UR1986_53

1986/53. Investigation of a cracked house at Sorell Street, George Town.

W. R. Moore

Abstract

A cracked house was investigated on the northern side of York Cove, George Town. A basalt rock platform with large basalt boulders is exposed on the northern shore of York Cove. The outside walls of the house were cracked but internally the cracking was very severe.

Seven shallow auger holes were drilled. The investigation was inconclusive because of access problems around the house and because the drill lacked penetration through the surface gravel in some holes, and through the deeper basalt boulders in other holes. The soil is a permeable grey silt (MH) and is underlain by a black clay (CH) which is expansive and contains a considerable percentage of montmorillonite. The clay is only 0.8 m thick and is underlain by basalt boulders and/or basalt.

Even though the clay is expansive and is thought to contribute to the cracking, the major cause is considered to be the poor foundations of the house. Recommendations were made for further investigation of the house foundation and, if required, further subsurface investigation.

INTRODUCTION

Mr and Mrs Gaetani, owners of the house at 1 Sorell Street, George Town requested the Department of Mines to undertake an investigation of the cracking of this house. This particular house has had a long history of cracking. The first owners, Temco Ltd, underpinned the south-east corner because of cracking. This initial cracking was thought to be a result of the digging of a deep trench for a pipeline across the south side of the property near the south-east corner of the house (fig. 1).

Little is known about the depth of this work, and after underpinning the house continued to crack. The explanation given by previous owners to Mr Gaetani was that the cracking was the result of blasting vibration from the removal of Garden Island during the widening of the shipping channel. Later, a local building inspector concluded that the cracking was a result of the wind lifting the eaves of the roof and cracking the house. He recommended a buttress wall with an archway be built from the north-east wall and the overhanging roof eaves be removed. Mr Gaetani was unconvinced but carried out the work. The cracking continued and he now considers that the cracking is caused by the pipeline drain.

LOCATION

The house at 1 Sorell Street is located on the south side of the shopping area of George Town, on the northern shore of York Cove [DQ854291]. The southern boundary of the block is close to the foreshore slope, which is approximately three metres high and slopes steeply down to high water level. Between this slope and the property boundary is a narrow foot track. The block itself is flat and no slumping occurs along this slope.

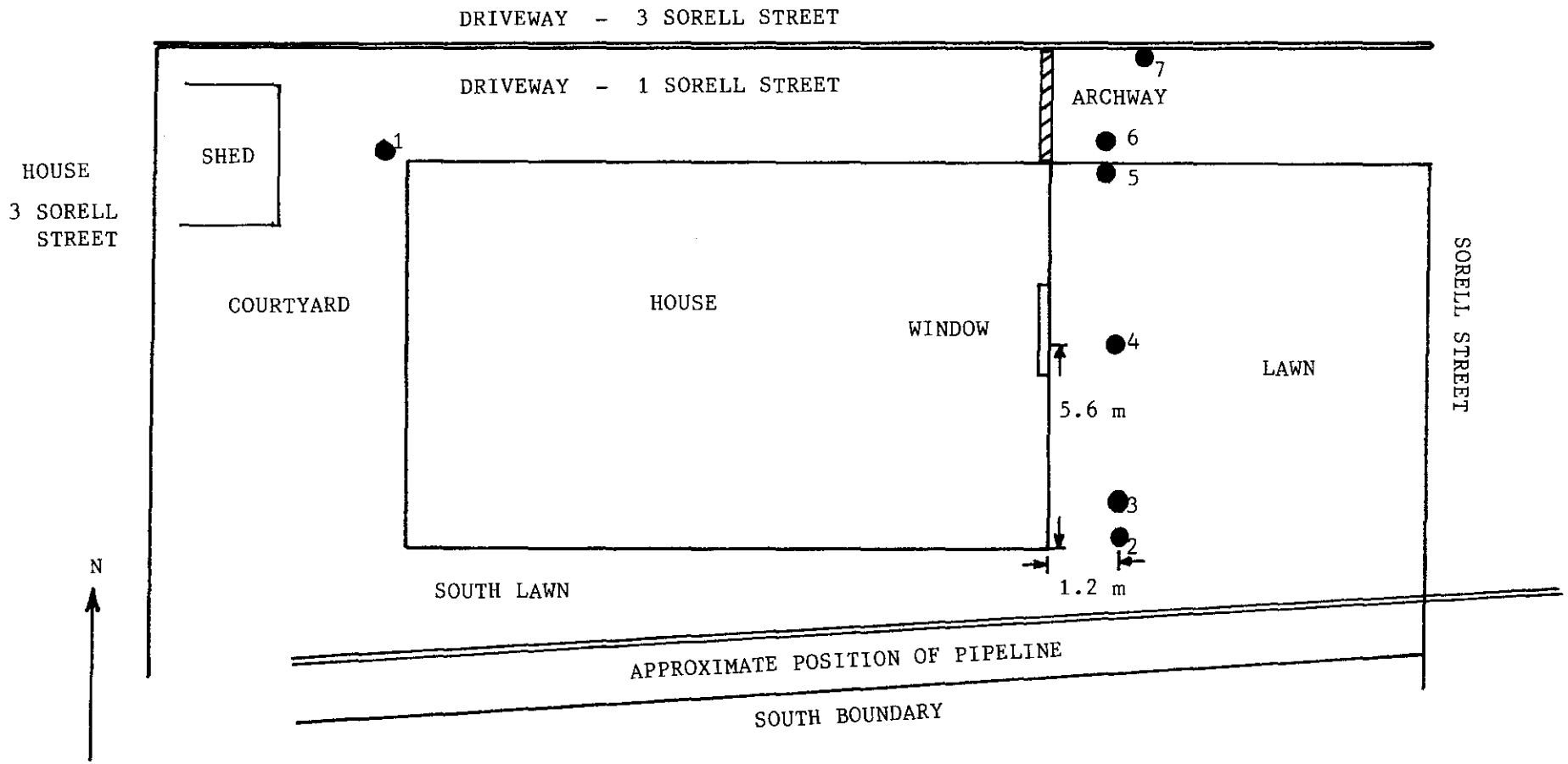

Figure 1. *Sketch plan showing location of drill holes*

5 cm

HOUSE CRACKING

Externally the house is not cracked to a degree that it could be classified as severe, which is defined as that the brick walls require complete replacement. The only area of severe cracking is on the north-east corner and the attached buttress arch wall. This wall will probably have to be pulled down. The external cracking appeared most severe along the east wall facing Sorell Street. External cracking occurred elsewhere but it is fairly widely distributed, with no obvious pattern observed.

It was inside the house that the damage is considered very severe. Wide and long cracks in the walls occur in most rooms. The floors appear to slope and are tilted towards the outside walls as if the house was domed in the centre.

INVESTIGATION

From the inspection of the house and block, there appeared no obvious simple explanation for the cracking. The trees on the front lawn facing Sorell Street were large and close enough to crack the eastern wall by taking the moisture out of the soil and any clay that may exist beneath the foundations, although it was difficult to see how these trees contributed to the severe internal cracking.

Mr Gaetani has built a large two-storied brick house close by, at the rear of 1 Sorell Street. In contrast, this house showed no cracking or any evidence of being under stress.

Slope movement as a cause appeared almost impossible because the slope to foreshore, although steep, was short and less than three metres in height. The slope is also at too great a distance from the house. There was no sign of any slumping, groundwater seepages, or marine erosion occurring along the foreshore of York Cove.

The writer suggested a limited drilling programme to the Gaetani's, with an auger hole at the rear of the house, and two other holes at the north-east and south-east corners. If access was possible, a fourth hole was planned on the south side of the house. Unfortunately it was not possible to get the drill to this planned site.

The aims of the investigation were:-

(a) To establish whether clay was present below the gravelly silty soil around the house.

(b) What was the thickness of this clay and was it consistent around the building?

(c) What were the properties of the clay, was it expansive, and was there any great variation in the moisture content?

SURFACE GEOLOGY

The soils are dark grey to black silts (MH) with gravel. They are friable and permeable. Along the bank of the foreshore they appeared well drained with no seepage observed.

On the foreshore of York Cove are coarse gravels and boulders of basalt. These are considered to overlie a basalt rock platform which is exposed on the northern and southern side of the entrance to York Cove (Gee and Legge, 1971).

SUBSURFACE GEOLOGY

The subsurface investigation was only partially successful because of the difficulty of access and lack of penetrating power of the drill in the gravel. Seven holes were drilled; their locations are shown on Figure 1. The lithological logs of these holes are given in Appendix 1.

Hole 1

This hole, at the rear of the house, penetrated a grey silty soil (0.7 m thick) with a layer of coarse river gravel (0.2 m thick) of white quartzite pebbles. This gravel contained clay and it formed a transitional layer to the underlying dark grey to black clay. This clay was highly plastic, moist and soft. The clay was 0.7 m thick with a brown sandy clay layer (0.2 m thick) at its base. Below this was either coarse gravel or boulders of basalt and/or basalt rock which the drill could not penetrate.

Holes 2 and 3

These holes were drilled at the south-east corner of the house. In these holes the drill could not penetrate the near-surface river gravel, composed mainly of quartzite pebbles, and the holes were stopped at 0.5 m and 0.6 m depth.

Hole 4

This hole was located approximately adjacent to the middle of the cracked eastern wall of the house. The surface soil and underlying gravel were penetrated to 0.8 m depth. A black, very stiff clay was drilled to a depth of 1.4 m, where coarse basalt boulders were encountered.

Below these boulders a brown-flecked, non-plastic clay, with small basalt rock fragments was retained on the auger bit. The clay had the appearance of weathered basalt and it appeared that in this hole the drill was stopped in basalt.

Holes 5 and 6

These holes were drilled close together at the north-east corner of the house. The sequence drilled was the same in both holes. A 0.8 m thick black silty soil (MH) with gravel and boulders overlies 0.6 m of dark-grey, stiff clay. Coarse basalt boulders or basalt rock was thought to be encountered below the clay, although no recognisable material from this layer was recovered in either of these two holes.

Hole 7

This was the third hole drilled in an attempt to establish if the material stopping the drill below the clay was basalt or basalt boulders. The hole was drilled towards the northern side of the driveway. A surface soil of silt and gravel (0.8 m thick) overlay 0.7 m of clay with some boulders in

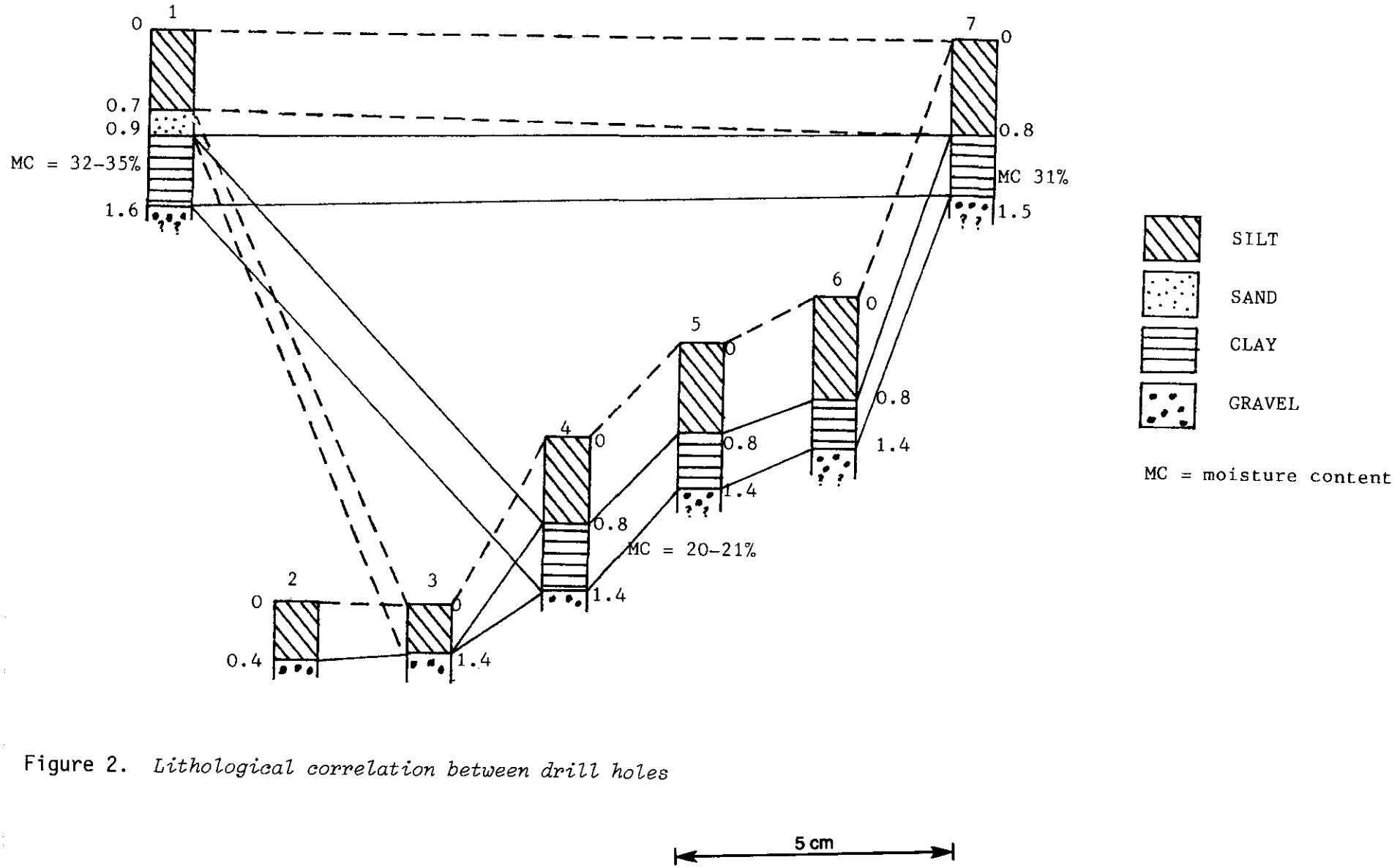

Figure 2. *Lithological correlation between drill holes*

the clay. The drill was stopped in either basalt or basalt boulders at similar depths to those in Holes 4 and 5.

SOIL LABORATORY RESULTS (TABLE 1)

The dark grey and black clay which underlies the silty soil and subsurface gravel was found to be highly plastic and expansive. The tested clay showed a range of plastic indices from 53-78 and linear shrinkage of 20% to 25%. X-ray diffraction of these clays showed mixed layers of kaolinite and montmorillonite which made the percentage of clay constituents only approximate, although the expansive montmorillonite is present in considerable amounts, with all samples exceeding 50%.

The soil was dry and friable in all the holes drilled. The low moisture content of the soil was confirmed in the laboratory; in Hole 1 the surface soil had a moisture content of 16% compared with the 32-35% of the underlying clay. The soil is permeable and free draining and it also non-plastic and non-expansive. It is difficult to see the soil having any influence on the house cracking. The moisture content of the clay from Holes 1 and 7, drilled on the northern side of the house, was 30-35% compared with clay from Hole 4 on the eastern side with a moisture content of 19-21%.

CONCLUSIONS

(1) The laboratory tests show the clay to be very expansive. With a friable, permeable soil cover present, this clay would be affected by moisture content fluctuations produced seasonally as well by longer periods of drought. Given an adequate thickness, such clays are considered capable of enough vertical movement fluctuations to cause a house to crack. Such cracking of houses is not uncommon in the Tamar Valley area where clay with a similar range of linear shrinkages occurs (Moore, 1983; 1985*a*; 1985*b*; 1986*a*; 1986*b*.

(2) If it is assumed that the drill was stopped in either basalt and/or basalt boulders, then the clay thickness is limited, with a maximum of 0.7 m around the perimeter of the house. A clay with a linear shrinkage of 20-25% and a thickness of 0.6-0.7 m is considered unlikely to create enough seasonal movement to crack a house with adequate foundations, particularly to the degree that has occurred internally at this house. Either another clay layer is present below the the basalt or boulder layer which the drill did not penetrate, or the foundations of the house are so inadequate that they cannot withstand the small movements of this thin clay layer.

(3) Of these two alternatives the writer considers that poor foundations, both in strength and design, is the most likely cause. The major evidence for this is that Gaetani's own house, situated close to 1 Sorell Street, appears to have the same surface geology (with the same surface soil) and is probably underlain by similar clay, but is not cracked. This house is two storied and is a heavier structure than that at 1 Sorell Street.

All the holes drilled through the clay stopped at approximately the same depth (1.4-1.6 m, fig. 2). This conformity of depth at which the drill stopped suggests to the writer that this surface is similar to the rock platform covered by large basalt boulders that is exposed in York Cove. A similar rock platform is thought to underlie the low marine terrace on which 1 Sorell Street and George Town is built.

Table 1. SOIL TESTING RESULTS, 1 SORELL STREET, GEORGE TOWN

Hole No.	Depth (m)	Moisture content (%)	Plastic limit	Liquid limit	Plastic index	Linear shrinkage (%)	XRD RESULTS			
							CLAY FRACTION			Total %
							Mixed kaolinite montmorillonite	Montmorillonite	Kaolinite	
1	0.6	16	Non	Plastic						15–20
	1.2	35	19	94	75	23	–	–	–	10–15
	1.6	32	22	75	53	20	30–40	50–60	0–10	5–10
4	0.6	19	17	72	55	20	–	–	–	15–20
	1.0	21	23	86	63	21	50–60	40–50	0–10	10–15
	1.4	20	16	81	65	22	60–70	30–40	0–10	10–15
7	1.2	31	19	97	78	25	80–90	0–10	0–10	5–10

NOTE: XRD fractions approximate estimates only because of mixed layers in the clay.

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

(4) The moisture content difference in the clay between Holes 1 and 7 on the driveway compared with Hole 4 on the eastern side of the house is thought to be caused by desiccation by the nearby trees on the lawn between the house and the footpath. No trees or large shrubs line the fine gravel driveway along the northern side of the house.

The clays are considered to be so impermeable that the low moisture content of clay from Hole 4 is unlikely to be caused by the old drain that runs along the south side of the house, approximately 10 m south of Hole 4.

Although the writer considers this investigation to be inconclusive, the cracking of the house is thought to be indirectly related to the underlying clay above which the house foundations are thought to be sitting. Seasonal and longer drought periods will cause movements within this clay. Even though such movements must be small, because of the thickness of the clay, when combined with poor foundations and with local areas of desiccation of the clay from the nearby trees, these movements are considered to be the likely cause of the damage.

RECOMMENDATIONS

(1) A thorough examination of the outside wall foundation can be undertaken on all four sides of the house. The only way to get adequate exposures is considered to be by a series of hand dug pits. These pits must be sited close enough to the wall so that the depth and thickness of the foundations are exposed and the type of material on which they are sitting can be examined.

(2) An examination of the piles beneath the house be made to see if an explanation for the severity of the internal cracking is possible. According to Mr Gaetani the internal piles are not conventional concrete piers or wooden blocks.

(3) If both the outside wall foundations and piling appear adequate to Mr Gaetani - a builder himself - then a further subsurface investigation will be required. Also a detailed internal levelling of the house will be required. The subsurface investigation will require two pits, one on the east and the other on the south side of the house. These pits will have to be dug by a backhoe that is large enough to penetrate the boulders and be able to dig deep enough to reach bedrock in both pits. The siting of the pits and the digging should be supervised by an engineering geologist. The detailed internal levelling of the house should be done from the centre of the house, room by room, to establish if 'doming' or arching is occurring, as appeared possible from visual inspection.

(4) If the foundations are considered inadequate then underpinning will be required. This work should be designed by a competent foundation engineer so as to withstand any possible movement in the clay.

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[28 August 1986]

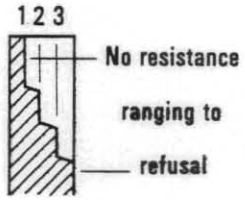
TASMANIA DEPARTMENT OF MINES

10/17

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

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 than 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

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

11/17

project: L. Gaetani, 1 Sorell Street, George Town, cracked house

location: NW corner of house, towards rear on driveway

co-ordinates: DQ852491

R.L.: 6 m

inclination: vertical

bearing:

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

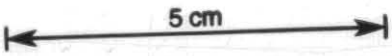
hole completed: 7.5.86

drilled by: B.E. Cox

logged by: W.R. Moore

checked by: R.C. Donaldson

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					ML	SILT WITH GRAVEL. Silt – grey, low plasticity. Fine, poorly graded. Gravel – fine, rounded quartz pebbles.	D	Fb		Silt and gravel
			S1		0.5							
			S2				GC	CLAYEY GRAVEL. Gravel, coarse quartz clay – grey, highly plastic	M	M >> Pl		Transisitional layer
					1.0		CH	CLAY. Dark grey-brown. Highly plastic. Few pebbles.	M >> Pl	S I F		Clay
			S3									
					1.5							
			S4				SC	CLAYEY SAND. Sand brown, fine. Clay – low-med. plasticity	D	H		Sandy clay
			S5					Drill stopped at 1.7 m. Could not penetrate. Coarse gravel or basalt rock.				Weathered Basalt?



TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 2

sheet 1 of 1

12/17

project: L. Gaetani, 1 Sorell Street, George Town. Cracked house

location: SE corner of house, on front lawn 1.2 m from house

co-ordinates: DQ852491

R.L.: 6 m

inclination: vertical

bearing:

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

hole completed: 7.5.86

drilled by: B.E. Cox

logged by: W.R. Moore

checked by: R.C. Donaldson

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					ML	SILT WITH GRAVEL. Silt, grey, organic – low plasticity. Gravel – coarse, heavy, quartz pebbles.	D	F1		Silt
					0.5		Gp	GRAVEL. Coarse, graded. quartz pebbles, rounded.	D	H		Gravel

Drill could not penetrate. Stopped 0.5 m.

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 3

sheet 1 of 1

13/17

project: L. Gaetani, 1 Sorell Street, George Town. Cracked house.

location: 0.8 m NW from SE corner of house. Front lawn

co-ordinates: DQ852491

R.L.:

inclination: Vertical

bearing:

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

hole completed: 7.5.86

drilled by: B.E. Cox

logged by: W.R. Moore

checked by: R.C. Donaldson

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					ML	SILT WITH GRAVEL. Silt, dark grey Fine, low-med. plasticity. Gravel coarse, heavy, quartz pebbles.	D	Fb		
							GP	GRAVEL. Coarse, poorly-graded. Quartz pebbles, rounded.	D	H		
								Drill could not penetrate. Stopped at 0.6 m.				

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 4

sheet 1 of 1

14/17

project: L. Gaetani, 1 Sorell Street, George Town, cracked house

location: 5.6 m from SE corner of house front lawn – below window

co-ordinates: DQ852491

R.L.: 6 m

inclination: Vertical

bearing:

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

hole completed: 7.5.86

drilled by: B.E. Cox

logged by: W.R. Moore

checked by: R.C.Donaldson

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	S1		0.5		ML	SILT WITH GRAVEL. Silt, black, low-med. plasticity, organic (roots,etc.) Gravel, coarse quartz, basalt, approx. 10% Poorly graded.	D	Fb		Silt and gravel
			S2		1.0		CH	CLAY. Black, dark-grey. Highly plastic. Coarse boulders of basalt present, 20–50 mm.	M < PL	V St		Black clay
			S3					CLAY. Yellow-brown, low-med. plasticity. Small basalt fragments.	D	H		Weathered Basalt??
								Drill refusal depth 1.5 m.				

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 5

sheet 1 of 1

15/17

project: L. Gaetani, 1 Sorell Street, George Town. Cracked house.

location: at NE corner of house. Front Lawn

co-ordinates: DQ852491

R.L.

inclination: 6 m vertical

bearing

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

hole completed: 7.5.86

drilled by: B.E. Cox

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 penetrometer kPa (25 50 100 200 400)	structure, geology
	None	None		0.5		ML	SILT. Black, organic, low–med. plasticity. Some gravel or boulders.	D	Fb		Silty soil
				1.0		CH	CLAY. Grey-black, highly plastic.	M < Pl	V St		Black clay
				1.4			GRAVEL or bedrock. Drill refusal depth 1.4 m.				Basalt?

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 6

sheet 1 of 1

16/17

project: L. Gaetani, 1 Sorell Street George Town. Cracked house

location: At NE corner of house. Driveway and lawn boundary

co-ordinates: DQ852491

R.L.: 6 m

inclination / bearing: Vertical

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

hole completed: 7.5.86

drilled by: B.E. Cox

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 penetrometer kPa (25 50 100 200 400)	structure, geology
	None	None		0.5		ML	SILT. Black, organic. Low–med. plasticity. Some gravel or basalt boulders.	D	Fb		Silty soil.
				1.0		CH	CLAY. Dark grey-black, highly plastic.	M < PL	V St		Black clay
						??	Gravel or bedrock.				Basalt?
							Drill refusal depth 1.4 m.				

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 7

sheet 1 of 1

17/17

project: L. Gaetani, 1 Sorell Street, George Town. Cracked house.

location: 2 m from edge of driveway, NE end of block.

co-ordinates: DQ852491

R.L.: 6 m

inclination: Certical

bearing:

drill type: Treifus

drill method: Auger

drill fluid: None

hole commenced: 7.5.86

hole completed: 7.5.86

drilled by: B.E. Cox

logged by: W.R. Moore

checked by: R.C. Donaldson

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			0.5		ML	SILT. Black, grey, fine, low plasticity, organic.	D	Fb		Silty soil.
			S1		1.0		CH	CLAY. Brown-black, highly plastic. Some heavy gravel and boulders drilled but not recovered.	M ≥ PL	S		Clay
					1.5		??	Drill refused at 1.5 m. Heavy gravel or basalt rock. One flake of unweathered basalt recovered.				Basalt? or basalt boulders

5 cm