m ³)
53 mm	100%				29.0%							-	(4,)
37.5 mm	100%			Result:	As Rcvd.								2.74
26.5 mm	100%			LB S:							LSM I	ength	Measured
19 mm	100%			UB S:								0	
13.2 mm	100%				nen Preparatio	on of specime	n and testing perf	formed on sa	mple sur	oplied to the	PSD p	reparatio	on method
9.5 mm	100%				tes: laboratory		and results peri			phea to the		-	
6.7 mm	100%			Hydrome	ter: Loss	on pre-trea	tment: n/a	Dispers	ant:	Sodiu	m Hexan	netaphos	phate
4.75 mm	100%				LB S = Lo	wer bound	specification	n/a	= Not a	oplicable	NP =	Non plas	tic
2.36 mm	98%			Definitio	ons: LSM = Lir	near shrinka	ge mould	ND :	= Not de	etermined	PSD	= Particle	size
1.18 mm	94%				UB S = UI	oper bound	specification	NO	= Not ob	otainable	disti	ribution	
600 µm	94%						GRADII		1ARY				
425 μm	93%			Clay*	Si	lt*	Fines	Sa	nd*	Gra	vel*	Co	bbles*
300 µm	93%			(<2 μm)	(>2 μm -	<75 μm)	(<75 μm)	(>75 μm	- <2 mm)	(>2 mm -	<60 mm)	(>60 m	m - <200 mm)
150 μm	92%			38.3%	51.	.5%	89.8%		9%		3%		0.0%
75 μm	90%			Hydrome	eter type = A.	STM	*Proportions base	ed on linear ir	nterpolati	on between sie	eve/particle	e of nearest	size and smaller
Hydromete	er (AS1289.3.6.3)					PARTI	CLE SIZE DISTR	RIBUTION					
Size	% Finer	100%								••••			
75.0 μm	90%	90%											
-	-	80%				8							
45.2 μm	83%	80% assing 60%				8							
32.2 μm	80%	Bercentage passing 60% 50% 40% 30%											
23.0 μm	76%	Sentage 40%											
16.5 μm	69%	Berc 30%											
12.1 μm	66%	20%	. -										
8.7 μm	62%	10%	6										
6.2 μm	57%	0%											Щ
4.5 μm	50%	· (0.0001	0.001 CLAY	0.01 SILT FRA	CTION	0.1 SAND FRACTI	1 ION		10 L FRACTION	COBBLES	6 BOULDEF	1000 25
3.0 μm	45%	,			FINE MEDIU		FINE MEDIUM			IEDIUM COARS			
1.3 μm	34%	c			002 0.006		075 0.2 0. Particle size (mm)		6	20	60	200 60	0
- Testing perf	-	Divisions	based on AS.	1289, interpolation					Data	roported		2/10/20	119
		10022.05					GSamaradiwa	INdid	Date	reported:	d cian -		010
Cert. ref.:				M18-0407_C						Approve	-	tory:	1
NATA	N			n number: 19 Impliance wit					4	5.00		- •	
	ти			SHALL ONLY	-		•	Gavari	Samar	adiwakara	- Sonier	Laborati	ory Engineer
Dhone:										Web:			
	+61 (03) 8862			+61 (03) 8862 standards identifie		nail:	melbgeolab@g	soluer.com.	au	web:		ww.golde	r.com.au J PSD Hydro - RL18

Soils testin Standard r AS1289.3.6.1	method (b	y sievin	g) with	hydromet	er follow o		t report	STRI	CTL	YCON	FIDE	TIAL	ER
Test request	: #:	TRM18-0	0407	Lab sar	nple ID:	LM	EL201809107			G	older A	ssocia	tes Pty Ltd
Client:	Hat	ch							1	MELBOURI	NE GEOTE	CHNICAL	LABORATORY
Client addre	ss: 61,	Petrie Te	rrace,Bri	sbane							Building 7,		a Corporate Park 588 Swan Street
Project ID:		181019	980	Lab rep	ort ref.:	LME	_18019419_6		1				nd, Victoria 3121
Droiget nom		C Embor	kmont F				Explorato	ry Hole		Sample de	pth (m):	6.00	- 6.50
Project name	e: NTS	SF Empar	ikment F	ailure ITRB			18022 (CE415		Client san	ple ref:		PT1
Location:	Cac	lia Mine					Project Re	eference:			-		
		Sp	ecimen	description:	(Sampling c	o-ordina	tes	Reduced
	(Based on	visual an	d tactile	assessment)	(MH) Clayey S sand	ilLT, high liq	uid limit,red bro	wn,trace	Ea	sting (m)	Northi	ng (m)	Level
PARTICLE S	SIZE DISTRIB	UTION	AS 1	1289.3.6.1	Sund								
Sieve Size	Passing	LB S	UB S	Standard:	AS 1289.2.1.1	AS 1289.3.1	.2 AS 1289.3.2.1	AS 1289.3	3.3.1	AS 1	289.3.4.1		AS 1289.3.5.1
125 mm	100%					1 point					Curl	ing/	Particle
75 mm	100%			Test:	Moisture content	Liquid	Plastic limit	Plastic inde		Linear shrinkage	Cruml	bling/	density
63 mm	100%				content	limit	iiiiii	mue	^	Shinkage	Crac	king	(t/m³)
53 mm	100%			Desult	38.0%								
37.5 mm	100%			Result:	As Rcvd.								2.89
26.5 mm	100%			LB S:					-		LSM I	ength	Measured
19 mm	100%			UB S:									
13.2 mm	100%			Specir	nen Preparatio	on of specime	n and testing perf	ormed on sa	mple s	upplied to the	PSD pr	eparati	on method
9.5 mm	100%			-	tes: laboratory						-	-	
6.7 mm	100%			Hydrome	ter: Loss	on pre-trea	tment: n/a	Dispers	ant:	Sodiu	m Hexam	netapho	sphate
4.75 mm	100%									applicable		Non plas	
2.36 mm	100%			Definiti	LB S = Lower bound specification n/a = Not applicable Definitions: LSM = Linear shrinkage mould ND = Not determined				= Particle				
1.18 mm	100%				•				obtainable		- Farticle	5120	
600 μm	98%			GRADING SUMMARY									
	98%			Clau*	c:	lt*	Fines		nd*	Cro	vel*	6	obbles*
425 μm				Clay* (<2 μm)	-	<75 μm)	rifies (<75 μm)	3df (>75 μm			<60 mm)		1001es - 1m - <200 mm)
300 μm	97%			44.1%		7%	92.9%	7.	1%		0%		0.0%
150 μm	95%			-		-	*Proportions base						
75 μm	93%	ļ t		Hydronne	eter type = A:	1						-	
Hydromete		100%	6 .				CLE SIZE DISTR				-0000-		
Size	% Finer	90%											
75.0 μm	93%	80%				and and a							
59.6 μm	92%	700							ļ				
42.4 μm	90%	assing 60%											
30.2 μm	88%	80 50%											
21.4 μm	85%	Bercentage passing 60% 50% 40% 30%		/	<u> </u>				<u> </u>				
15.3 μm	83%	, Der 30%	6										
11.2 μm	81%	209	6										
8.0 μm	76%	109	6									-	
5.8 μm	69%	، 0%	6										
4.2 μm	60%		0.0001	0.001 CLAY	0.01 SILT FRA	CTION	0.1 SAND FRACTION	1 2N	GRAV	10 VEL FRACTION	100 COBBLES	BOULDE	1000 RS
2.9 μm	53%				FINE MEDIU		FINE MEDIUM	1		MEDIUM COARS			
2.1 μm	47%	G		0.0	002 0.006		075 0.2 0.1	5 2	6	20	60 2	200 60	00
1.3 μm	33%	Divisions	based on AS	1289, interpolation	based on AS1726		Particle size (mm)						
Testing perfe	ormed by:		LM	F	Results revie	wed by:	GSamaradiwa	kara	Date	e reported:		2/10/2	018
Cert. ref.:	18101980_1	L8022 CE	415_TRM	v18-0407_CI	.SF_s180910	7_Rep019	419_6			Approve	ed signa	tory:	
	N	ATA accr	editatio	n number: 19	961 - Site:12	50 - Melbo	urne			650		1	9
NATA		Accredit	ed for co	mpliance wit	h ISO/IEC 17:	025 - Test	ing		1	7		81.85	
	TH	IS DOCL	MENT	SHALL ONLY	BE REPRO	DUCED IN	FULL	Gayani	Sama	radiwakara	- Senior	Laborat	ory Engineer
Phone:	+61 (03) 8862	2 3500	Fax:	+61 (03) 8862	3501 E-r	nail:	melbgeolab@g	older.com.	<u>au</u>	Web:	w	ww.golde	er.com.au
These tests were ca									-				d PSD Hydro - RL18

Soil Particle Density Report



		84 Guth P: +61 8 944	erth Laboratory rie Street Osborne Park Perth WA 6017 I1 0700 F: +61 8 9441 0701 www.golder.com nlab@golder.com.au				
Client:	Hatch						
	61 Petrie Terrace, Brisbane						
Project:	NTSF Embankment Failure ITRB	Date:	29/06/18				
Location:	Cadia Mine	Project No.:	18101981				
Test procedur	re: AS 1289.3.5.1						
Laborato	ry Reference Number	18060	9				
Sampla k	dentification	PL-BS	1				
Sample R	dentification	0-0.5m					
Material [Description	Sandy CLAY					
Temperat	ture of Test (°C)	21					
	age apparent Particle Density of on passing 2.36mm (g/cm ³)	2.78					

Notes: This test certificate replaces test certificate reference 18101981_180609_TR-180078_SG_Rev0

Tested as red	ceived	PLF1-011 RL0 7/12/12
Certificate F	Reference: 18101981_180609_TR-180078_SG_REV1	
	NATA Accreditation No: 1961 Perth	Stephen Mile
NATA	Accredited for compliance with ISO/IEC 17025	
	THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL	Stephen Abbey - Laboratory Manager (VIC)

Soil Particle Density Report



				84 Guthri F P: +61 8 944 ⁻¹ w	rth Laboratory ie Street Osborne Park Perth WA 6017 1 0700 F: +61 8 9441 0701 ww.golder.com lab@golder.com.au
Client:	Hatch				
	61 Peti	rie Terrace, Brisbane			
Project:	NTSF I	Embankment Failure ITRB		Date:	29/06/18
Location:	Cadia I			Project No.:	18101980
Fest procedu	ıre: AS 1289.	3.5.1	Г		
Laborato	ory Refer	ence Number		180788	3
Sample I	dentific	ation	1800	6 TP405 Blo	ick Sample
Sample	Gentino	1011		1.9-2.2r	n
Material	Descript	tion	C	CLAY (trace c	of sand)
Tempera	iture of 1	「est (°C)		20	
		arent Particle Density of ing 2.36mm (g/cm ³)		2.75	
Notes:					
Tested as rec	ceived				PLF1-011 RL0 7/12/12
Certificate R	Reference:	18101980_180788_TR-180102_SG_R	EV0	21 11	D JA
		NATA Accreditation No: 1961 Pe	erth	Stella	Me
NATA		Accredited for compliance with ISO/IE	EC 17025	10	
\checkmark	THI	S DOCUMENT SHALL ONLY BE REPRODU	UCED IN FULL	Stephen Abb	ey – Laboratory Manager (VIC)

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Bulk Density Test Report



Perth Laboratory 84 Guthrie Street, Osborne Park

Client:	Hatch	Date:		14/09/2018
Address:	61 Petrie Terrace, Brisbane	Project No	.:	18101980
Project:	NTSF Embankment Failure ITRB	Sample ID	:	CE406 SA4 23.8-23.9m
Location:	Cadia Mine	Laboratory	/ ID:	18020 - BD1

Sample preparation

A subsample was cored into a stainless steel ring. The subsample bulk density was measured directly from the internal volume of the ring and its wet mass. The subsample was removed from the ring and placed in a 110° oven for gravimetric moisture content measurement.

Mass - As Received Sample	g	1478.7
Water Content	%	19.8
Bulk Density	t/m ³	2.09

Notes:	Tested as received	Tested by:	K. Koh
THIS DOCUM	IENT SHALL ONLY BE REPRODUCED IN FULL	Reviewed by:	R. Fanni

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Bulk Density Test Report



Perth Laboratory 84 Guthrie Street, Osborne Park

Client:	Hatch	Date:		14/09/2018
Address:	61 Petrie Terrace, Brisbane	Project No).:	18101980
Project:	NTSF Embankment Failure ITRB	Sample ID	:	CE406 SA3 22.2-22.3m
Location:	Cadia Mine	Laborator	y ID:	18019 - BD1

Sample preparation

A subsample was cored into a stainless steel ring. The subsample bulk density was measured directly from the internal volume of the ring and its wet mass. The subsample was removed from the ring and placed in a 110° oven for gravimetric moisture content measurement.

Mass - As Received Sample	g	1052.5
Water Content	%	13.6
Bulk Density	t/m ³	2.05

Notes:	Tested as received	Tested by:	K. Koh
THIS DOCUM	IENT SHALL ONLY BE REPRODUCED IN FULL	Reviewed by:	R. Fanni



Client Hat	tch Pty Ltd	: AS 1289 2.1.1, 3.1.1, 3.1	Report No.	18050383-AL
	-		Workorder No.	0004181
Address PO	Box 425 SPRING H	IILL QLD 4004	Report Date	11/06/2018
Project H3	56804 - Cadia NTSF	Failure - Containm	ent Bund - Left Abutment	
Sample No.	18050383			
Test Date	5/06/2018			
Client ID	BM1 - BS1			
Depth (m)	1.00-1.20			
Liquid Limit (%)	46			
Plastic Limit (%)	25			
Plasticity Index (%)	21			
Linear Shrinkage (%) 11.5 *			
Moisture Content (%	6) 40.7			
Sample No.				
Test Date				
Client ID				
Depth (m)				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index (%)				
Linear Shrinkage (%)			
Moisture Content (%	(a)			
		-	d in a 125-250mm mould.	
mple/s supplied by the clie		* Cracking occurred	+ Curling occurred	Page 1 of 1 REP
he results of the tests, calibration	e with ISO/IEC 17025 - Testing ons, and/or measurements inc to Australian/National Standa	luded in	thorised Signatory	
Tested at Trilab	Brisbane Laboratory.		C. Park	Laboratory No.



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lient	Hatch Pty I	<u>Test Method: A</u> _td			Report N	0.	18060849-	AL
			·		Workorde	er No.	0004435	
ddress	PO Box 42	5 SPRING HIL	L QLD 40	04	Report Da	ate	13/07/2018	3
roject	H356804 -	Cadia						
Sample No	D.	18060849						٦
Test Date		12/07/2018						
Client ID		DH-410						
Depth (m)		19.65-19.95						
Liquid Lim	nit (%)	33						
Plastic Lin	nit (%)	23						
Plasticity I	Index (%)	10						
Linear Shr	rinkage (%)	6.0 +						
Moisture C	Content (%)	22.3						
		· · · · ·		T				٦
Sample No	D.							-
Test Date								-
Client ID								
Depth (m)								
Liquid Lim	nit (%)							
Plastic Lin	nit (%)							
Plasticity I	Index (%)							
Linear Shr	rinkage (%)							
Moisture C	Content (%)							
TES/REMARKS: mple/s supplied Accredited fc	The samples by the client or compliance with ISO/I	* EC 17025 - Testing.	Cracking o	ccurred	and in a 125-250 + Curling occ rised Signatory		Page 1 of 1	
	ests, calibrations, and/or are traceable to Australia			Ce				
Tes	sted at Trilab Brisbane L	aboratory.			C. Park		Ċ	ECHNICA



Client	Hatch Pty L	_td		<u>3.1.1, 3.1.2, 3.2</u> .	Report No Workorde		18080165-AL 0004644
Address	PO Box 42	5 SPRING H	ILL QLD 400)4	Report Da	ate	28/08/2018
Project	H356804 -	Cadia NTSF	Failure				
Sample No.		18080165	18080172	18080180	18080182	18080183	
Test Date		20/08/2018	20/08/2018	20/08/2018	23/08/2018	23/08/2018	
Client ID		CE408 - DH401	CE407 - DH402	CE407 - DH402	CE413 - DH404	CE406 - DH410	
Depth (m)		16.00	23.00	30.50	53.50-53.80	18.40-18.50	
Liquid Limit (%	6)	22	20	Not Obtainable	39	71	
Plastic Limit (%	%)	17	15	Not Obtainable	15	24	
Plasticity Inde	x (%)	5	5	Non Plastic	24	47	
Linear Shrinka	ige (%)	2.0 *	2.0	Not Obtainable	12.5 +	19.0 +	
Moisture Cont	ent (%)	21.5	18.6	15.6	20.1	27.5	
							•
Sample No.							
Test Date							
Client ID							
Depth (m)							
Liquid Limit (%	6)						
Plastic Limit (%	%)						
Plasticity Inde	x (%)						
Linear Shrinka	ige (%)						
Moisture Cont	ent (%)						



Client	Hatch Pty L	td		<u>3.1.1, 3.1.2, 3.2.</u>	Report No Workorde		18080185- <i>/</i> 0004644	۹L
ddress	PO Box 425	5 SPRING H	ILL QLD 400)4	Report Da		28/08/2018	
roject	H356804 - (Cadia NTSF	Failure					
Sample No.		18080185	18080187	18080189	18080192	18080196	18080197	1
Test Date		20/08/2018	20/08/2018	21/08/2018	21/08/2018	23/08/2018	20/08/2018	
Client ID		CE408 - DH401 - PS1	CE408 - DH401 - PS3	CE407 - DH402 - PS1	CE413 - DH404 - PS2	CE407 - DH402 - PT3	CE412 - DH405 - PT2	
Depth (m)		11.00-11.50	25.00-25.45	12.00-12.45	25.95-26.40	51.00-51.50	39.50-39.72	
Liquid Limit (%)	21	Not Obtainable	21	18	51	81	
Plastic Limit (%	b)	17	Not Obtainable	17	16	19	37	
Plasticity Index	(%)	4	Non Plastic	4	2	32	44	
Linear Shrinkag	ge (%)	1.0 *	Not Obtainable	1.0 *	0.5 *	15.0 +	17.5 +]
Moisture Conte	nt (%)	20.2	17.8	23.1	21.6	23.2	48.5	
						[٦
Sample No.								
Test Date Client ID								
Depth (m)								
Liquid Limit (%)							
Plastic Limit (%	b)							
Plasticity Index	(%)							
Linear Shrinka	ge (%)							
Moisture Conte	ent (%)							



4681 9/2018 080425 9/2018 E417 - 106 SA6 100-26.00 54 30
080425 9/2018 E417 - 006 SA6 00-26.00 54
9/2018 E417 - I06 SA6 I0-26.00 54
9/2018 E417 - I06 SA6 I0-26.00 54
E417 - 106 SA6 10-26.00 54
06 SA6 00-26.00 54
54
30
24
9.0 *
36.0
080439
9/2018
E416 - 107 PT3
60-26.95
60
29
31
1.0 +
38.7

ACCURATE QUALITY RESULTS FOR TOMORROW'S ENGINEERING



Client Hatch Pt	<u>Test Method: A</u> y Ltd		Report No.	18080441-AL
			Workorder No.	
Address PO Box 4	425 SPRING HIL	L QLD 4004	Report Date	12/09/2018
Project H356804	- Cadia NTSF F	ailure		
Sample No.	18080441			
Test Date	6/09/2018			
Client ID	CE416 - DH407 L3C			
Depth (m)	26.50-27.00			
Liquid Limit (%)	64			
Plastic Limit (%)	30			
Plasticity Index (%)	34			
Linear Shrinkage (%)	14.5 +			
Moisture Content (%)	38.4			
	T			
Sample No. Test Date				
Client ID				
Depth (m)				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index (%)				
Moisture Content (%)				
DTES/REMARKS: The sample		-	d in a 125-250mm mould.	Den 4 of 4
ample/s supplied by the client Accredited for compliance with IS		Cracking occurred	+ Curling occurred	Page 1 of 1 R
The results of the tests, calibrations, and this document are traceable to Austr	/or measurements includ	ed in		
Tested at Trilab Brisban	e Laboratory		C. Park	



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	Test Method: AS	G LIIVIII5 I 1289 2.1.1, 3.1.1, 3.1	EST REPORT .2, 3.2.1, 3.3.1, 3.4.1	
Client Hato	h Pty Ltd		Report No.	18090290-AL
			Workorder No.	0004846
Address PO I	Box 425 SPRING HILL	. QLD 4004	Report Date	04/10/2018
Project H35	6804 - Cadia NTSF Fa	ilure - Request 8	3	
Sample No.	18090290			
Test Date	28/09/2018			
Client ID	CE432 - L1B			
Depth (m)	19.80-20.30			
Liquid Limit (%)	40			
Plastic Limit (%)	27			
Plasticity Index (%)	13			
Linear Shrinkage (%)	8.0 *			
Moisture Content (%)	24.2			
Quanta Na			- I - I	
Sample No. Test Date				
Client ID				
Depth (m)				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index (%)				
Linear Shrinkage (%)				
Moisture Content (%)				
ES/REMARKS: The s	amples were tested air drie	ed, dry sieved and in	n a 125-250mm mould.	
nple/s supplied by the clien	t * (Cracking occurred	+ Curling occurred	Page 1 of 1 REP
e results of the tests, calibration	vith ISO/IEC 17025 - Testing. s, and/or measurements include o Australian/National Standards.	d in Auth	orised Signatory	NATA
Tostod at Trilah P	risbane Laboratory.	<i>C</i> .	C. Channon	ACCREDITED FO TECHNICAI COMPETENCI



Client	Hatch Pty L			, , .	3.2.1, 3.3.1, 3.4.1 Report Workor	No. der No.	18110003- 0005081	AL
Adress	PO Box 42	5 SPRING H	PRING HILL QLD 4004			Report Date		}
Project	H356804 -	Cadia NTSF	Failure					
Sample No.		18110003	18110005]
Test Date		1/11/2018	1/11/2018					
Client ID		CE432 - L1C · Lexan	CE433 - L1 - Lexan					
Depth (m)		20.30-20.80	33.20-33.80					
Liquid Limit (%)		40	26					
Plastic Limit (%)		24	17					
Plasticity Index ((%)	16	9					
Linear Shrinkage	e (%)	6.5 *	6.0 +					
Moisture Conter	nt (%)	28.2	28.2					
								Т
Sample No. Test Date								-
Client ID								-
Depth (m)								
Liquid Limit (%)								
Plastic Limit (%)								
Plasticity Index ((%)							
Linear Shrinkage	e (%)							
Moisture Conter	nt (%)							
ES/REMARKS:	The samples	were tested in a	an air dried stat	e, dry sieve	ed and in a 125-	250mm moul	ld.	
nple/s supplied by the	client		* Cracking oc	curred	+ Curling c	occurred	Page 1 of 1	REP(
Accredited for compl re results of the tests, cali this document are trace	brations, and/or	measurements incl	uded in	Authoris	sed Signatory		Ň	



Client Hatch	Pty Ltd		Report No. Workorder No.	19010573-AL 0005444
Address PO Bo	x 425 SPRING H	ILL QLD 4004	Report Date	25/01/2019
Project H3568	04 - Caida NTSF	Failure		
Sample No.	19010573	19010574		
Test Date	24/01/2019	24/01/2019		
Client ID	CE431 - SA- 1	CE431 - SA- 2		
Depth (m)	23.50-24.00	24.00-24.50		
Liquid Limit (%)	44	45		
Plastic Limit (%)	27	30		
Plasticity Index (%)	17	15		
Linear Shrinkage (%)	N/A	N/A		
Moisture Content (%)	26.3	31.8		
Samula Na			Г	
Sample No. Test Date				
Client ID				
Depth (m)				
Liquid Limit (%)				
Plastic Limit (%)				
Plasticity Index (%)				
Linear Shrinkage (%)				
Moisture Content (%)				
<u>TES/REMARKS:</u> The sar mple/s supplied by the client	nples were tested air	dried, dry sieved and i * Cracking occurred	n a 125-250mm mould. + Curling occurred	Dage 4 of 4
Accredited for compliance with			-	Page 1 of 1 REI
The results of the tests, calibrations, a this document are traceable to A	and/or measurements inc	luded in Auth	orised Signatory	



Client Hatch F	Pty Ltd			Report No. Workorder No.	19010703-AI 0005472
Address PO Box	425 SPRING H	ILL QLD 400)4	Report Date	01/02/2019
Project H35680)4 - Cadia NTSF	Failure			
Sample No.	19010703	19010704	19010705		
Test Date	30/01/2019	30/01/2019	30/01/2019		
Client ID	CE411A	CE416 - L2B	CE416 - L2C		
Depth (m)	16.00-16.50	24.50-25.00	25.00-25.50		
Liquid Limit (%)	61	73	67		
Plastic Limit (%)	31	33	32		
Plasticity Index (%)	30	40	35		
Linear Shrinkage (%)	12.5 +	13.0 +	14.0 +		
Moisture Content (%)	37.7	34.0	39.3		
Sample No.					
Client ID					
Depth (m)					
Liquid Limit (%)					
Plastic Limit (%)					
Plasticity Index (%)					
Linear Shrinkage (%)					
Moisture Content (%)					
	ples were tested air	dried, dry siev		-250mm mould. + Curling occurred	Page 1 of 1
Accredited for compliance with The results of the tests, calibrations, a this document are traceable to Au	nd/or measurements inc	luded in	Authorised	Signatory	NA



			IDU I IUN <u>S 1289 3.6.1, 2.1.1</u>	TEST REPORT	
Client	Hatch Pty Ltd			Report No.	18060849-G
			Workorder No.	4435	
Address	PO Box 425 SF	RING HILL QLD 40	04	Report Date	13/07/2018
Project	H356804 - Cad	ia			
Sample No.	18060849				
Test Date	13/07/2018				
Client ID	DH-410				
Depth (m)	19.65-19.95				
Moisture (%)	22.3				
AS SIEVE SIZE (mm)		PI	ERCENT PASSI	NG	
150					
75					
63					
53					
37.5					
26.5					
19					
13.2					
9.5					
6.7					
4.75	100				
2.36	94				
1.18	88				
0.600	80				
0.425	75				
0.300	70				
0.150	60				
	52				

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Authorised Signatory 0 C. Park



Laboratory No. 9926



	PARTI		E DISTRIE			PORT		
Client	Hatch Pty L	td	Jat method. Ad	1200 0.0.1, 2.1.	Report No).	18080182-0	G
					Workorde	r No.	4644	
Address	PO Box 425 SPRING HILL QLD 4004				Report Da	te	21/08/2018	i
Project	H356804 - (Cadia NTSF	Failure					
Sample No.	18080182	18080183]
Test Date	13/08/2018	13/08/2018						
Client ID	CE413 - DH404	CE406 - DH410						
Depth (m)	53.50-53.80	18.40-18.50						
Moisture (%)	20.1	27.5						1
AS SIEVE SIZE (mm)			PER		ING			
150								
75								
63								
53								
37.5								
26.5								
19								1
13.2								1
9.5								1
6.7								
4.75								
2.36	100	100						
1.18	99	98						
0.600	96	95						
0.425	95	94						
0.300	93	92						1
0.150	90	89]
	87	86						1

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Tested at Trilab Brisbane Laboratory.

TECHN Laboratory No. 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated. Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details. Trilab Pty Ltd ABN 25 065 630 506

Authorised Signatory

C. Park

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		PARTI		E DISTRI est Method: AS		-	PORT		
CI	ient	Hatch Pty L			1200 0.0.1, 2.1.	Report N Workorde		18080415-G 4681	j
Ac	dress	PO Box 425	5 SPRING H	ILL QLD 400	Report D		31/08/2018		
Pr	oject	H356804 - (Cadia NTSF	Failure					
	Sample No.	18080415	18080423	18080425	18080426	18080429	18080435		
	Test Date	20/08/2018	29/08/2018	29/08/2018	29/08/2018	29/08/2018	29/08/2018		
	Client ID	CE412 - DH405 SA3	CE417 - DH406 L3C	CE417 - DH406 SA6	CE415 - DH408 SA1	CE415 - DH408 SA4	CE416 - DH407 SA1		
	Depth (m)	60.70-60.80	20.80-20.85	25.90-26.00	4.12-4.30	20.20-20.40	21.85-21.90		
	Moisture (%)	11.7	26.3	36.0	38.4	17.3	34.1		
	AS SIEVE SIZE (mm)			PE	ING				
	150								
	75								
	63								
	53								
	37.5								
	26.5								
	19								
	13.2								
	9.5								
	6.7								
	4.75	100			100	100			
	2.36	99			99	97	100		
	1.18	95	100	100	97	89	99		
	0.600	87	99	95	92	76	99		
	0.425	82	99	90	90	69	99		
	0.300	77	98	83	87	62	98		
	0.150	69	94	70	80	47	97		
	0.075	62	90	60	76	37	96		

NOTES/REMARKS:

Sample/s supplied by the client

Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory CA

TECHNICAL

REP01103

Page 1 of 1

C. Channon

Laboratory No. 9926



		PARTIC			BUTION 1289 3.6.1, 2.1.		PORT		
C	ient	Hatch Pty Lt	d		1200 01011, 2111	Report N	0.	18090290-0	3
						Workorde		4846	
A	ddress	PO Box 425	SPRING H	ILL QLD 400	Report D	ate	27/09/2018		
Pr	oject	H356804 - C	adia NTSF	Failure - Re	quest 8				
							[I
	Sample No.	18090290							
	Test Date	24/09/2018							
	Client ID	CE432 - L1B							
	Depth (m)	19.80-20.30							
	Moisture (%)	24.2							
	AS SIEVE SIZE (mm)			PE	RCENT PASSI	NG			
	150								
	75								
	63								
	53								
	37.5								
	26.5								
	19								
	13.2								
	9.5								
	6.7	100							
	4.75	99							
	2.36	98							
	1.18	91							
	0.600	82							
	0.425	78							
	0.300	74							
	0.150	65							
	0.075	57							

NOTES/REMARKS:

Sample/s supplied by the client

Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory CA C. Channon



REP01103

Page 1 of 1

Laboratory No. 9926



	PARTIC					PORT		
Client	Hatch Pty Lte	.d	est Method: AS	1289 3.6.1, 2.1.	Report N	0.	18110003-0	
					Workord		5081	-
Address	ddress PO Box 425 SPRING HILL QLD 4004				Report D		08/11/2018	
					-			
Project	H356804 - C	adia NTSF	Failure					
			1	r			1	7
Sample No.	18110003							
Test Date	1/11/2018							
Client ID	CE432 - L1C - Lexan							
Depth (m)	20.30-20.80							
Moisture (%)	28.2							
AS SIEVE SIZE (mm)			PEI	RCENT PASSI	NG			
150								
75								
63								
53								
37.5								
26.5								
19								
13.2								
9.5								
6.7								
4.75	100							
2.36	97							
1.18	92							
0.600	85							
0.425	81							
0.300	77							
0.150	68							
0.075	59							
NOTES/REMARKS:								

Sample/s supplied by the client

Authorised Signatory

Page 1 of 1 REP01103

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Laboratory No. 9926

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Tested at Trilab Brisbane Laboratory.

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated. Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details. Trilab Pty Ltd ABN 25 065 630 506

0

C. Park



	PA	RTICL					RIB					ORT				
Client	Hatch Pty	y Ltd	163		nou:	AJ	1203	.0.3,	J.J. I	3	Report No.	18	0503	83-0	3	
		Workorder No. 0									04181					
Address	PO Box 4									9/5/18-21/5/18						
											Report Date		22/5/2018			
Project	H326804	- Cadia M		ailur	Δ.	<u> </u>	ntain	mont	R	l Ind	- Left Abutmer		., 0, 20	10		
Client ID	BM1 - BS			allul	e -	00	Indin		DU		Depth (m)		00-1.2	20		
Sieve Size	Passing	51									Depth (m)	1.	JU-1.2	20		
(mm)	rassing %	100	1							П						ТП
150.0	70															
75.0																
63.0		90	-							1						++
53.0										/						
37.5																
26.5		80				\parallel				\uparrow						111
19.0																
13.2		70														Щ
9.5																
6.7							ر اا									
4.75		60														Щ
2.36	100	(%)			М											
1.18	98	Passing (%) 05	-	-/												
0.600	95	Se 50														++
0.425	94	_														
0.300	93															
0.150	92	40	-													
0.075	91															
0.06	89															
0.043	83	30														
0.031	75 70															
0.023	63	20														
0.017	62	20														
0.0088	61															
0.0063	59	10	+			+			+	+	+++-++				$\left \right \right $	++
0.0044	58															
0.0036	56															
0.0031	55	0	.001			r).01	1			0.1	 1				<u>⊥⊥</u> 10
0.0026	54	Ŭ				·			Der	icl-						
0.0022	54								rart	ICIE	Size (mm)					
0.0013	53															
NOTES/REMARKS	<u>.</u> -															
	Ν	Moisture Co Sample/s รเ			clie	nt	-2.3	36mm	ı So	il P	article Density(t/m	³) 2.66	Pa	age 1 (of 1	REP0390
The results of the	ed for compliance	ce with ISO/IE tions, and/or n	C 17025 - neasurem	Testin ents in	ıg. clude						Authorised Signator	y y			TA	
	Tested at Trilab Brisbane Laboratory. C. Park Laboratory No. 9926															



	Р	ARTICL				RT
Client	Hatch P	Pty Ltd	Test Method: AS 1	209 3.0.3, 3.5.1 8	Report No.	18080197-G
					Workorder No.	0004644
Address	PO Box	425 SPRIN	IG HILL QLD 4004	1		13/8/18-21/8/18
Address	1 0 200	120 01 1 11			Test Date	
					Report Date	22/8/2018
Project			TSF Failure		1	
Client ID		- DH405 - F	PT2		Depth (m)	39.50-39.72
Sieve Size	Passing	100				
(mm)	%	-				
150.0						
75.0		90				
63.0 53.0						
37.5						
26.5		80	+ + + + + + + + + + + + + + + + + + +		┼┼┼╴┼╶┟╱╿┼┤	
26.5		1				
13.2						
9.5		- 70			/	
6.7		1				
4.75						
2.36	100	60				
1.18	97	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~				
0.600	86	Passing (%)				
0.425	79	ä				
0.300	73					
0.150	62	40				
0.075	54					
0.06	44					
0.051	40	30				
0.037	35					
0.026	31					
0.019	27	20				
0.014	25	4				
0.0099	24	10				
0.0071	17	- 10				
0.005	16	4				
0.0041	14 13	0				
0.0035	13	- 0.	001 0.0	1	0.1	1 10
0.0028	13	1		Particl	e Size (mm)	
0.0024	9	1				
0.0010		ļ				
NOTES/REMARKS	<u>5:</u>	- Moisture Co	ntent 18 5%	-2 36mm Soil	Particle Density(t/m ³)	2 55
			pplied by the client	-2.3011111 3011		2.55 Page 1 of 1 REP03904
A	ad for accord					
			2 17025 - Testing. easurements included in		Authorised Signatory	NATA
			National Standards.		Cen	
	Tested at Tri	ilab Brisbane Lat	ooratory.		C. Park	TECHNICAL COMPETENCE
			- 1	-		Laboratory No. 9926



	Р	ARTICL				TEST REPO	ORT		
Client	Hatch F	Pty Ltd	Test Method: A	5 1289 3.6.3	o, o.o.1 &	Report No.	180	80417-G	
						Workorder No			
Address	PO Box	425 SPRIN	IG HILL QLD 40	04		Test Date		8/18-31/8/1	0
									0
						Report Date	31/8	8/2018	
Project			TSF Failure			1			
Client ID		- DH405 SA	\8			Depth (m)	65.5	60-66.00	
Sieve Size	Passing	100							
(mm)	%	-							
150.0									
75.0		90				+ /			
63.0		_							
53.0		-							
37.5		80			+ + +	/ - -		+ + + + + + +	+++1
26.5		-							
19.0		-							
13.2 9.5		70				/		+ + + + + +	+++1
9.5 6.7		-							
4.75									
2.36		60							
1.18	100	Passing (%)							
0.600	96	ssin to							
0.425	90	କ 50 ଜୁ							
0.300	85				$\left \right $				
0.150	71	40							
0.075	59								
0.067	57								
0.048	53	30							
0.035	47								
0.025	42								
0.019	37	20							
0.014	32								
0.0097	29	4							
0.0069	23	10							
0.0049	20	4							
0.004	18	-							
0.0034	17	0 0.0	001	0.01		0.1	1		10
0.0028	16	4			Particle	e Size (mm)			
0.0024	15	4				-			
0.0014	11								
NOTES/REMARKS	<u>S:</u>	- Moisture Cor		-2.36m	m Soil F	Particle Density(t/m ²) 2.64	Page 1 of 4	PEDO200
			pplied by the client					Page 1 of 1	REP03904
The results of t	he tests, calib ient are tracea	orations, and/or m able to Australian/	C 17025 - Testing. easurements included in National Standards.	n	Ć.	orised Signatory		ACCREDITED FOR TECHNICAL COMPETENCE	
	lested at Tr	ilab Brisbane Lab	oratory.					Laborator	y No. 9926



	P	ARTICLE			TEST REPO	रा
Client	Hatch P	ty Ltd	Test Method: AS 1	289 3.6.3, 3.5.1 8	Report No.	18080420-G
					Workorder No.	0004681
Address	PO Box	425 SPRIN	G HILL QLD 4004	1	Test Date	22/8/18-31/8/18
				-		
					Report Date	31/8/2018
Project		4 - Cadia N				
Client ID		- DH406 L2E	3		Depth (m)	18.50-19.00
Sieve Size	Passing	100 T				
(mm)	%					
150.0	-					
75.0		90 -				
63.0					/	
53.0	-				/	
37.5		80 -		/		
26.5 19.0						
13.2						
9.5	+	70 -				
<u> </u>						
4.75						
2.36		60 -				
1.18	100	Passing (%)				
0.600	98	ussin - 05				
0.425	96	E 30				
0.300	95					
0.150	93	40 -	/			
0.075	90					
0.058	82					
0.048	76	30 -	_/			
0.034	71					
0.024	69					
0.018	62	20 -				
0.013	61					
0.0095	58					
0.0068	53	10 -				
0.0048	48					
0.0039	45	0 +				
0.0034	44	. 0.0	01 0.C	1	0.1	1 10
0.0028	40			Partic	le Size (mm)	
0.0024	38					
0.0015	30	ļ				
NOTES/REMARKS	<u>S:</u>	-			3.	
		Moisture Con Sample/s sup	tent 42.3% plied by the client	-2.36mm Soil	Particle Density(t/m ³)	2.49 Page 1 of 1 REP0390
		nce with ISO/IEC ations, and/or me	17025 - Testing. asurements included in	Aut	norised Signatory	ΝΑΤΑ
			National Standards.	6	Un	
	Tested at Tri	lab Brisbane Labo	oratory	<u> </u>	C. Channon	
					ample at the time of test	Laboratory No. 992



	Р	ARTICI										EPC	DRT	1				
Client	Hatch F	Pty Ltd	Те	st Meth	<u>10d:</u> /	<u>as 12</u>	289 3.	6.3, 3	5.5.1	<u>& 2</u>	.1.1 Report	No	1	80804	132 4	2		
		- y									-					G		
Address	PO Box	425 SPR	ING HI		D 4	004				+	Workore			00468		0/4	0	
Address	10 00	420 01 10				004					Test Da			3/8/18		8/1	8	
											Report	Date	3	1/8/20)18			
Project		4 - Cadia		Failure	е					_								
Client ID		<u> - DH409</u>	A L1								Depth	n (m)	1	4.50-1	15.0	0		
Sieve Size	Passing	10	0															
(mm)	%	-														11		
150.0		-										\square						
75.0 63.0		- 9	0															
53.0		-																
37.5		1									11							
26.5		8	0					-		+							++	
19.0		1								$\ $								
13.2	1	1																
9.5	100	- 7							/									
6.7	99	1						$\left \right $	1									
4.75	99	6	o															
2.36	99																	
1.18	99	,) Bu					/											
0.600	97	Passing (%)	0			\parallel		_										
0.425	95					XI.												
0.300	94	-																
0.150	90	4	0					-									++	
0.075	83	-																
0.066	77	-																
0.047	71	3	0															
0.034	66 64	-																
0.024	60	2	0															
0.013	57	1 -																
0.0093	49	1																
0.0066	44	1	0		+++	$\parallel \mid$		_	+	$\left \right $	\parallel	+ $+$ $+$			+	++	+++	
0.0047	40]																
0.0038	37																	
0.0033	36		0 0.001			0.01					0.1		1				 10	
0.0027	34	1							Parti	cle 9	Size (mm)		-					
0.0023	33	_								J.C C								
0.0014	30	ļ																
NOTES/REMARKS	<u>):</u>	-																
		Moisture C Sample/s s			clien	t	-2.3	6mm	Soil	Pa	rticle Dens	ity(t/m ³) 2.70		Page 1	of 1	REF	203904
The results of the	ne tests, calib	ance with ISO/I rations, and/or able to Australia	measuren	nents inc	luded	in			Au	tho	rised Signa	atory						
	Tested at Tr	ilab Brisbane L	aboratory.							c.	Channon			I			/ No.	9926



	Р	ARTICLI										EPOI	RT				
Client	Hatch F	Pty Ltd	Ies	t Meth	<u>ua:</u> A	10 12	oy 3.t	J.J, J.	<u>ə.1 (</u>	<u>× 2</u> .	Report N	10.	180	8043	36-0	ì	
		-									Workorde		0004		/U-C	-	
Address	PO Box	425 SPRIN	IG HIL	L QL	D 40	004					Test Dat			3/18-	2/0/	/10	
																10	
											Report D	Jate	3/9/	2018	5		
Project)4 - Cadia N		ailure	;					1							
Client ID		- DH407 L1	В								Depth	(m)	23.0	0-23	3.50)	
Sieve Size	Passing	1 00 ·	.														
(mm)	%	_											11				
150.0		_										1111					
75.0 63.0		90 -												_			
53.0																	
37.5		-															
26.5		- 80			+++		-+		$\left \right $	╢						++	++
20.5		1								$\ $							
13.0		_								/							
9.5		- 70 -					+			+							++
6.7		1						X									
4.75		- 															
2.36		- 60					/										\square
1.18	100	Passing (%)															
0.600	98	0. assir				1											
0.425	96	<u> </u>			/												
0.300	94			И													
0.150	86	40		44													
0.075	81																
0.06	72		Í I														
0.043	69	30		_	+++	+++-		_						_		$\left \right $	++
0.03	66																
0.022	63	_															
0.016	59	20															++
0.012	56	-															
0.0085	53																
0.006	51	10 ·															Ħ
0.0042	46	-															
0.0035	43	0 .															
0.003	43		001			0.01					0.1		1				10
0.0025	41	-						P	artic	le S	ize (mm)						
0.0021	39 35	-															
0.0013	35	ļ															
NOTES/REMARKS	<u>3:</u>	-					0.00		o	-							
		Moisture Cor Sample/s su			client		-2.36	imm	Soil	Pa	rticle Densit	y(t/m³)	2.77	Pa	ge 1 o	of 1	REP0390
The results of t	he tests, calib	ance with ISO/IEC rations, and/or m able to Australian/	easureme	ents incl	uded	in		6	Aut	hor C	ised Signat	ory	0				
	Tested at Tri	ilab Brisbane Lab	oratory.							c.	Channon				COMPETI		
			•											La	bora	atory	/ No. 992



	P	ARTICLE	E SIZE I							ORT			
Client	Hatch P	ty Ltd	rest met	<u>110u. r</u>	1205	<u></u> , .			Report No.	18	080439)-G	
									Workorder N		04681		
Address	PO Box	425 SPRIN	G HILL QI	_D 40	004				Test Date		/8/18-7	/0/18	
									Report Date)/2018	10/10	
									Report Date	7/8	0/2010		
Project		4 - Cadia N		e									
Client ID	1	DH407 PT	3						Depth (m)	25	.50-26.	95	
Sieve Size	Passing	100 -											
(mm)	%												
150.0										1111			
75.0		90 -				+						+++	
63.0 53.0													
37.5													
		80 -		$\left \right $		+				+++++		+++	+++
26.5 19.0	+							K					
13.2													
9.5		70 -										+++	+++
6.7								/					
4.75													
2.36		60 -											
1.18	100	Passing (%) 05											
0.600	96	ussin - 05											
0.425	94	E So											
0.300	90												
0.150	83	40 -			И—								
0.075	76				11								
0.056	61												
0.047	59	30 -	/	r									+++
0.034	56												
0.024	53												
0.018	48	20 -				+							+++
0.013	45												
0.0093	41												
0.0066	36	10 -											
0.0046	33												
0.0038	31	0 -											
0.0033	26	0.0	01		0.01			0	.1	1			10
0.0027	25						Partic	le Siz	ze (mm)				
0.0023	24												
0.0014	20												
NOTES/REMARKS	<u></u>	-						_		3.			
		Moisture Con		oli - « t		36mm	Soil	Part	icle Density(t/m	ĭ) 2.66	D .	4	DEBAG
		Sample/s sup									Page	1 of 1	REP039
		nce with ISO/IEC			in			Au	thorised Signato	Y	N		
		ations, and/or me ble to Australian/I			111			/	l a l				
	Tootod at T-	ah Brichana Lab	vratory.						C. Park	-			
		ab Brisbane Labo							0.1 ark		Lab	orator	y No. 99



	Р	ARTICL		ZE est Me										OR	Т				
Client	Hatch P	ty Ltd		501 WIC		<u>u. л</u>		03 3	.0.3,	<u>J.J.</u>	1.00		Report No.		1808	044	1-G	i	
													Workorder No) .	00046	581			
Address	PO Box	425 SPRII	NG HI	LL C) LD	40	04					1	Test Date		23/8/		3/9/	18	
													Report Date		3/9/2			10	
Drainat	1105000	4 Cadia N	ITOE	Failu									Report Date		31912	010			
Project		4 - Cadia N		Fallu	ire							1			<u> </u>		~~		
Client ID		- DH407 L3	SC										Depth (m)		26.50)-27	.00		
Sieve Size	Passing	100	1												-				
(mm)	%																		
150.0 75.0												$\ $							
63.0		90			++	+				_		\square					_		
53.0		-																	
37.5		-									1								
26.5		80		+	+	++	$\left \right $		+	4	\square	$\left \right $					+	++	$\left \cdot \right $
19.0	+	1																	
13.0		-																	
9.5		- 70			+	+	K			+	\square						+	\square	
6.7		1					/												
4.75																			
2.36		60			П														
1.18	100	%) 6i																	
0.600	99	Passing (%)																	
0.425	99	<u> </u>			/														
0.300	99																		
0.150	97	40	-		++					_									
0.075	96																		
0.064	86																		
0.046	83	30	-/		++	+				_							_		
0.033	80		/																
0.023	77	_																	
0.017	74	20	-		++	+				-							+		
0.013	72	-																	
0.0089	69																		
0.0064	60	10	1																\square
0.0045	55	-																	
0.0037	49	- 0																	Щ
0.0032	45		.001				0.01					C	0.1		1				10
0.0026	42	-								Par	ticle	e Si	ze (mm)						
0.0023	38	-																	
0.0014	26	<u> </u>																	
NOTES/REMARKS	<u>3:</u>	-			,			<u> </u>	~	~		_		3	~~				
		Moisture Co Sample/s su				ent		-2.3	6mr	n Sc	dil F	ar	ticle Density(t/m	°) 2.0	62	Pag	e 1 o	f 1	REP0390
The results of t	he tests, calibr	nce with ISO/IE rations, and/or n ble to Australiar	neasurer	nents i	ncluc		in			а С	uth	ori	sed Signatory					FOR	
	Tested at Tri	lab Brisbane La	boratory									с. (Channon						No. 992



	Р	ARTICLE	SIZE							ST I	RE	PO	RT				
Client	Hatch F	Pty Ltd	Test me	thou.		203	5.0.5, 0			por	t No).	1901	070	3-G		
										-		No.	00054				
Address	PO Box	425 SPRIN	G HILL Q	LD 4	004					st D			26/1/		0/1/	19	
										eport		ta	30/1/				
Project	LI25600	4 - Cadia NT	SE Eailu	r0					N	pon			30/1/	2013			
Project			SF Fallu	le						Dami	la /1	-	40.00	10	-0		
Client ID Sieve Size	CE411A Passing									Dept	n (r	n)	16.00)-10.3	50		
(mm)	rassing %	100 T															l
150.0	70																
75.0																	
63.0		90 -				++											
53.0																	
37.5											Λ						
26.5		80 -									1						
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13.2		- 70 -				\parallel	11		<u> </u>								
9.5								/	/								
6.7	_	4															
4.75		60 -						\square									
2.36		(%)					/										
1.18		Passing (%)															
0.600		- 05 aš		+++		++	\mathbf{I}				++-			\vdash			
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0.300	98					41											
0.150	93	40 -															
0.075	83 79				/												
0.005	79	- 30 -		\square													
0.040	75	30															
0.024	68																
0.018	62	20 -															
0.013	56	1															
0.0094	49	1															
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0.0024	29	4								,							
0.0014	22																
NOTES/REMARKS	<u>8:</u>	-															
		Moisture Cont				-2.3	36mm	Soil F	article	e Den	sity(t/m³) :	2.58	-			
		Sample/s sup			nt									Page	1 of 1	R	EP03904
Accredit	ed for complia	nce with ISO/IEC ² rations, and/or mea	17025 - Testi	ng.	lin				Autho	rised	Signa	atory		N	Δ		
		ible to Australian/N			1				/	2 -							
	Tested at Trila	b Brisbane Laboratory						<		C. Par	k	-					
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	P	ARTIC								TRE	POF	RT			
Client	Hatch P	ty Ltd	16	st meth	00: A	3 12	093	3.6.3, 3.5.1 8		oort No) .	1901	0704	-G	
		-							-	korder		00054		0	
Address	PO Box	425 SPF			D 40	04				t Date				11/14	<u> </u>
/					_ 10	υr							19-30	1/18	1
									Rep	oort Da	ate	30/1/	2019		
Project	H356804		NTSF F	ailure	9										
Client ID	CE416 -								D	epth (I	m)	24.50	-25.0	0	
Sieve Size	Passing		00												
(mm)	%														
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75.0			90												
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26.5						$\left \right $	\mathbb{V}								
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6.7															
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1.18		Passing (%)													
0.600	100	ssinę													
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0.425	99														
0.150	96		40												
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0.053	94														
0.038	92	:	30												
0.027	89														
0.02	86														
0.015	84	:	20												
0.011	81														
0.0078	77														
0.0056	73		10			+	+			+++					
0.004	68														
0.0033	67														
0.0029	64		0.001	1		1).01			0.1	I			1
0.0024	63								e Size (m	m)					
0.0021	61								(11	,					
0.0012	55														
NOTES/REMARKS	<u>8:</u>	-													
	_	Moisture (Sample/s			lient		-2.3	86mm Soil I	Particle	Density	(t/m ³) :	2.66	Page 1	of 1	REP03904
													rage 1		REP03904
The results of the test of	ed for compliar he tests, calibra ent are traceat	ations, and/o	or measurem	ents incl	uded i	n			Authori	sed Sign	atory		NA	TA	
									Ce	~				TED FOR	
	Tested at Trilab	o Brisbane Labo	oratory						C.	Park					v No. 9926



	PA	RTICLE								EST REPO	RT				
Client	Hatch Pty	Ltd	rest	wetho	<u>a: A</u>	5 1289 3	<u>3.0.3, 3</u>	. <u>5.1</u> č	<u>a 2.</u>	Report No.	10	01070)5-0-	ì	
	,									Workorder No		5472	.0-0	•	
Address	PO Box 4	25 SPRIN	GHILL		0 40	04			+				0/4	140	
Address		20 01 1414	OTHE	QLD	, 40	0-1				Test Date		1/19-3		/19	
										Report Date	30/	1/201	9		
Project	H356804	- Cadia N	TSF Fa	ilure					-						
Client ID	CE416 - L	.2C								Depth (m)	25.	00-25	.50		
Sieve Size	Passing	100 -													_
(mm)	%	100									╫┼─				
150.0															
75.0		90 -													Ц
63.0															
53.0															
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26.5								И							
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9.5															
4.75						/									
2.36	100	60 -													H
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0.300	94				´										
0.150	89	40 -													
0.075	82														
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0.031	73														
0.023	67														
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0.012	58														
0.0089	54														
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0.0045	45														
0.0037	42														
0.0032	41	0 - 0.0	01			0.01				0.1	1		I		
0.0026	39							Partic	le S	ize (mm)					
0.0023	37									-					
0.0013	33														
NOTES/REMARKS															
		loisture Con ample/s sup			ient	-2.3	36mm	Soil	Par	ticle Density(t/m ³) 2.72	Pag	e 1 of	1 F	REP0390
The results of t	ed for compliance he tests, calibration nent are traceable	ons, and/or me	asuremen	ts inclu		1			A	uthorised Signatory		Ň		À	
	Tested at Trilab Br	rishane Laborator	,						0	C. Park				OR AL CE	
	Testeu al TIIIao BI	ISUAILE LADUIATOL	1							C. Fark		Lal	oorat	orv N	No. 9926

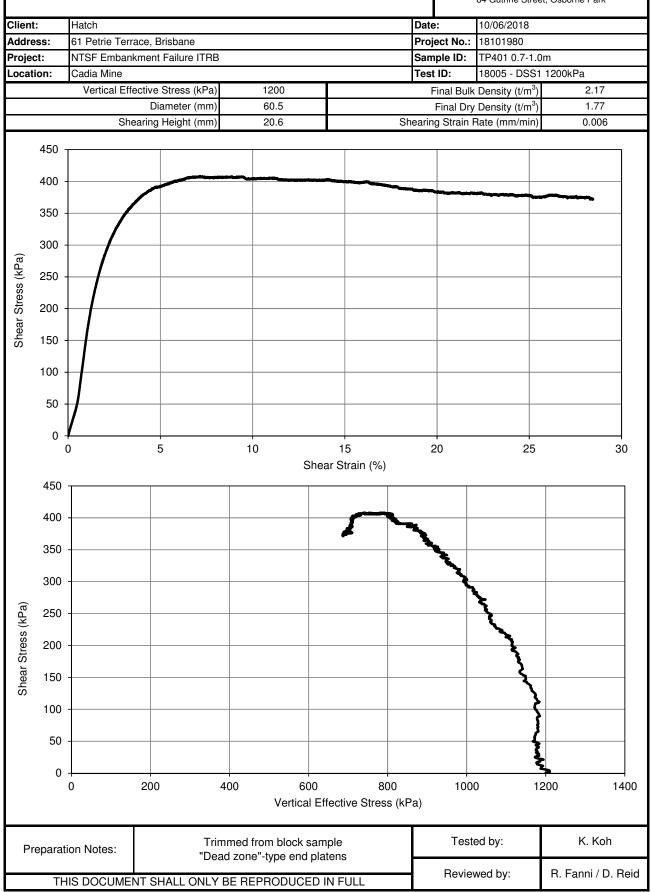


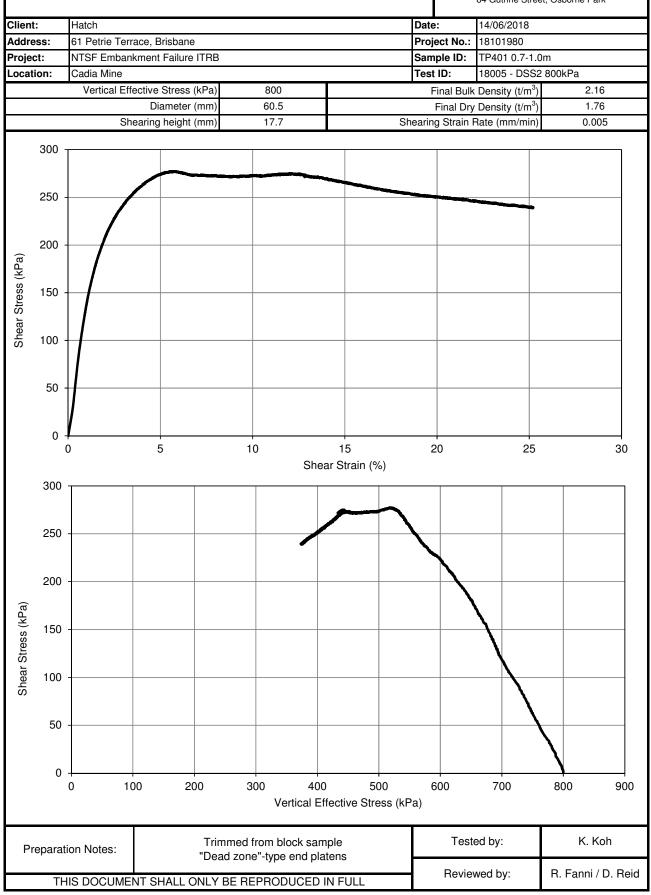
Client	Hatch Pty L	td	Test Method:		Report N Workord		18080190 0004644	-UW
Address	PO Box 425	5 SPRING H	ILL QLD 400)4	Report D	ate	14/08/201	8
Project	H356804 - (Cadia NTSF	Failure					
Sample No.	18080190	18080191	18080193	18080197	-	-	-	٦
Test Date	10/08/2018	10/08/2018	10/08/2018	10/08/2018	-	-	-	
Client ID	CE407 - DH402 - PS2	CE413 - DH404 - PS1	CE413 - DH404 - PS3	CE412 - DH405 - PT2	-	-	-	
Depth (m)	21.00-21.50	13.80-14.25	34.00-34.45	39.50-39.72	-	-	-	
Moisture (%)	17.8	21.3	23.2	48.5	-	-	-	
Wet Density (t/m ³)	2.11	1.95	1.95	1.70	-	-	-	
Dry Density (t/m³)	1.79	1.61	1.59	1.14	-	-	-	_
								_
Sample No.	-	-	-	-	-	-	-	7
Test Date	-	-	-	-	-	-	-	
Client ID	-	-	-	-	-	-	-	
Depth (m)	-	-	-	-	-	-	-	
Moisture (%)	-	-	-	-	-	-	-	
Wet Density (t/m³)	-	-	-	-	-	-	-	
Dry Density (t/m³)	-	-	-	-	-	-	-	1
TES/REMARKS:								
Accredited for co	Sample/s support Sample/s support	plied by the clie					Page 1 of 1	REP0
The results of the tests, this document are to	calibrations, and/or	measurements in	cluded in	Authorised	Signatory		I	
Tested	at Trilab Brisbane L	aboratory.		C. Par	k		Laborato	

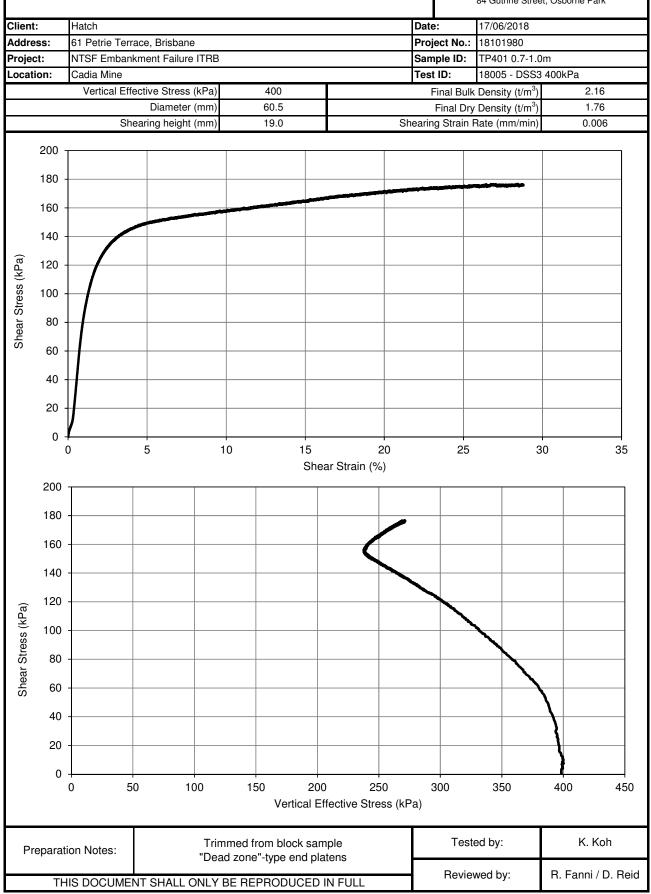


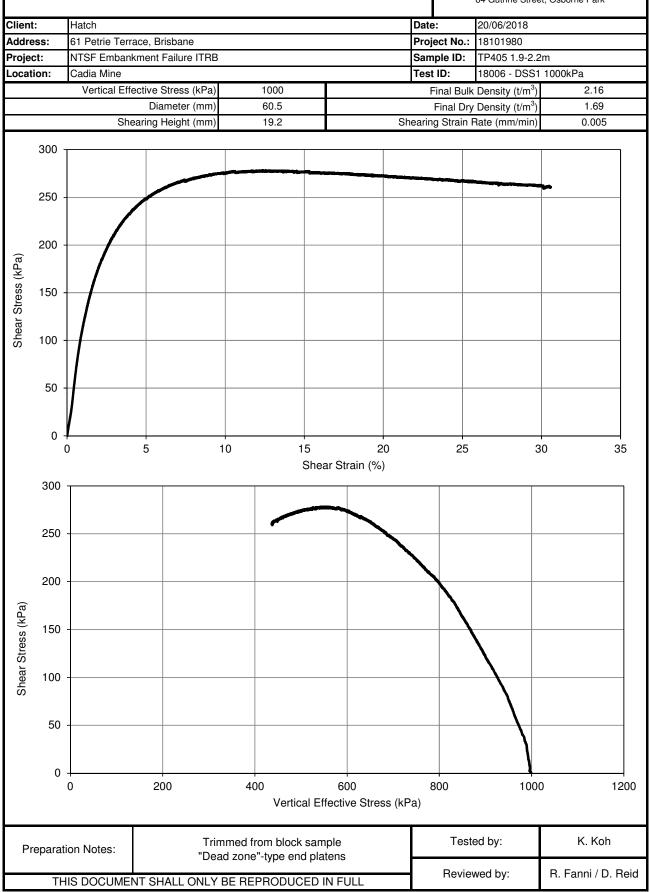
Client	Hatch Pty L	td			Report N Workorde		19010703 0005472	B-UW
Address	PO Box 42	5 SPRING H	ILL QLD 400	4	Report D	ate	31/01/2019	9
Project	H356804 -	Cadia NTSF	Failure					
Sample No.	19010703	19010704	19010705		-	-	-	
Test Date	25/01/2019	25/01/2019	13/02/1900	-	-	-	-	
Client ID	CE411A	CE416 - L2B	CE416 - L2C	-	-	-	-	
Depth (m)	16.00-16.50	24.50-25.00	25.00-25.50	-	-	-	-	
Moisture (%)	37.7	34.0	39.3	-	-	-	-	1
Wet Density (t/m³)	1.76	1.87	1.96	-	-	-	-	1
Dry Density (t/m³)	1.28	1.40	1.41	-	-	-	-	
Sample No.	-	-	-	-	-	-	-	7
Test Date	-	-	-	-	-	-	-	
Client ID	-	-	-	-	-	-	-	
Depth (m)	-	-	-	-	-	-	-	
Moisture (%)	-	-	-	-	-	-	-	
Wet Density (t/m ³)	-	-	-	-	-	-	-	1
Dry Density (t/m³)	-		-	-		-	-	
ES/REMARKS:	Sample/s curs	nliad by the alia	opt				Dare 4 of 4	
Accredited for con The results of the tests, this document are tr	mpliance with ISO/ calibrations, and/or	r measurements in	ng. Icluded in	Authorise	ed Signatory		Page 1 of 1	
Tested at Trilab Brisbane La		aninalional Sidho	aius.	С. <i>О</i> . С. Сн	annon		Laborato	

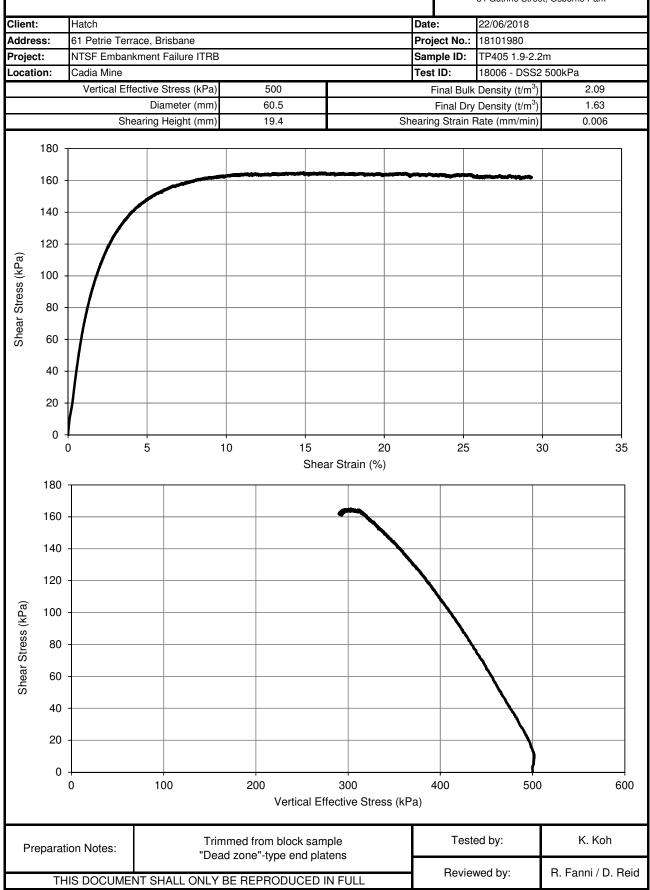
Annexure DB Direct Simple Shear Tests - Golders

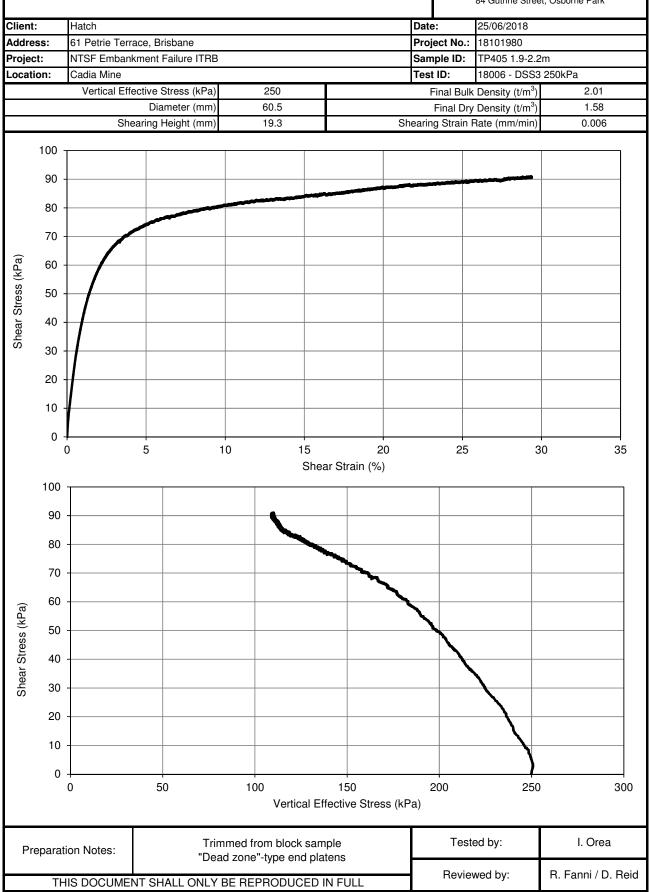


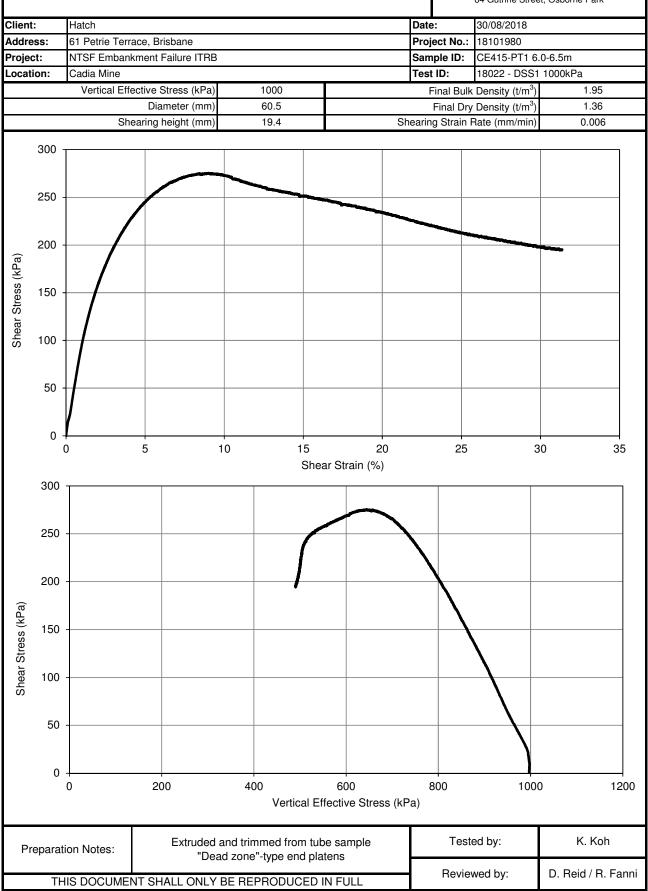


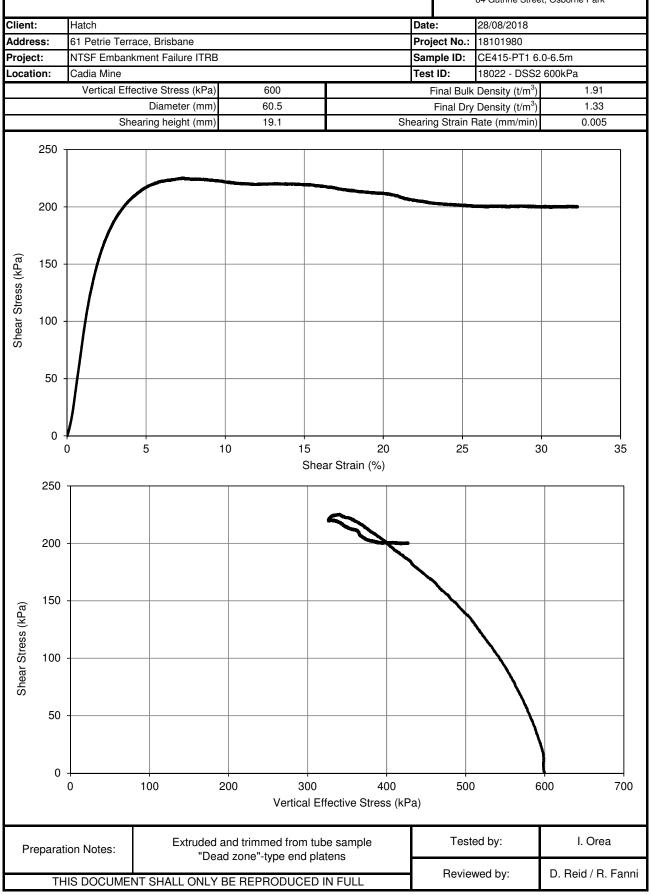


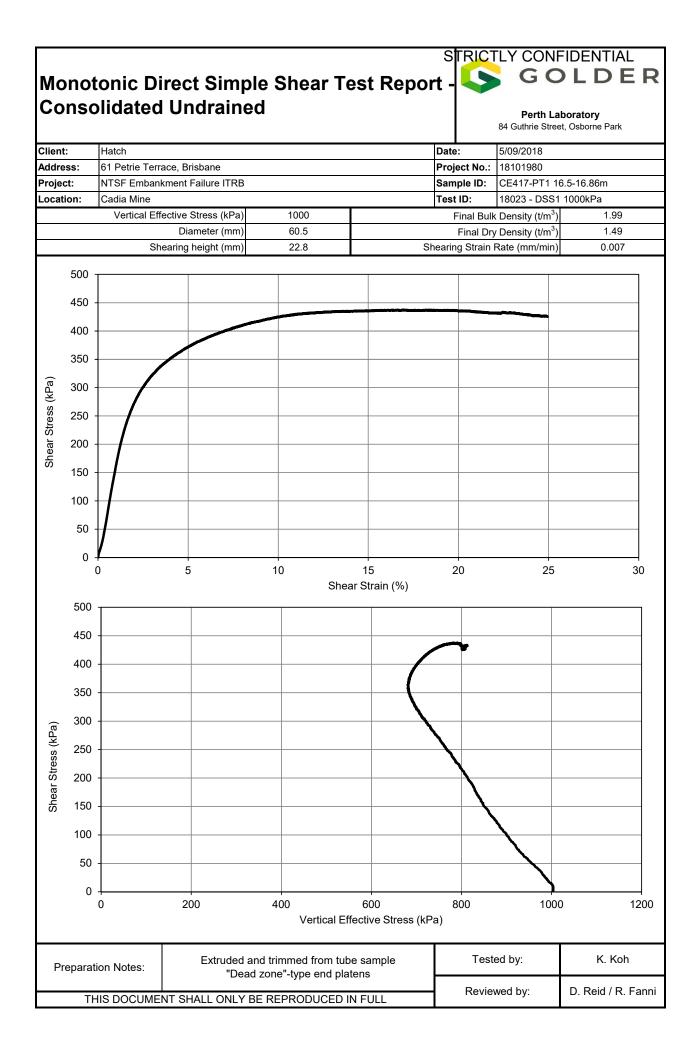


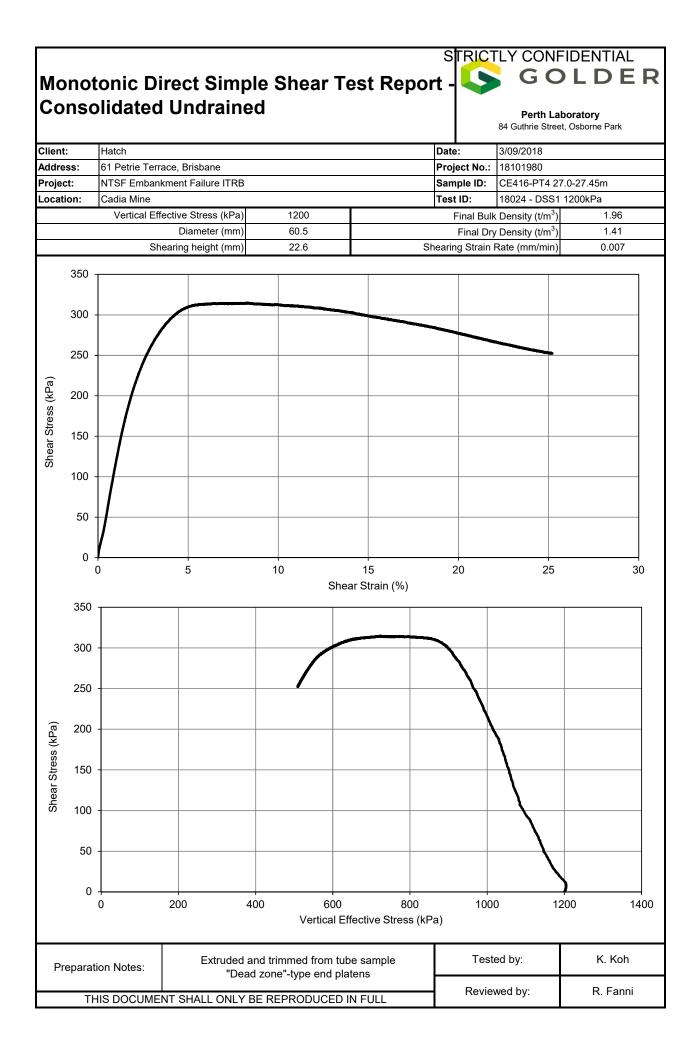


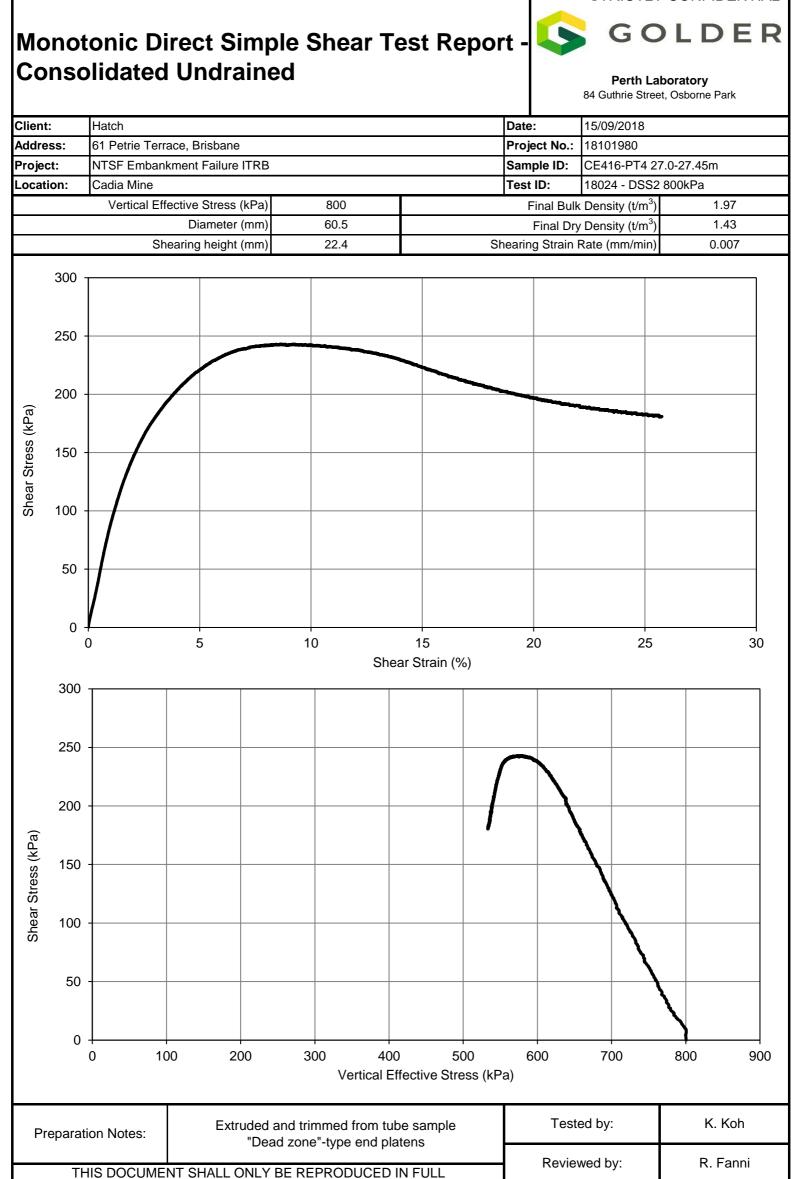






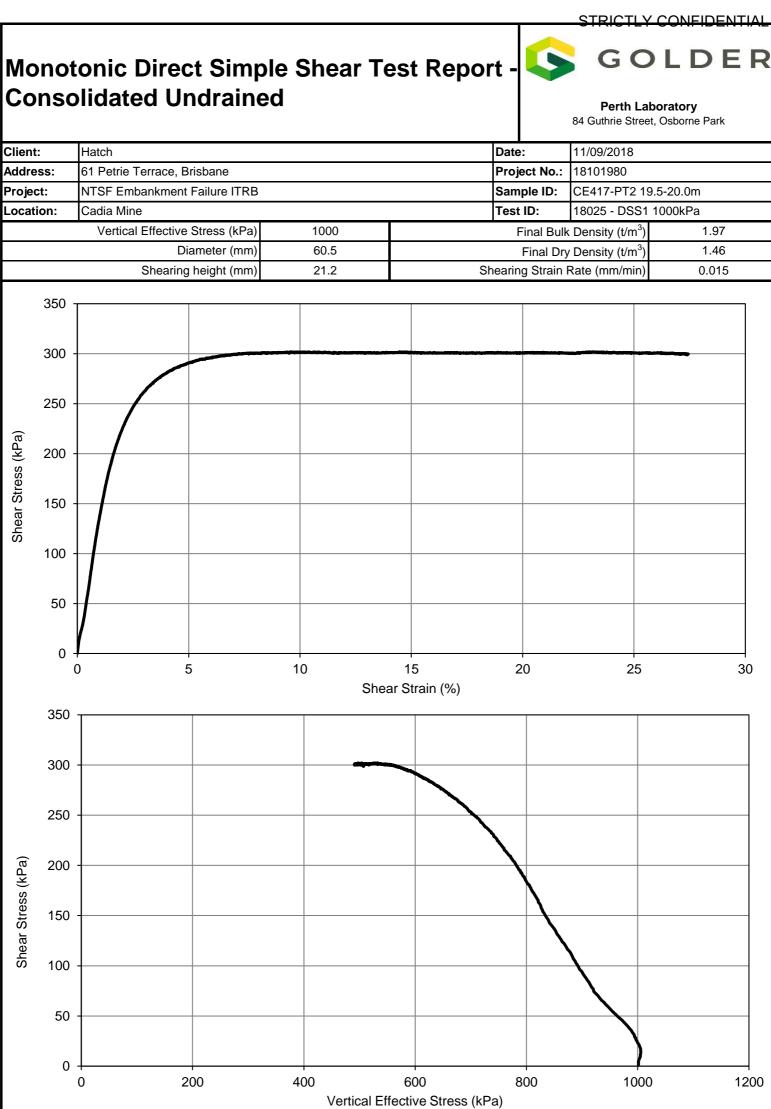




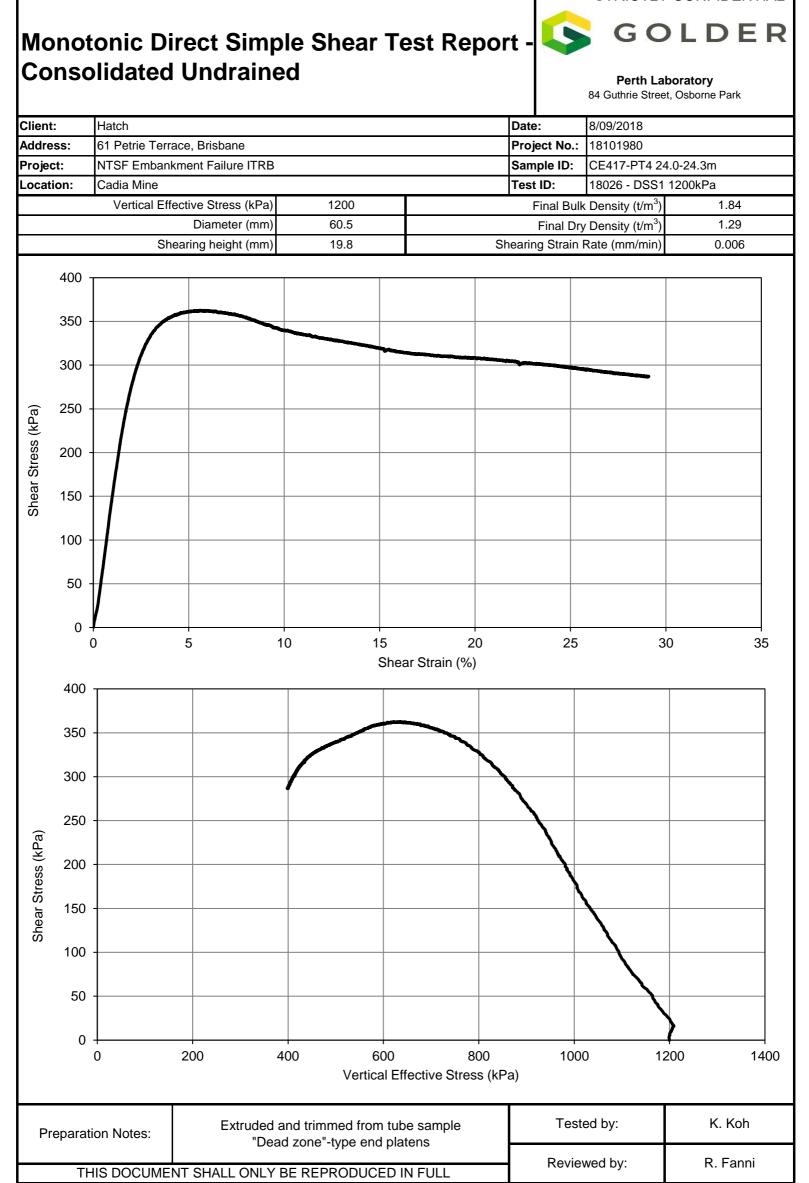


30

1200



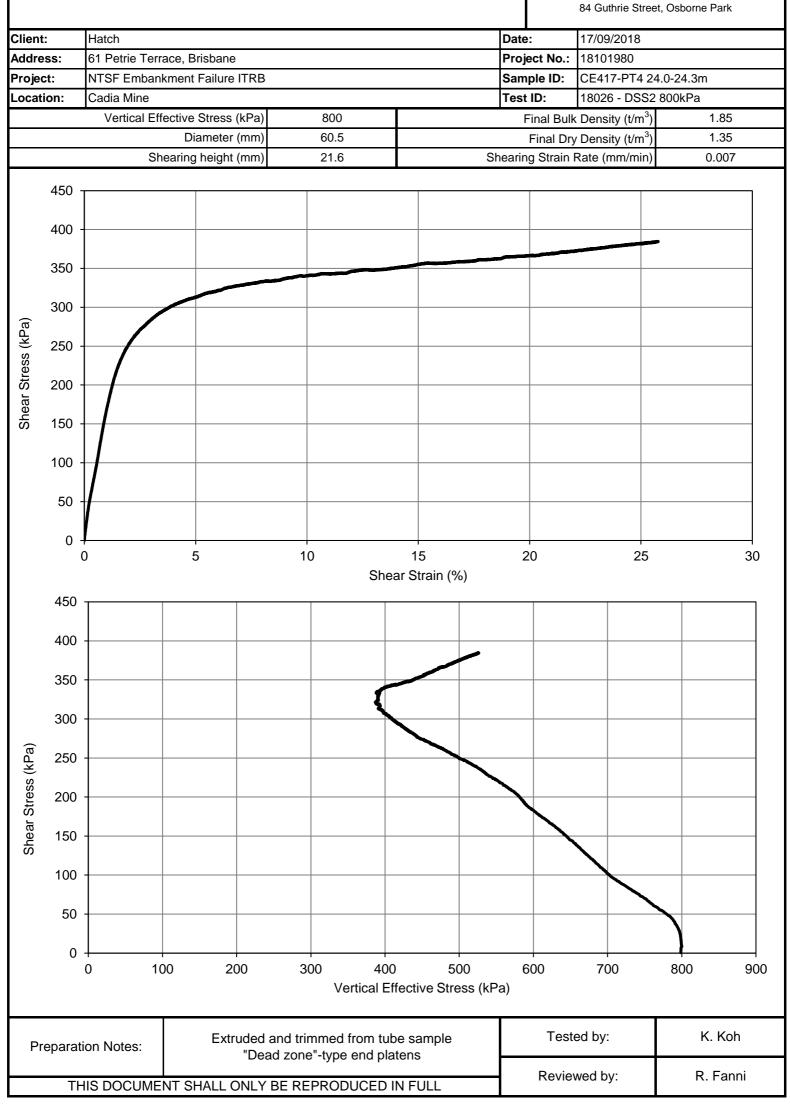
I. Orea Tested by: Extruded and trimmed from tube sample **Preparation Notes:** "Dead zone"-type end platens Reviewed by: R. Fanni THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL

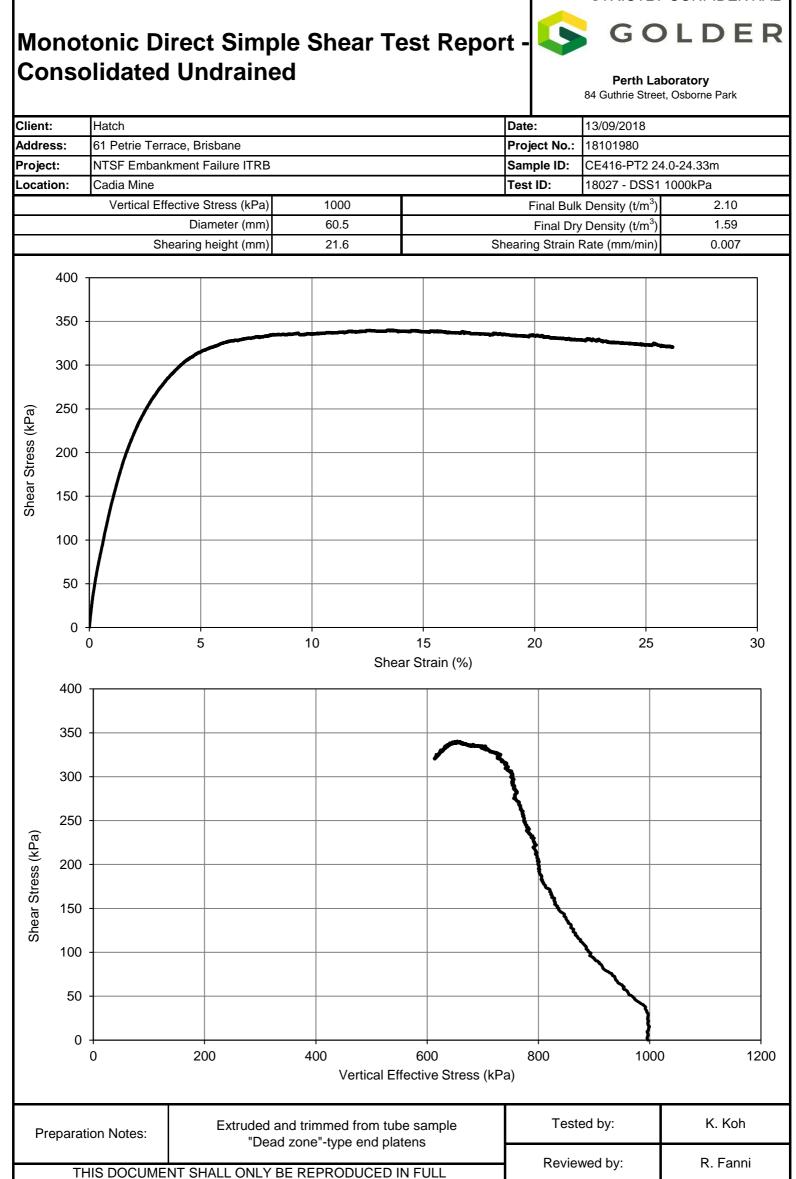


GOLDER

Monotonic Direct Simple Shear Test Report -Consolidated Undrained

Perth Laboratory

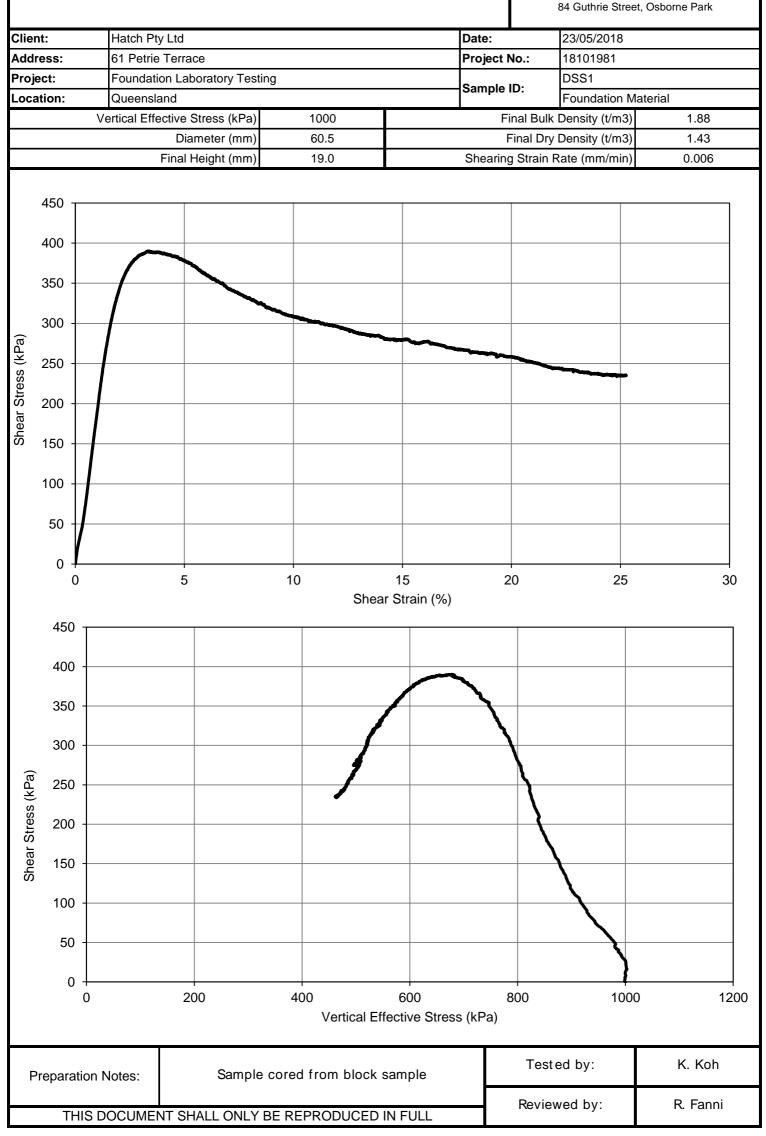




Monotonic Direct Simple Shear Test Report - Consolidated Undrained



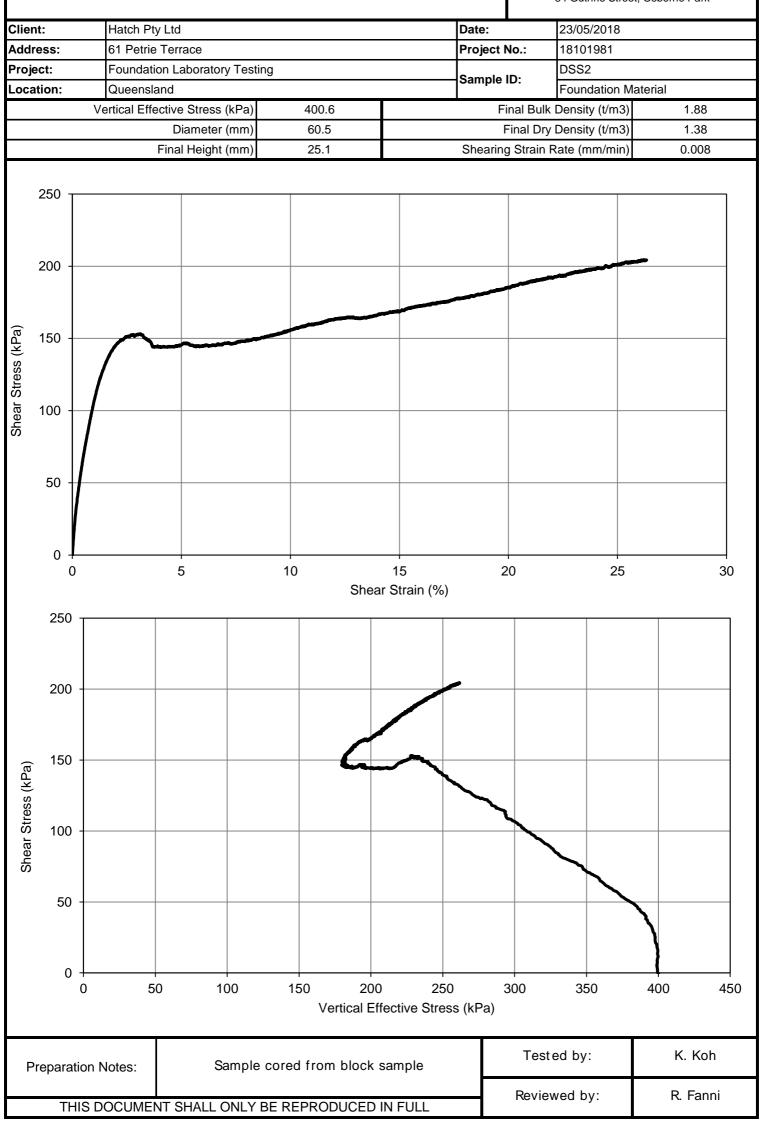
Perth Laboratory

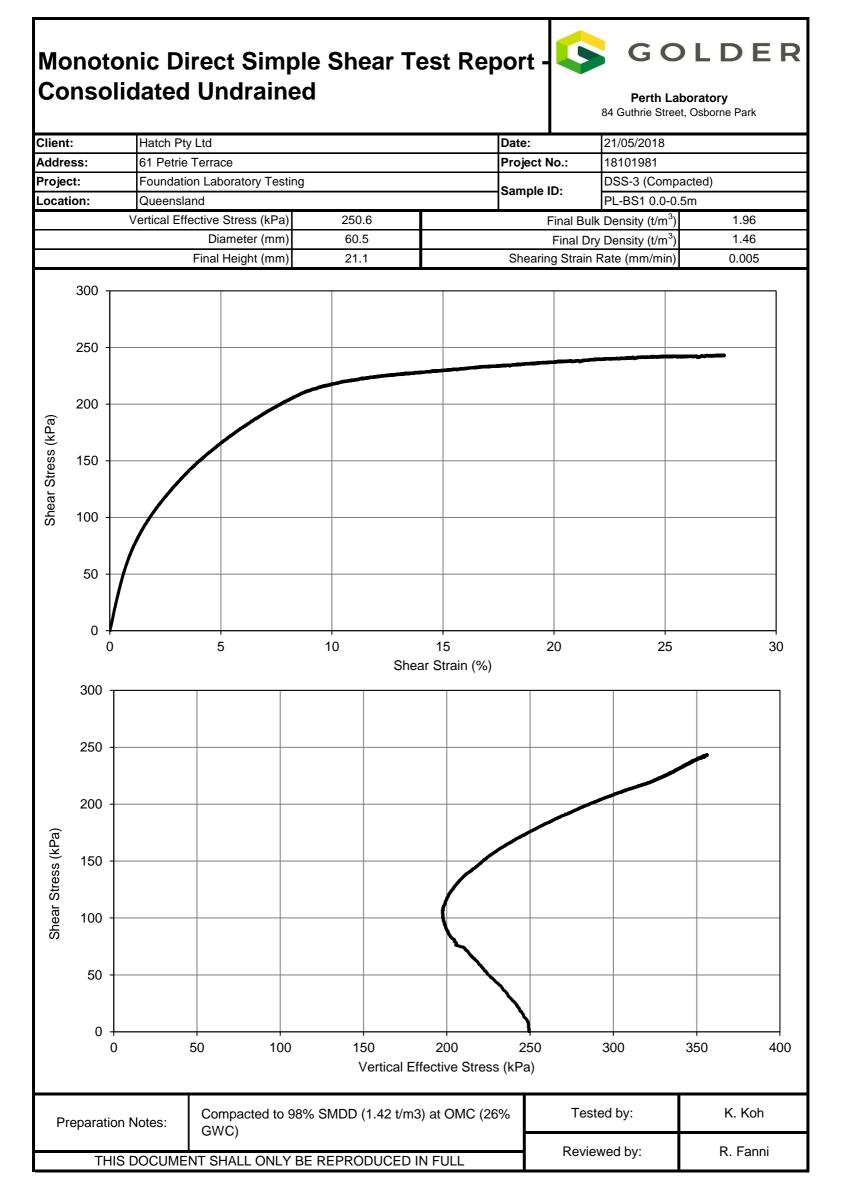


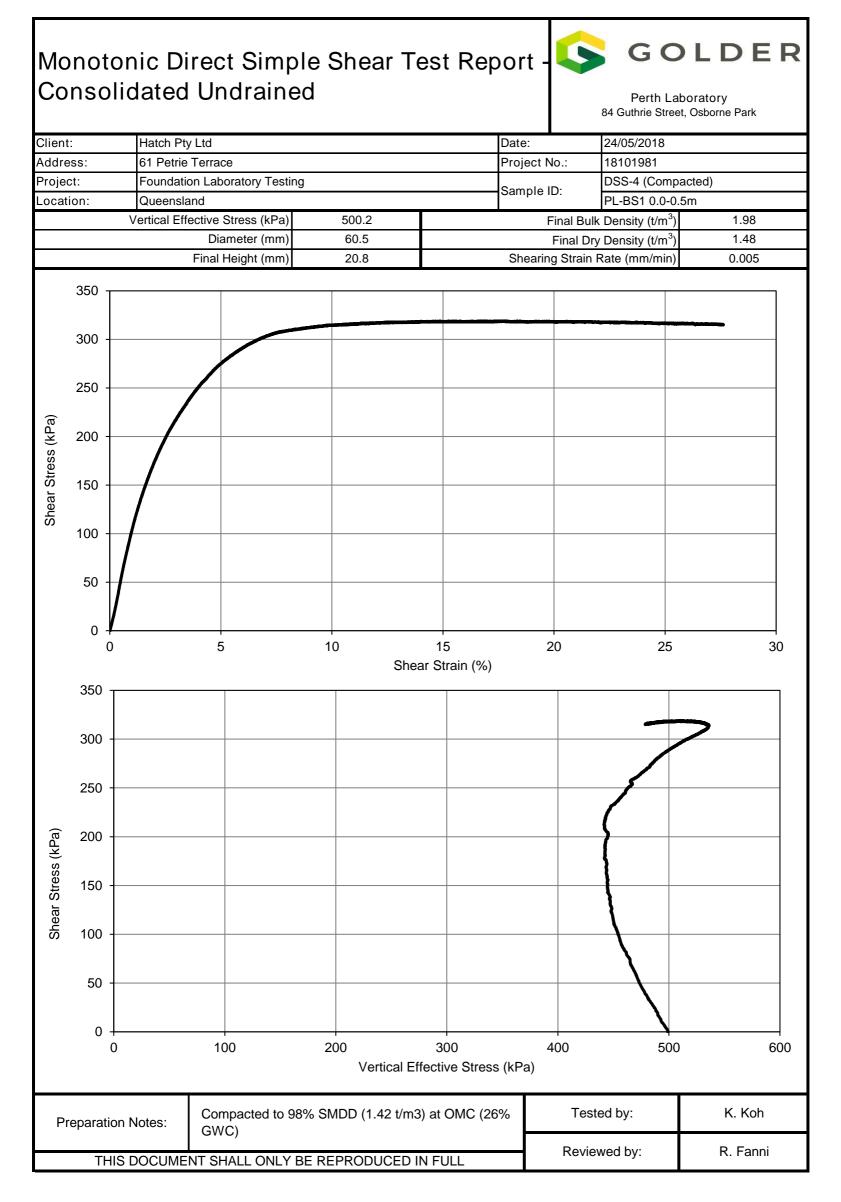
Monotonic Direct Simple Shear Test Report - Consolidated Undrained

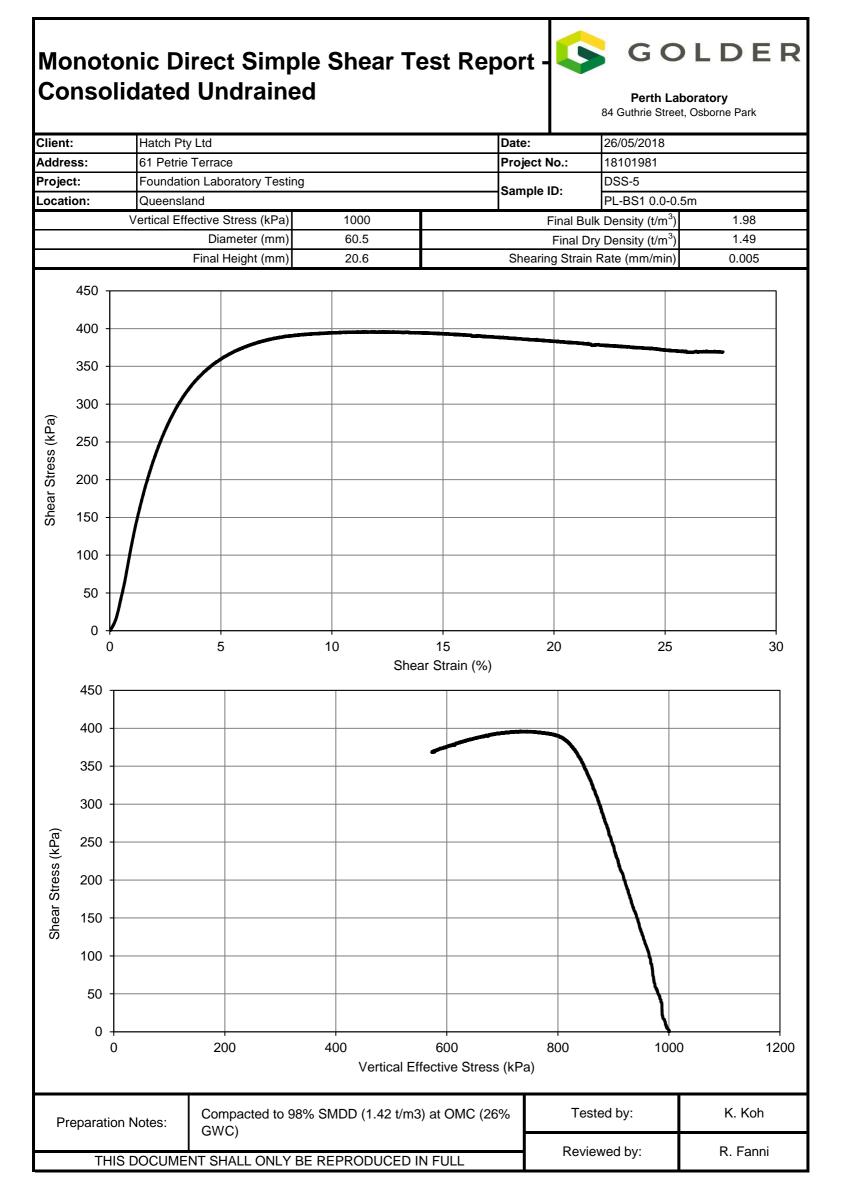
STRICTLY CONFIDENTIAL

S GOLDER









Annexure DC Direct Simple Shear Tests - Fugro



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	PT1		
Test Details:			
Test ID: CVO-SS01R		CVO-SS01R	
Consolidation Stress (kPa):		400	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	03/09/2018

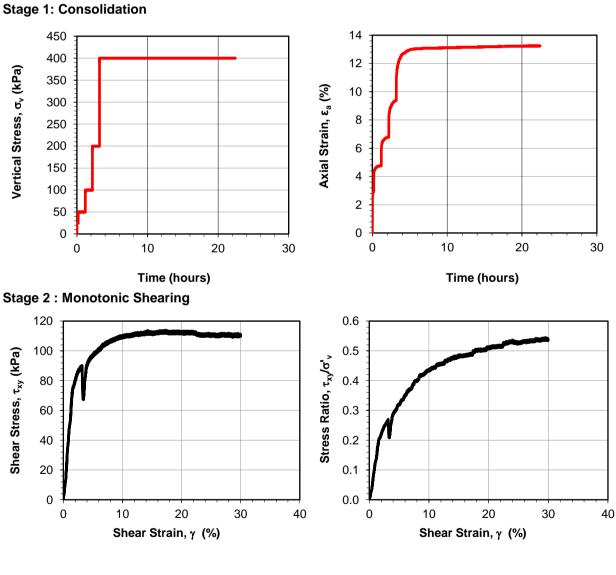
IPO Number: 2018-017 Sample ID: 2018-017-001 Borehole ID: CE411

Depth:	3.22 m to	3.26 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	22.04
Dry Density (t/m ³) :	1.52	1.75
Moisture Content (%) :	30.3 *	28.1

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
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Figure C1-Page 1



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT1

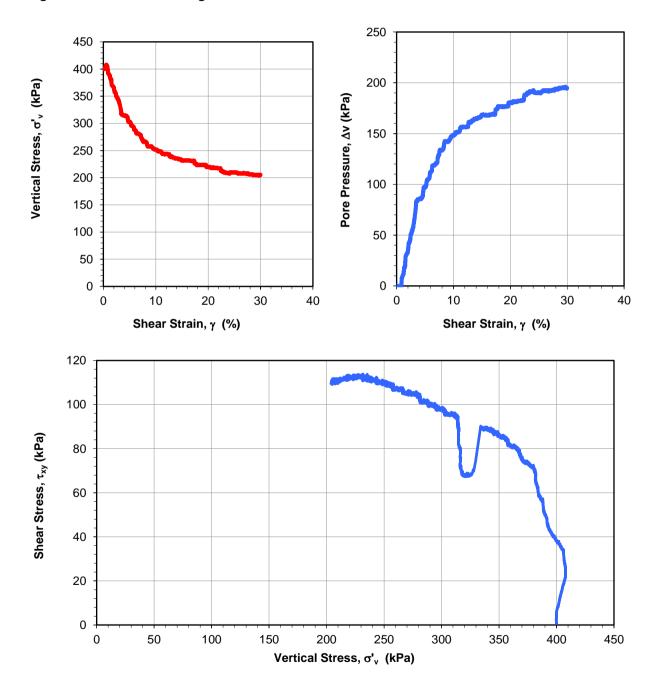
 IPO Number:
 2018-017

 Sample ID:
 2018-017-001

 Borehole ID:
 CE411

 Depth:
 3.22 m to 3.26 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
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Figure C1-Page 2



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	: PT1		
Test Details:			
Test ID:		CVO-SS02R	
Consolidation Stress (kPa):		800	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	07/09/2018

Stage 1: Consolidation

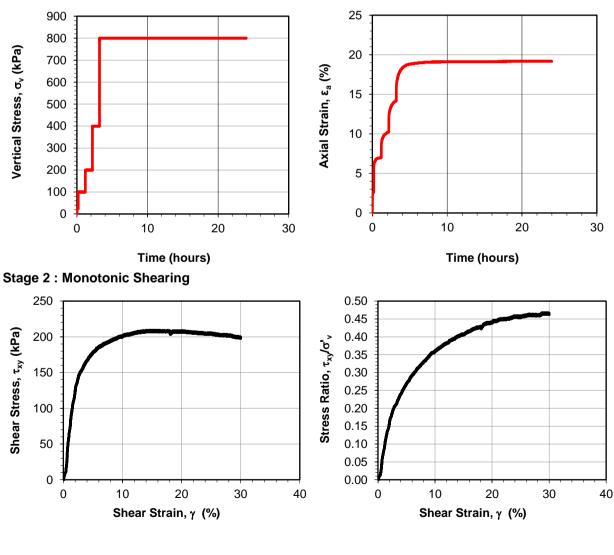
IPO Number: 2018-017 Sample ID: 2018-017-002 Borehole ID: CE411

Depth:	3.18 m to	3.22 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	20.53
Dry Density (t/m ³) :	1.50	1.85
Moisture Content (%) :	32.8 *	26.4

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C2-Page 1 N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS02R.xlsm

M-Files: FAM-18183



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT1

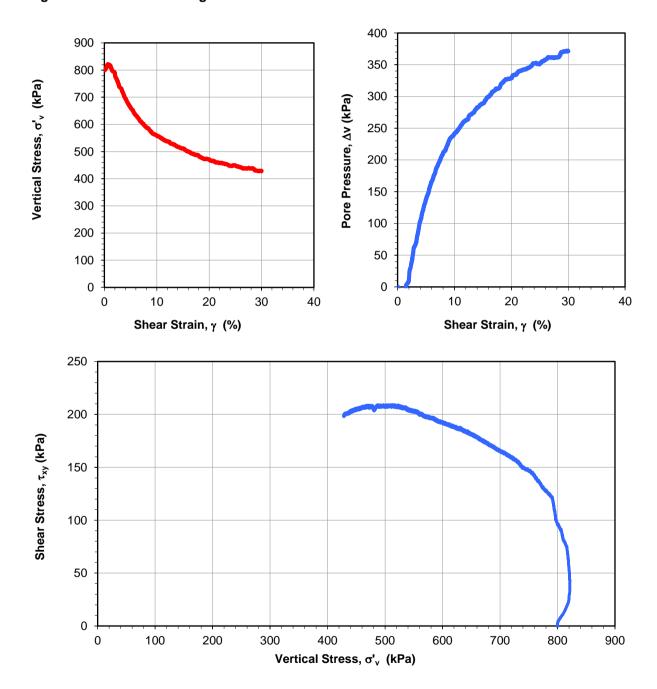
 IPO Number:
 2018-017

 Sample ID:
 2018-017-002

 Borehole ID:
 CE411

 Depth:
 3.18 m to 3.22 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
N:lagLAB/02.Projects/007.2018/LAB127730 - Cadia NTSF/03 Technical/04 Lab Testing/IPO 2018-017/11 Simple Shear/02 Processed data/QA Stage 2/CVO-SS02R.xlsm

Figure C2-Page 2



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	: PT1		
Test Details:			
Test ID: CVO-SS03		CVO-SS03	
Consolidation Stress (kPa):		1200	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	29/08/2018

Stage 1: Consolidation

IPO Number: 2018-017 Sample ID: 2018-017-003 Borehole ID: CE411

Depth:	3.26 m to	3.30 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.50	20.64
Dry Density (t/m ³) :	1.54	1.91
Moisture Content (%) :	30.5 *	25.0

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552

1400 25 1200 Vertical Stress, σ_v (kPa) 20 Axial Strain, ε_a (%) 1000 15 800 600 10 400 5 200 0 0 10 20 30 0 10 20 30 0 Time (hours) Time (hours) Stage 2 : Monotonic Shearing 0.50 350 0.45 300 Shear Stress, τ_{xy} (kPa) 0.40 Stress Ratio, τ_{xy}/σ'_v 250 0.35 0.30 200 0.25 150 0.20 0.15 100 0.10 50 0.05 0 0.00 0 10 20 30 40 10 20 30 40 0 Shear Strain, γ (%) Shear Strain, y (%)

Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C3-Page 1 N/agLAB/02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS03.xlsm



Client: Newcrest Mining Project: Cadia NTSF Failure - Laboratory Testing Location: Cadia Valley Operations Sample No.: PT1

IPO Number: 2018-017 Sample ID: 2018-017-003 Borehole ID: CE411 Depth: 3.26 m to 3.30 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552 Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C3-Page 2 N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS03.xlsm



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	PT4		
Test Details:			
Test ID:		CVO-SS04	
Consolidation Stress (kPa):		400	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	12/09/2018

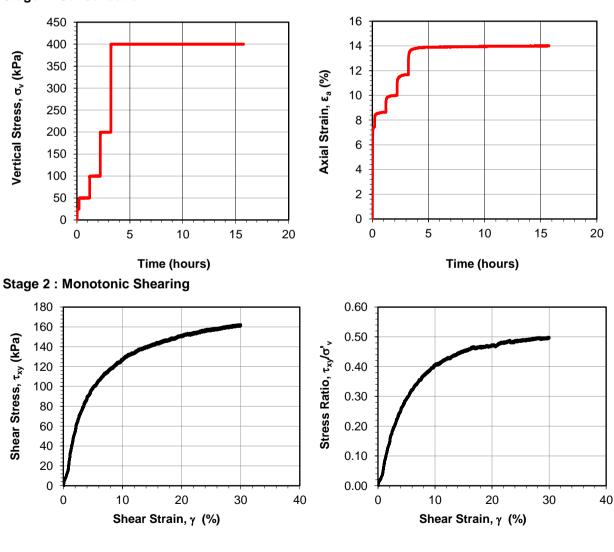
IPO Number: 2018-017 2018-017-008 Sample ID: Borehole ID: CE411A . - - -

Depth:	15.26 m to	o 15.30 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	21.84
Dry Density (t/m ³) :	1.58	1.84
Moisture Content (%) :	28.4 *	31.7

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C4-Page 1 N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 1\CVO-SS04.xlsm

Stage 1: Consolidation



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT4

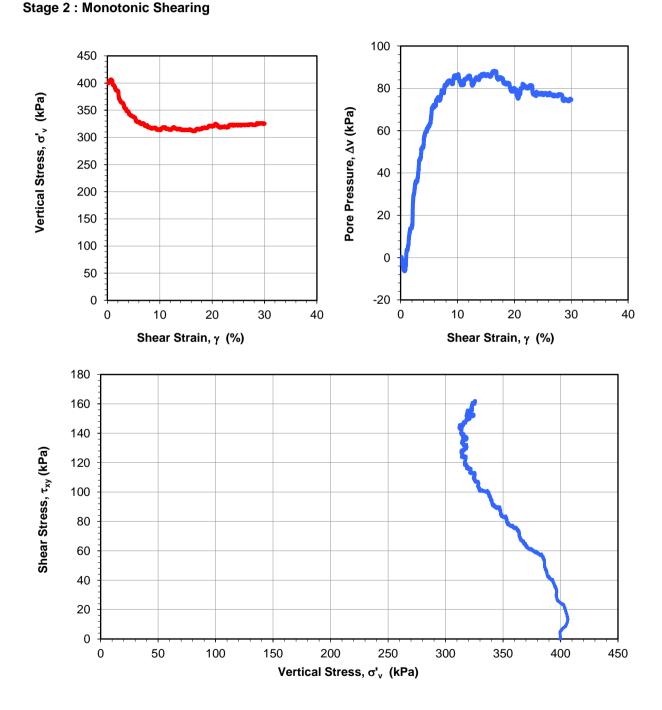
 IPO Number:
 2018-017

 Sample ID:
 2018-017-008

 Borehole ID:
 CE411A

 Depth:
 15.26 m to 15.30 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
N:lagLAB/02.Projects/007.2018/LAB127730 - Cadia NTSF/03 Technical/04 Lab Testing/IPO 2018-017/11 Simple Shear/02 Processed data/QA Stage 1/CVO-SS04.xlsm

Figure C4-Page 2



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	: PT4		
Test Details:			
Test ID: CVO-SS		CVO-SS05	
Consolidation Stress (kPa):		800	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	14/09/2018

Stage 1: Consolidation

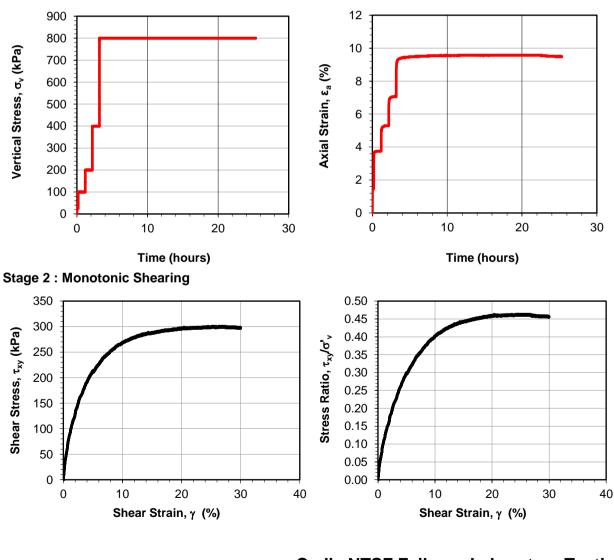
IPO Number: 2018-017 Sample ID: 2018-017-009 Borehole ID: CE411A

Depth:	15.22 m to	o 15.26 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	22.99
Dry Density (t/m ³) :	1.52	1.68
Moisture Content (%) :	31.3 *	37.0

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C5-Page 1 N/agLAB/02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS05.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT4

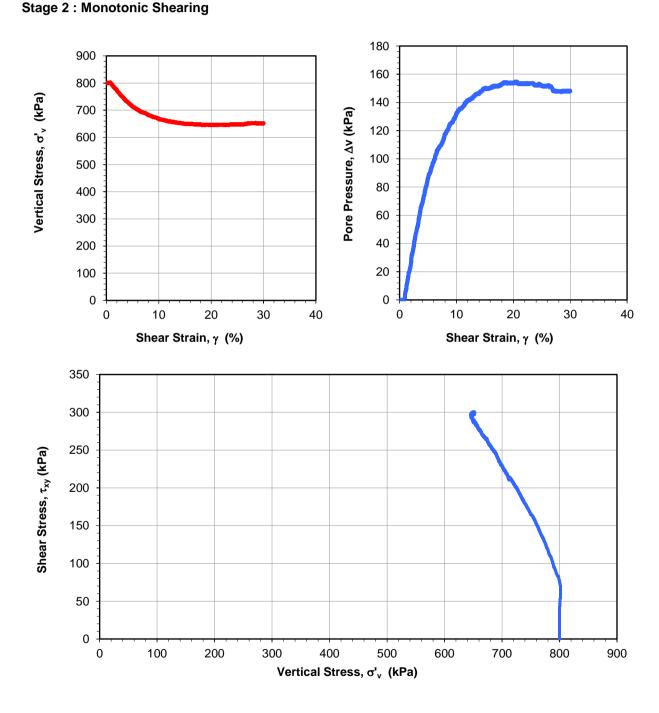
 IPO Number:
 2018-017

 Sample ID:
 2018-017-009

 Borehole ID:
 CE411A

 Depth:
 15.22 m to 15.26 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technica\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS05.xlsm

Figure C5-Page 2



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	PT4		
Test Details:			
Test ID:		CVO-SS06	
Consolidation Stress (kPa):		1200	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	17/09/2018

IPO Number: 2018-017 Sample ID: 2018-017-010 Borehole ID: CE411A

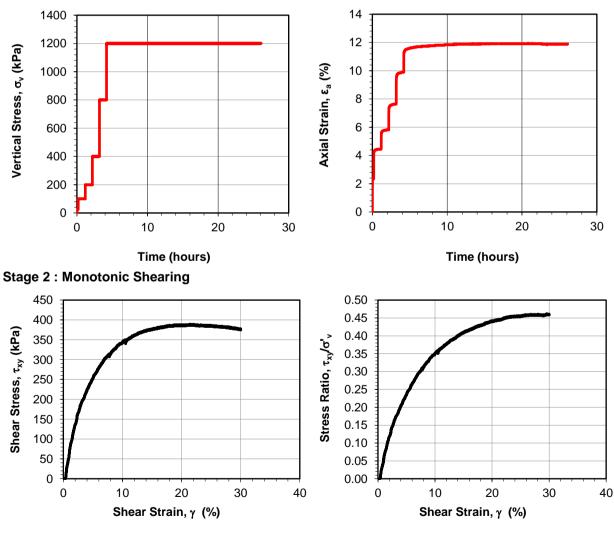
Depth:	15.18 m to	o 15.22 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	22.38
Dry Density (t/m ³) :	1.63	1.85
Moisture Content (%) :	24.3 *	31.9

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552

Stage 1: Consolidation



Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C6-Page 1 N/agLAB/02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS06.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT4

 IPO Number:
 2018-017

 Sample ID:
 2018-017-010

 Borehole ID:
 CE411A

 Depth:
 15.18 m to 15.22 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552 Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technica\04 Lab Testing\\PO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS06.xlsm

Figure C6-Page 2



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	PT5		
Test Details:			
Test ID: CVO-SS07		CVO-SS07	
Consolidation Stress (kPa):		400	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	31/08/2018

Stage 1: Consolidation

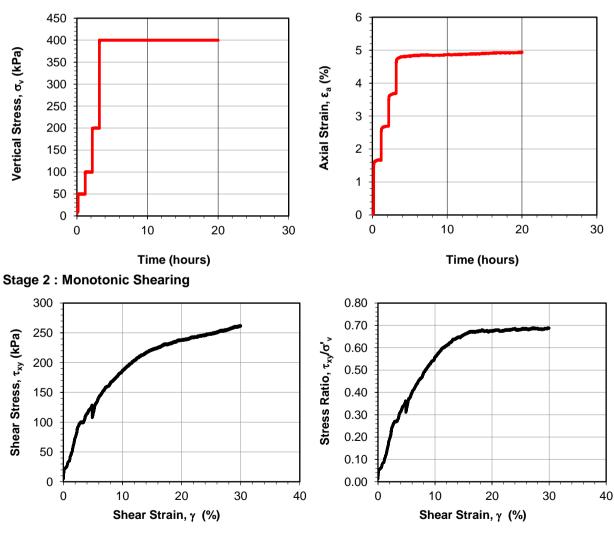
IPO Number: 2018-017 Sample ID: 2018-017-012 Borehole ID: CE411A

Depth:	16.86 m to	o 16.90 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.50	24.24
Dry Density (t/m ³) :	1.32	1.39
Moisture Content (%) :	40.8 *	46.1

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C7-Page 1 N/agLAB/02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS07.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT5

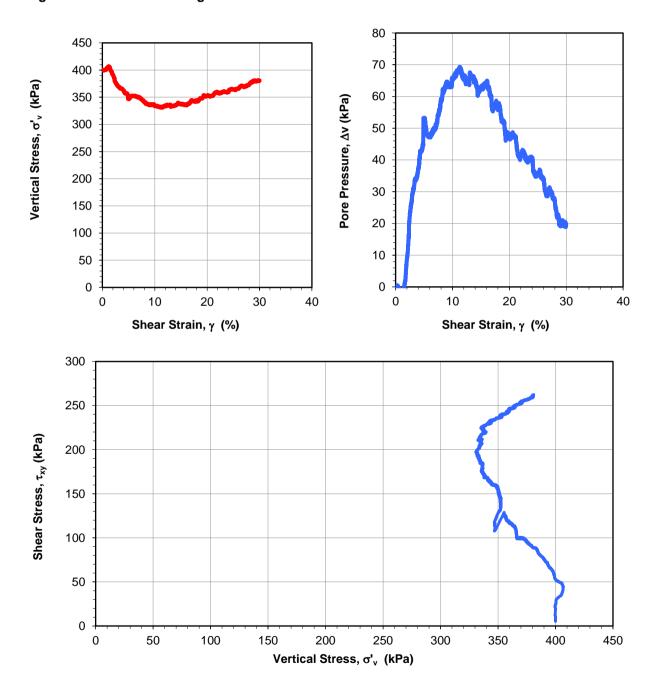
 IPO Number:
 2018-017

 Sample ID:
 2018-017-012

 Borehole ID:
 CE411A

 Depth:
 16.86 m to 16.90 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
N:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technica\04 Lab Testing\\PO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS07.xlsm

Figure C7-Page 2



Client:	Newcrest Mining		
Project:	Cadia NTSF Failure - Laboratory Testing		
Location:	Cadia Valley Operations		
Sample No.:	: PT5		
Test Details:			
Test ID:	Test ID: CVO-SS08		
Consolidation Stress (kPa): 800		800	
Shearing Rate (%/Hr)		5	

Tested By:	SF
Date:	08/09/2018

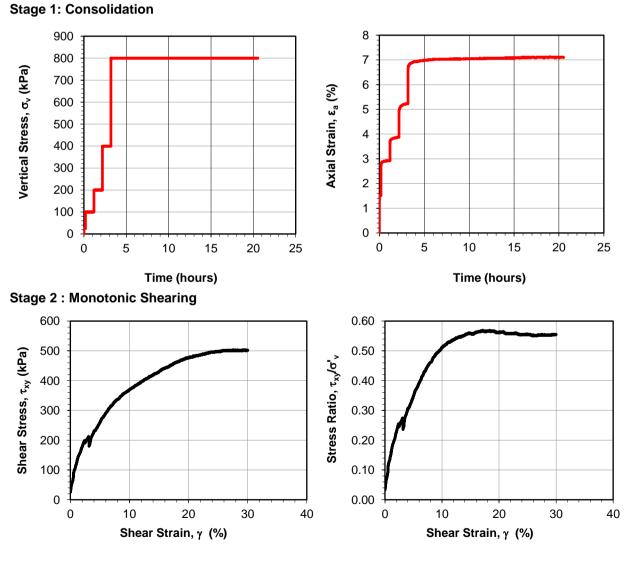
IPO Number: 2018-017 Sample ID: 2018-017-008 Borehole ID: CE411A

Depth:	16.78 m to 16.82 m	
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	23.60
Dry Density (t/m ³) :	1.46	1.57
Moisture Content (%) :	37.4 *	41.3

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730

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Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT5

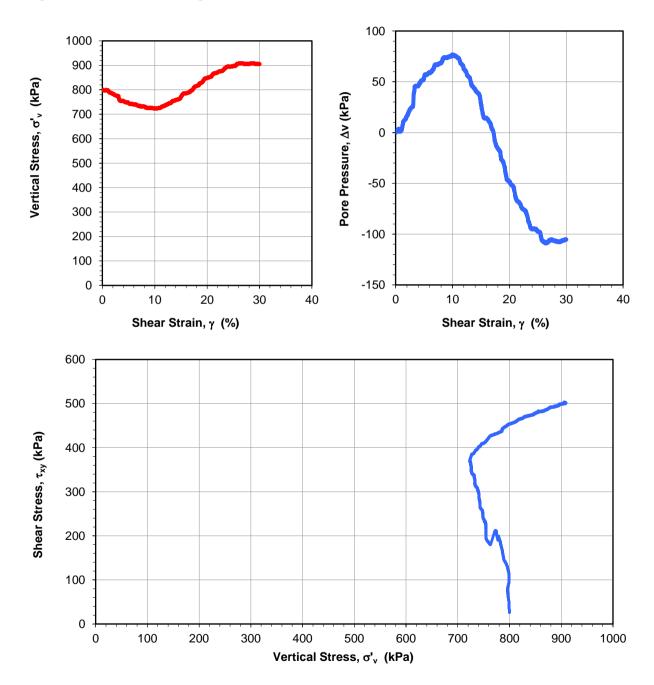
 IPO Number:
 2018-017

 Sample ID:
 2018-017-008

 Borehole ID:
 CE411A

 Depth:
 16.78 m to 16.82 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730

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Figure C8-Page 2



Client:	Newcrest Mining	
Project:	Cadia NTSF Failure - Laboratory Testing	
Location:	Cadia Valley Operations	
Sample No.:	PT5	
Test Details:		
Test ID:	Test ID: CVO-SS09R	
Consolidation Stress (kPa): 1200		1200
Shearing Rate (%/Hr)		5

Tested By:	SF
Date:	10/09/2018

IPO Number: 2018-017 Sample ID: 2018-017-014 Borehole ID: CE411A

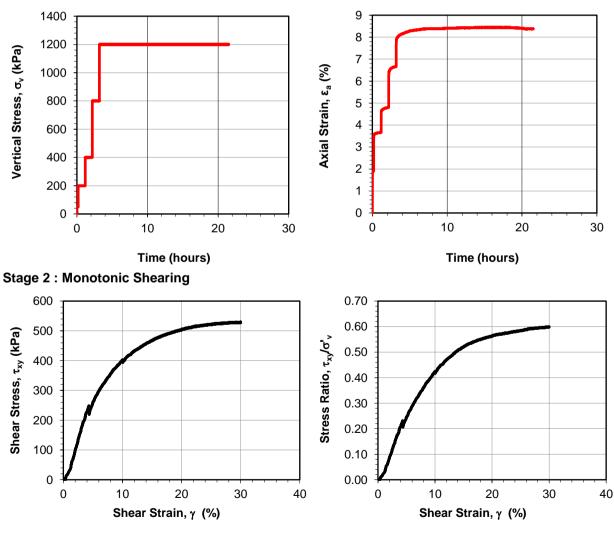
Depth:	16.74 m to	o 16.78 m
Sample Details:	Initial	Final
Sample Diameter (mm):	62.7	-
Sample Height (mm) :	25.40	23.27
Dry Density (t/m ³) :	1.49	1.63
Moisture Content (%) :	33.1 *	39.8

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample.

Checked By:	SRJ
Date:	27/9/2018

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552

Stage 1: Consolidation



Cadia NTSF Failure - Laboratory Testing **Monotonic Simple Shear**

Job No.LAB127730

Figure C9-Page 1 N:agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\11 Simple Shear\02 Processed data\QA Stage 2\CVO-SS09R.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT5

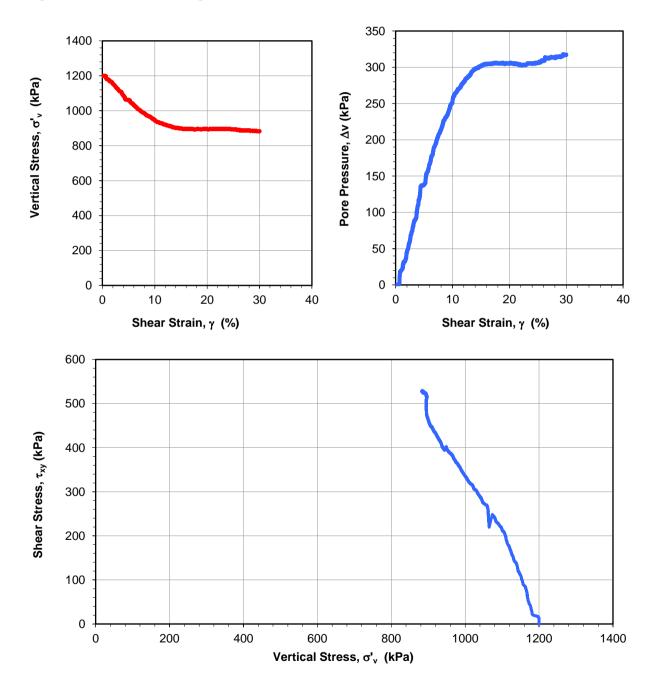
 IPO Number:
 2018-017

 Sample ID:
 2018-017-014

 Borehole ID:
 CE411A

 Depth:
 16.74 m to 16.78 m

SIMPLE SHEAR TEST Test Method: AGLab Test Procedure FAM-18552



Stage 2 : Monotonic Shearing

Cadia NTSF Failure - Laboratory Testing Monotonic Simple Shear

Job No.LAB127730
N:lagLAB/02.Projects/007.2018/LAB127730 - Cadia NTSF/03 Technical/04 Lab Testing/IPO 2018-017/11 Simple Shear/02 Processed data/QA Stage 2/CVO-SS09R.xlsm

Figure C9-Page 2

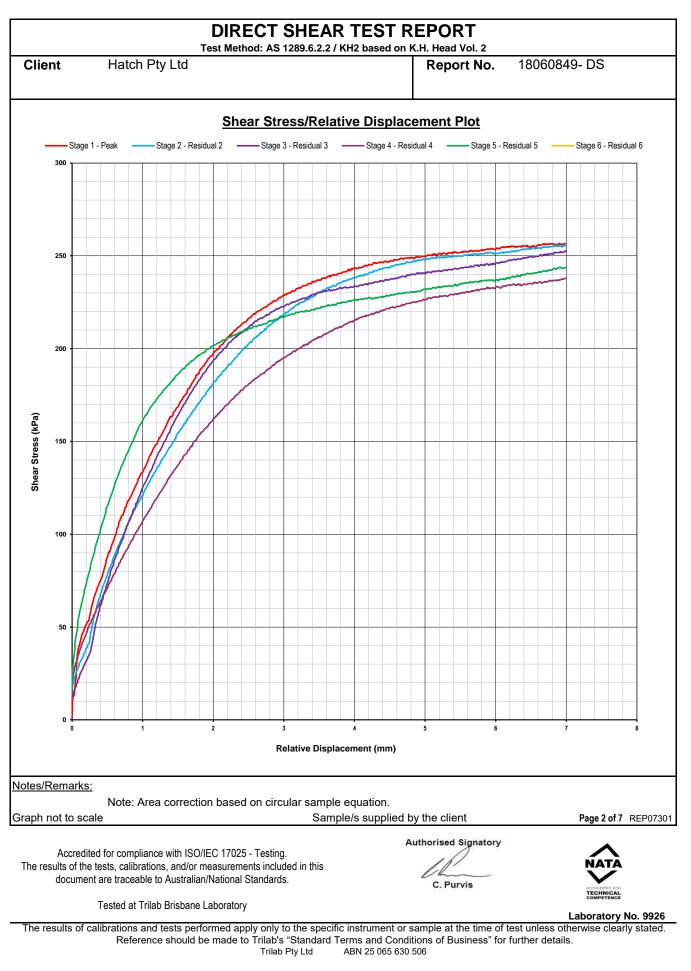
Annexure DD Direct Shear Tests - TriLabs



			AS 1289.6.2.2 / KH2 I				_
Client	Hatch P	ty Ltd			Repor	t No. 180)60849- DS
					Worko	order No 000)4435
Address	PO Box	425 SPRING HIL	L QLD 4004		Test D	Date 13/	07/2018
					Repor	t Date 23/	07/2018
Project	H35680	4 - Cadia					
Client ID	DH-410					epth (m) 19.65	
Description GRAVELLY CLAY - red/brown Sample Type Single individual soil specime Undisturbed.						ual soil specimen -	
SAMPLE DETAILS							
		Specimen Condition	Inun	dated			
	Specime	en Dimensions (mm)	69	9.5			
	Rat	e of Strain (mm/min)	0.0	010			
		Moisture Content (%)	22	2.3			
	Init	ial Wet Density(t/m ³)	1.	94			
			RESULTS OF T	ESTING	i		
		R	ESIDUAL RESULT	S	PEAK RESULTS		
Test Sta	ge	Residual Displacement (mm)	Normal Stress (kPa)	Correcte Stress	ed Shear s (kPa)	Normal Stress (kPa)	s Corrected Shear Stress (kPa)
Stage 1 - F	Peak	7.00	400.5	25	6.6	400.5	256.7
Stage 2 - Res	idual 2	7.00	400.5	25	5.6	400.5	255.8
Stage 3 - Res	idual 3	7.00	400.5	25	2.7	400.5	252.7
Stage 4 - Res	idual 4	7.00	400.5	23	7.9	400.5	237.9
Stage 5 - Res	idual 5	7.00	400.5	243	3.6	400.5	243.8
Stage 6 - Res	idual 6	-	-	-	-	-	-
<u>Notes/Remarks:</u>					_		
Graph not to scale		a correction based or		supplied b	y the clien	t	Page 1 of 7 REP07301
Accredite The results of the t document	d for compliar tests, calibrati are traceable	nce with ISO/IEC 17025 - ` ons, and/or measurement to Australian/National Sta ab Brisbane Laboratory	Testing. s included in this		c. Purvis		
The results of calib							Laboratory No. 9926 s otherwise clearly stated.
	Reference	e should be made to Tri T		and Conditi 25 065 630 5		ness" for further de	tails.

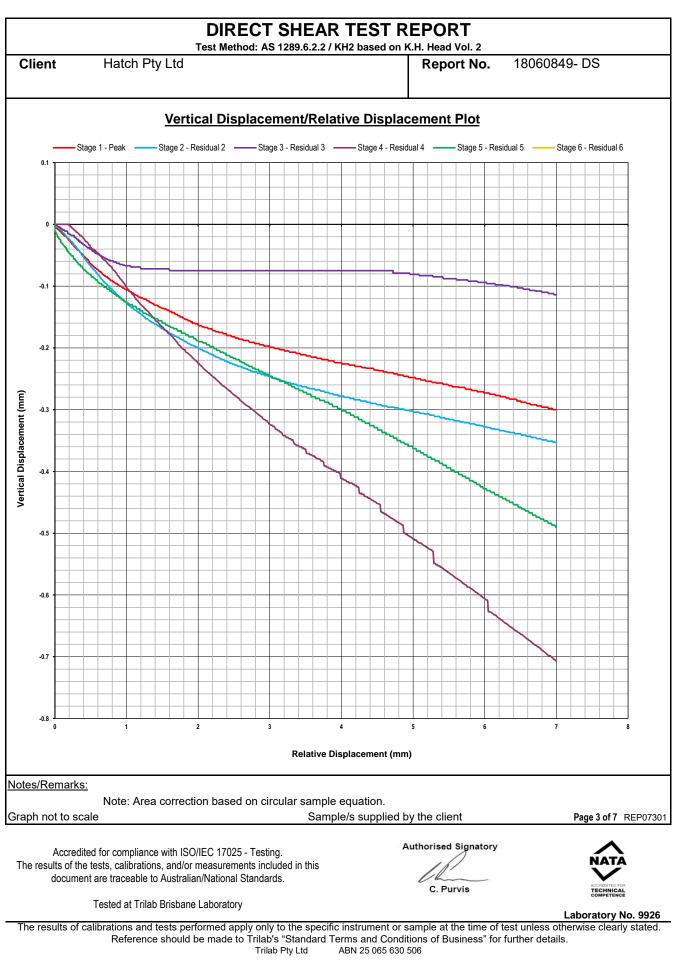


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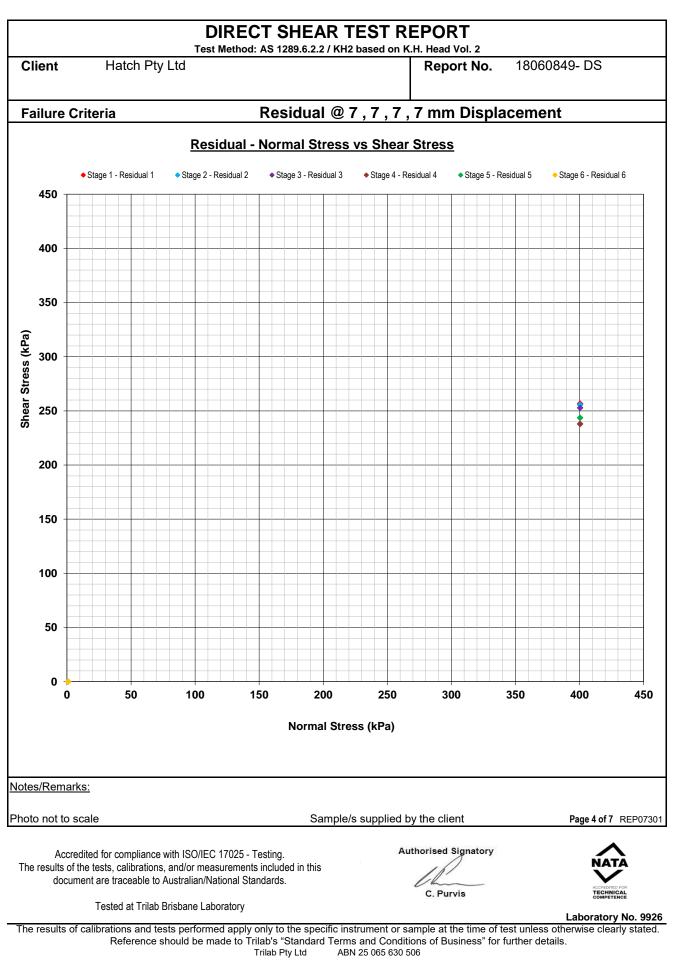


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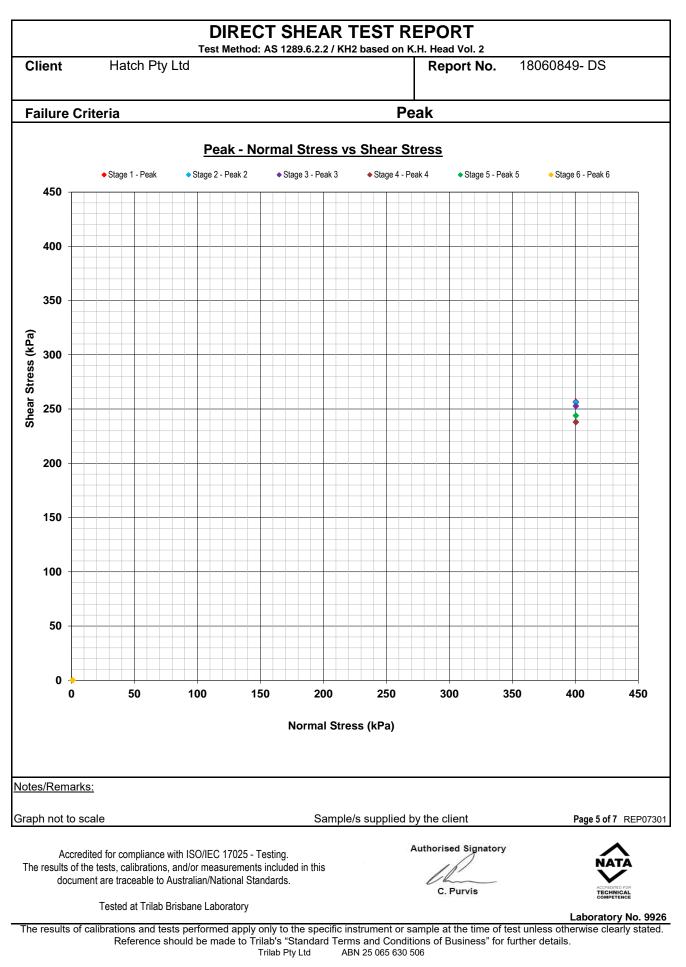
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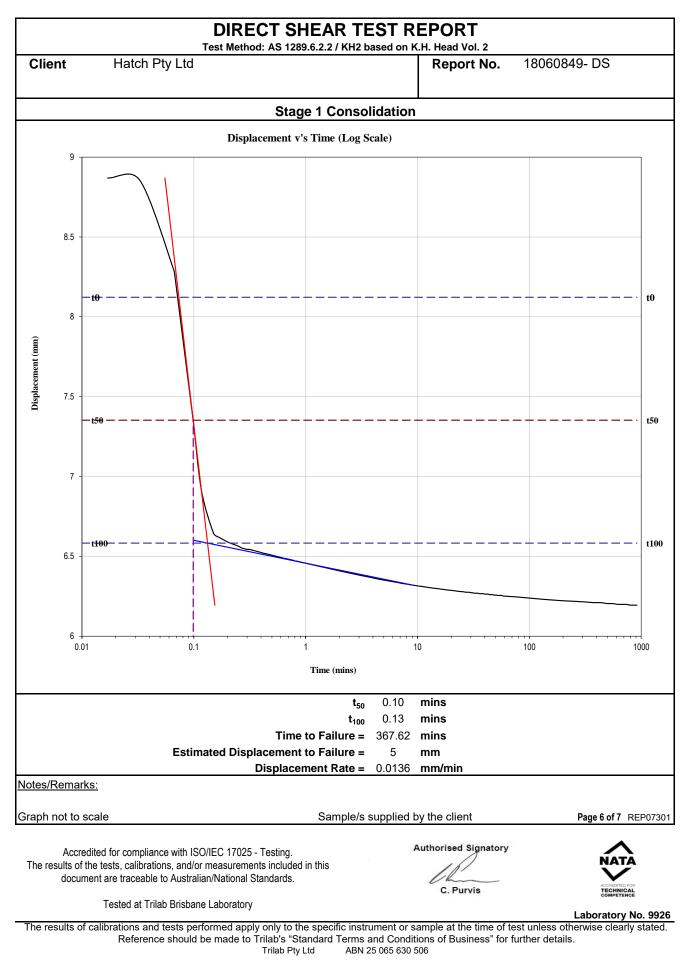
Geebung QLD 4034 Ph: +61 7 3265 5656





Brisban STRICTLY & NFIDENTIAL 346A Bilsen Road, Geebung

QLD 4034 Ph: +61 7 3265 5656





		DIRECT SHEAR t Method: AS 1289.6.2.2 / M			
Client	Hatch Pty Ltd	. meniou. Ao 1203.0.2.2 / F			0849- DS
		Before and A	After Photos		
		Before and /			
	CLIENT:	Hatch Pty Ltd			
	PROJECT:	H356804 - Cadia		BEFORE TE	ST
	LAB SAMPLE No.	18060849		DATE: 11/07/18	
	BOREHOLE:	DH-410	1	DEPTH: 19.65-1	9.95
	CLIENT:	Hatch Pty Ltd			
	PROJECT:	H356804 - Cadia		AFTER TES	
	LAB SAMPLE No.	18060849		DATE: 22/07/18	
	BOREHOLE:	DH-410		DEPTH: 19.65-19	.95
Notes/Remai	<u>ks:</u>				
Graph not to	scale	Samp	le/s supplied by	the client	Page 7 of 7 REP07301
The results of	edited for compliance with ISO/IE0 the tests, calibrations, and/or mea ment are traceable to Australian/N	asurements included in this ational Standards.	Auti	horised Signatory C. Purvis	
	Tested at Trilab Brisbane La				Laboratory No. 9926
The results o	f calibrations and tests perform Reference should be n	ade to Trilab's "Standard Te		ons of Business" for further de	



		-	AS 1289.6.2.2 / KH2 I	-	-			
Client	Hatch P	ty Ltd			Repor	t No. 1806	0849- DS	
					Worko	order No 0004	435	
Address	PO Box	425 SPRING HIL	L QLD 4004		Test D	Date 13/07	/2018	
					Report Date 23/07/2018			
Project	H35680	4 - Cadia						
Client ID	DH-410					epth (m) 19.65-1		
Description GRAVELLY CLAY - red/brown Sample Type Single individual soil specime Undisturbed. Undisturbed.						I soil specimen -		
SAMPLE DETAILS								
		Specimen Condition	Inun	dated				
	Specime	en Dimensions (mm)	69	9.5				
	Rat	e of Strain (mm/min)	0.0	010				
	Initial N	Moisture Content (%)	22	2.3				
	Init	ial Wet Density(t/m ³)	1.	88				
RESULTS OF TESTING								
		R	ESIDUAL RESULT	S	PEAK RESULTS			
Test Stag	ge	Residual Displacement (mm)	Normal Stress (kPa)	Correcte Stress		Normal Stress (kPa)	Corrected Shear Stress (kPa)	
Stage 1 - P	eak	7.00	800.1	38	0.5	800.1	380.5	
Stage 2 - Res	idual 2	7.00	800.1	36	9.1	800.1	369.1	
Stage 3 - Res	idual 3	7.00	800.1	39	3.3	800.1	393.3	
Stage 4 - Res	idual 4	7.00	800.1	37	8.1	800.1	378.1	
Stage 5 - Res	idual 5	7.00	800.1	39	9.0	800.1	399.0	
Stage 6 - Res	idual 6	-	-	-	-	-	-	
<u>Notes/Remarks:</u> Graph not to scale		a correction based or		uation. supplied b	y the clien	t	Page 1 of 7 REP07301	
Accredite The results of the t document	d for compliar ests, calibrati are traceable	nce with ISO/IEC 17025 - ` ons, and/or measurement to Australian/National Sta lab Brisbane Laboratory	Testing. s included in this		C. Purvis			
The results of calib		tests performed apply o						
	Reference	e should be made to Tri T		and Conditi 25 065 630 5		ness" for further detail	S.	

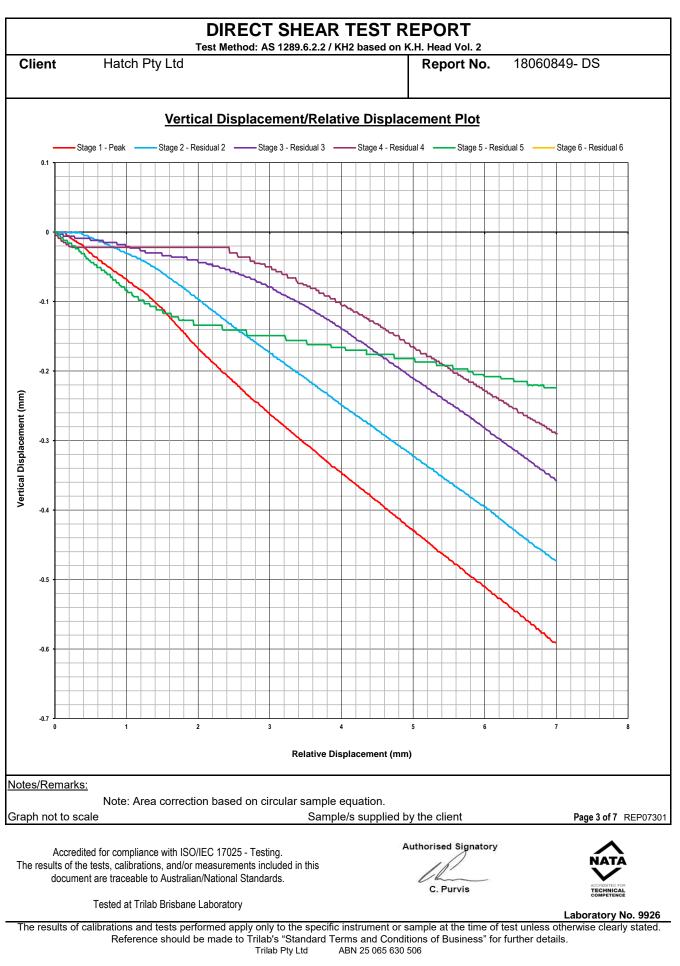


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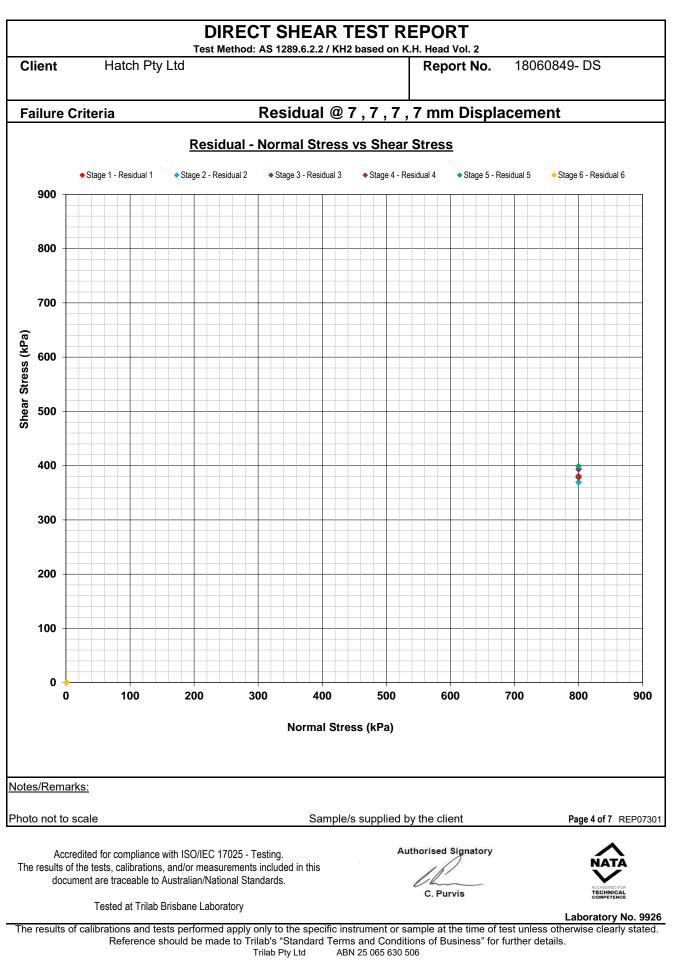


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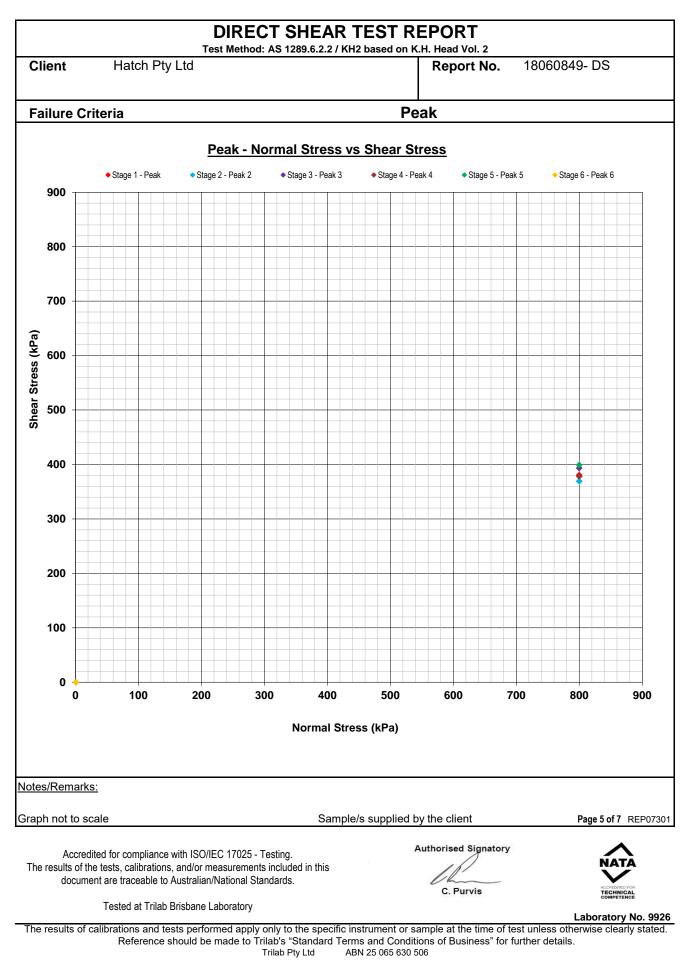
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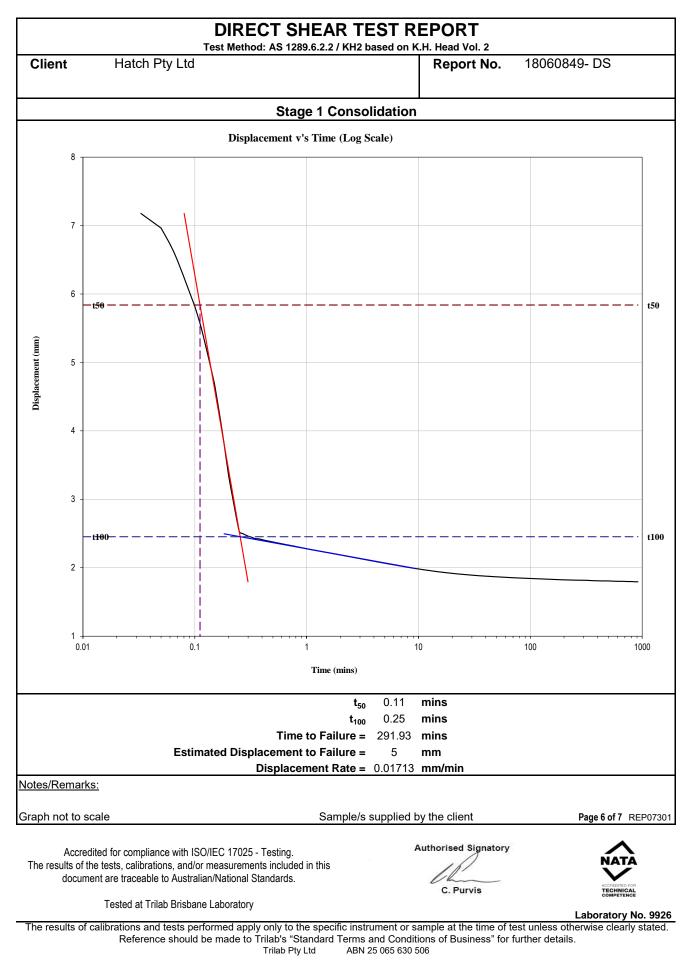
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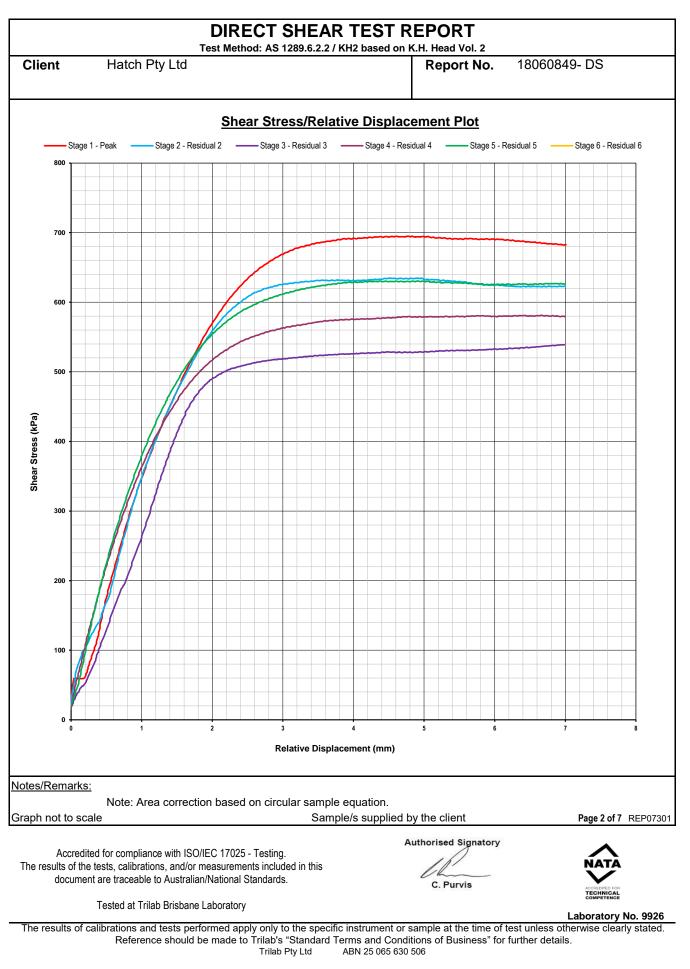
		IRECT SHEA Method: AS 1289.6.2.2	-	-		
Client	Hatch Pty Ltd			Report No.	18060849- D	6
		Before and	d After Photos			
	CLIENT:	Hatch Pty Ltd				
	PROJECT:	H356804 - Cadi	ia	BEFO	RE TEST	
	LAB SAMPLE No.			DATE: 11/	07/18	
	BOREHOLE:	DH-410		DEPTH: 1	9.65-19.95	
				10		
	CLIENT:	Hatch Pty Ltd				
	PROJECT:	H356804 - Cadia	a	AFTE	R TEST	
	LAB SAMPLE No.	18060849		DATE: 22/	07/18	
	BOREHOLE:	DH-410	all the same	DEPTH: 19	.65-19.95	
Notes/Rema						
Graph not to	scale	Sar	mple/s supplied by	the client	Page 7	of 7 REP07301
The results of	edited for compliance with ISO/IEC the tests, calibrations, and/or mea ment are traceable to Australian/N	surements included in this ational Standards.	Auth	C. Purvis	Ĩ	CONCEPTED FOR ECHNICAL DIMPETENCE
	Tested at Trilab Brisbane Lab	-				atory No. 9926
The results o	f calibrations and tests perform Reference should be m	ed apply only to the speci ade to Trilab's "Standard Trilab Pty Ltd		ns of Business" for f		clearly stated.



			AS 1289.6.2.2 / KH2 I				
Client	Hatch P	ty Ltd			Repor	t No. 18060)849- DS
					Worko	order No 00044	135
Address	PO Box	425 SPRING HIL	L QLD 4004		Test D	Date 13/07	/2018
					Repor	t Date 23/07	/2018
Project	H35680	4 - Cadia					
Client ID	DH-410					epth (m) 19.65-1	
Description	GRAVE	LLY CLAY - red/b	rown	Samp	ole Type	Single individual Undisturbed.	soil specimen -
			SAMPLE DE	TAILS			
		Specimen Condition	Inun	dated			
	Specime	en Dimensions (mm)	69	9.5			
	Rat	e of Strain (mm/min)	0.0	010			
	Initial N	Noisture Content (%)	22	2.3			
	Init	ial Wet Density(t/m ³)	1.	86			
			RESULTS OF T	ESTING	i		
		R	ESIDUAL RESULT	S	PEAK RESULTS		
Test Sta	ge	Residual Displacement (mm)	Normal Stress (kPa)		ed Shear s (kPa)	Normal Stress (kPa)	Corrected Shear Stress (kPa)
Stage 1 - F	Peak	7.00	1200.1	68	2.7	1200.1	694.9
Stage 2 - Res	idual 2	7.00	1200.1	62	3.0	1200.1	634.7
Stage 3 - Res	idual 3	7.00	1200.1	53	9.0	1200.1	539.0
Stage 4 - Res	idual 4	7.00	1200.1	57	9.9	1200.1	581.3
Stage 5 - Res	idual 5	7.00	1200.1	62	6.6	1200.1	630.5
Stage 6 - Res	idual 6	-	-		-	-	-
Notes/Remarks:							
notes/Remarks.	Note: Are	a correction based or	ı circular sample equ	uation.			
Graph not to scale	e		Sample/s	supplied b	y the clien	t	Page 1 of 7 REP07301
The results of the	tests, calibrati are traceable	nce with ISO/IEC 17025 - ons, and/or measurement to Australian/National Sta ab Brisbane Laboratory	s included in this	Auti	C. Purvis	natory	COMPETENCE Laboratory No. 9926
The results of calil		tests performed apply o e should be made to Tri T	lab's "Standard Terms		ons of Busi		

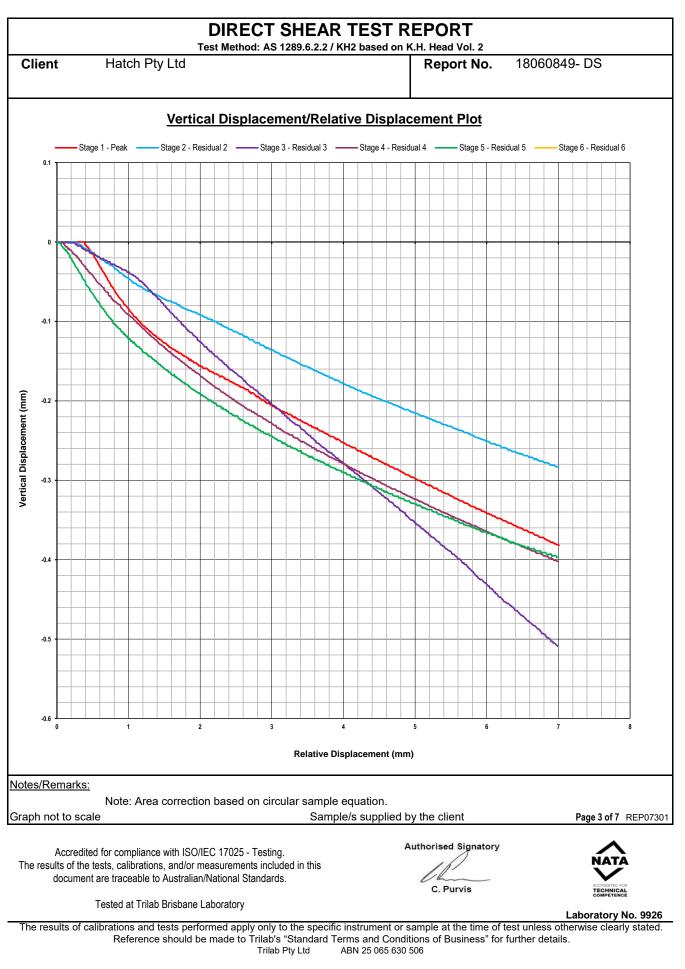


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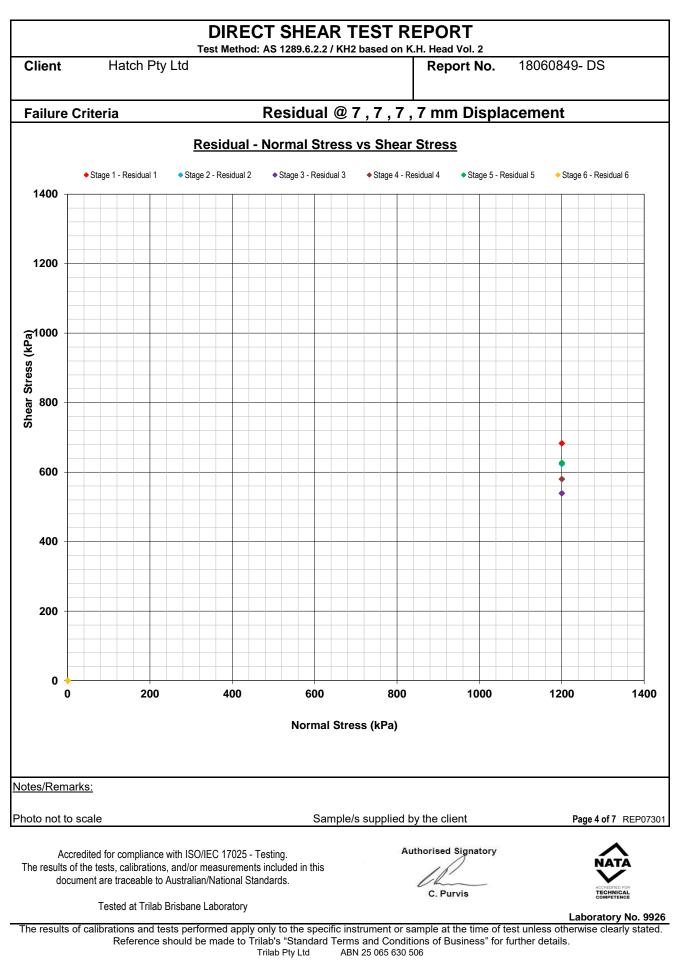


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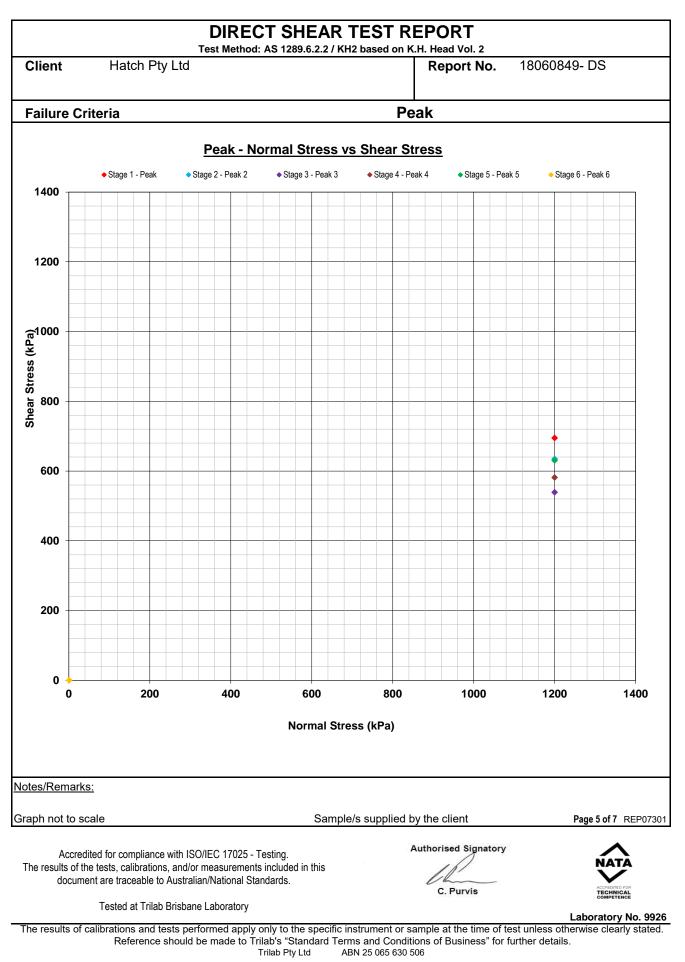
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Geebung QLD 4034 Ph: +61 7 3265 5656

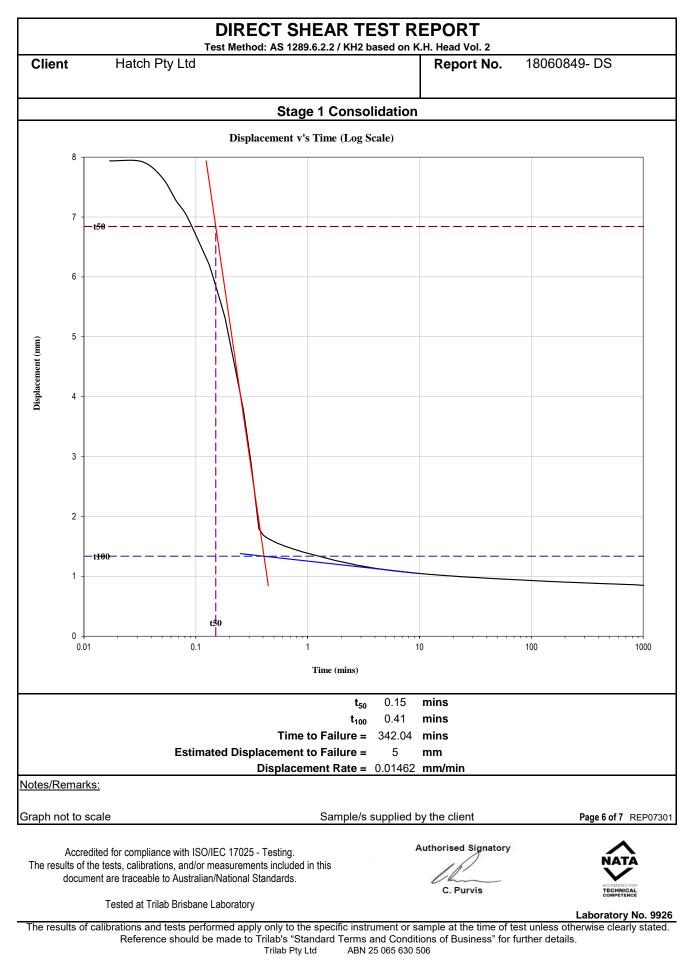




Brisban STRICTLY Con NFIDENTIAL 346A Bilsen Road, 2 Kimmer Place, Geebung Queens Park

QLD 4034 Ph: +61 7 3265 5656

Queens Park WA 6107 Ph: +61 8 9258 8323





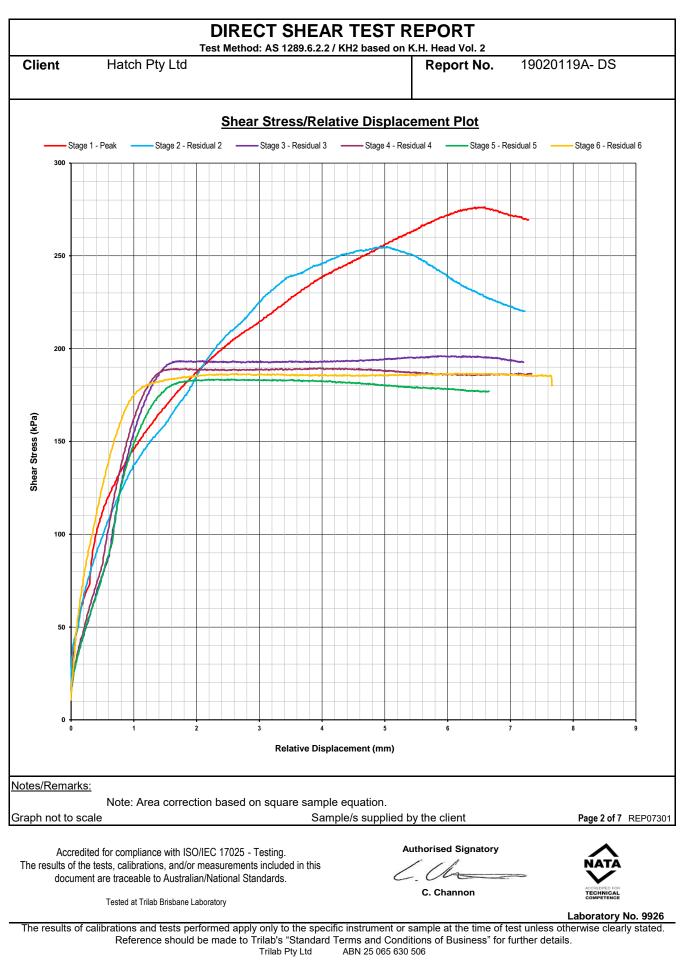
		DIRECT SHEAR t Method: AS 1289.6.2.2 / M			
Client	Hatch Pty Ltd	. meniou. Ao 1203.0.2.2 / F			0849- DS
		Before and A	After Photos		
		Before and /			
	CLIENT:	Hatch Pty Ltd			
	PROJECT:	H356804 - Cadia		BEFORE TE	ST
	LAB SAMPLE No.	18060849		DATE: 11/07/18	
	BOREHOLE:	DH-410	1	DEPTH: 19.65-1	9.95
	CLIENT:	Hatch Pty Ltd			
	PROJECT:	H356804 - Cadia		AFTER TES	
	LAB SAMPLE No.	18060849		DATE: 22/07/18	
	BOREHOLE:	DH-410		DEPTH: 19.65-19	.95
Notes/Remai	<u>ks:</u>				
Graph not to	scale	Samp	le/s supplied by	the client	Page 7 of 7 REP07301
The results of	edited for compliance with ISO/IE0 the tests, calibrations, and/or mea ment are traceable to Australian/N	asurements included in this ational Standards.	Auti	horised Signatory C. Purvis	
	Tested at Trilab Brisbane La				Laboratory No. 9926
The results o	f calibrations and tests perform Reference should be n	ade to Trilab's "Standard Te		ons of Business" for further de	



1		_				_		
			AS 1289.6.2.2 / KH2 I					
Client	Hatch P	ty Ltd			Repor	rt No.	19020	0119A- DS
					Worko	order No	00055	07
Address	PO Box	425 SPRING HIL	L QLD 4004		Test D	Date	8/02/2	019
					Repor	t Date	28/02/	2019
Project	H35680	4 - Cadia NTSF F	ailure					
Client ID	CE416 -					epth (m) 2		
Description	SILTYC	CLAY - brown		Samp	ole Type	Single inc Remoulde		soil specimen -
SAMPLE DETAILS								
		Specimen Condition	Inun	dated				
	Specime	en Dimensions (mm)	60	*60				
	Rat	e of Strain (mm/min)	0.0	800				
	Initial N	Noisture Content (%)	34	1.2				
	Init	ial Wet Density(t/m ³)	1.	87				
	RESULTS OF TESTING							
	RESIDUAL RESULTS			PEAK RESULTS				
Test Stag	ge	Residual Displacement (mm)	Normal Stress (kPa)		ed Shear s (kPa)	Normal S (kPa		Corrected Shear Stress (kPa)
Stage 1 - P	eak	6.00	500.2	27	2.5	500.	2	276.3
Stage 2 - Res	idual 2	6.00	500.2	24	0.3	500.	2	254.9
Stage 3 - Res	idual 3	6.00	500.2	19	5.9	500.	2	196.1
Stage 4 - Res	idual 4	6.00	500.2	18	6.3	500.	2	189.5
Stage 5 - Res	idual 5	6.00	500.2	17	8.5	500.	2	183.6
Stage 6 - Res	idual 6	6.00	500.2	18	6.6	500.	2	186.8
Notes/Remarks:								
		a correction based or						
Graph not to scale)		Sample/s	supplied b	y the clien	t		Page 1 of 7 REP07301
The results of the t	ests, calibrati	nce with ISO/IEC 17025 - ons, and/or measurement	s included in this	Au	thorised Sig	gnatory		NATA
document		e to Australian/National Sta b Brisbane Laboratory	andards.		C. Channe	on		
The results of calib	prations and	tests performed apply of	only to the specific inst	rument or sa	ample at the	e time of test	unless oth	Laboratory No. 9926 nerwise clearly stated.
		e should be made to Tri	lab's "Standard Terms		ons of Busi			

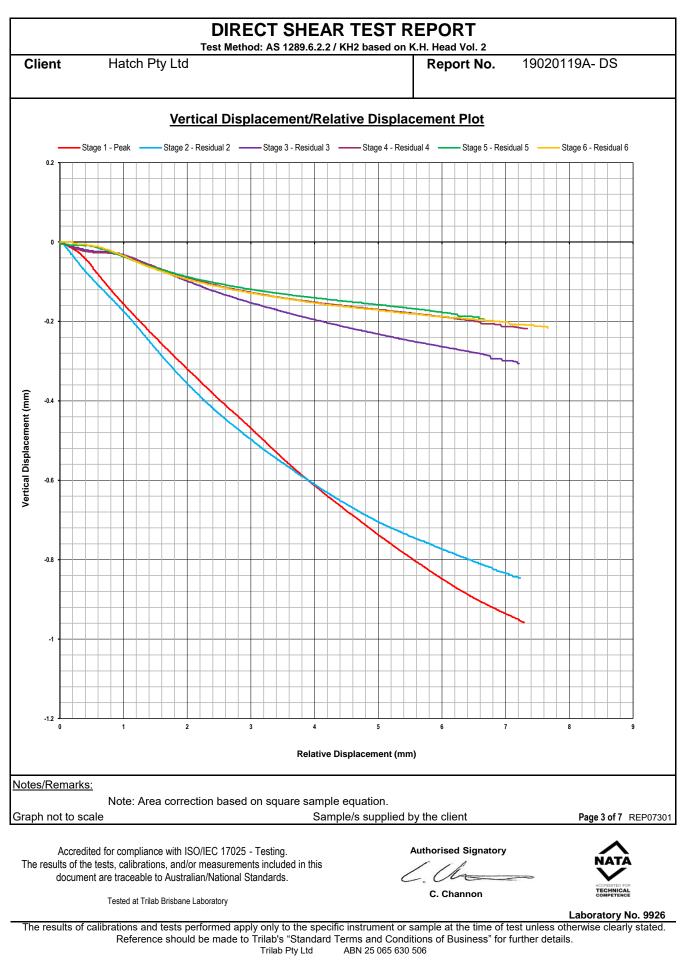


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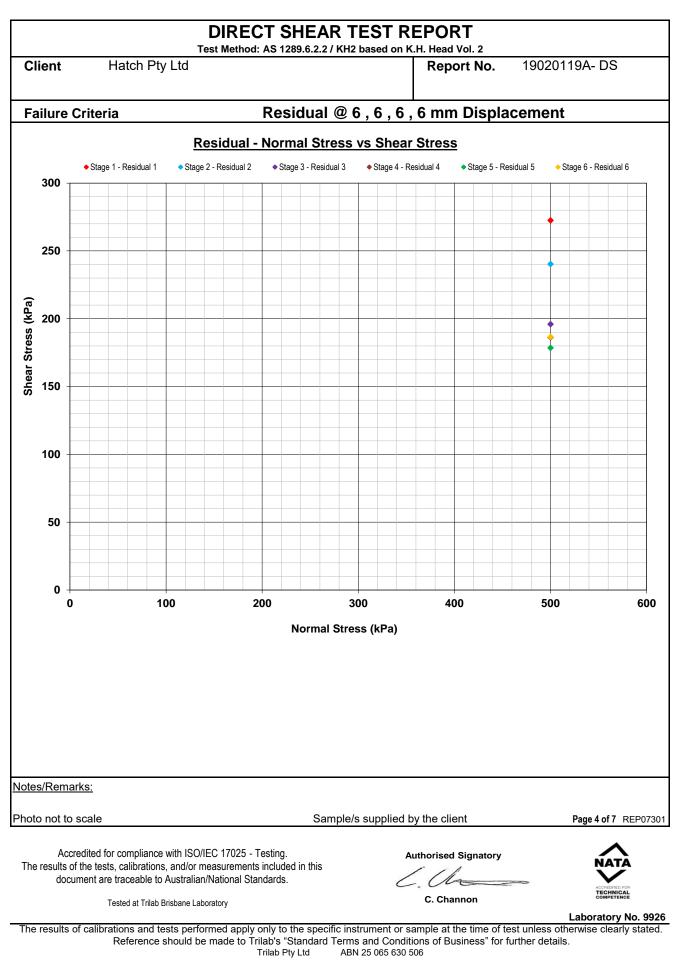


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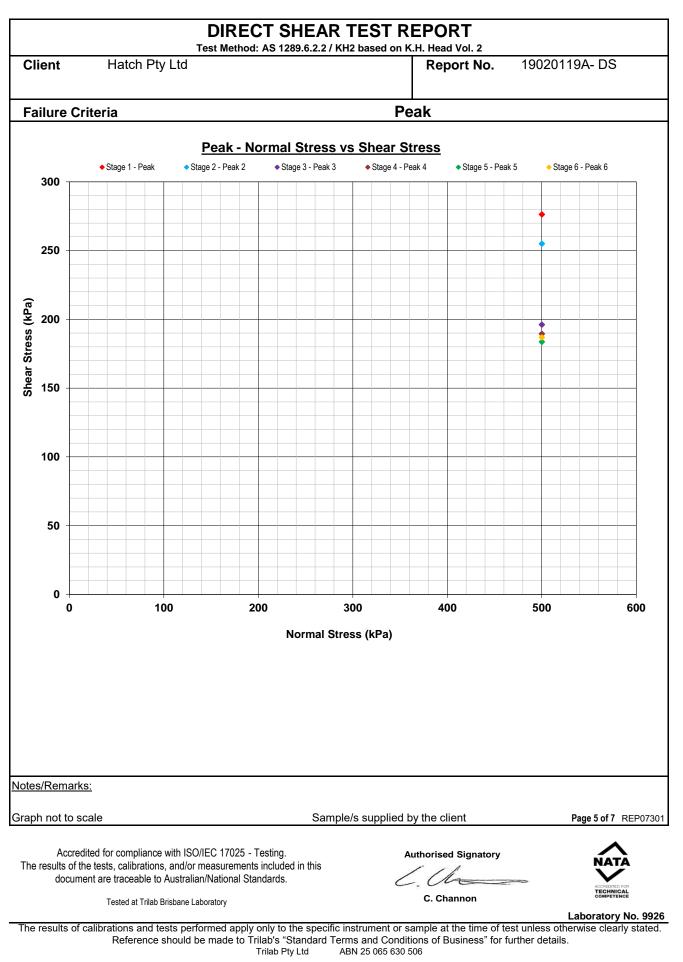


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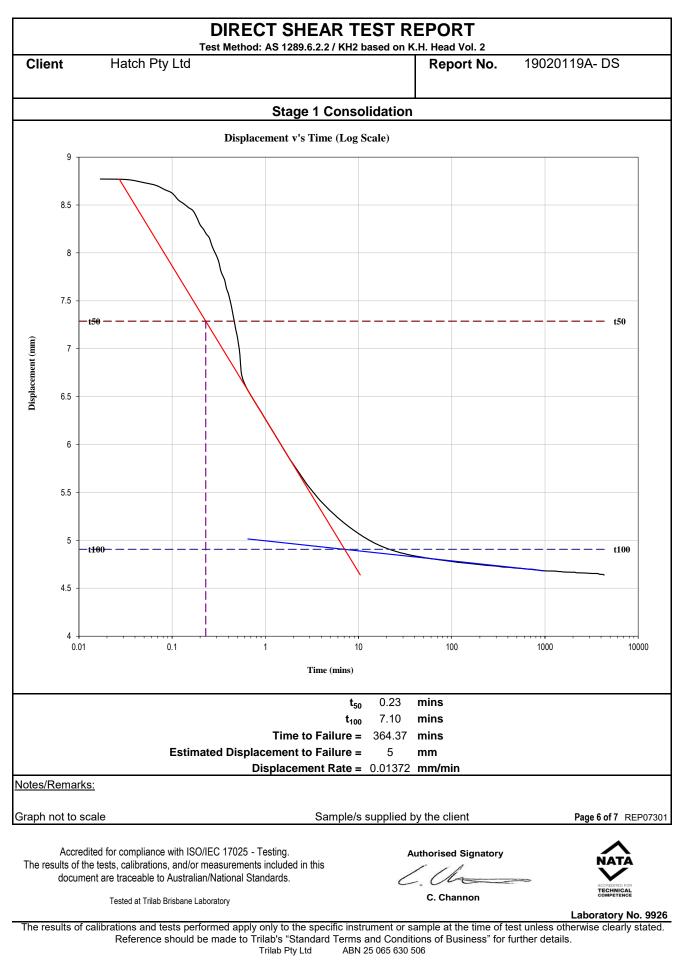
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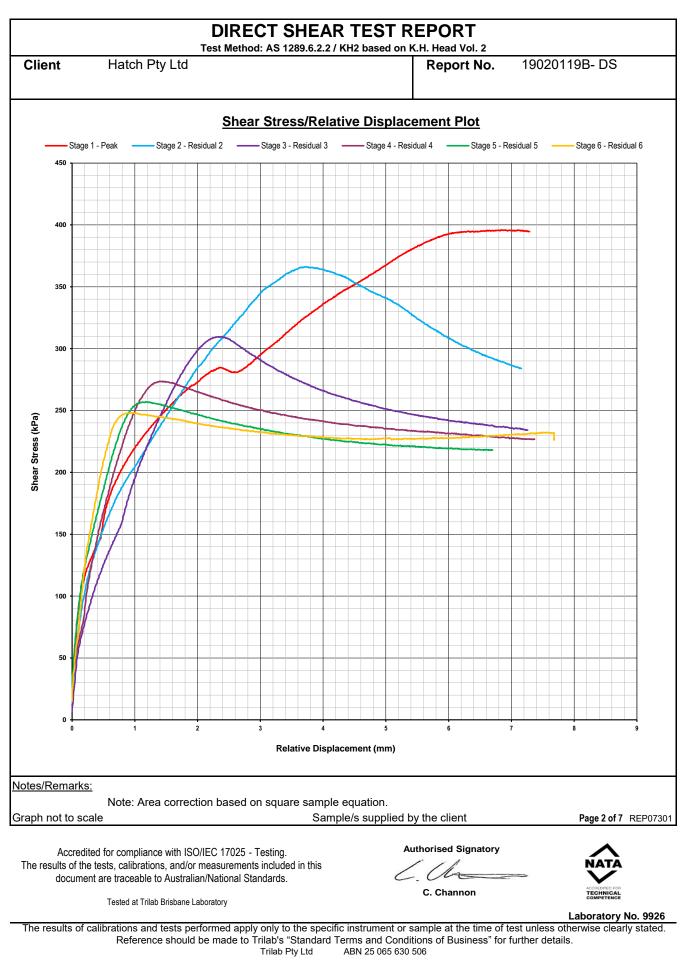
		DIRECT SHEAR					
Client	Hatch Pty Ltd		Report No.	19020119A- DS			
		Before and Af	ter Photos				
	CLIENT:	Hatch Pty Ltd					
	PROJECT:	H356804 - Cadia N Failure	AFIE	RTEST			
	LAB SAMPLE No.	19020119	DATE: 28/0				
	BOREHOLE:	CE416 - L2B	DEPTH: 24	DEPTH: 24.50-25.00			
Notes/Remar							
Graph not to		Sample	/s supplied by the client	Page 7 of 7 REP0730			
Accre The results of	edited for compliance with ISO/IEC the tests, calibrations, and/or mea ment are traceable to Australian/N	2 17025 - Testing. Isurements included in this	Authorised Signatory				
	Tested at Trilab Brisbane Labora		C. Channon	ACCONSTRUCTOR TECHNICAL COMPETENCE Laboratory No. 9920			
The results of			strument or sample at the time of te ns and Conditions of Business" for f	est unless otherwise clearly stated			



		-	T SHEAR T	-	-			
Client	Hatch P	ty Ltd			Repor	t No.	19020)119B- DS
					Workd	order No	00055	07
Address	PO Box	425 SPRING HIL	L QLD 4004		Test D	Date	8/02/2	019
					Repor	t Date	28/02/	2019
Project	H35680	4 - Cadia NTSF F	ailure					
Client ID	CE416 -					epth (m) 2		
Description	SILTYC	CLAY - yellow/brov	vn	Samp	le Type	Remould		soil specimen -
SAMPLE DETAILS								
		Specimen Condition	Inun	dated				
	Specime	en Dimensions (mm)	60	*60				
	Rate	e of Strain (mm/min)	0.0	800				
	Initial Moisture Content (%) 34.2			1.2				
	Initi	ial Wet Density(t/m ³)	1.	87				
			RESULTS OF T	ESTING				
	RESIDUAL RESULTS			S	PEAK RESULTS			
Test Stag	ge	Residual Displacement (mm)	Normal Stress (kPa)	Correcte Stress		Normal \$ (kPa		Corrected Shear Stress (kPa)
Stage 1 - P	eak	6.00	800.1	39	3.1	800.	.1	396.0
Stage 2 - Res	idual 2	6.00	800.1	31	0.0	800.	.1	366.3
Stage 3 - Res	idual 3	6.00	800.1	242	2.5	800.	1	309.8
Stage 4 - Res	idual 4	6.00	800.1	23	1.7	800.	1	273.6
Stage 5 - Res	idual 5	6.00	800.1	21	9.6	800.	.1	257.0
Stage 6 - Res	idual 6	6.00	800.1	22	7.9	800.	.1	248.1
<u>Notes/Remarks:</u>	NI / -							
Graph not to scale		a correction based or		ation. supplied b	y the clien	t		Page 1 of 7 REP07301
The results of the t	ests, calibrati are traceable	nce with ISO/IEC 17025 - ons, and/or measurement to Australian/National Sta o Brisbane Laboratory	s included in this		thorised Sig C. Channe			ACREDITE FOR TECHNICAL
The second second			and the second					Laboratory No. 9926
The results of calib		tests performed apply o e should be made to Tri T	lab's "Standard Terms		ons of Busi			

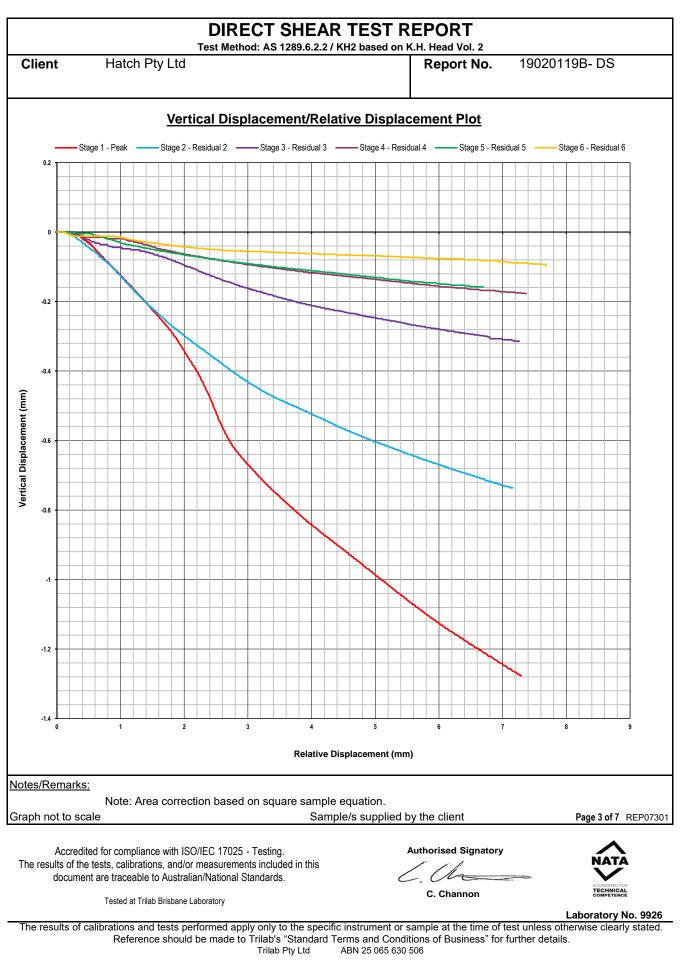


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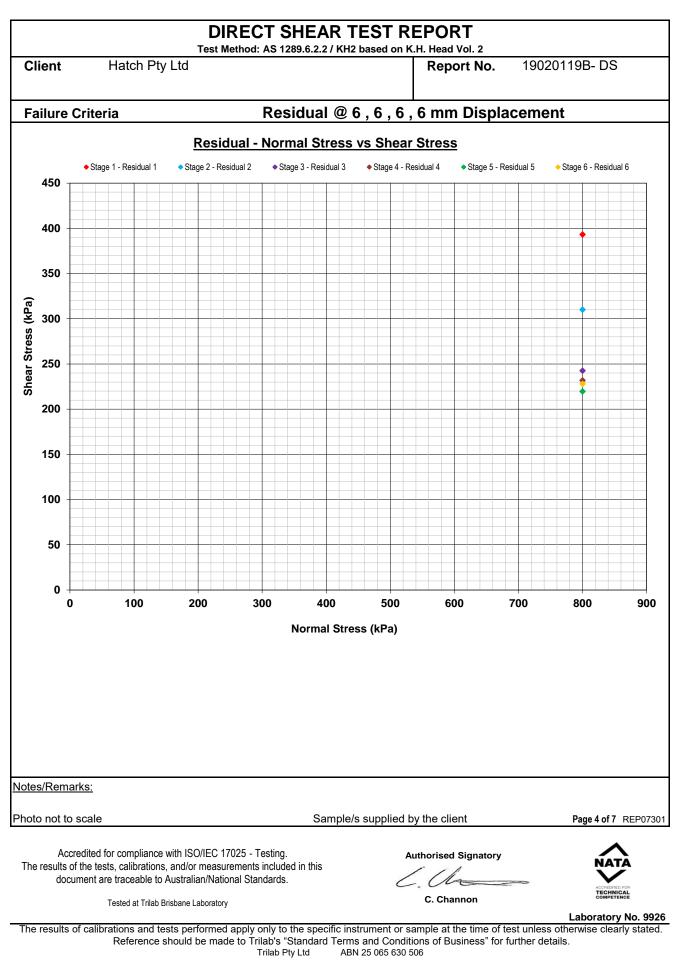


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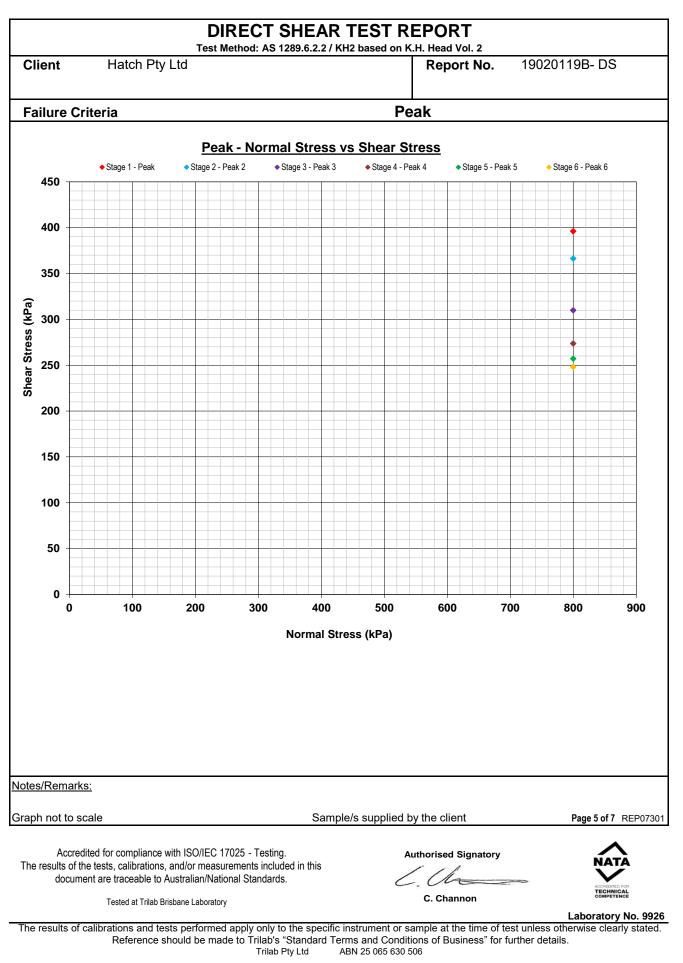


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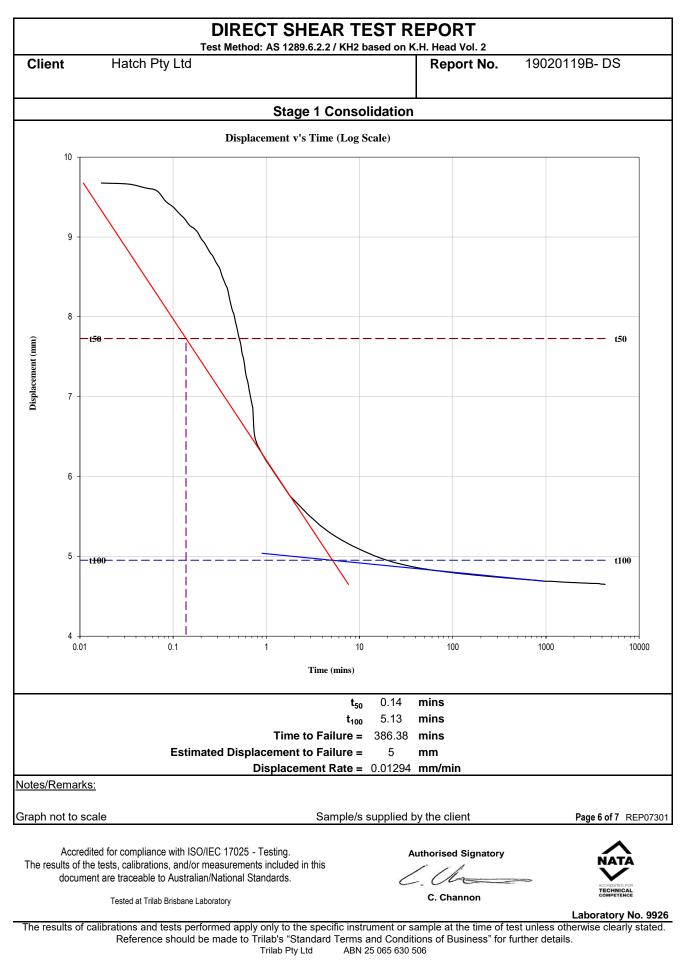
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	DIRECT SHEAR TES	-	
Hatch Pty Ltd		Report No.	19020119B- DS
	Before and After P	hotos	
CLIENT:	Hatch Pty Ltd		
PROJECT:	H356804 - Cadia NTSF	AFTE	R TEST
LAB SAMPLE No.	19020119	DATE: 28/0	2/19
BOREHOLE:	CE416 - L2B		
ks: scale edited for compliance with ISO/IEC the tests, calibrations, and/or mea nent are traceable to Australian/N: Tested at Trilab Brisbane Labora	; 17025 - Testing. surements included in this ational Standards.	plied by the client Authorised Signatory C. Channon	Page 7 of 7 REPOT
	Hatch Pty Ltd CLIENT: PROJECT: LAB SAMPLE No.	Hatch Pty Ltd Before and After P CLIENT: Hatch Pty Ltd PROJECT: H356804 - Cadia NTSF Failure LAB SAMPLE No. 19020119	Before and After Photos CLIENT: Hatch Pty Ltd PROJECT: H356804 - Cadia NTSF AFTER Failure DATE: 28/0



			T SHEAR T					
Client	Hatch P				Repor		19020	0119C- DS
					Worko	order No	00055	07
Address	PO Box	425 SPRING HIL	L QLD 4004		Test D	Date	8/02/2	019
					Repor	t Date	28/02/	2019
Project	H35680	4 - Cadia NTSF F	ailure					
Client ID	CE416 -					epth (m) 2		
Description	SILTYC	CLAY - yellow/brov	vn	Samp	le Type	Remould		soil specimen -
SAMPLE DETAILS								
		Specimen Condition	Inun	dated				
	Specime	en Dimensions (mm)	60	*60				
	Rat	e of Strain (mm/min)	0.0	800				
	Initial N	loisture Content (%)	34	1.2				
	Init	ial Wet Density(t/m ³)	1.	87				
RESULTS OF TESTING								
	RESIDUAL RESULTS			PEAK RESULTS				
Test Sta	ge	Residual Displacement (mm)	Normal Stress (kPa)	Correcte Stress		Normal S (kPa		Corrected Shear Stress (kPa)
Stage 1 - P	eak	6.00	1200.0	301	1.6	1200	0.0	397.9
Stage 2 - Res	idual 2	6.00	1200.0	354	4.6	1200	0.0	471.5
Stage 3 - Res	idual 3	6.00	1200.0	348	3.7	1200	0.0	363.2
Stage 4 - Res	idual 4	6.00	1200.0	368	3.2	1200	0.0	368.6
Stage 5 - Res	idual 5	6.00	1200.0	361	1.8	1200	0.0	367.2
Stage 6 - Res	idual 6	-	-	-		-		-
<u>Notes/Remarks:</u>	N / -							
Graph not to scale		a correction based or		ation. supplied b	y the clien	t		Page 1 of 7 REP07301
The results of the f	tests, calibrati are traceable	nce with ISO/IEC 17025 - ons, and/or measurement to Australian/National Sta	s included in this	Aut	horised Sig Che C. Channe			
		b Brisbane Laboratory						Laboratory No. 9926
The results of calib		tests performed apply on the should be made to Tri						nerwise clearly stated.
				25 065 630 50				

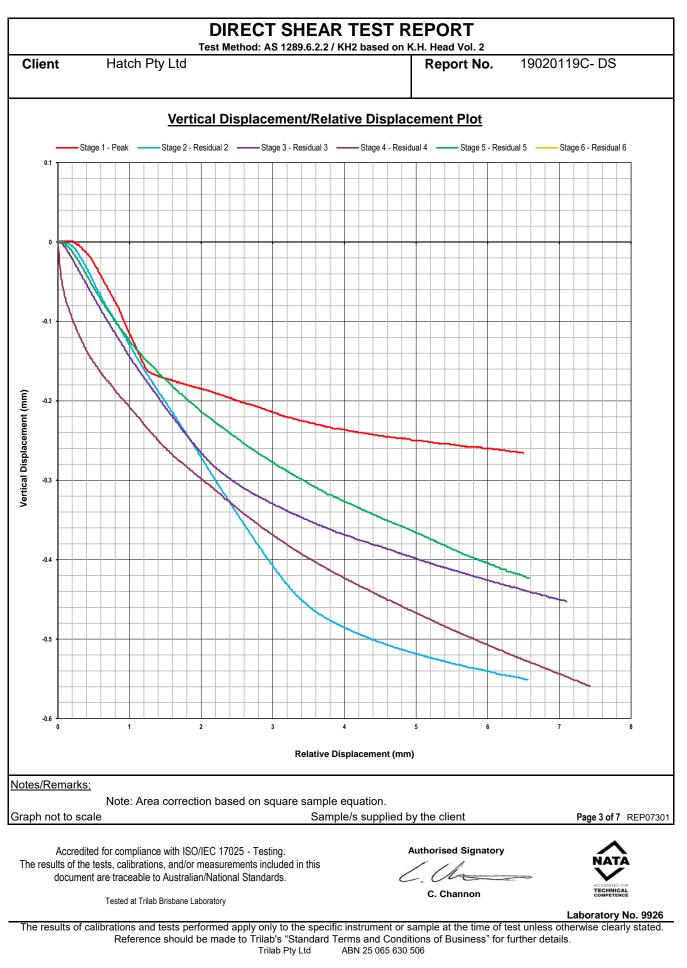


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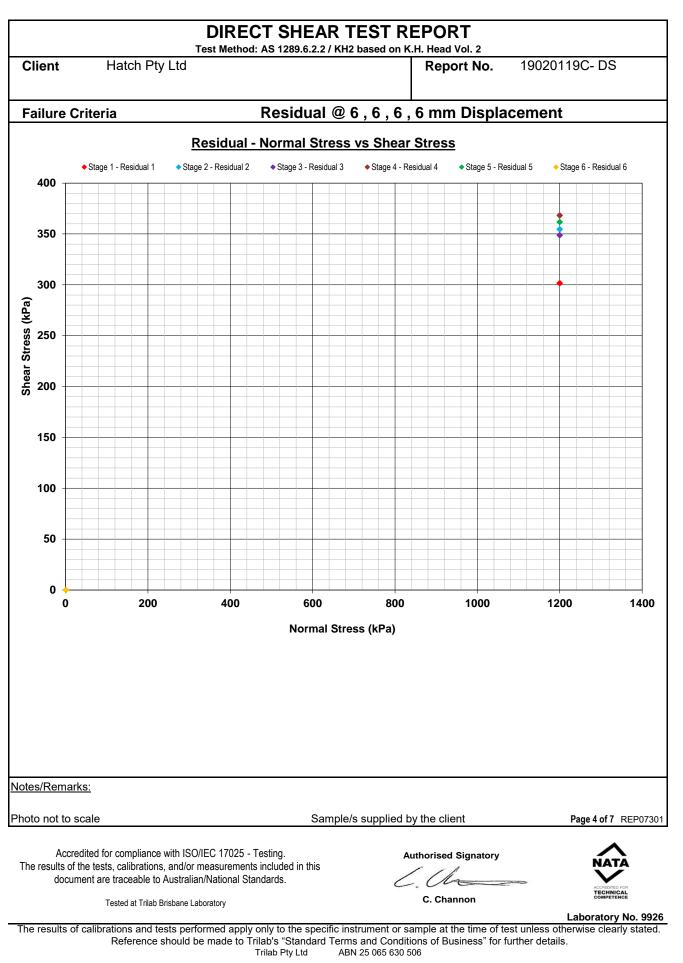


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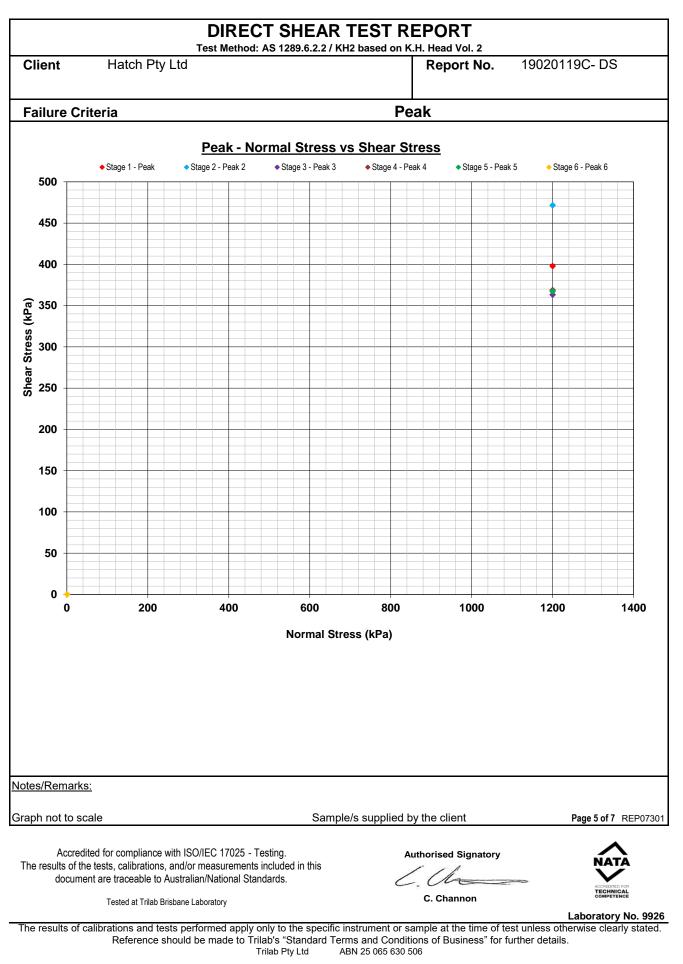


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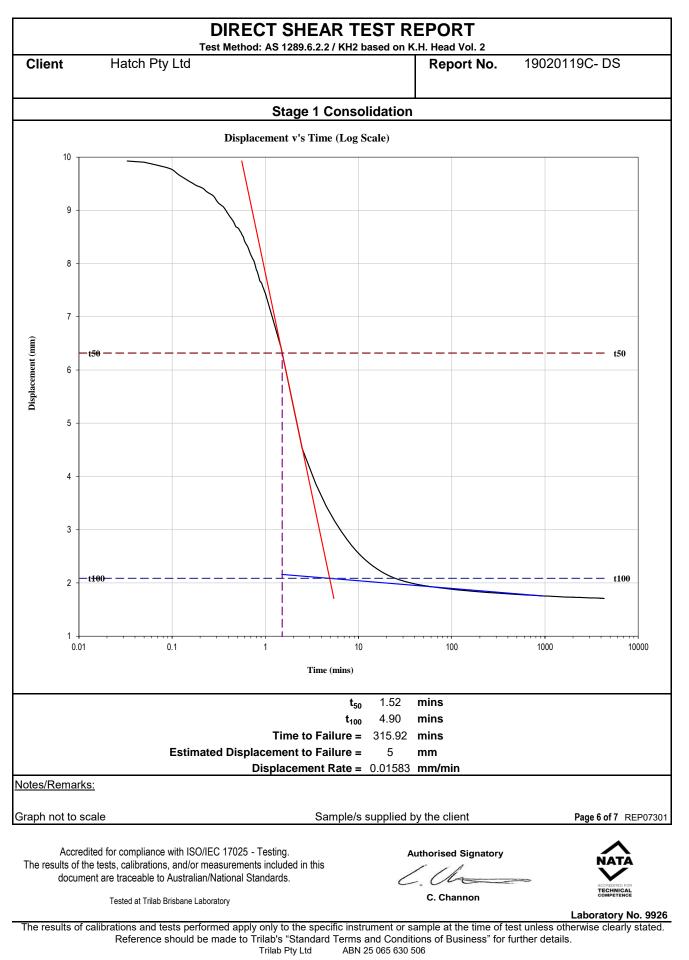




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Queens Park WA 6107 Ph: +61 8 9258 8323





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Geebung2 Kimmer Place,
Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

		DIRECT SHEAR TE t Method: AS 1289.6.2.2 / KH2 bas		
lient	Hatch Pty Ltd		Report No.	19020119C- DS
		Before and After	Photos	
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTS Failure	F AFTEI	R TEST
	LAB SAMPLE No.	19020119	DATE: 28/0	2/19
	BOREHOLE:	CE416 - L2B	DEPTH: 24	.50-25.00
		· · · · · · · · · · · · · · · · · · ·		
tes/Remar	<u>ks:</u>			
		Sample/s su	upplied by the client	Page 7 of 7 RE
he results of		2 17025 - Testing. Isurements included in this ational Standards.	upplied by the client Authorised Signatory C. Channon	Page 7 of 7 RE

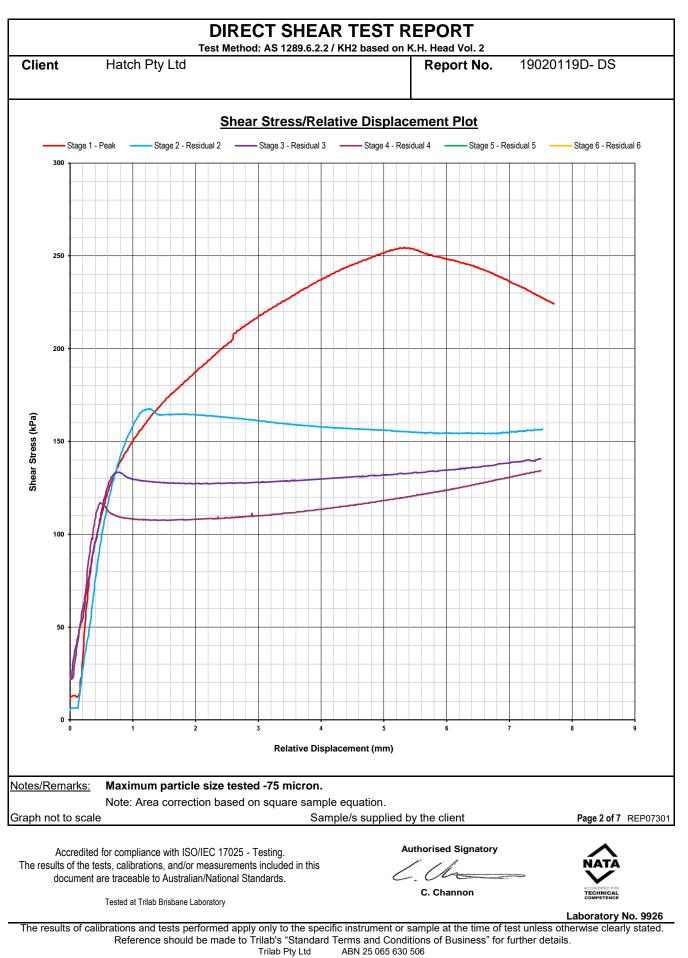


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Geebung2 Kimmer Place,
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		-	-	EST REPOR					
Client	Hatch P		<u>AU 1200.0.2.2 / NH2 I</u>	Repor		0119D- DS			
		-		Work	Workorder No 0005507				
Address	PO Box	425 SPRING HIL	L QLD 4004		Test Date 4/03/2019				
				Repor	t Date 13/03/	/2019			
Project	H35680	4 - Cadia NTSF F	ailure						
Client ID	CE416 -	- L2B			epth (m) 24.50-2				
Description	SILTY C	CLAY - brown		Sample Type	Single individual soi Remoulded as requ	l specimen - ested by the client.			
			SAMPLE DE	TAILS					
		Specimen Condition	As Re	ceived					
	Specime	en Dimensions (mm)	60	*60					
	Rat	e of Strain (mm/min)	0.0	008					
	Initial N	Moisture Content (%)	33	33.9					
	Init	ial Wet Density(t/m ³)	1.	88					
			RESULTS OF T	ESTING					
		Ā	ESIDUAL RESULT	S	PEAK R	ESULTS			
Test Stage		Residual Displacement (mm)	Normal Stress (kPa)	Corrected Shear Stress (kPa)	Normal Stress (kPa)	Corrected Shear Stress (kPa)			
Stage 1 - P	Peak	7.50	500.0	228.7	500.0	254.6			
Stage 2 - Res	idual 2	7.50	500.0	156.6	500.0	167.7			
Stage 3 - Res	idual 3	7.50	500.0	140.6	500.0	140.6			
Stage 4 - Res	idual 4	7.50	500.0	134.3	500.0	134.3			
Stage 5 - Res	idual 5	-	-	-	-	-			
Stage 6 - Res	idual 6	-	-	-	-	-			
<u>Notes/Remarks:</u>		n particle size tested a correction based or		ation					
Graph not to scale				supplied by the clien	t	Page 1 of 7 REP07301			
The results of the f	tests, calibrati	nce with ISO/IEC 17025 - ons, and/or measurement to Australian/National St	s included in this	Authorised Sig C. Cha- C. Channel					
	Tested at Trila	b Brisbane Laboratory		2. •		TECHNICAL COMPETENCE			
The results of calib		tests performed apply							
	Reterence	e should be made to Tri ت		and Conditions of Busi 25 065 630 506	ness" for further details	5.			

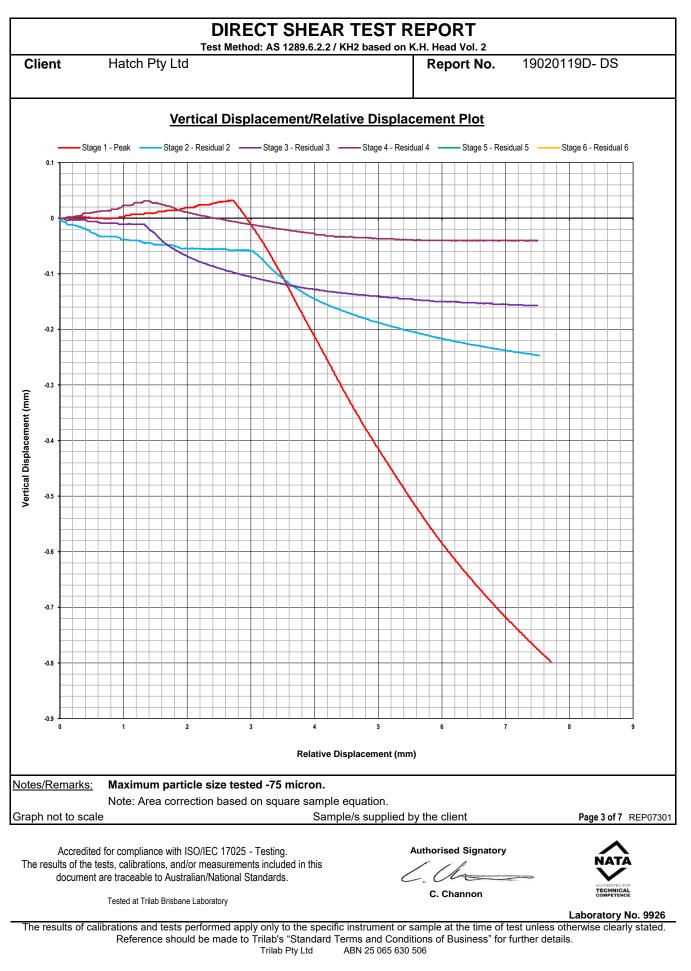


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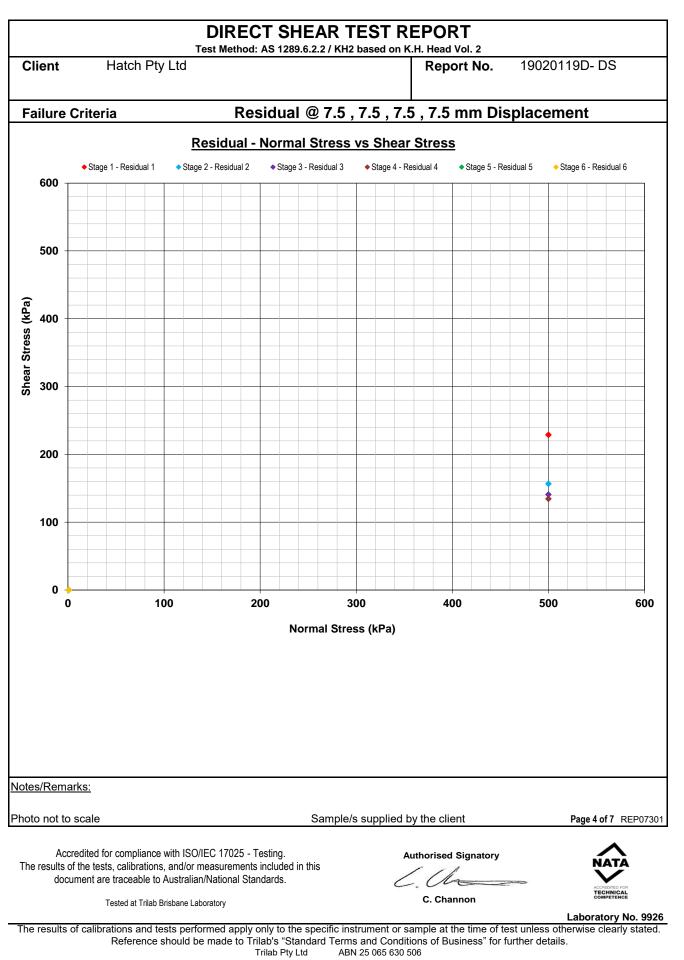


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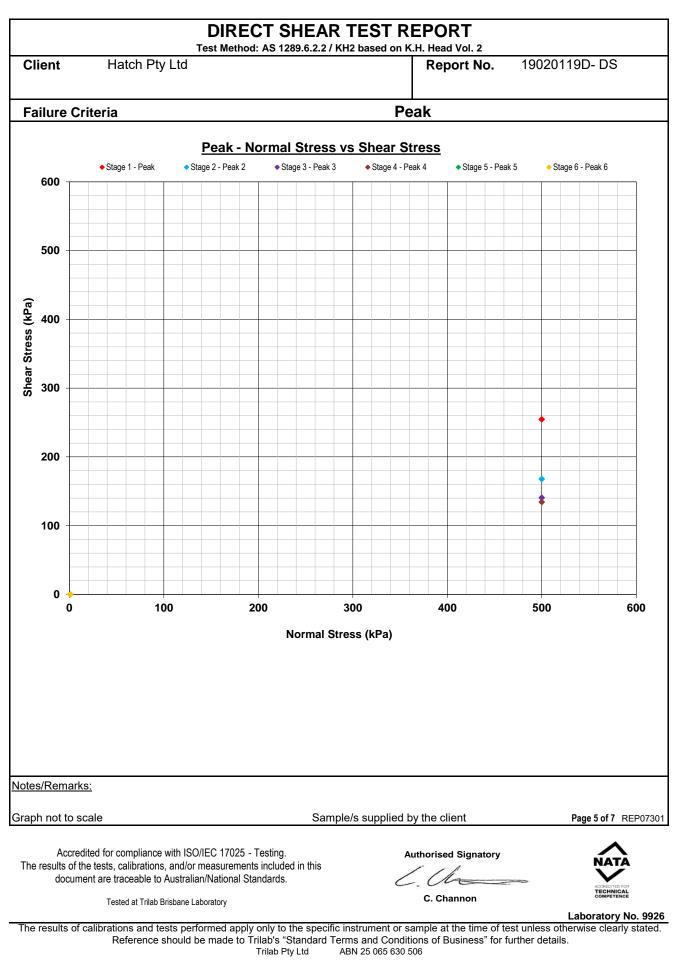


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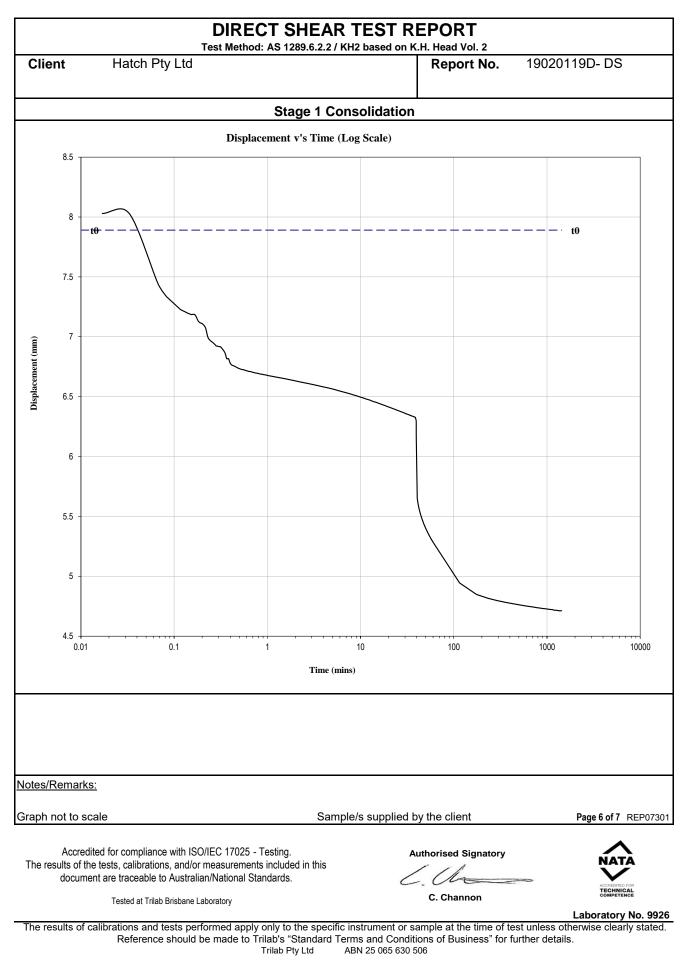
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Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

		DIRECT SHEAR		
Client	Hatch Pty Ltd		Report No.	19020119D- DS
		Before and Af	ter Photos	
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia N Failure	TSF AFTE	R TEST
	LAB SAMPLE No.	19020119	DATE: 12/0	3/19
	BOREHOLE:	CE416 - L2B	DEPTH: 24	.50-25.00
Notes/Remar	<u>ks:</u>			
Graph not to	scale	Sample	/s supplied by the client	Page 7 of 7 REP07301
The results of	edited for compliance with ISO/IEC the tests, calibrations, and/or mea nent are traceable to Australian/N Tested at Trilab Brisbane Labora	surements included in this ational Standards.	Authorised Signatory	ACCREDITE FOR TECHNICAL COMPETENCE
The record		-	strument or sample at the time of te	Laboratory No. 9926
The results 0	Reference should be m	nade to Trilab's "Standard Term	ns and Conditions of Business" for f N 25 065 630 506	urther details.



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				EST REPOR					
Client	Hatch P			Repor		0119E- DS			
				Worko	order No 00055	607			
Address	PO Box	425 SPRING HIL	L QLD 4004	Test D	Test Date 20/02/2019				
				Repor	t Date 13/03/	2019			
Project	H35680	4 - Cadia NTSF F	ailure						
Client ID	CE416 -			De	epth (m) 24.50-2	5.00			
Description SILTY CLAY - yellow/brown Sample Type Single individual soil specimen - Remoulded as requested by the									
			SAMPLE DE	TAILS					
		Specimen Condition	Inune	dated					
	Specime	en Dimensions (mm)	60 ⁻	*60					
	Rat	e of Strain (mm/min)	0.0	800					
	Initial N	Noisture Content (%)	34	34.2					
	Init	ial Wet Density(t/m ³)	1.	87					
			RESULTS OF T	ESTING					
		Я	ESIDUAL RESULT	S	PEAK R	ESULTS			
Test Stage Di		Residual Displacement (mm)	Normal Stress (kPa)	Corrected Shear Stress (kPa)	Normal Stress (kPa)	Corrected Shear Stress (kPa)			
Stage 1 - P	eak	6.00	1200.0	548.8	1200.0	552.0			
Stage 2 - Res	idual 2	6.00	1200.0	341.4	1200.0	428.6			
Stage 3 - Res	idual 3	6.00	1200.0	399.7	1200.0	400.6			
Stage 4 - Res	idual 4	-	-	-	-	-			
Stage 5 - Res	idual 5	-	-	-	-	-			
Stage 6 - Res	idual 6	-	-	-	-	-			
<u>Notes/Remarks:</u> Graph not to scale		a correction based or		ation. supplied by the clien	t	Page 1 of 7 REP07301			
Accredite	d for compliar	nce with ISO/IEC 17025 -	Testing.	Authorised Sig					
		ons, and/or measurement to Australian/National Sta		C. Che					
	Tested at Trilal	b Brisbane Laboratory		C. Channo	on	Laboratory No. 9926			
The results of calib		tests performed apply of should be made to Tri				nerwise clearly stated.			
	Relefence			25 065 630 506					

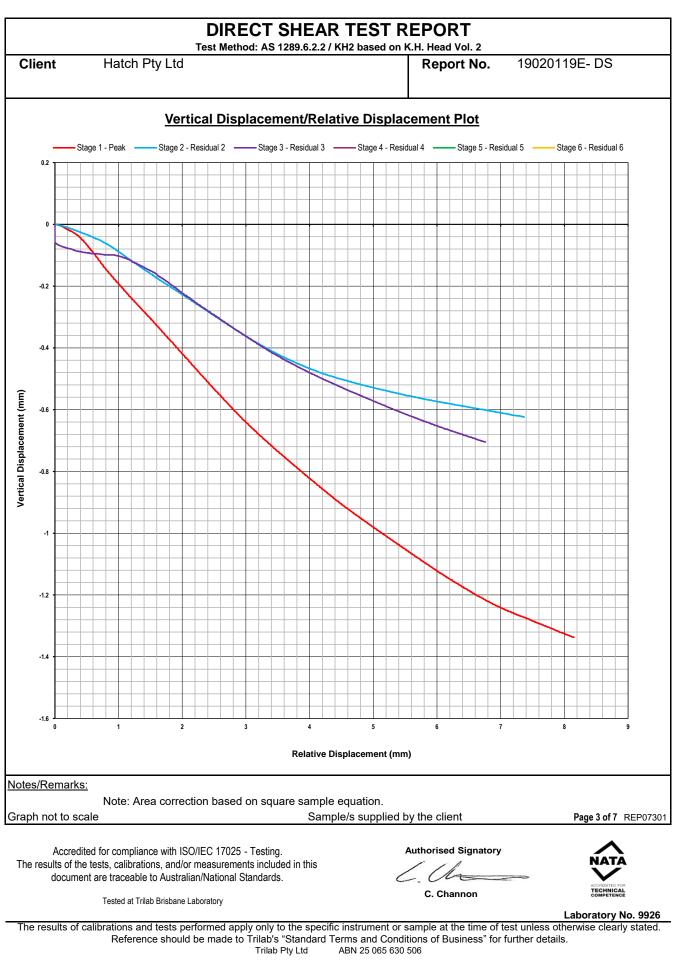


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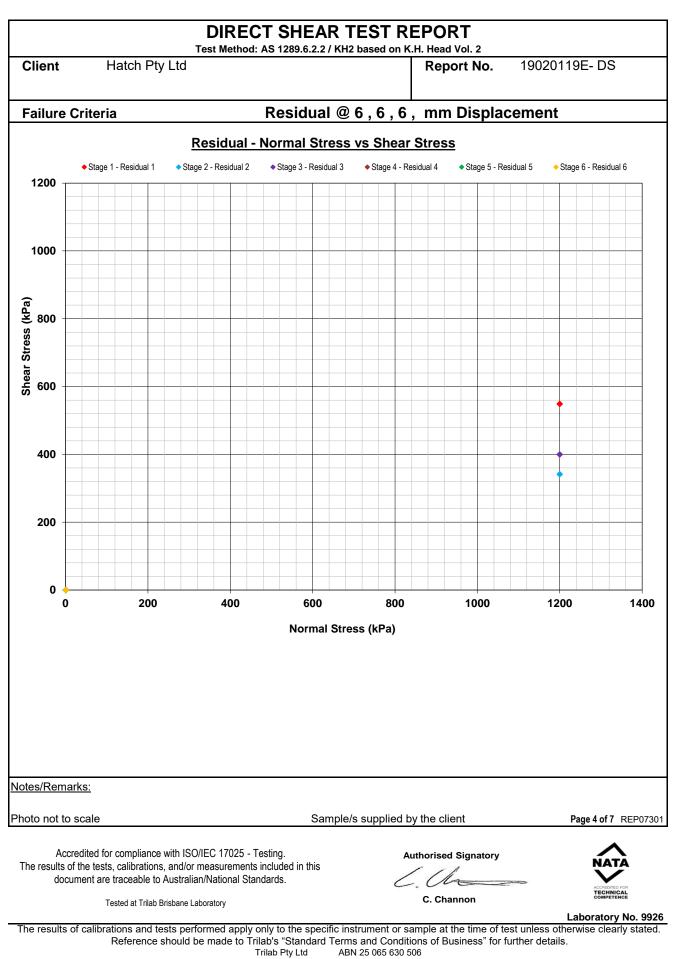


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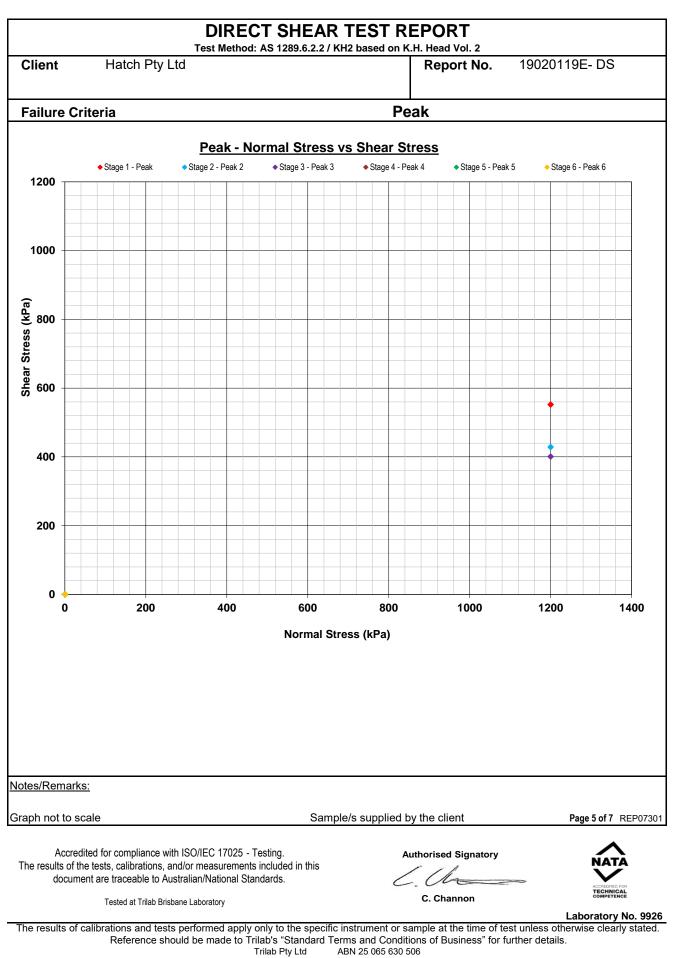


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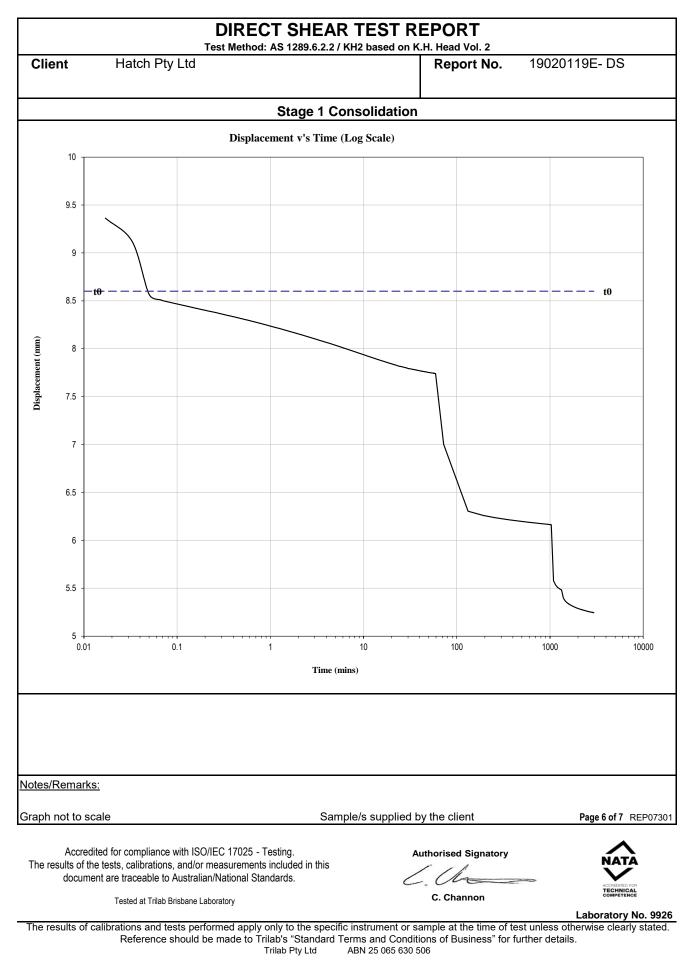
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Geebung2 Kimmer Place,
Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

		DIRECT SHEAR T t Method: AS 1289.6.2.2 / KH2		
Client	Hatch Pty Ltd		Report No.	19020119E- DS
		Before and Af	ter Photos	
	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia N	TSF AFTE	R TEST
	LAB SAMPLE No.	Failure 19020119	DATE: 28/0	2/19
	BOREHOLE:	CE416 - L2B	DEPTH: 24	
<u>Notes/Remar</u>	<u>ks:</u>			
Graph not to	scale	Sample/	/s supplied by the client	Page 7 of 7 REP07301
The results of	edited for compliance with ISO/IEC the tests, calibrations, and/or mea ment are traceable to Australian/N	surements included in this	Authorised Signatory	
	Tested at Trilab Brisbane Labora		C. Channon	TECHNICAL COMPETENCE Laboratory No. 9926
The results o		nade to Trilab's "Standard Term	strument or sample at the time of te is and Conditions of Business" for f N 25 065 630 506	est unless otherwise clearly stated.

Annexure DE CIU Triaxial Tests - Golders



Isotropically Consolidated Undrained (CIU)

Perth Laboratory 84 Guthrie Street, Osborne Park

					In .		
Client:	Hatch	latch			Date:	13/09/2018	
Address:	61 Petrie Teri	race, Brisl	bane		Project No.:	18101980	
Project:	NTSF Emban	kment Fa	ilure ITRB		Sample ID:	CE415-PT1 6.0-6.5m	
Location:	Cadia Mine	Cadia Mine			Test ID:	18022 - TX1 1000kPa	
Initial Height (m	Initial Height (mm): 133		Final Liquor Content (%):	41.3%	Strain Rate (mm/min):		0.03
Initial Diameter	Initial Diameter (mm):		Final Dry Density (t/m ³):	1.39	B Response (%):		98%
Trimmings GWC (%):		-	Final Void Ratio (-):	-	Mean Effective Consolidation Stress (kPa):		1000
Initial Dry Densi	Initial Dry Density (t/m ³): 1		Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):		1.00



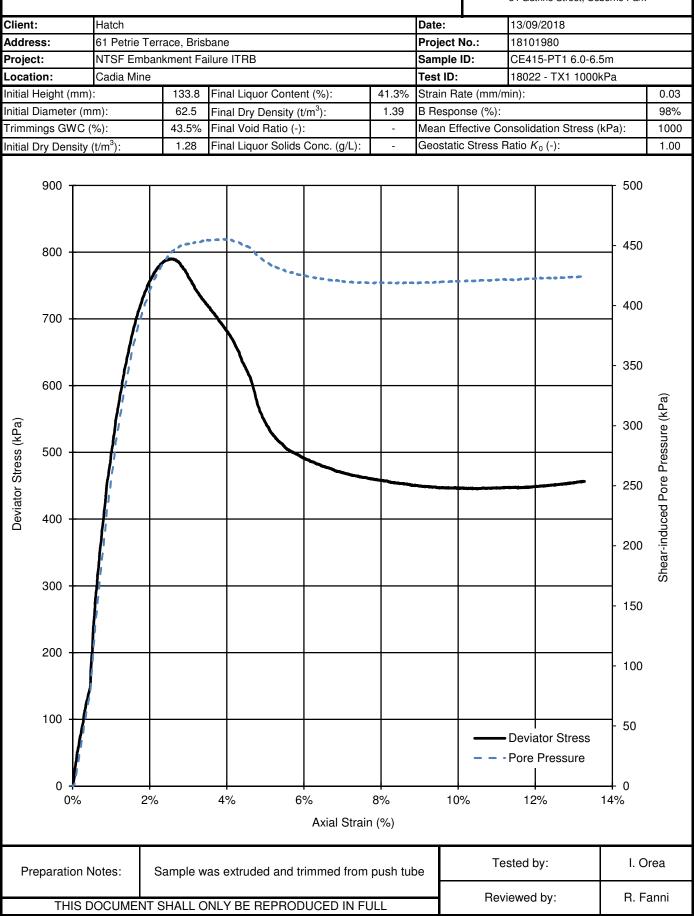
18022 CE415-PT1 6.0-6.5m CIU - 1000kPa extruded



Sar	nple Before Test		Sample After Test	
Preparation Notes:	Preparation Notes: Sample was extruded and trimmed from push tube		Tested by: I. Orea	
THIS DOCUME	NT SHALL ONLY BE REPRODUCED I	N FULL	Reviewed by:	R. Fanni



Isotropically Consolidated Undrained (CIU)



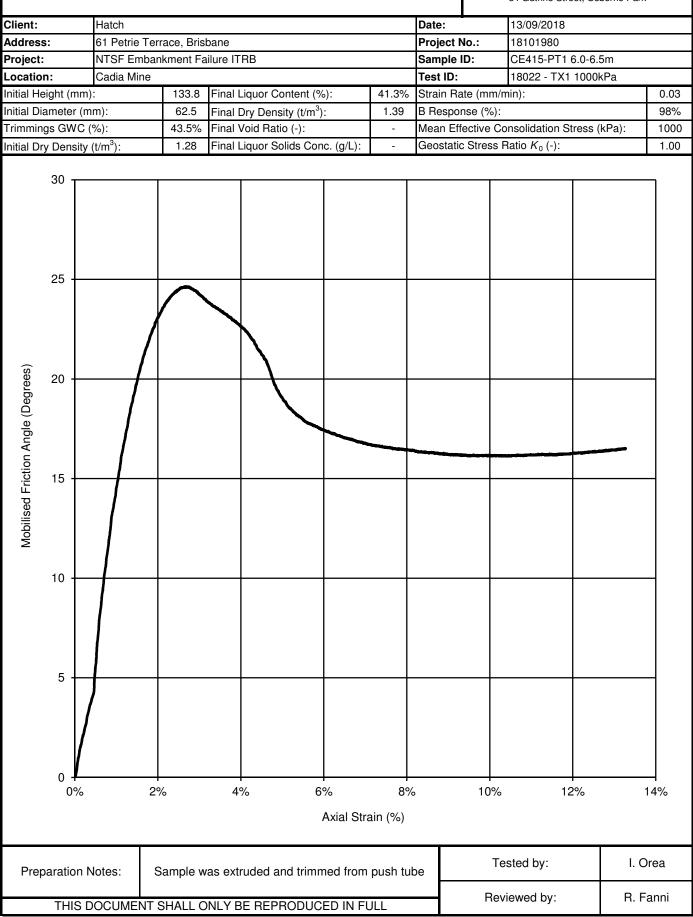


Isotropically Consolidated Undrained (CIU)

Client:	Hatch				Date:		13/09/2018			
Address:	61 Petrie Te	errace, Brist	oane		Project N	Project No.: 18101980				
Project:	NTSF Emb	ankment Fa	ilure ITRB		Sample	D:	CE415-PT1	6.0-6.5m		
Location:	Cadia Mine				Test ID:		18022 - TX	1 1000kPa	l	
Initial Height (mm)):	133.8	Final Liquor Content (%):	41.3%	Strain Ra	ite (mm/n	nin):		0.0	.03
Initial Diameter (m	וm):	62.5	Final Dry Density (t/m ³):	1.39	B Respo	nse (%):			98	8%
Trimmings GWC	(%):	43.5%	Final Void Ratio (-):	-	Mean Eff	ective Co	onsolidation S	Stress (kPa	a): 10	000
Initial Dry Density		1.28	Final Liquor Solids Conc. (g/L):	-	Geostatio	Stress F	Ratio K_0 (-):		1.0	.00
900 - 800 - 700 - 600 - 600 - 600 - 300 - 200 - 100 - 0 - 0 -		200	400 6 Mean Effective S	500 tress p' (1,0	00	1,200	0
Preparation 1	Notes:	Sample w	as extruded and trimmed from	push tuk	be	Te	sted by:		I. Orea	
			NLY BE REPRODUCED IN FU			Rev	iewed by:		R. Fanni	i



Isotropically Consolidated Undrained (CIU)







Perth Laboratory

1							
Client:	Hatch	latch [13/09/2018	
Address:	61 Petrie Terr	ace, Brist	bane		Project No.:	18101980	
Project:	NTSF Emban	kment Fa	ilure ITRB		Sample ID:	CE416 PT4 27.00-27.45	
Location:	Cadia Mine	Cadia Mine			Test ID:	18024 - TX1 1000kPa	
Initial Height (m	Initial Height (mm): 126.9		Final Liquor Content (%):	35.2%	Strain Rate (mm/min):		0.005
Initial Diameter	(mm):	64.0	Final Dry Density (t/m ³):	1.47	B Response (%):		95%
Trimmings GWC (%): 36		36.5%	Final Void Ratio (-):	1.16	Mean Effective Consolidation Stress (kPa):		1001
Initial Dry Density (t/m ³): 1.40		1.40	Final Liquor Solids Conc. (g/L):	-	Geostatic Stress Ratio K_0 (-):		1.00



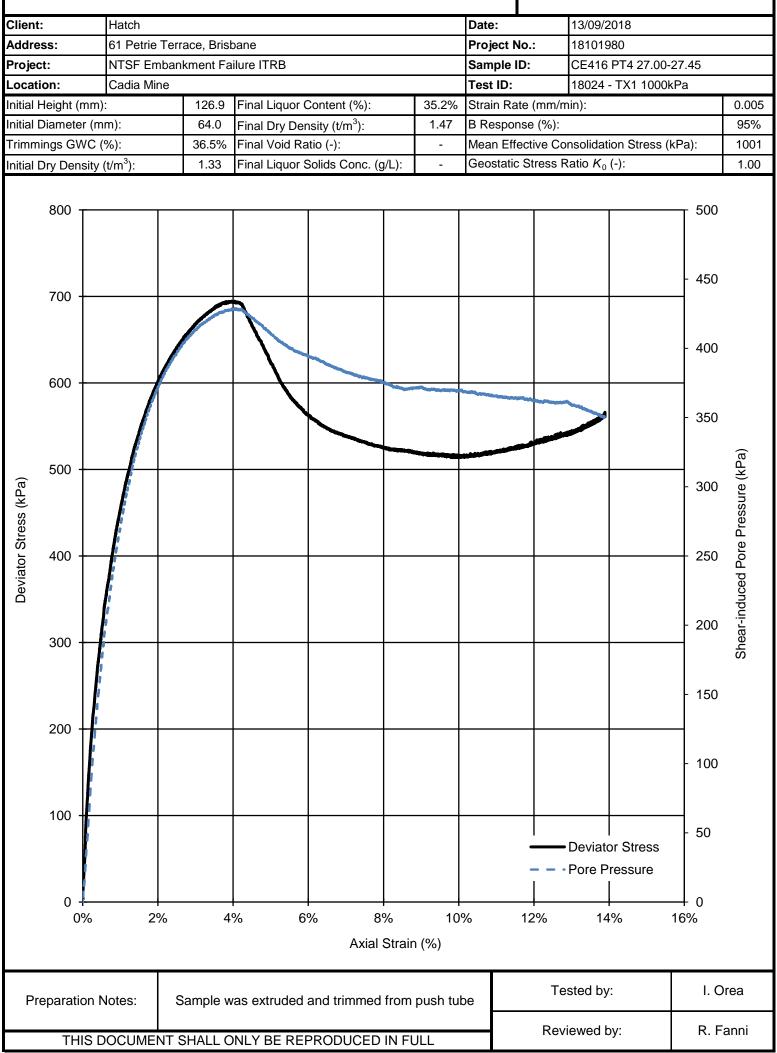


Sar	nple Before Test		Sample After Test	
Preparation Notes:	Sample was extruded and trimmed t	rom push tube	Tested by: I. Or	
			Reviewed by:	R. Fanni
THIS DOCUME	NT SHALL ONLY BE REPRODUCED I	NFULL		





Perth Laboratory







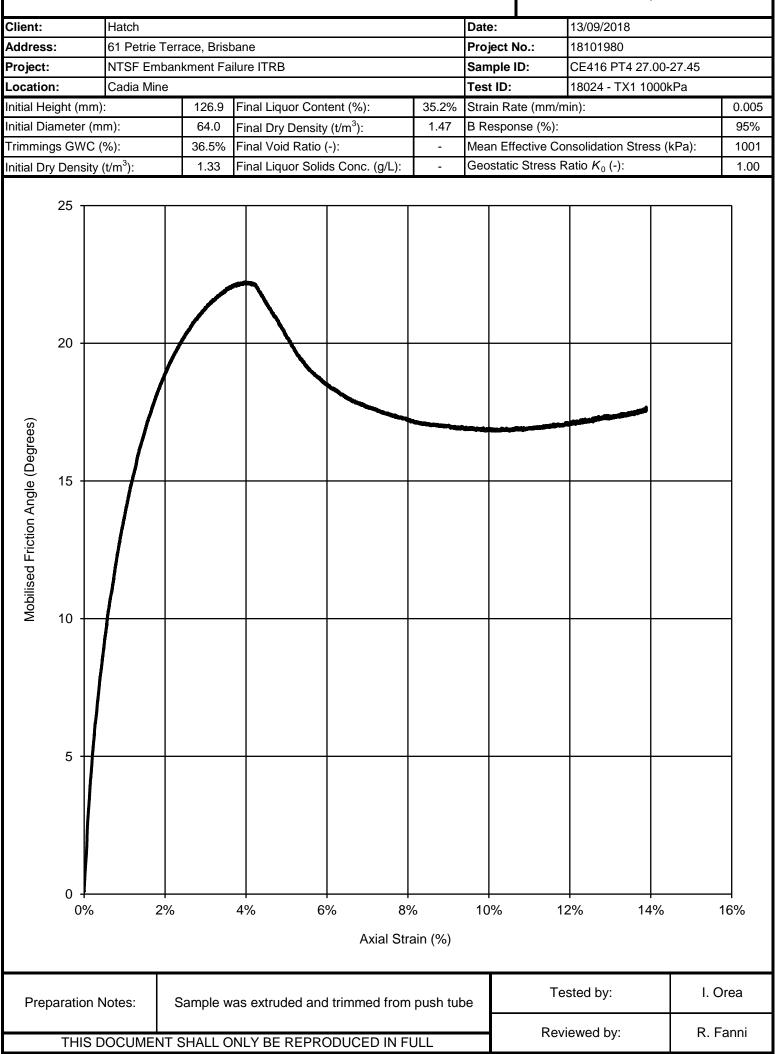
Perth Laboratory

Client: Hatch Address: 61 Petrie Terra Project: NTSF Embank Location: Cadia Mine Initial Height (mm): Initial Diameter (mm): Trimmings GWC (%): Initial Dry Density (t/m ³): 800 700 600	126.9 64.0 36.5%		1.47 1.02			0.005
Project: NTSF Embank Location: Cadia Mine Initial Height (mm): Initial Diameter (mm): Trimmings GWC (%): Initial Dry Density (t/m³): 800 700	126.9 64.0 36.5%	ilure ITRB Final Liquor Content (% Final Dry Density (t/m ³) Final Void Ratio (-):	1.47 1.02	Sample ID: Test ID: Strain Rate (r B Response Mean Effectiv	CE416 PT4 27.00-27.4 18024 - TX1 1000kPa mm/min): (%): ve Consolidation Stress (kPa	0.005 95%): 1001
Location: Cadia Mine Initial Height (mm): Initial Diameter (mm): Trimmings GWC (%): Initial Dry Density (t/m ³): 800 700	126.9 64.0 36.5%	Final Liquor Content (% Final Dry Density (t/m ³) Final Void Ratio (-):	1.47 1.02	Test ID: Strain Rate (r B Response Mean Effectiv	18024 - TX1 1000kPa nm/min): (%): ve Consolidation Stress (kPa	0.005 95%): 1001
Initial Height (mm): Initial Diameter (mm): Trimmings GWC (%): Initial Dry Density (t/m ³): 800 700	64.0 36.5%	Final Dry Density (t/m ³) Final Void Ratio (-):	1.47 1.02	Strain Rate (r B Response Mean Effectiv	nm/min): (%): /e Consolidation Stress (kPa	95%): 1001
Initial Diameter (mm): Trimmings GWC (%): Initial Dry Density (t/m ³): 800 700	64.0 36.5%	Final Dry Density (t/m ³) Final Void Ratio (-):	1.47 1.02	B Response Mean Effectiv	(%): ve Consolidation Stress (kPa	95%): 1001
Trimmings GWC (%): Initial Dry Density (t/m ³): 800 700	36.5%	Final Void Ratio (-):	1.02	Mean Effectiv	e Consolidation Stress (kPa): 1001
800					•	,
800	1.33	Final Liquor Solids Con	c. (g/L): -	Geostatic Str	ess Ratio K ₀ (-):	1.00
700						
Deviator Stress d (KPa)	200	400 Mean Ef	600 fective Stress <i>p</i> '		1,000	1,200
Preparation Notes: Sa	ample w	as extruded and trimn	ned from push tu	be	Tested by:	I. Orea
	-	NLY BE REPRODUC			Reviewed by:	R. Fanni





Perth Laboratory





Isotropically Consolidated Undrained (CIU)

Perth Laboratory 84 Guthrie Street, Osborne Park

Client:	Hatch	latch D					26/10/2018		
Address:	61 Petrie Terr	ace, Brist	bane		Project N	lo.:	18101980		
Project:	NTSF Emban	kment Fa	ilure ITRB		Sample I	D:	CE416-PT2 24.00-24.33m		
Location:	Cadia Mine	Cadia Mine					18027 - TX1 400kPa		
Initial Height (mm):	126.0	Final Liquor Content (%):	28.8%	Strain Rate (mm/min):		nin):	0.002	
Initial Diameter (n	Initial Diameter (mm):		Final Dry Density (t/m ³):	1.57	B Response (%):			96%	
Trimmings GWC (%):		27.9%	Final Void Ratio (-):	0.82	Mean Effective Consolidation Stress (kPa):		nsolidation Stress (kPa):	402	
Initial Dry Density	(t/m ³):	1.54	Final Liquor Solids Conc. (g/L):	-	Geostatio	: Stress F	Ratio K_0 (-):	0.99	



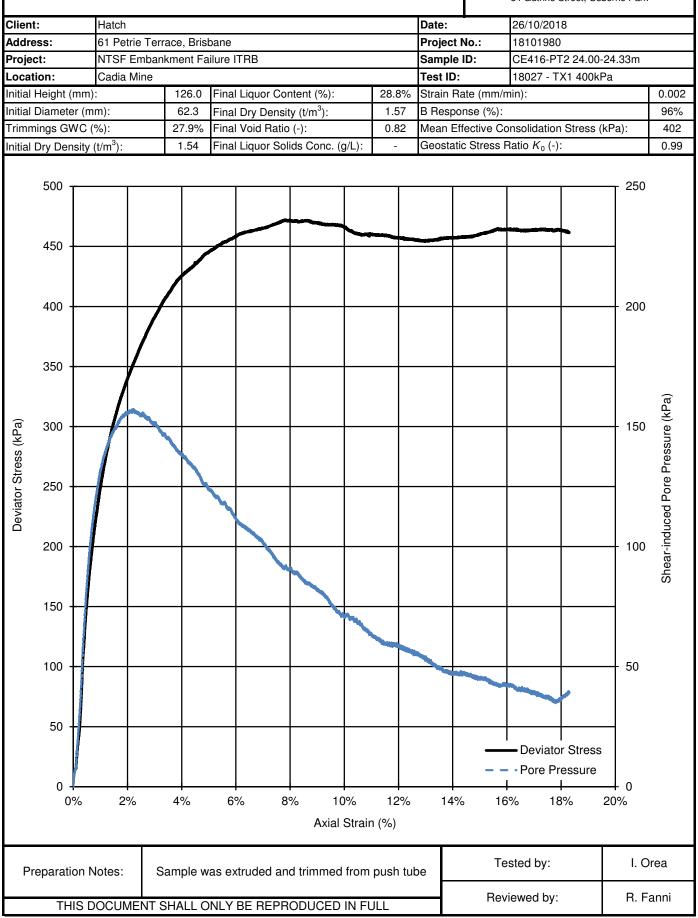
extruded



Sai	nple Before Test	Sample After Test				
Preparation Notes:	Sample was extruded and trimmed f	rom push tube Tested by: I. Ore				
			Reviewed by:	R. Fanni		
THIS DOCUME	NT SHALL ONLY BE REPRODUCED I	N FULL	Heviewed by.	n. raiiii		



Isotropically Consolidated Undrained (CIU)



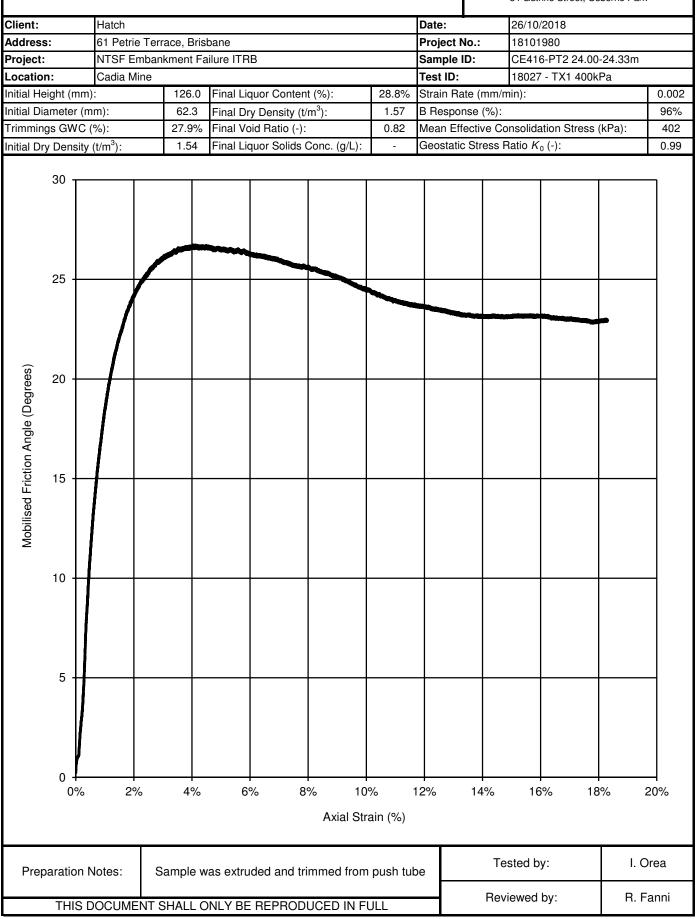


Isotropically Consolidated Undrained (CIU)

lient:	Hatch				Date:	e: 26/10/2018				
ddress:		ie Terrace, Brisbane Project No.: 18101980								
roject:		mbankment Fa			Sample ID:					
ocation:	Cadia M				Test ID:					
itial Height			Final Liquor Content (%)	: 28.8%	Strain Rate		0.00			
-	. ,									
iitial Diame rimmings G		62.3 27.9%	Final Dry Density (t/m ³): Final Void Ratio (-):	1.57 0.82	B Response	e (%): tive Consolidation Stres	96° s (kPa): 40			
	ensity (t/m ³):	1.54	Final Liquor Solids Conc			tress Ratio K_0 (-):	S (KPA). 40			
	500					\sim				
2	400									
	350				1					
Stress q (250									
	200									
1	50									
1	00									
	50									
	0	100	200 Mean Effe	300 ective Stress <i>p</i> ' (400 (kPa)	0 500	600			
Prepara	tion Notes:	Sample w	as extruded and trimm	ed from push tul	be	Tested by:	I. Orea			
		<u> </u>	NLY BE REPRODUCE			Reviewed by:	R. Fanni			



Isotropically Consolidated Undrained (CIU)



Annexure DF CIU Triaxial Tests – Trilabs



Brisbare RICTLY CONFIDENTIAL 346A Bilsen Road, 2 Kimmer Place,

Geebung QLD 4034 Ph: +61 7 3265 5656

2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

			•			-	-				
Client:	Hatch P	tv I td			Test Method: A	S1289.6.4		Report No.:	18080195 - C	U	
	naton i							-			
Address	PO Box	425 SP	RING HI		0 4004		VVC	orkorder No.	0004644		
Addie33							_	Test Date:	6/09/2018		
							F	Report Date:	25/09/2018		
Project:	H356804			Failure							
Client Id.:	CE407 -					De	pth (m):	50.00-50.50			
Description:	CLAY -	dark gre	y and br	own							
			1		MPLE & TE		1				
Initial Height:		mm			loisture Content:	23.1	%		e of Strain: 0.005	%/min	
Initial Diameter: L/D Ratio:		mm		Final IV	loisture Content: Wet Density:	17.5 2.13	% t/m ³	B Response: 97 %			
L/D Ralio.	2.0.1				Dry Density:		t/m ³				
Sample Type:	Single Indivi	idual Undisti	urbed Specir	men	,		-				
					TEST RE	SULTS	5				
					FAILURE D	ETAILS					
	Confining	Back		Failure		Principal Eff	ective Stresse	es	Deviator Stress	Strain	
Effective Pressure	Pressure	Pressure	Initial Pore	Pore	σ ' ₁		σ'₃	σ'_1 / σ'_3			
613 kPa	1101 kPa	488 kPa	488 kPa	672 kPa	842 kP		429 kPa		413 kPa	2.99 %	
812 kPa	1301 kPa	489 kPa	489 kPa	700 kPa	1177 kF	-	601 kPa		576 kPa	4.69 %	
1227 kPa	1703 kPa	476 kPa	476 kPa	800 kPa	1689 kF	a	903 kPa	a 1.871	786 kPa	6.58 %	
	•		•							•	
				FA	ILURE EN	IVELO	PES				
			Interpreta		ween stages :	1 to 2	2 to 3		1 to 3		
					sion C' (kPa) :	3.3	60.0		34.0		
		Angle of	Shear Res		⊅' (Degrees) :	18.7	15.0	D. //	16.3		
				Fa	ailure Criteria:	Peak Pr	incipal Stres	s Ratio			
Remarks:	Tested as Re	anivad									
Sample/s supplied l		ceiveu							Pag	e 1 of 7	
										P03001	
	dited for com						Authoris	sed Signatory	N	АТА	
The results of t docum	ne tests, call ient are trace						6.0	Channon	ACC	REDITED FOR	
	Tootod -	t Trilah Brick	ano Labora	ton			U. U	mannon	TE		
	lested at	t i rilad Brist	oane Laborat	tory.					Laborate	ory Number	

9926 The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.

Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details. Trilab Pty Ltd ABN 25 065 630 506



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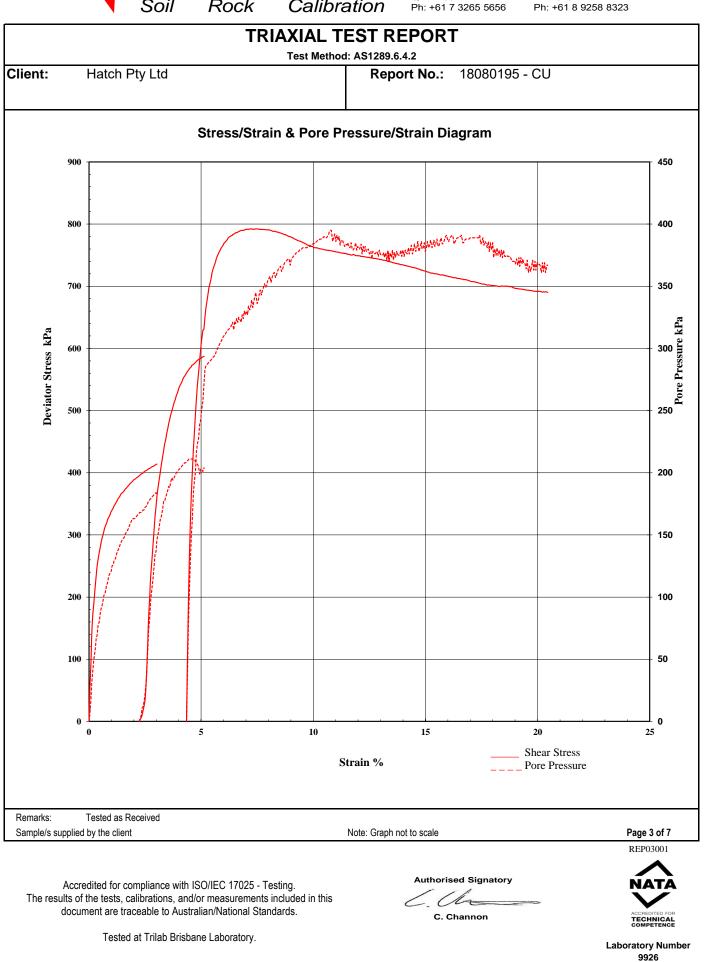
				TEST R				
Client:	Hatch Pty Ltc		Test Me			18080195 - Cl	J	
			Mohr	Circle Diag	ram			
1800								
1600								
1400								
1200								
Shear Stress (kPa) 000 000								
Shear S								
600								
400	-							
200			\frown					
0	0 200	400	600 Frincipa	800 1 I Stress (kPa)		200 1400	1600	1800
		Interpreta	tion between stag		2 to 3		1 to 3	
	Angle		Cohesion C' (k stance Ф' (Degre Failure Crit	Pa): 3.3 es): 18.7	60.0 15.0 incipal Stress F	Ratio	34.0 16.3	
Remarks: Sample/s s	Tested as Received supplied by the client			Note: Graph	not to scale		Pa	ige 2 of 7
The res	Accredited for compliance sults of the tests, calibration document are traceable to	s, and/or measure Australian/Natior	ements included in the name of	nis	Authorised S		Ņ	
	Tested at Trilab	Brisbane Laborat	ory.					tory Number 9926

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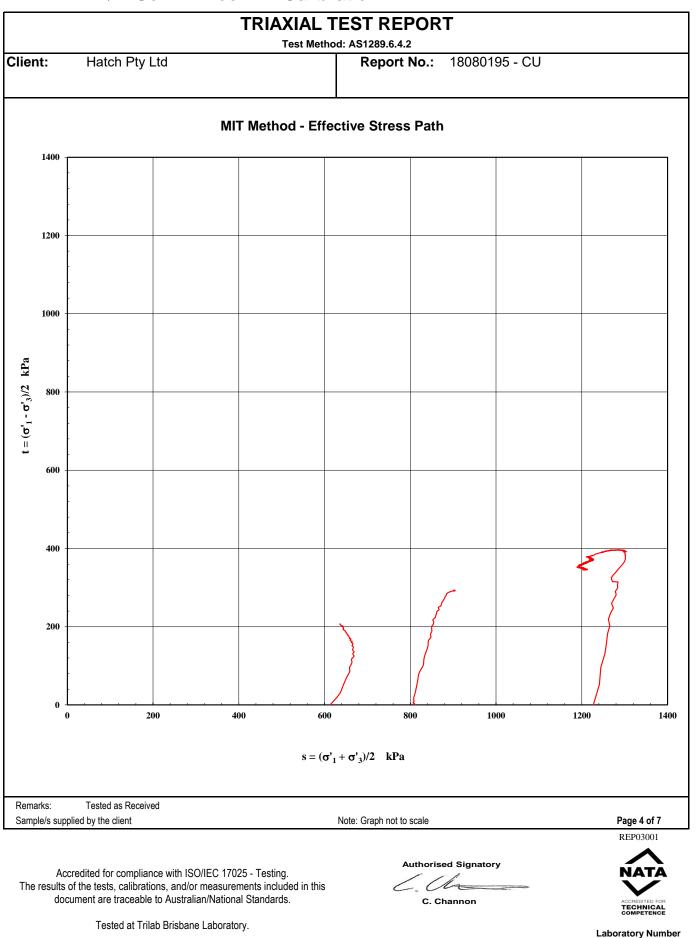


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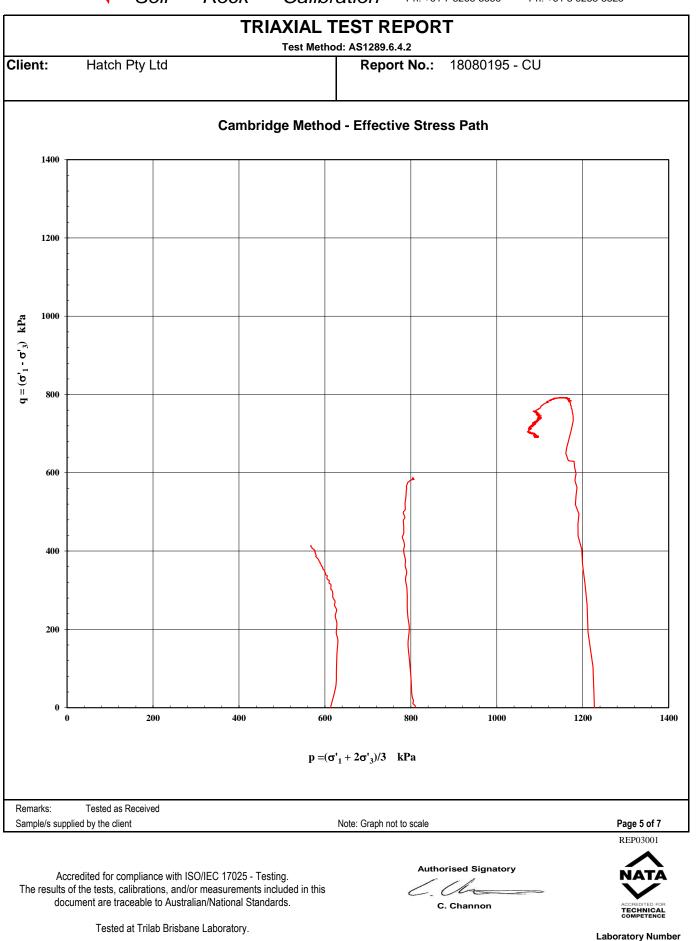


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> Laboratory Number 9926

lient:	Hatch Pty Ltd	Test Method: AS1289.6.4.2		
nent.		Kepolt	110 10000190 - 00	
	CLIENT:	Hatch Pty Ltd		
- 1	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TEST	
	LAB SAMPLE No.	18080195	DATE: 10/08/18	
- 1	BOREHOLE:	CE407 - DH402 - PT2	DEPTH: 50.00-50.5	0
	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia NTSF Failure	AFTER TEST	7
	LAB SAMPLE No.		DATE: 2009/18	
- 1	BOREHOLE:	CE407 - DH402 - PT2	DEPTH: 50.00-50.50	in the second se
	-			
Remarks:	Tested as Received			_
Sample/s sup	oplied by the client	Note: Photo not to s	scale	Page 6 of 7
				REP03001
Ac	ccredited for compliance with ISO/IFC	2 17025 - Testina.	thorised Signatory	NAT
The results	ccredited for compliance with ISO/IEC of the tests, calibrations, and/or mea	c 17025 - Testing. Isurements included in this	thorised Signatory	Ň
do	cument are traceable to Australian/Na	ational Standards.	C. Channon	

Tested at Trilab Brisbane Laboratory.

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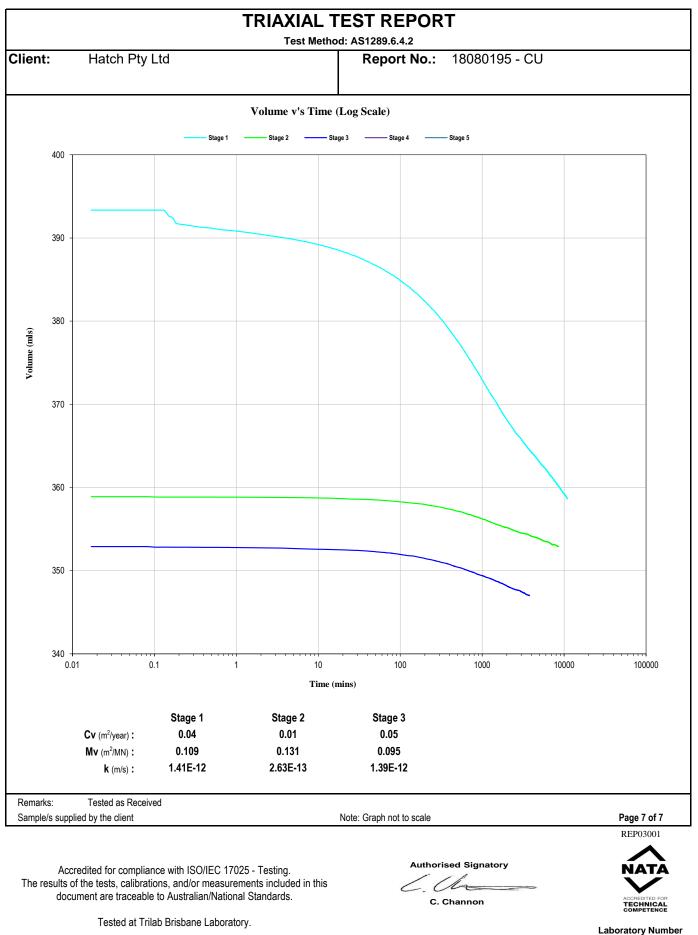


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QLD 4034 Ph: +61 7 3265 5656

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			•		XIAL TE					
Client:	Hatch P	ty Ltd						Report No.:	18080196 - Cl	J
							Wo	orkorder No.	0004644	
Address	PO Box	425 SPI	RING HI	LL QL	0 4004			Test Date:	17/08/2018	
							F	Report Date:	12/09/2018	
Project:	H35680	4 - Cadia	a NTSF I	Failure						
Client Id.:	CE407 -	DH402	- PT3			Dep	oth (m):	51.00-51.50		
Description:	CLAY -	brown								
				SA	MPLE & TE	ST DETA	ILS			
Initial Height:	127.1	mm		Initial N	loisture Content:	20.7	%	Rat	e of Strain: 0.004	%/min
Initial Diameter:	62.8	mm		Final N	loisture Content:		%	В	Response: 98	%
L/D Ratio:	2.0 : 1				Wet Density:		t/m ³ t/m ³			
Sample Type:	Single Indivi	idual Undisti	urbed Specir	men	Dry Density:	1.77	Vm			
					TEST RE	SULTS	;			
					FAILURE D	DETAILS				
	Confining	Back		Failure		Principal Eff	ective Stresse		Deviator Stress	Strain
Effective Pressure	Pressure 1698 kPa	Pressure 496 kPa	496 kPa	Pore 973 kPa	σ' 1 1590 kF	Pa	σ' 3 725 kPa	σ'_1 / σ'_3	866 kPa	5.77 %
1202 KFd	1090 KFa	490 KFa	490 KFa	973 KFa	1390 Kr	Fa	725 Ki a 2.194		000 KFa	5.77 %
				FA	ILURE EN	IVELO	PES			
			Interpreta	ation bet	ween stages :					
					sion C' (kPa) :					
		Angle of	Shear Res		Φ' (Degrees) :			- Dalla		
				Fa	ailure Criteria:	Peak Pri	ncipal Stres	s Ratio		
Remarks:	Tested as Re	ceived							David	4 . 47
Sample/s supplied b	by the client									1 of 7 03001
Accred	dited for com	pliance with	ISO/IEC 17	025 - Test	ting.		Authoris	sed Signatory	N	ATÀ
The results of t	he tests, cali	brations, an	d/or measur	ements inc	cluded in this		6.0	han	-	
docum	ent are trace				alus.		C. C	Channon		
	Tested a	t Trilab Brist	ane Labora	tory.						ry Number 926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.

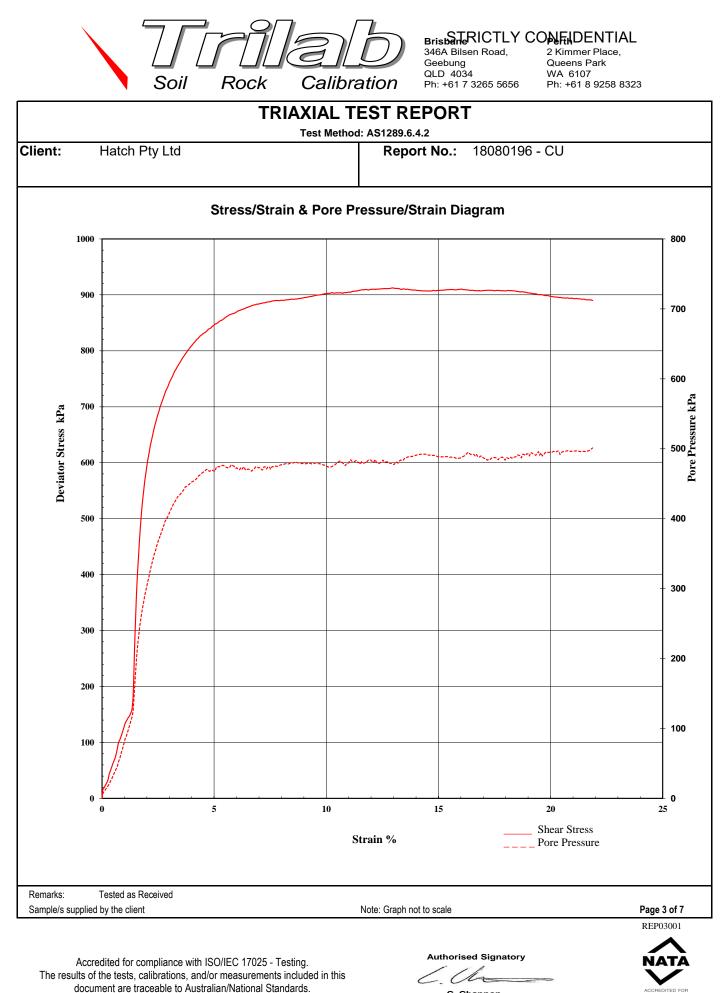


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		-	TRIAXIAL	TEST R				
Client:	Hatch Pty Ltd					80196 - CU		
			Mohr C	ircle Diagra	am			
1600								
	-							
1400	-							
	-							
1200	-							
	-							
1000								
Shear Stress (kPa) 08	-							
• Stress	-							
Shear	-							
600 ·	-							
	-							
400	-							
	-							
200	-							
	-							
0 -								
	0 200	400	600 Principal	800 Stress (kPa)	1000	1200	1400	1600
		Interpretatio	on between stage	9 5 :				
	Angle o		Cohesion C' (kРа ance Ф' (Degrees					
Remarks:	Tested as Received		Failure Criter		ncipal Stress Ratio)		
Sample/s si	upplied by the client			Note: Graph r	not to scale			age 2 of 7 REP03001
	Accredited for compliance w	rith ISO/IEC 1702	5 - Testina.		Authorised Signa	itory	I	
	ults of the tests, calibrations, document are traceable to A	and/or measurem	ents included in this	3	C. Chamon			
	Tested at Trilab Br	isbane Laborator	у.					atory Number 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.



C. Channon

Laboratory Number 9926

TECHNICAL

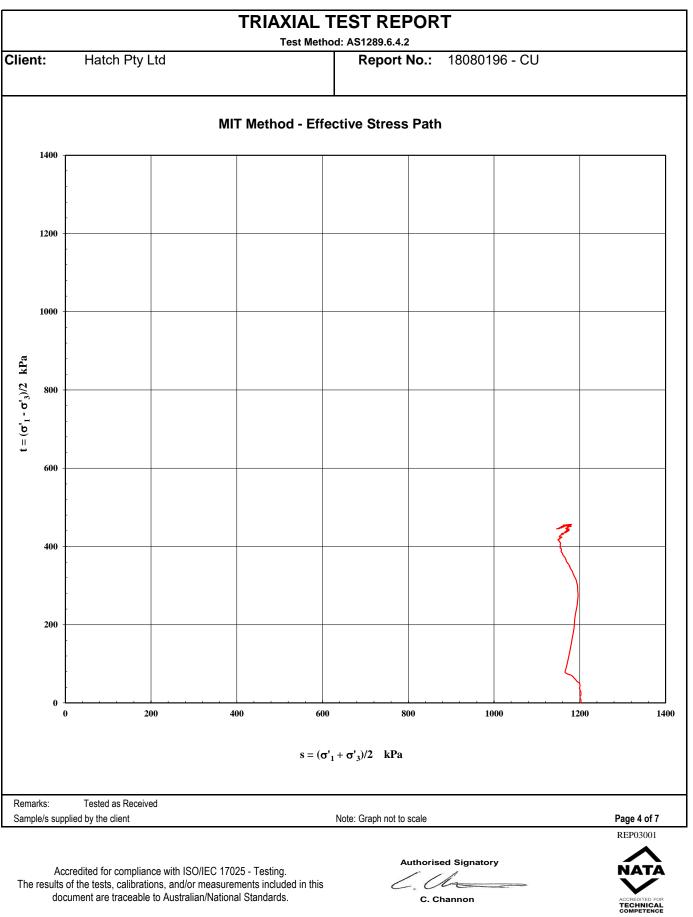
Tested at Trilab Brisbane Laboratory.

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.



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> Laboratory Number 9926



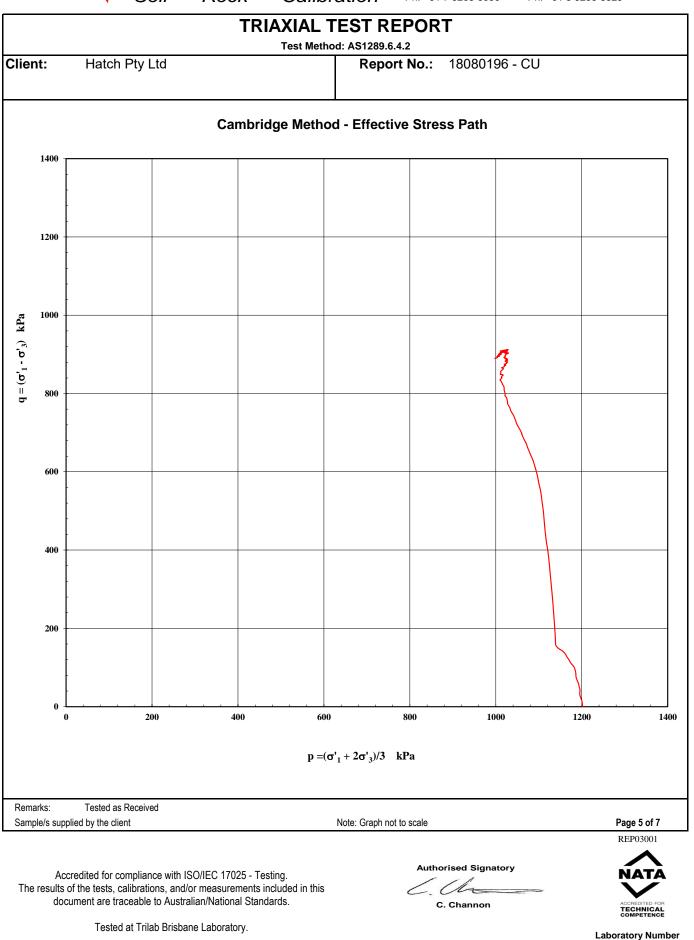
Tested at Trilab Brisbane Laboratory.

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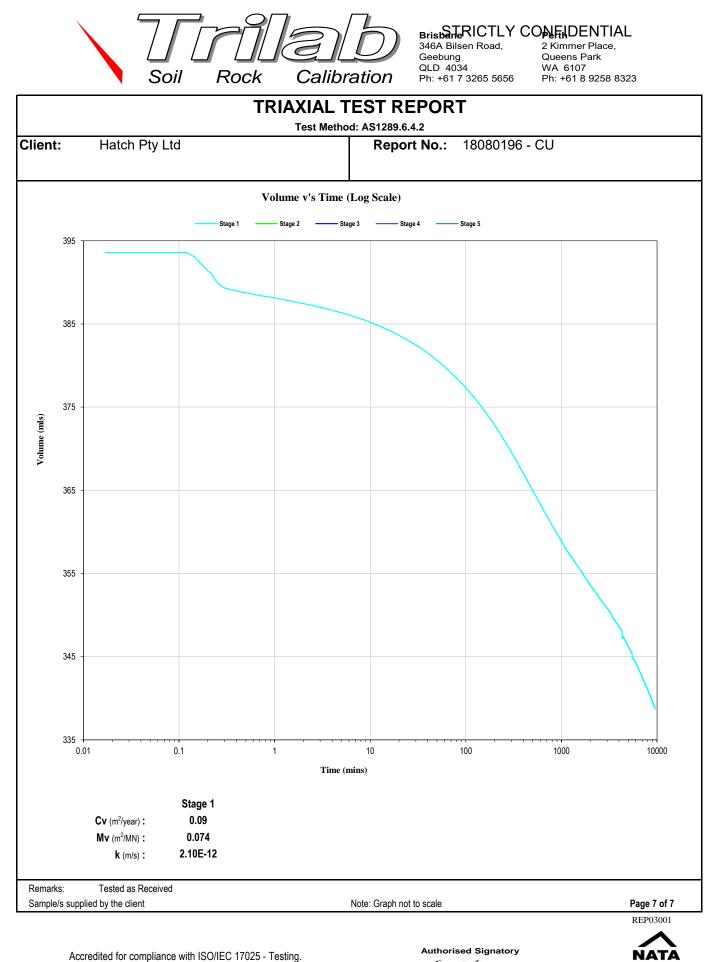
Geebung QLD 4034 Ph: +61 7 3265 5656

2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

9926

		TRIAXIAL TE	AS1289.6.4.2	RT		
Client:	Hatch Pty Ltd		Report No.:	18080196 - CU		
	CLIENT:	Hatch Pty Ltd				
	PROJECT:	H356804 - Cadia Failure	NTSF	BEFORE TES	бт	
	LAB SAMPLE No.	18080196		DATE: 13/08/19		
	BOREHOLE:	CE407 - DH402 -	· PT3	DEPTH: 51.00-51	.50	
10 10 10 10 10 10 10 10 10 10 10 10 10 1						
	CLIENT:	Hatch Pty Ltd				
	PROJECT:	H356804 - Cadia	NTSF	AFTER TEST DATE: 31 / 8 / 18		
	LAB SAMPLE No.	Failure 18080196				
2	BOREHOLE:	CE407 - DH402 -		DEPTH: 51.00-51.50		
Remarks:	Tested as Received					
Sample/s s	upplied by the client	N	ote: Photo not to scale		Page 6 of 7	
					REP03001	

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Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

Laboratory Number 9926

TECHNICAL

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Geebung QLD 4034 Ph: +61 7 3265 5656

2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

			-		XIAL TE					
Client:	Hatch P	ty Ltd						Report No.:	18080420 - Cl	J
							Wo	orkorder No.	0004681	
Address	PO Box	425 SPI	RING HI	ll Qle	D 4004			Test Date:	28/08/2018	
							F	Report Date:	12/09/2018	
Project:	H356804	4 - Cadia	a NTSF I	Failure						
Client Id.:	CE417 -	DH406	L2B			De	pth (m):	18.50-19.00		
Description:	SILTY C	LAY- or	ange an	d grey						
				SA	MPLE & TE	ST DET	AILS			
Initial Height:	130.7	mm			loisture Content:	38.6	%		e of Strain: 0.005	%/min
Initial Diameter:	60.1	mm		Final N	loisture Content:	38.6	%	В	Response: 97	%
L/D Ratio:	2.2 : 1				Wet Density: Dry Density:	1.82 1.31	t/m ³ t/m ³			
Sample Type:	Single Indivi	dual Undisti	urbed Specir	nen	Dry Density.	1.01	UIII			
	-									
					TEST RE	SULTS	6			
					FAILURE D	ETAILS				
	Confining	Back		Failure		Principal Ef	fective Stress		Deviator Stress	Strain
Effective Pressure	Pressure	Pressure	Initial Pore	Pore	σ' ₁		σ' ₃	σ'_1 / σ'_3	520 kDo	2 59 9/
799 kPa	1299 kPa	500 kPa	500 kPa	938 kPa	881 kP	a	361 kP	a 2.439	520 kPa	3.58 %
				F 4						
					ILURE EN	IVELO	PES			
			Interpreta		ween stages : sion C' (kPa) :					
		Angle of	Shear Resi		Φ' (Degrees) :					
		J • •			ailure Criteria:	Peak Pr	incipal Stres	s Ratio		
Remarks:	Tested as Re	ceived								
Sample/s supplied b	by the client									1 of 7
									KEP	03001
Accred	dited for com	pliance with	ISO/IFC 17	025 - Test	tina.		Authori	sed Signatory	N	
The results of t	he tests, cali	brations, an	d/or measure	ements inc	cluded in this		6.0	hand		
docum	ent are trace	able to Ausi	ralian/Natior	nal Standa	ards.		C. (Channon	ACCRE TEC Com	
	Tested at	Trilab Brist	ane Laborat	tory.						ry Number 26

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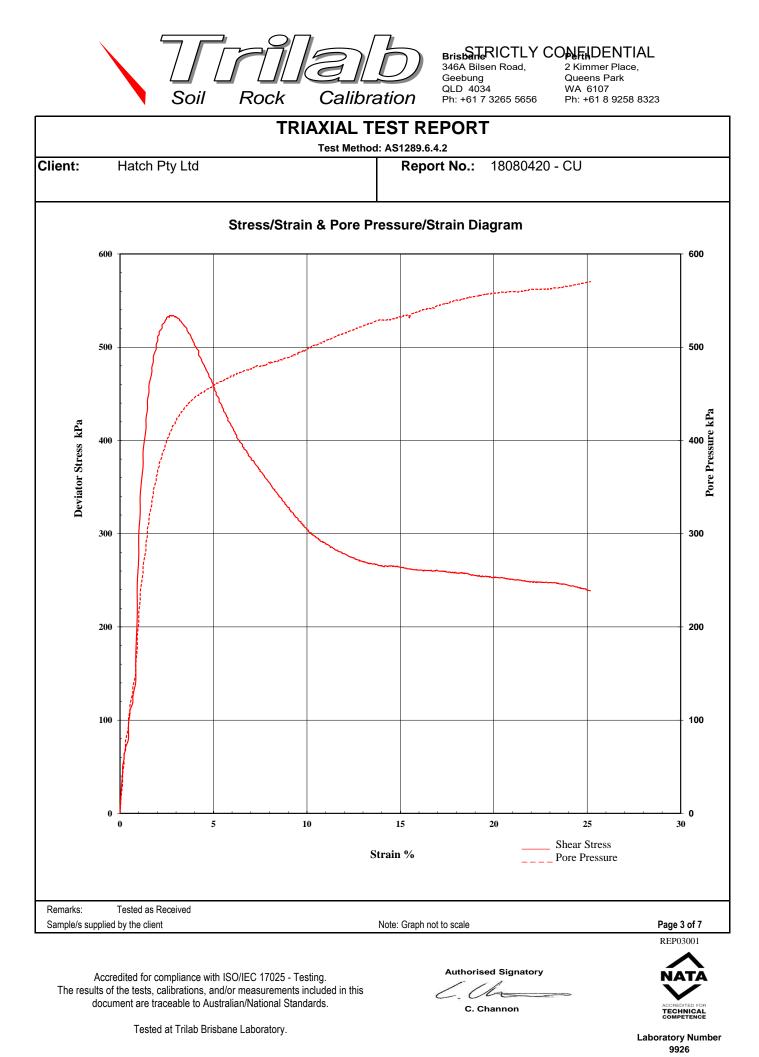


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					EST RE		Г			
Client:	Hatch Pty Ltd					ort No.:	180804	20 - CU		
000			N	lohr Cir	cle Diagra	am				
900										
800										
700										
600										
Shear Stress (kPa) 000										
Shear St										
300										
200										
100										
	100	200	300	400) 50	0	600	700	800	900
			P	rincipal St	ress (kPa)					
	Angle		sistance Φ'	n C' (kPa)	:	ncipal Stres	s Ratio			
Remarks: Sample/s sup	Tested as Received plied by the client				Note: Graph ne				Ра	ge 2 of 7
The result	Accredited for compliance is of the tests, calibrations ocument are traceable to Tested at Trilab E	, and/or meası Australian/Nati	urements inclue ional Standard	ded in this		6.0	d Signatory			EP03001

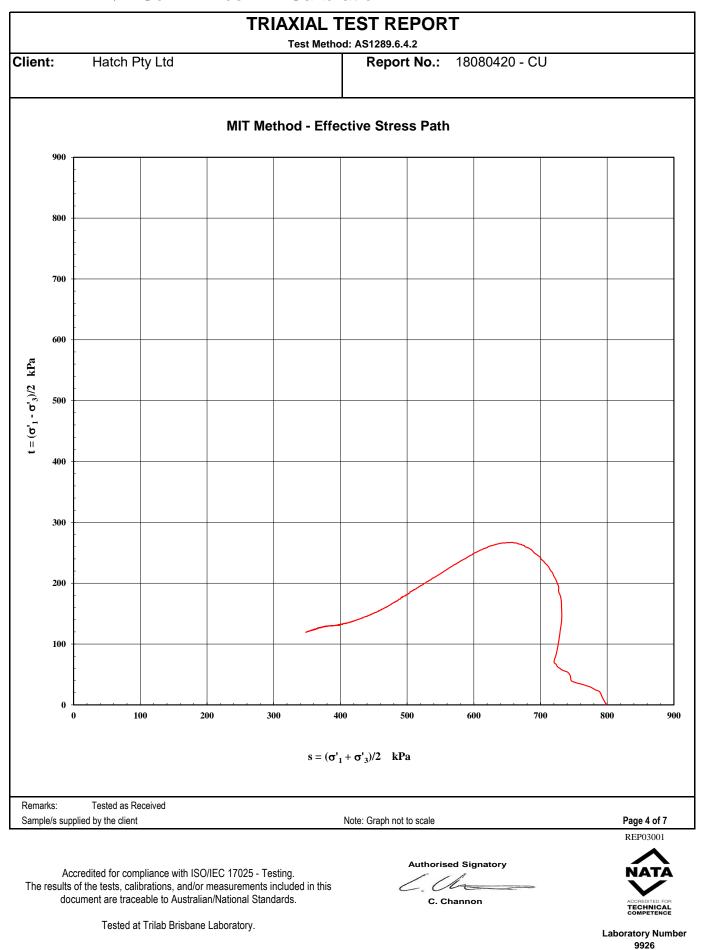
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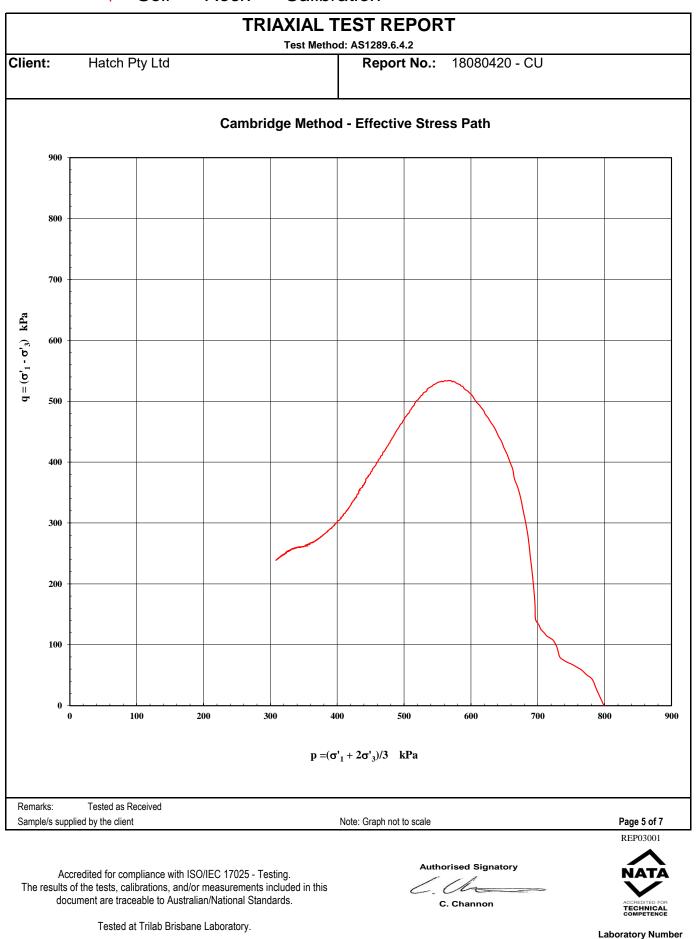


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		TRIAXIAL TE Test Method:	AS1289.6.4.2	XI				
nt:	Hatch Pty Ltd	Report No.: 18080420 - CU						
Γ	CLIENT:	Hatch Pty Ltd						
	PROJECT:	H356804 - Cadia M Failure	NTSF	BEFORE TEST				
	LAB SAMPLE No.			DATE: 28/08/18				
	BOREHOLE:	CE417 - DH406 L	2B	DEPTH: 18.50-19.0	0			
F	CLIENT:	Hatch Pty Ltd						
	PROJECT:	H356804 - Cadia I Failure	NTSF	AFTER TEST				
	LAB SAMPLE No.	18080420		DATE: OT. PALLS	ATE: OT. PALLE			
	BOREHOLE:	CE417 - DH406 L	2B	DEPTH: 18.50-19.0	0			
arks:	Tested as Received supplied by the client	NI	ote: Photo not to scale		Page 6 of			
16/5 5	อนคุณอน มห เมอ เมอมเ	INC.			REP0300			
resu	Accredited for compliance with ISC Its of the tests, calibrations, and/or document are traceable to Australia	measurements included in this	6.0	Sed Signatory				

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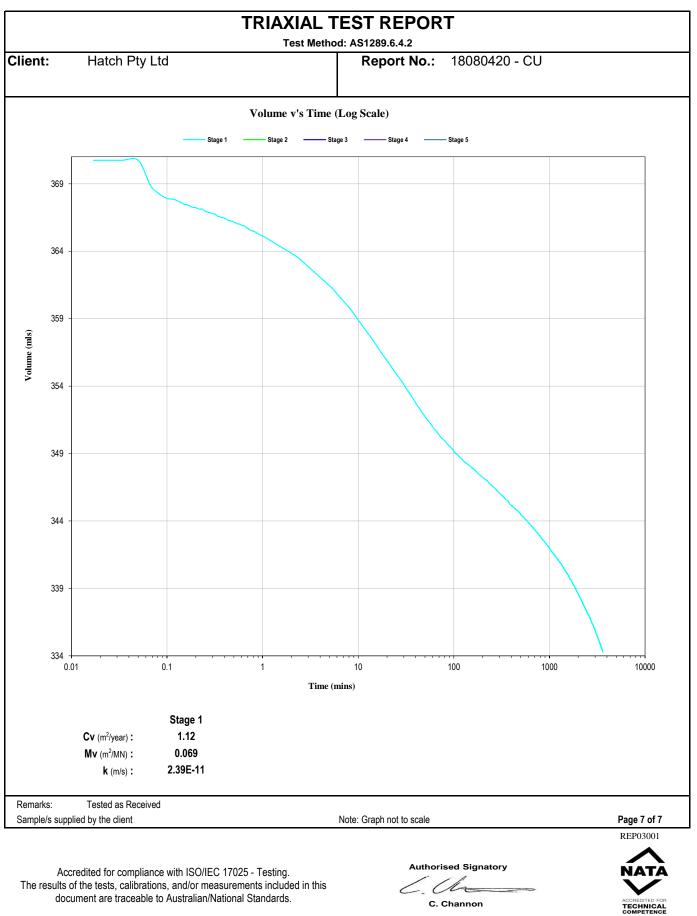


Brisbart RICTLY CONFIDENTIAL 346A Bilsen Road, Geebung

QLD 4034 Ph: +61 7 3265 5656

2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

> Laboratory Number 9926



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Queens Park WA 6107 Ph: +61 8 9258 8323

			•		XIAL TE	-	-			
Client:	Hatch P	ty Ltd						Report No.:	18080420 - C	U
		-					Wo	orkorder No.	0004681	
Address	PO Box	425 SP	RING HI	LL QLE	0 4004			Test Date:	30/08/2018	
							R	Report Date:	12/09/2018	
Project:	H356804	4 - Cadia	a NTSF I	Failure						
Client Id.:	CE417 -	DH406	L2B			De	pth (m):	18.50-19.00		
Description:	SILTY C	LAY- or	ange an	d grey						
				SA	MPLE & TE	ST DETA	AILS			
Initial Height:	130.8	mm		Initial N	loisture Content:	41.1	%	Ra	te of Strain: 0.005	%/min
Initial Diameter:		mm		Final M	loisture Content:	45.3	%	В	Response: 98	%
L/D Ratio:	2.0 : 1				Wet Density:		t/m ³ t/m ³			
Sample Type:	Sinale Indivi	dual Undist	urbed Specir	men	Dry Density:	1.22	VIII			
				-						
					TEST RE	SULTS	6			
					FAILURE D	ETAILS				
	Confining	Back		Failure		Principal Eff	ective Stresse		Deviator Stress	Strain
Effective Pressure	Pressure	Pressure	Initial Pore	Pore	σ ' ₁		σ'₃	σ' ₁ / σ' ₃		-
194 kPa	699 kPa	505 kPa	505 kPa	589 kPa	380 kP		110 kPa		270 kPa	3.25 %
394 kPa	899 kPa	505 kPa	505 kPa	683 kPa	611 kP	а	216 kPa	a 2.828	395 kPa	5.88 %
				FA	ILURE EN	IVELO	PES			
			Interpreta		ween stages :	1 to 2				
			_		sion C' (kPa) :	48.0				
		Angle of	Shear Res		Φ' (Degrees) :	21.7		D. //		
				Fa	ailure Criteria:	Peak Pr	incipal Stres	s Ratio		
Remarks:	Tested as Re	ceived								
Sample/s supplied l		CEIVEU							Page	e 1 of 7
									-	P03001
										^
	dited for com						Authoris	sed Signatory	Ň	АТА
The results of t docum	the tests, call nent are trace						6.0	hannan	ACCF	REDITED FOR
	Testad at	Trilah Brick	ane Labora	ton			C. C	Channon		
	resteu at	I I III AU DI ISL	ane Labula	ισry.						

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Laboratory Number

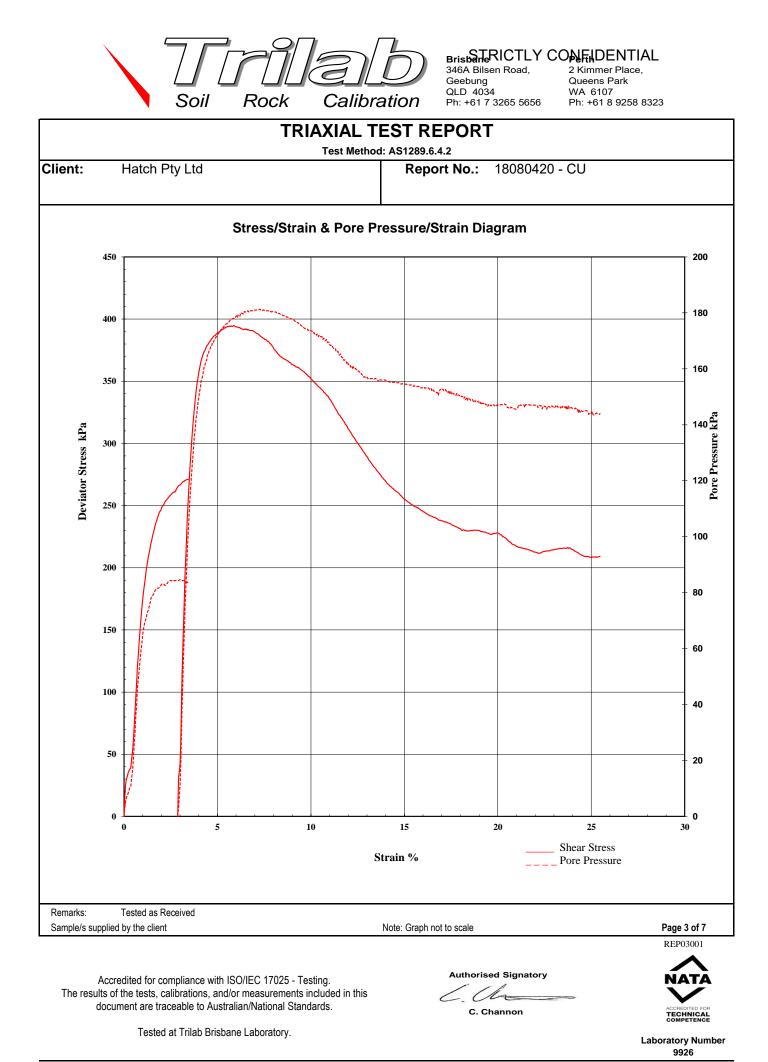


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Queens Park WA 6107 Ph: +61 8 9258 8323

				TRIAXIA Test M		ST REPC S1289.6.4.2	DRT			
Clien	it:	Hatch Pty Ltd				Report N	o.: 180804	420 - CU		
	700			Mohr	Circle	Diagram				
	700									
	600 -									-
	500									-
Shear Stress (kPa)	400									
Shear 5	300									-
:	200									-
	100									-
	0	100	200		300 al Stress	400 (kPa)	50	0 6	500 70	ב 00
		Angle of		tion between sta Cohesion C' (stance Φ' (Degr Failure Cr	kPa) : ees) :	l to 2 48.0 21.7 Peak Principal S	Stress Ratio			
Rema Samp		Tested as Received blied by the client				e: Graph not to sc			Page 2 of 7	
The	e results	ccredited for compliance wi s of the tests, calibrations, a pcument are traceable to Au Tested at Trilab Bri	nd/or measure Istralian/Natior	ements included in nal Standards.	this	Ć.	orised Signatory			
			SUATIC LADUIAL	ory.					Laboratory Nun 9926	nbe

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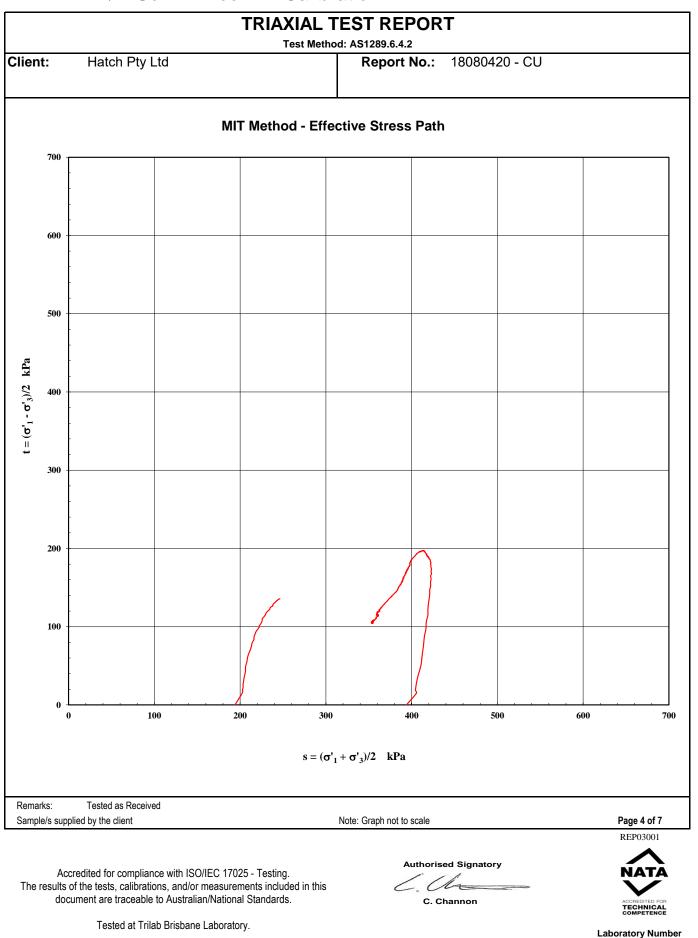


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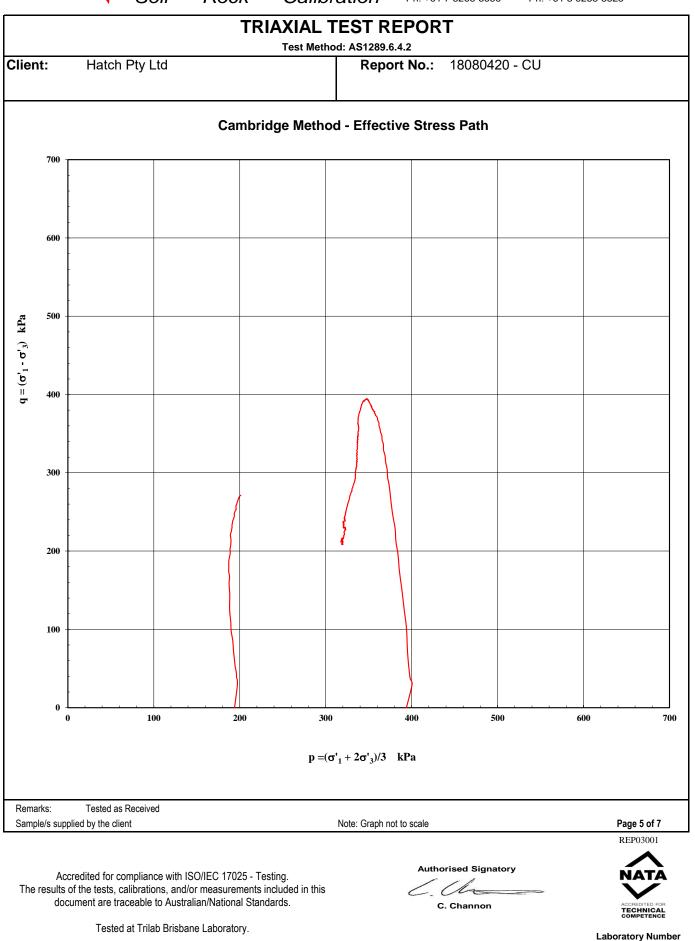


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> Laboratory Number 9926

		TRIAXIAL TEST RE Test Method: AS1289.6.4.		
Client:	Hatch Pty Ltd	Report	No.: 18080420 - CU	
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TEST	•
	LAB SAMPLE No.	18080420	DATE: 27/08/18	
	BOREHOLE:	CE417 - DH406 L2B	DEPTH: 18.50-19.0	0
	and a straight be		design of the second	
		State State State		
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTSF	AFTER TEST	
3		Failure		
	LAB SAMPLE No.		DATE: 12/09/18	
	BOREHOLE:	CE417 - DH406 L2B	DEPTH: 18.50-19.00	
Remarks:	Tested as Received			
Sample/s	supplied by the client	Note: Photo not to	scale	Page 6 of 7
				REP03001
	Accredited for compliance with ISO/II	EC 17025 - Testing.	uthorised Signatory	NATA
The resu	Its of the tests, calibrations, and/or m	easurements included in this	. Uh	\sim
(document are traceable to Australian	พลแบกลา อเลกนลานร.	C. Channon	ACCREDITED FOR TECHNICAL COMPETENCE

Tested at Trilab Brisbane Laboratory.

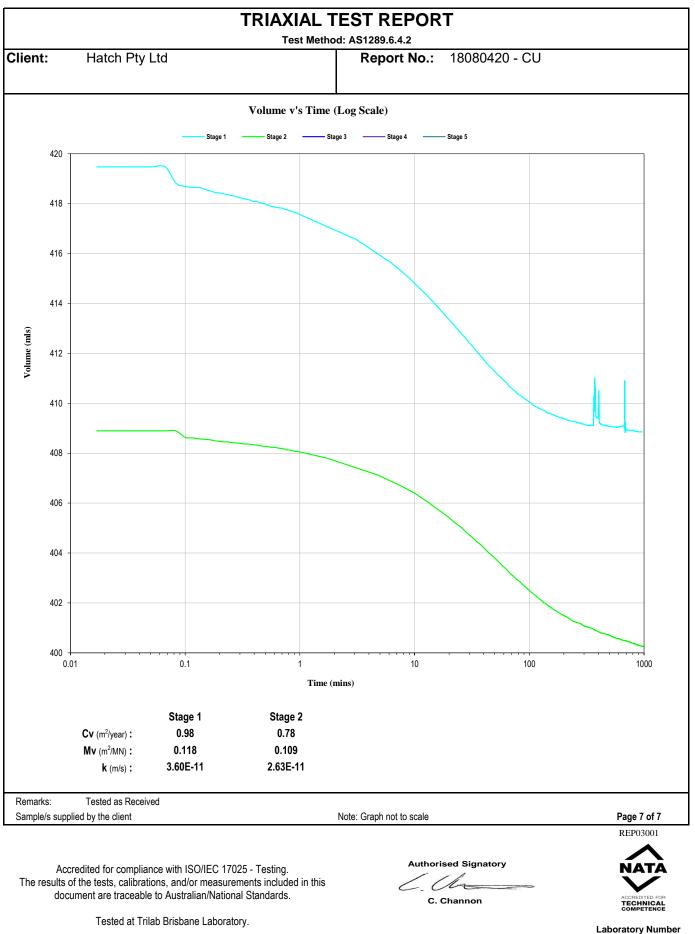
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9926

			•		XIAL TE	-	-			
Client:	Hatch P	ty Ltd						Report No.:	18080432 - C	U
							Wo	orkorder No.	0004681	
Address	PO Box	425 SPI	RING HI	LL QL	0 4004			Test Date:	30/08/2018	
							F	Report Date:	13/09/2018	
Project:	H356804	4 - Cadia	a NTSF I	Failure				•		
Client Id.:	CE411A	- DH40	9A L1			De	pth (m):	14.50-15.00		
Description:	SILTY C	LAY- m	ottled ora	ange y	ellow brown					
				SA	MPLE & TE	ST DETA	AILS			
Initial Height:		mm			loisture Content:	24.6	%	Ra	te of Strain: 0.005	%/min
Initial Diameter:		mm		Final N	loisture Content:	24.3	%	В	Response: 99	%
L/D Ratio:	2.1 : 1				Wet Density: Dry Density:		t/m ³ t/m ³			
Sample Type:	Single Indivi	dual Undistu	urbed Specir	men	Bry Bonony.	1.01	0111			
					TEST RE	SULTS	5			
	1				FAILURE D					
Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	σ' ₁	Principal Eff	$\frac{\text{ffective Stresses}}{\sigma'_{3}} \frac{\sigma'_{1} / \sigma'_{3}}{\sigma'_{1} / \sigma'_{3}}$		Deviator Stress	Strain
398 kPa	900 kPa	502 kPa	502 kPa	698 kPa	669 kP	а	202 kPa		467 kPa	3.20 %
786 kPa	1296 kPa	510 kPa	510 kPa	880 kPa	1239 kF	a	416 kPa	a 2.978	823 kPa	6.04 %
1194 kPa	1697 kPa	503 kPa	503 kPa	1063 kPa	1824 kF	^a	634 kPa	a 2.877	1190 kPa	8.47 %
				FA	ILURE EN	IVELO	PES			
			Interpreta		ween stages :	1 to 2	2 to 3		1 to 3	
					sion C' (kPa) :	40.2	37.2		39.2	
		Angle of s	Shear Resi		Φ' (Degrees) :	27.0	27.2	o Dotio	27.1	
				Γč	ailure Criteria:	Peak Pr	incipal Stres	s Ralio		
Remarks:	Tested as Re	ceived								1 of 7
Sample/s supplied I	by the client									e 1 of 7 P03001
	dited for com						Authoris	sed Signatory	N.	ATÀ
The results of t docum	the tests, calil nent are trace						6.0	h		REDITED FOR
doodii							C. C	Channon		CHNICAL IPETENCE
	Tested at	t Trilab Brisb	ane Laborat	tory.					Laborato	rv Number

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.

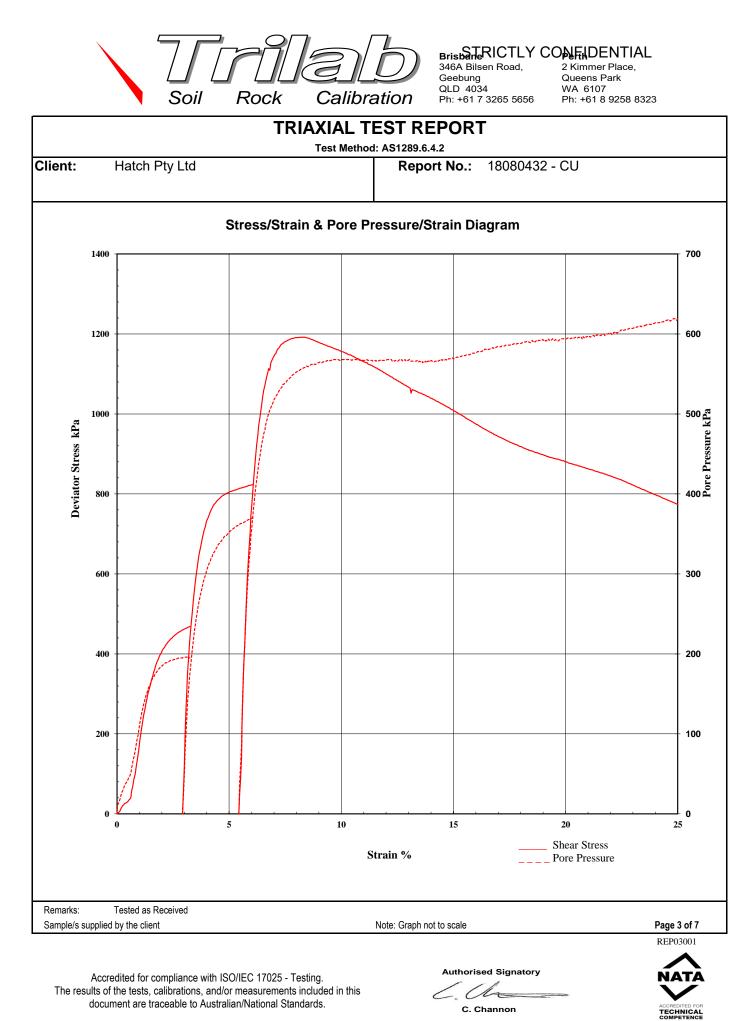


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					IAL TE		EPORT	•			
Client:	Hatch P	ty Ltd		16			ort No.:	18080432	- CU		
				M	ohr Circl	e Diaqı	ram				
2000						<u> </u>					
1800											
1600											
1400											
(kPa) s (kPa)											
Shear Stress (kPa) 0001 (kPa)											
800	-										
600	-										
400	-										
200											
0	0 200		00		800 ncipal Stre	1000 ss (kPa)	1200	1400	1600	1800	2000
		Angle o		ation betweer Cohesion istance Φ' (D	C' (kPa) : Degrees) :	1 to 2 40.2 27.0	2 to 3 37.2 27.2		1 to 39.2 27.2	2	
Remarks: Sample/s s	Tested as Re supplied by the client			Failure	e Criteria:	Peak Pr lote: Graph	incipal Stress	Katio			ge 2 of 7
The res	Accredited for con sults of the tests, ca document are trac	librations, a	and/or measur	ements include			Authorised		2		2P03001
	Tested	at Trilab Br	isbane Labora	tory.						Laborat	ory Number 9926

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Tested at Trilab Brisbane Laboratory.

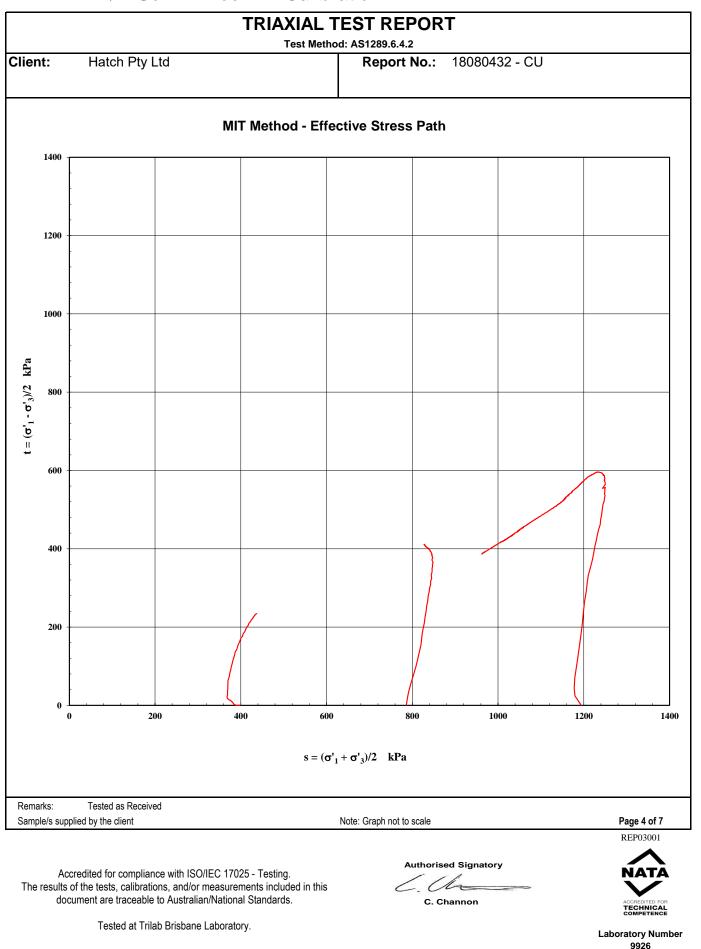
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Laboratory Number 9926



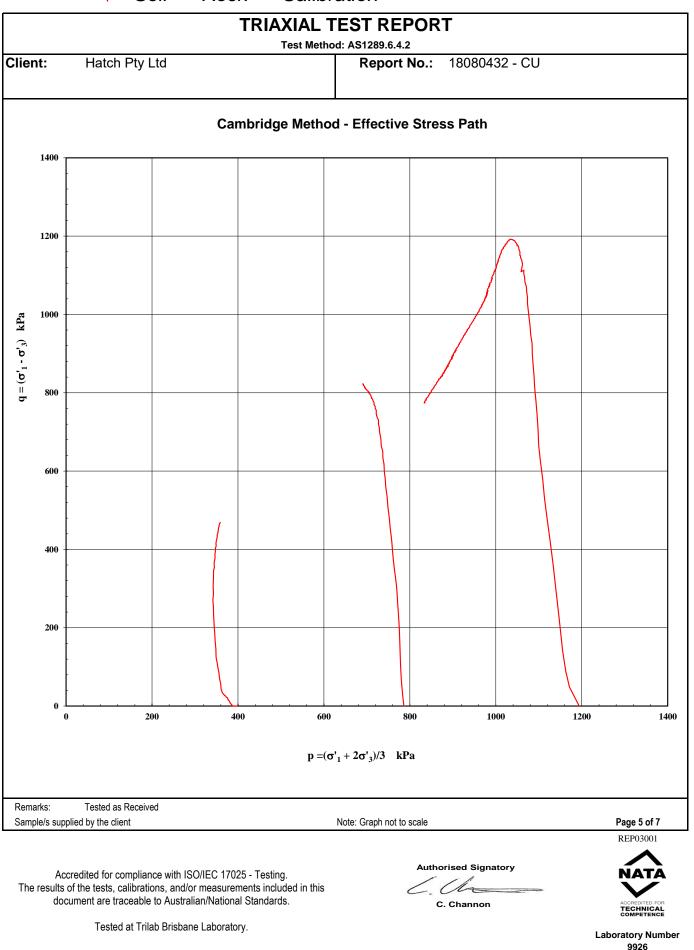
346A Bilsen Road, Geebung QLD 4034 Ph: +61 7 3265 5656 2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323



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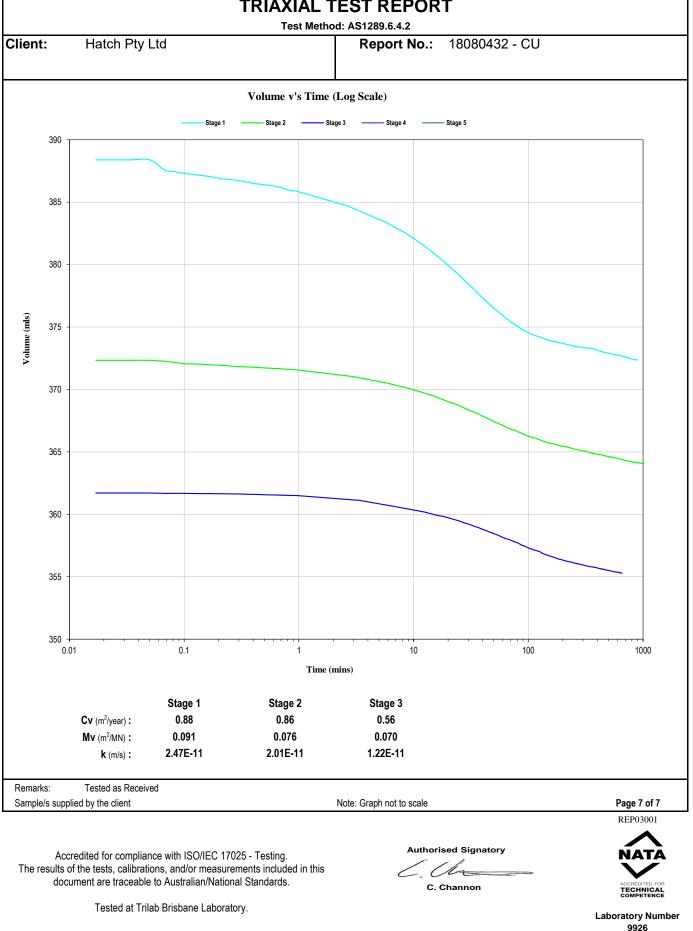
	3011			1 7 3265 5656 Ph: +61 8 9	200 0020		
		TRIAXIAL TES		RT			
lient:	Hatch Pty Ltd			18080432 - CU			
	CLIENT:	Hatch Pty Ltd					
	PROJECT:	H356804 - Cadia N	TSF	BEFORE TE	er		
	LAB SAMPLE No.	Failure 18080432		DATE: 27/08/1			
	BOREHOLE:	CE411A - DH409A	. L1	DATE: 24100110 DEPTH: 14.50-15.00			
[CLIENT:	Hatch Pty Ltd					
	PROJECT:	H356804 - Cadia N Failure	TSF	AFTER TEST DATE: en.en.18			
	LAB SAMPLE No.	18080432					
	BOREHOLE:	CE411A - DH409A	L1	DEPTH: 14.50-15.00			
Remarks: Sample/s s	Tested as Received upplied by the client	Note	: Photo not to scale		Page 6 of 7		
The resu	Accredited for compliance with ISO/ Its of the tests, calibrations, and/or r document are traceable to Australian Tested at Trilab Brisbane	neasurements included in this n/National Standards.	6.0	ed Signatory Acceleration	REP03001		

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2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

TRIAXIAL TEST REPORT Test Method: AS1289.6.4.2												
Client: Hatch Pty Ltd								Report No.:	18080436 - CU			
						Wo	orkorder No.	0004681				
Address PO Box 425 SPRING HILL QLD 4004							Test Date:	30/09/2018				
						Report Date: 13/09/2018						
Project: H356804 - Cadia NTSF Failure												
Client Id.:								23.00-23.50				
Description: SILTY CLAY- orange brown												
				SA	MPLE & TE							
Initial Height:	130.5	mm			loisture Content:	26.3	%		e of Strain: 0.006	%/min		
Initial Diameter: L/D Ratio:	61.0 2.1 : 1	mm		⊢inal M	loisture Content: Wet Density:	28.1 2.01	% t/m ³	В	Response: 98	%		
	4 .1.1				Dry Density:		t/m ³					
Sample Type: Single Individual Undisturbed Specimen												
TEST RESULTS												
		1			FAILURE D							
Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	σ' ₁	Principai Επ	Principal Effective Stresses		Deviator Stress	Strain		
1199 kPa	1698 kPa	499 kPa	499 kPa	1085 kPa	1592 kF	Da	613 kPa	σ'1 / σ'3 a 2.598	979 kPa	3.10 %		
					ILURE EN	IVELO	PES					
			Interpreta		ween stages :							
		Angle of a	Shear Resi		sion C' (kPa) : Þ' (Degrees) :							
Angle of Shear Resistance Φ' (Degrees) : Failure Criteria: Peak Principal Stress Ratio												
							·					
Remarks: Tested as Received												
Sample/s supplied by the client									Page REPO			
									^			
Accredited for compliance with ISO/IEC 17025 - Testing. Authorised Signatory								ΔTÀ				
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.								DITED FOR				
C. Channon TECHNICAL COMPETENCE												
Tested at Trilab Brisbane Laboratory.								Laborator 99				

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.

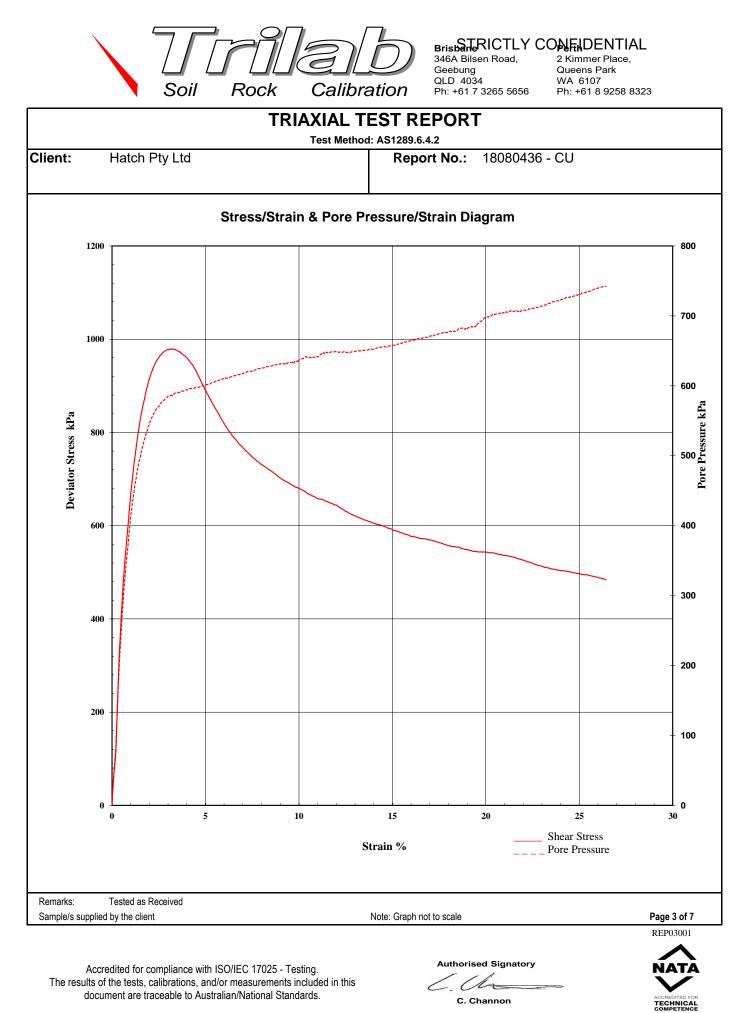


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		-	TRIAXIAL . Test Meth	TEST RE od: AS1289.6.4						
Client:	Hatch Pty Ltd				Report No.: 18080436 - CU					
			Mohr Ci	rcle Diagra	m					
1600										
- - 1400 -										
1200 -										
- - 0001 - -										
Shear Stress (kPa) 00										
600										
- 400 -										
200										
0										
0	200	400	600 Principal S	800 tress (kPa)	1000	1200	1400	1600		
	Angle o		n between stages Cohesion C' (kPa ance Φ' (Degrees Failure Criteri):):	ipal Stress Ratio)				
Remarks: Sample/s sup	Tested as Received oplied by the client			Note: Graph not	to scale			Page 2 of 7		
The resul	Accredited for compliance v ts of the tests, calibrations, locument are traceable to A Tested at Trilab B	and/or measurem ustralian/National	ents included in this Standards.	C	Authorised Signa	atory	I	REP03001		

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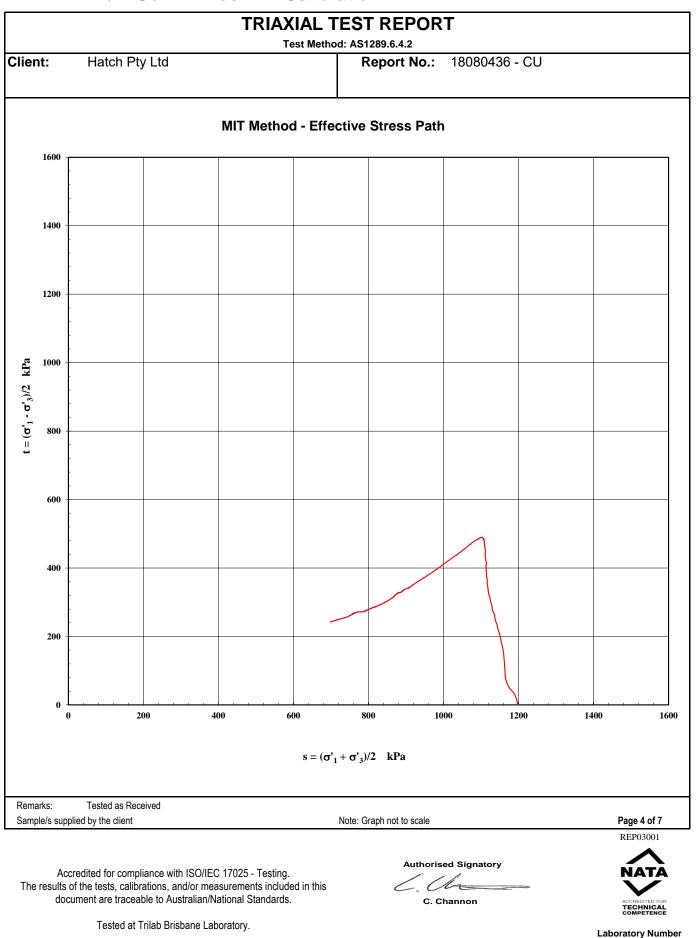
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Reference should be made to Trilab's "Standard Terms and Conditions of Business" for further details. Trilab Pty Ltd Laboratory Number 9926



346A Bilsen Road, Geebung QLD 4034 Ph: +61 7 3265 5656 2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

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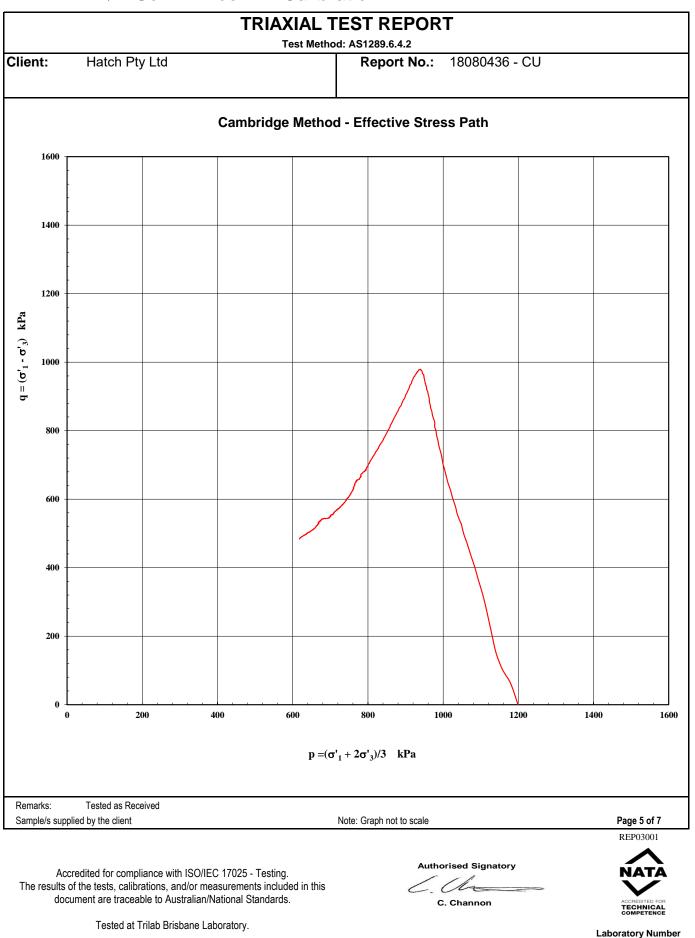


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		TRIAXIAL TEST RE Test Method: AS1289.6.4		
lient:	: Hatch Pty Ltd		t No.: 18080436 - CU	
22	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TEST	
	LAB SAMPLE No. BOREHOLE:	18080436 CE416 - DH407 L1B	DATE: 28/08/18 DEPTH: 23.00-23.50	
1		a carried		-
		-	State of the local division of the local div	
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTSF Failure	AFTER TEST	
T	LAB SAMPLE No.	18080436	DATE: 07.09.18.	
	BOREHOLE:	CE416 - DH407 L1B	DEPTH: 23.00-23.50	
		SUP	ALC: NO	
1		No. 1	Charles and	
		A TAN	Designation of the	
			A A BALLAND	
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			State State	
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emarks ample/	s: Tested as Received s supplied by the client	Note: Photo not	to scale	Page 6 of 7
				REP03001
			Authorised Signatory	\wedge
he re	Accredited for compliance with IS sults of the tests, calibrations, and/o	O/IEC 17025 - Testing.	- Un	
	document are traceable to Austral		C. Channon	
	Tested at Trilab Brisban	e Laboratory		COMPETE

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Laboratory Number

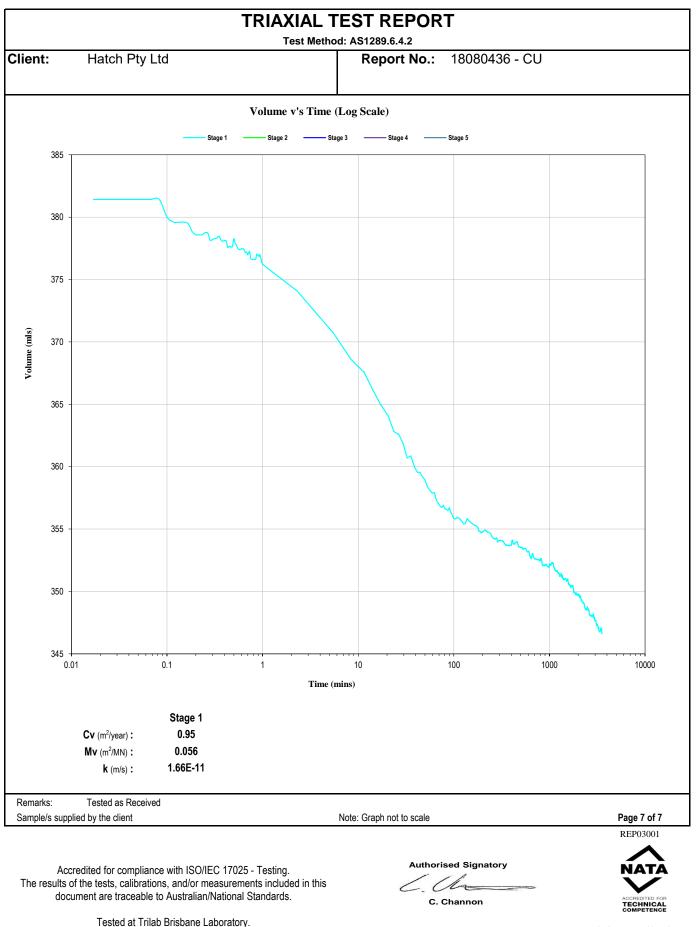


Brisbart RICTLY CONFIDENTIAL 346A Bilsen Road, Geebung

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> Laboratory Number 9926



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Geebung QLD 4034 Ph: +61 7 3265 5656

Queens Park WA 6107 Ph: +61 8 9258 8323

			-		XIAL TE	-	-			
Client:	Hatch P	ty Ltd						Report No.:	18080436 - C	U
							Wo	rkorder No.	0004681	
Address	PO Box	425 SP	RING HI	ll QL[D 4004			Test Date:	30/08/2018	
							R	Report Date:	13/09/2018	
Project:	H356804	4 - Cadia	a NTSF I	Failure				•		
Client Id.:	CE416 -	DH407	L1B			Dej	pth (m):	23.00-23.50		
Description:	SILTY C	LAY- or	ange bro	own						
				SA	MPLE & TE	ST DETA				
Initial Height:	129.9	mm		Initial N	loisture Content:	28.0	%	Rat	e of Strain: 0.006	%/min
Initial Diameter:		mm		Final N	loisture Content:	34.0	%	В	Response: 97	%
L/D Ratio:	2.1 : 1				Wet Density: Dry Density:		t/m ³ t/m ³			
Sample Type:	Single Indivi	dual Undist	urbed Specir	men	Dry Density.	1.57	UIII			
	0		•							
					TEST RE	SULTS	6			
		T			FAILURE D					1
	Confining	Back	Initial Dava	Failure	σ' ₁	Principal Eff	ective Stresse	σ'_1 / σ'_3	Deviator Stress	Strain
Effective Pressure 400 kPa	901 kPa	501 kPa	501 kPa	Pore 654 kPa	σ ₁ 691 kP	a	σ' 3 247 kPa		444 kPa	1.59 %
801 kPa	1302 kPa	501 kPa	501 kPa	791 kPa	1205 kF	-	511 kPa		694 kPa	2.68 %
				FA	ILURE EN	IVELO	PES			
			Interpreta	ation bet	ween stages :	1 to 2	_			
			interpret		sion C' (kPa) :	75.7				
		Angle of	Shear Res		Φ' (Degrees) :	18.7				
				Fa	ailure Criteria:	Peak Pri	incipal Stres	s Ratio		
Remarks:	Tested as Re	ceived								
Sample/s supplied l									Page	e 1 of 7
									REI	203001
	-1141 C	-l' '''		00F T	·		Authoris	ed Signatory		
Accre The results of t	dited for com the tests, cali						//	10		
	nent are trace						C. C	channon	ACCF	CHNICAL
	-	.							COM	MPETENCE

Laboratory Number 9926

Tested at Trilab Brisbane Laboratory.

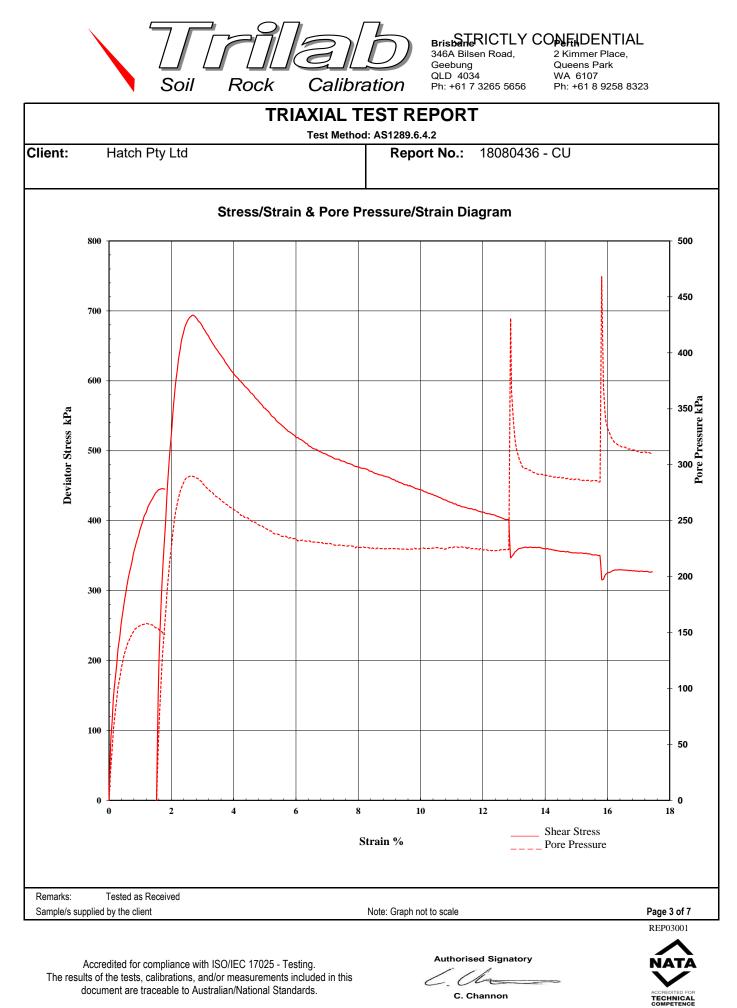
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		TRIAXIAL TE	EST REPOR	г	
Client:	Hatch Pty Ltd		Report No.:	18080436 - CU	
		Mohr Circ	le Diagram		
1400					
1200	-				
1000					
Shear Stress (kPa)	-				
Shear 009	-				
400	-				
200					
0	0 200 40	00 600 Principal Stre	800 ss (kPa)	1000	1200 1400
	Angle of Shear Res	ation between stages : Cohesion C' (kPa) : istance Φ' (Degrees) : Failure Criteria:	1 to 2 75.7 18.7 Peak Principal Stres	s Ratio	
Remarks: Sample/s s	Tested as Received upplied by the client		Note: Graph not to scale		Page 2 of 7 REP03001
	Accredited for compliance with ISO/IEC 17 ults of the tests, calibrations, and/or measu document are traceable to Australian/Nation Tested at Trilab Brisbane Labora	rements included in this onal Standards.	6.0	d Signatory	
			c instrument or sample at the time	e of test unless otherwise clearly stated.	Laboratory Number 9926



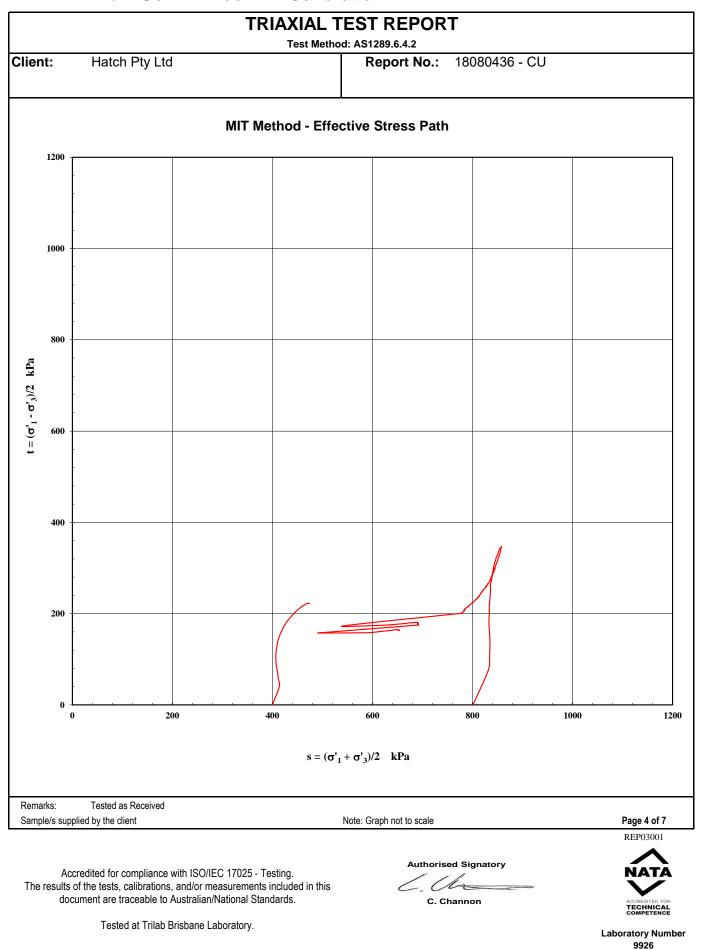
Tested at Trilab Brisbane Laboratory.

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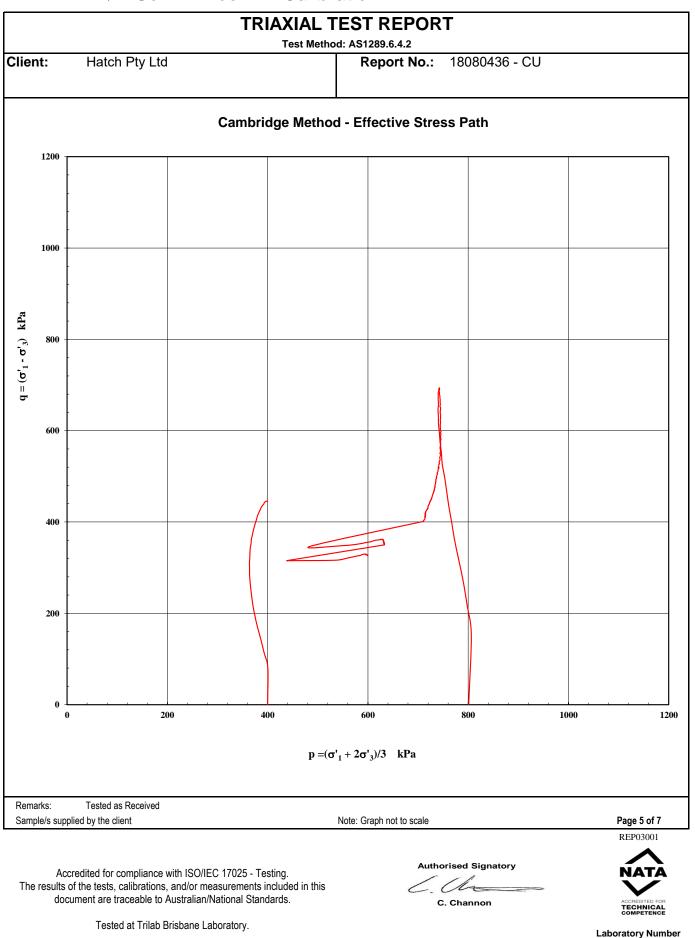


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Queens Park WA 6107 Ph: +61 8 9258 8323

lient:	Hatch Pty Ltd	Test Method: AS1289.6.4.2 Report No.:	18080436 - CU
15111.	Haton i ty Llu		10000-00
	CLIENT:	Hatah Pty I td	
	PROJECT:	Hatch Pty Ltd H356804 - Cadia NTSF	
	PROJECT:	Failure	BEFORE TEST
	LAB SAMPLE No.	18080436	DATE: 27 08 18
	BOREHOLE:	CE416 - DH407 L1B	DEPTH: 23.00-23.50
	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia NTSF Failure	AFTER TEST
	LAB SAMPLE No.		DATE: 07. 09. 10.
	BOREHOLE:	CE416 - DH407 L1B	DEPTH: 23.00-23.50
Remarks:	Tested as Received		
	upplied by the client	Note: Photo not to scale	Page 6 of 7
		C 17025 - Testing.	ed Signatory

Laboratory Number 9926

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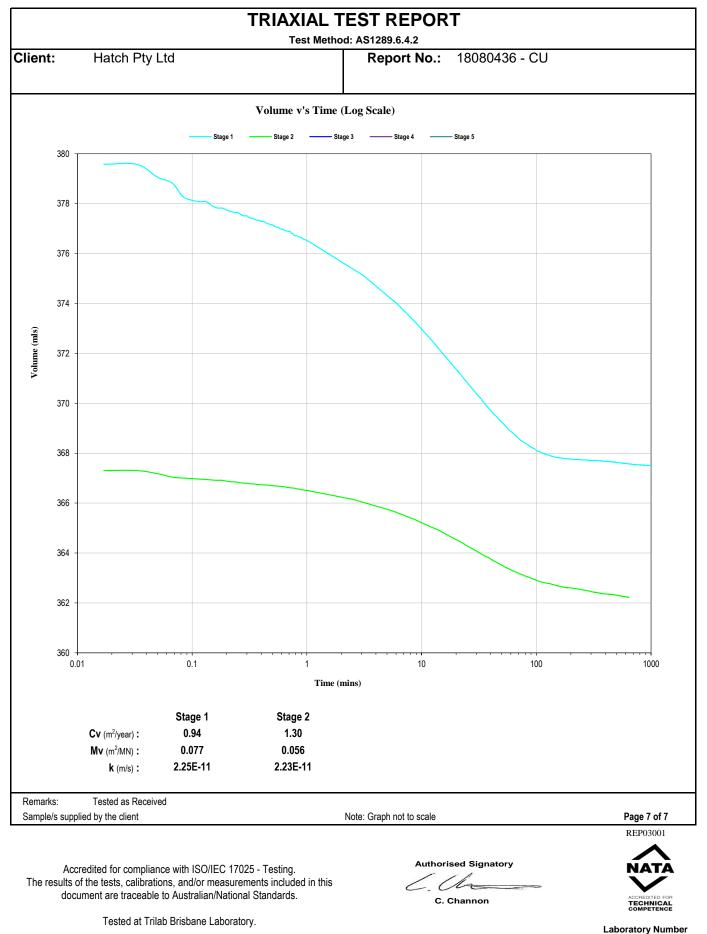


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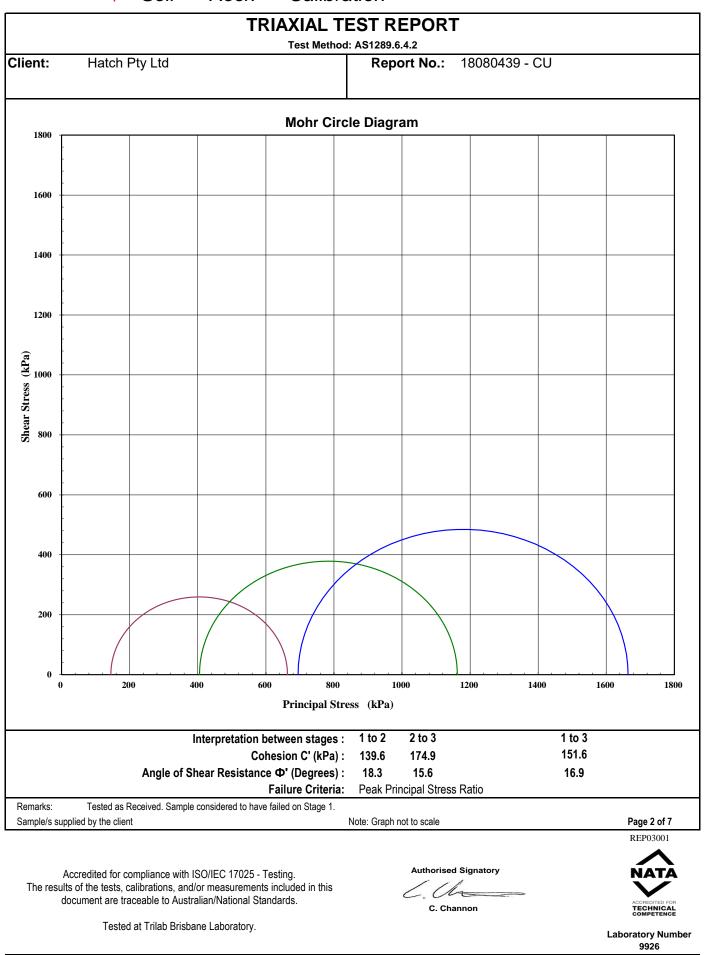
9926

			•		XIAL TES	-	-			
Client:	Hatch Pt	ty Ltd						Report No.:	18080439 - Cl	J
							Wo	orkorder No.	0004681	
Address	PO Box	425 SPI	RING HI	ll QLD	D 4004			Test Date:	30/09/2018	
							F	Report Date:	13/09/2018	
Project:	H356804	4 - Cadia	a NTSF I	Failure						
Client Id.:	CE416 -	DH407 PT3 Depth (m): 25						25.50-26.95	5	
Description:	SILTY C	LAY- br	own							
				SA	MPLE & TE	ST DFTA				
Initial Height:	129.3	mm		-	loisture Content:	38.7	%	Ra	te of Strain: 0.005	%/min
Initial Diameter:	63.3	mm		Final M	loisture Content:	38.8	%	B	Response: 97	%
L/D Ratio:	2.0 : 1				Wet Density:		t/m ³			
Sample Type:	Single Indivi	dual Undisti	Irbed Specir	men	Dry Density:	1.33	t/m ³			
					TEST RE	SULTS	6			
					FAILURE D	ETAILS				
	Confining	Back		Failure		Principal Eff	ective Stresse		Deviator Stress	Strain
Effective Pressure	Pressure	Pressure	Initial Pore	Pore	σ' ₁ 663 kP	-	σ' ₃	σ' ₁ /σ' ₃	519 kPa	0.74.0/
400 kPa 799 kPa	899 kPa 1298 kPa	499 kPa 499 kPa	499 kPa 499 kPa	754 kPa 893 kPa	003 KP 1162 kF		145 kPa 405 kPa		519 kPa 757 kPa	2.74 % 4.90 %
1203 kPa	1703 kPa	500 kPa	500 kPa	1008 kPa	1664 kF	Pa	695 kPa	2.396	970 kPa	6.81 %
				FA	ILURE EN	IVELO	PES			
			Interpreta	ation bet	ween stages :	1 to 2	2 to 3		1 to 3	
			-	Cohe	sion C' (kPa) :	139.6	174.9		151.6	
		Angle of	Shear Resi		Ф' (Degrees) :	18.3	15.6		16.9	
				Fa	ailure Criteria:	Peak Pr	incipal Stres	s Ratio		
Remarks: Sample/s supplied b		ceived. Samp	le considerec	d to have fa	iled on Stage 1.				Page	e 1 of 7
The results of t	ent are trace	orations, an able to Ausi	d/or measure	ements ind nal Standa	cluded in this		6.0	Sed Signatory		eorred For HNICAL PPETENCE

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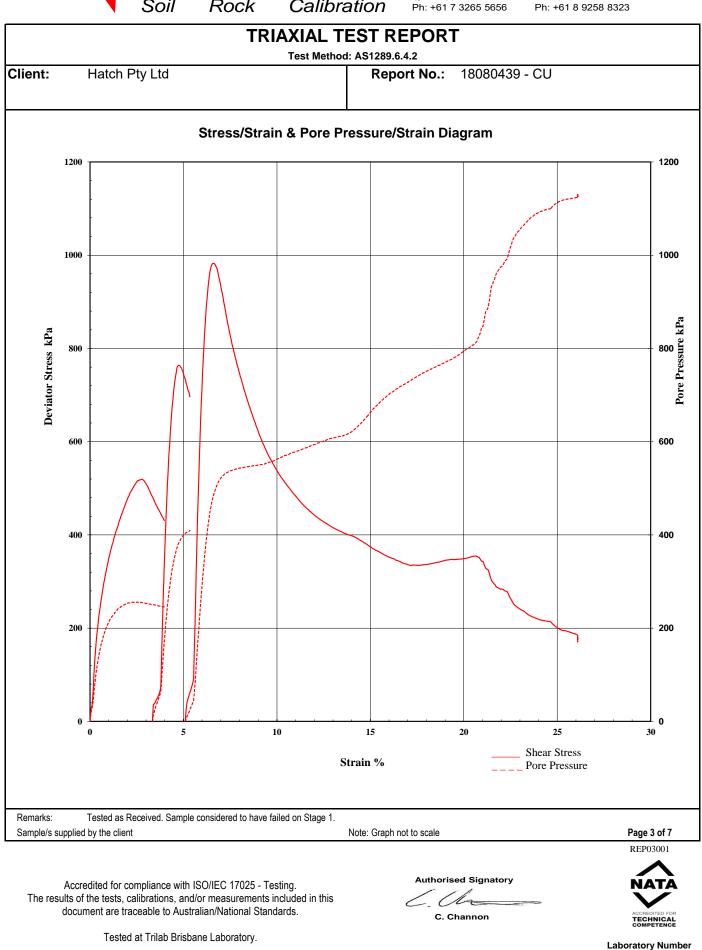


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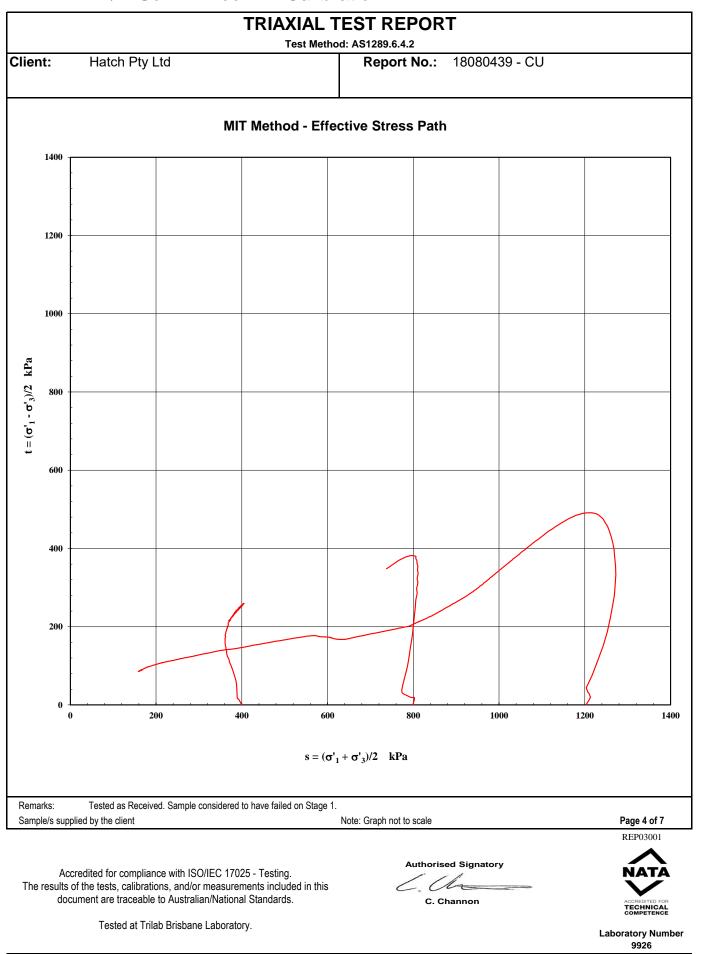
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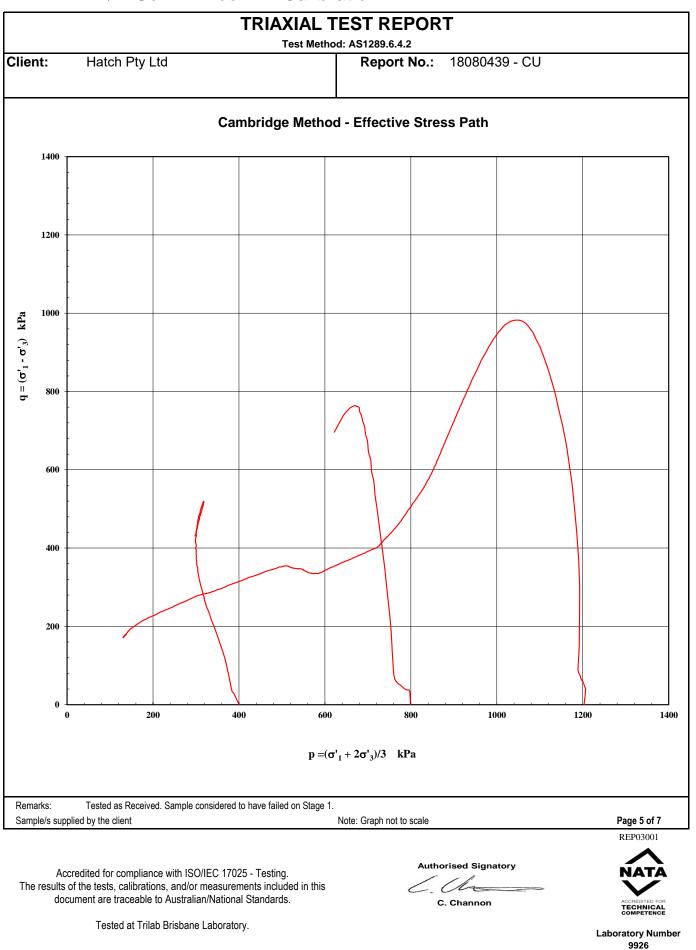
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		TRIAXIAL TEST Test Method: AS12		
Client:	Hatch Pty Ltd		eport No.: 18080439 - CU	
	CLIENT:	Hatch Pty Ltd	/	
	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TEST	
	LAB SAMPLE No.	18080439	DATE: 27/08/18	
	BOREHOLE:	CE416 - DH407 PT3	DEPTH: 25.50-26.9	5
	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia NTS Failure	AFTERTEST	
- 15	LAB SAMPLE No BOREHOLE:	. 18080439 CE416 - DH407 PT3	DATE: 004/18 DEPTH: 25.50-26.9	-
Remarks: Sample/s s	Tested as Received. Sample c supplied by the client	onsidered to have failed on Stage 1. Note: Pho	oto not to scale	Page 6 of 7
	Accredited for compliance with ISO	/IEC 17025 - Testing. measurements included in this	Authorised Signatory	REP03001

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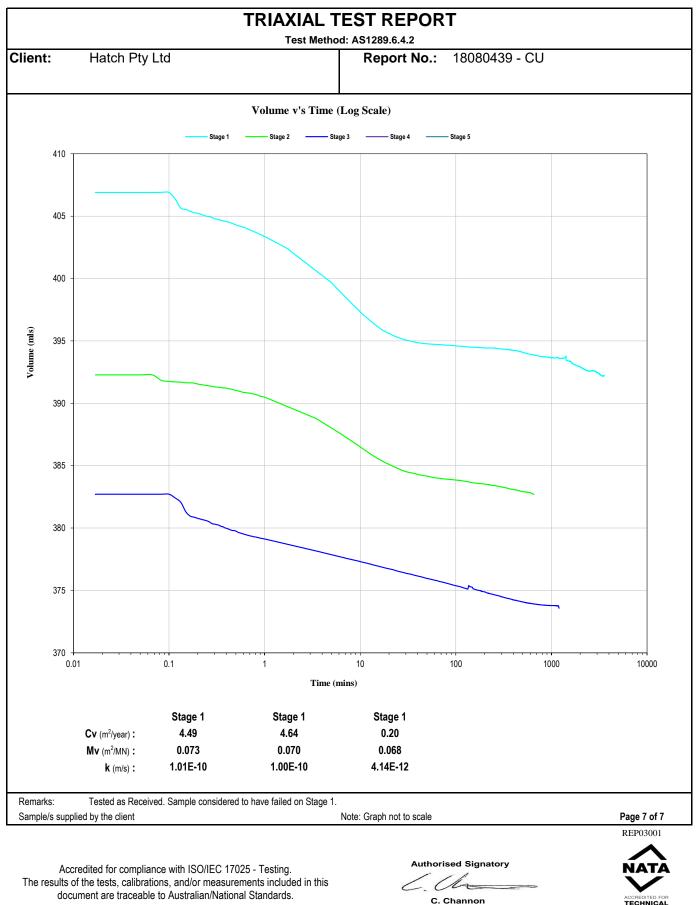
Brisbart RICTLY CONFIDENTIAL 346A Bilsen Road, Geebung QLD 4034

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Laboratory Number 9926



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					XIAL TES					
Client:	Hatch P	ty Ltd						Report No.:	18080441 - Cl	J
							Wo	orkorder No.	0004681	
Address	PO Box	425 SPI	RING HI	LL QLE	0 4004			Test Date:	30/09/2018	
							F	Report Date:	13/09/2018	
Project:	H356804	4 - Cadia	a NTSF I	Failure						
Client Id.:	CE416 -	DH407	L3C			Dep	oth (m):	26.50-27.00		
Description:	SILTY C	LAY- br	own							
				SA	MPLE & TE	ST DETA				
Initial Height:	129.3	mm			loisture Content:		%		e of Strain: 0.005	%/min
Initial Diameter: L/D Ratio:	61.4 2.1 : 1	mm		⊢ınal M	loisture Content: Wet Density:	37.9 1.88	% t/m ³	В	Response: 97	%
	4 .1.1				Dry Density:		t/m ³			
Sample Type:	Single Indivi	dual Undistu	urbed Specir	men	* *					
					TEST RE	SULTS	6			
					FAILURE D	ETAILS				
5 #	Confining	Back		Failure		Principal Eff	ective Stresse		Deviator Stress	Strain
Effective Pressure	Pressure 1701 kPa	Pressure 497 kPa	497 kPa	Pore 1046 kPa	σ' 1 1336 kF	D _a	σ' 3 655 kPa	σ' ₁ / σ' ₃ a 2.039	681 kPa	2.88 %
1207 NF a	IIVI NEd	τσι κΓα	777 NF a	IUTU KEA	1000 KF	u	000 876	2.000	UUT NEA	2.00 /0
				FA	ILURE EN	IVELOI	PES			
			Interpreta		ween stages :					
					sion C' (kPa) :					
		Angle of	Shear Res		Φ' (Degrees) : ailure Criteria:	Dook Dri	ncinal Stree	s Ratio		
				Га	anure Criteria:	reak Pfi	ncipal Stres	ร กันเบ		
Remarks:	Tested as Re	ceived								
Sample/s supplied b		551750							Page	e 1 of 7
									REP	03001
Accred	dited for com	pliance with	ISO/IFC 17	025 - Test	ina		Authoris	sed Signatory	N	
The results of t	he tests, cali	brations, an	d/or measure	ements ind	cluded in this		6.0	han	- 1	
docum	ent are trace	able to Aus	ralian/Natioi	nai Standa	ards.		C. C	Channon	ACCR TEC COM	
	Tested at	Trilab Brist	ane Labora	tory.						ry Number 926

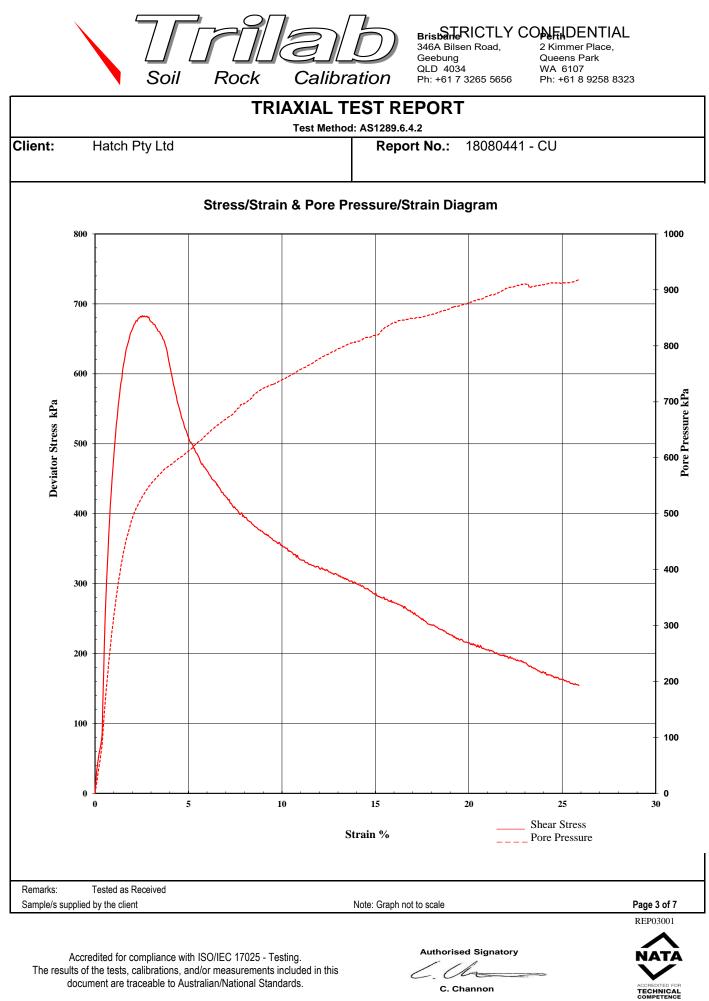
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				Т	
Client:	Hatch Pty Ltd	lest Method	Report No.:	18080441 - CU	
		Mohr Circ	le Diagram		
1400					
1200					
1000					
Shear Stress (kPa)					
Shear Str					
- 400 - - -					
200					
0 L	200	400 600	800	1000	1200 1400
		Principal Str	ess (kPa)		
		erpretation between stages : Cohesion C' (kPa) : ar Resistance Φ' (Degrees) : Failure Criteria:	Peak Principal Stres	ss Ratio	
Remarks: Sample/s sup	Tested as Received oplied by the client		Note: Graph not to scale		Page 2 of 7
The result	Accredited for compliance with ISC ts of the tests, calibrations, and/or locument are traceable to Australia	measurements included in this an/National Standards.	6.0	ed Signatory	REP03001
	Tested at Trilab Brisbane	b Laboratory. Ins and tests performed apply only to the spec			Laboratory Number 9926



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Test Method: AS1289.6.4.2 **Client:** Hatch Pty Ltd 18080441 - CU **Report No.: MIT Method - Effective Stress Path** 1400 1200 1000 $t = (\sigma'_1 - \sigma'_3)/2 \quad kPa$ 800 600 400 200 0 400 1400 0 200 600 800 1000 1200 $s = (\sigma'_1 + \sigma'_3)/2$ kPa Remarks: Tested as Received

TRIAXIAL TEST REPORT

Sample/s supplied by the client Note: Graph not to scale
Authorised Signatory

Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Tested at Trilab Brisbane Laboratory.

Authorised Signatory
C. Cha
C. Channon



Page 4 of 7 REP03001

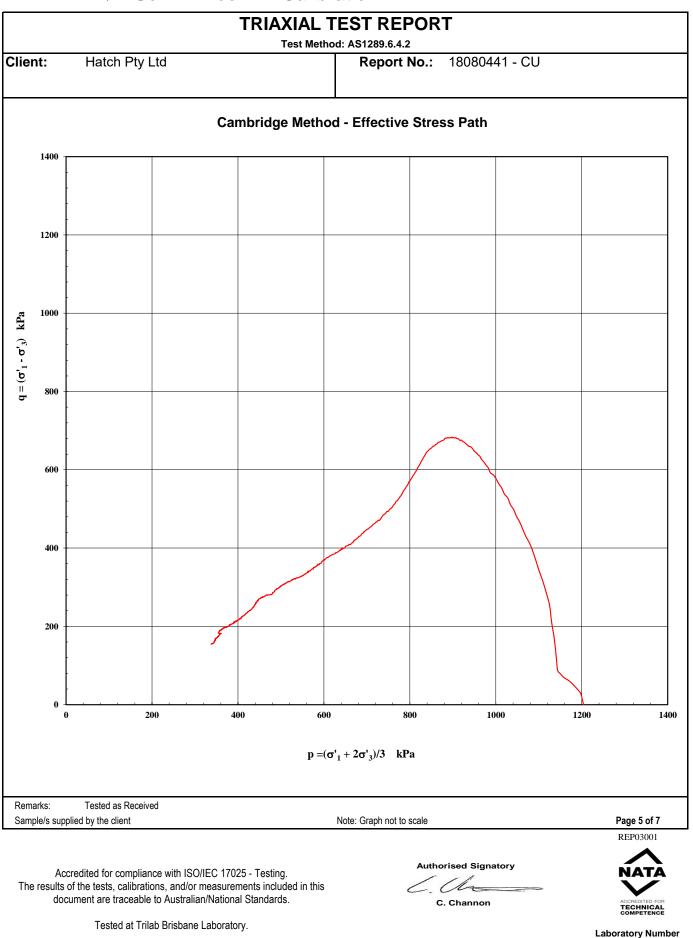
Laboratory Number 9926

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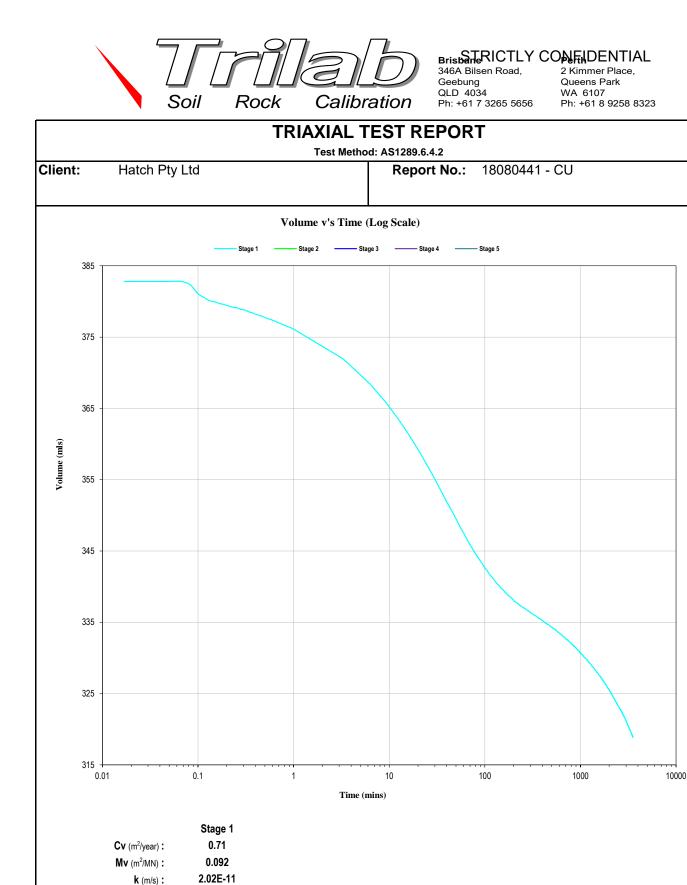


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		TRIAXIAL TES Test Method: AS		RT	
Client:	Hatch Pty Ltd		Report No.:	: 18080441 - CU	
	CLIENT:	Hatch Pty Ltd			
			FOR		
	PROJECT:	H356804 - Cadia N Failure	ISF	BEFORE TEST	Г
	LAB SAMPLE No.	18080441		DATE: 25 08 18	
	BOREHOLE:	CE416 - DH407 L30	C	DEPTH: 26.50-27.0	00
F	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia NTS	SF	AFTER TEST	
	LAB SAMPLE No.	Failure 18080441		DATE: 07/ 09/ 2018	
	BOREHOLE:	CE416 - DH407 L3C		DEPTH: 26.50-27.00	0
Remarks	:: Tested as Received s supplied by the client	Note	Photo not to scale		Page 6 of 7
·	Accredited for compliance with IS sults of the tests, calibrations, and/o document are traceable to Australi	D/IEC 17025 - Testing. • measurements included in this		sed Signatory	
	Tested at Trilab Brisban		1		Laboratory Num 9926

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.



Sample/s supplied by the client Note: Graph not to scale Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations, and/or measurements included in this a document are traceable to Australian/National Standards.

Remarks:

Tested as Received

Tested at Trilab Brisbane Laboratory.

Authorised Signatory

C. Channon

TECHNICAL Laboratory Number 9926

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Queens Park WA 6107 Ph: +61 8 9258 8323

				TRIAXI							
Client:	Hatch	Ptv Ltd		Tes	t Method: A	51289.6.4		Report No.:	180804	41 - C	U
		· · , _ · · ·					\M/				-
Address	PO Bo	x 425 SF	PRING H	ILL QLD 4	004						
Project:	L13568	04 Cod		Failura				Neport Date.	13/09/2	.010	
				i alluie		De	nth (m):	26 50-27 00			
					I	De	pui (iii).	20.00-21.00			
Description.		OLAT -I	5100011	C A MI							
Initial Height	t: 131.2	mm						Rat	e of Strain:	0.005	%/min
-		mm				34.5	%			100	%
L/D Ratio	o: 2.1 : 1					1.91	t/m ³				
					Dry Density:	1.41	t/m³				
1	100			Mo	nr Circle	Diagra	m				
1.											
Client: Hatch Pty Ltd Report No.: 18080441 - CU Address PO Box 425 SPRING HILL QLD 4004 Test Date: 30/08/2018 Report Date: 13/09/2018 Report Date: 13/09/2018 Project: H356804 - Cadia NTSF Failure Depth (m): 26.50-27.00 Description: SILTY CLAY - brown SAMPLE & TEST DETAILS Rate of Strain: 0.005 % Initial Meight: 131.2 mm Initial Moisture Content: 35.6 % Brasponse: 100 % UD Ratio: 2.1:1 mm Initial Moisture Content: 35.6 % Brasponse: 100 % g g g Mohr Circle Diagram Mohr Circle Diagram 000 % Brasponse: 100 % g g g g g g g 1400 izo izo izo izo izo izo % Izo izo											
	Hatch Pty Ltd Report No.: 18080441 - CU s PO Box 425 SPRING HILL QLD 4004 Test Date: 30/08/2018 s: H356804 - Cadia NTSF Failure Report Date: 13/09/2018 d: CE416 - DH407 L3C Depth (m): 26.50-27.00 stion: SILTY CLAY - brown SAMPLE & TEST DETAILS IHeight: 1312 mm Initial Moisture Content: 35.6 % Rate of Strain: 0.005 %/ Depth (m): 26.50-27.00 Well Dessity: 1.31 Depth (m): 26.50-27.00 Simple for Cadia NTSF Failure Mole Cate Test DETAILS Initial Moisture Content: 35.6 % Rate of Strain: 0.005 %/ B Response: 100 % Dy Density: 1.41 tim ³ Mohr Circle Diagram Image for Mohr Circle Diagram <										
10	000				-						
	-										
a)	-										
(kP	500										
tress	-										
ar St	600										
She	-										
	400				Workorder No. 0004681 QLD 4004 Test Date: 30/08/2018 Report Date: 13/09/2018 Nure Depth (m): 26.50-27.00 SAMPLE & TEST DETAILS itial Moisture Content: 35.6 % Wet Density: 1.91 t/m ³ Dry Density: 1.41 t/m ³ Mohr Circle Diagram Mohr Circle Diagram 600 800 1000 1200 1400 Principal Stress (kPa) 100 100 1400 Principal Stress 110 2 200 1400 Principal Stress 120 1400 Principal Stress 110 2 200 1400 Principal Stress 110 2 200 1400						
	-										
,	200										8 8 8 9 005 %/min 00 % 9 Page 1 of 6
	200			Itest Date: 30/00/2018 Report Date: 13/09/2018 VTSF Failure Depth (m): 26.50-27.00 Mn SAMPLE & TEST DETAILS Rate of Strain: 0.005 %/min Initial Moisture Content: 35.6 % Rate of Strain: 0.005 %/min Unitial Moisture Content: 34.5 % B Response: 100 % Wet Density: 1.91 t/m³ Dry Density: 1.41 t/m³ Mohr Circle Diagram Mohr Circle Diagram Image: Content Conten Conten Conten Content Content Conten Content Content Content C							
			(
		200	40	0 6	<u> .</u> 00	800	1000	1200	1400		
				Princ	cipal Stress	(kPa)					
			Interpret								
					-						
		Angle of	f Shear Res								
Sample Type:	Single Indi	vidual I Indistu	rhed Specimor								
	-	งเนนส์ บาเนเรีย	ibeu opeciiilei	1						Pag	e 1 of 6
										RE	P03001

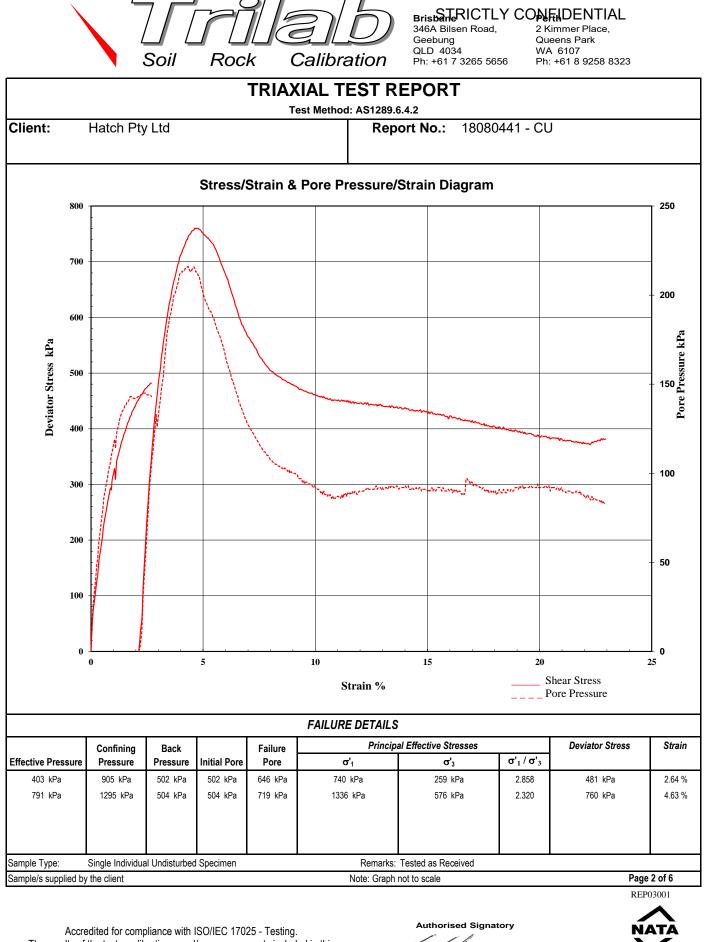
Accredited for compliance with ISO/IEC 17025 - Testing. The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.

Authorised Signatory C.Ch C. Channon

Laboratory Number 9926

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C. Channon

Laboratory Number 9926

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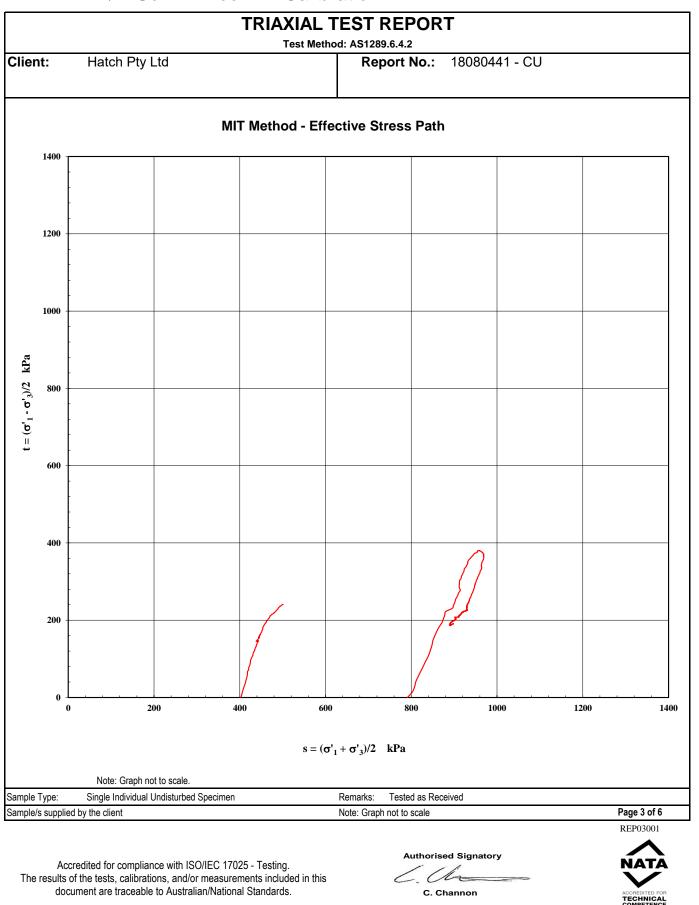
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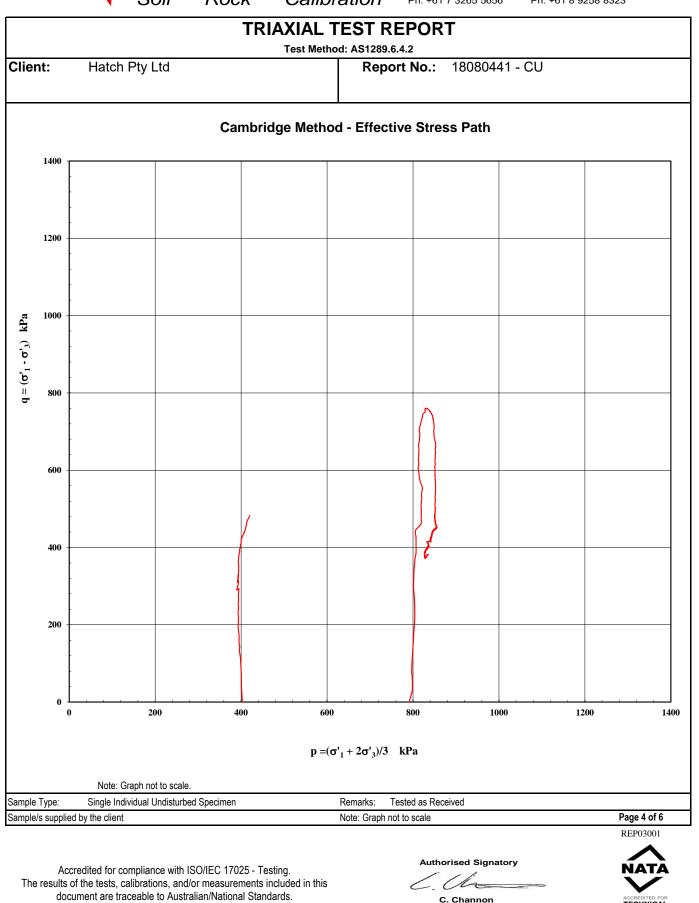
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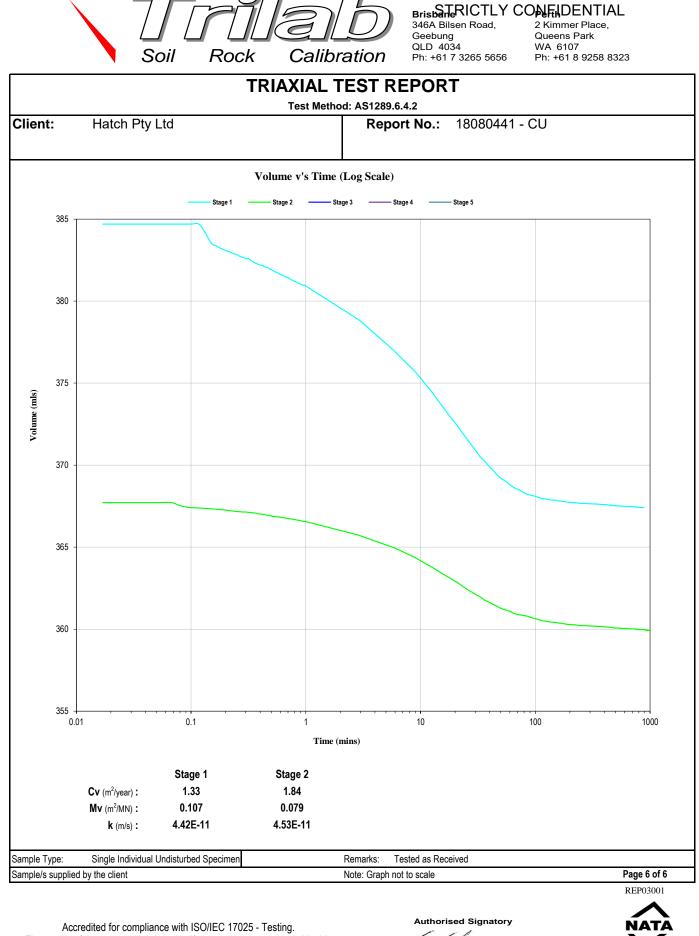
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ent:	Hatch Pty Ltd		Report No	.: 18080441 - CU	
	Trateri Fiy Liu		Report No	10000441-00	
1	CLIENT:	Hatch Pty Ltd		A CLARK STREET	
	PROJECT:	H356804 - Cadia	NTSF	BEFORE TEST	
	LAB SAMPLE No.	Failure 18080441		DATE: 27 08 18	
	BOREHOLE:	CE416 - DH407	L3C	DEPTH: 26.50-27.00	
	DOREHOLE				
				1991	100
				A Contraction	
				Star Ball	
2					
		Real Property lies			
	CLIENT:	Hatch Pty Ltd			
	PROJECT:	H356804 - Cadia	NTSF	AFTER TEST	
	LAB SAMPLE No.	Failure 18080441		DATE: 07.09.19	
	BOREHOLE:	CE416 - DH407	L3C	DEPTH: 26.50-27.00	
l					
	e: Single Individual Undisturbed S	Specimen		Received	Page 5 of 6
le/s su		Specimen	Remarks: Tested as Note: Graph not to scal		Page 5 of 6 REP03001
	e: Single Individual Undisturbed S		Note: Graph not to scal		
le/s su	e: Single Individual Undisturbed S)/IEC 17025 - Testing.	Note: Graph not to scal	e	

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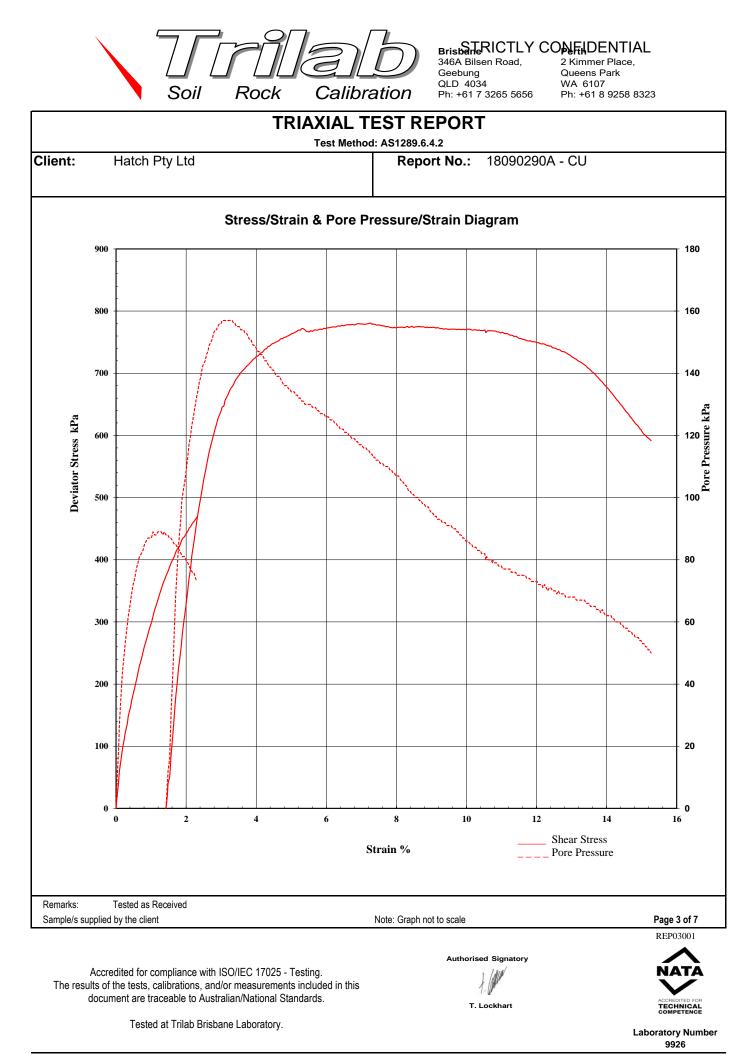
TRIAXIAL TEST REPORT												
Test Method: AS1289.6.4 Client: Hatch Pty Ltd							Report No.:	180000	18090290A - CU			
Chem.	Hatch Pty Ltd							-				
Address	ddress PO Box 425 SPRING HILL QLD 4004						Wo	orkorder No.	0004846			
Address	PO Box 425 SPRING HILL QLD 4004						Test Date:	25/09/20	25/09/2018			
							F	Report Date:	4/10/20	18		
Project:	H356804 - Cadia NTSF Failure - Request 8											
Client Id.:	CE432 -	L1B				pth (m):	19.80-20.30)				
Description: SILTY CLAY - brown/pale-brown												
SAMPLE & TEST DETAILS												
Initial Height:	131.4	mm		Initial Moisture Content: 24.2			%		te of Strain:	0.005	%/min	
Initial Diameter:	61.5	mm		Final Moisture Content: 24.8			% t/m ³	B Response: 97 %				
L/D Ratio:	2.1 : 1				Wet Density: Dry Density:	2.00 1.61	t/m ³					
Sample Type: Single Individual Undisturbed Specimen												
TEST RESULTS												
FAILURE DETAILS												
	Confining	Back		Failure		Principal Eff			Deviator Stress		Strain	
202 kPa	Pressure 700 kPa	498 kPa	498 kPa	Pore 576 kPa	σ' 1 574 kPa		σ' 3 124 kPa	$\frac{\sigma'_1 / \sigma'_3}{4.632}$	450 kF	20	2.08 %	
400 kPa	899 kPa	490 kPa	490 kPa	653 kPa	952 kPa		124 kPa 4.632 246 kPa 3.869		706 kPa		3.64 %	
									-			
				F 4								
				FA	ILURE EN		PES					
			Interpreta		ween stages :	1 to 2						
					sion C' (kPa) :	54.3						
		Angle of a	Snear Res		Φ' (Degrees) : ailure Criteria:	30.8 Peak Pr	incipal Stres	s Ratio				
					andre Onteria.	TCakii		3 1 400				
Remarks: Sample/s supplied b	Tested as Re by the client	ceived								Page	1 of 7	
biolo adphilod i	, onone										03001	
							Authorised Signatory			\checkmark		
Accredited for compliance with ISO/IEC 17025 - Testing.								N/	АТА			
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.								1.0		ACCRE	DITED FOR	
T. Lockhart TECHNICAL COMPETENCE										PETENCE		
									I		ry Number 26	

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TRIAXIAL TEST REPORT Test Method: AS1289.6.4.2									
Client	: Hatch Pty Ltd			Report No	b.: 18090290/	A - CU			
Mohr Circle Diagram									
10	00			_					
8									
	- -								
. (kPa)									
Shear Stress (kPa)									
4	00								
	- -								
2									
	0 20			60	0	800	1000		
				s (kPa)					
	Angle of	Interpretation between st Cohesion C' Shear Resistance Φ' (Deg Failure C	(kPa) : rees) :	1 to 2 54.3 30.8 Peak Principal S	Stress Ratio				
Remarks: Tested as Received Sample/s supplied by the client Note: Graph not to scale							Page 2 of 7		
Accredited for compliance with ISO/IEC 17025 - Testing.							REP03001		
Tested at Trilab Brisbane Laboratory.							Laboratory Numbe 9926	∍r	



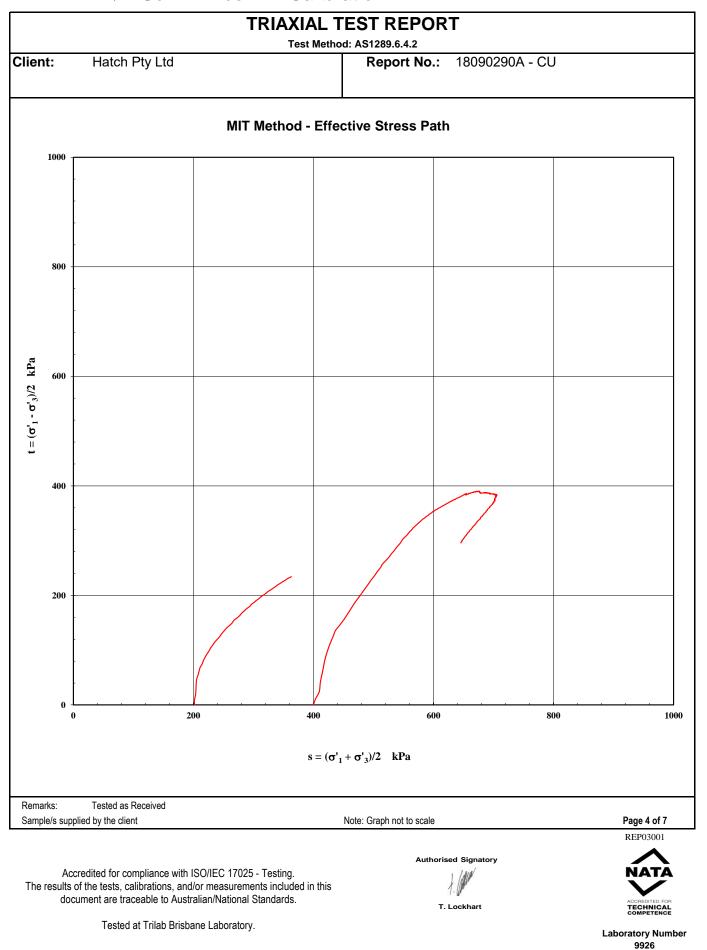
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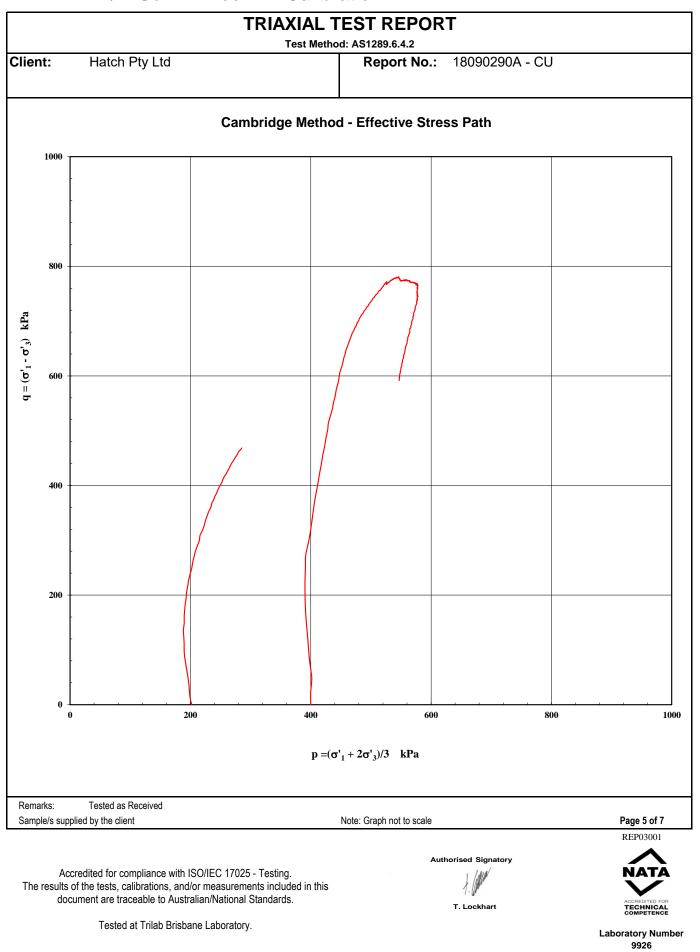
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> Laboratory Number 9926

		TRIAXIAL TE	EST REPOI : AS1289.6.4.2	RT	
Client:	Hatch Pty Ltd			18090290A - CU	
	CLIENT:	Hatch Pty Ltd	4		
	PROJECT:	H356804 - Cadia		BEFORE TEST	1.1
	LAB SAMPLE No.	Failure - Reques	st 8		
	BOREHOLE:	CE432 - L1B	1. 2. 2	DATE: 9/09/18 DEPTH: 19.80-20.30	
				DEI III. 19.80-20.30	
	PROJECT:	Hatch Pty Ltd H356804 - Cadia		AFTER TEST	
		Failure - Request 18090290 A	10	DATE: 3/10/1	8
		CE432 - L1B		DEPTH: 19.80-20.30	
Remarks:	Tested as Received				
Sample/s su	upplied by the client	Ν	lote: Photo not to scale		Page 6 of 7
The result	Accredited for compliance with ISO/IEC ts of the tests, calibrations, and/or mea ocument are traceable to Australian/Na	surements included in this		sed Signatory	REP03001

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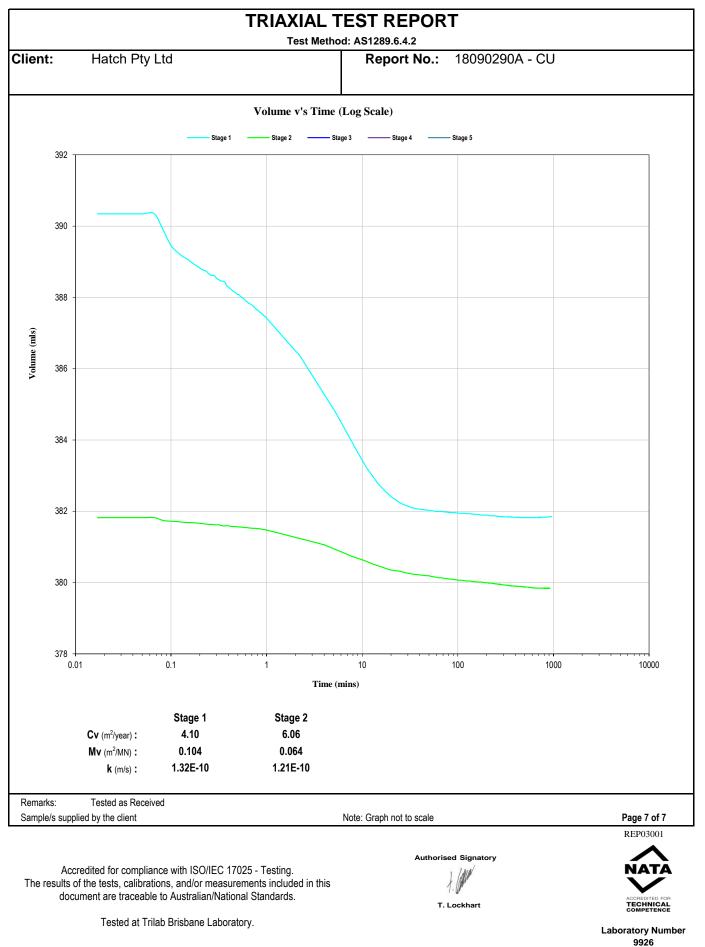
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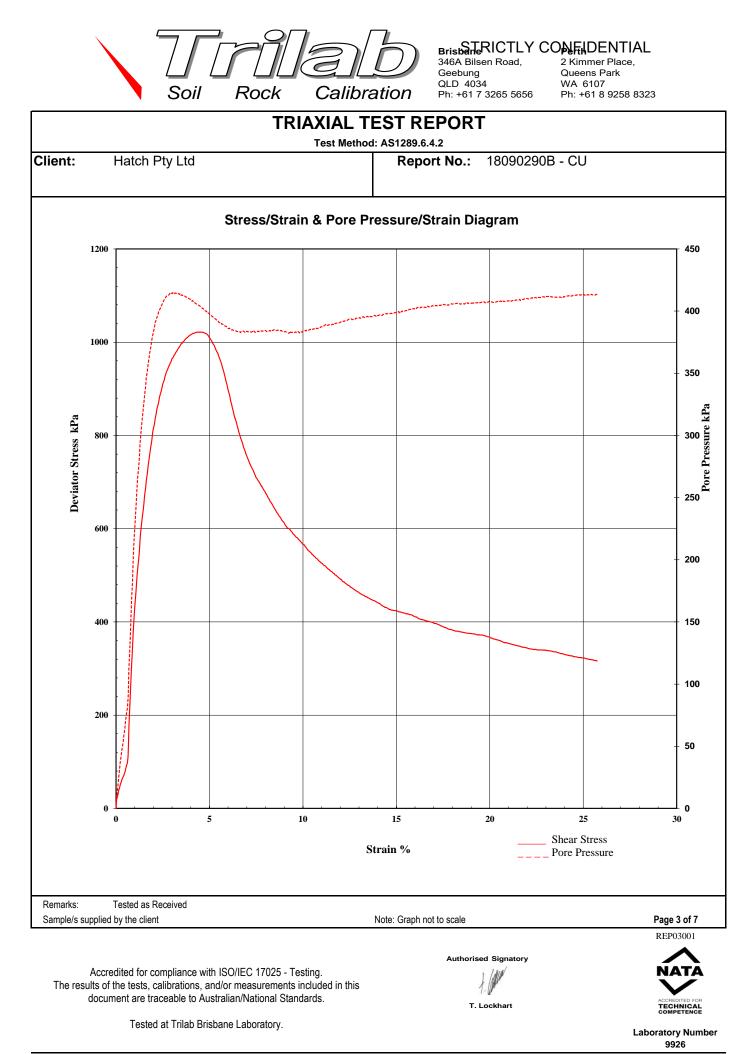
2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323

			•		XIAL TE						
Client:	Hatch Pt	tv Ltd			Test Method: A	\$1289.6.4		Report No.:	180902	90B - C	CU
		,						rkorder No.	000484		-
Address	PO Box	425 SPI	RING HI	LL QL	D 4004			Test Date:	27/09/20		
							R	eport Date:	4/10/20		
Project:	H356804	4 - Cadia	a NTSF I	Failure	- Request 8	}				-	
Client Id.:	CE432 -						pth (m):	19.80-20.30)		
Description:	SILTY C	LAY -br	own/ pal	e-brow	'n						
				SA	MPLE & TE	ST DET	AILS				
Initial Height:		mm			loisture Content:	24.2	%		te of Strain:	0.005	%/min
Initial Diameter: L/D Ratio:		mm		Final N	Noisture Content: Wet Density:	25.6 1.98	% t/m ³	В	Response:	96	%
	2.2.1				Dry Density:	1.59	t/m ³				
Sample Type:	Single Indivi	dual Undistu	urbed Specir	nen							
					TEST RE	SULTS	6				
	1	1			FAILURE D						
Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	σ' ₁	Principal Ef	fective Stresse σ' ₃	s σ'1/σ'3	Deviator S	Stress	Strain
795 kPa	1299 kPa	504 kPa	504 kPa	915 kPa	1392 kF	a	384 kPa		1009 k	Pa	3.77 %
							_				
				FA	ILURE EN	IVELO	PES				
			Interpreta		ween stages :						
		Angle of	Shoar Rosi		sion C' (kPa) : Φ' (Degrees) :						
		Aligie of			ailure Criteria:	Peak Pr	incipal Stress	s Ratio			
							•				
Remarks:	Tested as Re	ceived								_	
Sample/s supplied b	by the client										1 of 7 03001
							Authoris	ed Signatory			^
	dited for com							1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1		Ň.	ATĀ
The results of t docum	ne tests, calif ient are trace						- ·	Lockhart		ACCRE	
	Tested at	Trilab Brist	oane Laborat	tory.			1.1				
											y Number 26
	The re	esults of calibra	tions and tests p	erformed app	oly only to the specific in	strument or sai	nple at the time of	test unless otherwise clea	arly stated.		



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		TRIA		EST REI : AS1289.6.4.		Г		
Client:	Hatch Pty Ltd		Test Method	Report		18090290B -	CU	
			Mohr Circ	le Diagran	n			
1400				lo Diagram				
1200								
-								
1000								
-								
Shear Stress (kPa)								
hear St								
∞ ₆₀₀ –								
-								
400								
-								
200 -								
-								
0								
0	200	400	600 Principal Stro	80 ess (kPa)	0	1000	1200	1400
	Ir	iterpretation betw	-					
	Angle of Sh	ear Resistance Φ				.		
Remarks:	Tested as Received	Fai	lure Criteria:	Peak Princip		s katio		D 0 /-
Sample/s sup	plied by the client			Note: Graph not t	o scale			Page 2 of 7 REP03001
The result	accredited for compliance with IS s of the tests, calibrations, and/c	or measurements inc	luded in this		Autho	rised Signatory		NATA
do	ocument are traceable to Austra Tested at Trilab Brisbar		rds.			T. Lockhart		ACCREDITED FOR TECHNICAL COMPETENCE
			nnly only to the encor	ic instrument or some	le at the time	e of test unless otherwise clea		aboratory Number 9926



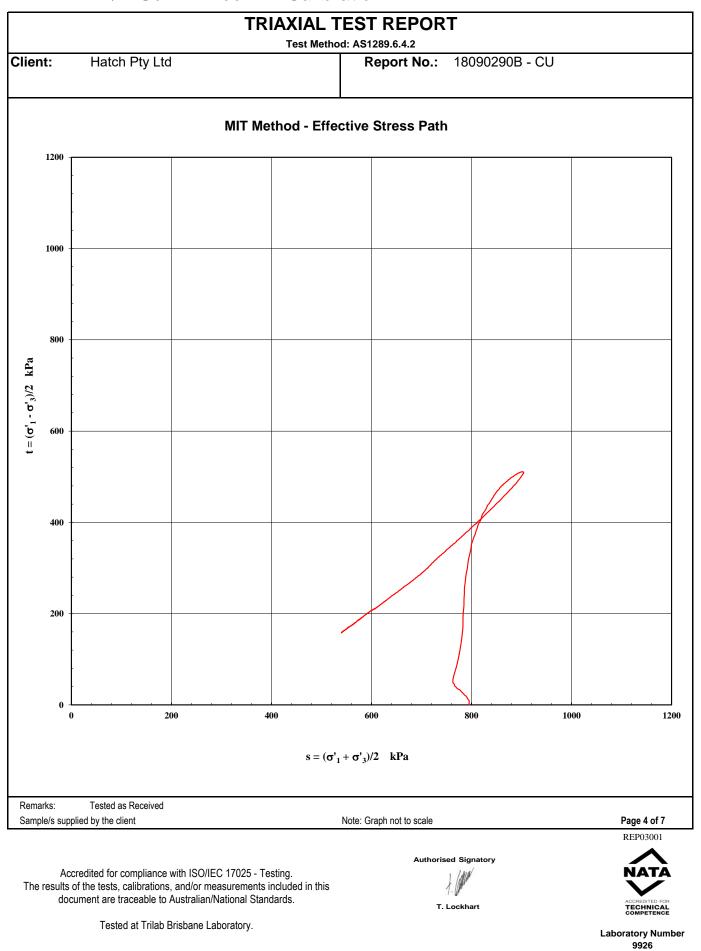
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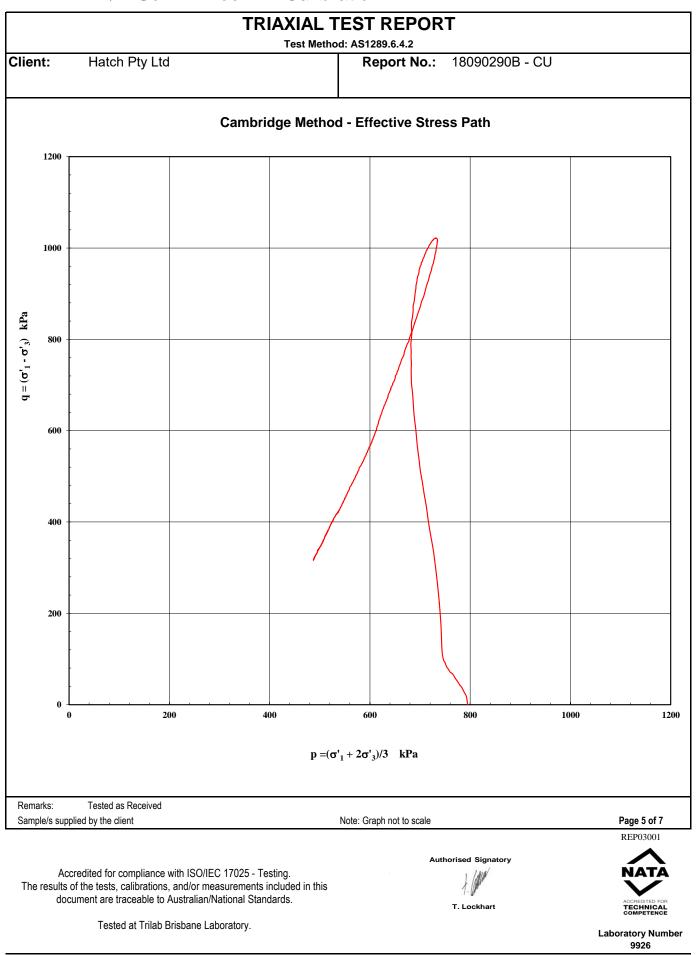
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> Laboratory Number 9926

		TRIAXIAL TE	EST REPC AS1289.6.4.2	DRT	
Client:	Hatch Pty Ltd		Report No	.: 18090290B - CU	
	CLIENT:	Hatch Pty Ltd			
- 1	PROJECT:	H356804 - Cadia		BEFORE TEST	
- 1	LAB SAMPLE No.	Failure - Reques	st 8	DATE: 19/08/18	_
- 1	BOREHOLE:	CE432 - L1B		DEPTH: 19.80-20.30	
- 1					
		Hatch Pty Ltd H356804 - Cadia N	TSF		7
		Failure - Request 8		AFTER TEST	
- 1		18090290 💪 CE432 - L1B		DATE: 02/\0/\8 DEPTH: 19.80-20.30	
	BOREHOLE:	CE432 - LIB		DEPTH: 19.80-20.30	
Remarks: Sample/s sup	Tested as Received plied by the client	N	ote: Photo not to scale	9	Page 6 of 7
Jampio/J Jup	price of the origin	- IN			REP03001
The results	credited for compliance with ISO/IEC of the tests, calibrations, and/or mea cument are traceable to Australian/Na	surements included in this	Autho	orised Signatory	

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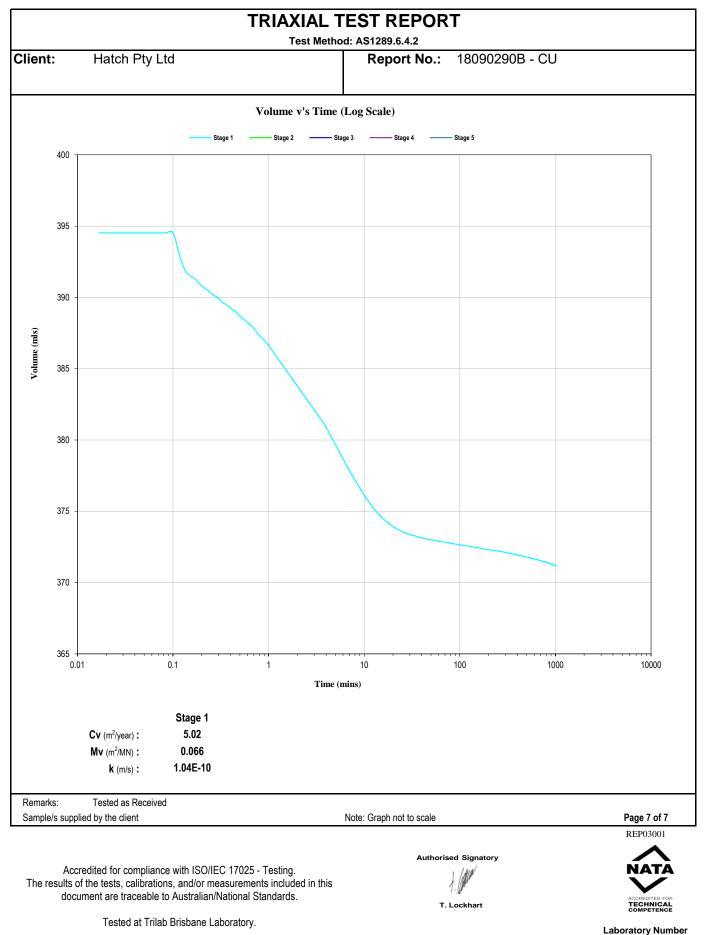


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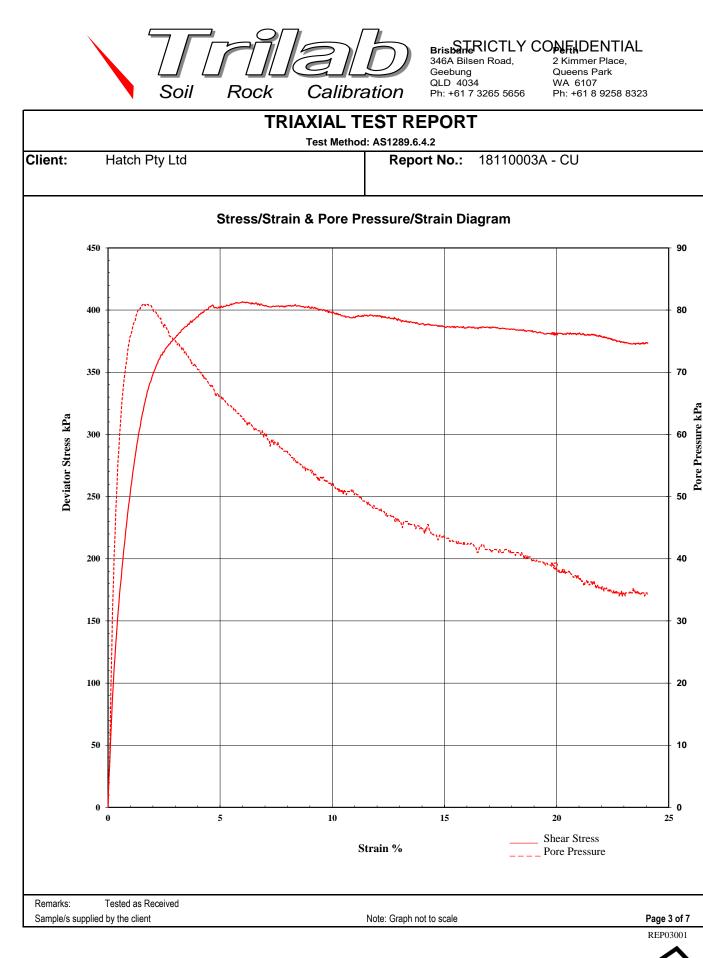
			-								
Client:	Hatch Pt	v I td			Test Method: A	S1289.6.4		Report No.:	1811000	34 (
Chem.	TIALCH FI	y Liu						-		3A - C	.0
Address	PO Box	125 QDI			1004		Wo	orkorder No.	0005081	_	
Address	FO DOX	423 SFI			5 4004			Test Date:	2/11/201		
							F	Report Date:	15/11/20	18	
Project:	H356804	4 - Cadia	a NTSF I	ailure							
Client Id.:	CE432 -	L1C - L	exan			De	pth (m):	20.30-20.80)		
Description:	SILTY C	LAY- gr	ey and o	range	brown						
				SA	MPLE & TE	ST DET	AILS				
Initial Height:	128.0	mm			loisture Content:	28.2	%			0.002	%/min
Initial Diameter:	60.8	mm		Final N	loisture Content:	27.8	%	В	Response:	98	%
L/D Ratio:	2.1 : 1				Wet Density: Dry Density:	1.94 1.52	t/m ³ t/m ³				
Sample Type:	Sinale Indivi	dual Undisti	urbed Specin	nen	Dry Density.	1.92	VIII				
					TEST RE	SULTS	S				
	-	ī			FAILURE D	ETAILS					
F (() D	Confining	Back		Failure		Principal Ef	fective Stresse	es σ'1/σ'3	Deviator Str	ress	Strain
Effective Pressure	Pressure 700 kPa	Pressure 504 kPa	504 kPa	Pore 583 kPa	σ' ₁ 481 kP	a	σ'3 117 kPa		364 kPa		2.35 %
130 Ki a	700 Ki a	504 Ki a	504 Ki a	505 Ki a	401 Ki	a		4.035	00 4 Ki d		2.55 %
							550				
					ILURE EN	IVELO	PES				
			Interpreta		ween stages :						
		Angle of			sion C' (kPa) :						
		Angle of	Shear Resi		Φ' (Degrees) : ailure Criteria:	Peak Pr	incipal Stres	s Ratio			
						TOURT		5 1440			
Remarks:	Tested as Red	ceived								_	
Sample/s supplied b	by the client									-	1 of 7 03001
											^
	dited for com						Authoris	sed Signatory		Ñ/	ATĀ
The results of t	he tests, calit ent are trace						6.0	hand	-		DITED FOR
docam							C. C	Channon			
	Tested at	Trilab Brist	ane Laborat	ory.					La		y Number
										99	26

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			TR		EST REPC	DRT		
Clier	nt:	Hatch Pty Ltd			Report No	o.: 18110003A	- CU	
				Mohr Cire	le Diagram			
	500							
	400							
Shear Stress (kPa)	300 -							
Shear S	200							
	- 100 - - - -							
	0 L 0	10	0	200 Dringing LStr	30	0	400	500
	advs :		Shear Resistance	nesion C' (kPa) :		Stress Ratio		
Rema Samp		Tested as Received oplied by the client			Note: Graph not to sca	ale	Page 2 REP0	
Th	ne result	Accredited for compliance with ts of the tests, calibrations, ar locument are traceable to Aus Tested at Trilab Bris	nd/or measurements stralian/National Star	included in this	Ć.	orised Signatory Charles C. Channon		
				ed apply only to the spec	ific instrument or sample at t	the time of test unless otherwise c	Laboratory 992	



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Authorised Signatory

C. Channon

ACCREDITED FOR TECHNICAL COMPETENCE

9926

ΝΑΊ

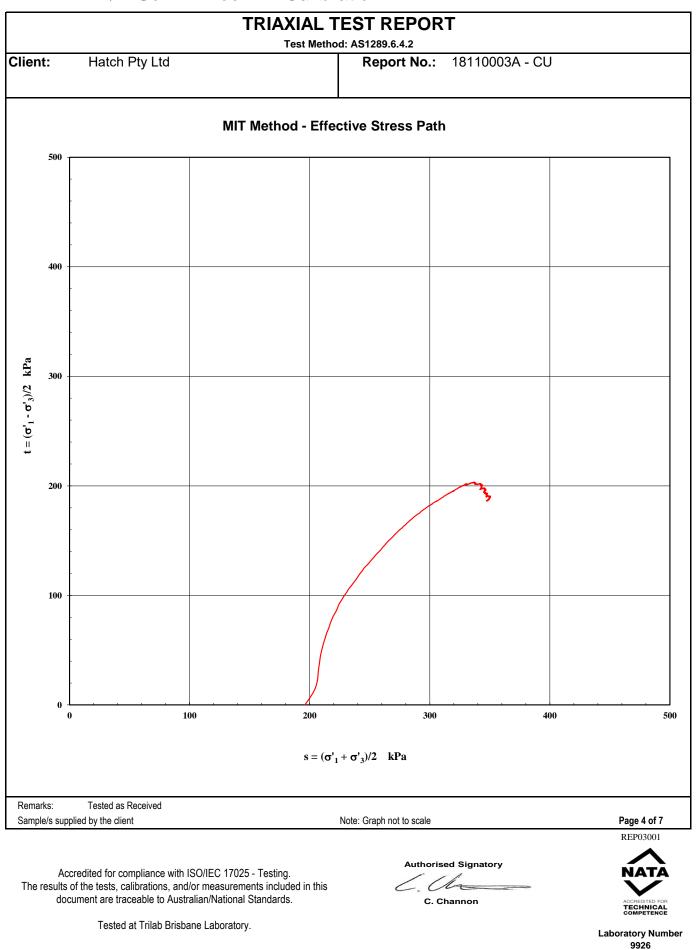
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Trilab Pty Ltd



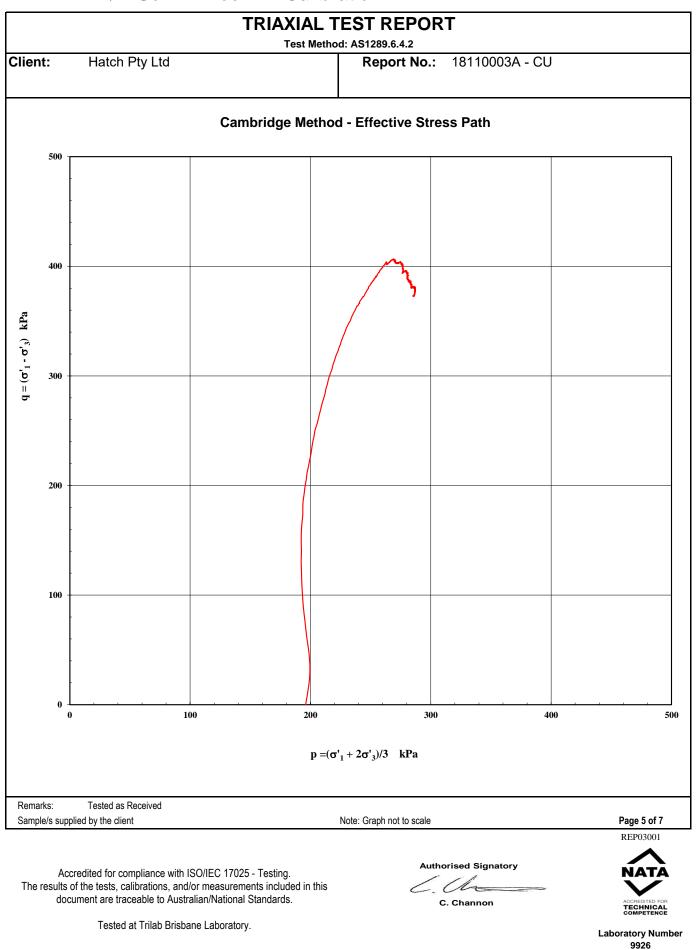
346A Bilsen Road, Geebung QLD 4034 Ph: +61 7 3265 5656 2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323



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Queens Park WA 6107 Ph: +61 8 9258 8323

		TRIAXIAL TEST REPOR Test Method: AS1289.6.4.2	τι	
Client:	Hatch Pty Ltd		18110003A - CU	
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TEST	
	LAB SAMPLE No.		DATE:01/11/18	
	BOREHOLE:	CE432 - L1C - Lexan	DEPTH: 20.30-20.8	0
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia NTSF Failure	AFTER TEST	
	LAB SAMPLE NO		DATE: 12/11/18	
	BOREHOLE:	CE432 - L1C - Lexan	DEPTH: 20.30-20.80	
Remarks:	Tested as Received	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
	upplied by the client	Note: Photo not to scale		Page 6 of 7 REP03001
The resul	Accredited for compliance with ISO/IE Its of the tests, calibrations, and/or me document are traceable to Australian/	EC 17025 - Testing.	ed Signatory	

Tested at Trilab Brisbane Laboratory.

Laboratory Number 9926

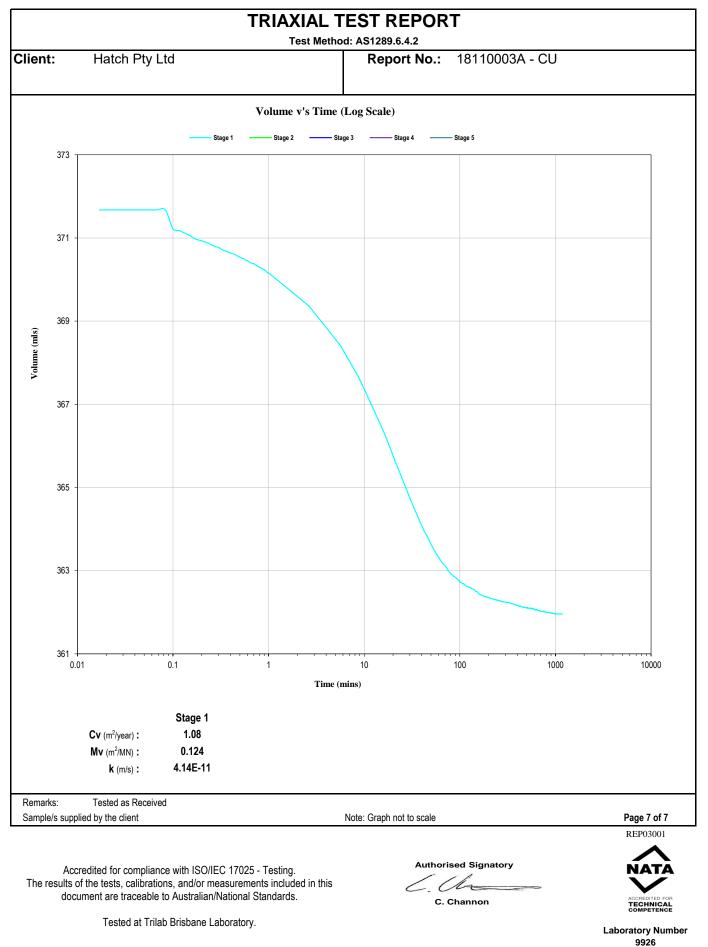
The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.



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Geebung QLD 4034 Ph: +61 7 3265 5656

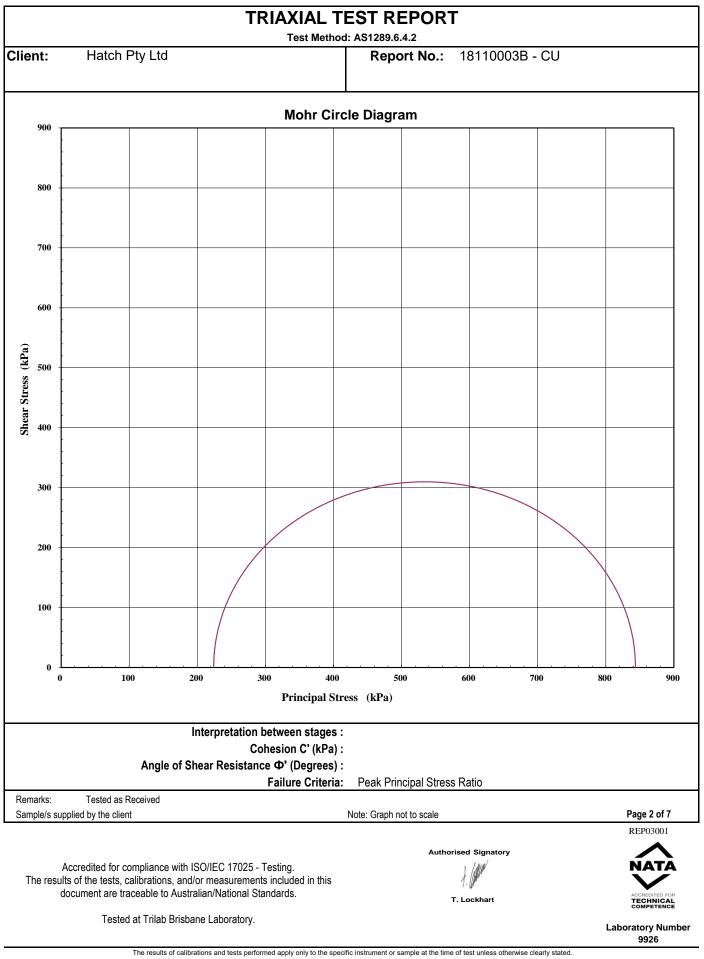
Queens Park WA 6107 Ph: +61 8 9258 8323

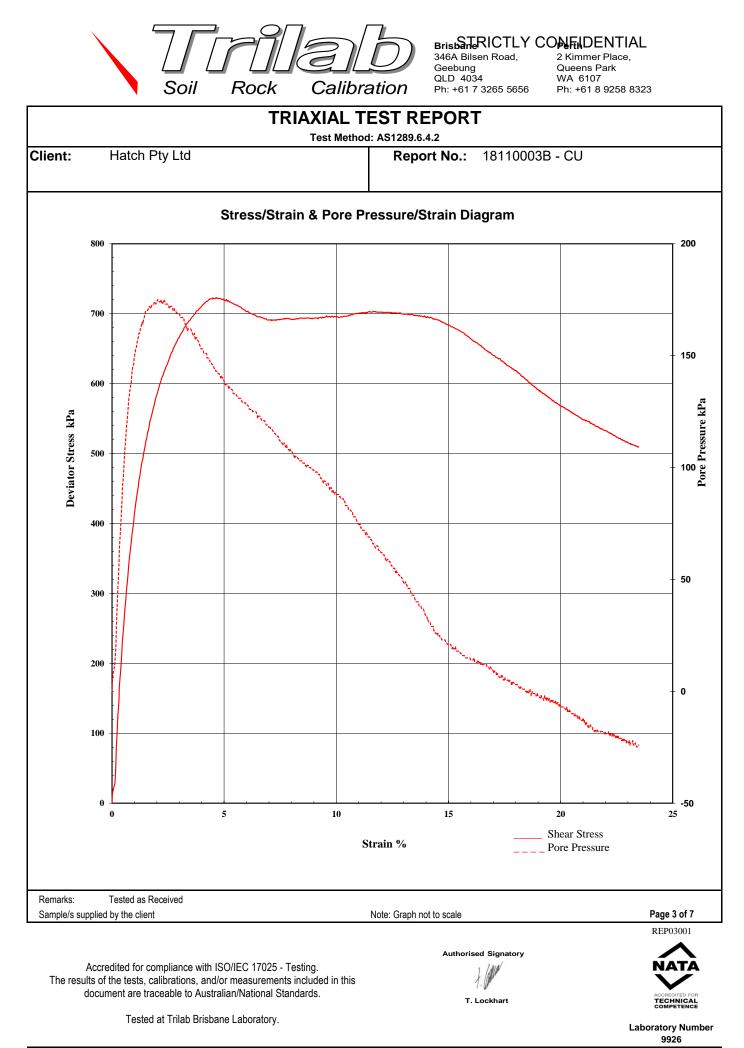
			•		XIAL TES					
Client:	Hatch Pt	ty Ltd						Report No.:	18110003B - (CU
							Wo	orkorder No.	0005081	
Address	PO Box	425 SPI	RING HI	ll Qli	D 4004			Test Date:	8/11/2018	
							F	Report Date:	16/11/2018	
Project:	H356804	4 - Cadia	a NTSF I	ailure						
Client Id.:	CE432 -	L1C - L	exan			De	pth (m):	20.30-20.80)	
Description:	SILTY C	LAY - b	rown/ora	nge/ye	llow					
				SA	MPLE & TE	ST DETA	AILS			
Initial Height:	129.0	mm			loisture Content:	28.2	%		te of Strain: 0.002	%/min
Initial Diameter: L/D Ratio:	61.3 2.1 : 1	mm		Final N	loisture Content:	25.4 1.95	% t/m ³	В	Response: 97	%
L/D Ralio.	2.1.1				Wet Density: Dry Density:	1.95	t/m ³			
Sample Type:	Single Indivi	dual Undisti	urbed Specir	nen	, ,					
					TEST RE	SULTS	6			
		Ī			FAILURE D	ETAILS				T
Effective Pressure	Confining	Back	Initial Dara	Failure Pore	σ' ₁	Principal Efi	fective Stresse	es σ' ₁ /σ' ₃	Deviator Stress	Strain
398 kPa	Pressure 800 kPa	402 kPa	402 kPa	576 kPa	844 kP	а	σ' 3 224 kPa		620 kPa	2.36 %
				FA	ILURE EN	VELO	PES			
			Interpreta		ween stages :					
		Analsse			sion C' (kPa) :					
		Angle of	Snear Res		Φ' (Degrees) : ailure Criteria:	Peak Pr	incipal Stres	s Ratio		
						TOURTT		5 1 4410		
Remarks:	Tested as Re	coived								
Sample/s supplied b									Page	1 of 7
									REP	03001
A		- 1'		005 T	·		Authoris	ed Signatory		
The results of t		prations, and	d/or measure	ements in	cluded in this			J. Collar		
docum	ent are trace	able to Aust	ralian/Natior	nal Standa	ards.		т.	Lockhart		EDITED FOR HNICAL PETENCE
	Tested at	Trilab Brisb	ane Laborat	ory.						ry Number
										926

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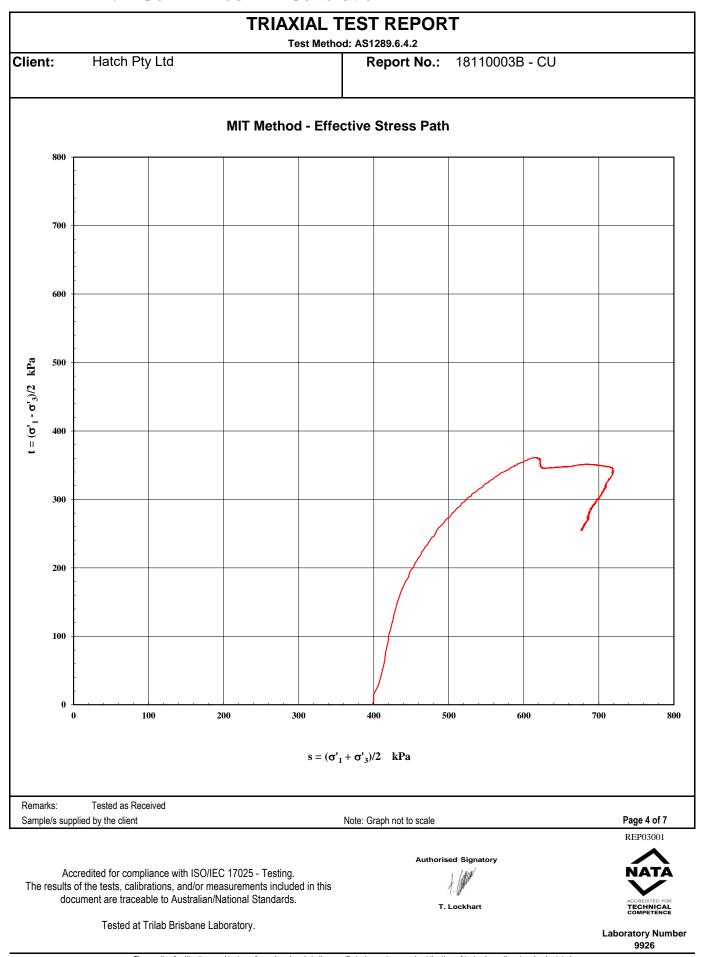




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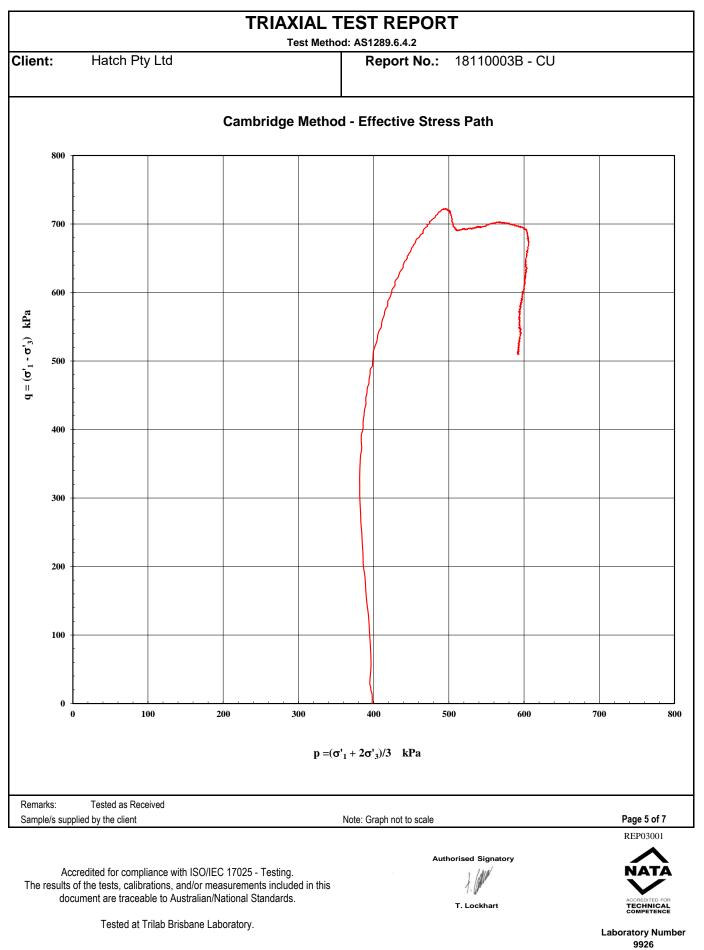
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		TRIAXIAL TE		
Client:	Hatch Pty Ltd		Report No.: 18110003B - CL	
	CLIENT:	Hatch Pty Ltd		
	PROJECT:	H356804 - Cadia N	TSF BEFORE	TEST
	LAB SAMPLE No.	Failure 18110003	DATE: 01	12
	BOREHOLE:	CE432 - L1C - Lexa		-20.80
	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia N Failure	TSF AFTER T	EST
	LAB SAMPLE No. BOREHOLE:	18110003 CE432 - L1C - Lex	DATE: 16/11/ an DEPTH: 20.30-	//8
Remarks: Sample/s s	Tested as Received supplied by the client	Note	e: Photo not to scale	Page 6 of 7
The resul	Accredited for compliance with ISO/ Its of the tests, calibrations, and/or n document are traceable to Australian Tested at Trilab Brisbane I	IEC 17025 - Testing. neasurements included in this n/National Standards.	Authorised Signatory	

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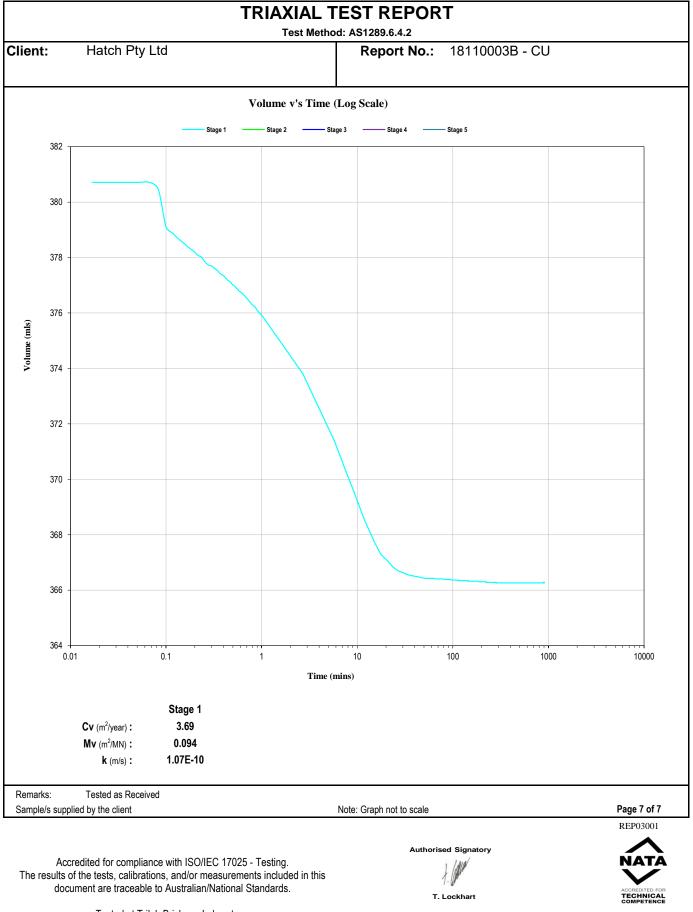


Brisb RICTLY CONFUDENTIAL 346A Bilsen Road, Geebung QLD 4034

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> Laboratory Number 9926



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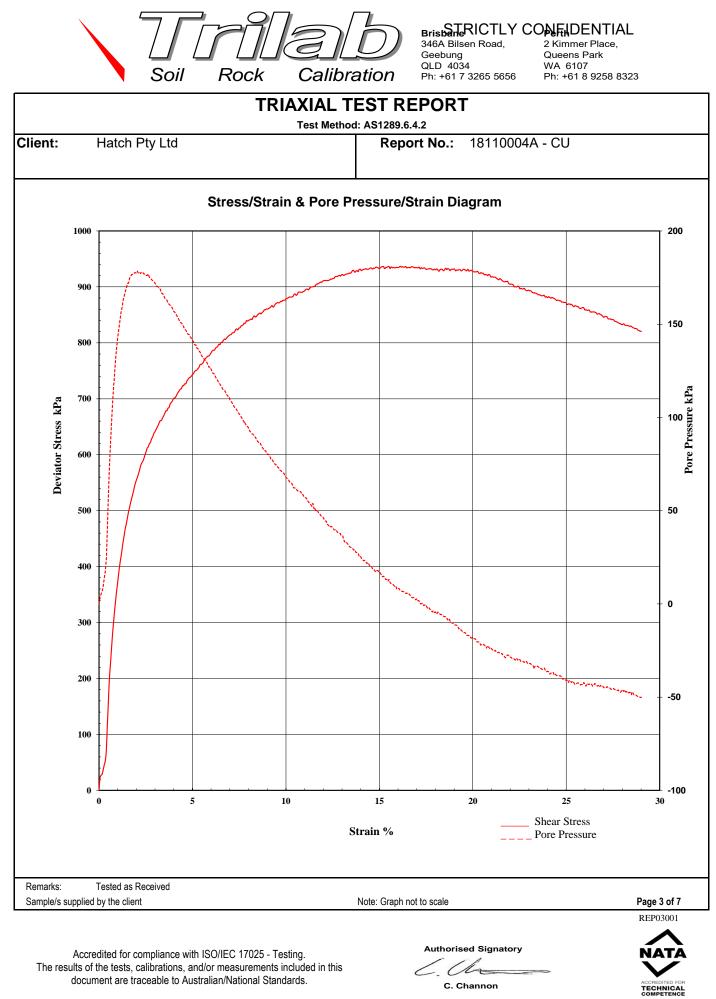
			•		XIAL TE					
Client:	Hatch Pt	ty Ltd						Report No.:	18110004A - C	U
							Wo	orkorder No.	0005081	
Address	PO Box	425 SPI	RING HI	LL QLE	D 4004			Test Date:	2/11/2018	
							F	Report Date:	15/11/2018	
Project:	H356804	4 - Cadia	a NTSF F	ailure				•		
Client Id.:	CE432 -	L2 - Lex	kan			De	oth (m):	22.80-23.20)	
Description:	SILTY C	LAY- ye	llow brow	wn						
				SA	MPLE & TE	ST DETA				
Initial Height:	128.3	mm		Initial N	loisture Content:	17.5	%	Ra	te of Strain: 0.004	%/min
Initial Diameter:	61.6	mm		Final N	loisture Content:	20.3	%	В	Response: 98	%
L/D Ratio:	2.1 : 1				Wet Density: Dry Density:		t/m ³ t/m ³			
Sample Type:	Single Indivi	dual Undistu	urbed Specin	nen	Dry Density.	1.70	UIII			
					TEST RE	SULTS	5			
					FAILURE D					
Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	σ' ₁	Principal Eff	ective Stresse σ' ₃	σ'_1 / σ'_3	Deviator Stress	Strain
400 kPa	900 kPa	500 kPa	500 kPa	669 kPa	892 kF	a	231 kPa		661 kPa	3.28 %
				FA	ILURE EN	IVELO	PES			
			Interpreta		ween stages :					
		Angle of			sion C' (kPa) :					
		Angle of a	Shear Resi		Φ' (Degrees) : ailure Criteria:	Peak Pri	ncipal Stres	s Ratio		
						1 out 1				
Remarks:	Tested as Re	ceived								
Sample/s supplied b	by the client									1 of 7 03001
										^
	dited for com						Authori	sed Signatory	Ň.	ATÀ
The results of t docum	he tests, calil ent are trace						6.0	hame	ACCRE	DITED FOR
	Tested at	Trilah Brich	ane Laborat	orv			C. C	Channon		HNICAL PETENCE
	i colcu di	טוומט טוואנ		.ory.					Laborator 99	y Number 26

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BrisbarreCONFIDENTIAL346A Bilsen Road,
Geebung2 Kimmer Place,
Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

			KIAL TE		T	
Client:	Hatch Pty Ltd			Report No.:	: 18110004A - (CU
		N	Iohr Circle	e Diagram		
1000	-					
800	-					
Shear Stress (kPa) 00	-					
55 400	-					
200	-					
0	0 200		400	600		800 1000
			incipal Stress	s (kPa)		
		Shear Resistance Φ'	n C' (kPa) : (Degrees) :	Peak Principal Stre	ess Ratio	
Remarks: Sample/s	Tested as Received supplied by the client		No	ote: Graph not to scale		Page 2 of 7
The res	Accredited for compliance with sults of the tests, calibrations, an document are traceable to Aus Tested at Trilab Brisl	d/or measurements includ tralian/National Standards	ded in this	6.0	sed Signatory	
			only to the specific	instrument or sample of the f	ime of test unless otherwise clear	Laboratory Number 9926



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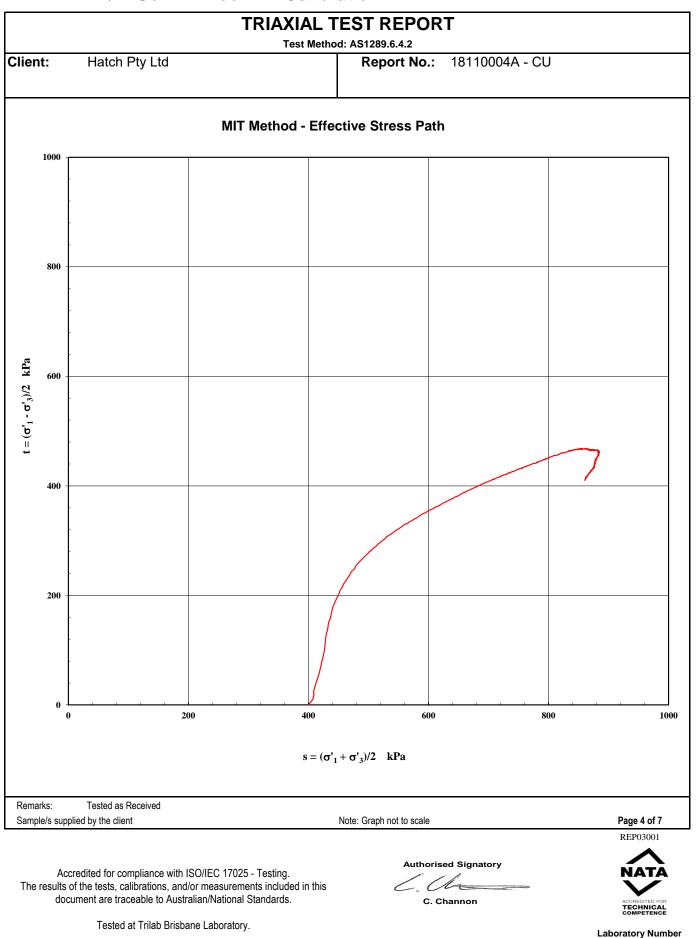
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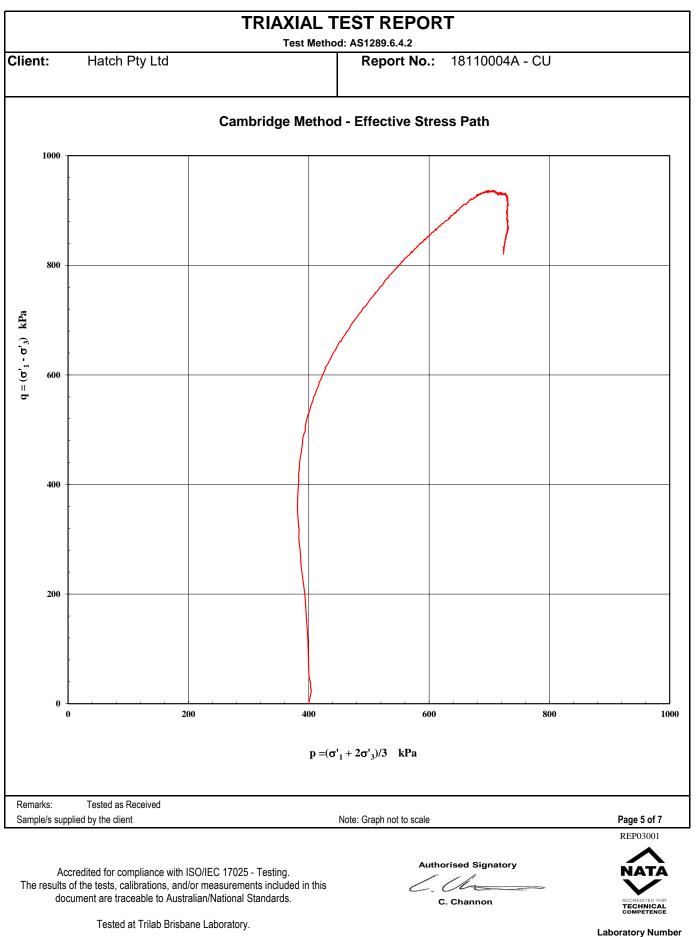


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Queens Park WA 6107 Ph: +61 8 9258 8323

		TRIAXIAL TEST REP Test Method: AS1289.6.4.2	
ent:	Hatch Pty Ltd		No.: 18110004A - CU
	CLIENT:	Hatah Dtr. I td	
	PROJECT:	Hatch Pty Ltd H356804 - Cadia NTSF	
2	TROOLET.	Failure	BEFORE TEST
	LAB SAMPLE No.	18110004	DATE: 01 11 18
	BOREHOLE:	CE432 - L2 - Lexan	DEPTH: 22.80-23.20
	CLIENT:	Hatch Pty Ltd	
	PROJECT:	H356804 - Cadia NTSF	AFTED TEST
	PROJECT:	H356804 - Cadia NTSF Failure	AFTER TEST
	PROJECT: LAB SAMPLE No.	H356804 - Cadia NTSF Failure 18110004	DATE: 9.11.10.
	PROJECT:	H356804 - Cadia NTSF Failure	
	PROJECT: LAB SAMPLE No. BOREHOLE:	H356804 - Cadia NTSF Failure 18110004	DATE: 9.11.19 DEPTH: 22.80-23.20
marks: mple/s su	PROJECT: LAB SAMPLE No. BOREHOLE:	H356804 - Cadia NTSF Failure 18110004	DATE: 9.11.19 DEPTH: 22.80-23.20

Tested at Trilab Brisbane Laboratory.

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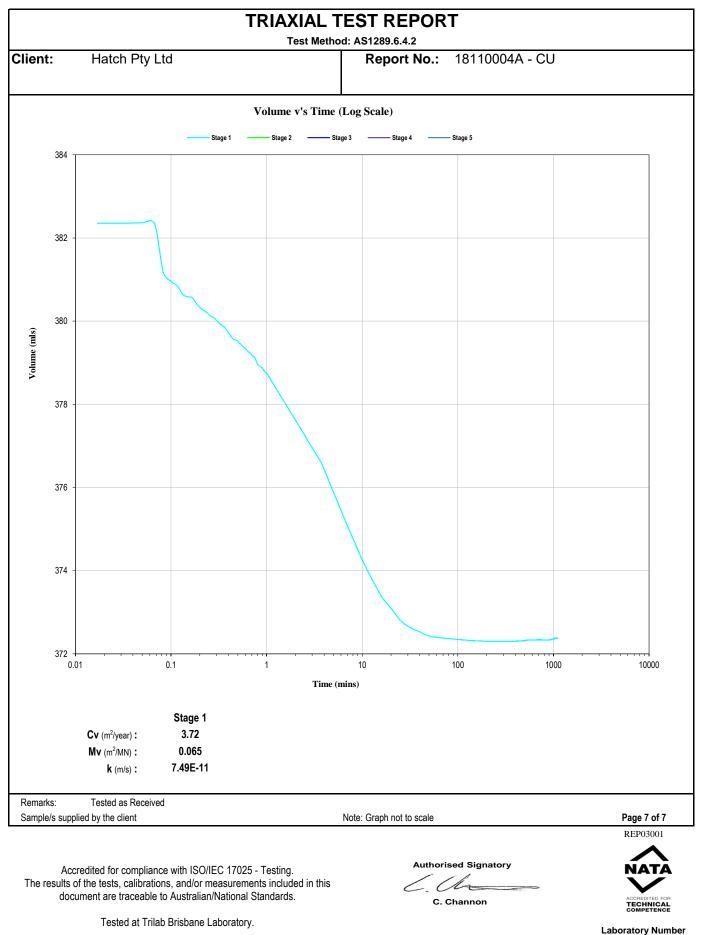
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Laboratory Number 9926



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TRIAXIAL TEST REPORT Test Method: AS1289.6.4.2											
Client: Hatch Pty Ltd							Report No.:		18110004B - CU		
						Wo	orkorder No.	0005081			
Address	PO Box	425 SPI	RING HI	LL QLE	0 4004			Test Date:	6/11/2018		
							F	Report Date:	15/11/2018		
Project:	H356804	4 - Cadia	a NTSF I	Failure				-			
Client Id.:	CE432 -	L2 - Lex	xan			Dej	oth (m):	22.80-23.20			
Description:	SILTY C	LAY- ye	llow brow	wn							
				SA	MPLE & TE	ST DETA					
Initial Height:	128.7	mm		Initial N	loisture Content:				te of Strain: 0.004 %/min		
Initial Diameter:	59.6	mm		Final M	loisture Content:	20.3	%	В	Response: 99	%	
L/D Ratio:	2.2 : 1				Wet Density: Dry Density:		t/m ³ t/m ³				
Sample Type:	Single Indivi	dual Undistu	urbed Specir	nen	2.9 2 6.16.(9)						
TEST RESULTS											
		1	1		FAILURE D						
Effective Pressure	Confining Pressure	Back	luitial Dama	Failure Pore	σ' ₁	Principal Eff	ective Stresse σ' ₃	σ'_1 / σ'_3	Deviator Stress	Strain	
800 kPa	1299 kPa	499 kPa	499 kPa			Pa	499 kPa		1158 kPa	4.00 %	
						ioon m u					
FAILURE ENVELOPES											
			Interpreta		ween stages :						
		Angle of			sion C' (kPa) :						
Angle of Shear Resistance Φ' (Degrees) : Failure Criteria: Peak Principal Stress Ratio											
Remarks:	Tested as Re	ceived									
Sample/s supplied b	by the client									1 of 7	
Accredited for compliance with ISO/IEC 17025 - Testing.									Ň.	NATA	
The results of the tests, calibrations, and/or measurements included in this document are traceable to Australian/National Standards.							ACCRE	ACCREDITED FOR			
C. Channon TECHNI COMPET											
										y Number 26	

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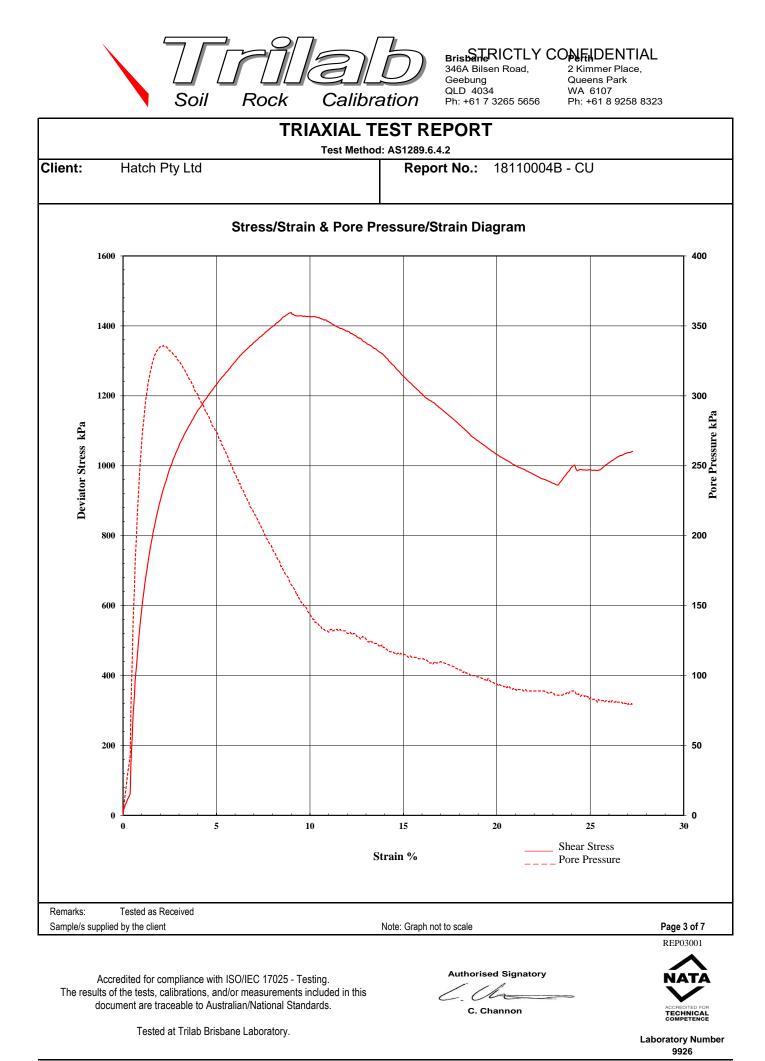


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				IAL TES	ST REPO	RT			
Client:	Hatch Pty Ltc	l	Te	St Method. A	Report No	.: 181100	004B - CU		
			Мо	ohr Circle	Diagram				
1800									
1600									
1400									
1200									
Shear Stress (kPa) 000 000									
Shear St									
600 -									
400									
200									
0	200	400	600 Prin	800 ncipal Stress	1000 (kPa)	1200	1400	1600	1800
	Angle	-	etation betweer Cohesion esistance Φ' (D Failure	C' (kPa) :)egrees) :	Peak Principal St	ress Ratio			
Remarks: Sample/s sup	Tested as Received oplied by the client			Not	e: Graph not to scale	9			ge 2 of 7
The result	Accredited for compliance ts of the tests, calibration locument are traceable to	is, and/or meas	surements include	ed in this	6.0	rised Signatory		Ň	EP03001
	Tested at Trilab	Brisbane Labo	oratory.					Labora	ompetence tory Number 9926

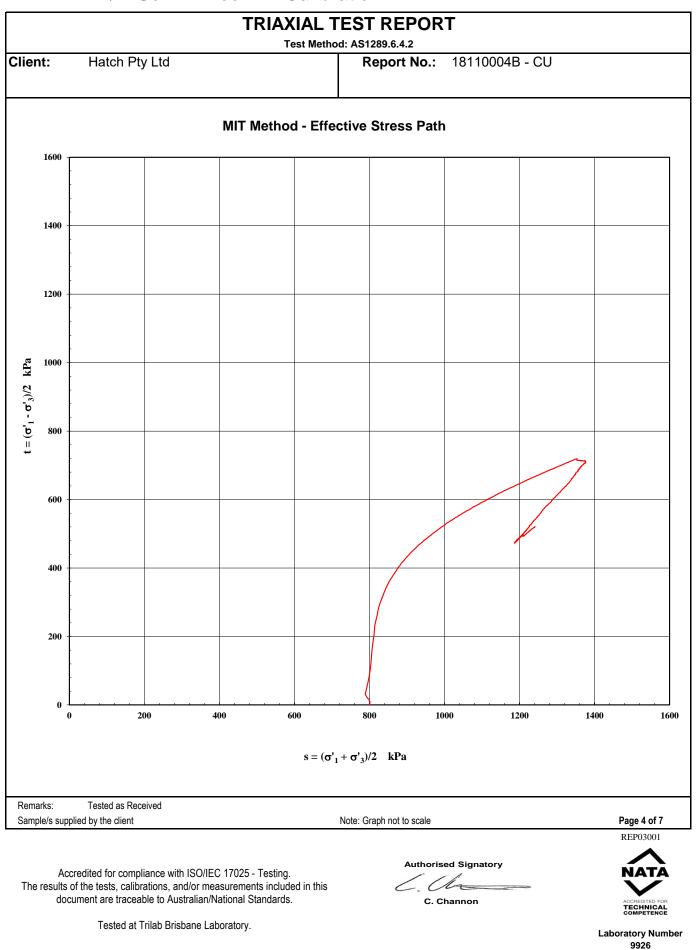
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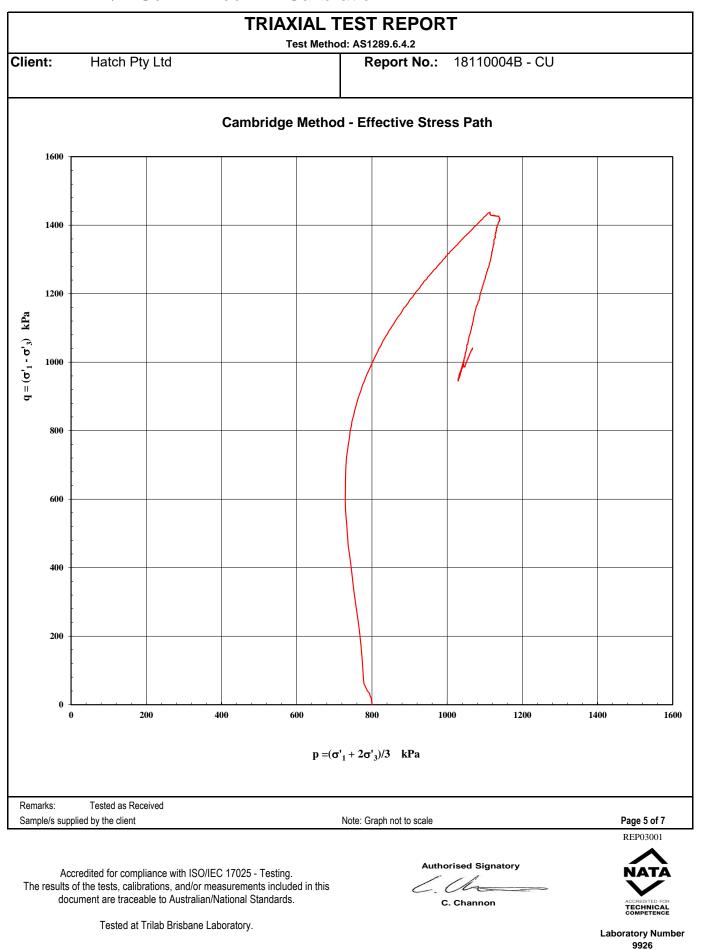
346A Bilsen Road, Geebung QLD 4034 Ph: +61 7 3265 5656 2 Kimmer Place, Queens Park WA 6107 Ph: +61 8 9258 8323



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		TRIAXIAL TEST Test Method: AS128					
t:	Hatch Pty Ltd	Rej	Report No.: 18110004B - CU				
	CLIENT:	Hatch Pty Ltd					
-	PROJECT:	H356804 - Cadia NTSI	F				
1	INCOLCT.	Failure	BEFORE IE				
	LAB SAMPLE No.	18110006	DATE: OI	8			
1	BOREHOLE:	CE416 - L1C	DEPTH: 23.50-2	4.00			
	CLIENT:	Hatch Pty Ltd					
	PROJECT:	H356804 - Cadia NTS Failure	F AFTER TES'	Г			
	LAB SAMPLE No	· 18110004	DATE: 12/11/	18			
	BOREHOLE:	CE432 - L2 - Lexan	DEPTH: 22.80-23.				
	Tested as Received	Note: Dhot	o not to scale				
ks: e/s sur	onlied by the client	NOLE. FIUL		Daga 6 of			
e/s sup Ac results	pplied by the client ccredited for compliance with ISO, s of the tests, calibrations, and/or r ocument are traceable to Australia	measurements included in this	Authorised Signatory	Page 6 of REP0300 NAT			

The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.

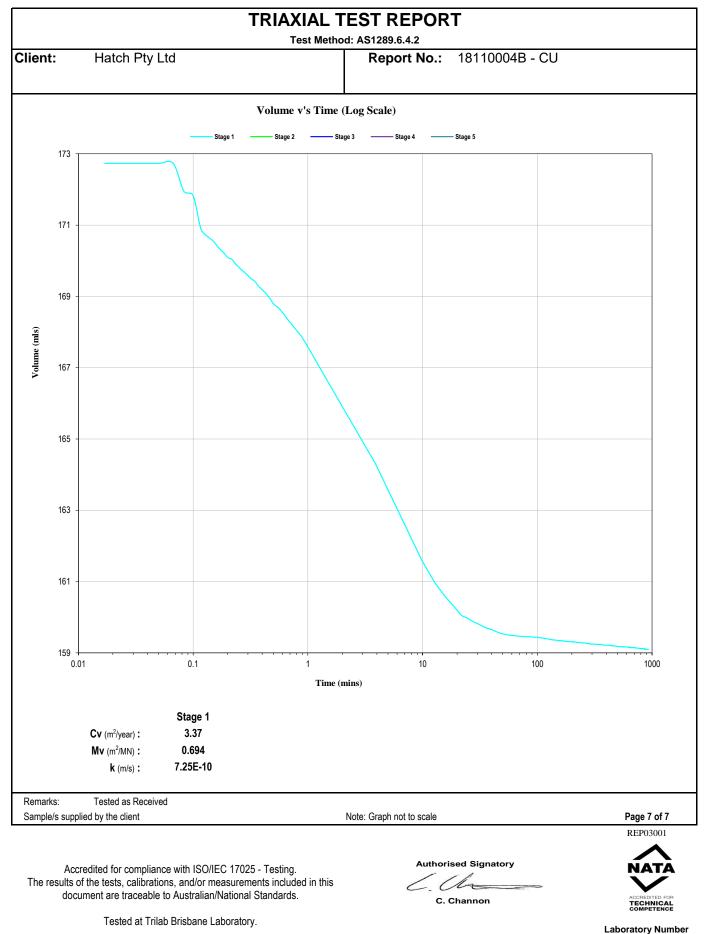


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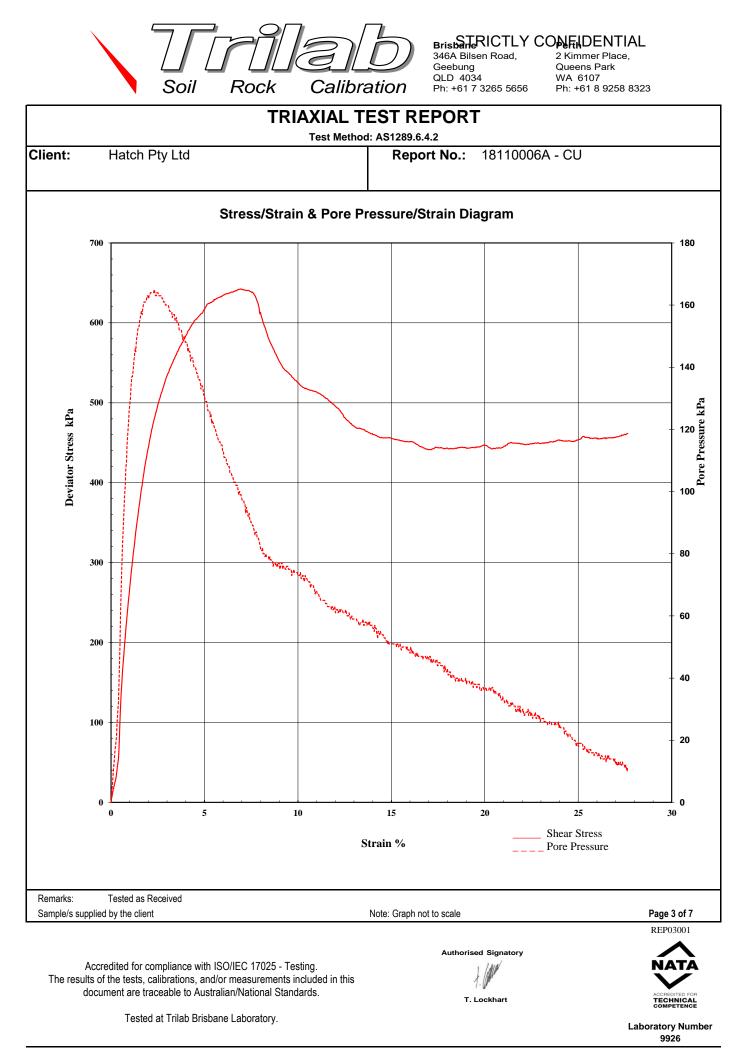
BrisbarreCONFIDENTIAL346A Bilsen Road,
Geebung2 Kimmer Place,
Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

					XIAL TES						
Client:	Hatch P	ty Ltd						Report No.:	181100	06A - C	U
							Wo	rkorder No.	000508	1	
Address	PO Box	425 SPI	RING HI	LL QLE	0 4004			Test Date:	6/11/20	18	
							R	Report Date:	15/11/2	018	
Project:	H356804	4 - Cadia	a NTSF I	ailure							
Client Id.:	CE416 -	L1C				De	pth (m):	23.50-24.00			
Description:	SILTY C	LAY- or	ange/bro	wn							
			r		MPLE & TE		1				
Initial Height:	129.4	mm			loisture Content:	26.4	%		e of Strain:	0.002	%/min
Initial Diameter: L/D Ratio:	61.5 2.1 : 1	mm		Final IV	loisture Content: Wet Density:	28.5 2.00	% t/m ³	В	Response:	97	%
L/D Ratio.	2.1.1				Dry Density:	1.58	t/m ³				
Sample Type:	Single Indivi	idual Undisti	urbed Specir	nen							
					TEST RE	SULTS	6				
		T			FAILURE D						
Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	σ' ₁	Principal Eff	fective Stresse σ' ₃	σ'_1 / σ'_3	Deviator S	tress	Strain
400 kPa	802 kPa	402 kPa	402 kPa	562 kPa	777 kP	а	240 kPa		537 kF	Pa	3.06 %
		1									
				FA	ILURE EN	IVELO	PES				
			Interpreta		ween stages :						
					sion C' (kPa) :						
		Angle of	Shear Res		Φ' (Degrees) : ailure Criteria:	Peak Pri	incipal Stress	s Ratio			
				16	andre Onteria.	ICANII		5 1/410			
Demedies	Taskad as Da										
Remarks: Sample/s supplied t	Tested as Re by the client	ceivea								Page	1 of 7
										REP	03001
			100/150 /=				Authorise	ed Signatory			$\mathbf{\Lambda}$
Accree The results of t	dited for com he tests, calil							f later			ATA
	ient are trace						T. I	Lockhart		TEC	DITED FOR
	Tested at	t Trilab Brist	oane Laborat	ory.							
											ry Number 26
	The r	esults of calibra	tions and tests p	erformed app	ly only to the specific in	nstrument or sar	nple at the time of	test unless otherwise clear	ly stated.		



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Geebung2 Kimmer Place,
Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

						DRT		
Clien	nt:	Hatch Pty Ltd		i est Method	Report N	o.: 18110	006A - CU	
			ľ	Aohr Circ	le Diagram			
:	800							
,	700							
	600							
	500							
Shear Stress (kPa)	400 -							
	300							
2	200							
	100 -							
	0 [0	100	200 30	00	400	500	600	700 800
			Р	rincipal Str	ess (kPa)			
		Angle of SI	near Resistance Φ'	on C' (kPa) :	Peak Principal S	Stress Ratio		
Rema Samp		Tested as Received plied by the client			Note: Graph not to sc	ale		Page 2 of 7
The	e results	ccredited for compliance with I s of the tests, calibrations, and, ocument are traceable to Austra	or measurements inclu alian/National Standard	ded in this		Authorised Signat	ory	REP03001
		Tested at Trilab Brisba	ne Laboratory.					Laboratory Number 9926
			ations and tests performed app Reference should be made to	Trilab's "Standard [·] Trila				



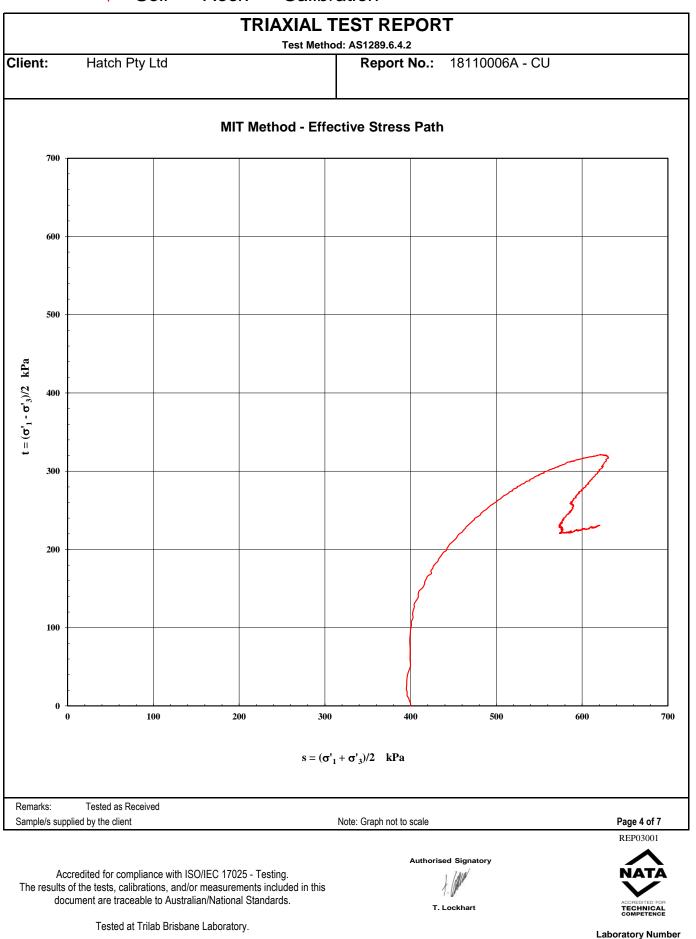
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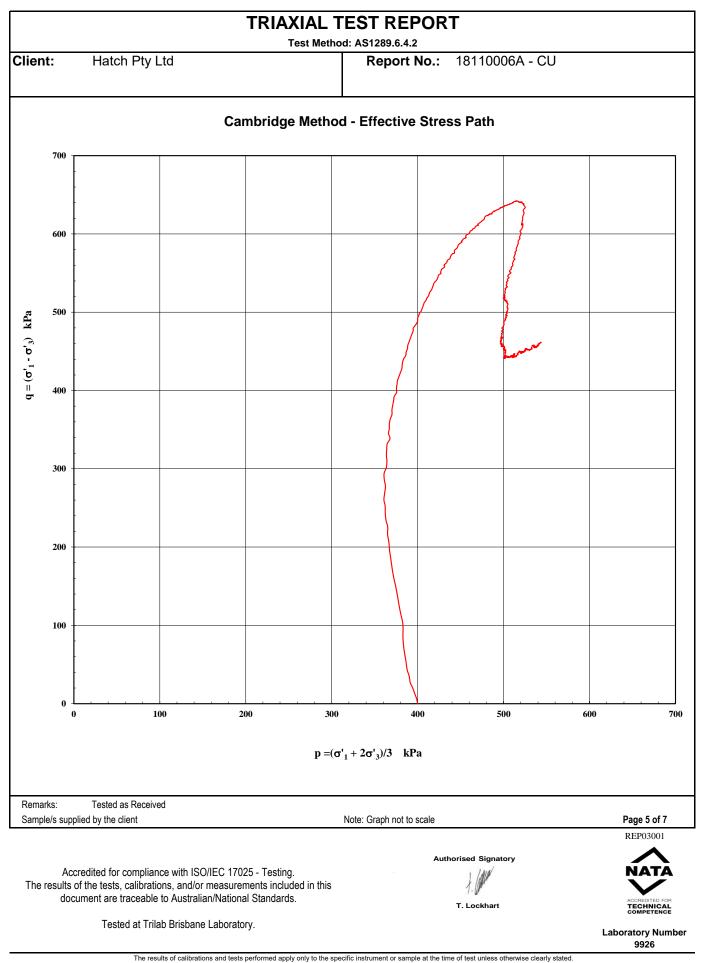


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9926

		TRIAXIAL TEST REPO Test Method: AS1289.6.4.2	DRT
lient:	Hatch Pty Ltd		b.: 18110006A - CU
	CLIENT:	Hatch Pty Ltd	
	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TEST
	LAB SAMPLE No. BOREHOLE:	18110006 CE416 - L1C	DATE: 01/11/18 DEPTH: 23.50-24.00
	CLIENT:	Hatch Pty Ltd	
	PROJECT:	H356804 - Cadia NTSF Failure	AFTER TEST
	LAB SAMPLE N		DATE: 15/11/18
Remarks:	Tested as Received		
ample/s su	pplied by the client	Note: Photo not to scal	•
The result	ccredited for compliance with ISO/IE s of the tests, calibrations, and/or me ocument are traceable to Australian/N	C 17025 - Testing. asurements included in this	T. Lockhart REP03001
	Tested at Trilab Brisbane La	boratory.	Laboratory Nur

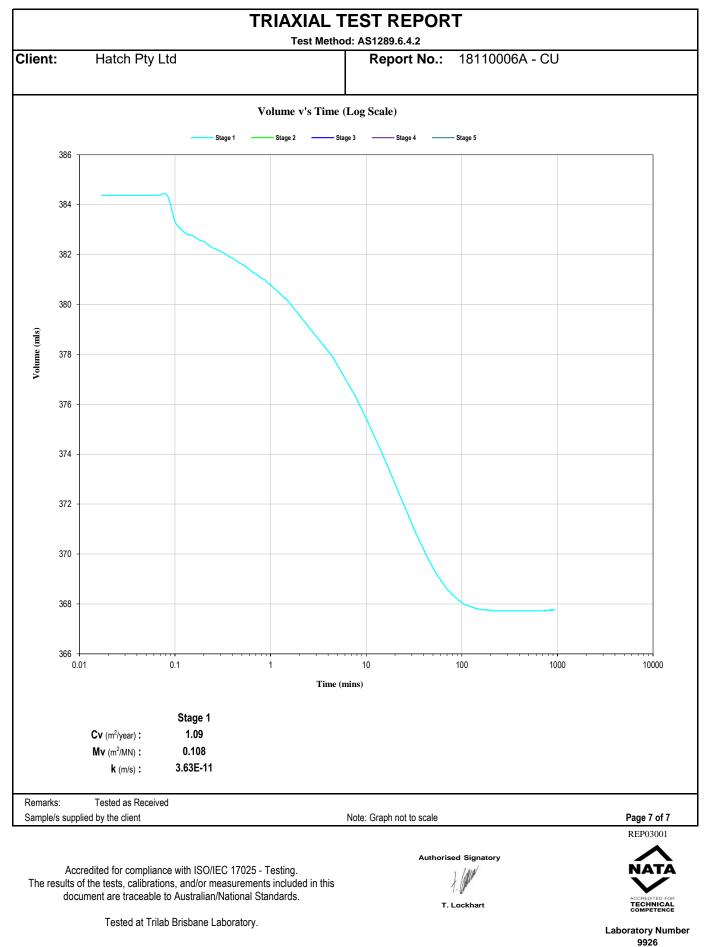
The results of calibrations and tests performed apply only to the specific instrument or sample at the time of test unless otherwise clearly stated.



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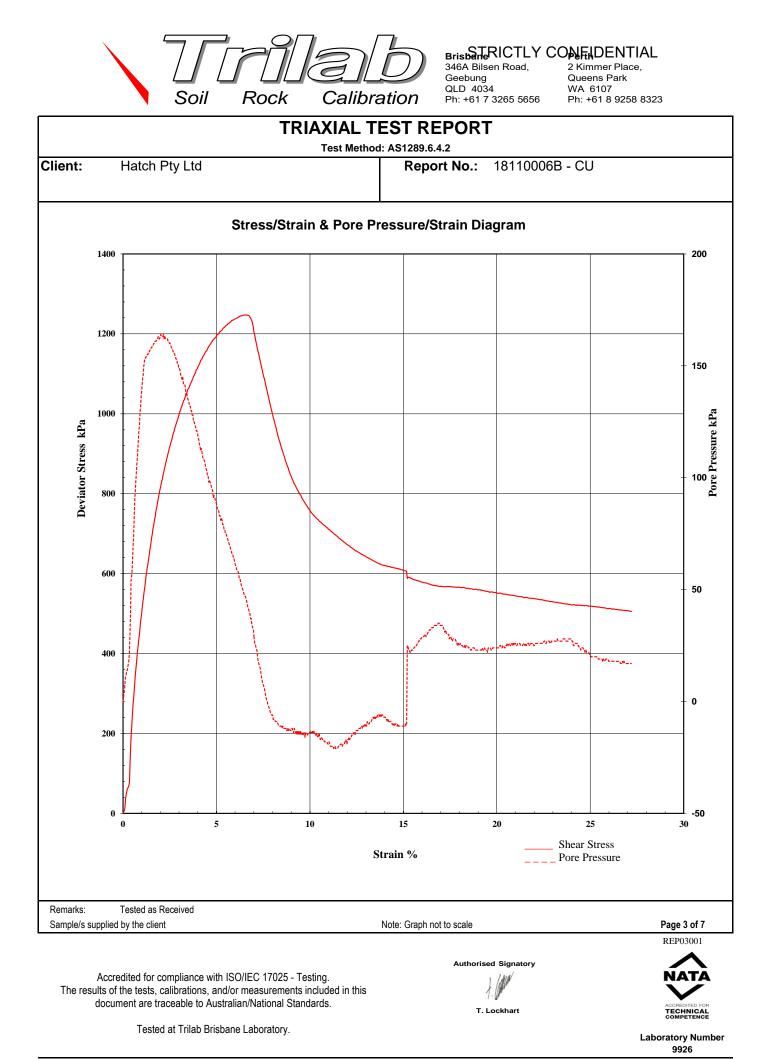
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Geebung2 Kimmer Place,
Queens ParkQLD 4034WA 6107Ph: +61 7 3265 5656Ph: +61 8 9258 8323

			-		XIAL TES	-	-				
Client:	Hatch P	ty Ltd						Report No.:	181100	06B - 0	CU
							Wo	rkorder No.	000508	31	
Address	PO Box	425 SPI	RING HI	LL QLE	0 4004			Test Date:	7/11/20)18	
							R	eport Date:	15/11/2	2018	
Project:	H356804	4 - Cadia	a NTSF I	ailure							
Client Id.:	CE416 -					De	pth (m):	23.50-24.00			
Description:	SILTY C	LAY - o	range/br	own							
1.225111.2514	400.7				MPLE & TE					0.000	0/ /
Initial Height: Initial Diameter:	129.7 61.4	mm mm			loisture Content: loisture Content:	26.4 27.5	% %		e of Strain: Response:	0.002 97	%/min %
L/D Ratio:	2.1 : 1			i indi iv	Wet Density:	2.00	t/m ³	D	rtesponse.	51	70
					Dry Density:	1.59	t/m ³				
Sample Type:	Single Indivi	dual Undistu	urbed Specir	nen							
					TEST RE	SULTS	5				
		1			FAILURE D						r
Effective Pressure	Confining Pressure	Back Pressure	Initial Pore	Failure Pore	σ' ₁	Principal Efi	ective Stresse σ'₃	σ'_1 / σ'_3	Deviator	Stress	Strain
796 kPa	1301 kPa	505 kPa	505 kPa	609 kPa	1849 kF	a	692 kPa		1157	kPa	4.45 %
				FA	ILURE EN	VELO	PES				
			Interpreta		ween stages :						
					sion C' (kPa) :						
		Angle of	Shear Resi		⊅' (Degrees) :	Deels Dr	incided Chron	- Detie			
				Γ¢	ailure Criteria:	Peak Pi	incipal Stress	S Ralio			
Remarks: Sample/s supplied b	Tested as Re by the client	ceived								Page	1 of 7
										-	03001
			100 11				Authorise	ed Signatory			\land
Accrea The results of t	dited for com he tests, calil							f aller			
	ent are trace						т. і	Lockhart		TEC	
	Tested at	Trilab Brist	ane Laborat	ory.							PETENCE ry Number
											926
	The r	esults of calibra	tions and tests p	erformed app	ly only to the specific in	strument or sar	nple at the time of	test unless otherwise clea	rly stated.		



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			TF				ORT				
Client:	Hatch Pty	Ltd		Test I		81289.6.4.2 Report N	lo.: 18 ⁻	110006B	- CU		
				Moh	r Circle	Diagram					
2000											
1800 -											
1600											
1400											
(kPa) (kPa)											
Shear Stress (kPa)											
800 -											
600											
400											_
200											_
0	200	400	600	800 Princij	10 pal Stress		200	1400	1600	1800	2000
	A	Inter		hesion C'	(kPa) : rees) :	eak Principal	Stress Rati	0			
Remarks: Sample/s sup	Tested as Receipplied by the client	ved				: Graph not to s		-		Page 2	of 7
م The result	Accredited for comp ts of the tests, calibi locument are tracea	ations, and/or m	neasurement /National Sta	s included in			Authorised S	nya ^j		REP030	

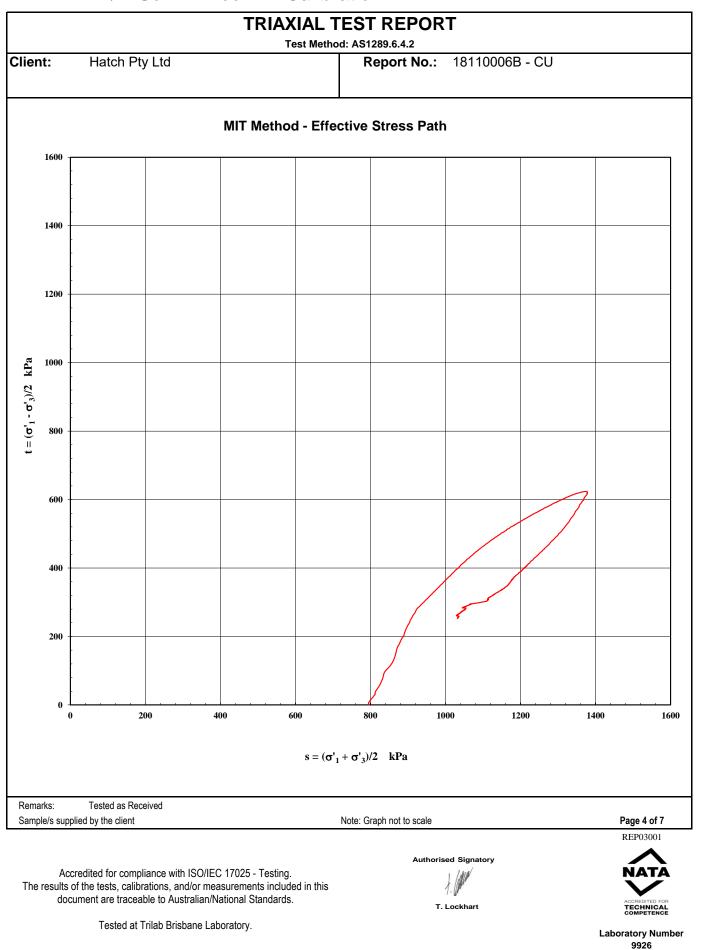


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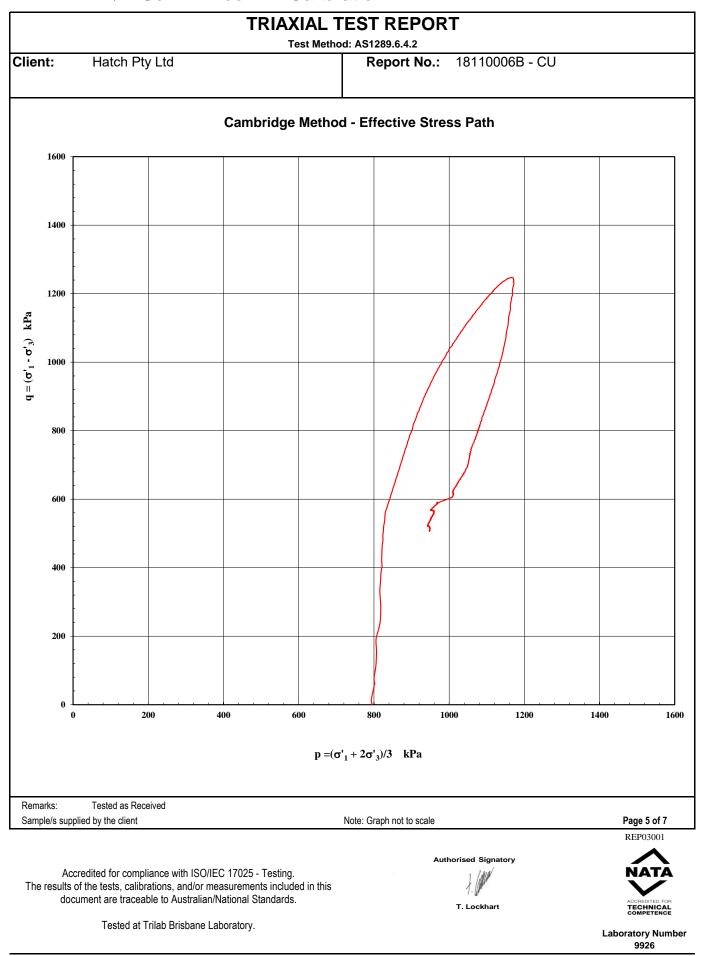


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> Laboratory Number 9926

		TRIAXIAL TEST REF Test Method: AS1289.6.4.2		
Client:	Hatch Pty Ltd		No.: 18110006B - CU	
	CLIENT:	Hatch Pty Ltd		
- 1	PROJECT:	H356804 - Cadia NTSF Failure	BEFORE TES	
	LAB SAMPLE No.	18110006	DATE: 01/11/18	
- 1	BOREHOLE:	CE416 - L1C	DEPTH: 23.50-24.	
	CLIENT: PROJECT:	Hatch Pty Ltd H356804 - Cadia NTSF	AFTER TEST	
	LAB SAMPLE No.	Failure 18110006		2
	BOREHOLE:	CE416 - L1C	DATE: 15/11/1 DEPTH: 23.50-24.0	
Remarks: Sample/s supr	Tested as Received blied by the client	Note: Photo not to	scale	Page 6 of 7
Acc The results o	credited for compliance with ISO/IEC of the tests, calibrations, and/or mea ument are traceable to Australian/Na	A 17025 - Testing. surements included in this	Authorised Signatory	

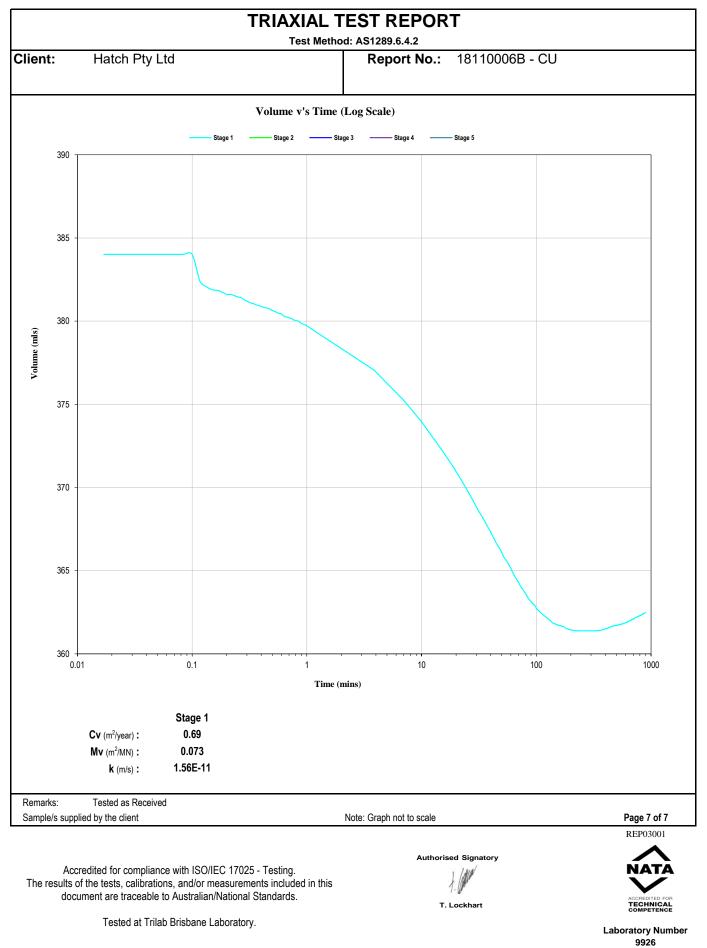
Tested at Trilab Brisbane Laboratory.

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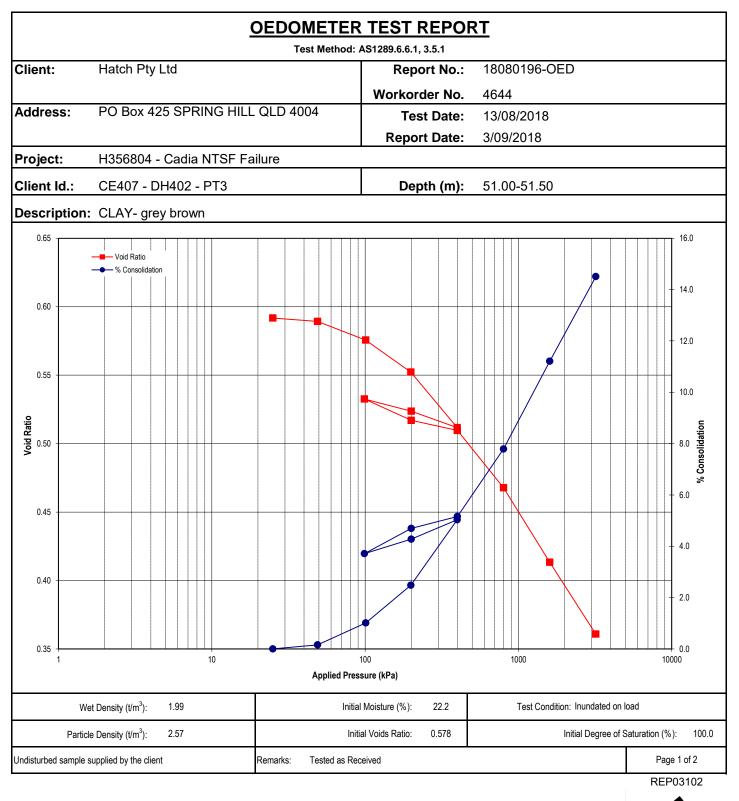


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Annexure DG Oedometer Consolidation Tests



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			OEDO	METEF	RTEST	REPORT		
			Те	est Method:	AS1289.6.6			
Client:	Hatch Pty Ltd				Rep	oort No.: 18080	196-OED	
				24		rder No. 4644		
Address:	PO Box 425 SPF		_ QLD 400	J4		est Date: 13/08/		
Project:	H356804 - Cadia		iluro		Repo	ort Date: 3/09/2	018	
			allule			(1 () 5(00	54 50	
Client Id.:	CE407 - DH402				De	epth (m): 51.00-	51.50	
Description:	CLAY- grey brow	/n						
	•			<u>TEST</u>	RESUL	<u>TS</u>		
Stage	Load	Cc	k	Cv (m²/yr)	Mv (kPa⁻¹x10⁻³)	C _a x 10 ⁻³	% Consolidation
	(kPa)		(m/s)	t ₅₀	t ₉₀			
1	25-49	0.009	1.5E-09	3.79	74.12	0.066	0.39	0.2
2	49-101	0.043	1.5E-09	0.87	29.23	0.165	0.85	1.0
3	101-199	0.079	1.4E-09	0.81	29.71	0.151	1.76	2.5
4	199-399	0.134	7.7E-10	0.43	18.90	0.131	1.78	5.0
5	399-200	0.040	2.3E-10	0.71	18.25	0.040	0.35	4.3
6	200-99	0.029	1.8E-11	0.26	0.97	0.058	1.21	3.7
7	99-200	0.051	4.7E-10	0.86	14.96	0.101	0.42	4.7
8	200-400	0.024	1.2E-10	0.88	15.63	0.024	1.12	5.2
9	400-800	0.139	3.9E-10	0.24	18.01	0.069	3.36	7.8
10	800-1602	0.181	6.4E-12	0.23	0.44	0.046	3.05	11.2
11	1602-3200	0.175	1.0E-11	0.29	1.38	0.023	2.75	14.5
								_
Remarks:	Tested as Received							Page 2 of 2

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Tested at Trilab Brisbane Laboratory.

Authorised Signatory 1

C. Channon



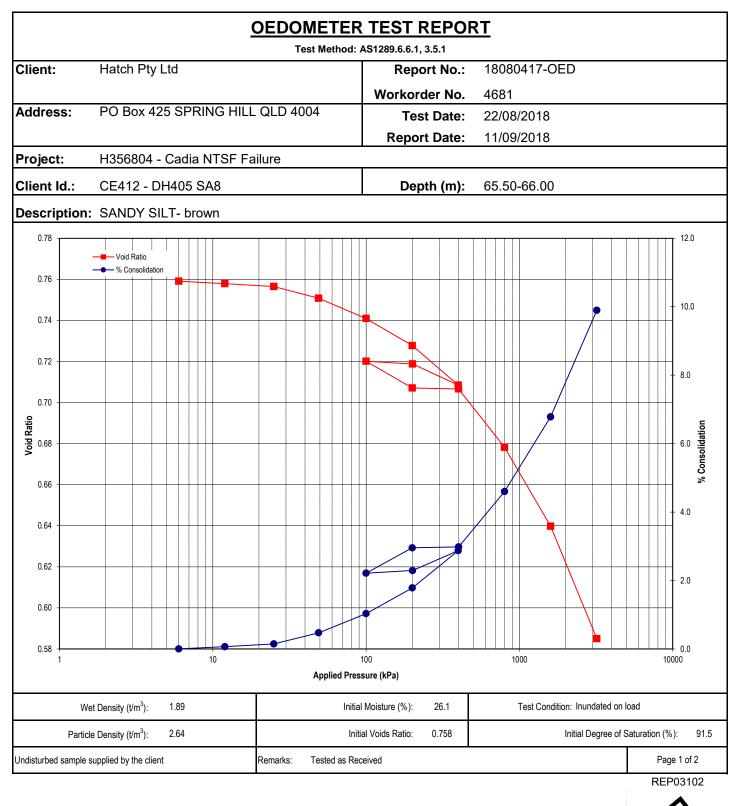
REP03102

Laboratory Number 9926

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Laboratory Number 9926

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ABN 25 065 630 506



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			OEDO	METEF	R TEST	REPORT		
			Те	est Method:	AS1289.6.6	.1, 3.5.1		
Client:	Hatch Pty Ltd				Rep	oort No.: 18080	417-OED	
					Worko	rder No. 4681		
Address:	PO Box 425 SPR	ING HILL	_ QLD 400	04		est Date: 22/08/		
Project:	H356804 - Cadia		niluro		Repo	ort Date: 11/09/	2018	
Client Id.:	CE412 - DH405 S				De	epth (m): 65.50-	66.00	
	SANDY SILT- bro					,pan (iii). 00.00	00.00	
Description				TEST	RESUL	TS		
Stage	Load	Cc	k	Cv (m²/yr)	Μν (kPa ⁻¹ x10 ⁻³)	C _a x 10 ⁻³	% Consolidation
	(kPa)		(m/s)	t ₅₀	t ₉₀			
1	6-12	0.004	4.9E-09	20.37	139.76	0.113	0.43	0.1
2	12-25	0.004	2.2E-09	271.75	117.66	0.061	0.32	0.1
3	25-49	0.019	4.6E-09	4.26	108.68	0.135	0.45	0.5
4	49-100	0.032	1.4E-09	6.10	41.79	0.110	0.64	1.0
5	100-200	0.044	3.0E-09	264.48	128.06	0.076	0.92	1.8
6	200-399	0.064	1.7E-09	167.26	98.24	0.056	1.23	2.9
7	399-201	0.035	2.6E-09	5.12	275.97	0.030	0.09	2.3
8	201-100	0.004	2.5E-10	13.52	105.92	0.008	0.11	2.2
9	100-200	0.043	1.2E-09	63.10	51.76	0.076	0.04	3.0
10	200-401	0.002	2.9E-11	171.58	69.79	0.001	0.32	3.0
11	401-800	0.095	6.3E-10	72.55	48.55	0.042	1.84	4.6
12	800-1599	0.128	8.3E-10	149.00	93.92	0.029	2.66	6.8
13	1599-3200	0.182	2.0E-10	38.79	30.65	0.021	3.68	9.9
Remarks:	Tested as Received							Page 2 of 2

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REP03102

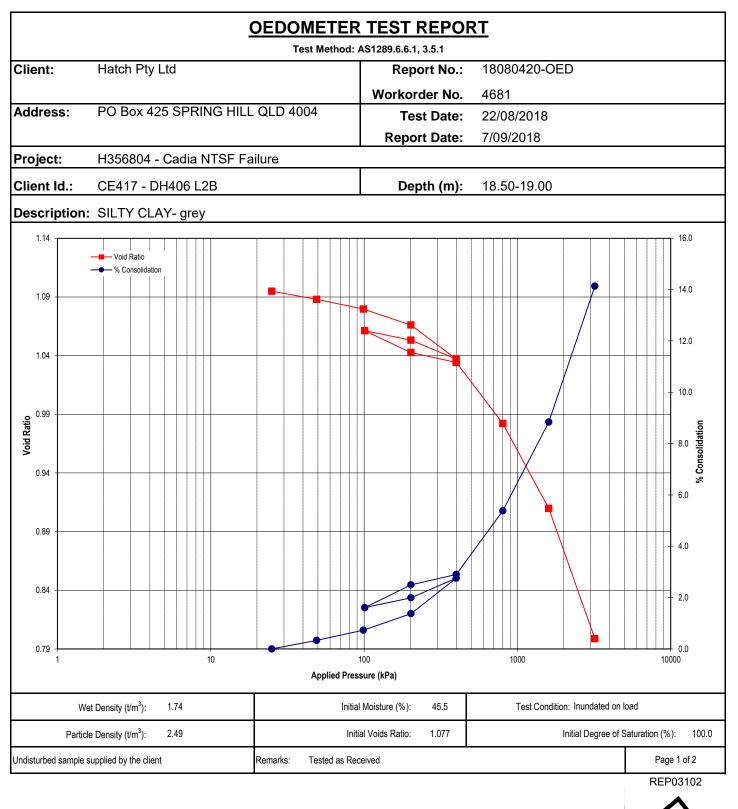
Laboratory Number 9926

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					AS1289.6.6	REPORT		
Client:	Hatch Pty Ltd		-				420-OED	
					Worko	rder No. 4681		
Address:	PO Box 425 SPR	ING HILL	. QLD 400)4	Те	est Date: 22/08/	2018	
					Repo	ort Date: 7/09/2	018	
Project:	H356804 - Cadia		ilure					
Client Id.:	CE417 - DH406 L	_2B			De	epth (m): 18.50-	19.00	
Description:	SILTY CLAY- gre	у						
				<u>TEST I</u>	RESUL	<u>TS</u>		
Stage	Load	Cc	k	Cv (m²/yr)	Mv (kPa⁻¹x10⁻³)	C _a x 10 ⁻³	% Consolidation
	(kPa)		(m/s)	t ₅₀	t ₉₀			
1	25-49	0.024	6.1E-09	10.56	141.94	0.138	0.37	0.3
2	49-99	0.027	3.2E-09	29.20	130.22	0.080	0.79	0.7
3	99-202	0.044	2.3E-09	15.22	117.88	0.063	0.88	1.4
4	202-399	0.098	1.2E-09	6.00	53.23	0.071	1.45	2.8
5	399-202	0.054	1.4E-09	5.13	109.19	0.040	0.25	2.0
6	202-101	0.027	7.1E-10	2.54	58.96	0.039	0.55	1.6
7	101-202	0.062	2.0E-09	9.29	73.06	0.089	0.19	2.5
8	202-399	0.028	3.8E-10	9.91	58.59	0.021	0.73	2.9
9	399-803	0.171	1.6E-10	2.41	8.09	0.063	1.95	5.4
10	803-1602	0.241	7.6E-11	1.24	5.39	0.046	3.52	8.8
11	1602-3199	0.370	4.1E-10	0.87	36.75	0.036	5.96	14.1
Remarks:	Tested as Received	1	1		1			Page 2 of 2

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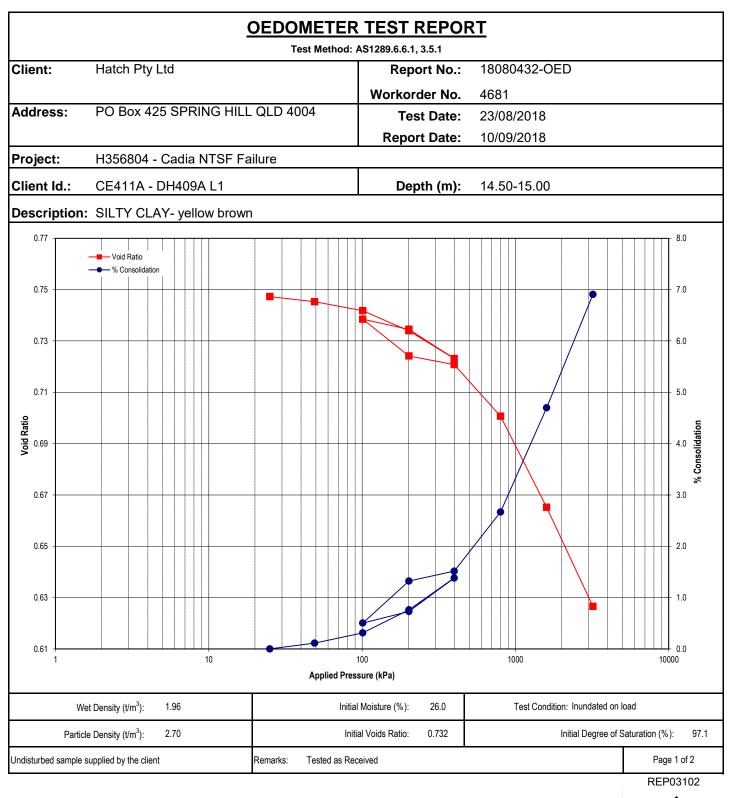
REP03102

Laboratory Number 9926

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			OEDO	METEF	R TEST	REPORT		
			Те	est Method:	AS1289.6.6	.1, 3.5.1		
Client:	Hatch Pty Ltd				Rep	oort No.: 18080	432-OED	
						rder No. 4681		
Address:	PO Box 425 SPR	ING HILL	_ QLD 400	J4		est Date: 23/08/		
Project:	H356804 - Cadia		viluro		Repo	ort Date: 10/09/	2018	
-					De	anth (m) 14.50	45.00	
Client Id.:	CE411A - DH409				De	epth (m): 14.50-	15.00	
Description:	SILTY CLAY- yel	low browr	ו	TEOT		70		
	1	1	T	<u>1ESI I</u>	RESUL	<u>15</u>		_
Stage	Load	Cc	k	Cv (m²/yr)	M∨ (kPa ⁻¹ x10 ⁻³)	C _a x 10 ⁻³	% Consolidation
	(kPa)		(m/s)	t ₅₀	t ₉₀			
1	25-49	0.007	1.4E-09	21.54	97.38	0.047	0.26	0.1
2	49-101	0.011	1.3E-09	11.59	113.47	0.038	0.36	0.3
3	101-202	0.026	6.1E-10	35.07	44.07	0.045	0.71	0.8
4	202-399	0.037	1.1E-09	28.25	111.99	0.032	0.88	1.4
5	399-202	0.039	1.9E-09	16.54	183.12	0.034	0.05	0.7
6	202-101	0.013	3.9E-10	8.70	55.25	0.022	0.13	0.5
7	101-202	0.047	1.8E-09	26.75	70.33	0.081	0.10	1.3
8	202-399	0.011	1.9E-10	37.39	62.81	0.010	0.29	1.5
9	399-800	0.067	5.8E-10	31.59	64.15	0.029	1.46	2.7
10	800-1599	0.118	4.0E-10	17.49	48.82	0.026	1.99	4.7
11	1599-3202	0.128	1.5E-10	12.74	34.34	0.014	2.98	6.9
Remarks:	Tested as Received							Page 2 of 2

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REP03102

Laboratory Number 9926

Tested at Trilab Brisbane Laboratory.



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT1

 IPO Number:
 2018-017

 Sample ID:
 2018-017-004

 Borehole ID:
 CE411

 Depth:
 3.13 m to 3.18 m

Test Details:	
Test ID:	CE-OED-01
Tested By:	BB/SL/KM
Date:	11/09/2018
Checked By:	TC
Date:	27/9/2018

Sample Details:	Initial	Final
Sample Diameter (mm) :	60.0	60.0
Sample Height (mm) :	21.85	18.22
Dry Density (t/m ³) :	1.52	1.79
Moisture Content (%) :	26.2 *	22.6
Soil Particle Density (t/m ³) :	2.	79

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample

1-DIMENSIONAL CONSOLIDATION TEST Test Method: AS 1289.6.6.1

Stage		σν	е	Cv	m _v	k
				m²/year	m²/kN	m/sec
	1	25	0.824	-	1.0E-03	-
	2	50	0.801	528.8	5.0E-04	8.2E-08
Loading	3	100	0.764	639.8	4.1E-04	8.1E-08
	4	200	0.714	821.5	2.9E-04	7.3E-08
	5	400	0.657	966.9	1.7E-04	5.0E-08
Unloading	6	200	0.658	-	-	-
Unioading	7	100	0.660	-	-	-
Re-Loading	8	200	0.660	-	-	-
ite-Loading	9	400	0.655	-	-	-
	10	800	0.604	2,132.8	7.7E-05	5.1E-08
Loading	11	1,600	0.552	2,011.5	4.0E-05	2.5E-08
	12	3,200	0.507	1,973.8	1.8E-05	1.1E-08
	13	800	0.511	-	-	-
Unloading	14	200	0.522	-	-	-
	15	25	0.542	-	-	-

Cadia NTSF Failure - Laboratory Testing 1-Dimensional Consolidation

Figure B-1 - Page 1

Job No.LAB127730

L:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\07 Consolidation\03 Final\Rev 0\For Client\2018-017-004 CE-OED-01.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT1

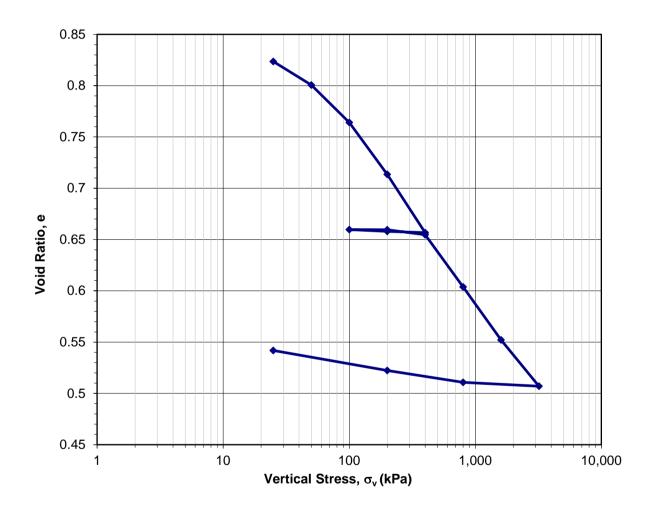
 IPO Number:
 2018-017

 Sample ID:
 2018-017-004

 Borehole ID:
 CE411

 Depth:
 3.13 m to 3.18 m

1-DIMENSIONAL CONSOLIDATION TEST Test Method: AS 1289.6.6.1



Cadia NTSF Failure - Laboratory Testing 1-Dimensional Consolidation

Figure B-1 - Page 2

Job No.LAB127730

L\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\07 Consolidation\03 Final\Rev 0\For Client\2018-017-004 CE-OED-01.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT2

 IPO Number:
 2018-017

 Sample ID:
 2018-017-006

 Borehole ID:
 CE411A

 Depth:
 12.91 m to 12.95 m

Test Details:				
Test ID:	CE-OED-02			
Tested By:	BB/KM/SL			
Date:	05/09/2018			
Checked By:	TC			
Date:	27/9/2018			

Sample Details:	Initial	Final	
Sample Diameter (mm) :	60.0	60.0	
Sample Height (mm) :	25.50	25.05	
Dry Density (t/m ³) :	1.52	1.62	
Moisture Content (%) :	25.8 *	25.8 * 26.9	
Soil Particle Density (t/m ³) :	2.	2.87	

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample

1-DIMENSIONAL CONSOLIDATION TEST Test Method: AS 1289.6.6.1

Stage		σ_{v}	е	C _v	m _v	k
		kPa		m²/year	m²/kN	m/sec
	1	25	0.786	-	4.6E-04	-
	2	50	0.778	1,233.9	1.9E-04	7.1E-08
Loading	3	100	0.768	1,972.9	1.1E-04	6.9E-08
	4	200	0.752	2,007.9	9.0E-05	5.6E-08
	5	400	0.729	2,595.8	6.6E-05	5.3E-08
L ha la a dina ri	6	200	0.733	-	-	-
Unloading	7	100	0.737	-	-	-
Dologding	8	200	0.735	-	-	-
Re-Loading	9	400	0.727	-	-	-
	10	800	0.703	2,236.8	3.5E-05	2.4E-08
Loading	11	1,600	0.663	848.8	2.9E-05	7.7E-09
	12	3,200	0.598	1,264.5	2.5E-05	9.6E-09
	13	800	0.617	-	-	-
Unloading	14	200	0.643	-	-	-
	15	25	0.682	-	-	-

Cadia NTSF Failure - Laboratory Testing 1-Dimensional Consolidation

Figure B-2 - Page 1

Job No.LAB127730

L:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\07 Consolidation\03 Final\Rev 0\For Client\2018-017-015 CE-OED-03.xIsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT2

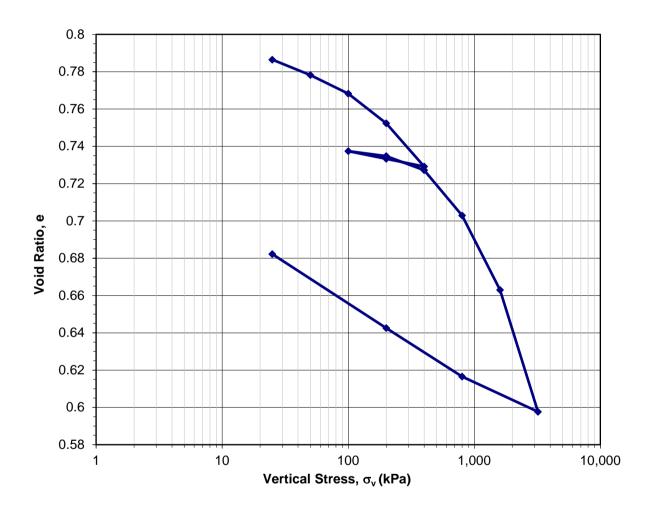
 IPO Number:
 2018-017

 Sample ID:
 2018-017-006

 Borehole ID:
 CE411A

 Depth:
 12.91 m to 12.95 m

1-DIMENSIONAL CONSOLIDATION TEST Test Method: AS 1289.6.6.1



Cadia NTSF Failure - Laboratory Testing 1-Dimensional Consolidation

Figure B-2 - Page 2

Job No.LAB127730

L:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\07 Consolidation\03 Final\Rev 0\For Client\2018-017-015 CE-OED-03.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT5

 IPO Number:
 2018-017

 Sample ID:
 2018-017-015

 Borehole ID:
 CE411A

 Depth:
 16.70 m to 16.74 m

Test Details:				
Test ID:	CE-OED-03			
Tested By:	BB/SL/KM			
Date:	11/09/2018			
Checked By:	TC			
Date:	27/9/2018			

Sample Details:	Initial	Final	
Sample Diameter (mm) :	60.0	60.0	
Sample Height (mm) :	22.13	21.54	
Dry Density (t/m ³) :	1.44	1.45	
Moisture Content (%) :	30.9 *	34.7	
Soil Particle Density (t/m ³) :	2.	2.83	

*Moisture content calculated using trimmings; may not be equal to moisture content of whole sample

1-DIMENSIONAL CONSOLIDATION TEST Test Method: AS 1289.6.6.1

Stage		σ_{v}	е	Cv	m _v	k
		kPa		m²/year	m²/kN	m/sec
	1	25	0.982	-	4.0E-04	-
	2	50	0.978	2,330.5	8.6E-05	6.2E-08
Loading	3	100	0.973	2,944.2	4.8E-05	4.4E-08
	4	200	0.970	4,052.3	1.7E-05	2.2E-08
	5	400	0.958	5,118.7	3.0E-05	4.9E-08
Unloading	6	200	0.961	-	-	-
Unioading	7	100	0.963	-	-	-
Re-Loading	8	200	0.961	-	-	-
Re-Loading	9	400	0.957	-	-	-
	10	800	0.946	4,754.6	1.3E-05	1.9E-08
Loading	11	1,600	0.928	4,446.5	1.2E-05	1.6E-08
	12	3,200	0.874	1,834.9	1.7E-05	9.9E-09
	13	800	0.890	-	-	-
Unloading	14	200	0.905	-	-	-
	15	25	0.923	-	-	-

Cadia NTSF Failure - Laboratory Testing 1-Dimensional Consolidation

Figure B-3 - Page 1

Job No.LAB127730

L:\agLAB\02.Projects\007.2018\LAB127730 - Cadia NTSF\03 Technical\04 Lab Testing\IPO 2018-017\07 Consolidation\03 Final\Rev 0\For Client\2018-017-004 CE-OED-01.xlsm



Client:Newcrest MiningProject:Cadia NTSF Failure - Laboratory TestingLocation:Cadia Valley OperationsSample No.:PT5

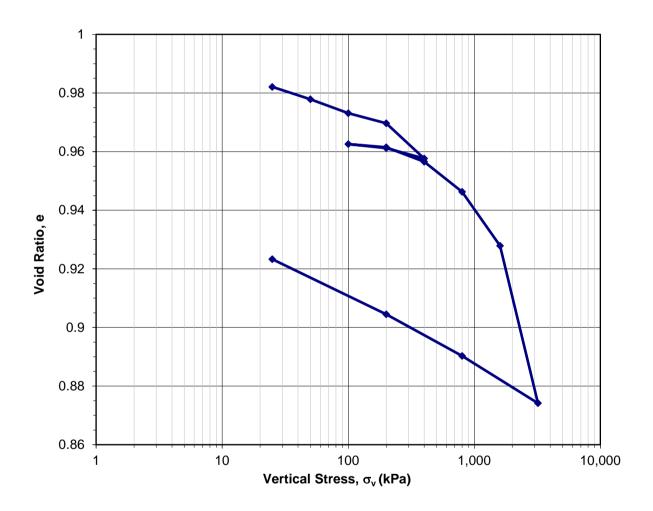
 IPO Number:
 2018-017

 Sample ID:
 2018-017-015

 Borehole ID:
 CE411A

 Depth:
 16.70 m to 16.74 m

1-DIMENSIONAL CONSOLIDATION TEST Test Method: AS 1289.6.6.1



Cadia NTSF Failure - Laboratory Testing 1-Dimensional Consolidation

Figure B-3 - Page 2

Job No.LAB127730

Annexure DH CRS Consolidation Tests

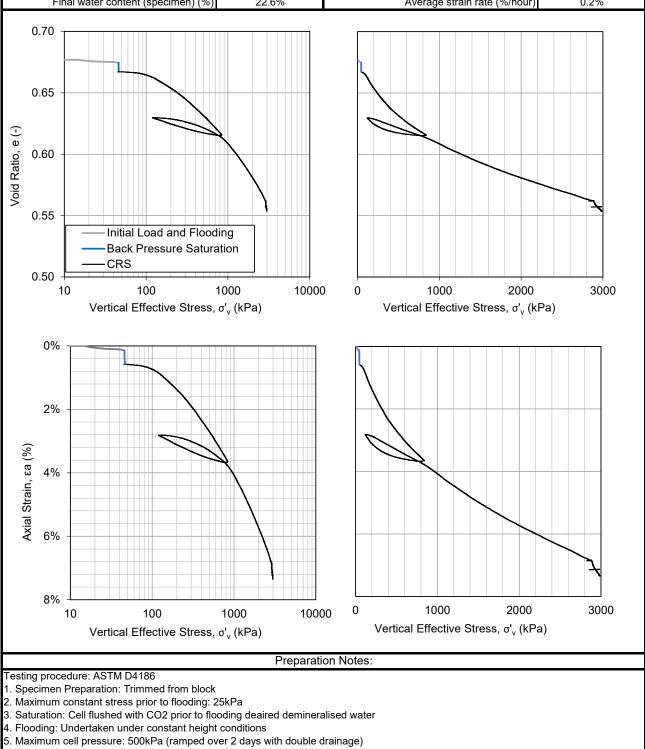
Constant Rate of Strain Consolidation Test

G

Perth Laboratory 84 Guthrie Street, Osborne Park

ER

Client:	Hatch		Date:	2/7/2018	
Address:	61 Petrie Terrace Brisbane		Project No.:	18101980	
Project:	NTSF Embankment Failure ITRB		Sample ID:	TP401 0.7-1.0m	
Location:	Cadia Mine		Sample ID:	18005 - CRS1	
	Diameter (mm)	60.0	S	pecific gravity (-)	2.80
Initia	al water content (trimmings) (%)	21.3%	Init	ial Void Ratio (-)	0.68
Initial Height (mm)		18.44	Initial Dry Density (t/m ³)		1.67
Final water content (specimen) (%) 22.		22.6%	Average stra	ain rate (%/hour)	0.2%

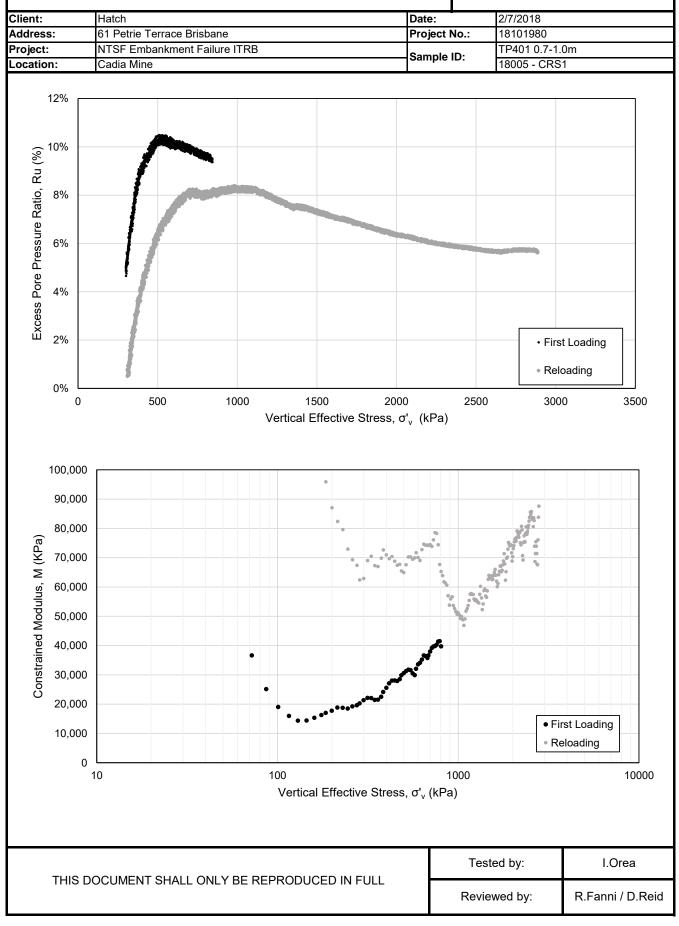


THIS DOCUMENT SHALL ONLY BE REPRODUCED IN FULL	Tested by:	I.Orea
THIS DOCOMENT SHALL ONET BE REFRODUCED IN FOLL	Reviewed by:	R.Fanni / D.Reid

Constant Rate of Strain Consolidation Test

ら GOLDER

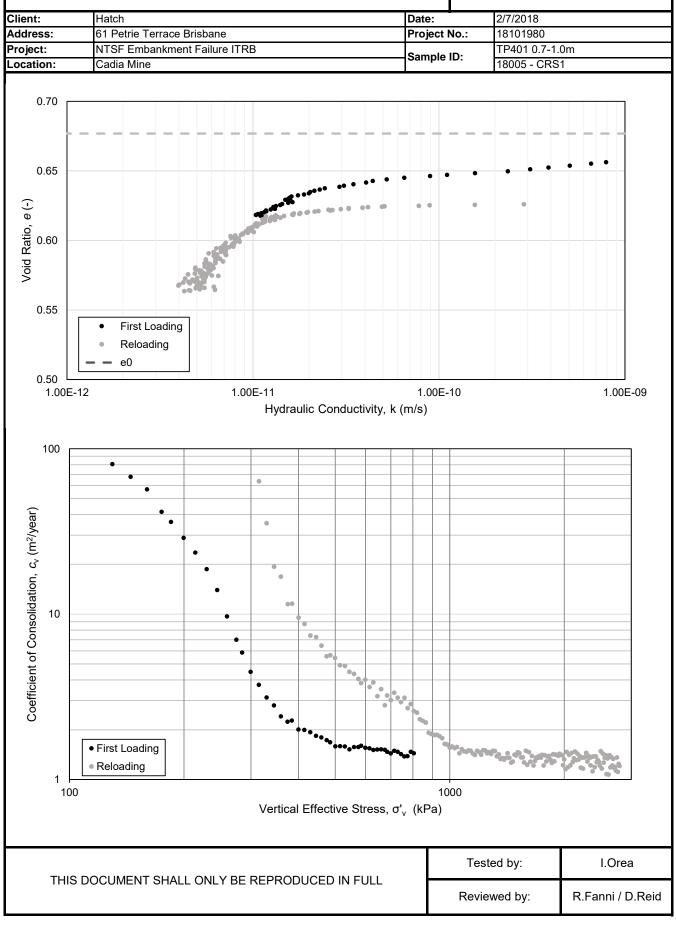
Perth Laboratory



Constant Rate of Strain Consolidation Test



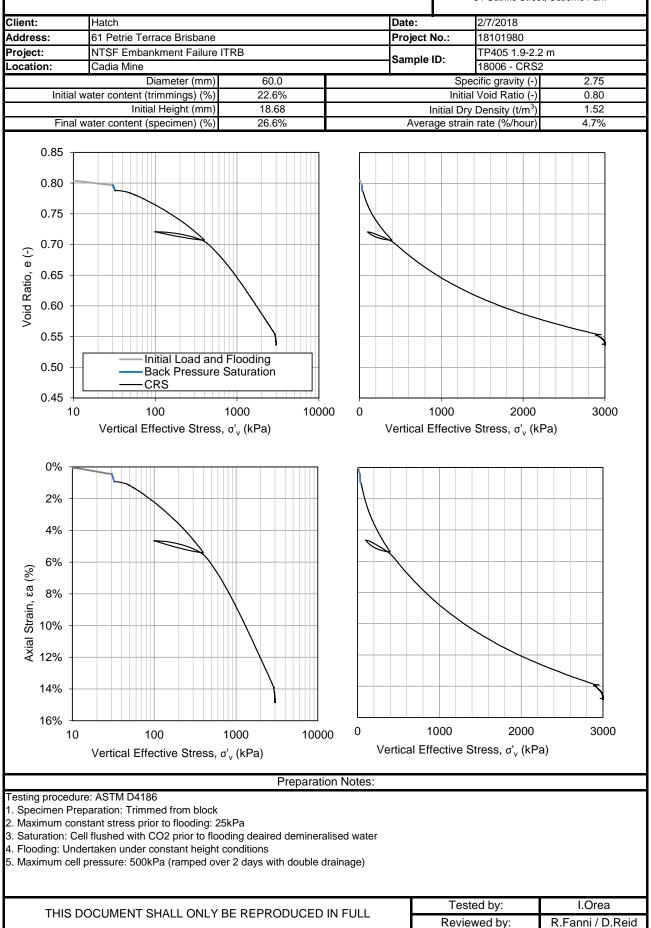
Perth Laboratory



Constant Rate of Strain Consolidation

G

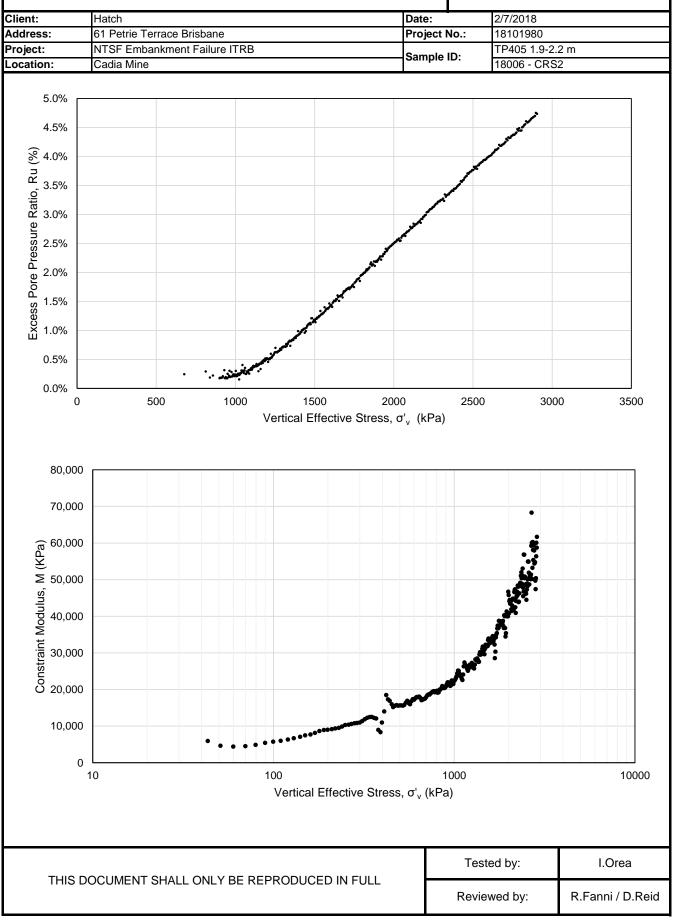
Perth Laboratory



Constant Rate of Strain Consolidation Test

ら GOLDER

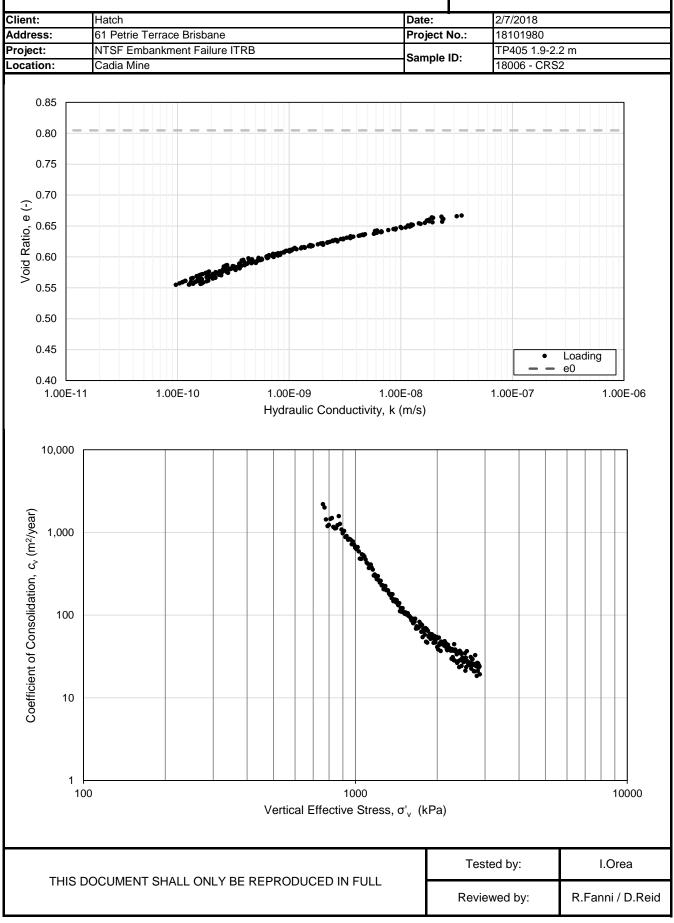
Perth Laboratory



Constant Rate of Strain Consolidation Test

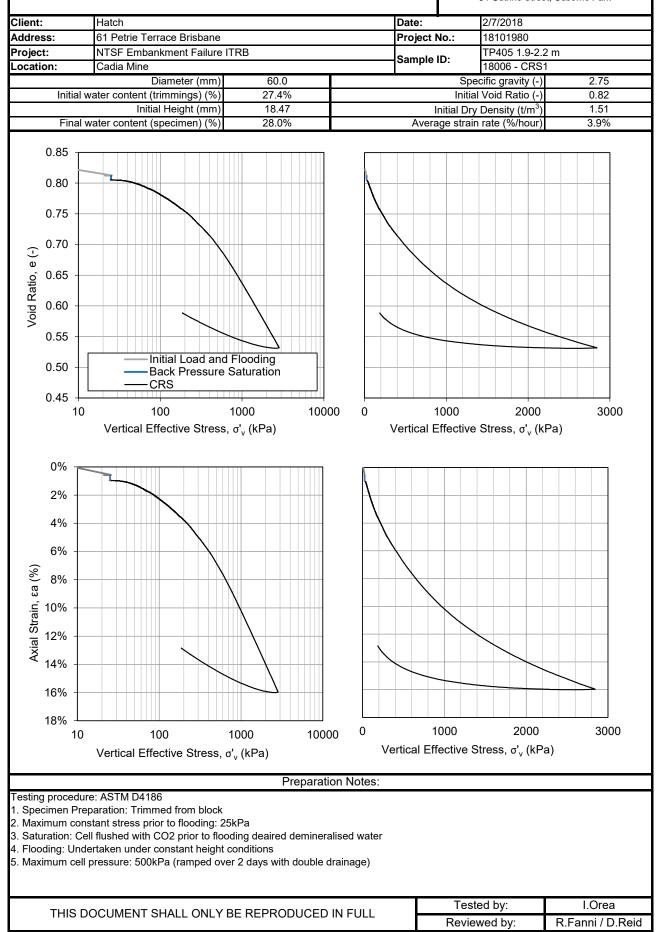


Perth Laboratory



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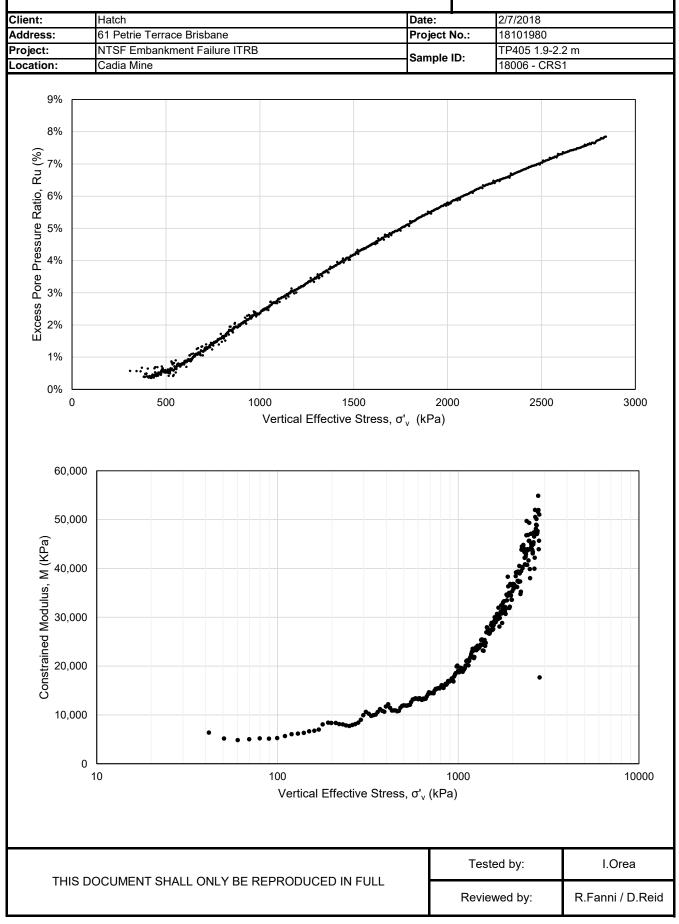
Perth Laboratory



Constant Rate of Strain Consolidation Test

ら GOLDER

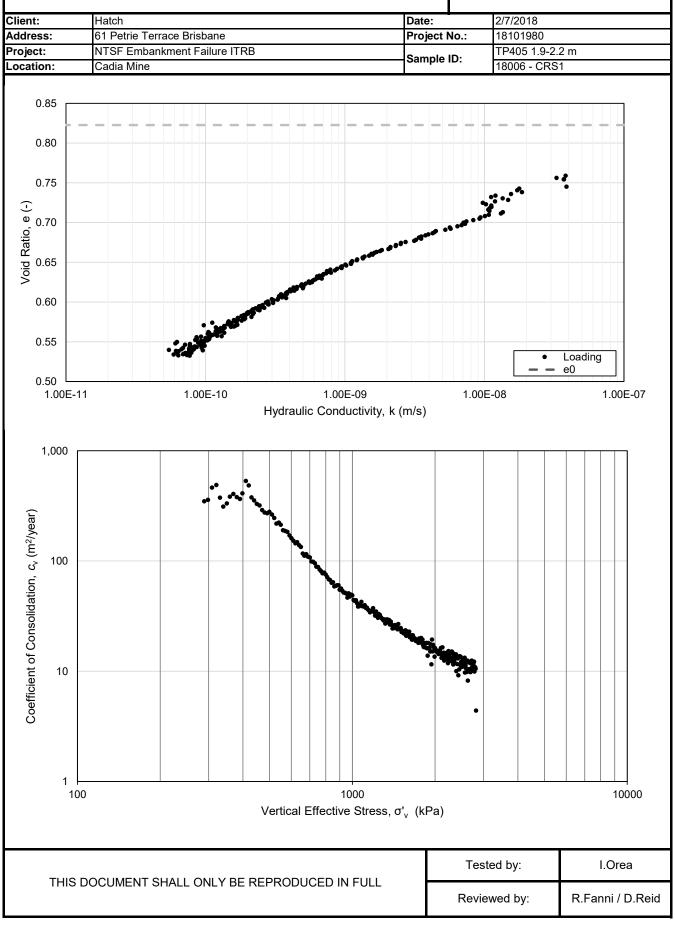
Perth Laboratory

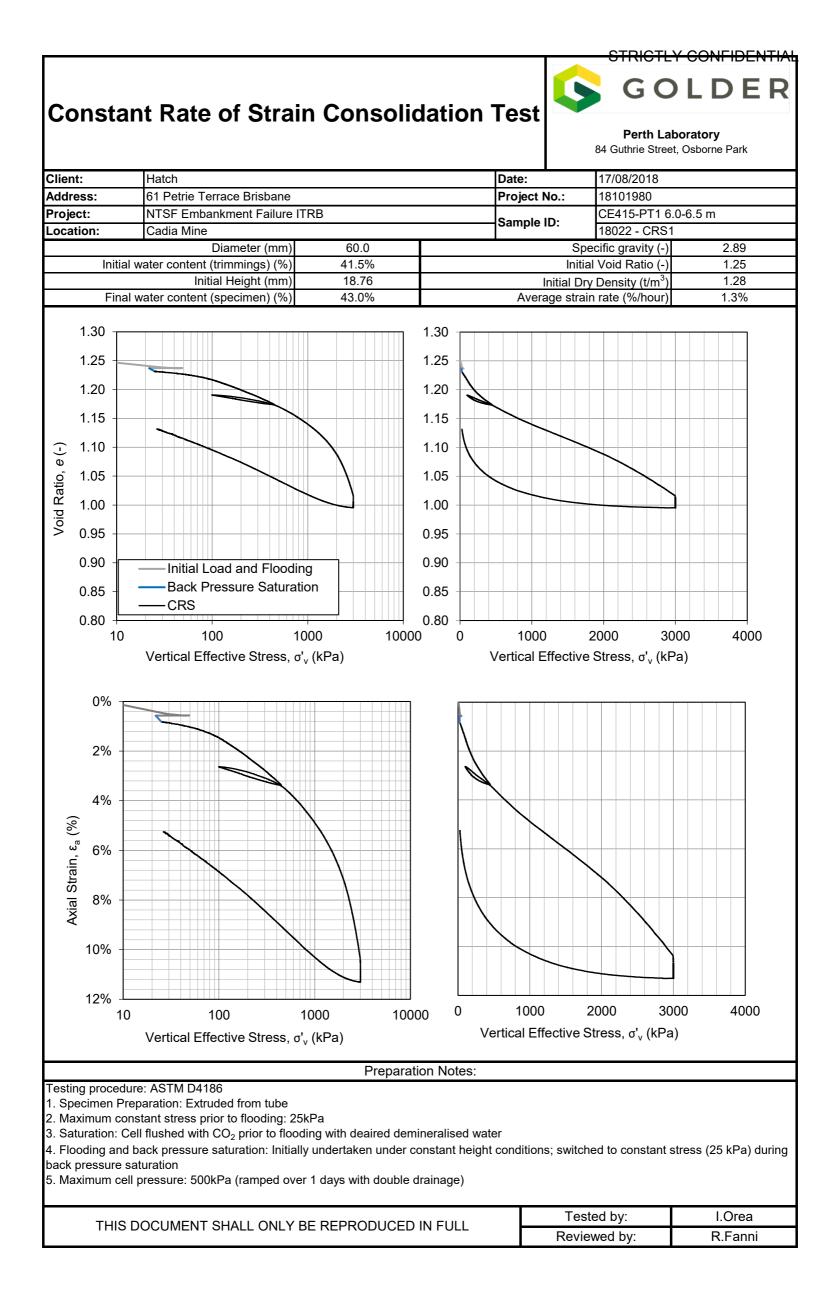


Constant Rate of Strain Consolidation Test

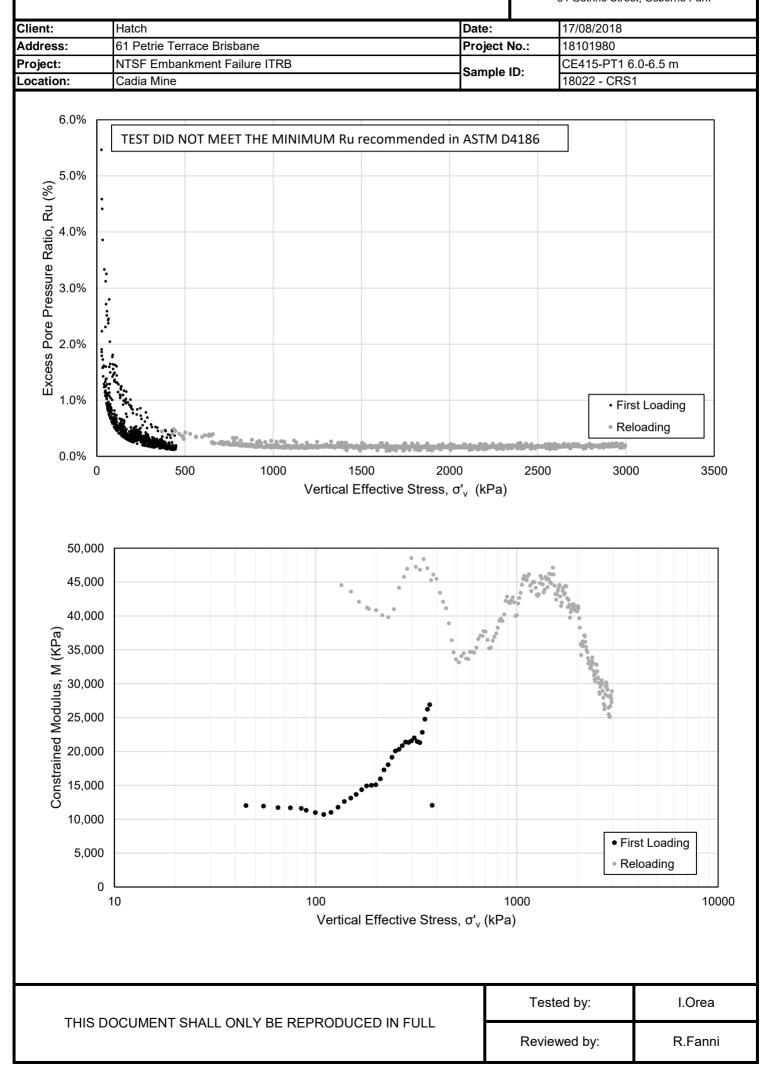


Perth Laboratory

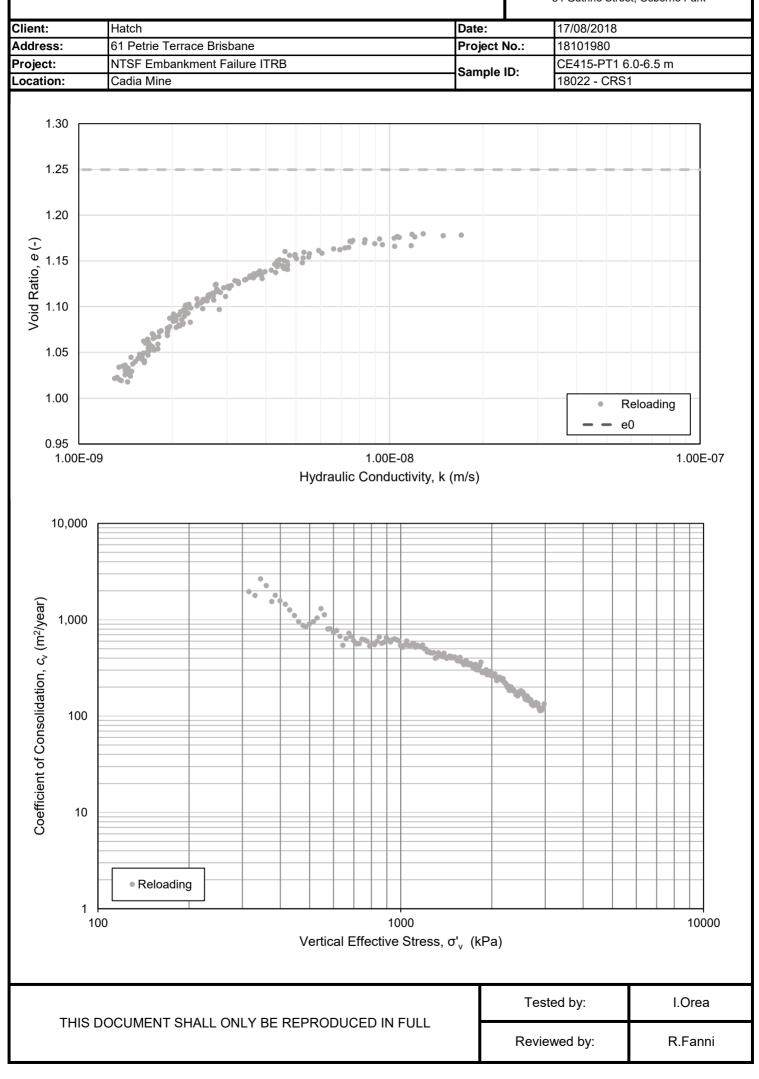


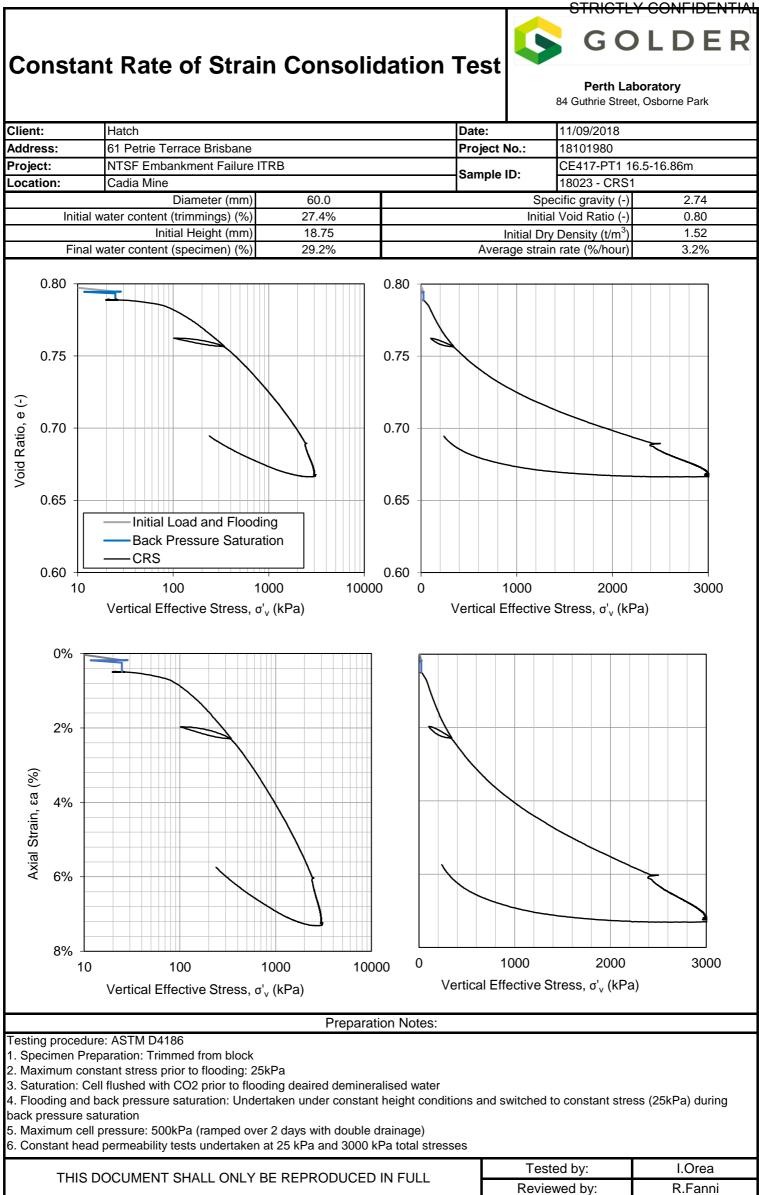




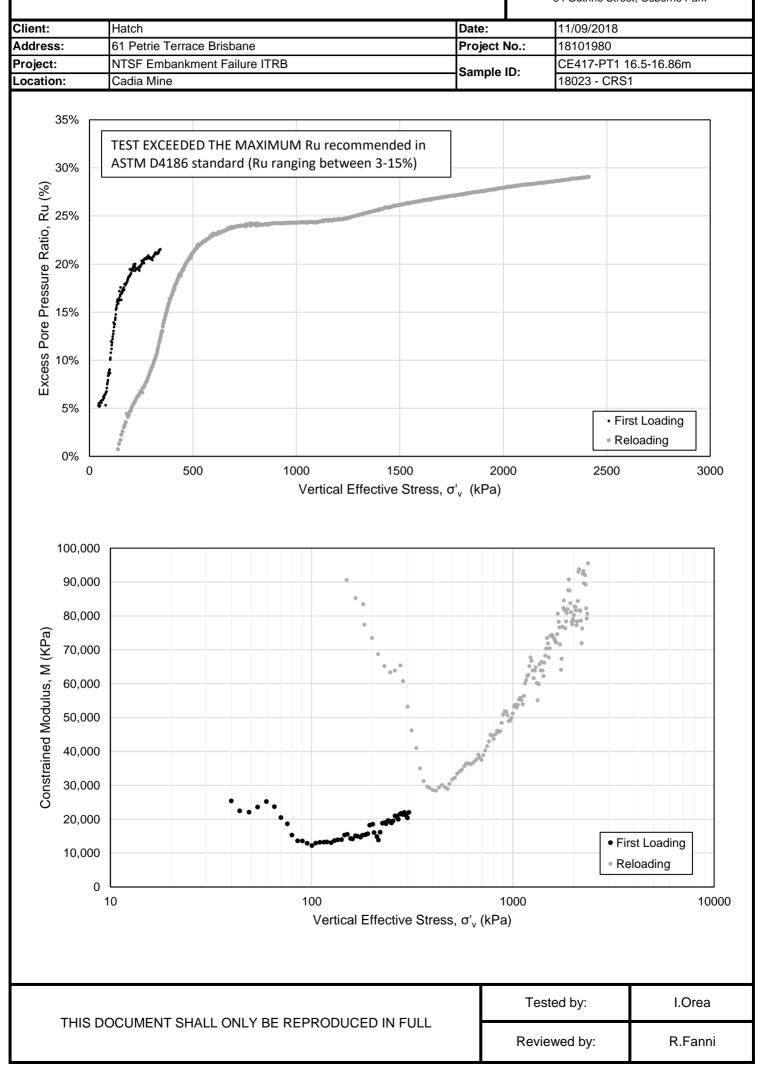




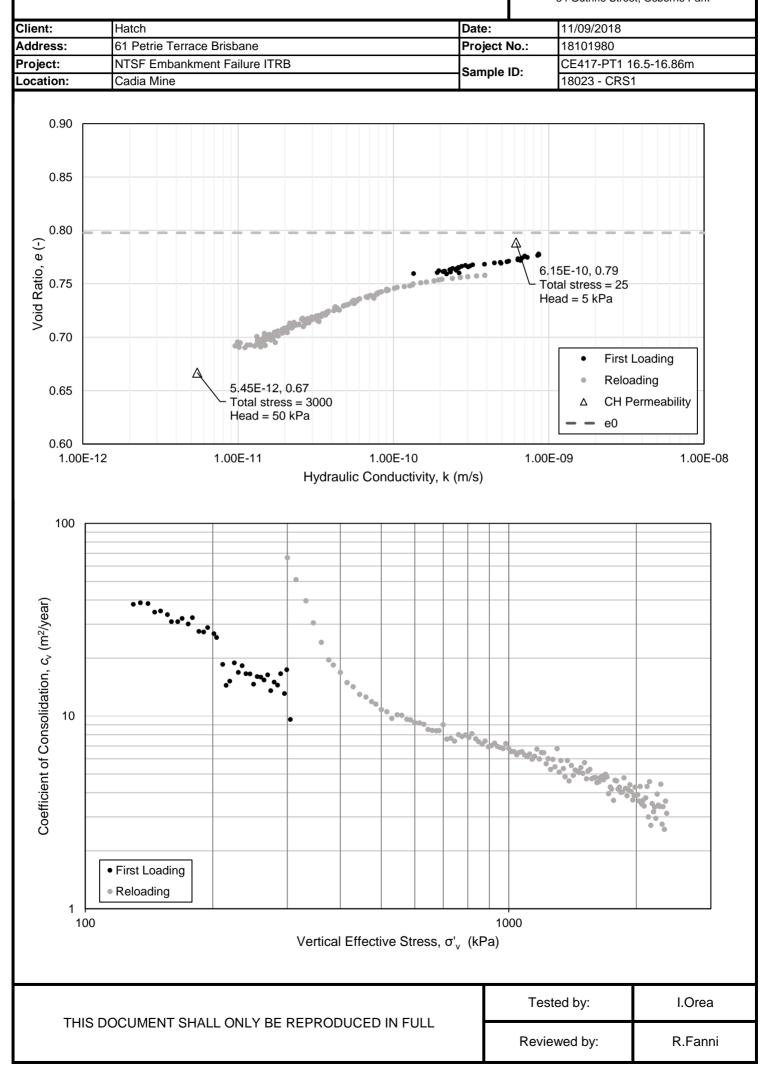


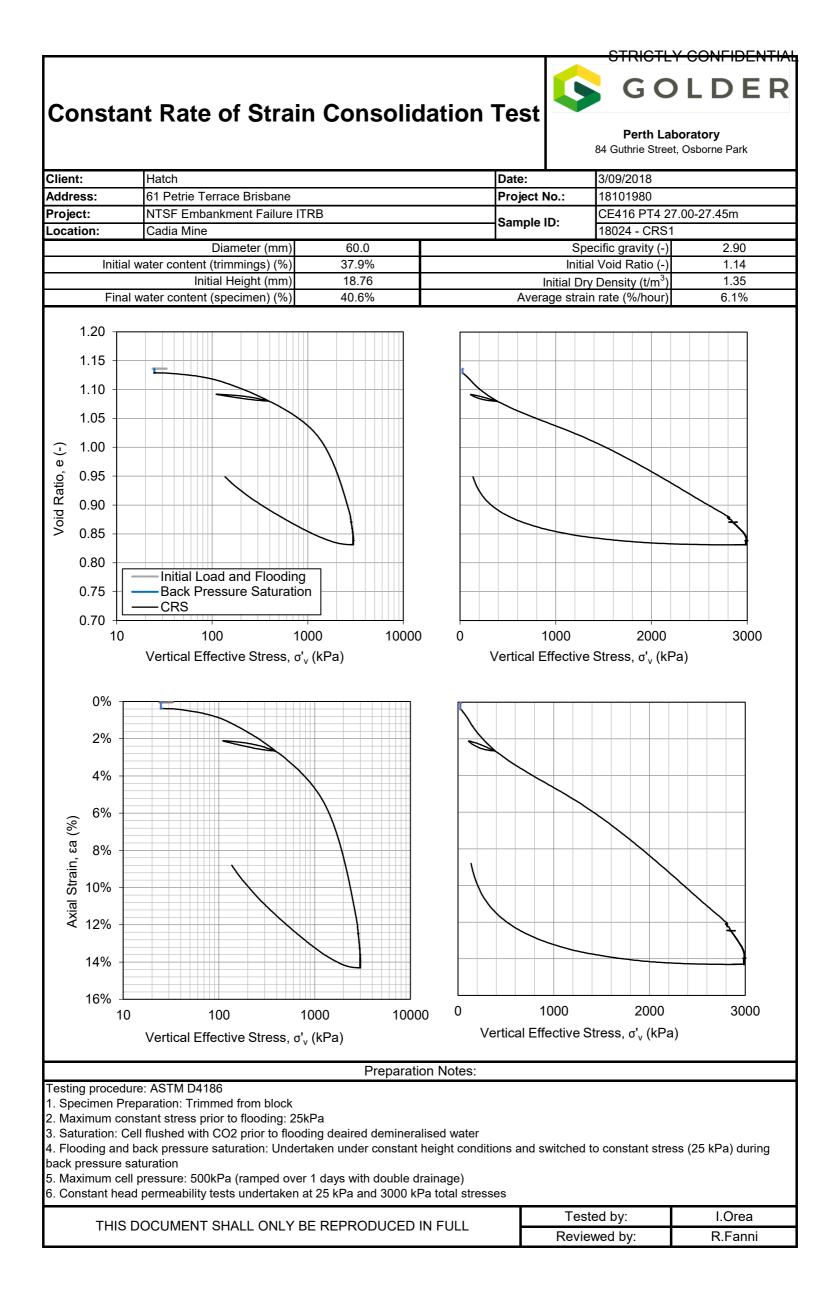




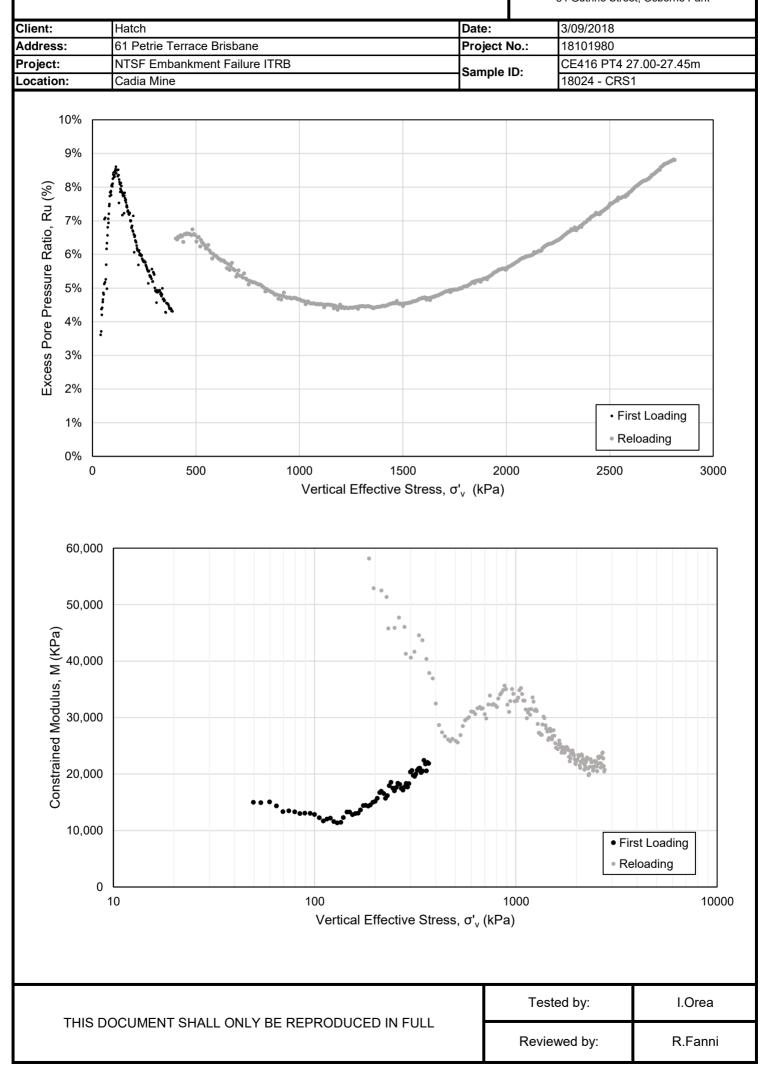




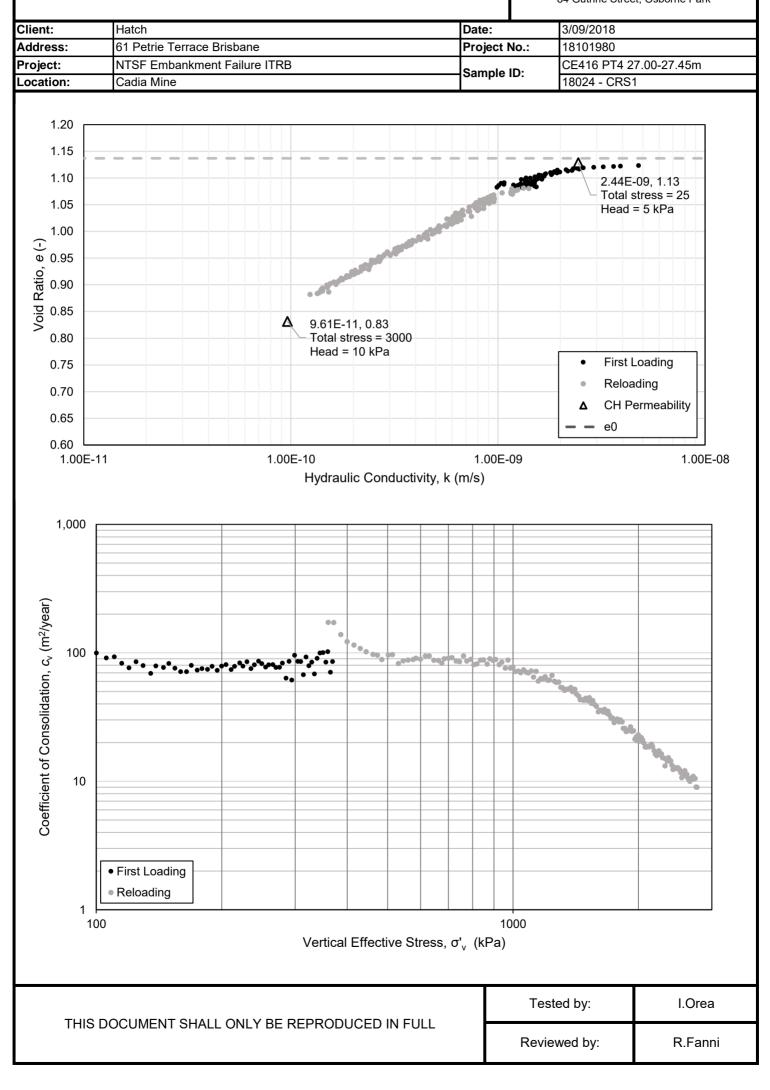












Annexure DI Miscellaneous Tests



Client:Golder Associates Pty LtdJob number:18_1341Sample:18_1341_01Client ID:PL01-BS1 0.0-0.5mDate:21-08-18Analysis :Semi-quantitative XRD analysis

Sample preparation

The sample was supplied by the client to Microanalysis Australia on 13th of August 2018 for the above mentioned analyses. A representative sub –sample was removed and lightly ground such that 90% was passing 20 µm. Grinding to this size helps eliminate preferred orientation.

Analysis

Only crystalline material present in the sample will give peaks in the XRD scan. Amorphous (non crystalline) material will add to the background. The search match software used was Eva 4.2. An up-to-date ICDD card set was used. The X-ray source was cobalt radiation.

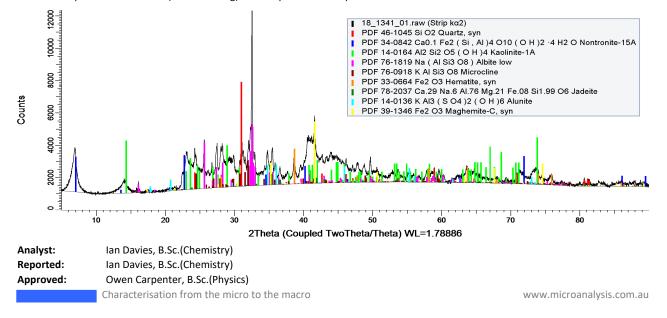
No standards were used in the quantification process. The concentrations were calculated using the peak area integration method where the area of the 100% peak for each mineral phase is summed and the relative percentages of each phase calculated based on the relative contribution to the sum. This method allows for some attention to be paid to preferred orientation but is limited in considering substitution and lattice strain.

Summary

The phases are listed in order of interpreted concentration:

Mineral phase	Concentration (%)	ICDD match probability
Albite low (Na (Al Si3 O8))	31	good
Kaolinite-1A (Al2 Si2 O5 (O H)4)	17	medium
Microcline (K Al Si3 O8)	14	good
Nontronite-15A (Ca0.1 Fe2 (Si , Al)4 O10 (O H)2 ·4 H2 O)	11	medium
Quartz, syn (Si O2)	10	good
Maghemite-C, syn (Fe2 O3)	5	medium
Hematite, syn (Fe2 O3)	5	good
Alunite (K Al3 (S O4)2 (O H)6)	3	low
Jadeite (Ca.29 Na.6 Al.76 Mg.21 Fe.08 Si1.99 O6)	3	low

The ICDD match probability is reported as an indication as to how well the peak positions and relative intensities for the sample matched those in the published literature (www.icdd.org) for that particular compound.



37 Kensington Street East Perth WA 6004



Client:Golder Associates Pty LtdJob number:18_1341Sample:18_1341_02Client ID:TP401-BL1 0.7-1.0mDate:21-08-18Analysis :Semi-quantitative XRD analysis

Sample preparation

The sample was supplied by the client to Microanalysis Australia on 13th of August 2018 for the above mentioned analyses. A representative sub –sample was removed and lightly ground such that 90% was passing 20 µm. Grinding to this size helps eliminate preferred orientation.

Analysis

Only crystalline material present in the sample will give peaks in the XRD scan. Amorphous (non crystalline) material will add to the background. The search match software used was Eva 4.2. An up-to-date ICDD card set was used. The X-ray source was cobalt radiation.

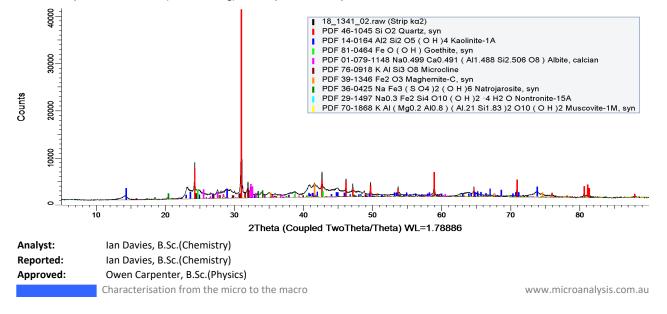
No standards were used in the quantification process. The concentrations were calculated using the peak area integration method where the area of the 100% peak for each mineral phase is summed and the relative percentages of each phase calculated based on the relative contribution to the sum. This method allows for some attention to be paid to preferred orientation but is limited in considering substitution and lattice strain.

Summary

The phases are listed in order of interpreted concentration:

Mineral phase	Concentration (%)	ICDD match probability
Quartz, syn (Si O2)	42	good
Albite, calcian (Na0.499 Ca0.491 (Al1.488 Si2.506 O8))	19	good
Microcline (K Al Si3 O8)	12	good
Kaolinite-1A (Al2 Si2 O5 (O H)4)	9	medium
Maghemite-C, syn (Fe2 O3)	7	medium
Natrojarosite, syn (Na Fe3 (S O4)2 (O H)6)	6	good
Goethite, syn (Fe O (O H))	3	medium
Muscovite-1M, syn (K Al (Mg0.2 Al0.8) (Al.21 Si1.83)2 O10 (O H)2)	1	low
Nontronite-15A (Na0.3 Fe2 Si4 O10 (O H)2 ·4 H2 O)	1	low

The ICDD match probability is reported as an indication as to how well the peak positions and relative intensities for the sample matched those in the published literature (www.icdd.org) for that particular compound.



37 Kensington Street East Perth WA 6004



Client:Golder Associates Pty LtdJob number:18_1341Sample:18_1341_03Client ID:TP405-BL1 1.9-2.2mDate:21-08-18Analysis :Semi-quantitative XRD analysis

Sample preparation

The sample was supplied by the client to Microanalysis Australia on 13th of August 2018 for the above mentioned analyses. A representative sub –sample was removed and lightly ground such that 90% was passing 20 µm. Grinding to this size helps eliminate preferred orientation.

Analysis

Only crystalline material present in the sample will give peaks in the XRD scan. Amorphous (non crystalline) material will add to the background. The search match software used was Eva 4.2. An up-to-date ICDD card set was used. The X-ray source was cobalt radiation.

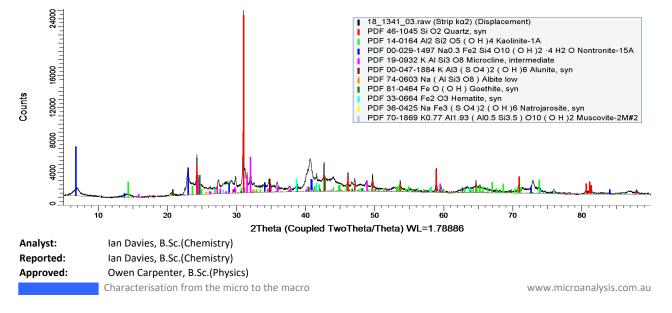
No standards were used in the quantification process. The concentrations were calculated using the peak area integration method where the area of the 100% peak for each mineral phase is summed and the relative percentages of each phase calculated based on the relative contribution to the sum. This method allows for some attention to be paid to preferred orientation but is limited in considering substitution and lattice strain.

Summary

The phases are listed in order of interpreted concentration:

Mineral phase	Concentration (%)	ICDD match probability
Quartz, syn (Si O2)	28	good
Nontronite-15A (Na0.3 Fe2 Si4 O10 (O H)2 ·4 H2 O)	26	medium
Microcline, intermediate (K Al Si3 O8)	19	good
Kaolinite-1A (Al2 Si2 O5 (O H)4)	8	medium
Alunite, syn (K Al3 (S O4)2 (O H)6)	7	medium
Goethite, syn (Fe O (O H))	4	medium
Hematite, syn (Fe2 O3)	3	medium
Albite low (Na (Al Si3 O8))	3	medium
Muscovite-2M#2 (K0.77 Al1.93 (Al0.5 Si3.5) O10 (O H)2)	2	low
Natrojarosite, syn (Na Fe3 (S O4)2 (O H)6)	1	low

The ICDD match probability is reported as an indication as to how well the peak positions and relative intensities for the sample matched those in the published literature (www.icdd.org) for that particular compound.



37 Kensington Street East Perth WA 6004



37 Kensington Street East Perth

Client:	Golder Associates Pty Ltd
Job number:	18_1484
Sample:	18_1484_01
Client ID:	CE406 SA3 22.2-22.3m
Date:	14-09-18
Analysis :	Semi-quantitative XRD analysis

Sample preparation

The sample was supplied by the client to Microanalysis Australia on 5th of September 2018 for the above mentioned analyses. A representative sub –sample was removed and lightly ground such that 90% was passing 20 μ m. Grinding to this size helps eliminate preferred orientation.

Analysis

Only crystalline material present in the sample will give peaks in the XRD scan. Amorphous (non crystalline) material will add to the background. The search match software used was Eva 4.2. An up-to-date ICDD card set was used. The X-ray source was cobalt radiation.

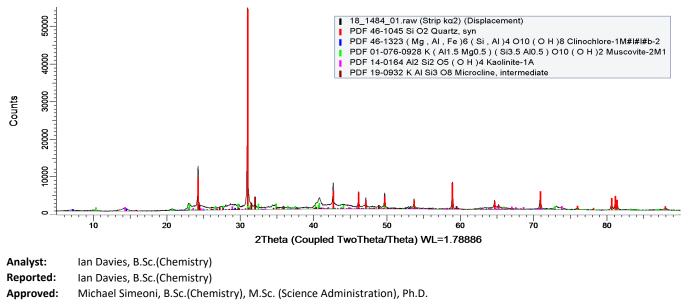
No standards were used in the quantification process. The concentrations were calculated using the normalized reference intensity ratio method where the intensity of the 100% peak divided by the published I/Ic value for each mineral phase is summed and the relative percentages of each phase calculated based on the relative contribution to the sum. This method allows for slight attention to be paid to preferred orientation but is limited in considering other factors including but not limited to; variable crystallinity, alteration, fluorescence, substitution and lattice strain.

Summary

The phases are listed in order of interpreted concentration:

Mineral phase	Concentration (%)	
Quartz, syn (Si O2)	57	good
Microcline, intermediate (K Al Si3 O8)	20	good
Muscovite-2M1 (K (Al1.5 Mg0.5) (Si3.5 Al0.5) O10 (O H)2)	16	medium
Kaolinite-1A (Al2 Si2 O5 (O H)4)	4	medium
Clinochlore-1M#I#I#b-2 ((Mg , Al , Fe)6 (Si , Al)4 O10 (O H)8)	2	low

The ICDD match probability is reported as an indication as to how well the peak positions and relative intensities for the sample matched those in the published literature (www.icdd.org) for that particular compound.





Client:Golder Associates Pty LtdJob number:18_1484Sample:18_1484_02Client ID:CE416 PT4 27.0-27.45mDate:14-09-18Analysis :Semi-quantitative XRD analysis

Sample preparation

The sample was supplied by the client to Microanalysis Australia on 5th of September 2018 for the above mentioned analyses. A representative sub –sample was removed and lightly ground such that 90% was passing 20 μ m. Grinding to this size helps eliminate preferred orientation.

Analysis

Only crystalline material present in the sample will give peaks in the XRD scan. Amorphous (non crystalline) material will add to the background. The search match software used was Eva 4.2. An up-to-date ICDD card set was used. The X-ray source was cobalt radiation.

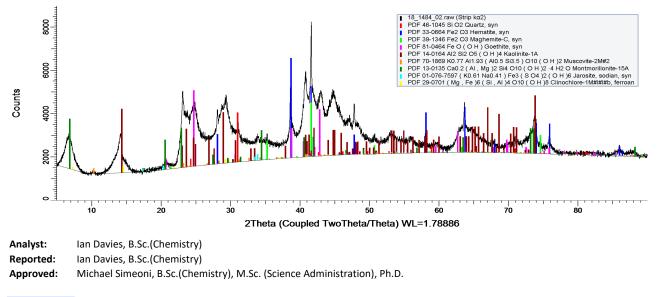
No standards were used in the quantification process. The concentrations were calculated using the normalized reference intensity ratio method where the intensity of the 100% peak divided by the published I/Ic value for each mineral phase is summed and the relative percentages of each phase calculated based on the relative contribution to the sum. This method allows for slight attention to be paid to preferred orientation but is limited in considering other factors including but not limited to; variable crystallinity, alteration, fluorescence, substitution and lattice strain.

Summary

The phases are listed in order of interpreted concentration:

Mineral phase	Concentration (%)	
Kaolinite-1A (Al2 Si2 O5 (O H)4)	25	medium
Montmorillonite-15A (Ca0.2 (Al , Mg)2 Si4 O10 (O H)2 ·4 H2 O)	19	medium
Hematite, syn (Fe2 O3)	16	good
Maghemite-C, syn (Fe2 O3)	15	good
Goethite, syn (Fe O (O H))	11	good
Quartz, syn (Si O2)	6	good
Muscovite-2M#2 (K0.77 Al1.93 (Al0.5 Si3.5) O10 (O H)2)	5	medium
Clinochlore-1M#I#I#b, ferroan ((Mg , Fe)6 (Si , Al)4 O10 (O H)8)	3	low
Jarosite, sodian, syn ((K0.61 Na0.41) Fe3 (S O4)2 (O H)6)	1	low

The ICDD match probability is reported as an indication as to how well the peak positions and relative intensities for the sample matched those in the published literature (www.icdd.org) for that particular compound.



37 Kensington Street East Perth



37 Kensington Street East Perth

Client:	Golder Associates Pty Ltd
Job number:	18_1484
Sample:	18_1484_03
Client ID:	CE415 PT1 6.0-6.5m
Date:	14-09-18
Analysis :	Semi-quantitative XRD analysis

Sample preparation

The sample was supplied by the client to Microanalysis Australia on 5th of September 2018 for the above mentioned analyses. A representative sub –sample was removed and lightly ground such that 90% was passing 20 μ m. Grinding to this size helps eliminate preferred orientation.

Analysis

Only crystalline material present in the sample will give peaks in the XRD scan. Amorphous (non crystalline) material will add to the background. The search match software used was Eva 4.2. An up-to-date ICDD card set was used. The X-ray source was cobalt radiation.

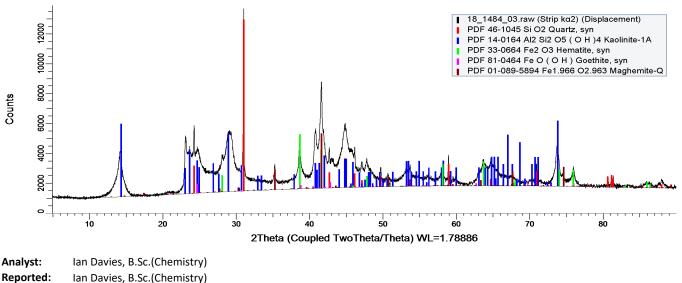
No standards were used in the quantification process. The concentrations were calculated using the normalized reference intensity ratio method where the intensity of the 100% peak divided by the published I/Ic value for each mineral phase is summed and the relative percentages of each phase calculated based on the relative contribution to the sum. This method allows for slight attention to be paid to preferred orientation but is limited in considering other factors including but not limited to; variable crystallinity, alteration, fluorescence, substitution and lattice strain.

Summary

The phases are listed in order of interpreted concentration:

Mineral phase	Concentration (%)	
Kaolinite-1A (Al2 Si2 O5 (O H)4)	43	medium
Quartz, syn (Si O2)	30	good
Hematite, syn (Fe2 O3)	13	good
Maghemite-Q (Fe1.966 O2.963)	12	medium
Goethite, syn (Fe O (O H))	2	medium

The ICDD match probability is reported as an indication as to how well the peak positions and relative intensities for the sample matched those in the published literature (www.icdd.org) for that particular compound.



Approved: Michael Simeoni, B.Sc. (Chemistry), M.Sc. (Science Administration), Ph.D.

Dry Density Moisture Content Relationship Report

Perth Laboratory 84 Guthrie Street Osborne Park

GOLDER

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CERTIFICATE OF ANALYSIS								
EB1826989	Page	: 1 of 2						
	Laboratory	Environmental Division Brisbane						
: MR CHRIS CHANNON	Contact	: Customer Services EB						
: 346A BILSEN RD	Address	: 2 Byth Street Stafford QLD Australia 4053						
GEEBUNG QLD, AUSTRALIA 4031								

Telephone	: +61-7-3243 7222
Date Samples Received	: 07-Nov-2018 13:08
Date Analysis Commenced	: 13-Nov-2018
Issue Date	: 15-Nov-2018 12:11



This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with **Quality Review and Sample Receipt Notification.**

Signatories

Work Order Client Contact Address

Telephone

Order number

C-O-C number

Quote number

No. of samples received

No. of samples analysed

Project

Sampler

Site

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD



General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key: CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.

LOR = Limit of reporting

^ = This result is computed from individual analyte detections at or above the level of reporting

ø = ALS is not NATA accredited for these tests.

~ = Indicates an estimated value.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)	Client sample ID		18110181 / CE417 - DH406 L2B / 18.50-19.00m	 	 	
Client sampling date / time		07-Nov-2018 00:00	 	 		
Compound	CAS Number	LOR	Unit	EB1826989-001	 	
				Result	 	
EA101: Loss on Ignition						
Loss on Ignition @ 550°C		0.1	%	7.1	 	

Annexure DJ Laboratory Test Procedures

Simple Shear – Rigid Boundary Laboratory Testing Procedure

Document Number: FAM-18552

Responsible Person: APAC Director of GeoConsulting

		Sint	Juglo	DALL	
3	Issued for Use	Surendra Rajkarnikar Laboratory Engineer	Terry Chang Laboratory Manager	David Williams APAC Director of GeoConsulting	22/05/2018
Rev	Description	Prepared	Checked	Approved	Date



RECORD OF CHANGES

Revision	Reason for Change	Page Number(s)
3	 Updated formatting to Fugro Standard Updated references 	ThroughoutThroughout
2	Review and updated	
1	OpCo removed and replaced with Fugro	

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1. OBJECTIVES

This procedure sets out methods for simple shear tests (monotonic, creep and cyclic) on undisturbed and reconstituted samples using the two different types of rigid boundary type simple shear apparatus at the Fugro Advanced Geotechnical Laboratory (AGLab) (namely Geocomp and Geojac). In these apparatus the specimen is confined using stack of rings. The test shall be conducted in a temperature controlled environment.

2. SCOPE

This test procedure applies to tests carried out in AGLab and field laboratories under AGLab control. Use <u>Simple Shear Mono Static SS - (Geojac) Test Worksheet</u> (FAM-18184), <u>Simple Shear Mono</u> <u>Static - (GeoComp) Test Worksheet</u> (FAM-18206), <u>Simple Shear Mono Static SS - (Geojac) Creep</u> <u>Test Worksheet</u> (FAM-18180) in conjunction with this procedure.

3. **RESPONSIBILITIES**

AGLab Manger

The AGLab Laboratory Manager has the responsibility to ensure that this procedure will be carried out by a trained and competent operator in accordance with the <u>AGLab Laboratory Manual</u> (FAM-17562).

Test Operator

The Test Operator has the responsibility to comply with this test procedure and where applicable the related processes and procedures stated in the <u>AGLab Procedures Manual</u> (FAM-17563).

4. APPARATUS

- i. Normal loading device for applying normal load to the sample which is capable of maintaining constant load during the consolidation phase of a test, and allow continuous adjustment of displacement/load during shearing such that the specimen change in height is not more than 0.05% when using either active or passive height control;
- ii. Horizontal loading device for applying load to the specimen with sufficient capacity and control to deform the specimen at the required rate of displacement;
- iii. Two load cells, one for measuring normal load and one for measuring shear load, with an accuracy of ±1% of the applied maximum load for a given test;
- iv. Two displacement measuring devices, one for vertical displacement and one for shear displacement, with an accuracy of at least 0.25% of full range;
- v. Rigid stacked rings for providing lateral confinement to the sample. The thickness of the individual stacked rings is less than 1/10th of the specimen thickness in order to allow relatively uniform shear deformation;
- vi. Water bath or burette, which stores distilled water for supplying water to the sample;
- vii. A base pedestal and a top cap with drainage outlets of the same diameter as the test specimen;
- viii. The top end cap is designed to have a central seating to connect to the axial load cell mounted to the loading ram;
- ix. A shear slide table (base carrier) to hold the base pedestal, which allows at least 30% shear strain;

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- x. Guide to align the top cap during sample preparation, if required;
- xi. Top and bottom skirting rings, which are designed to securely hold the specimen and transfer shear to the specimen without horizontal slippage at the interface;
- xii. Porous discs with diameter slightly smaller than the specimen diameter and can be recessed into the top cap and base pedestal such that the contact interface is flush with the edge of the cap;
- xiii. Filter paper of same diameter as the test specimen;
- xiv. Seamless rubber membrane of internal diameter equal to or slightly less than the specimen diameter;
- xv. O-rings of internal diameter slightly smaller than the diameter of the end caps;
- xvi. Membrane stretcher and O-ring placing tool;
- xvii. Trimming devices, e.g. cutting ring, wire saw, or spatulas;
- xviii. Apparatus for determination of moisture content as described in AS1289.2.1.1;
- xix. Balance with a limit of performance not greater than 0.1% of the specimen mass or 0.05g whichever is greater;
- xx. Measuring device with a precision of not less than 0.1 mm.
- xxi. Compaction mould with an extension collar and of the same internal diameter as the specimen;
- xxii. Spacer plug with diameter slightly smaller than the specimen diameter, to which a removable lifting handle can be fitted.

5. RELATED DOCUMENTS

5.1 References

Title	Document No.
ASTM Standard: Standard Test Method for Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils.	ASTM D6528-07
Australian Standard: Methods of testing soils for engineering purposes - Soil moisture content tests - Determination of the moisture content of a soil - Oven drying method (standard method)	AS1289.2.1.1-2005
Australian Standard: Methods of Testing Soils for Engineering Purposes – Definitions and General Requirements	AS1289.0-2014
AGLab Procedures Manual	FAM-17563
AGLab Laboratory Manual	FAM-17562

5.2 Records

Title	Document No.	Responsibility	Retention Period
Geojac Mono Blank Test Worksheet	FAM-18184	Laboratory Manager	7 Years
Simple Shear GeoComp Blank Test Worksheet	FAM-18206	Laboratory Manager	7 Years
Simple Shear Geojac Creep Blank Test Worksheet	FAM-18180		
Test Report	AGLab report	Laboratory Manager	7 Years

5.3 Superseded Documents

This document has been prepared and approved as part of the Fugro APAC BMS implementation. This document is a consolidation of similar pre-existing Fugro APAC Service Line specific process and does not introduce significant change to the BMS of Fugro operations within APAC. Documentation incorporated into, and superseded by this Procedure are:

<u>Simple Shear – Rigid Boundary Laboratory Testing Procedure</u> (aL-PT45)



6. SAMPLE TESTING

The following describes the sample preparation method for simple shear using stacked rings confining system. The sample diameter can be between 45 mm and 80 mm, and the minimum height shall be 14 mm. The height to diameter ratio shall not exceed 0.4.

6.1 Undisturbed Sample

- i. If required, the sample will be X-rayed prior to testing to check for suitability;
- ii. Extrude sufficient material from the sampling tube to prepare the test sample.
- iii. Gently push the cutting ring along the axis of the sample until the ring is fully embedded into the sample. Trim off the excess material so that the sample is flush with the edges of the ring by using appropriate trimming devices. Ensure that both the top and bottom ends of the specimen are trimmed flush with the ring;
- iv. Measure and record the weight of the specimen and the cutting ring to the nearest 0.01 g;
- v. Measure and record the diameter and height of the specimen to the nearest 0.01 mm;
- vi. Determine the initial moisture content from the excess material trimmed off from the specimen in accordance with <u>AS1289.2.1.1.</u>
- vii. Place a saturated porous disc and moist filter paper on the base pedestal. Gently push the test specimen from the ring to the base pedestal. After that, place the second porous disc and moist filter paper on top of the specimen followed by the top end cap. Sample preparation guide should be used to align the top and bottom caps, if applicable.
- viii. Using the membrane stretcher and O-ring placing tool, place the rubber membrane around the specimen, using O-rings to seal the membrane to the base pedestal;
- ix. Gently lower the skirting ring over the specimen until it rests on the O-ring, ensuring that the skirt protrudes at least 2-3 mm from the soil surface. Place the stack of smooth Teflon coated rings around the sample followed by the top skirting ring. The total thickness of the stacked rings should be such that at the end of consolidation, the top soil surface should be at least 2 mm above stacked rings. Use an O-ring to seal the membrane to the top end cap. Lock the stacked rings using locating pins;

6.2 Reconstituted Sample

There are a number of methods to prepare a reconstituted specimen.

6.2.1 Compaction Method

This method can be used for different types of materials (both find and coarse grained materials) and generally includes:

- i. Determine the dry density and moisture content required to prepare the sample;
- ii. Determine the total weight of specimen required, adding an extra 10% for initial moisture content determination;
- iii. Measure and record the height, internal diameter, to 0.01mm and the weight of the compaction mould, to 0.01g;

- iv. Measure the depth of the extension collar, and the thickness of the spacer plug, to 0.1 mm. The thickness of the spacer plug should be equal to the depth of the extension collar. Fit the collar securely to the top of the mould.
- v. Place a saturated porous disc and moist filter paper on the base pedestal;
- vi. The material will be placed into the mould in three layers. Place one portion of the material into the mould. Compact the soil using a tamping rod until the thickness of material is about one-third of the height of the mould. The top surface of the compacted layer must be scarified before adding the next layer. Add another portion of the material to form a second layer and compact the soil until the height is about two-third of the height of the mould. Finally, add the last portion of the material into the mould, followed by the spacer plug. Compact the sample until the top of the plug is flush with the top of the collar.
- vii. Remove the spacer plug and extension collar from the mould. Trim off the excess material so that the test specimen is flush with the edges of the mould by using appropriate trimming devices.
- viii. Measure and record the weight of the specimen and the mould to the nearest 0.01g;
- ix. Determine the initial moisture content from the leftover material in accordance with <u>AS1289.2.1.1</u>.
- x. Transfer the test specimen to the base pedestal as described in clause 6.1 (vii) to 6.1 (ix).

6.2.2 Slurry Consolidation Method

This method can be used to reconstitute fine-grained specimens, e.g. silts and clays.

- i. Sample can be prepared from undisturbed or disturbed materials;
- ii. Mix material thoroughly by adding water until the mixture is homogenous and forming a thin paste;
- iii. Apply vacuum to remove the entrapped air from the sample;
- iv. Pour the slurry into a stainless steel tube with two-way drainage, ensuring that there is no entrapped air bubbles in the sample;
- v. Allow the sample to settle on its own weight until no further settlement occurs;
- vi. Apply a small seating load (1 to 2 kPa) to the sample and allow it to settle until no further settlement occurs;
- vii. Apply load increments such as to double the previous load until final consolidation pressure is achieved. In each loading stage, allow the sample to consolidate before adding the next increment;
- viii. On completion of the consolidation, the specimen is extruded from the tube. Prepare the specimen in accordance to steps specified in clause 6.1 (Undisturbed sample)

6.2.3 Vibration Method

This method can be used for oven-dried or wet granular material.

i. Place a porous disc and a filter paper on the base pedestal and a rubber membrane around the base pedestal. Use O-rings to seal the membrane to the base pedestal;

- Lower the skirting ring over the base pedestal until it rests on the O-ring. Place the stack of smooth Teflon coated rings on top of the bottom skirting ring, followed by the top skirting ring. The total thickness of the stacked rings should be such that at the end of consolidation, the top soil surface should be at least 2 mm above the stacked rings. Lock the stacked rings using locating pins;
- iii. Fully stretch and fold the membrane over the top of skirting ring such that the surface of membrane is smooth and wrinkle free;
- iv. Measure the diameter and required height of the mould assembly to the nearest 0.1 mm;
- v. Attach the mould assembly to the vibrating table.
- vi. Determine the total mass of material required to the prescribed density to the nearest 0.01 g. Adding an extra 10% for initial moisture content determination;
- vii. Pour all the material into the empty space contained by membrane and stacked rings, followed by the spacer plug and the surcharge;
- viii. Vibrate the sample with surcharge weight until the required height is reached. Amplitude of vibration should be selected in such a way that he target density is achieved within a few minutes without violent shaking;
- ix. Gently remove the spacer plug from the specimen. Put the filter paper and porous stone, followed by the top end cap on top of the specimen;
- x. Fold up the membrane around the top end cap and seal with O-rings



7. PROCEDURE

7.1 Sample Set Up

- i. Transfer the sealed specimen to the base carrier of the machine. Lock the base pedestal to the base carrier. Lower the vertical loading ram and connect it to the top end cap.
- ii. For system using water bath (e.g. Geocomp machine) for supplying water to the specimen, inundate the specimen with water by filling the water bath with distilled water to the level of specimen height;
- iii. For system using burette (e.g. Geojac machine) for supplying water to the specimen, attach flow tubing or drainage lines to base pedestal and top end cap. Add distilled water to burette. Flush water through the specimen using a small head difference equivalent to about 3 kPa until all visible air has been removed from the drainage lines. Adjust the position of the drainage pipes to equalise the top and bottom pressures;
- iv. Start the DSS test program and input specimen details, test details and test parameters. Note that the test is performed using a semi-automated system for test control and data acquisition, which allows the user to define the test conditions by entering the specimen information and test parameters into the system. Set the interval of readings to be taken. Ensure that all the readings (loads and displacements) are recorded by the data logger

7.2 Consolidation

- i. Set the target consolidation pressure and consolidation time target. Ensure that the consolidation time is sufficiently longer for the sample to fully consolidate.
- ii. Start the test;
- iii. Observe the vertical displacement change when the target pressure is reached. Allow the specimen to be fully consolidated before proceeding to the next step. Taylor's root time plot method is monitored to ensure that the specimen is fully consolidated

7.3 Monotonic Shear

- i. For Geojac system, lock the vertical loading ram into fixed position to maintain constant specimen height;
- ii. Remove the pin from the stacked rings;
- iii. Specify the strain rate and maximum displacement (or strain limit);
- iv. Start the test and shear the specimen at the preselected shear rate in the specified direction;
- v. The test is continued until the stopping criteria or limit of machine is reached, whichever occurred first

7.4 Creep Test

Creep is time dependent shear deformation caused by constant shear stress. The test is performed by having a sustained shear stress on the specimen and measuring the shear strain against time. (Note: The following procedure is only applicable for Geojac machine using Digishear software).

- i. Calculate the target shear load where the creep test to be performed;
- ii. Program a data acquisition schedule in the system (manual mode) based on time, which will be used for creep data processing;
- iii. Stop consolidation phase.
- iv. Remove the pin from the stacked rings;
- v. In the 'Shear' mode interface, specify the strain limit and a very small displacement rate to ensure that the height is maintained during creep. The displacement rate selected should be small enough and does not cause significant effect on the test;
- vi. In the load control tab of Horizontal axis window (manual mode), using the load control feature, specify target shear load and required ramp time;
- vii. Start the time based data acquisition (manual mode);
- viii. Click the "Start" button on the "Shear" mode interface to begin the dummy shear test;
- ix. Click the "Start" button on the Horizontal axis window (manual mode) to begin the creep test;
- In this phase, the specimen will be sheared at the preselected ramp time until target shear load is reached. The specimen will then be allowed to creep while maintaining the shear load constant;
- xi. The test is continued until there is no horizontal movement or the specified strain limit is reached

7.5 Cyclic Shear Test

Cyclic shear test consists of cyclic shearing phase and post-cyclic monotonic shearing phase. (Note: The following procedure is only applicable for Geocomp system).

7.5.1 Cyclic Shearing

- i. Cyclic shearing can be either stress controlled or displacement controlled. The test information required for a cyclic test include:
 - a. Number of cycles.
 - b. Frequency or cycle period;
 - c. For stress controlled mode, specify the cyclic stress ratio and the strain limit to be applied, .
 - d. For displacement controlled mode, specify the cyclic strain and the minimum stress ratio to be applied.
 - e. The termination criteria could be maximum number of cycles, or either maximum strain limit (for stress cyclic) or the minimum stress ratio (for strain cyclic), whichever occurs first.
 - f. Start the test. The test is continued until the stopping criteria or limit of the machine is reached.

7.5.2 Post – Cyclic Monotonic Shearing (Optional)

- i. In this phase, the specimen is sheared monotonically after the cyclic shearing phase;
- ii. Specify the strain rate and maximum displacement (or strain limit) required for the test;
- iii. The test is continued until the stopping criteria or equipment limit is reached

7.6 Sample Removal

- i. Disconnect cell from vertical loading ram. Release vertical and horizontal loads.
- ii. Dismantle the setup and remove the specimen from the machine.
- iii. Take photographs of the tested sample.
- iv. Determine final moisture content by taking a portion of material from the specimen in accordance with <u>AS1289.2.1.1.</u>

8. CALCULATION

Calculate the initial density, ρ_{t} of the specimen:

$$\rho_t = \frac{1000 \text{ m}_o}{\text{H}_o \text{A}_o} \tag{1}$$

where

ρ_t	=	Initial density of the specimen, in t/m ³
m₀	=	Initial mass of specimen, in grams
H₀	=	Thickness of the specimen, in mm
Ao	=	Cross-sectional area of the specimen, in mm ²
		$A_0 = \frac{\pi D_0^2}{4}$
Do	=	Diameter of the specimen, in mm

Calculate the initial dry density, ρ_d of the specimen:

$$\rho_{\rm d} = \frac{100 \,\rho_{\rm t}}{100 + w_{\rm o}} \tag{2}$$

where

۱

$$\rho_d =$$
Initial dry density of the specimen, in t/m³
w_o = Initial moisture content of the specimen, in percent.

Calculate axial strain, ε_a , for a given applied load:

$$\varepsilon_{a} = \frac{\Delta H}{H} \cdot 100 \tag{3}$$

where

Eа	=	Axial strain, in %
ΔH	=	Change in height of the specimen, mm
Н	=	H_{o} , initial height of specimen during consolidation phase calculation, mm
Н	=	H _f , Height of specimen after consolidation during shear phase calculation, mm

Calculate shear strain, γ , for a given applied load:

$$\gamma = \frac{\Delta L}{H_{\text{eff}}}.100 \tag{4}$$

where

γ	=	Shear strain, in %
ΔL	=	Change in horizontal displacement, mm
H_{eff}	=	Total height of specimen between stacked rings

Calculate the vertical stress, $\sigma_{\text{v}},$ for a given applied load:

$$\sigma_{\rm v} = \frac{1000 \, \rm F}{\rm A} \tag{5}$$

where

F	=	Measured applied vertical load, N.
А	=	Cross-sectional area of the specimen, in mm ²

Calculate the shear stress, τ_{xy} for a given load:

$$\tau_{xy} = \frac{1000 \,\mathrm{F_h}}{\mathrm{A}} \tag{6}$$

where

$ au_{xy}$	=	Shear stress, kPa
F_{h}	=	Measured applied horizontal load, N.
А	=	Cross-sectional area of the specimen, in mm ²

Calculate stress ratio for a given load:

Stress ratio
$$=\frac{\tau_{xy}}{\sigma_v}$$
 (7)

where

Stress ratio	=	Stress ratio based on horizontal (xy) plane
σν	=	Vertical stress, kPa

Calculate the excess pore water pressure, Δu :

$$\Delta u = \sigma_{vo} - \sigma_v \tag{8}$$

where

σ_{v0}	=	Initial vertical stress, kPa
σν	=	Vertical stress during shearing, kPa

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9.1 General

The following results and general information are reported:

- i. Project title and client;
- ii. Date of test;
- iii. Laboratory where the test was performed;
- iv. Identifying number of specimen (i.e. client's identifying number, laboratory sample id, etc.);
- v. Reference to this procedure

9.2 Standard Reporting for Sample Details and Consolidation Phase

- i. Initial and final moisture content to 0.1%;
- ii. Initial dry density, of the specimen to 0.01 t/m³;
- iii. Initial specimen diameter and height to 0.1 mm.
- iv. Consolidation stress (kPa).
- v. For consolidation phase:
 - a. Plot of vertical stress against time;
 - b. Plot of axial strain against time

9.3 Standard Reporting for Monotonic Shear Test

- i. Shearing rate (mm/min), for monotonic test.
- ii. Plot of shear stress against shear strain;
- iii. Plot of stress ratio against shear strain;
- iv. Plot of vertical stress against shear strain;
- v. Plot of pore pressure against shear strain;
- vi. Plot of shear stress against effective vertical stress

9.4 Standard Reporting for Creep Test

- i. Creep stress, in kPa
- ii. Plots of shear stress against time (during ramping stage and for the whole duration of the test);
- iii. Plots of shear strain against time (during ramping stage and for the whole duration of the test);
- iv. Plots of normal stress against time (during ramping stage and for the whole duration of the test).

LABORATORY TESTING PROCEDURES

Laboratory testing of the tailings and foundation soils is undertaken according to the procedures provided in Table 1 and Table 2, respectively.

Table 1: Laboratory testing procedures for tailings characterisation

Test Name	Procedure
Sample Preparation	•
Bulk Sample Preparation	GAPMW 1.1.2
Total Dissolved Solids Measurement of Bulk Sample	GAPMW 1.1.5
Triaxial Testing	
Specimen Preparation	
Moist Tamped Loose Specimen Preparation for Triaxial Testing	GAPMW 3.1.1
Moist Tamped Dense Specimen Preparation for Triaxial Testing	GAPMW 3.1.2
Testing	
Strain Controlled Triaxial Test of Moist Tamped Reconstituted Specimen Isotropically Consolidated	GAPMW 3.2.1
Constant Shear Drained Test with Servo Stress Controlled	GAPMW 3.2.4
Constant Shear Drained Test with Dead-Weight Stress Controlled	GAPMW 3.2.5
Cyclic Direct Simple Shear Testing	
Specimen Preparation	
Moist Tamped Loose Specimen Preparation for Direct Simple Shear Testing	GAPMW 4.1.1
Testing	
Cyclic Direct Simple Shear Test	GAPMW 4.2.2
Bender Elements Testing	
Shear Wave Velocity Measurement Using Bender Elements for Triaxial Test of Specimen Consolidated Anisotropically	GAPMW 3.4.2

Table 2: Laboratory testing procedures for foundation soil characterisation

Test Name	Procedure
Sample Preparation	
Bulk Sample Preparation	GAPMW 1.1.4
Tube Sample Preparation	GAPMW 1.2.1
Block Sample Preparation	GAPMW 1.2.2
Consolidation Testing	
Constant Rate of Strain Consolidation Test	GAPMW 2.1
Triaxial Testing	
Specimen Preparation	
Intact Specimen Preparation for Triaxial Testing	GAPMW 3.1.5
Testing	
Strain Controlled Triaxial Test of Intact Specimen Isotropically Consolidated	GAPMW 3.3.1
Direct Simple Shear Testing	
Specimen Preparation	
Compacted Specimen Preparation for Direct Simple Shear Testing	GAPMW 4.1.2
Intact Specimen Preparation for Direct Simple Shear Testing	GAPMW 4.1.3
Testing	
Monotonic Direct Simple Shear Test	GAPMW 4.2.1

Foundation Soils

GAPMW 1.1.4 – BULK SAMPLE PREPARATION Scope

The purpose of this procedure is to provide the steps for preparation of a bulk sample to a target moisture content.

Equipment

The sample preparation was undertaken using a mixing tray.

Procedure

The sample preparation is undertaken using the following steps:

- 1) The received sample is emptied from the bucket and placed on a mixing tray (Figure 1).
- 2) The sample is mixed thoroughly and sealed in a sample bag. A subsample is taken to determine the initial moisture content of the sample.
- 3) Demineralised water is added to bring the sample to a target moisture content.
- 4) The sample is mixed thoroughly in the bag and left to cure. A subsample is taken to check the moisture content of the cured sample before testing.



Figure 1: Received sample placed on a mixing tray

GAPMW 1.2.1 – TUBE SAMPLE PREPARATION Scope

The purpose of this procedure is to provide the steps for preparation of a tube sample for testing.

Equipment

The tube samples were extruded using a Geo-Con Universal Vertical Extruder (Figure 1).



Figure 1: Geo-Con tube sample extruder



Procedure

The sample preparation is undertaken using the following steps:

- 1) The end caps of the tube sample are removed, and the length of voids measured from both ends of the tube to estimate available sample length for testing.
- 2) The tube is inverted and positioned with the top facing downwards in the extruder.
- 3) The sample is slowly extruded from the bottom of the tube for triaxial and index testings. For direct simple shear and constant rate of strain consolidation testings, the sample is slowly extruded into a stainless-steel ring of the same diameter as the tube.
- 4) The extruded specimen is cut and trimmed to the required size for testing.
- 5) The trimmings are used for gravimetric water content measurements and the remaining trimmings sealed in a sample bag for index testing.
- 6) The tube is wrapped with cling film, covered with end caps and stored for further testing.

Pictures of this procedure are provided in Figure 2 to Figure 7.



Figure 2: As received tube sample



Figure 3: Top end of tube





Figure 4: Bottom end of tube





Figure 5: Sample extruded for triaxial testing



Figure 6: Sample extruded into a stainless-steel ring for DSS and CRS testings



Figure 7: Trimming of specimen to required size for testing



GAPMW 1.2.2 – BLOCK SAMPLE PREPARATION Scope

The purpose of this procedure is to provide the steps for preparation of a block sample for testing.

Equipment

The block samples were prepared using stainless-steel coring rings and scalpel (Figure 1).



Figure 1: Stainless-steel coring ring and scalpel

Procedure

The sample preparation is undertaken using the following steps:

- 1) The box is opened from the top to access the block sample.
- 2) Specimens are carefully cored from the surface of the block sample using stainless-steel coring rings and a scalpel.
- 3) The cored specimens are cut and trimmed to the required size for testing. The trimmed specimens are wrapped with cling film and stored in a sealed bag.
- 4) The trimmings are used for gravimetric water content measurements and the remaining trimmings sealed in a sample bag for index testing.
- 5) The block sample is wrapped with cling film and aluminium foil. The top of the box is sealed, and the block sample stored for further testing.

Pictures of this procedure are provided in Figure 2 to Figure 6.



Figure 2: As received block sample



Figure 3: Accessing block sample from the top of box



Figure 4: Coring specimen from block sample



Figure 5: Cored specimens: before coring (left) and after coring (right)

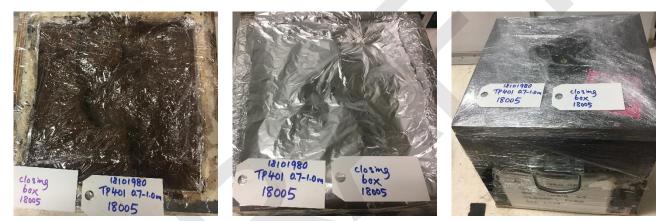


Figure 6: Wrapping and sealing block sample after coring

GAPMW 2.1 – CONSTANT RATE OF STRAIN CONSOLIDATION TEST Scope

The purpose of this procedure is to provide the steps for undertaking constant rate of strain (CRS) consolidation testing. CRS testing can be undertaken significantly faster than a conventional oedometer as the typical rule of loading stages of 24 hours duration is not required. During the test the specimen is loaded continuously maintaining an approximate constant axial strain rate. During axial loading, excess pore pressure is allowed to develop at the base of the specimen to allow inference of hydraulic conductivity and coefficient of consolidation. The hydraulic conductivity can be also directly measured by undertaking constant head permeability testing at different loading stages, from the base pump to the top surface of the specimen.

Equipment

The CRS test is undertaken in a GDS automatic oedometer device, with the software capable to undertake CRS testing. Testing is undertaken in accordance with ASTM D4186¹. The device is provided of a 50kN load frame, fully enclosed stainless-steel cell, cell and base pumps, pore pressure differential transducer (PPT) mounted at the base of the cell, 5 mm spring-loaded LVDT displacement sensor and 32 kN capacity submersible load cell. The GDS automatic oedometer is illustrated in a picture and schematically in Figure 1. The GDS automatic oedometer device is equipped of a stepper motor driven unit controlled either manually or from a PC. A CRS cell is fitted on the loading pedestal. The CRS cell is similar to a conventional triaxial cell as both cells are closed to the external environment allowing the cell to be entirely filled with water. However, in a CRS cell the specimen is exposed to the cell pressure, while in a triaxial cell, the specimen is separated from the cell environment by a membrane.

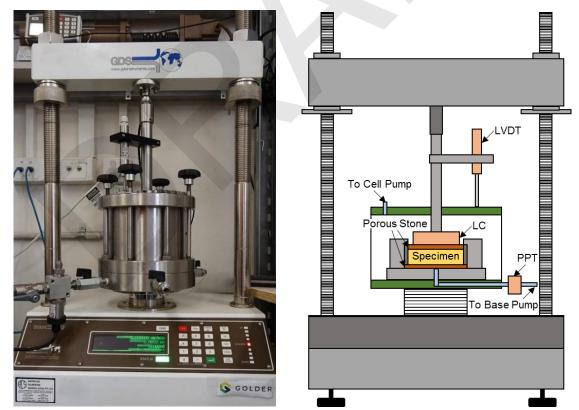


Figure 1: GDS load frame with stainless-steel CRS cell (left) and schematic of CRS testing device (right)

¹ ASTM D4186 / D4186M-12e1, Standard Test Method for One-Dimensional Consolidation Properties of Saturated Cohesive Soils Using Controlled-Strain Loading, ASTM International, West Conshohocken, PA, 2012, www.astm.org

Procedure

The CRS test is undertaken in a 60 mm diameter specimen. The specimen is restrained by a stainless-steel ring provided of top and bottom porous stones and filter papers. The base is separated from the cell environment via a system of sealing O-rings, allowing to measure excess pore pressure at the base of the specimen during axial loading. The specimen is confined in a stainless-steel chamber with axial stresses measured by a submersible load cell. Vertical strain is measured with a LVDT, pressures are provided by 3 MPa capacity pumps, while the specimen base pressure is measured using a pore pressure transducer.

The test is undertaken using the following steps:

- 1) The base porous stone and filter paper are placed dry on the CRS base to prevent swelling of the specimen.
- 2) The specimen is extruded from the tube² or cored from the block³ sample and placed within a stainlesssteel CRS ring. The top end of the specimen is trimmed to form a flat surface.
- 3) The top porous stone and filter paper are placed dry on the top end of the specimen inside the CRS ring and the bottom end of the specimen is trimmed to the size required for the testing.
- 4) Trimmings are taken during specimen preparation from both ends of the specimen to enable measurement of the initial gravimetric water content.
- 5) The specimen mass is taken, and initial height measured using a digital calliper.
- 6) The specimen is placed on the base porous stone and filter paper.
- 7) The remaining CRS components including the sealing O-rings are assembled (**Error! Reference source not found.**).
- 8) The CRS cell is closed and a seating load of 10 kPa applied.
- 9) The test commenced, and the stress is increased to 25 kPa and left to consolidate under this load.
- 10) The cell is flushed with CO₂ for approximately 1 hour and then flooded with deaired demineralised water under constant height conditions.
- 11) Back pressure is ramped up to 500 kPa over a period of time depending on material type under double drainage and constant height conditions. If the stress dropped below 25 kPa, the back pressure saturation is interrupted to bring the stress back to 25 kPa before continuing saturation.
- 12) Once back pressure saturation is completed, constant head permeability test is undertaken under 25 kPa constant stress.
- 13) The constant rate of strain test is undertaken by targeting an axial strain rate until a target stress is achieved. The strain rate is guessed based on material type with the intent to provide excess pore pressure ratio (Ru = excess pore pressure / total stress) within 3% 15%.
- 14) Unloading and reloading loop from 400 kPa to 100 kPa is undertaken.
- 15) The constant rate of strain test is continued to a target vertical stress of 3000 kPa.

³ GAPMW 1.2.2 Block Sample Preparation



² GAPMW 1.2.1 Tube Sample Preparation

- 16) Once the target vertical stress is achieved, the total vertical stress is maintained, and constant head permeability test is undertaken.
- 17) The specimen and cell pressures are finally unloaded, and the CRS disassembled.

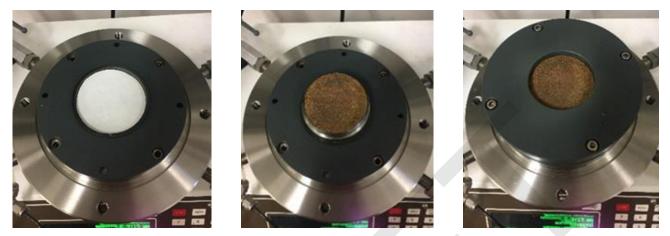


Figure 2: CRS test device setup: base porous stone and filter paper (left), specimen in stainless-steel ring with top porous stone and filter paper (middle), sealing components assembled (right)

GAPMW 3.1.5 – INTACT SPECIMEN PREPARATION FOR TRIAXIAL TESTING

Scope

The purpose of this procedure is to prepare an intact (undisturbed) specimen for triaxial testing. The specimen is generally extruded from a tube or cored from a block sample.

Equipment

The preparation is undertaken using a scalpel, split mould and membrane stretcher (Figure 1). Standard triaxial end caps (Figure 2) are used in this procedure.



Figure 1: Scalpel and split mould to trim specimen (left) and membrane stretcher (right)

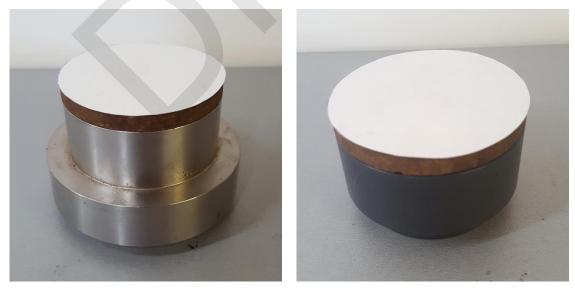


Figure 2: Standard triaxial end caps with porous stones and filter papers

Procedure

The following steps are undertaken to prepare the intact specimen:

- 1) The specimen extruded from the tube sample¹ is trimmed to a height of approximately 2 times the specimen diameter using a scalpel and a split mould to hold the specimen.
- 2) Initial specimen mass is measured and the dimensions taken using a digital calliper measuring both diameter and height at different locations.
- 3) Porous stone and filter paper are placed dry (to reduce initial swelling) on the bottom end cap and the specimen is placed on top.
- 4) A membrane is placed around the specimen using a membrane stretcher and sealed to the bottom end cap with sealing grease and O-rings.
- 5) Top filter paper and porous stone are placed dry on the specimen. The top end cap is added and the membrane is sealed.
- 6) The triaxial device is assembled and the cell filled with water.

The typical specimen during and after preparation is shown in Figure 3.



Figure 3: Specimen placed on bottom end cap (left) and specimen sealed with membrane and O-rings (right)

¹ GAPMW 1.2.1 Tube Sample Preparation



GAPMW 3.2.1 - Strain Controlled Triaxial Test of Intact Specimen Isotrophically Consolidated

GAPMW 3.3.1 – STRAIN CONTROLLED TRIAXIAL TEST OF INTACT SPECIMEN ISOTROPICALLY CONSOLIDATED Scope

Triaxial testing involves the preparation of a cylindrical specimen of material, wrapped in an impervious membrane. A confining stress is then applied to the specimen, and the material allowed to come to equilibrium under the applied stress. The initial stress can either be isotropic (the same all around the specimen), or K_0 , which typically involves a higher vertical stress than horizontal stress on the specimen.

The purpose of this procedure is to undertake a strain controlled triaxial test of intact specimen extruded from a tube sample. Tests are undertaken consolidating a specimen isotropically and sheared under undrained strain control conditions.

Equipment

The tests were undertaken using a standard GDS triaxial device (Figure 1) with 50 kN digital load frame, 3 MPa 200 cc pressure volume controllers, submersible load cell, pore pressure transducer and linear variable displacement transducer.



Figure 1: Standard GDS triaxial device

Procedure

The test is undertaken using the following steps:

- 1) The specimen is prepared using the intact specimen preparation procedure¹.
- 2) The cell and back pressure are increased to promote back pressure saturation of the specimen. Ramping of the cell and back pressure is undertaken typically within a period of 24 hours. A back pressure of 500 kPa was generally used. During this process, an approximate difference between cell and back pressure of 20 kPa is maintained, to prevent the specimen being subjected to significant effective stresses.
- 3) Once the target saturation back pressure is reached and volume change is negligible, degree of saturation is assessed performing a B-value check. For this, the specimen drainage valves are closed, and an all-around pressure is applied to the specimen while monitoring and recording the pore pressure response at the base of the specimen. All tests undertaken in this study obtained a B-value of 0.95 or greater.
- 4) The specimen is consolidated to the target stress in one step, via two stages, one undrained loading stage and a final drained dissipation stage. In the undrained loading stage, the specimen drainage valves are closed, and an isotropic confining pressure is applied to the specimen until the pore pressure response is steady. In the drained dissipation stage, the specimen drainage valves are opened to allow consolidation.
- 5) Once consolidation is complete, the specimen is sheared either drained or undrained depending on the desired test conditions. The specimen is generally sheared to a minimum of 20% axial strain or terminated before if significant deformation occurs.
- 6) After the test is completed, the specimen drainage valves are closed and the water in the cell is emptied.
- 7) The specimen is removed and end of test moisture content is taken. Area correction is applied based on the visually-observed shape of the deformed specimen at the end of shearing (i.e. right cylinder, parabola or slip plane).

The typical end of test specimen is provided in Figure 2.

¹ GAPMW 3.1.5 Intact Specimen Preparation for Triaxial Testing



GAPMW 3.2.1 - Strain Controlled Triaxial Test of Intact Specimen Isotrophically Consolidated



Figure 2: End of test typical deformed specimen with a slip plane

GAPMW 4.1.2 – COMPACTED SPECIMEN PREPARATION FOR DIRECT SIMPLE SHEAR TESTING

Scope

The purpose of this procedure is to prepare a compacted specimen for direct simple shear (DSS) testing.

Equipment

The preparation was undertaken using a special DSS mould designed to allow preparation of compacted specimen. This mould allows to undertake preparation of a specimen with accurate height control during compaction. The DSS mould is shown in Figure 1.



Figure 1: DSS mould for preparation of compacted specimen

Procedure

The specimen preparation is undertaken using the following steps:

- 1) The DSS is prepared with the rings and a latex membrane neatly fixed against the inner wall of the rings.
- 2) The top end platen is attached to the top cap of the mould and the DSS bolted to the base of the mould.
- 3) The sample is prepared to its optimum moisture content1 and placed inside the DSS.
- 4) The sample is compacted to a known density (98% of standard maximum dry density) in one layer by lowering the top cap of the mould. The height and volume of the specimen is pre-determined by the inner dimensions of the DSS in the mould.
- 5) The DSS with compacted specimen is removed from the mould and finished to assemble to the device.
- 6) The DSS device is assembled and the top platen is lowered down using the computer-controlled software to a given bedding load of generally 25 kPa.

¹ GAPMW 1.1.4 Bulk Sample Preparation to Optimum Moisture Content



7) The DSS base is tightened via four screws located at each corner to the main device, the restraint arms to reduce specimen rotation during shear assembled and the test commenced.

The specimen preparation procedure is shown in Figure 2 to Figure 5.

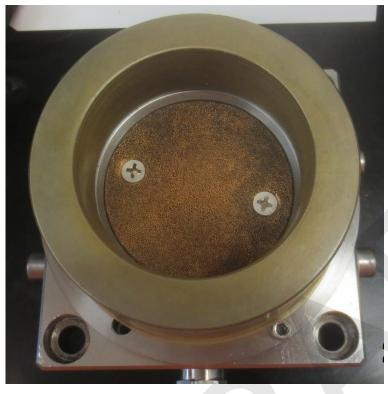


Figure 2: DSS prepared with rings and membrane

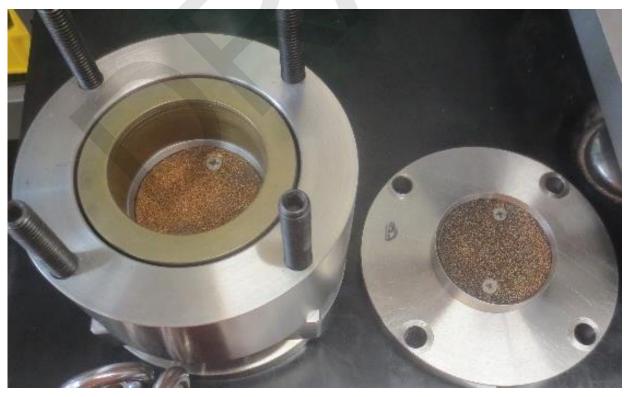


Figure 3: DSS bolted to the base of mould (left) and top end platen attached to top cap of mould (right)

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GAPMW 4.1.2 – Compacted Specimen Preparation for Direct Simple Shear Testing



Figure 4: DSS specimen inside compactor mould: before compaction (left) and after compaction (right)

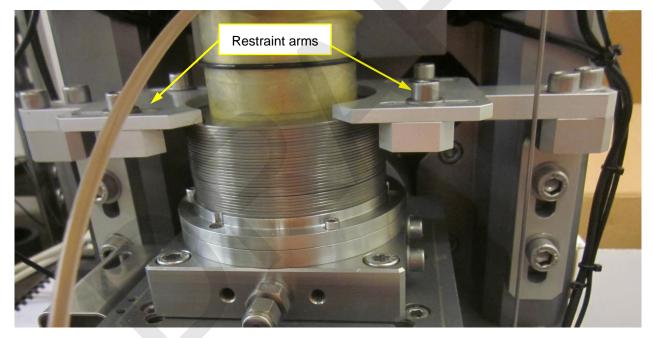


Figure 5: DSS device assembled with restraint arms mounted

GAPMW 4.1.3 – INTACT SPECIMEN PREPARATION FOR DIRECT SIMPLE SHEAR TESTING

Scope

The purpose of this procedure is to prepare an intact (undisturbed) specimen for direct simple shear (DSS) testing. The specimen is generally extruded from a tube or cored from a block sample.

Equipment

The preparation is undertaken using a scalpel and 60 mm diameter stainless-steel ring shown in Figure 1.



Figure 1: 60 mm diameter stainless-steel ring and scalpel

Procedure

The specimen preparation is undertaken using the following steps:

- The specimen extruded from 63 mm diameter tube sample¹ is trimmed to a diameter of 60 mm using a scalpel and 60 mm diameter stainless-steel ring. The specimen from block sample² is cored directly into a 60 mm stainless-steel ring.
- 2) The top and bottom ends are trimmed to a specimen height of approximately 27 mm.
- 3) The specimen is placed on the bottom platen of the DSS and the latex membrane and rings are placed around the specimen.
- 4) The DSS device is assembled and the top platen is lowered down using the computer-controlled software to a given bedding load of generally 10 kPa.
- 5) The DSS base is tightened via four screws located at each corner to the main device, the restrain arms to reduce specimen rotation during shear assembled and the test commenced.

The specimen preparation procedure is shown in Figure 2 to Figure 5.

² GAPMW 1.2.2 Block Sample Preparation



¹ GAPMW 1.2.1 Tube Sample Preparation

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Figure 2: Trimming specimen extruded from 63 mm diameter tube sample to 60 mm diameter

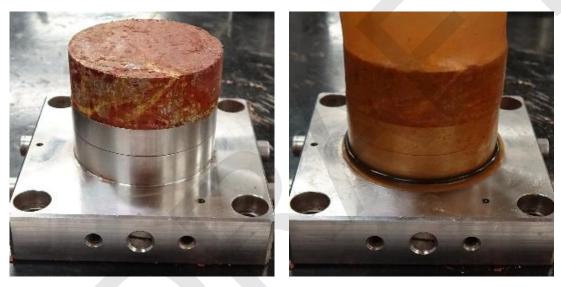


Figure 3: Trimmed specimen on DSS base platen (left) and covered with membrane (right)

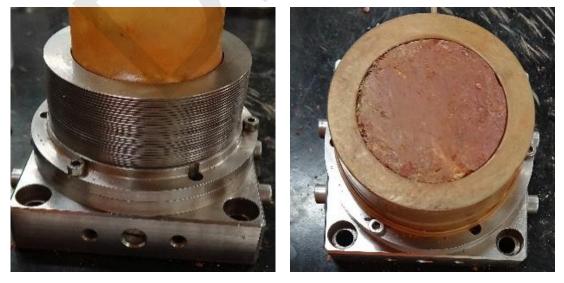


Figure 4: DSS rings in place (left) and membrane folded outwards for DSS device assembly (right)

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GAPMW 4.1.3 – Intact Specimen Preparation for Direct Simple Shear Testing

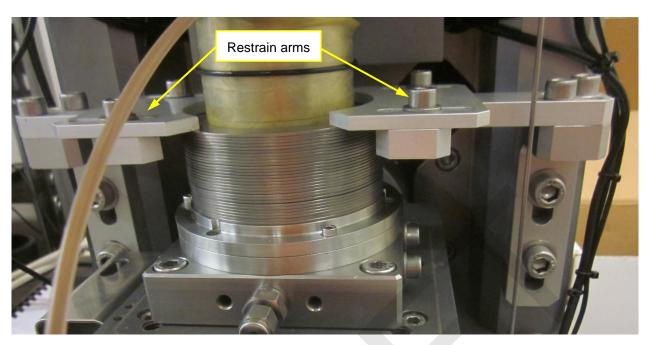


Figure 5: DSS device assembled with restrain arms mounted

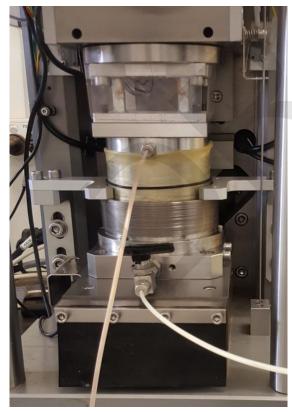
GAPMW 4.2.1 – MONOTONIC DIRECT SIMPLE SHEAR TEST Scope

Direct simple shear (DSS) testing involves preparation of a cylindrical specimen with a typical height to diameter ratio of about 0.4 within a membrane that is laterally constrained by a stack of low-friction metal rings. The material is vertically consolidated to the desired stress with or without an initial static shear stress (α , bias). Owing to the lateral restraint provided by the stack of rings, consolidation occurs under a K_0 condition (i.e. zero lateral strain). Once consolidation is completed, the specimen is sheared monotonically by moving the lower platen horizontally while the top platen remains still. Monotonic loading is analogous to static undrained loading, such as when undrained conditions initiate within contractive material.

It should be noted that while DSS testing provides undrained strength parameters, the test itself is not undrained. Rather than restrict drainage, constant volume conditions are enforced via computer control of the test. Should the specimen contract, the top platen would begin to move downwards, reducing the height of the specimen. However, the computer control system prevents this from occurring by reducing the vertical stress to maintain a constant height. The excess pore pressures that would have developed within the specimen can then be inferred from the changes in vertical stress required to maintain constant height. This testing method has been shown to provide the same results as tests with enforced drainage conditions (Finn 1985¹, Dyvik et al. 1987²).

Equipment

Specimens were tested using a GDS electro-mechanical dynamic cyclic simple shear (EMDCSS) system shown in Figure 1.







¹ Finn, WDL 1985. Aspects of constant volume cyclic simple shear. Proceedings of Advances in the Art of Testing of Soils under Cyclic Conditions, pp 74-98 (ASCE, New York). ² Dyvik, R, Berre, T, Lacasse, S and Raadim, B 1987. Comparison of truly undrained and constant volume direct simple shear tests. Géotechnique, Vol 37, No 1, pp 3-10.



The device is capable of carrying out DSS testing under monotonic and cyclic conditions. The GDS DSS base and top platens are specially designed to allow saturation to occur by applying a flow, generally from the bottom of the specimen to its top via a pump or a water reservoir. Leaks are prevented introducing a series of O-rings at the base and top of the DSS platens and by placement of a sealing agent.

DSS testing is undertaken in 60 mm diameter compacted (bulk) and intact (tube or block) specimens using dead zone end platens (Figure 2 and Figure 3).

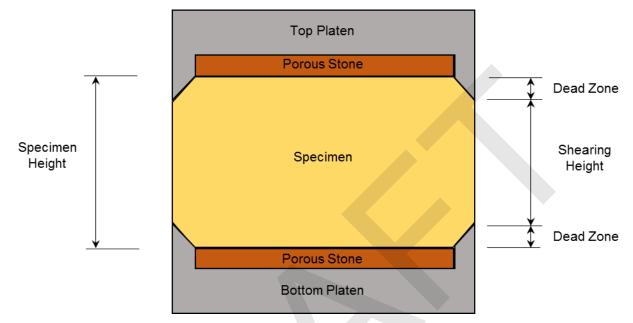


Figure 2: Schematic of DSS specimen between dead zone end platens



Figure 3: Dead zone end platen

Procedure

The test is undertaken using the following steps:

- 1) A specimen is prepared according to the compacted³ or intact⁴ specimen preparation procedures.
- 2) The DSS device is assembled and the top platen is lowered down using the computer-controlled software to a given bedding load of generally 10 kPa.
- 3) The initial specimen height is calculated based on height calibration undertaken using a block of known height, and the test is commenced.
- 4) The specimen is consolidated to the vertical effective stress for saturation and water is flushed through the specimen from the base to the top. If the sample appears saturated, the saturation step is not undertaken.
- 5) The specimen is consolidated to the target vertical effective stress in stages.
- 6) The specimen is sheared monotonically at a strain rate of around 2% per hour.
- 7) Once the test is completed, the DSS is dissembled, the specimen removed and dried in a 110°C oven to obtain the mass of dry solids and moisture content of the specimen.

The typical end of test specimen is provided in Figure 4.

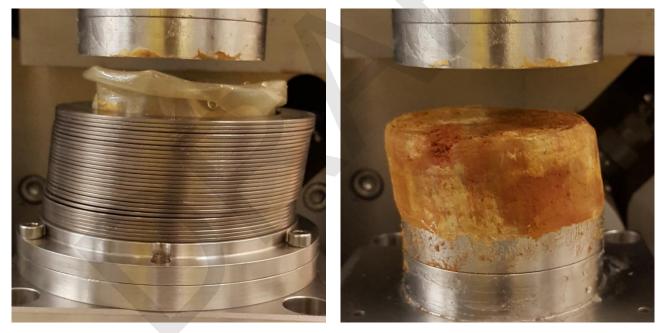


Figure 4: End of test specimen

⁴ GAPMW 4.1.3 Intact Specimen Preparation for Direct Simple Shear Testing



³ GAPMW 4.1.2 Compacted Specimen Preparation for Direct Simple Shear Testing

Tailings

GAPMW 1.1.2 – BULK SAMPLE PREPARATION Scope

The purpose of this procedure is to provide the steps for preparation of a bulk sample to a homogeneous condition that is suitable for testing.

Equipment

The sample preparation was undertaken using a 40°C oven, drying trays and 2.36 mm opening size sieve.

Procedure

The sample preparation is undertaken using the following steps:

- The received sample is emptied from the bucket, placed on drying trays and dried in a 40°C oven to a moisture content of around 7~12% or first prepared as a thick slurry by adding process water before drying.
- 2) The 40°C oven-dried moist sample is passed through a 2.36 mm opening size sieve, separating the agglomerates from the sieved material. The agglomerates are broken down by hand and re-sieved until all material passes through the sieve.
- 3) The sieved sample is mixed thoroughly and sealed in a sample bag for testing.

Pictures of this procedure are provided in Figure 1 to Figure 4.



Figure 1: Sample prepared as thick slurry

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Figure 2: As received sample in drying trays



Figure 3: Sieving process



Figure 4: Sieved material

GAPMW 1.1.5 – TOTAL DISSOLVED SOLIDS MEASUREMENT OF BULK SAMPLE

Scope

The purpose of this procedure is to provide the steps to measure the total dissolved solids of a bulk sample.

Equipment

The test is undertaken using a funnel, filter paper, syringe and beakers.

Procedure

The test is undertaken using the following steps:

- 1) A subsample is taken from the sample prepared according to the bulk sample preparation procedure¹
- 2) The specimen is placed in a beaker and dried in the 110°C oven
- 3) A known amount of demineralised water is added to the oven-dried specimen, mixed thoroughly, and left to settle
- 4) Clear solution is decanted using a syringe and filtered into another beaker through a funnel
- 5) The mass of the decanted solution is taken and the solution dried in the 110°C oven to determine the salt (dissolved solids) content
- 6) The total dissolved solids in the bulk sample is calculated from the salt content of decanted solution, amount of added demineralised water and the initial dry mass of the specimen.

Pictures of this procedure are provided in Figure 1 and Figure 2.

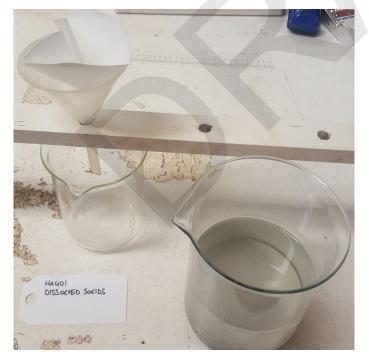


Figure 1: Filter-funnel setup and specimen before decanting

¹ GAPMW 1.1.2 Bulk Sample Preparation

GAPMW 1.1.5 - Total Dissolved Solids Measurement of Bulk Sample

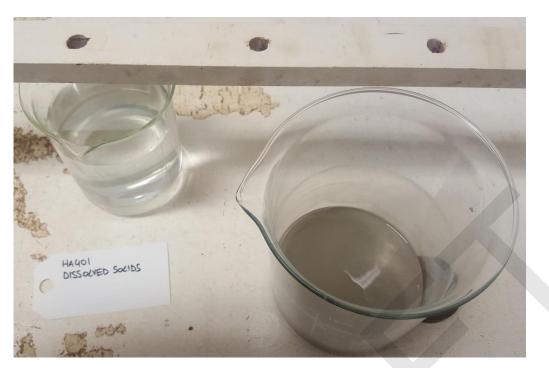


Figure 2: Decanted clear solution and specimen after decanting

GAPMW 3.1.1 – MOIST TAMPED LOOSE SPECIMEN PREPARATION FOR TRIAXIAL TESTING

Scope

The purpose of this procedure is to prepare a loose specimen using the moist tamping preparation technique for triaxial testing.

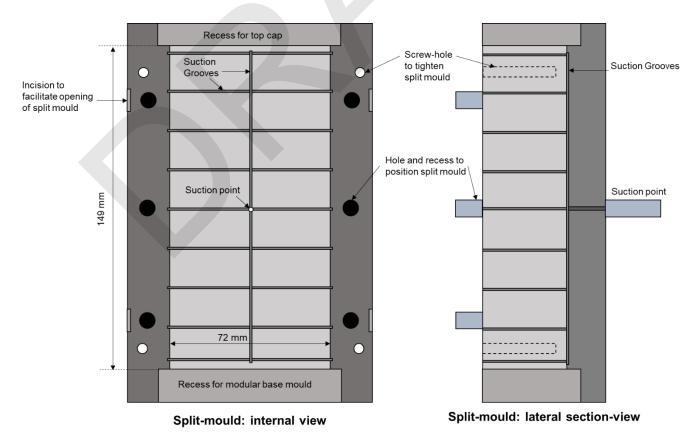
Equipment

The preparation is undertaken using a split mould to allow preparation of loose specimens of 72 mm diameter and 149 mm height.

To enable placement of a specimen into the freezer without transfer of the entire triaxial base, a specially designed modular base platen system is used. The modular base consists of:

- 1) A "cradle" that mounts to the triaxial base with a recess
- 2) A base platen that fits tightly within the cradle recess
- 3) A drainage line for the base of the specimen exiting from the side of the base platen
- Additional valves connected to the top and bottom drainage lines, to allow sealing the specimen at locations closer than the outer drainage control valves of the triaxial cell and removal of the sample for freezing.

The split mould and modular base are shown in Figure 1 and Figure 2, respectively. The modular base and top cap are shown in Figure 3 to Figure 4.





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GAPMW 3.1.1 – Moist Tamped Loose Specimen Preparation for Triaxial Testing



Figure 2: Split mould internal (left) and external view (right)

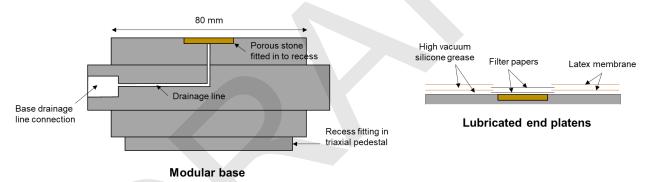


Figure 3: Modular base (left) and lubricated end platens (right)



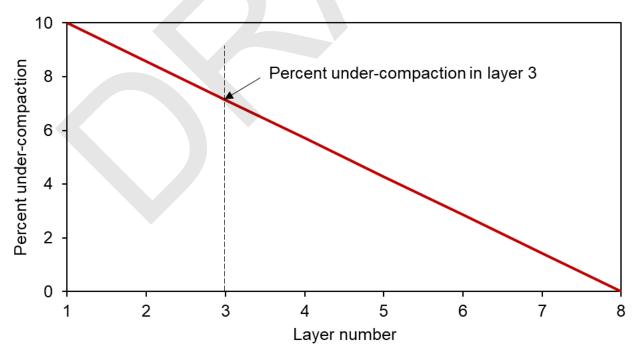
Figure 4: Modular base with lubricated end platens (left) and top cap with lubricated end platens (right)

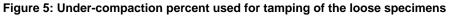
Procedure

The following steps are undertaken to prepare the loose moist tamped specimens:

- 1) Porous stones, filter papers and layers of trimmed latex membrane lubricated with high vacuum silicone grease are placed at the top and bottom end caps.
- 2) A cylindrical split mould is placed on the triaxial base pedestal with a membrane held against the walls of the mould by suction provided from a vacuum pump.
- 3) The sample is tamped using the undercompaction technique proposed by Ladd 1978¹ to promote a homogenous density along the specimen height. In this procedure, the sample is compacted in eight layers of equal thickness and varying masses.
- Specimens are prepared tamping the material within the mould in eight layers using an under-compaction percentage of 10% for the first (bottom) layer and 0% for the final (top) layer (Figure 5).
- 5) Once the specimen is tamped, the top cap is placed and a suction of maximum 20 kPa is applied to the specimen with a vacuum pump to enable the specimen shape to be maintained during mould removal and test setup.
- 6) Initial specimen dimensions are taken using a digital calliper measuring both diameter and height at different locations.
- 7) The triaxial device is assembled and the cell filled with water.

The under-compaction percentage adopted for the tamping of the loose specimens is provided in Figure 5. Pictures of this procedure are provided in Figure 6 to Figure 7.





¹ Ladd, R 1978. Preparing test specimens using undercompaction. Geotechnical Testing Journal, Vol 1, No 1, pp 16–23.

GAPMW 3.1.1 – Moist Tamped Loose Specimen Preparation for Triaxial Testing





Figure 6: Split moulds with membrane under suction (left) and during specimen preparation with scarified layer prior tamping of next layer (right)



Figure 7: Tamped specimen prior placement of top cap (left) and with top cap after removal of split mould (right)

GAPMW 3.1.2 – MOIST TAMPED DENSE SPECIMEN PREPARATION FOR TRIAXIAL TESTING

Scope

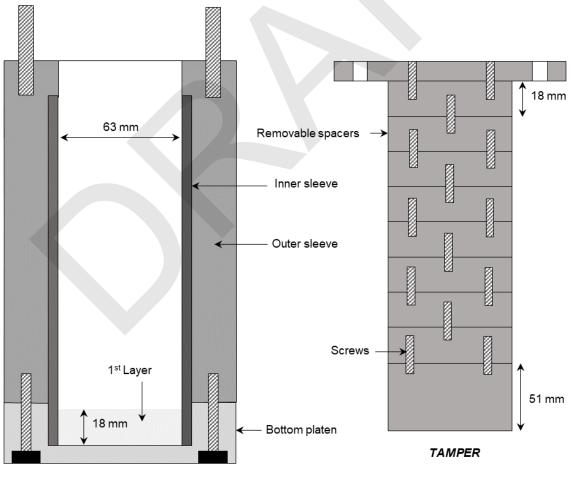
The purpose of this procedure is to prepare a dense specimen, while avoiding the application of significant compaction stresses that may lead to an overconsolidated specimen after subsequent consolidation in a triaxial cell. The specimen is compacted by combining drop height compaction with gentle vibration of the mould.

Equipment

The compaction mould is designed to prepare the specimen in 8 layers, each with a height of 18 mm. Specimens are prepared to an approximate height of 144 and diameter of 63 mm.

A suction top cap typically used for undertaking extension triaxial testing is used in this procedure. The suction cap is used to limit the rotation of the top cap during shearing, thus forcing shearing to occur vertically. This allows shearing to continue to high strains even after shear bands develop in dense specimens.

The compaction mould developed for this process is schematically illustrated in Figure 1 and shown in Figure 2 to Figure 6.



TAMPING MOULD

Figure 1: Tamper schematic view



Figure 2: View of different components of compactor: mould base platen with the inner sleave (left), outer sleave (middle) and adjustable height tamper with top platen to allow controlling the height (right)

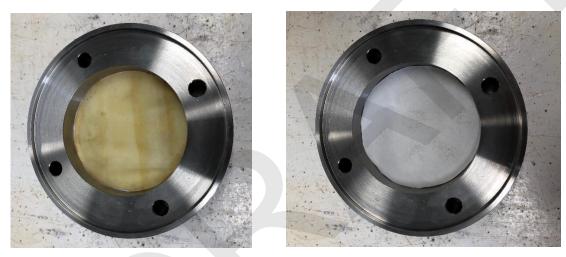


Figure 3: Mould base platen with sandwich of paper filter, latex membrane and paper filter at its bottom



Figure 4: Tamper with top platen to allow controlling the tamping height

GAPMW 3.1.2 – Moist Tamped Dense Specimen Preparation for Triaxial Testing



Figure 5: Tamper dismantled with various spacers



Figure 6: Tamper mounted with screws to allow dropping height control

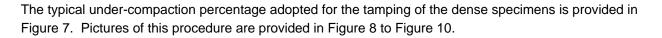
Procedure

The following steps are undertaken to prepare the dense specimens:

- 1) The sample is prepared at a moisture content such that vibration will induce additional densification (i.e. wetter than typical moist tamping to produce loose samples)
- Compaction is undertaken in eight layers using the Ladd undercompaction technique (Ladd 1978¹) with an under-compaction percentage of 5% to 10% for the first (bottom) layer and 0% for the final (top) layer (Figure 7).
- 3) A sandwich of filter paper, latex membrane and filter paper is placed at the bottom of the mould to prevent the specimen from bonding to the mould, which could lead to damage of the specimen during subsequent extrusion
- 4) The inner sleeve is placed at the bottom of the mould
- 5) The outer sleeve encasing the inner sleeve is screwed to the bottom platen
- 6) The first layer is placed and gently levelled
- 7) The tamper is placed on top of the sample and tamping is provided by dropping the tamper from a height of approximately 2 cm or less, until compaction via drop height can no longer occur
- 8) The mould is then gently vibrated by providing horizontal manual rotations until the tamper is in contact with the edges of the outer mould, thus indicating that the target height has been achieved
- 9) If free standing water is present on the specimen surface, this is removed with a syringe
- 10) The first tamper spacer is unscrewed to allow the second layer to be tamped to its target height
- 11) Steps 6 to 10 are repeated until all layers have been compacted
- 12) The screws at the bottom of the compaction mould are removed and the inner sleeve housing the specimen taken out
- 13) The tamper's spacers are reassembled, the inner sleeve containing the specimen is placed within the tamper and left for a couple of hours to allow the draining of water from the specimen, thus allowing the specimen to become slightly unsaturated
- 14) The tamper is than used to extrude the specimen and the specimen trimmed as required to its target height for the testing
- 15) Initial specimen dimensions are taken using a digital calliper measuring both diameter and height at different locations
- 16) Porous stones, filter papers and layers of lubricated trimmed latex membrane are placed at the top and bottom end caps
- 17) A latex membrane is placed around the sample sealed by O-rings
- 18) The triaxial device is assembled and the cell filled with water.

¹ Ladd, R 1978. Preparing test specimens using undercompaction. Geotechnical Testing Journal, Vol 1, No 1, pp 16–23.





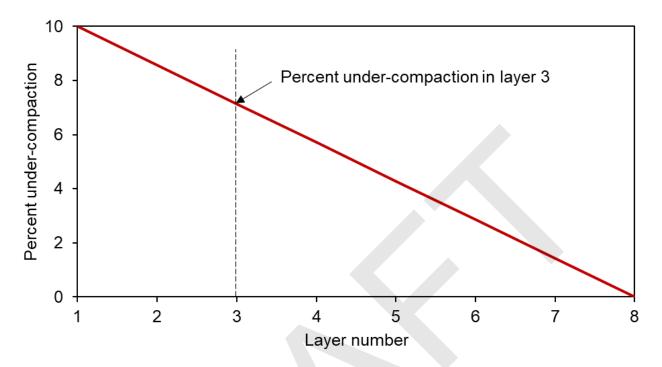


Figure 7: Typical under-compaction percent used for tamping of the dense specimens



Figure 8: Water at surface of sample at vibration of mould (left) and specimen after compaction inside inner sleeve

GAPMW 3.1.2 – Moist Tamped Dense Specimen Preparation for Triaxial Testing

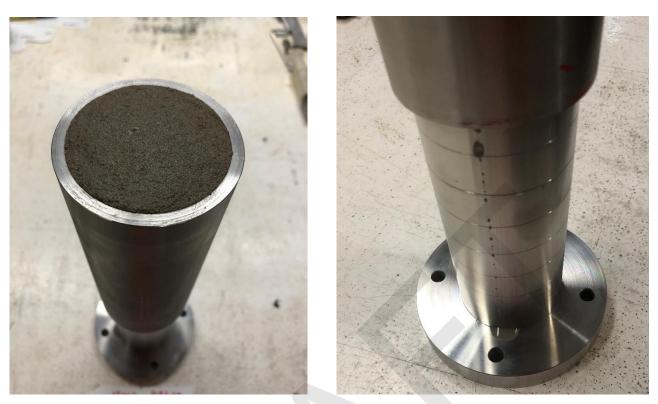


Figure 9: Specimen on top of tamper during water draining stage (left) and water draining from specimen (right)

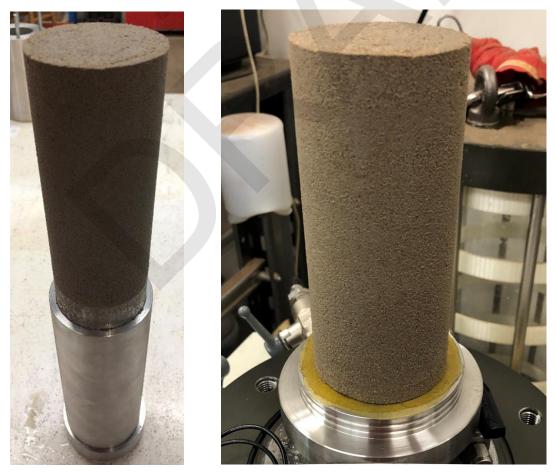


Figure 10: Specimen extruded using tamper (left) and sample on triaxial base platen (right)

GAPMW 3.1.2 – Moist Tamped Dense Specimen Preparation for Triaxial Testing



Figure 11: Specimen with suction top cap assembled and inside cell

GAPMW 3.2.1 – STRAIN CONTROLLED TRIAXIAL TEST OF MOIST TAMPED RECONSTITUTED SPECIMENS ISOTROPICALLY CONSOLIDATED

Scope

Triaxial testing involves the preparation of a cylindrical specimen of material, wrapped in an impervious membrane. A confining stress is then applied to the specimen, and the material allowed to come to equilibrium under the applied stress. The initial stress can either be isotropic (the same all around the specimen), or K_0 , which typically involves a higher vertical stress than horizontal stress on the specimen.

The purpose of this procedure is to undertake strain controlled triaxial test of specimen prepared using the moist tamping technique. The specimens are prepared using either the moist tamped loose or dense preparation procedures. Tests are undertaken consolidating a specimen isotropically and sheared under drained or undrained strain control conditions.

Equipment

The tests were undertaken using a standard GDS triaxial device (Figure 1) with 50 kN digital load frame, 3 MPa 200 cc pressure volume controllers, submersible load cell, pore pressure transducer and linear variable displacement transducer.



Figure 1: Standard GDS triaxial device



Procedure

The test is undertaken using the following steps:

- 1) The specimen is prepared using either the moist tamped loose¹ or dense² preparation procedures.
- 2) The moist tamped loose specimen is flushed with CO₂ for approximately 1 hour, followed by flushing with deaired deionised water imposing a differential head of approximately 5 kPa from the bottom to the top of the specimen. Flushing is carried out until bubbles are no longer observed leaving the top of the specimen. Flushing with CO₂ and deaired deionised water is not carried out for the dense specimens as these specimens are prepared in a near-saturated condition.
- 3) The cell and back pressure are increased to promote saturation of the material by forcing air into solution. Ramping of the cell and back pressure is undertaken typically within a period of six hours. During this process, an approximate difference between cell and back pressure of 20 kPa is maintained, to prevent the specimen being subjected to significant effective stresses.
- 4) Once the target saturation back pressure is reached, and volume change is negligible, degree of saturation is assessed performing a B-value check. For this, the specimen drainage valves are closed, and an all-around pressure is applied to the specimen while monitoring and recording the pore pressure response at the base of the specimen. All tests undertaken in this study obtained a B-value of 0.95 or greater, which indicated that the pore pressure response of the specimen was 95% or greater than of the applied load, indicating a material of sufficient saturation for testing.
- 5) The specimen is consolidated to the target stress in one step, via two stages, one undrained loading stage and a final drained dissipation stage. In the first stage, the specimen drainage valves are closed, and an isotropic confining pressure is applied to the specimen until the pore pressure response is steady. In the second stage, the specimen drainage valves are opened to allow consolidation.
- 6) Once consolidation is complete, the specimen is sheared either drained or undrained depending on the desired test conditions. The specimen is generally sheared to a minimum of 20% axial strain, to enable critical state conditions to be inferred where possible.
- 7) After the test is completed, the specimen drainage valves are closed and the water in the cell is emptied.
- 8) The specimen void ratio is determined by measuring moisture content at the end of test, adopting the freezing method (Sladen and Handford, 1987³) which involves carefully removing the specimen from the triaxial apparatus and freezing the specimen with the membrane, caps and drainage lines attached to prevent any water loss.
- 9) Area correction is applied based on the visually-observed shape of the deformed specimen at the end of shearing (i.e. right cylinder or parabola).

³ Sladen J.A. and Handford G. (1987). A potential systematic error in laboratory testing of very loose sands. Canadian Geotechnical Journal, 1987, (24)3: 462-466



¹ GAPMW 3.1.1 Moist tamped loose sample preparation for triaxial testing

² GAPMW 3.1.2 Moist tamped dense specimen preparation for triaxial testing

GAPMW 3.2.1 - Strain Controlled Triaxial Test of Moist Tamped Reconstituted Specimens Isotropically Consolidated

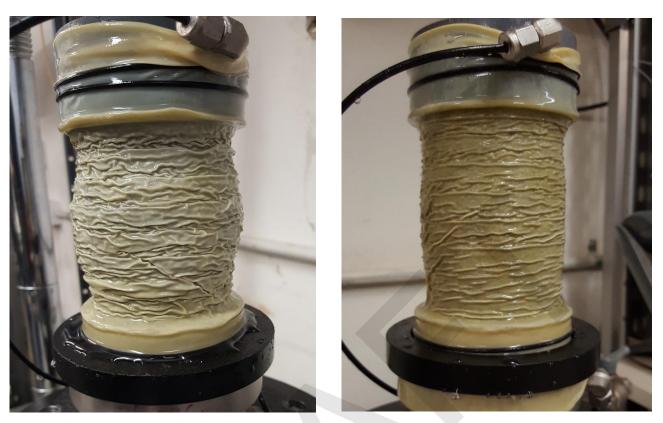


Figure 2: End of test typical deformed specimen to a parabola shape (left) and right cylinder shape (right)



Figure 3: Frozen specimen before removal of membrane and caps (left) and after (right)

GAPMW 3.2.4 – CONSTANT SHEAR DRAINED TEST WITH SERVO STRESS CONTROLLED

Scope

The purpose of this procedure is to provide the steps for undertaking constant shear drained (CSD) testing using a stress servo controller.

Equipment

A standard triaxial GDS device with an additional a servo controller is used to undertake the CSD collapse testing (Figure 1). The servo controller is a DigiRFM device manufactured by GDS which enables direct connection of the load cell and load frame (Figure 2). This direct linkage greatly increases the response time of the load frame. The DigiRFM allows via adjustment of the PID setting to achieve a maximum speed of the load frame of over 90 mm/min if the specified load suddenly reduces.



Figure 1: View of the GDS triaxial device





Figure 2: View of DigiRFM servo-controller mounted at the back of the load frame

Procedure

The test is undertaken using the following steps:

- 1) A specimen is prepared to its target density and consistency using the loose moist tamping preparation procedure.
- 2) A suction of maximum 20 kPa is applied to the specimen with a vacuum pump to enable the specimen shape to be maintained during test setup.
- 3) Initial specimen dimensions are taken using a digital calliper measuring both diameter and height at different specimen locations
- 4) The triaxial device is assembled and the cell filled with water.
- 5) The specimen is flushed with CO₂ for approximately one hour.
- 6) The specimen is then flushed with water imposing a differential head of approximately 5 kPa from the bottom to the top of the specimen; flushing is carried out until bubbles are no longer observed to emerge from the pipe connected to the top of the specimen.
- 7) Back pressure saturation is undertaken over ~3 hours, maintaining a mean effective stress of 20 kPa.
- 8) Once the target saturation back pressure is reached, and volume change is negligible, a *B*-check is undertaken targeting a *B* value greater than 95%.
- 9) The specimen is then unloaded over ~3 hours to a cell pressure of 0 kPa and back pressure of -20 kPa.
- 10) The cell water is drained, the cell removed, and the specimen dimension taken using a digital calliper, to allow a more accurate measurement of specimen diameter for subsequent anisotropic consolidation.
- 11) The specimen is then reloaded following step 7.
- 12) The specimen is slowly consolidated anisotropically (i.e. confining and deviator stress increased) to its target K_0 . The confining stress increase occurs at an approximate rate of 5 kPa per hour.
- 13) Once the target consolidation pressure is achieved, the specimen is left under the target anisotropic stress conditions for approximately 24 hours.

- 14) The CSD stage is then commenced by slowly increasing the back pressure at a rate of 15 kPa per hour. Test data are captured at intervals of one second, to provide stress conditions as close to failure as practicable.
- 15) Once failure occurs the specimen drainage valves are closed, and specimen void ratio determined by measuring its moisture content at the end of test, adopting the freezing method (Sladen and Handford, 1987¹).

The CSD stage is video recorded with sound, to capture the rapid failure that initiates when the stress conditions reach the relevant instability stress ratio for the specimen's state.

The testing steps are provided in a diagram shown in Figure 3.

STEP 1. Specimen preparation STEP 2. Suction applied to specimen to maintain its shape STEP 3. Initial specimen dimensions taken STEP 4. Assembling of triaxial device and specimen dockina STEP 5 and 6. CO₂ and water flushing STEP 7. Back pressure saturation STEP 8. B-Check STEP 9. Unloading back pressure STEP 10. Dissembling of triaxial cell and measure of new specimen dimensions for K₀ consolidation STEP 11. Reloading back pressure STEP 12. Anisotropic consolidation (15 kPa/hour) STEP 13. Standby consolidation under K₀ for 24 hours STEP 14. CSD stage increasing back pressure to 10-15 kPa/hour

STEP 15. Void ratio determination

Figure 3: CSD testing steps diagram

¹ Sladen J.A. and Handford G. (1987). A potential systematic error in laboratory testing of very loose sands. Canadian Geotechnical Journal, 1987, (24)3: 462-466



GAPMW 3.2.5 – CONSTANT SHEAR DRAINED TEST WITH DEAD-WEIGHT STRESS CONTROLLED

Scope

The purpose of this procedure is to provide the steps for undertaking constant shear drained (CSD) testing using a 'dead-weight' hanger system.

Equipment

A standard triaxial GDS device has been modified to undertake CSD collapse testing using dead-weights. The adjustments made to the standard triaxial device to allow CSD test to be undertaken are indicated in Figure 1. The system in use for a CSD test is shown in Figure 2.

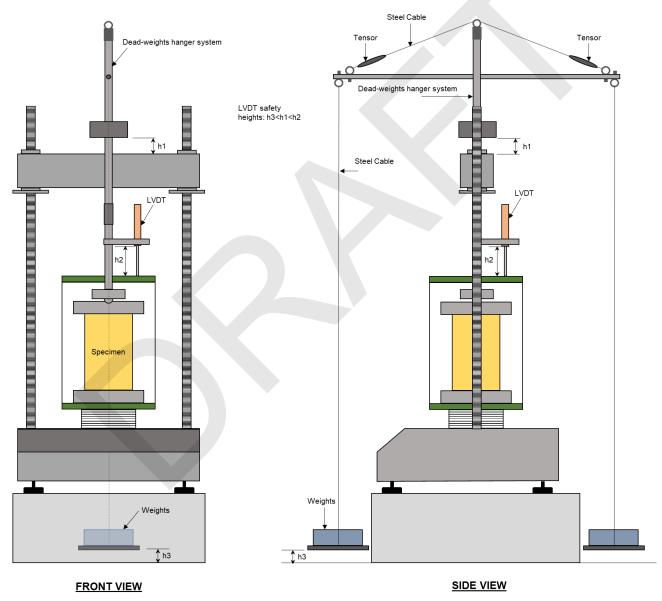


Figure 1: Front and side view of triaxial device modified for CSD testing using a dead-weights hanger system

GAPMW 3.2.5 – Constant Shear Drained Test with Dead-weight Stress Controlled

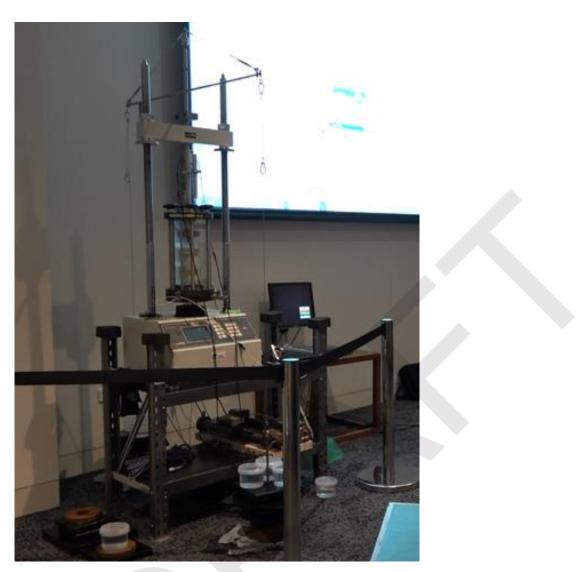


Figure 2: CSD triaxial during testing

Procedure

The test is undertaken using the following steps:

- 1) A specimen is prepared to its target density and consistency.
- 2) A suction of maximum 20 kPa is applied to the specimen with a vacuum pump to enable the specimen shape to be maintained during test setup.
- 3) Initial specimen dimensions are taken using a digital calliper measuring both diameter and height at different specimen locations
- 4) The triaxial device is assembled and the cell filled with water.
- 5) The dead-weights hanger system is connected to the loading ram. Its vertical travel is initially controlled by using the triaxial cross-bar to gently lower the loading ram and hanger system down when necessary to "dock" to the specimen.
- 6) The specimen is flushed with CO₂ for approximately one hour.

- 7) The specimen is then flushed with water imposing a differential head of approximately 5 kPa from the bottom to the top of the specimen; flushing is carried out until bubbles are no longer observed to emerge from the pipe connected to the top of the specimen.
- 8) Back pressure saturation is undertaken over ~3 hours, maintaining an effective stress of 20 kPa. During this stage the clamp locking the dead-weights hanger system is unlocked and the weights are progressively added to prevent the cell pressure from lifting the hanger system. By keeping a dead-weight slightly higher than that required to balance the cell pressure, the hanger remains in a constant position resting on the cross bar.
- 9) Once the target saturation back pressure is reached and volume change is negligible, a *B*-check is undertaken targeting a *B* value greater than 95%.
- 10) The specimen is then unloaded over ~3 hours to a cell pressure of 0 kPa and back pressure of -20 kPa.
- 11) The cell water is drained, the cell removed, and the specimen dimension taken using a digital calliper, to allow a more accurate measurement of specimen diameter for subsequent anisotropic consolidation.
- 12) The specimen is then reloaded following step 8.
- 13) The specimen is slowly consolidated anisotropically (i.e. deviator stress increased) to its target anisotropic stress conditions by adding weights to the hanger system. The application of load to the specimen is regulated through use of the cross bar, to prevent any rapid loading occurring during this process. The deviator stress increase occurs at an approximate rate of 12 kPa per hour (i.e. approximately 4 kg of weight per hour assuming a specimen diameter of 65 mm). Owing to the manual loading requirement, the anisotropic consolidation is undertaken in stages, i.e. 10 hours of loading during daytime and 14 hours of standby, maintaining a constant stress overnight.
- 14) Once the target consolidation pressure is achieved, the specimen is left under K_0 consolidation for 24 hours.
- 15) The CSD stage is then commenced by slowly increasing the back pressure at a rate of 10 kPa per hour. Test data are captured at intervals of 1 second, to provide stress conditions as close to failure as practicable.
- 16) Once failure occurs the specimen drainage valves are closed, and specimen void ratio determined by measuring its moisture content at the end of test, adopting the freezing method.

The CSD stage is video recorded with sound, to capture the rapid failure that initiates when the stress conditions reach the relevant instability stress ratio for the specimen's state.

The testing steps are provided in a diagram shown in Figure 3.

STEP 1. Specimen preparation
STEP 2. Suction applied to specimen to maintain its shape
STEP 3. Initial specimen dimensions taken
STEP 4 and 5. Assembling of triaxial device and specimen docking
STEP 6 and 7. CO ₂ and water flushing
STEP 8. Back pressure saturation
STEP 9. B-Check
STEP 10. Unloading back pressure
STEP 11. Dissembling of triaxial cell and measure of new specimen dimensions for <i>K</i> ₀ consolidation
STEP 12. Reloading back pressure
STEP 13. Anisotropic consolidation (15 kPa/hour)
STEP 14. Standby consolidation under K_0 for 24 hours STEP 15. CSD stage increasing back pressure to 10
kPa/hour
STEP 16. Void ratio determination

Figure 3: CSD testing steps diagram

GAPMW 3.4.2 – SHEAR WAVE VELOCITY MEASUREMENT USING BENDER ELEMENTS FOR TRIAXIAL TEST OF SPECIMEN CONSOLIDATED ANISOTROPICALLY

Scope

The purpose of this procedure is to provide the steps for measuring the shear wave velocity (V_s) of a triaxial specimen consolidated anisotropically using bender elements. When V_s and the bulk density (ρ_b) of the specimen at the time of measurement are known, the small strain shear modulus (G₀) can be determined by the following equation:

$$G_0 = \rho_b * V_s^2$$

The shear wave velocity is calculated by recording the time (t) required for the wave to travel through the specimen from the bottom through the top. Rather than the length of the specimen, the travel distance is defined as the length between the tip of the bender elements or tip-to-tip distance (L_{tt}). Therefore, the shear wave velocity is calculated by the following equation:

$$V_s = L_{tt} / t$$

Figure 1 shows an example of a transmitted and received signal using bender elements.

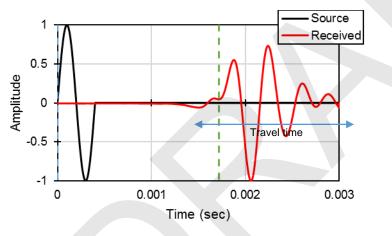


Figure 1: Transmitted and received signals using bender element system

Different criteria have been explored to select the point at which the arrival time (t) occurs in a bender element system such as (A) first deflection, (B) first bump maximum, (C) zero after first bump, and (D) major first peak as shown in Figure 2 (Lee and Santamarina, 2005¹).

¹ Lee and Santamarina (2005) Bender Elements: Performance and Signal Interpretation Journal of Geotechnical and Geoenvironmental Engineering, Vol. 131, No. 9, September 1, 2005. ©ASCE, ISSN 1090-0241/2005/9-1063–1070



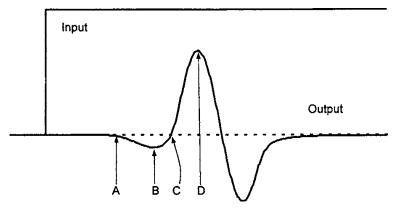
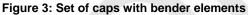


Figure 2: Different first arrival points as described by Lee and Santamarina, 2005

Equipment

A GDS wave function generator and data acquisition device is added to a standard triaxial GDS equipment. The triaxial cell is equipped with a pair of caps that have bender elements protruding from the centre of the caps as shown in Figure 3.





When a voltage excitation is sent to one bender element, the element physically bends laterally (hence the name) creating a wave that propagates through the porous medium (triaxial specimen). When the other element receives the signal, it generates an electrical response. The transmitted signal deteriorates as it travels through the specimen requiring the received signal to be amplified. A computer program developed by GDS is used to control several features such as the period, amplitude and waveform of the input signal, the triggering mechanism (e.g. manual or configured), the amplification factor of the received signal, and data storage. The three main variables stored in a single file are; time, input signal, received signal.

Procedure

The test is undertaken using the following steps:

- 1) A specimen is prepared in accordance to the loose moist tamped triaxial preparation procedure, with the following exemptions:
 - a) The standard caps are replaced with a pair of caps with bender elements
 - b) A connection ring for the cell is required at the base to allow access of the connection ports for the bender element caps

- c) Installation of the bender elements caps requires proper alignment during the setup
- 2) A suction of maximum 20 kPa is applied to the specimen with a vacuum pump to enable the specimen shape to be maintained during test setup.
- 3) Initial specimen dimensions are taken using a digital calliper measuring both diameter and height at different specimen locations
- 4) The triaxial device is assembled and the cell filled with water.
- 5) The specimen is flushed with CO₂ for approximately one hour.
- 6) The specimen is then flushed with water imposing a differential head of approximately 5 kPa from the bottom to the top of the specimen; flushing is carried out until bubbles are no longer observed to emerge from the pipe connected to the top of the specimen.
- 7) Back pressure saturation is undertaken over ~3 hours, maintaining a mean effective stress of 20 kPa.
- 8) Once the target saturation back pressure is reached, and volume change is negligible, a B-check is undertaken targeting a *B* value greater than 95%.
- 9) The specimen is then unloaded over ~3 hours to a cell pressure of 0 kPa and back pressure of -20 kPa.
- 10) The cell water is drained, the cell removed, and the specimen dimension taken using a digital calliper, to allow a more accurate measurement of specimen diameter for subsequent anisotropic consolidation.
- 11) The specimen is then reloaded following step 7.
- 12) Using the BE program, the following parameters must be defined:
 - a) Specimen height
 - b) Data sampling frequency and time
 - c) Amplification factor or gain (auto)
 - d) Input signal waveform (sinusoidal), period (varies) and amplitude (14V)
 - e) Wave type: compressional wave (P) or shear wave (S)
 - f) Trigger type (manual)
- 13) The input signal is sent by pressing the trigger button.
- 14) Several periods are used to determine a range with a good quality signal.
- 15) At least three signals with different periods are recorded individually
- 16) The height of the specimen at the time of measurement is recorded.
- 17) The specimen is consolidation under anisotropic conditions targeting a K_0 of 0.6.
- 18) The process is repeated as many times as required, typically at the end of each consolidation stage generally every approximately 100 kPa mean effective stress. Arrival time and thus shear wave velocity can be obtained using the GDS program or during the data process analysis.
- 19) At the end of testing, the deviatoric stress is reduced to near zero stress to achieve near isotropic conditions allowing drainage of the specimen during the process.

- 20) After achieving steady conditions, confining stresses are further reduced to a confining effective stress of 20 kPa at the same time the back pressure is reduced to zero allowing the specimen to drain.
- 21) Following the reduction of stresses to 20 kPa, the cell pressure is reduced to zero and the back pressure to -20 kPa.
- 22) After the specimen achieves steady conditions the drainage valves are closed, and the cell is disassembled while the sample is under suction.
- 23) The end of test sample dimensions is taken using a digital calliper measuring both diameter and height at different locations to allow its comparison with the specimen void ratio inferred from the end of test freezing method (Sladen and Handford, 1987²).
- 24) The top cap with the bender element is carefully removed and replaced with a standard cap provided of drainage valves.
- 25) The specimen is flipped upside down and the bottom cap is also replaced with a standard cap of drainage valves.
- 26) The specimen void ratio is determined by measuring its moisture content at the end of test, adopting the freezing method which involves freezing the specimen with the membrane, replaced standard caps and drainage lines attached.

The specimen at step 10 (specimen measurement after saturation prior to K_0 consolidation) and step 23 (end of test specimen measurement) is shown in Figure 4.

² Sladen J.A. and Handford G. (1987). A potential systematic error in laboratory testing of very loose sands. Canadian Geotechnical Journal, 1987, (24)3: 462-466



GAPMW 3.4.2 - Shear Wave Velocity Measurement using Bender Elements for Triaxial Test of Specimen Consolidated Anisotropically



Figure 4: Specimen condition prior to K₀ consolidation (left) and at end of test (right)

GAPMW 4.1.1 - Moist Tamped Loose Specimen Preparation for Direct Simple Shear Testing

GAPMW 4.1.1 – MOIST TAMPED LOOSE SPECIMEN PREPARATION FOR DIRECT SIMPLE SHEAR TESTING

Scope

The purpose of this procedure is to prepare a loose specimen using the moist tamping preparation technique for direct simple shear (DSS) testing.

Equipment

The preparation was undertaken using a special DSS mould designed to allow preparation of loose specimen and a suction pump. This mould allows to undertaking preparation of a specimen while allowing the membrane to be neatly fixed on the DSS rings by application of suction.

The GDS specimen preparation mould and the DSS mould while suction is applied are shown in Figure 1.



Figure 1: GDS specimen preparation mould (left) and DSS mould while suction is applied (right)

Procedure

The specimen preparation is undertaken using the following steps:

- 1) The DSS is prepared with the rings with a latex membrane neatly fixed against the walls of the mould by applying suction.
- 2) The sample is placed inside the DSS and tamped to a known density in one layer while applying suction. A stainless steel ring is used to facilitate placement of the material inside the DSS while tamping to the height of the last DSS ring.
- 3) The DSS device is assembled and the top platen is lowered down using the computer-controlled software to a given bedding load of approximately 10 kPa.
- 4) The suction is removed, and the specimen preparation mould dissembled.
- 5) The DSS base is tightened via four screws located at each corner to the main device, the restrain arms to reduce specimen rotation during shear assembled and the test commenced.

The specimen preparation procedure is shown in Figure 2 to Figure 5.

GAPMW 4.1.1 - Moist Tamped Loose Specimen Preparation for Direct Simple Shear Testing



Figure 2: Placement of loose sample in DSS mould with stainless steel ring used to facilitate material placement

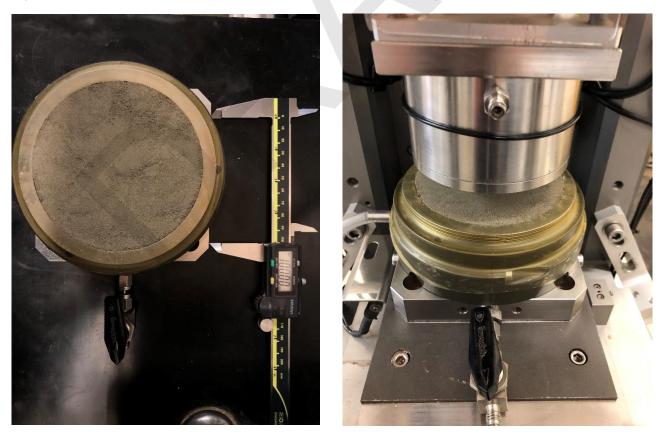


Figure 3: Tamped specimen outside DSS device (left) and fitted on the DSS base while still under suction (right)

GAPMW 4.1.1 - Moist Tamped Loose Specimen Preparation for Direct Simple Shear Testing

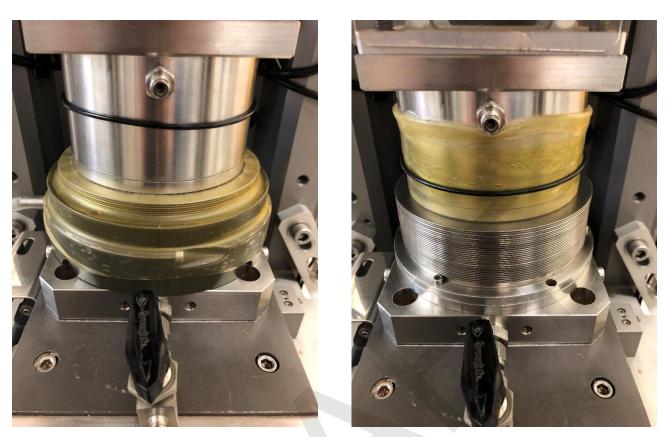


Figure 4: Top DSS platen lowered down to specimen surface (left) and with specimen preparation mould dissembled (right)

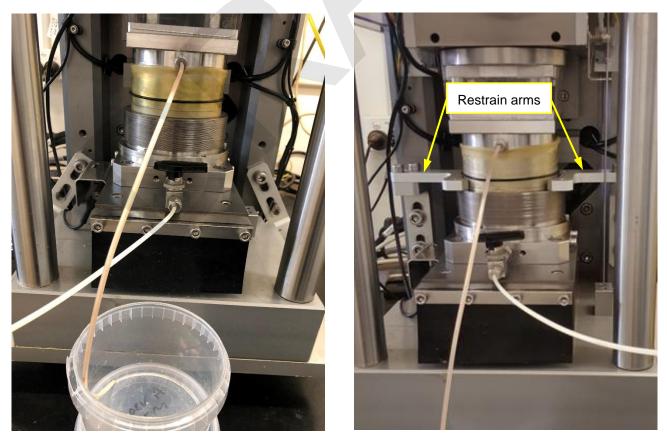


Figure 5: DSS device assembled without (left) and with (right) restrain arms mounted

GAPMW 4.2.2 – CYCLIC DIRECT SIMPLE SHEAR TEST Scope

Direct simple shear (DSS) testing involves preparation of a cylindrical specimen with a typical height to diameter ratio of about 0.4 within a membrane which is laterally constrained by a stack of low-friction metal rings. The material is vertically consolidated to the desired stress with or without an initial static shear stress (α , bias). Owing to the lateral restraint provided by the stack of rings, consolidation occurs under a K_0 condition (i.e. zero lateral strain). Once consolidation is completed, the specimen is sheared cyclically by moving the lower platen horizontally while the top platen remains still. Following cyclic loading, the specimen is sheared monotonically provide an indication of post-cyclic strength. This may, in some instances, provide an assessment of post-liquefaction strength.

It should be noted that while DSS testing provides undrained strength parameters, the test itself is not undrained. Rather than restrict drainage, constant volume conditions are enforced via computer control of the test. Should the specimen contract, the top platen would begin to move downwards, reducing the height of the specimen. However, the computer control system prevents this from occurring by reducing the vertical stress to maintain a constant height. The excess pore pressures that would have developed within the specimen can then be inferred from the changes in vertical stress required to maintain constant height. This testing method has been shown to provide the same results as tests with enforced drainage conditions (Finn 1985¹, Dyvik et al. 1987²).

Equipment

Specimens were tested using a GDS electro-mechanical dynamic cyclic simple shear (EMDCSS) system shown in Figure 1.

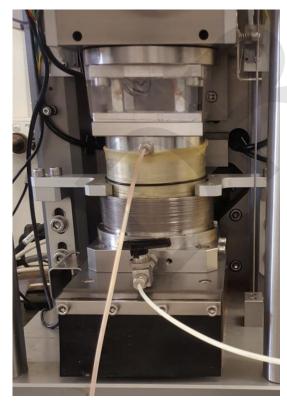


Figure 1: GDS electro-mechanical DSS device



¹ Finn, WDL 1985. Aspects of constant volume cyclic simple shear. Proceedings of Advances in the Art of Testing of Soils under Cyclic Conditions, pp 74-98 (ASCE, New York). ² Dyvik, R, Berre, T, Lacasse, S and Raadim, B 1987. Comparison of truly undrained and constant volume direct simple shear tests. Géotechnique, Vol 37, No 1, pp 3-10.



The device is capable of carrying out DSS testing under monotonic and cyclic conditions. The GDS DSS base and top platens are specially designed to allow saturation to occur by applying a flow, generally from the bottom of the specimen to its top via a pump or a water reservoir.

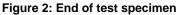
Procedure

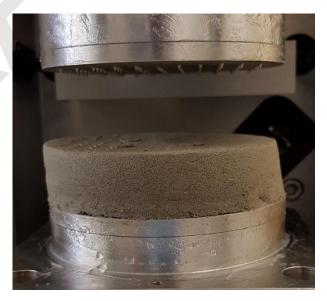
The test is undertaken using the following steps:

- 1) A specimen is prepared according to the loose tamping preparation procedure³ in a 100 mm diameter specimen.
- 2) The specimen is consolidated to the vertical effective stress for saturation of generally 15 kPa and water is flushed through the specimen from the base to the top.
- 3) For tests without bias, the specimen is consolidated to the target vertical effective stress in stages. For tests with a bias, the specimen is consolidated to the target vertical and horizontal effective stresses by ramping at a vertical stress rate of 10 ~ 25 kPa/hour.
- 4) The specimen is sheared cyclically by applying a sinusoidal cyclic stress at a loading frequency of 1 Hz.
- 5) Once the cyclic shear stage is completed, a post-cyclic monotonic shearing stage is undertaken. For testing with bias that during cyclic loading reached the maximum positive shear strain of the device, a" reverse" post-cyclic monotonic shear stage is undertaken i.e. where post-cyclic shearing is in the opposite direction the bias application.
- 6) Once the test is completed, the DSS is dissembled, the specimen removed and dried in a 110°C oven for moisture content measurement.

The typical end of test specimen is provided in Figure 2.







³ GAPMW 4.1.1 Moist Tamped Loose Specimen Preparation for Direct Simple Shear Testing

