

URI 986-68

1986/68. Preliminary report on building cracking at the Tasmanian State Institute of Technology campus at Newnham.

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Abstract

Widespread cracking is occurring on many of the buildings on the T.S.I.T. campus at Newnham. This cracking is reported to have started in 1982-1983, the drought years in Launceston, and is continuing. It is thought to be related to foundation movements caused by differential ground movements from an underlying expansive clay.

Two auger holes at two proposed building sites showed thin permeable river terrace gravel and silt overlying very highly plastic and expansive clay. Within the clay are minor beds and lenses of sandstone, sandy clay etc., some of which are cemented. The selective nature of the cracking is possibly due to the differences in lithology and thickness in the underlying sediments, aided by the large number of trees growing so close to the buildings.

Little to no detailed subsurface information of the campus site is available and it is recommended that a subsurface investigation, including drilling and soil testing, be undertaken to establish the cause of cracking. This investigation should be undertaken before any remedial work on the cracking is contemplated.

INTRODUCTION

As a result of a request from Mr G. R. Taplin of Smith, Sale and Burbury, consulting engineers to the Tasmanian State Institute of Technology, an inspection of the widespread, and in places intensive cracking of several of the buildings at the T.S.I.T. campus was made by the writer on 27 August 1986. A further inspection was made on 5 September with W. L. Matthews, Acting Supervising Geologist of the Engineering Geology Section. After this inspection a meeting was held with the College's building supervisor and the consulting engineer concerning the cracking. As requested by the supervisor, this report confirms, in writing, the result of these inspections, the possible causes, and an outline of the initial investigation required to ascertain the cause of the cracking. The establishment of the cause or causes of the cracking appears essential before any remedial measures or repairs to the building are contemplated.

BUILDING CRACKING - HISTORY AND POSSIBLE CAUSES

As far as can be ascertained from discussion with the building maintenance staff, the cracking started in 1982-1983 (significant drought years in Launceston), when there was low total rainfall and little or no winter rains occurring. Since then the cracking has continued, with very significant movements measured on some buildings according to Mr Taplin's measurements (plate 1).

From the inspections, the cracking is thought to be related to foundation movements caused by differential ground movements from the underlying expansive clay, which responds to seasonal and longer term moisture fluctuations (plate 2).

These expanding and contracting movements are possibly combined with small translational downslope movements in some buildings, related to soil creep and/or initial incipient landslide movement. These factors, combined with different design of the building's foundations and weight etc., may have added further to the problem (plate 3). The height and number of trees so close to the buildings foundations, which are desiccating the underlying clay, is likely to prove a significant factor as a cause of the cracking of many of the buildings (plate 4).

LOCATION AND GEOLOGY

The campus of the T.S.I.T. is situated on a river terrace overlooking the flood plain of the River Tamar, with some buildings sited close to the break in slope marking the edge of this terrace (plate 5). Two recent auger holes drilled close together at the proposed building sites for the Sports Institute building (Moore, 1986) and the Nurses Training Centre Building, together with outcrops below on the highway, suggest the campus is underlain by river terrace sediments of Quaternary age overlying clay of the Launceston Beds of Tertiary age (Longman, 1964). A buried Tertiary age river valley crops out on the highway north of the Maritime College and this buried valley may extend south under the T.S.I.T. campus area.

The river terrace sediments comprise units of permeable, coarse gravel and silt of varying thicknesses but these units generally appear to be thin. The Launceston Beds in the Newnham area are dominantly clay and sandy clay with minor beds or lenses of soft sandstone and gravel. These minor beds or lenses in the clay may be cemented - or partially cemented - forming impermeable moisture barriers at the top of the clay.

Even though the broad outline of the geology under the campus is simple, in detail, a considerable variation in the lithology and thickness of both the overlying river terrace sediments and underlying Launceston Beds, both laterally as well as in depth, is likely to be present. It is these detailed lithological variations, combined with the clay's very high plasticity and linear shrinkage, and seasonal moisture content fluctuations on the outside of the buildings compared with beneath the buildings, that is thought to be a major cause of the problem. Similar lithological and moisture content variations within clay have caused the cracking of a number of houses investigated by the writer in the Tamar Valley. All of these investigations required preliminary drilling to obtain the necessary geological information. Similarly, at the T.S.I.T. where little or no subsurface information is available, drilling is considered a prerequisite for any investigation of the cracking.

RECENT AUGER DRILLING ON TWO PROPOSED BUILDING SITES ON THE CAMPUS

Indications of the types of variations, and how quickly these changes can occur, is seen in the recent auger drilling at the T.S.I.T. (fig. 1). Even though the holes were only 24.4 m apart, the hole at the Nurses Training Centre encountered 0.2 m of fill followed by 1.6 m of river gravel and silt overlying dry clay; whereas at the Sports Institute site, 1.4 m of river gravel and silt was drilled before encountering moist clay (see drill logs Appendix 1). The clay in both holes was lithologically similar, very highly plastic, and expansive (fig. 1 and 2; Tables 1-3).

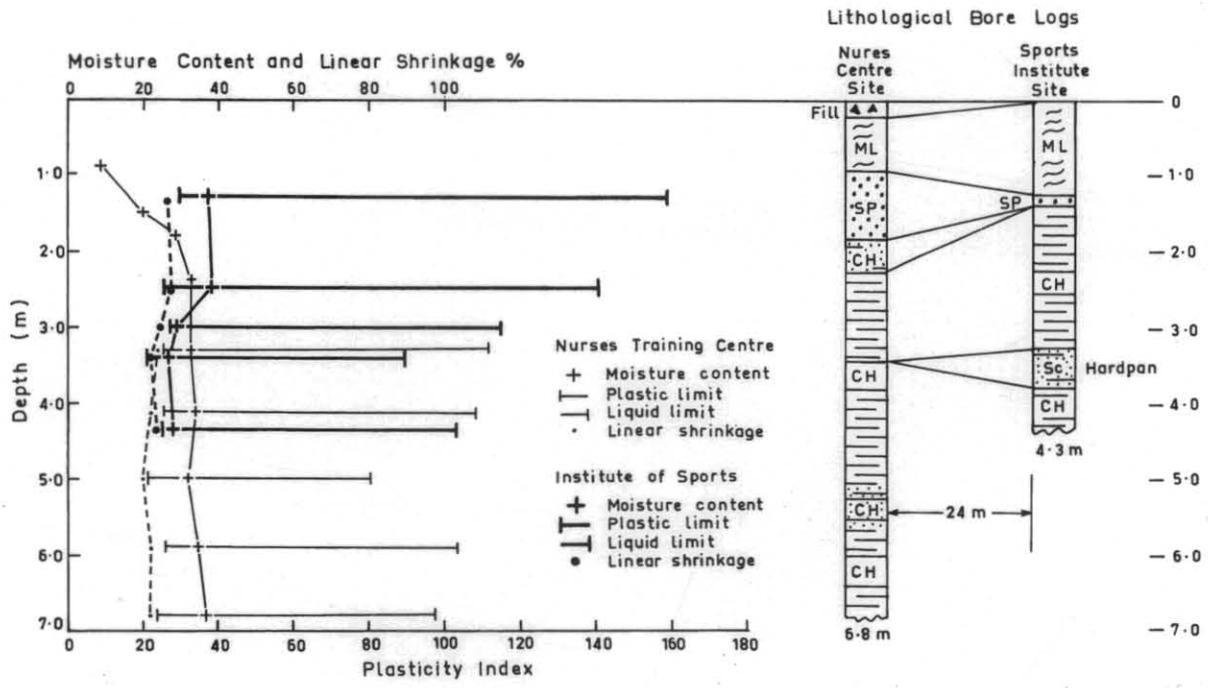


Figure 1. Soil testing results and diagrammatic logs.

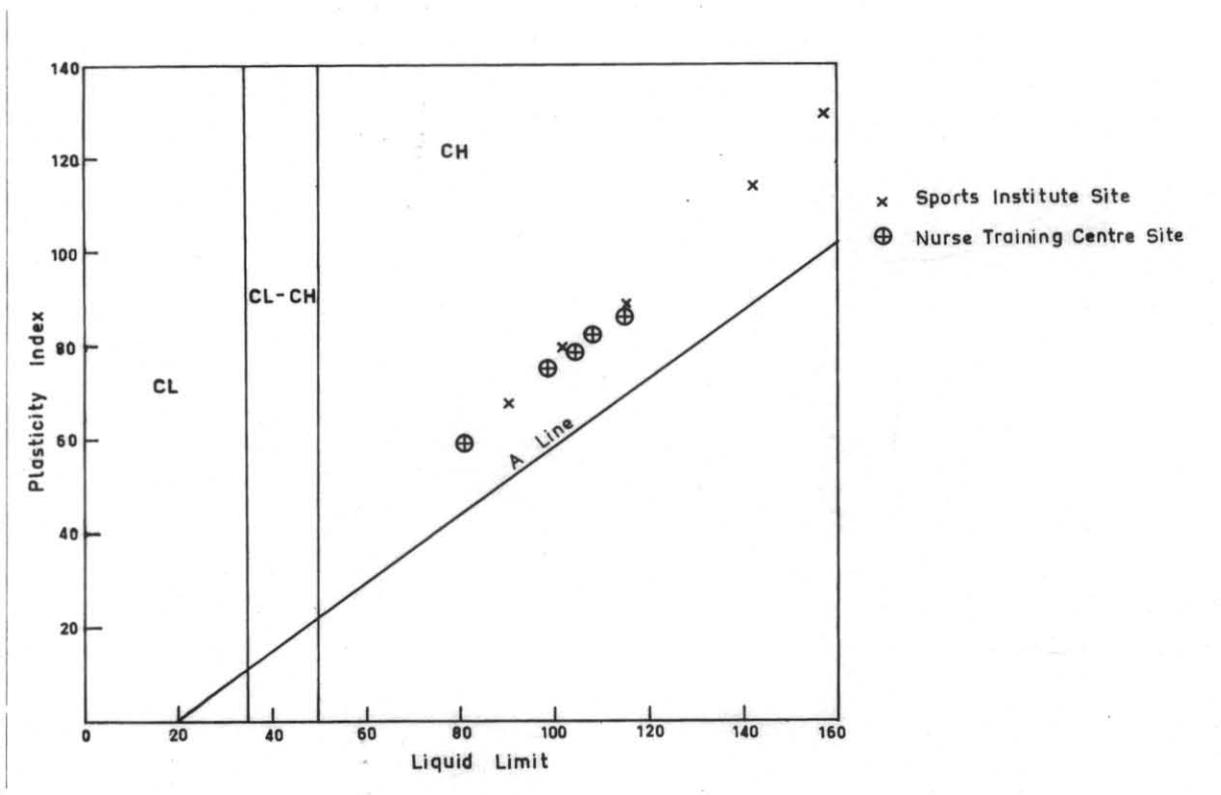
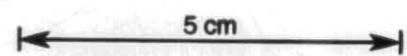


Figure 2. Clay classification diagram, T.S.I.T. building sites.



Only 2.9 m of clay was drilled at the Sports Institute site before gravel was encountered which the drill could not penetrate. In this clay a hard pan of sandy clay (0.4 m thick), which acts as a barrier for moisture penetration within the clay, was encountered (Moore, 1986). At the Nurses Training Centre site, 5.0 m of clay was drilled to a depth of 6.8 m with no hard pan layer or gravel encountered in the clay (fig. 1).

Another example of the variation occurring at the Nurses Training Centre site was shown when investigation pits dug for Mr Taplin into the river terrace gravel contained considerable amounts of water. The drill hole, drilled at a distance of approximately 10.4 m, was completely dry, even after being left open for over a week.

The contrast between moisture content profiles of the clay in the auger holes at the two proposed building sites is a further example of the variations likely to occur on the campus. At the Nurses Training Centre, the moisture content rose from 20% to 36%, whereas at the Sports Institute site, it declined from 38% to 28% with depth (fig. 1). All of these small variations could have an influence on the potential movement of the subsurface on which these buildings will be situated.

#### RECOMMENDATIONS

With no subsurface information available for the existing building or the general campus area, it appears necessary to undertake a detailed drilling programme to obtain an understanding of the geology of the site. This will require both diamond drill and auger holes using a light Gemco rig, and collecting undisturbed and disturbed samples. This drilling may have to be supplemented by some backhoe pits in critical areas. The surface terrace sediments will require grain size analysis, permeability testing and, if large amounts of water are present, possibly some pump tests. The clay drilled will require soil laboratory testing with routine moisture content, Atterberg limits, and linear shrinkage tests, as well as some X.R.D. analyses for clay compositions. Shear box testing may be required on selected samples as well as some consolidation tests.

#### ESTIMATED COST - DEPARTMENT OF MINES

The drilling may require supplementary mapping, photographing of the cracks, and monitoring and levelling of the buildings, etc. The cost of this work, including geologists' time, is estimated to be approximately \$10,000, of which drilling costs will be the major component.

Even if Civil and Civic release their original drilling results of 1970-1971 on the campus site, this information will only supplement the above investigation and will not replace it. All of this investigation will be carried out in conjunction with G. R. Taplin, consulting engineer, and other staff of Smith, Sale and Burbury Limited, Launceston.

#### ACKNOWLEDGEMENTS

The photographs were taken by M. J. Dix, drilling by B. E. Cox, and soil testing by R. N. Woolley, all of the Department of Mines, Rosny Park.

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[16 October 1986]

Table 1. SOIL TESTING RESULTS FROM BUILDING SITES, T.S.I.T CAMPUS

## INSTITUTE OF SPORTS BUILDING

Sample no.	Depth (m)	Moisture content (%)	Plastic limit	Liquid limit	Plastic index	Linear shrinkage (%)
1	1.3	37	30	159	129	27
2	2.5	38	27	141	114	28
3	3.0	29	28	115	87	26
4	3.4	27	22	90	68	23
5	4.3	28	24	103	79	25

## NURSES TRAINING CENTRE BUILDING

Sample no.	Depth (m)	Moisture content (%)	Plastic limit	Liquid limit	Plastic index	Linear shrinkage (%)
1	0.9	9	-	-	-	-
2	1.5	20	-	-	-	-
3	1.8	29	-	-	-	-
4	2.4	32	-	-	-	-
5	3.3	33	27	113	86	24
6	4.1	34	26	108	82	24
7	5.0	32	22	81	59	21
8	5.9	35	26	104	78	23
9	6.8	36	24	99	75	23

Table 2. X-RAY DIFFRACTION MINERALOGY OF CLAY SAMPLES, INSTITUTE OF SPORTS BUILDING

Sample	Clay mineralogy (%)			Total quartz (%)
	Montmorillonite	Kaolinite	Goethite	
S1	15-20	50-55	30-35	5-10
S2	25-30	40-45	25-30	5-10
S3	25-30	40-45	25-30	5-10
S4	20-25	40-45	30-35	10-15
S5	20-25	45-50	25-30	10-15

Soil testing and clay mineralogy testing by R.N. Woolley  
Department of Mines, Hobart.

Table 3. RESULTS OF SOIL LABORATORY TESTING OF SAMPLES FROM THE PROPOSED NURSES TRAINING CENTRE

Depth (m)	Moisture content (%)	Plastic limit	Liquid limit	Plasticity Index	Linear Shrinkage (%)	XRD results			Soil laboratory classification	
						Clay fraction (%)				
						Kaolinite	Montmorillonite	Goethite		
0.9	9								ML	
1.5	20								GP	
1.8	29								GP	
2.4	32					NOT ENOUGH CLAY SAMPLE COLLECTED FOR TESTING			-	
3.3	33	27	113	86	24	45-50	40-45	10-15	10-15	CH
4.1	34	26	108	82	24					CH
5.0	32	22	81	59	21					CH
5.9	35	26	104	78	23	60-65	30-35	5-10	5-10	CH
6.8	36	24	99	75	23					CH

Testing by R. N. Woolley, Department of Mines, Rosny Park



Plate 1. *Cracking at beam/pillar joints, cafeteria, main building.*



Plate 2. *Cracking around base of pillar because of proximity of trees to building.*

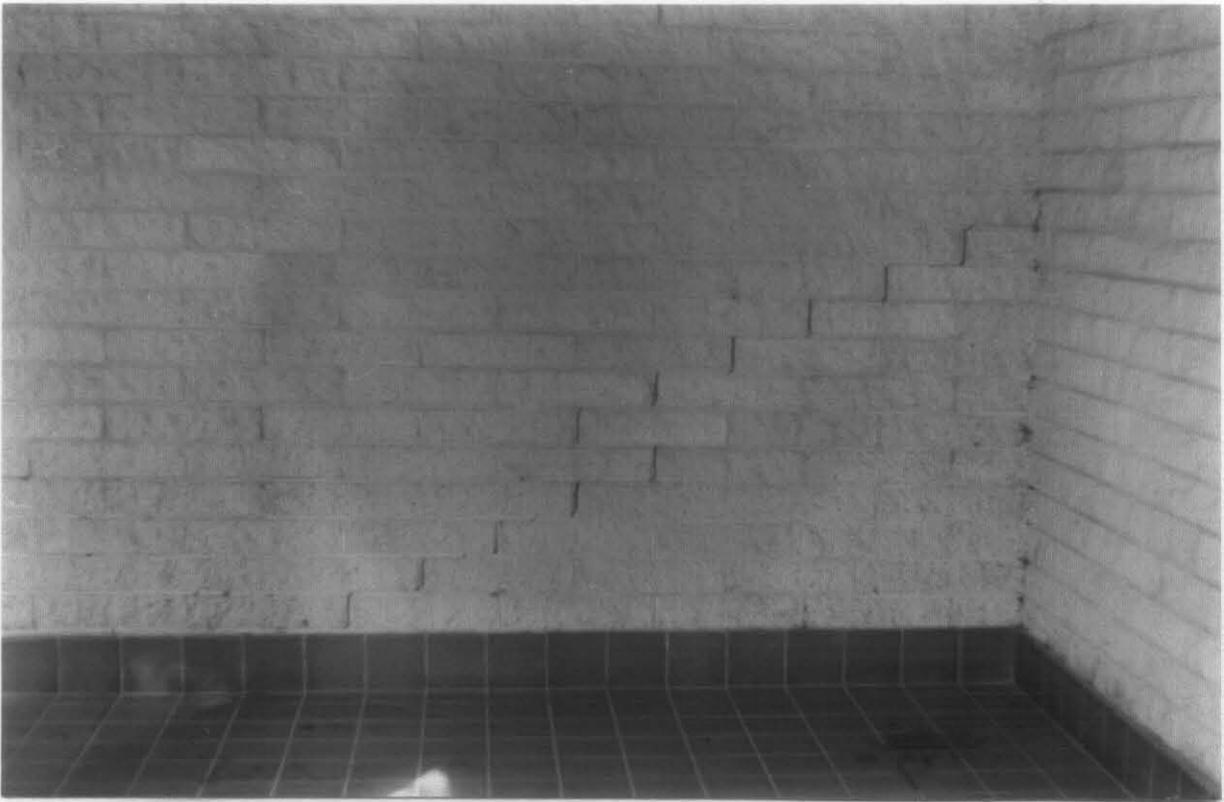


Plate 3. *Cracking in brickwork of main building, possibly caused by foundation movements.*



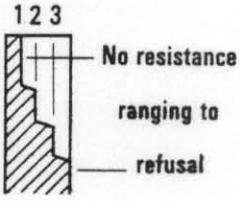
Plate 4. *Close proximity of large trees to Administration building.*



Plate 5. *Campus buildings, showing close proximity to terrace edge on River Tamar side.*

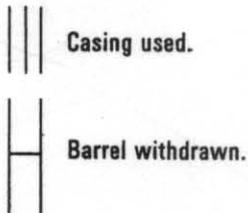
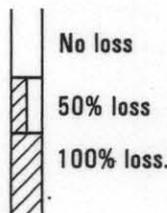
# EXPLANATION SHEET FOR ENGINEERING LOGS

## Borehole and excavation log

<p><b>Penetration</b></p> 	<p><b>Water</b></p> 	<p><b>Notes - samples and tests</b></p> <p>U50 Undisturbed sample 50mm diameter. D Disturbed sample. N Standard penetrometer blow count for 300mm. N* SPT + sample.</p>	<p><b>Material classification</b></p> <p>Based on Unified Soil Classification System. In Graphic Log materials are represented by clear contrasting symbols consistent for each project.</p>
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<p><b>Moisture content</b></p> <p>D Dry, looks and feel dry. M Moist, no free water on hand when remoulding. W Wet, free water on hand when remoulding. LL Liquid limit. PL Plastic limit. PI Plasticity Index.</p> <p>eg. <math>M &gt; PL</math> - Moist, moisture content greater than the plastic limit.</p>	<p><b>Consistency</b></p> <p>VS Very soft. S Soft. F Firm. St Stiff. VSt Very stiff. H Hard. Fb Friable.</p> <p>Notes: X on log is test result — is range of results.</p>	<p><b>Density index</b></p> <table border="0"> <tr> <td></td> <td>hand penetrometer (kPa)</td> <td></td> <td>%</td> </tr> <tr> <td>VL</td> <td>&lt; 25</td> <td>Very loose.</td> <td>0 - 15</td> </tr> <tr> <td>L</td> <td>25 - 50</td> <td>Loose.</td> <td>15 - 35</td> </tr> <tr> <td>MD</td> <td>50 - 100</td> <td>Medium dense.</td> <td>35 - 65</td> </tr> <tr> <td>D</td> <td>100 - 200</td> <td>Dense.</td> <td>65 - 85</td> </tr> <tr> <td>VD</td> <td>200 - 400</td> <td>Very Dense</td> <td>85 - 100</td> </tr> <tr> <td></td> <td>&gt; 400</td> <td></td> <td></td> </tr> </table>		hand penetrometer (kPa)		%	VL	< 25	Very loose.	0 - 15	L	25 - 50	Loose.	15 - 35	MD	50 - 100	Medium dense.	35 - 65	D	100 - 200	Dense.	65 - 85	VD	200 - 400	Very Dense	85 - 100		> 400		
	hand penetrometer (kPa)		%																											
VL	< 25	Very loose.	0 - 15																											
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D	100 - 200	Dense.	65 - 85																											
VD	200 - 400	Very Dense	85 - 100																											
	> 400																													

## Cored borehole log

<p><b>Case - lift</b></p> 	<p><b>Fluid loss</b></p> 	<p><b>Lugeons</b></p> <p>Lugeon units (<math>\mu L</math>) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of <math>1 \times 10^{-4}</math> mm/sec.</p>	<p><b>Graphic log</b></p>  <p>No core. Rock substances represented by clear, contrasting symbols consistent for each project.</p>
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<p><b>Weathering</b></p> <p>Fr Fresh. SW Slightly weathered. HW Highly weathered. EW Extremely weathered.</p>	<p><b>Strength</b></p> <table border="0"> <tr> <td>EL</td> <td>Extremely low.</td> <td>point load strength index <math>I_s</math> (50) (MPa)</td> <td>&lt; 0.03</td> </tr> <tr> <td>VL</td> <td>Very low.</td> <td></td> <td>0.03 - 0.1</td> </tr> <tr> <td>L</td> <td>Low.</td> <td></td> <td>0.1 - 0.3</td> </tr> <tr> <td>M</td> <td>Medium.</td> <td></td> <td>0.3 - 1</td> </tr> <tr> <td>H</td> <td>High</td> <td></td> <td>1 - 3</td> </tr> <tr> <td>VH</td> <td>Very high.</td> <td></td> <td>3 - 10</td> </tr> <tr> <td>EH</td> <td>Extremely high.</td> <td></td> <td>&gt; 10</td> </tr> </table> <p>Note: X on log is test result.</p>	EL	Extremely low.	point load strength index $I_s$ (50) (MPa)	< 0.03	VL	Very low.		0.03 - 0.1	L	Low.		0.1 - 0.3	M	Medium.		0.3 - 1	H	High		1 - 3	VH	Very high.		3 - 10	EH	Extremely high.		> 10	<p><b>Significant defects</b></p> <p>Significant defects shown graphically.</p> 
EL	Extremely low.	point load strength index $I_s$ (50) (MPa)	< 0.03																											
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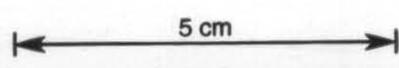
# ENGINEERING LOG - BOREHOLE

borehole no. 1  
sheet 1 of 1

12/13

project	Institute of Sports building		location	T.S.I.T. Campus, Newnham, Launceston			
co-ordinates	5102-54164		drill type	Triefus		hole commenced	6.5.86
R.L.	22 m (approximate)		drill method	Auger		hole completed	6.5.86
inclination	vertical		drill fluid	None		drilled by	B.E. Cox
bearing	--					logged by	W.R. Moore
						checked by	R.C. Donaldson

penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
	None		1.0		ML	SILT with minor gravel. SILT grey and grey-brown, fine-poorly graded. Gravel - scattered pebbles, coarse, 25-50 mm quartzite pebbles.	D	VL ↓ L		Silt
	None	S1	2.0		GP	GRAVEL - Med. to coarse, poorly graded	D	MD		Gravel
	None	S2	2.0		CH	CLAY - Brown to grey-brown, highly plastic. Odd pebble of quartzite and dolerite.	M < PL	V St.		Clay
	None	S3	3.0		SC	SANDY CLAY - Orange clay, low plasticity, sand, fine.	D	H		Sandy clay
	None	S4	4.0		CH	CLAY - Orange-brown, highly plastic. Some small pebbles.	M PL	H		Hardpan Clay
	None	S5				Drilled to refusal, possible gravel layer.  Depth 4.3 m.				



# ENGINEERING LOG - BOREHOLE

13/13

project	Proposed site, nurses training centre	location	T.S.I.T. Campus, Newnham, between Eng. Block and Gymnasium		
co-ordinates	5102-54164	drill type	Treifus	hole commenced	4.9.86
R.L.	22 m (approx.)	drill method	Auger	hole completed	4.9.86
inclination	Vertical	drill fluid	none	drilled by	B.E. Cox
bearing	--			logged by	W.R. Moore
				checked by	R.C. Donaldson

penetration 1 2 3	support water	notes samples, tests	metres		graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa				structure, geology
			R.L.	depth						25	50	100	200	
						F	Fill. Mainly dolerite gravel							Fill
		S1		1.0		ML	SILT with minor gravel. Silt brown, fine, poorly graded. Gravel coarse Quartzite rounded pebbles. Some Organics.	D Fr	VL L					Silty soil
		S2				GP	GRAVEL Medium - coarse, silt matrix Silt fine, yellow <10%. Pebbles rounded quartzite and dolerite, dominantly small 1-2 mm.	D	MD					River terrace gravel
		S3		2.0		CH	Clay with gravel. Clay highly plastic, red, H<PL. As above pebbles, small rounded +10%	D H	St					Transitional zone
	None			3.0		CH	Clay - high plasticity, red, some minor grey clay bands.	H Pl	V St.					Clay Launceston Beds
	None			4.0		CH								
		S7		5.0		CH	Clay. High plasticity, orange. Some sand, fine >10% poorly graded	M	V St.					
		S8		6.0		CH	Clay. High plasticity - grey orange	M Pl	H					
		S9				CH								
							Hole stopped at 6.8 m. Adequate depth reached.  N.B. All samples collected: Disturbed							

