UR1986_32

1986/32. Subsurface investigation of a cracked house at Packham Street, Launceston

W.R. Moore

Abstract

One auger hole was drilled at both ends of a cracked house in north-east Launceston to investigate the clay underlying the house's foundation. Both auger holes passed through a surface layer of black organic clay soil and dark brown clay with gravelly clay at the base. All of these clays were highly plastic and moist. Underlying these was a rubbly yellow clay which was dry and had a low plasticity. Both holes ended in what appeared to be heavy gravel at 2.6 m and 3.7 m depth.

The samples collected at the base of the clay soil at 0.9 m depth had very high liquid limits (156 and 174), plastic index of 126 and 145, and linear shrinkage of 28-31%. The liquid limit declined rapidly and constantly and at 2.4 m in Hole 1, in the dry, yellow rubbly clay, was 45, PI was 29 and LS 12%. In the surface layers the moisture content was high in the clay and declined with depth in Hole 1 but in Hole 2 remained constantly high.

The cracking of the house is thought to be caused by the expansive clay soils. To reach the non-expansive clay at 2.4 and 3.4 m would be too costly for conventional underpinning.

INTRODUCTION

At the request of R. Gowland of Gowlands Structural Drafting of Launceston, an inspection of Mr and Mrs Q. Munnings' cracked house at 8 Packham Street, Alanvale, was made on 16 April. Packham Street is part of a recent subdivision on the west side of Alanvale Road north of Bethune Park [EQ099175].

The house at 8 Packham Street is a modern, single-storied, in-line (N-S) brick veneer dwelling with a garage on the south end, integrated within the house. The concrete slab foundation of the garage is reported to be of lighter construction than the foundation slab for the remainder of the house.

DEGREE OF CRACKING

The most severe cracking occurs at the south-eastern corner and along the southern wall of the garage. This end of the house appears to have dropped. The southern wall of the garage may have to be partially, if not totally, rebuilt. Consequently the garage section would have to be classified as severely cracked.

Cracks occur on the three other walls. If the movement could be stabilised, some of these cracks could be repaired without replacing bricks, while in others the bricks will require replacement. Therefore the cracking of the house would be classified as slight to moderate.

The owner had dug a trench below the house foundations at the north-west corner of the house. Expansive clay was exposed in this shallow pit. The presence of this clay indicated that the cracking was caused by foundation movement from the underlying clay. It was recommended that two or three auger holes be drilled as close as possible to the foundations where

access was possible.

DRILLING

Two auger holes were drilled on 29 April using a light trailer-mounted Triefus drill. Augers of 100 mm diameter were used and samples were collected from the drill bit as each flight of augers was drilled.

One hole was drilled at the rear of the house close to the south-east corner and the other hole was drilled at the north-west corner of the house. The sedimentary succession drilled in Hole 1 was capped by a heavy black clay soil surface layer. This soil was highly plastic and 0.9 m thick. The clay was soft (120 kpa) and very moist. As the house foundations were probably dug in this soil layer, the soil was sampled at 0.9 m depth near the base of these foundations.

Beneath the black soil was a very highly plastic dark brown clay. The clay was moist and stiff and 1.2 m thick. Samples were collected at the top and bottom of this intermediate clay layer. Below 2.1 m gravel was encountered in the clay, which became harder but was still moist. This gravelly clay was difficult to drill. Only 25-50 mm fragments of a slightly weathered dolerite boulder and some ironstone nodules were recovered from the gravel.

Below this gravel there was a significant lithological change at 2.4 m depth, changing to a rubbly yellow clay. This yellow clay was dry and appeared (from field tests) to be of low plasticity. In this clay were small dolerite pebbles. The clay was difficult to drill and the drill refused to penetrate any deeper than 4.3 m. The bit appeared to be rolling on heavy gravel.

Hole 2 was drilled near the cracked NW corner of the house. A similar lithological sequence was drilled in this hole as in Hole 1, except that all the units above the rubbly clay were thicker and this distinctive lithological change occurred at 3.4 m compared with 2.4 m depth in Hole 1. Drill refusal occurred at 3.7 m in Hole 2 in gravel.

LABORATORY RESULTS

As the lithological sequence and units were so similar in the two holes drilled, the cost of testing all the samples appeared not to be justified. All the samples from Hole 1 and the top sample from Hole 2 were tested for moisture content, Atterberg limits and linear shrinkage as well as being X-rayed for composition of the clay. The remaining samples of Hole 2 were only tested for moisture content (Table 1).

The two upper samples from Holes 1 and 2 at 0.9 m depth were extremely-high plasticity clays (plasticity indices of 145 and 126) and very expansive, with linear shrinkages of 31% and 28%. Sample 1 from Hole 1 had the highest liquid limit (174) of any sample tested to date in the soil laboratory at the Department of Mines. Both of these samples had unusual mixed layer montmorillonite and kaolin composition, comprising a total of 90-95% of the total composition of the clay, with only 0-5% quartz present.

From the exceptionally high liquid limit value of 174 of sample 1 at 0.9 m depth in Hole 1, the samples collected lower at 1.6, 2.3 and 2.6 m depths gave the following results; the liquid limit declined rapidly and constantly with depth with values of 119, 77 and 45; the plastic limit and linear shrinkage showed smaller but constant declines in values with depth (fig. 1).

This decline in plasticity with depth is shown by use of the laboratory criteria of the International Soil Classification system. Sample 1 from 0.9 m has an extremely high plasticity; and sample 4 from 2.6 m is medium, or transitional from low to high plasticity (fig. 3).

The moisture content of the samples from Hole 1 are high but with a constant decline from 38% to 23% with depth (fig. 2). Hole 2 moisture contents are equally as high (42%) but show little general decline, only minor irregularities (fig. 2).

INVESTIGATION RESULTS

(1) The two clay samples collected immediately below the house foundation depth from both holes have very high liquid limits. With such high values, the black clay soil and underlying dark brown clay have the capacity to absorb large amounts of water. This capacity is reflected in their high plastic index and linear shrinkage. Thus the soil and clay on which the foundations of 8 Packham Street are situated have a considerable potential for movement during seasonal wetting and drying. Such movements would have been enhanced during the long dry periods of 1983-84, causing the house's foundations to be considerably stressed.

(2) It is fortunate that the high plasticity and expansiveness declines rapidly with depth in Hole 1 (fig. 1). It is likely that similar reductions occur in Hole 2 but these samples have not been tested to date.

(3) A hard dry rubbly clay occurs at 2.4 m depth in Hole 1 and 3.4 m in Hole 2. This clay shows a low plasticity (plastic index 29), low linear shrinkage (12%) and a low moisture content (23%) in Hole 1. In Hole 2 this rubbly yellow clay gave a surprisingly high moisture content but when it was drilled it was classified as dry.

(4) A thicker expansive soil and clay layer underlies the north-east corner of the house compared with the south-east corner. The depth to the non-expansive gravelly clay layer was 2.4 m in Hole 1 and 3.4 m in Hole 2.

(5) A difference in moisture content profiles occurs between Hole 1 and Hole 2. No obvious explanation for the difference was seen, although the nearby pit dug by the owner and exposing the clay was full of water when Hole 2 was drilled.

CONCLUSIONS

(1) The cracking of the walls of the house at 8 Packham Street is considered to be caused by the expansive soil and clay on which the house foundations are situated.

(2) The reported different thickness of the foundations of the garage compared with the house would have an influence on the severity of this cracking but to what degree is not known.

(3) The thickness of the expansive soil and clay in Hole 1 is greater by one metre compared with Hole 2. With the high moisture content profile of this hole, uplift movement is conceivably greater at the northern end of the house compared with the southern end. This may explain the dropping of level that appears to occur at the southern

end of the house. To prove this hypothesis would require more drilling and detailed precise levelling inside the house.

(4) No previous subsurface drilling and soil testing has occurred in this subdivision. The tested values are so high in the soil and underlying clay that this problem would be difficult to foresee by either the then Lilydale Council building inspectors or the builder of this house.

RECOMMENDATIONS

(1) The house cracking should continue to be monitored by the owner.

(2) The remaining samples of Hole 2 be tested for Atterberg limits, linear shrinkage etc. This is to confirm that the rapid decline of plasticity and linear shrinkage found in Hole 1 occurs in Hole 2 as presumed in this report.

(3) If such a decline is present in both holes, conventional underpinning of the foundations would reduce this movement considerably. To be completely effective this underpinning would be required to reach the non-expansive rubbly yellow clay at 2.4 m depth at the south-east corner and 3.4 m at the north-west corner of the house. The cost of such a technique is considered to be prohibitively high for these depths.

(4) A foundation structural engineer be consulted to ascertain the feasibility and possible cost of some drilled pillar and strengthening beam structure to support the foundations of the areas severely cracked, namely the garage. Conventional underpinning may be considered sufficient in other areas where other cracking is limited.

(5) Concrete paths etc. with waterproofing plastic beneath be considered along the northern and southern side of the house to diminish the seasonal moisture fluctuations occurring at the house foundations.

[11 June 1986]

Table 1. SOIL TESTING RESULTS

Hole	Sample No.	Depth (m)	Moisture Content (%)	Plastic Limit	Liquid Limit	Plastic Index	Linear Shrinkage (%)	XRD (%)			
								Mont.	Kaol.	Lep.	Quartz
1	S1	0.9	38	29	174	145	31	Mixed layer 90 - 95		0-5	0-5
	S2	1.6	36	24	119	95	23	80-85	15-20		5-10
	S3	2.3	28	19	77	58	18	80-85	15-20		20-25
	S4	2.6	23	16	45	29	12	85-90	10-15		10-15
2	S1	0.9	42	30	156	126	28	Mixed layer 90-95		0-5	-
	S2	1.6	41	-							
	S3	2.6	32	-							
	S4	3.4	40	-							
	S5	3.7	38	-							

Testing by R.N. Woolley, Department of Mines, Hobart

Clay minerals: Mont = montmorillonite; Kaol = Kaolinite; Lep = lepidocrosite

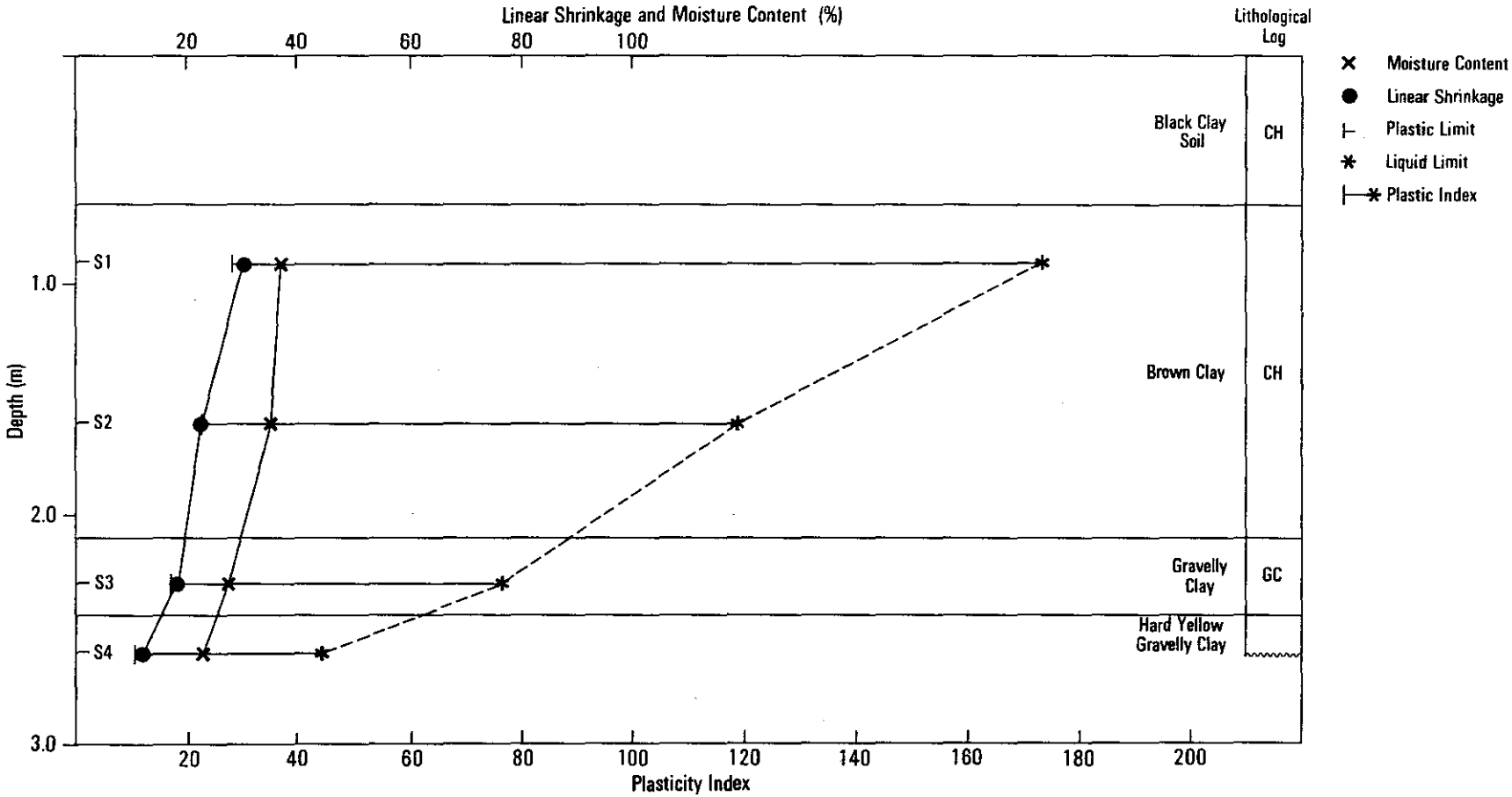
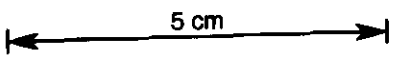


Figure 1. *Soil testing results and log, Hole 1*



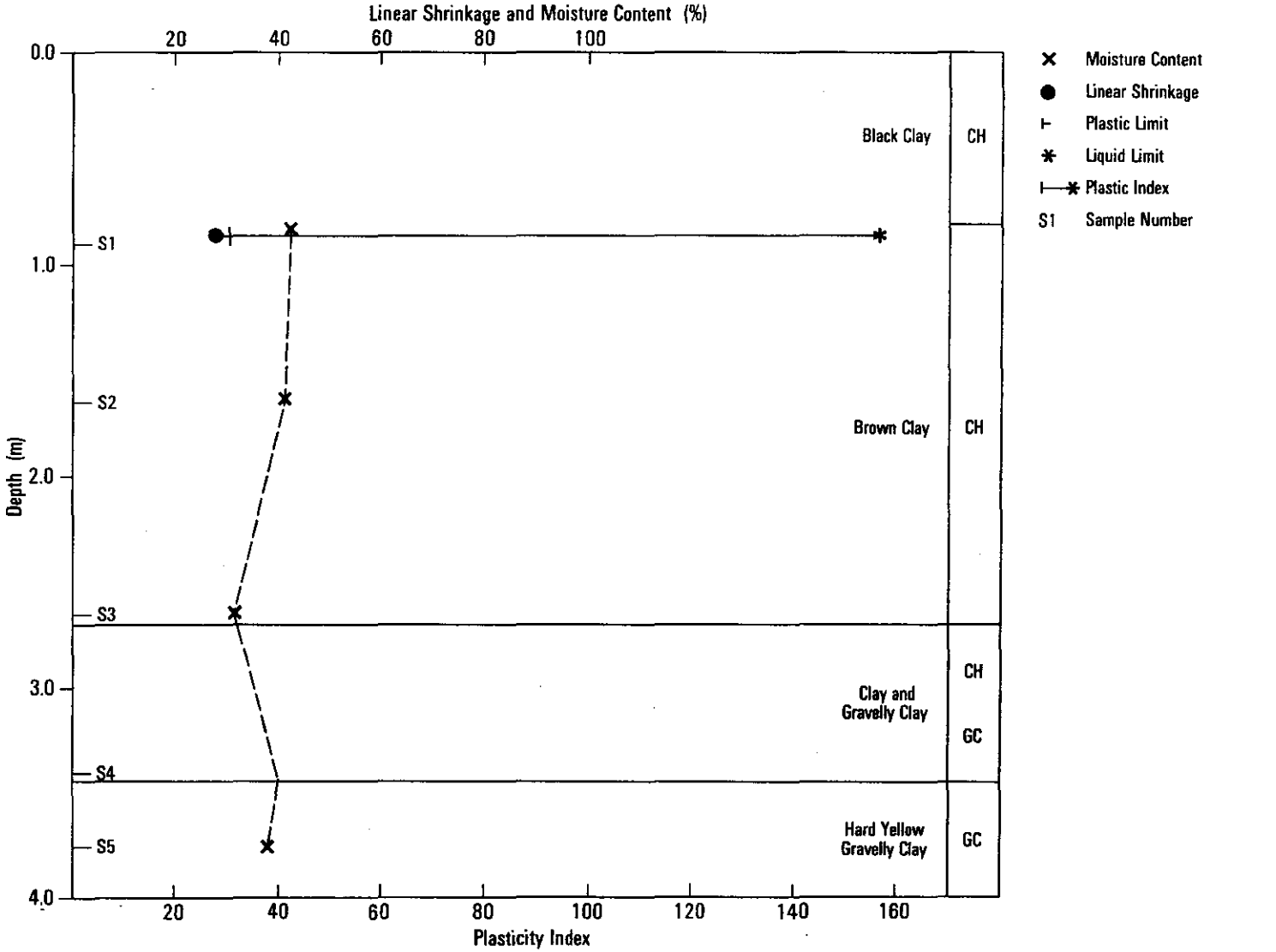


Figure 2. *Soil testing results and log, Hole 2.*

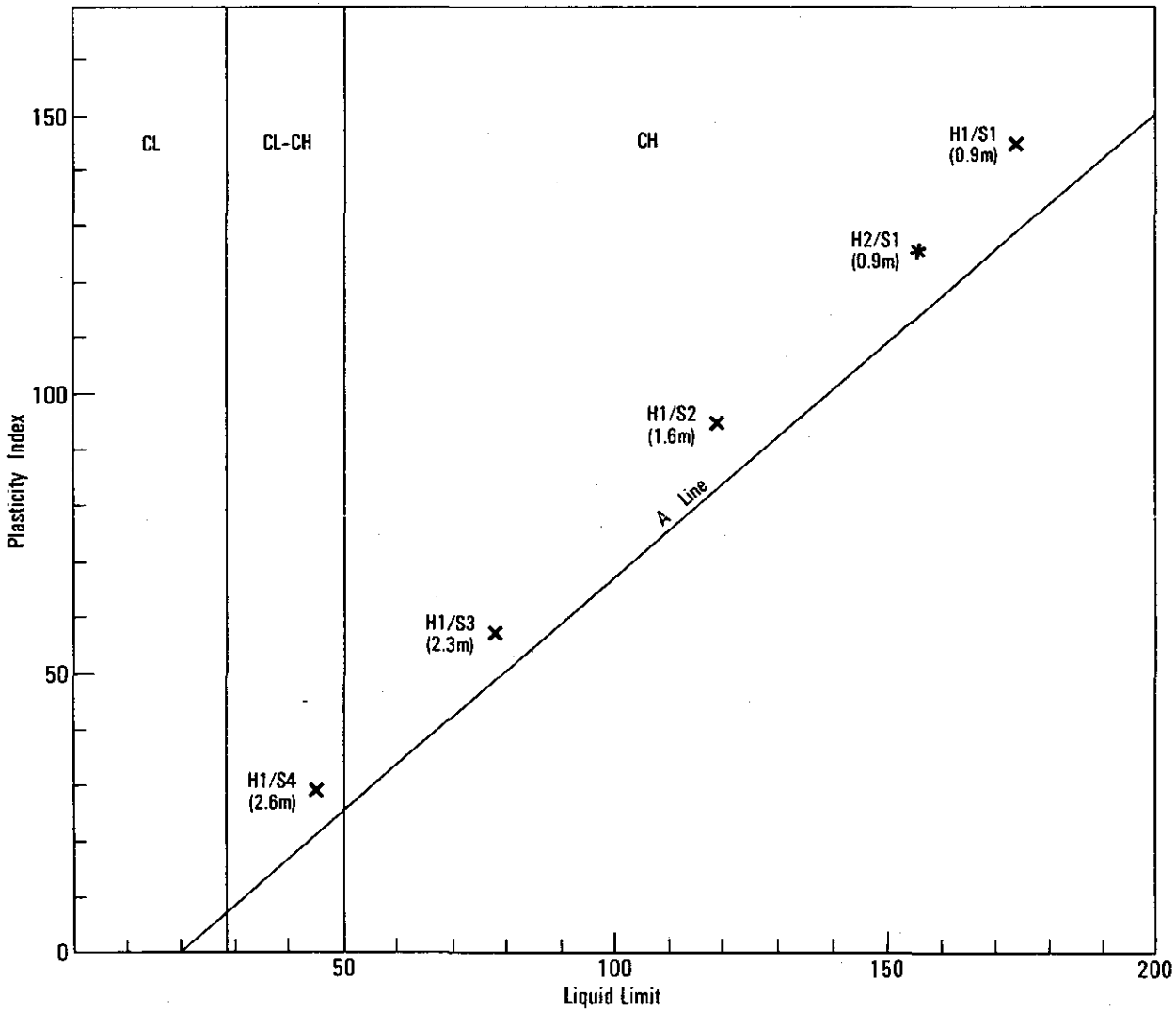


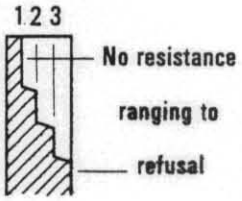
Figure 3. *Clay classification diagram*

5 cm

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undisturbed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N*	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

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.

eg. M > PL – Moist, moisture content greater then the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 – 50
F	Firm.	50 – 100
St	Stiff.	100 – 200
VSt	Very stiff.	200 – 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result

— is range of results.

Density index

		%
VL	Very loose.	0 – 15
L	Loose.	15 – 35
MD	Medium dense.	35 – 65
D	Dense.	65 – 85
VD	Very Dense	85 – 100

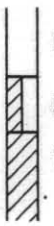
Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss



No loss

50% loss

100% loss.

Lugeons

Lugeon units (μL) 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 1×10^{-4} mm/sec.

Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

Strength

		point load strength index $I_{s(50)}$ (MPa)
EL	Extremely low.	< 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

Note: X on log is test result.

Significant defects

Significant defects shown graphically.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 1

sheet 1 of 1

10/11

project Mr & Mrs Q. Munnings — location 8 Packham Street, Alanvale - SE corner

co-ordinates 5099-54175 — drill type Treifus — drill method Auger — hole commenced 29.4.86 — hole completed 29.4.86

R.L. 28 m — drilled by B.E. Cox

inclination vertical — drill fluid None — logged by W.R.M

bearing – — checked by R.C.D.

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
	None	None					CH	*Clay*. Black, highly plastic, organic.	V M M ≥ PL	S		Soil and subsoil
			S1		1.0		CH	*Clay*. Dark brown, highly plastic.	M ≥ PL	St		Clay
			S2		2.0							
			S3				GC	*Gravelly clay*. Clay as above, gravel, coarse 15-30 mm dolerite pebbles.	M	V St		Clay with gravel
			S4				GC	*Clay*. Yellow - rubbly. med. plasticity. Some Jdl pebbles.	D	H		Yellow clay gravel
								Drill refused at 2.6 m (felt like heavy gravel)				Possibly heavy gravel.
								Penetrometer measurements from disturbed samples taken from each auger.				

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 2

sheet 1 of 1

11/11

project: Mr & Mrs Q. Munnings

location: 8 Packham Street, Alanvale - NW corner

co-ordinates: 5099-54175

R.L.: 28 m

inclination: vertical

bearing: -

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 29.4.86

hole completed: 29.4.86

drilled by: B.E. Cox

logged by: W.R.M.

checked by: R.C.D.

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa 25 50 100 200 400	structure, geology
							OH	*Clay*. Black, organic, high plasticity with roots etc. Friable.	M	S		Soil
							CH	*Clay*. Black, high plasticity.	M < PL	V St		Clay subsoil
			S1		1.0		CH	*Clay*. Brown, highly plastic.	V M — M M ≧ PL	S — St		Clay
			S2		2.0							
			S3		3.0		CH & GC	*Gravelly clay*. Clay, yellow-brown, highly plastic. Dolerite pebbles small, 25-30 mm.	M < PL	V St		Clay with gravel
			S4				GC	*Clay and gravel*. Clay - yellow, rubbly. Low to medium plasticity	D	H		Clay and gravel
			S5					Drill refused at 3.7 m (appeared to be on coarse gravel).				
								Penetrometer measurements only approximate. Taken from disturbed samples from augers.				

5 cm