

UR1985_48

1985/48. House cracking at Devon Hills Estate, Breadalbane

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Abstract

House cracking, thought to be due to blasting operations from a nearby dolerite quarry, was reported by a resident of Devon Hills Estate. Auger drilling showed the house to be underlain by clay subsoils over dolerite. Nearby houses, with no reported cracking, were underlain by silty soils over mudstone. Cracking is confined to two small areas adjoining the main structure, on the sunniest side of the house where moisture fluctuations would be greatest. The most likely cause of the cracking is expansive clay causing differential movement.

INTRODUCTION

A request was received from J.W. Dempster, Mining Engineer, Launceston on 31 May 1984 that the Engineering Geology Section investigate the cause of house cracking at Devon Hills Estate near Breadalbane. Mr Dempster had received several complaints from residents of this estate as to the severity of the house vibration, resulting from the blasting operations at the nearby Talisker Quarries, now taken over by Brambles Ltd.

In addition some complaints of house cracking were received, particularly from Mr Harris whose house on Lot 5 is the nearest on the estate to the quarry (fig. 1). Mr Harris was of the opinion that the cracking of his house was caused by the vibration from the quarry's blasting operations.

INVESTIGATION PROGRAMME

The quarry, and the houses from which complaints had been received, were visited on 7 June 1984. Investigation drilling was undertaken on 26 and 27 June 1984, followed by mapping and photography of the house cracks.

This investigation was to be followed by vibration measuring at the estate, particularly at Harris' house, when some heavy blasting was planned. With the change of ownership of the quarry and a change of responsibility for the vibration measurements within the Department, this second stage of the investigation became delayed. With a change in the pattern of blasting and better control in the quarry, these vibration measurements are now considered unwarranted.

The results of the investigation were forwarded to both Mr Harris and Mr Dempster in July/August 1984, and with no further investigation work required, the report can now be finalised. This final report is required in case any further complaints occur in the future.

GEOLOGY

The quarry is situated on the south-west slope of Devon Hills ridge [EQ138010], west of the Midland Highway, and is approximately one kilometre north-west of Harris' house. Dolerite is quarried and exposures of dolerite occur to the south-east along the Devon Hills ridge, north of the estate. Radial-jointed dolerite forms 1.5 m high benches in a shallow abandoned quarry near the Midland Highway and outside Harris' north-west boundary.

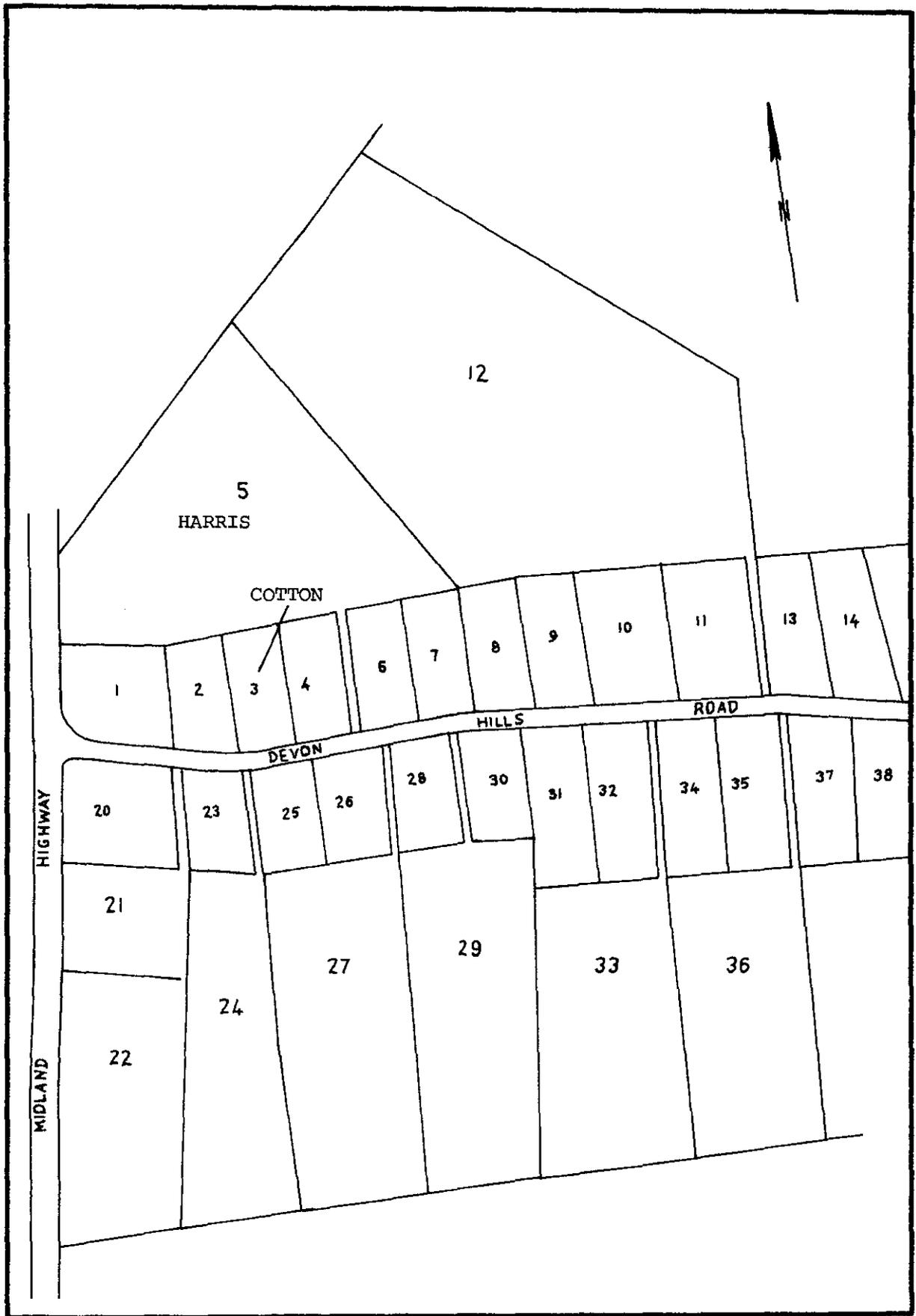


Figure 1. *Devon Hills Estate.*

5 cm

Flat exposures of dolerite crop out in the stream bed of the east-west flowing creek south of Harris' house. Clay is exposed in the water-hole banks in this stream and baked siltstone pebbles of Permian age were also found here. These pebbles and boulders are found south of the stream extending up on to the east-west ridge on which the Devon Hills Estate's access road is situated. The Permian sediment/dolerite contact appears to run in an east-west direction north of the foot of the northern slope of the ridge, on which the majority of the homes are situated.

SUBSURFACE INVESTIGATION

It is significant that although complaints of excessive vibration have been received from the residents of the houses on the northern side of the Devon Hills Road, as for example Cotton's (Lot 3, fig. 1), no house cracking has been reported. From surface mapping, these houses appear to be underlain by siltstone and possibly mudstone of Permian age. The only complaint of cracking associated with blasting was at Harris' (Lot 5, fig. 1). This house is located close to dolerite outcrops but appears to be situated on a black surface clay soil with a subsoil of brown clay, both of which are plastic and possibly with a high linear shrinkage.

It was considered important to establish the thickness of this clay above the dolerite at Harris' and to establish if the houses on the ridge were underlain by sediments of Permian age.

Six holes were auger drilled, the locations of which are shown on Figure 2. The lithological logs are given in Appendix 1. Four holes were drilled on Harris' property (Lot 5) and two on Cotton's (Lot 3). Three holes on Lot 5 were drilled around the house and the fourth was drilled between the house and the old quarry with dolerite outcrops, approximately in line with the Talisker quarry. One hole on Lot 3 was drilled south of the stream, close to where the dolerite/Permian sediment contact was thought to be located. The sixth hole was on the ridge on the west boundary of Lot 3, near the house.

All the holes on Lot 5 encountered dolerite at a shallow depth of between 0.8-0.9 m, overlain by black clay soil and clay subsoil, with the drill being stopped by the dolerite. In contrast on Lot 3, the drill was still penetrating when stopped in the Permian mudstone. The depths of these two holes were 1.7 m and 1.5 m. The hole drilled on the ridge of the Devon Hills Estate encountered silty soil with no clay, and little moisture was present in the soil or the underlying mudstone.

SOIL LABORATORY RESULTS

Clay samples were collected from the subsurface horizon in Holes 1-5 and the clay tested in the laboratory. The results of these tests are given in Table 1 and the plasticity classification graph in Figure 3. These results show that the subsurface clay in the dolerite area varies from a low to very high plasticity with a plasticity index range of <37 to 131. The clay with the highest plasticity index is that overlying the Permian mudstone in the shallow stream depression (Hole 5). The clay samples with a low plasticity index were rubbly but their laboratory values are lower than anticipated from field inspections.

The linear shrinkages reflect the plasticity indices for the low to medium plasticity clay. Sample 4, with the highest plasticity index, had a linear shrinkage of 28%.

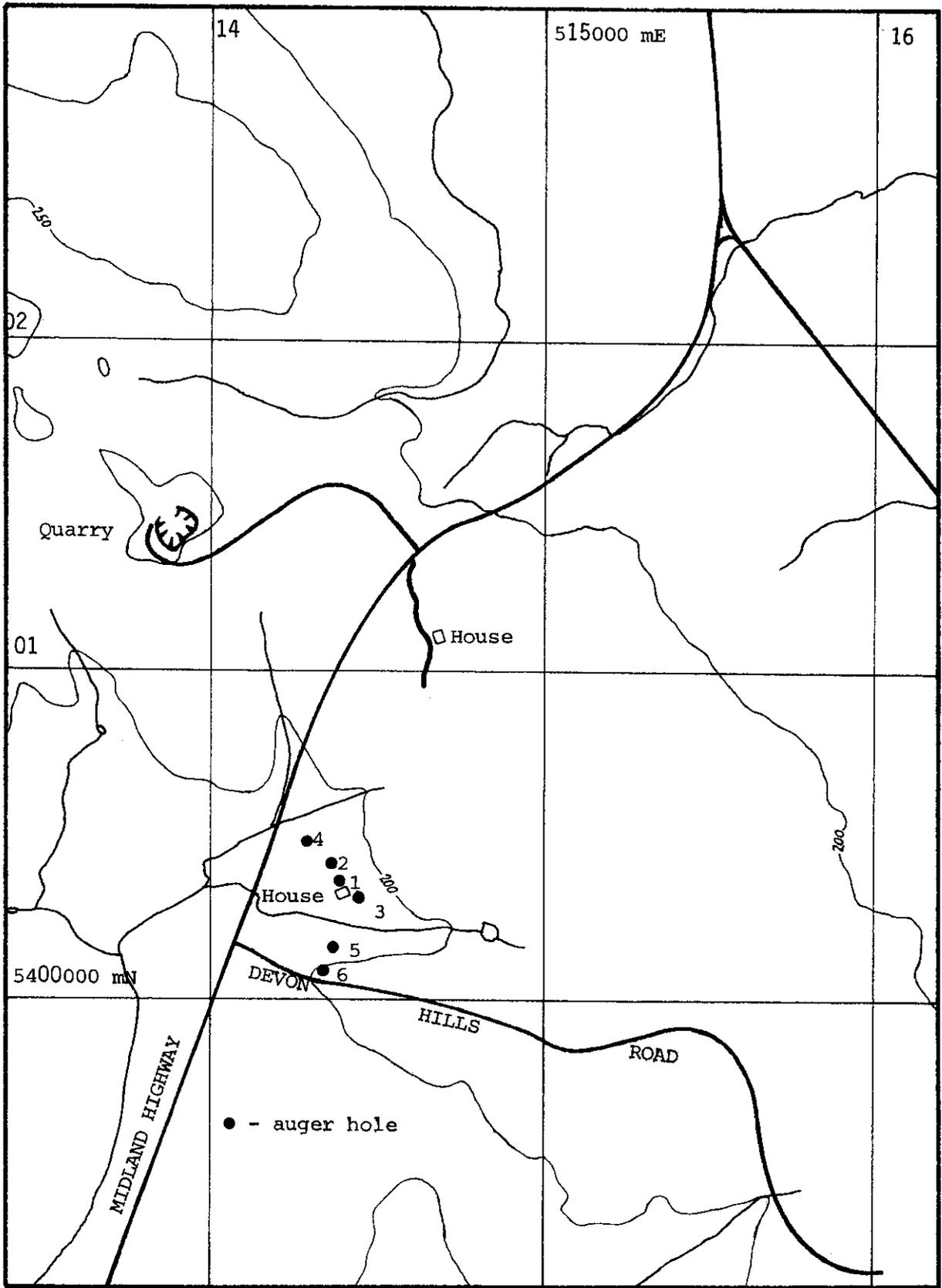
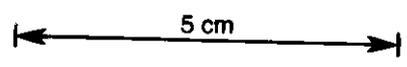


Figure 2. Location map, showing positions of auger holes



CRACKING OF HARRIS' HOUSE

The cracking at Harris' house is confined to two small areas. The first, on the north-east corner, occurs on two single ornamental brick walls, each with an arched entrance, enclosing a small lawn. The other crack is on a thin concrete slab-verandah along the east wall. No cracking was seen or reported on the main house.

The northern arched entrance was cracked at the apex of the arch, with a four millimetre wide crack 240 mm long. The eastern entrance was cracked in a similar position, with a crack one millimetre wide and 130 mm long. The wall of the annexe has pulled away from the main structure of the house.

The verandah crack was 1.5 m long and of variable width and crossed the verandah and the concrete guttering along its edge. The cracking around this house is considered minor by the writer and would be classified as slight on the 1981 Building Research Scale for House Cracking. Both the verandah and the annexe are light structures and appendages to the main house. They are situated on the sunnier north and east side of the house where the moisture content of the underlying soil and clay would fluctuate greatly.

CONCLUSION

- (1) The existence of expansive clay above the dolerite on Lot 5 makes differential foundation movements an alternative explanation to vibration from quarry blasting as the cause of the house's cracking. To the writer, it appears a more likely cause because the cracking is confined to the two light structures (the patio walls and concrete verandah and walkway). No cracking occurs on the main structure of the house. The foundations of the house are likely to be stronger than the two cracked units. The wall has clearly pulled away from the house, indicating differential movements between the house and patio wall. Both the patio and the verandah are in the sunniest position of the house, facing the north and east, and the clay in these areas probably has the greatest seasonal moisture content fluctuation.
- (2) Vibration from the blasting was reported from Lot 3, as well as other houses on the Devon Hills Estate ridge, but no structural damage was reported or seen on the two-storeyed house on Lot 3. This house and the others nearby are underlain by a dry silty soil and subsoil overlying Permian mudstone. No expansive clay was found on the auger hole drilled on this ridge.
- (3) A house of similar age to Harris' exists on Devon Hills ridge on the east side of the Midland Highway (fig. 2). No complaints of damage or excessive vibration from blasting have been received by the Department of Mines from the residents of this house. This house is closer to the quarry and appears to be founded on dolerite. If the damage to Harris' house was the result of blasting vibration, damage would also be anticipated on a house located in this position and founded on dolerite rock.

RECOMMENDATIONS

If any further complaints of blasting damage are received from Harris, or any other resident on the Devon Hills Estate, vibration

monitoring should be undertaken.

Vibration measuring stations should be set up on the house on Devon Hill ridge founded on dolerite; on Harris' house on clay and dolerite; and on the ridge at Devon Hills Estate (for example Cotton's) on sites underlain by Permian sediments.

[20 August 1985]

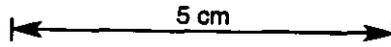


Table 1. SOIL TESTING RESULTS, DEVON HILLS ESTATE

House	Sample	Depth (m)	MC (%)	LL	PL	LS	PI	Classification
Harris	H1	0.5	24	37			<37	CL
Harris	H2	0.5	27	79	26	19	53	CH
Harris	H3	0.5	22	40	21	8	19	CL-CM
Harris	H4	0.5	50	152	29	31	123	CH
Cotton	H5	0.5	33	157	26	28	131	CH

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

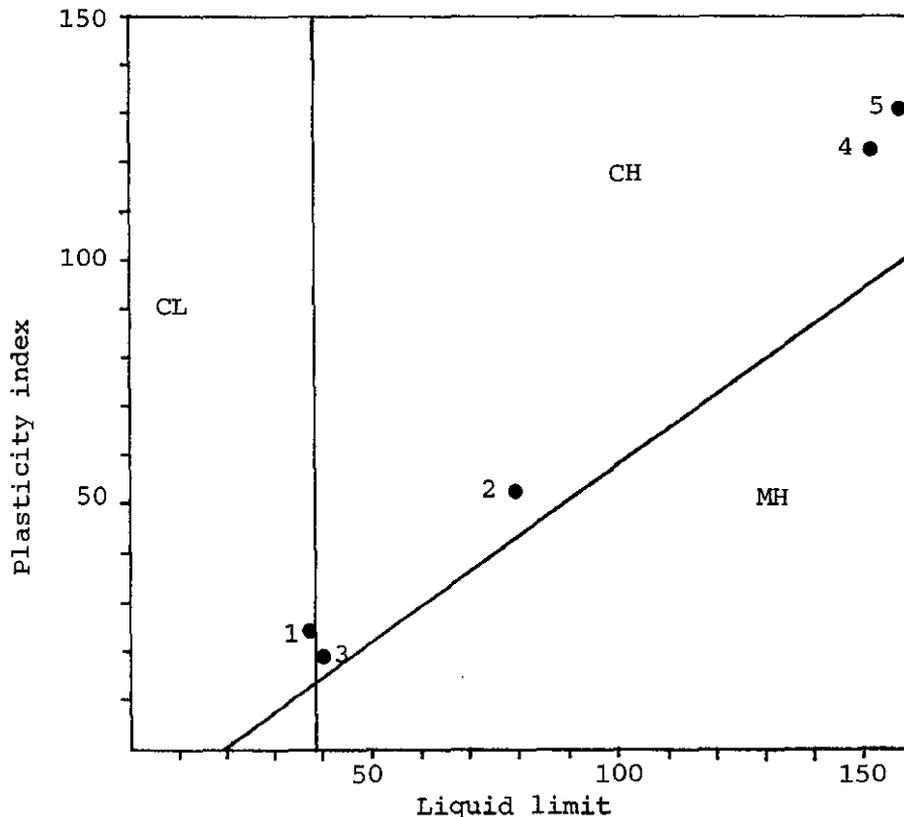
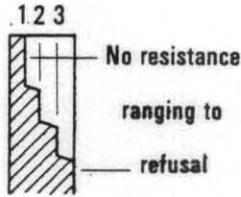


Figure 3. Plasticity chart of clay samples.

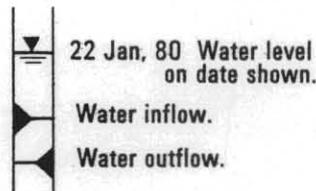
EXPLANATION SHEET FOR ENGINEERING LOGS

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

- | 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. | |

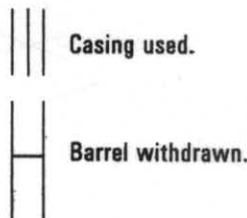
Notes: X on log is test result
— is range of results.

Density index

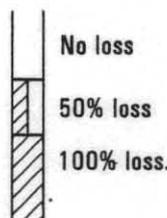
- | Density index | % |
|------------------|----------|
| VL Very loose. | 0 - 15 |
| L Loose. | 15 - 35 |
| MD Medium dense. | 35 - 65 |
| D Dense. | 65 - 85 |
| VD Very Dense | 85 - 100 |

Cored borehole log

Case - lift



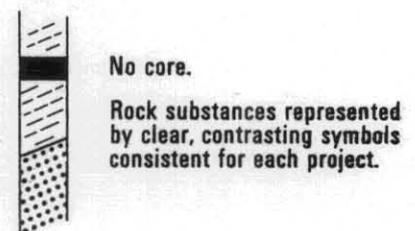
Fluid loss



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



Weathering

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

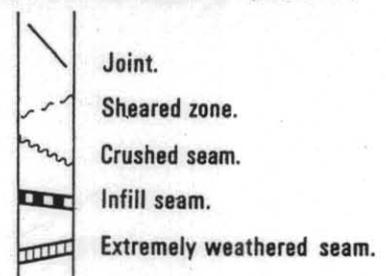
Strength

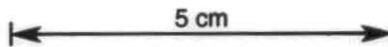
- | Strength | point load strength index $I_{5(50)}$ (MPa) |
|--------------------|---|
| EL Extremely low. | < 0.03 |
| VL Very low. | 0.03 - 0.1 |
| L Low. | 0.1 - 0.3 |
| M Medium. | 0.3 - 1 |
| H High | 1 - 3 |
| VH Very high. | 3 - 10 |
| EH Extremely high. | > 10 |

Note: X on log is test result.

Significant defects

Significant defects shown graphically.



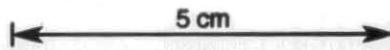


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ENGINEERING LOG - BOREHOLE

project	House cracking, Devon Hills	location	Lot 5: near north wall of house		
co-ordinates	EQ144004	drill type	Proline	hole commenced	27.6.84
R.L.	218 m	drill method	Auger	hole completed	27.6.84
inclination	vertical	drill fluid	None	drilled by	B. Cox
bearing	--			logged by	W.R.M.
				checked by	R.C.D.

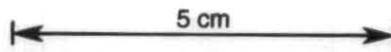
penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
	None					Clay - Organic, highly plastic with roots	M	S		Surface soil
	None	S1	0.5		CH	Clay - Brown, highly plastic with limonite nodules	M	S		Subsurface clay
	Small amount of water at interface		1.0		Jd1	Drill refused to penetrate - grating on rock.				Dolerite



ENGINEERING LOG - BOREHOLE

project	House cracking, Devon Hills	location	Lot 5: north boundary of lawn
co-ordinates	EQ143005	drill type	Proline
R.L.	198 m	drill method	Auger
inclination	Vertical	drill fluid	None
bearing	--	hole commenced	27.6.84
		hole completed	27.6.84
		drilled by	B. Cox
		logged by	W.R.M.
		checked by	R.C.D.

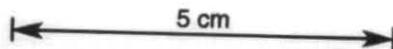
penetration	support	water	notes samples, tests	metres	R.L.	depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
1	2	3												
							~ ~ ~	OH	Clay - Organic, med.-high plasticity, roots.	M	S			Surface soil
	None	None		S2		0.5		CH	Clay - with pebbles and ironstone nodules. Dark grey-brown. Clay highly plastic. Pebbles of ironstone and dolerite.	M	S			Subsurface clay
			Small amount of water at interface			1.0			Drill refused to penetrate - grating on rock.					Dolerite



ENGINEERING LOG - BOREHOLE

project	House cracking, Devon Hills		location	Lot 5: south entrance driveway	
co-ordinates	EQ145003	drill type	Proline	hole commenced	27.6.84
R.L.	198 m	drill method	Auger	hole completed	27.6.84
inclination	vertical	drill fluid	None	drilled by	B. Cox
bearing	--			logged by	W.R.M.
				checked by	R.C.D.

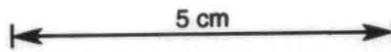
penetration 1 2 3	support water	notes samples, tests	metres R.L. depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetr- ometer kPa 25 50 100 200 400	structure, geology
	None				OH	Clay - Organic, med. plasticity	M	S		Surface soil
	None	S3	0.5		CH	Clay - Dark brown, highly plastic. Small ironstone pellets.	M	Vs		Subsurface clay
			1.0			Drill refused to penetrate				Dolerite



ENGINEERING LOG - BOREHOLE

project	House cracking, Devon Hills		location	Lot 5: In paddock, NE of house	
co-ordinates	EQ142005	drill type	Proline	hole commenced	27.6.84
R.L.	197 m	drill method	Auger	hole completed	27.6.84
inclination	vertical	drill fluid	None	drilled by	B. Cox
bearing	--			logged by	W.R.M.
				checked by	R.C.D.

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	structure, geology
						OH	Clay - Organic, highly plastic.	M	S		Surface soil
			S4	0.5		CH	Clay - Yellow-brown, few ironstone nodules. Highly plastic.	M	S		Subsurface clay
				1.0			Drill refused to penetrate				Dolerite

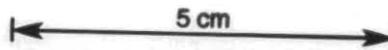


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borehole no. 5
sheet 1 of 1

ENGINEERING LOG - BOREHOLE

project	House cracking, Devon Hills	location	Lot 3: northern boundary
co-ordinates	EQ143002	drill type	Proline
R.L.	190 m	drill method	Auger
inclination	vertical	drill fluid	None
bearing	--	hole commenced	27.6.84
		hole completed	27.6.84
		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. 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	structure, geology
									kPa	
	None				OH	Clay - Black, organic	M	S		Surface soil
	None	S5	0.5		CH	Clay - Yellow, highly plastic.	M	S		Subsurface clay
			1.0							
			1.5		ML	Silt - Yellow-brown, fine-grained.	D	H		Weathered zone
						Mudstone - Yellow-grey. Rock fragments.				Permian mudstone
			2.0			Drill stopped as underlying rock identified.				



ENGINEERING LOG - BOREHOLE

project	House cracking, Devon Hills	location	on ridge west of Lot 3 house
co-ordinates	EQ143001	drill type	Proline
R.L.	200 m	drill method	Auger
inclination	vertical	drill fluid	None
bearing	--	hole commenced	27.6.84
		hole completed	27.6.84
		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		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
			R.L.	depth						
					OL	Silt - Organic, grey with plant mater	D	S		Surface soil
				0.5	ML	Mudstone - Fine, grey, weathered layer with rock fragments. Ground by auger to fine silt and rock flour.	D	H		Deeply weathered zone
				1.0		Transitional Zone				Transitional zone
				1.5		Mudstone, Red and grey baked with rock fragments. Rock ground by auger to fine silt and rock flour.	D	V H		Grey-red Permian mudstone
						Drill stopped - underlying rock identified.				