

1988/21. Investigation of a cracked house in Windermere Road, East Tamar.

W. R. Moore

INTRODUCTION

The Department of Mines, in a letter of 28 April 1987 from Mr E.T. Aspinall, was requested to undertake an investigation of a cracked home 'Treetops' at Windermere, East Tamar. A further request for a technical report was made on 18 April 1988.

The house is situated on the river side of Windermere Road, on a 5° slope which steepens to 9° and 12° down to the river flats. The two storied brick-veneer house is located close to the road, with an extensive concrete driveway and courtyard on the west and south. The north and east sides of the property are mainly in lawn (Plate 1).

The exterior of the house has only slight damage, with a major vertical crack present down the east wall (Plate 2). This crack cuts some bricks but is mainly confined to the mortar. The major damage occurs on the concrete ground floors of the garage and billiard room. Here the cracking is widespread and, in some areas, severe. Measurements on these cracks by the owner indicated some doming was occurring beneath these floors.

Mr Aspinall, and other residents of the area, are aware that the Department of Mines has been mapping and investigating old landslides above Windermere Road. He was also aware that a neighbour's house, three blocks to the west (Mrs Pickett's), is cracked and is being monitored for foundation movements by the Department of Mines.

INVESTIGATION

From an inspection of the house and block no evidence for translational downslope movement could be detected. The cracking in the garage and billiard room concrete floor appeared to be associated with arching or doming in the centre of the house. This doming phenomenon is generally associated with slab foundations underlain by expansive soil, such as the clay found at Windermere. The soil moisture content builds up under the centre of the slab causing the clay to expand, whereas around the periphery of the slab the clay dries and shrinks.

Measuring the doming and arching requires precise surveying and levelling within and from outside the house. This survey was too costly to recommend to the owner by a private surveyor and it is too time consuming for the Department surveyor. The writer recommended that four auger holes be drilled as close as convenient to the house. As well as this drilling, the control survey line along Windermere Road above Picketts house should be extended east to cover Aspinall's house.

DRILLING

The lithological logs of the five drill holes are given in Appendix 1 and the location of these drill holes is shown on Figure 1.

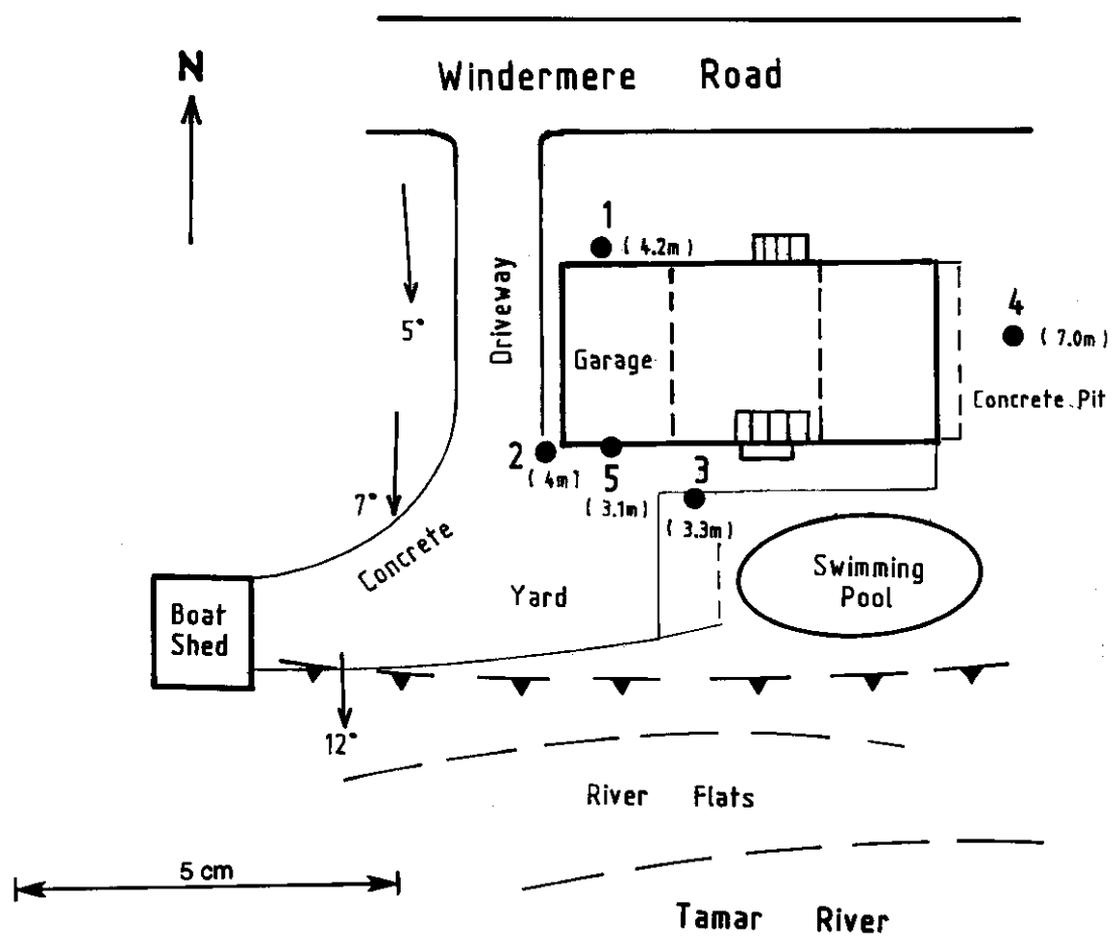


Figure 1. Sketch location plan of bore holes

Hole 1, drilled near the north (front) wall of the house by the garage was drilled in clay to a refusal depth of 4.2 m. The clay (with the exception of the garden organic soil layer) was orange in colour and was highly plastic. At depth it changed from firm to very stiff, and on testing with hand penetrometer measured 300-350 kPa. The samples collected were moist but the hole was dry on drilling and made no water over the 24 hours it was left open.

Hole 2, drilled at the SW corner of the house near the garage, was in orange clay to its refusal depth of four metres. A soft zone with limonite and ironstone gravel bands was present at 0.9 and 1.8 m. Penetrometer testing of this soft zone gave results of 200-250 kPa, compared with 300-350 kPa for the other clay drilled at this location. This hole was also dry on drilling and made no water.

Hole 3, drilled at the rear of the house, was in brown and orange clay. A cemented ironstone band was encountered at a depth of 1.6 m and the hole was stopped by pebbles or clayey gravel at depth of 3.3 m. These pebbles were identified by the driller as basalt.

Hole 4, the deepest hole, was drilled on the eastern lawn away from the septic tank emergency overflow concrete pit along this house wall. In the

top metre pebbles of basalt and thin ironstone gravel were encountered in the clay. This surface layer was hard to drill and the clay was classified as very stiff. The remainder of the hole was in orange and stiff clay to a depth of seven metres. This depth is well below the level where any seasonal or long-term moisture content fluctuations are likely to penetrate. This hole made water with the standing water level at 6.2 m.

Hole 5 was drilled through a hole in the concrete floor from the garage doorway (Plate 3), at an angle of 60°. The orange-brown and brown clay were stiff to very stiff, with a soft zone at the bottom of the hole. This hole was dry and made no water. Surprisingly no steel mesh was found in the concrete in the hole made in the garage floor. This was confirmed by Mr Aspinall, who tested the garage floor of the house using the Department of Mines Garrett ADS 'Deep Seeker' metal detector.

SOIL LABORATORY RESULTS

Clay samples from all five holes were tested for moisture content, and the profiles of these are shown in Figure 2. With the exception of Hole 3, all moisture content profiles show only minor fluctuations and are in the range of 35-45%. Hole 3 clay is noticeably drier but this is a factor of the location being near the concrete yard and partially under shelter.

Clay samples from Holes 1 and 4 were tested in the soil laboratory for Atterberg limits, linear shrinkages, and composition (Table 1). The Unified Soil Classification of the clay samples tested is shown in Figure 3.

Table 1. SOIL LABORATORY RESULTS

Hole	Depth (m)	MC (%)	PL	LL	PI	LS (%)	XRD clay				
							Kaol.	Mont.	Goeth.	Hall.	Gibb.
1	0.9	40	34	162	128	25	60	15	25		
	1.6	41	28	139	111	24	60	20	20		
	2.5	43	27	124	97	23	65	15	15		5
	3.4	49	30	131	100	22	60	15	20		5
	4.0	41	32	128	96	21	60	20	15		
2	0.9	33	28	91	63	20	65	10	25		
	1.6	40	29	109	80	22	75	20	5		
	2.5	38	24	118	94	25	70	20	10		
	3.4	37	25	113	88	24	-	-	-		
	4.3	36	26	124	98	25	60	25	15		
	5.2	36	23	132	109	27	-	-	-		
	6.1	34	26	127	101	24	65	20	10		5
7.0	33	24	126	102	25	75	15	5		5	

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

MC = moisture content, PL = plastic limit, LL = liquid limit, PI = plasticity index, LS = linear shrinkage

Clay minerals: Kaol = kaolinite, Mont = montmorillonite, Goeth = goethite
Hall = halloysite, Gibb = gibbsite

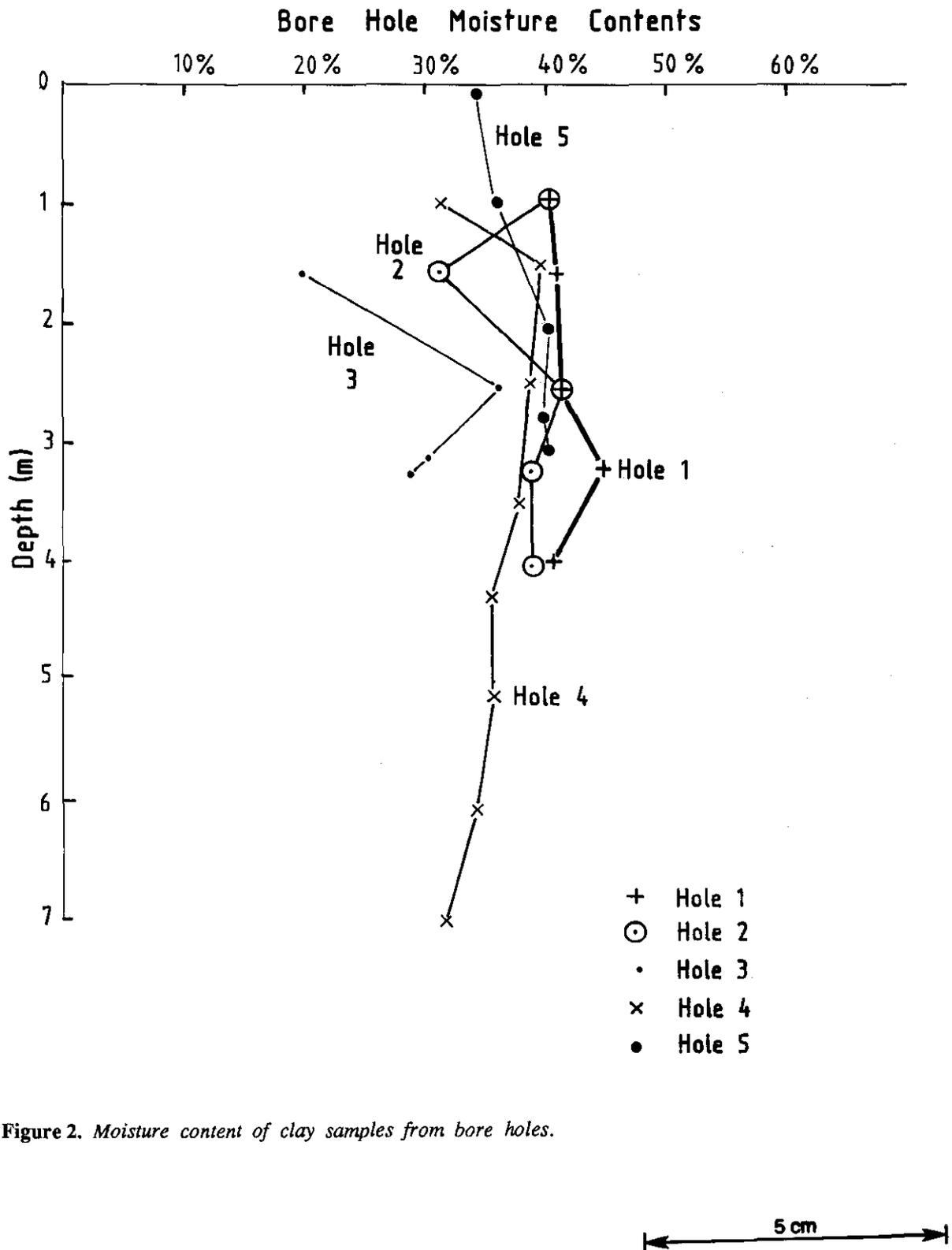


Figure 2. Moisture content of clay samples from bore holes.

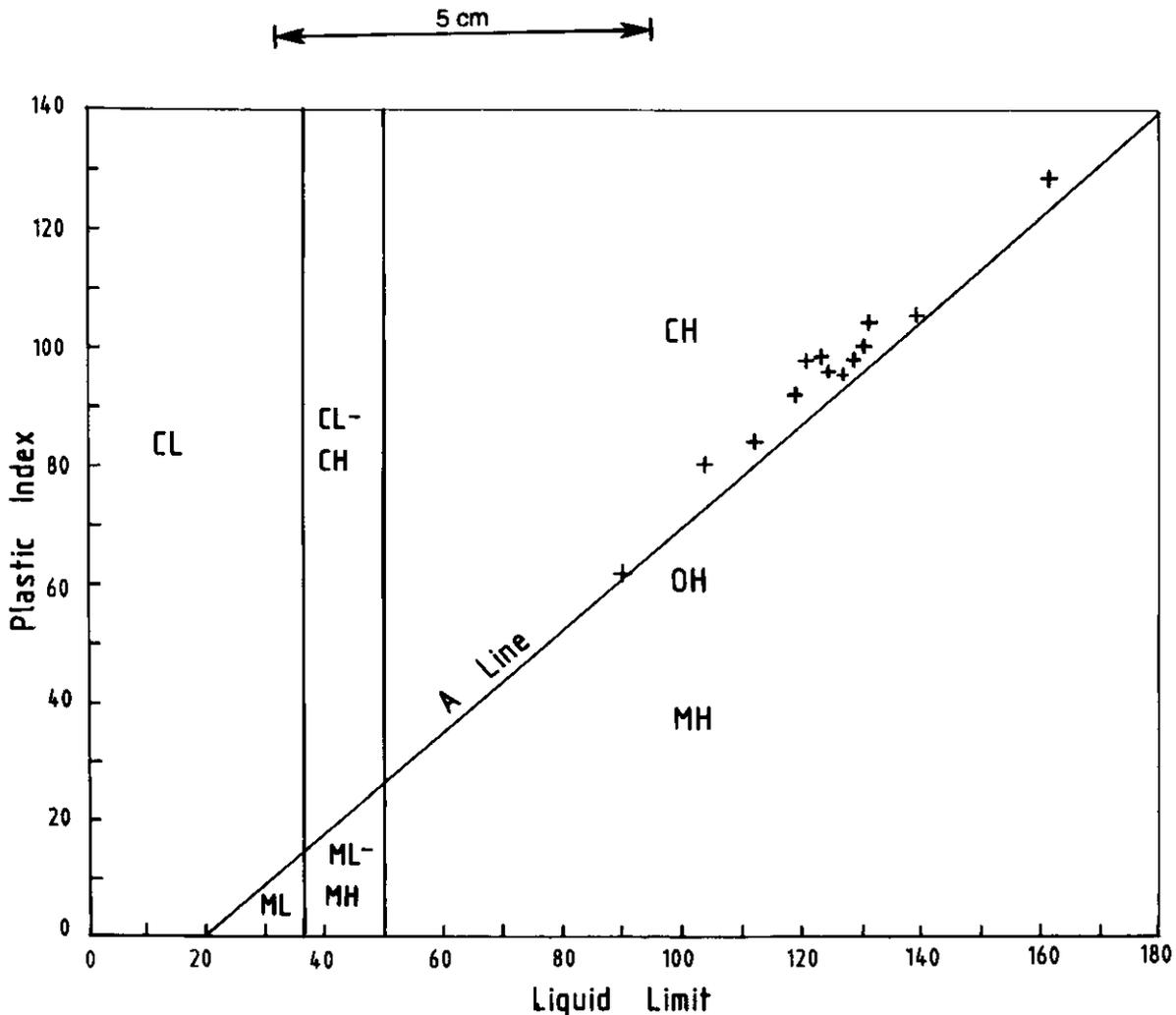


Figure 3. Unified Soil Classification of clay samples

The clay from all holes, both from field and laboratory tests, is highly plastic (CH). By the Australian Standard Classification 2870-1986 the clay would now be classified as extremely reactive (E) with plasticity indices ranging from 63-128, with an average plasticity index of 97.5. Because of the likely landslide risk the location is classified as a problem site (P).

Reflecting these very high plasticities, the clay has high linear shrinkages of 20-27%, with an average of 23.6%. Given that the seasonal and longer cyclical term (drought) soil moisture content profile fluctuates to a depth of between 3-4 m, the theoretical total movement could be as high as 140 mm, with differential movement of 70 mm. These values are similar to those established elsewhere at Windermere and in the Tamar Valley in the thick clay soils of the Launceston Beds of Tertiary age.

SITE MOVEMENT MEASUREMENTS AND MONITORING

This section of the report summarises the survey measurements provided by G. Benn (Table 2), the Department of Mines' Surveyor. The survey error is estimated to be ± 1 mm.

The extended survey line along Windermere Road was completed on 29 June 1987 to cover Aspinall's house. This line, the distance to the house and levels, are surveyed at approximately 1-2 monthly intervals.

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Table 2. SURVEY MEASUREMENTS, ASPINALL'S, WINDERMERE ROAD.**Distance (cumulative) - millimetres**

Survey point	Survey date						Total
	29.6.87	9.7.87	3.9.87	1.12.87	7.4.88	19.5.88	
West corner of house	-	-3	-6		-19	-18	-19
East corner of house	-	-1	-1	NIL	-4	-4	-4

Heights (cumulative) - millimetres

Level point	Survey date						Total
	20.4.87	9.7.87	3.9.87	1.12.87	7.4.88	19.5.88	
Front NW	-	-3	-2	-2	NIL	NIL	-
Front NE	-	-2	-1	-1	NIL	+1	+1
Rear SW	-	-1	-	-1	-10	-6	-6
Rear SE	-	-3	-	NIL	-17	-17	-17
Under garage	-	-	-	-3	-10	-8	-8

Surveying by G. Benn, Surveyor, Department of Mines

Distance

From the road surveys measured between 27 June and 3 September 1987, 6 mm of downslope translational movement was measured on the west side of the house. Between 3 September and 1 December 1987 no further movement was measured but between 1 December 1987 and 7 April 1988 a further movement of 13 mm was experienced on the west side of the house and 4 mm on the east side of the house.

Movements of the house were consistent with movements of the road. Even though new survey points were placed around the house, differential movement between the house and the road during the period 3 September 1987 to 7 April 1988 appeared to be nil. From these measurements it appears that the house is moving downslope by probably the same distance and rate as the road above it.

Levels

The west front corner height of the house fell 3 mm between 28 April and 9 July 1987. This level remained static to 1 December 1987 and then rose 3 mm to 7 April 1988, back to its original level. On the east front corner of the house, between 29 April and 9 July 1987, the height fell 2 mm and then climbed gradually back to its original height by 7 April 1988.

At the rear (south-east corner) of the house no appreciable movement was measured to 1 December 1987 but by 7 April 1988 this corner had fallen 17 mm. A similar pattern of movement was recorded on the south-west corner. The falls at the rear of the house were confirmed by levelling on 19 May 1988.

PIEZOMETER LEVELS - HOLE 4

Slotted casing was inserted in Borehole 4 and top of the hole sealed from surface water infiltration. Water levels were measured between May and August 1987 with the following results:

13.05.87	Standing water level 6.20 m
20.05.87	Standing water level 5.68 m
15.07.87	Standing water level 5.96 m
17.08.87	Standing water level 6.08 m

Measurements were discontinued after this date because of the shortage of field staff. In April 1988 a water sample was taken for chemical and bacterial analysis. These analyses are included in Appendix 2.

RESULTS OF INVESTIGATION

- (1) Aspinall's house is situated on very highly plastic and expansive clay. Drilling has established that this clay, with only minor lithological variations, occurs to a depth of 7 m at this site.
- (2) From field examination and soil laboratory results, the clay at Aspinall's is similar to clay found elsewhere at Windermere. The clay belongs to the Tertiary-aged Launceston Beds.
- (3) With seasonal and longer term soil moisture fluctuations extending down to 3 to 4 metres in this expansive clay, total foundation movement may be as much as 140 mm, with differential movements of 70 mm possible at the site.
- (4) No landslide shear plane, faceted shearing or shear polish of the clay was recognised in drilling the holes.
- (5) Extensive old landslides have been mapped upslope above the road at Aspinalls (Moore, in prep.).
- (6) Surveying has established downslope translational movement in excess of 20 mm occurring on the road above, and on Aspinall's house. Vertical movements of 2-3 mm have also been measured at the front of the house, with a 17 mm drop in level at the rear of the house.
- (7) The water table appears to be at 6 m depth with only minor fluctuations noted. The groundwater contains no excess phosphates, nitrates or

fluorides, and its bacterial level is considered normal for groundwater (D. Baker, pers. comm.) compared with water from bores at Pickett's.

- (8) No steel mesh was found in the garage floor when Hole 5 was drilled. A metal detector survey indicated that no steel mesh is present in the concrete floor of the garage. In contrast steel was detected by this instrument in the concrete driveway and courtyard, where it was known to be present by the owner.

CONCLUSIONS

- (1) With such highly expansive and plastic clay being present, continuous seasonal and longer-term movements can be anticipated at this site. Arching and doming is very likely to occur beneath the concrete floor of the garage and billiards room. The lack of reinforcing steel in these floors, with such movements, would cause the concrete to crack.

The extensive concrete driveway and courtyard along the western and southern walls may have stopped cracking of these walls. With such expansive clays, it is surprising that more cracking is not present on this house. This is possibly because the Aspinall's keep lawns and gardens regularly watered.

- (2) The translational downslope movement found from surveying appears not to have affected the house. When the presence of these movements was first established they were thought to be soil creep downslope as a result of the expansive clay (Moore, 1986). Recent survey measurements along this section of Windermere Road indicate that these movements are too large and appear to occur as a single pulsation associated with a sharp rise in the water table. This latter information was only recognised by instrument monitoring consisting of a continuous data storage unit coupled to 3-dimensional strain gauges, bore level probe, and an automatic rain gauge at Pickett's.
- (3) The extent and depth of this translational movement is not known but it is likely to affect more houses than the two investigated to date, (Pickett's and Aspinall's). Because of resident resistance it has not been possible for other houses to be examined or monitored at this locality.
- (4) The cause of this downslope movement has not been established but the writer considers it likely to be the reactivation of the old landslide that is present upslope from this locality. Similar reactivation of an old slide is considered to have destroyed, to date, one house at Windermere, 1.2 km west of Aspinall's (Telfer, in press).
- (5) With the detailed morphological landform mapping and investigation carried out to date, all the built-up area along this section of Windermere would now be zoned as Class V on the Landslide Risk Zone Map of the Tamar Valley, and not Zone III as originally considered.
- (6) Only by continuing and expanding this instrumental monitoring and subsurface investigation will it be possible to establish the rate and cause of these movements in this area of Windermere.

RECOMMENDATIONS

- (1) Monitoring by survey be continued, and if funds are available similar instrumentation to that at Pickett's should be installed at Aspinall's house. This instrumentation should include a bore recorder on bore 4. This would allow confirmation of the records at Pickett's.
- (2) Periodic checks be undertaken on water quality and bacterial level of the water in bore 4.
- (3) The Council be approached so that the open gutter along Windermere Road be kerbed and guttered in concrete, with an adequate fall to get all excess water off this section of Windermere Road and the house blocks along the lower side of the road.
- (4) A concrete border be placed along the eastern and southern walls of Aspinall's house with waterproof sheeting underneath this concrete.
- (5) The garage and billiards room floors be re-concreted with adequate steel-reinforced mesh in the concrete to withstand the vertical movements of the expansive clay.
- (6) Regular watering of lawns and gardens continue.
- (7) When the Department of Mines records cover a longer period of time and the records are more comprehensive and definite for both Aspinall's and Pickett's, the neighbouring residents be notified of these movements. This will hopefully allow monitoring and investigations to be extended to other houses in the area thought likely to be affected, particularly by the downslope movements.

REFERENCES

MOORE, W. R. 1986. Investigations of cracking of S. Pickett's house, Windermere Road, Windermere. *Unpub. Rep. Dep. Mines Tasm.* 1986/83.

MOORE, W. R. In prep. Recognition of old landslides at Windermere. Their origin, reactivation, and effect on landslide risk zoning.

TELFER, A. L. In press. Landslides and land use planning. *Bull. geol. Surv. Tasm.* 63.

[6 July 1988]



Plate 1a. *North and east walls of house.*



Plate 1b. *West and south walls of house.*

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Plate 2. *Drilling angled hole, garage floor, south wall.*

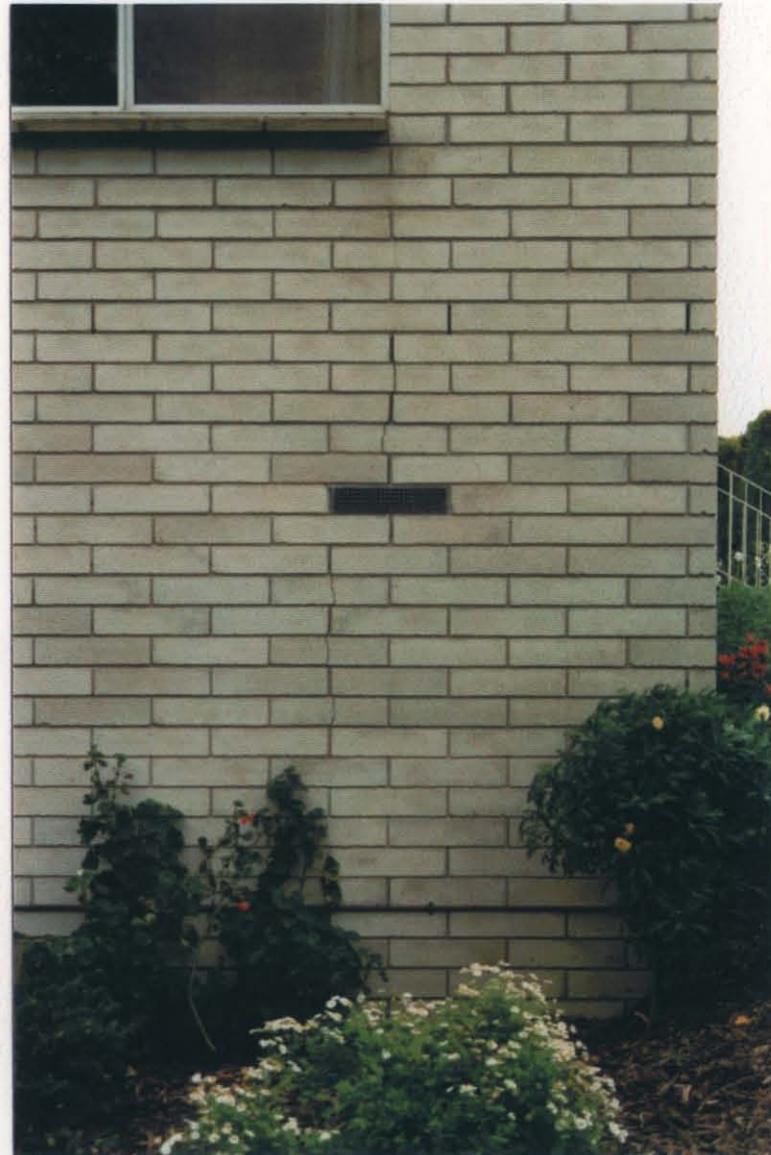


Plate 3. *Cracking in east wall.*

APPENDIX 1

Lithological logs of drill holes

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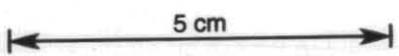
borehole no. 1

sheet 1 of 1

ENGINEERING LOG - BOREHOLE

project	E.T. Aspinall, house cracking RSD 1250, Windermere	location	NW corner of house
co-ordinates	5015 54261	drill type	Triefus
R.L.	14 m	drill method	Auger
inclination	Vertical	drill fluid	None
bearing	-	hole commenced	13.5.87
		hole completed	13.5.87
		drilled by	B.E. Cox
		logged by	W.R. Moore
		checked by	

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
					OH	CLAY - Organic - with roots, dark brown				Top soil
	None	S1	1.0		CH	CLAY - highly plastic, orange	M	F		Clay derived from Launceston Beds Tertiary Age
	None	S2								
		S3	2.0							
		S4 (tube)	3.0							
		S5								
		S6	4.0							
						Drilled to refusal. S4 - depth 2.5 m, tube sample. Tested hand penetrometer 300-350 kPa.				



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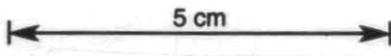
borehole no. 2
sheet 1 of 1

ENGINEERING LOG - BOREHOLE

project E.T. Aspinall House cracking RSD 1250, Windermere location SW corner of house

co-ordinates 5015 54261 drill type Triefus hole commenced 15.8.87
 drill method Auger hole completed 15.8.87
 R.L. 13 m drilled by B.E. Cox
 inclination vertical drill fluid none logged by W.R. Moore
 bearing - checked by

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 25 100 200 400	structure, geology
					OH	CLAY - Black organic, with roots	D	S		Topsoil
						CLAY - Orange, highly plastic	M	St		Clay
		S1 S2 (tube)	1.0		CH	CLAY WITH GRAVEL - Brown. Clay highly plastic, dark brown. Gravel - fine, ironstone 1-2 mm 10%	M	S		Soft Zone
		S3 tube	2.0			Clay changes to orange-brown with depth.		F		
	None				CH	CLAY - Orange, highly plastic	M	St		Launceston Beds
	None							V		
		S4	3.0					St		
		S5						St		
		S6	4.0			Drilled to refusal				
						S2 1.0 m Tested hand penetrometer 300-350 kPa S3 1.8 m Tested hand penetrometer 200-250 kPa Both tube samples.				



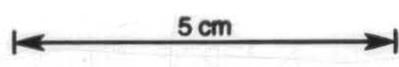
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borehole no. 3
sheet 1 of 1

ENGINEERING LOG - BOREHOLE

project E.T. Aspinall, house cracking RSD 1250, Windermere	location N. side of house on edge of lawn
co-ordinates 5015 54261 R.L. 13 inclination 13 bearing Vertical	drill type Triefus drill method Auger drill fluid None
hole commenced 14.5.87 hole completed 14.5.87 drilled by B.E. Cox logged by W.R. Moore checked by	

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 25 50 100 200 400	structure, geology
1 2 3												
				0.9		OH	CLAY - Brown, organic, highly plastic.	D	Fr			Soil and subsoil
				1.0		CH	CLAY - brown, highly plastic	M	V			Clay
				1.3					St			
				1.6			CLAY - Rubbly ironstone band	M	H			Iron Pan
				2.0		CH	CLAY - brown, highly plastic	M	St			
				2.5								
				3.0			Clay with pebbles (Tb)	M	V			Clay
				3.2					St			
				3.3			Hole stopped 3.3 m - pebble layer			H		



ENGINEERING LOG - BOREHOLE

borehole no. 4

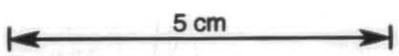
sheet 1 of 1

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project E.T. Aspinall, house cracking location On lawn on east side of house
 RSD 1250, Windermere

co-ordinates 5012 54261 drill type Triefus hole commenced 14.5.87
 R.L. 14 m drill method Auger hole completed 14.5.87
 inclination vertical drill fluid None drilled by B.E. Cox
 bearing logged by W.R. Moore
 checked by

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 25 50 100 200 400	structure, geology
			R.L.	depth							
	None	None					CLAY WITH PEBBLES CLAY - orange brown, highly plastic Pebbles - basalt >3.0 mm ironstone <1 mm	M	V		Soil and subsoil
		S1		1		CH	CLAY - brown, highly plastic	M	St		Clay of
		S2		2			↓ Gradual change in colour				
		S3		3							
		S4		4							
		S5		5		CH	CLAY - Orange, highly plastic	H	St		Launceston Beds
		S6		6							Tertiary
		SWL S7		6							Age
		S8		7							
							Drill stopped - depth required obtained				



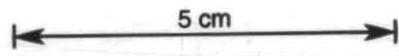
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borehole no. 5
sheet 1 of 1

ENGINEERING LOG - BOREHOLE

project	E.T. Aspinall, house cracking	location	Garage floor, 1 m from door
	RSD 1250 Windermere		N side of house
co-ordinates	5015 54261	drill type	Triefus
R.L.	13	drill method	Auger
inclination	60°	drill fluid	None
bearing	180°	hole commenced	1.7.87
		hole completed	1.7.87
		drilled by	B. Cox
		logged by	W.R. Moore
		checked by	

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 index	hand penetr- ometer kPa	structure, geology
				R.L.	depth							
			S1				G	Concrete and gravel				Concrete
								CLAY - brown, highly plastic		St		
			S2		1		CH			M		
								CLAY - Orange, highly plastic		M	V	Firm Clay
			S3		2					St		
			S4									
			S5		3					M	St	Moist and Soft Zone
			Hole stopped, adequate depth reached.									



APPENDIX 2

Analysis of water sample

Registered Number	881599
pH	7.8
Conductivity (uS/cm)	10000
Item (mg/l)	
CO ₃	Nil
HCO ₃	810
Cl	4310
SO ₄	290
Ca	200
Mg	730
Fe	<0.1
Al	<0.2
K	1.6
Na	1780
TDS	9590
Hardness - permanent	2830
- temporary	670
Alkalinity as CaCO ₃	670
PO ₄	<0.04
NO ₃	<5
F	0.4

Analysis by Department of Mines laboratory, Launceston.