UR1982_28

1982/28. House cracking at Carinya Street, Blackmans Bay

D.J. Sloane

Abstract

A house at Blackmans Bay has developed several brickwork cracks over the past five years. One crack in particular has developed along a vertical construction joint in the south wall brickwork. The crack is closed at ground level but gradually increases in separation to about 20 mm at roof level above the first floor.

The foundation of the southern wall has not been constructed to design specifications as regards width, depth, thickness, and amount of reinforcing.

Underlying the foundations are expansive clay and sandy clay, Shrinkage and swelling of these underlying materials are considered responsible for foundation failure on the south wall and subsequent cracking. Climatic conditions have been very dry for the past five years resulting in similar house problems elsewhere. A water pipe leak below the ground floor slab may have initiated some foundation movement, although the extent of their influence is impossible to determine.

Cracking of the garage, and especially at its junction with the house, is related to foundation construction and expansive soil problems.

INTRODUCTION

A house owned by Mr C. Meech at Carinya Street, Blackmans Bay [EN260384] has been inspected by this Department on two previous occasions, in April 1979 and March 1981. Cracking to the house had occurred and the owner was anxious to determine its cause, in order to effect remedial measures. Mr R. Locke of Scott and Furphy Engineers Pty Ltd and architect Mr D. Kelley also examined and reported on the problem during March 1981. The Department of Mines and Mr Locke considered that the cause of the south wall crack (fig. 2) was heave in the central part of the wall caused by a water pipe leak below the floor slab. Mr Kelley considered that the major crack was caused by settlement of the south-eastern corner.

Investigations during June 1982 are a continuation of previous studies, but have been conducted in more detail to determine properties of foundation materials and to study crack displacements.

The sequence of events in relation to this house is outlined below:

1972 - house constructed
1976 - January - water pipe leak below floor slab. Low rainfall period began.
1977 - February - main construction joint crack noticed.
- stairwell wall cracks.
1979 - June, July - initial Department of Mines visit.
1981 - March - Locke, Kelley, Department of Mines inspection.
- tell-tale attached to construction joint
- August, September - tell-tale cracked. 3 mm closure horizontally.
1982 - May - tell-tale opened 3 mm. East side dropped approximately 1 mm.

INVESTIGATIONS

A series of four, 75 mm diameter, hand augered holes were drilled along the southern and eastern walls to a depth of two metres (fig. 1). Disturbed samples were taken for laboratory analysis and samples were described in the field. The owner later drilled another three auger holes and samples were presented to this Department for inspection. Sliding weight penetrometer profiles were obtained adjacent to the first four auger holes. The owner exposed the footings of the south wall in several locations which were measured and recorded, together with the location and displacement of external house cracks. Surveyed horizontal lines of steel pins were located on the external walls to measure brickwork displacement and to act as reference points for further monitoring.

R. Woolley performed the laboratory tests to determine linear shrinkages, moisture contents, and atterberg limits of selected samples, and assisted in the field investigations.

DESCRIPTION AND PROPERTIES OF FOUNDATION MATERIALS

Four 75 mm diameter hand augered holes were initially drilled along the southern and eastern walls (fig. 1; CM1, 2, 3, 4). The owner drilled a further three holes (CM5, 6, 7) and samples were provided for inspection. These holes (Appendix 1) show that between 0.3 and 0.6 m of grey-brown silty sand (SM) overlies highly plastic (CH) clay and sandy clay (CH-CL). The sandy topsoil and fill(?) appears to vary in thickness over the house site. Towards Carinya Street to the west, where little excavation has occurred, the topsoil has a thickness of 0.3 m, but thickening occurs to the east as the thickness is 0.6 m adjacent to the east wall of the house. It is uncertain whether part of this material is fill, as the topsoil in this area appears too thick. The underlying clay and sandy clay is mottled bright yellowish-brown to dull yellowish-brown and contains up to 30% medium quartz sand. Clayey sand (CL) occurs at depths of between 1.4 and 1.8 m. The clayey sand is composed of medium to fine quartz sand with a trace of muscovite. Colouring is mottled, bright yellowish-brown, dull yellow-orange, to reddish-brown at depth. Clay fines comprise 20 to 30% in places and are highly plastic. Some lenses and minor layers of CH clay occur in the clayey sand. At depths of 1.6 m and greater, the sand content is much higher and the material is friable, in contrast to the stiff to very stiff overlying materials. Red-brown mottling and mica content increase with depth, related possibly to soil profile development over the weathered Triassic sandstone bedrock. X-ray diffraction analysis of the clay fraction of various samples indicates a kaolinite, montmorillonite, and illite clay composition. Samples from auger hole CM3 were much more dispersive than the remainder, indicating that the montmorillonite could be of the sodium type, as distinct from the calcium type. Sodium montmorillonite has high shrink-swell properties because of a greater ability to take water into its structure than the calcium type. Sodium montmorillonite is also susceptible to cation exchange, with consolidation and a decrease in volume if calcium ions exchange with sodium ions.

Linear shrinkage

Three tests (Appendix 2) from samples taken from a depth of one metre indicate values of between 15 and 17%. One test from a depth of 1.5 m gave a lower value of 13%. These values are quite high and provide a good indication of shrink-swell behaviour on drying and wetting.

Moisture content

Moisture profiles (Appendix 2) from holes CM1, 2, 3, and 4 were all similar, with values ranging from about 25% at 0.5 m depth to about 15% at 2.0 metres. Seasonal fluctuations are to be expected within this depth range, especially within 1.5 metres of the ground surface. Further profiles will be obtained at the end of winter and summer to investigate these seasonal variations.

Atterberg limits

Five tests on the clay and sandy clay horizons indicate high plasticity. From a depth of one metre liquid limits range between 65 and 75% with plasticity indices between 43 and 47% (four tests). At a lower depth of 1.5 m, sandier materials have lower values with liquid limits between 50 and 60% and plasticity indices between 28 and 34% (two tests).

Falling weight penetrometer testing

Four falling weight penetrometer probes were located adjacent to auger holes CM1, 2, 3, and 4 (Appendix 2). The results have been used for comparative purposes and to determine the presence of denser materials up to two metres below the ground surface. The essential feature of the profiles is the presence of easily penetrated sandy topsoil and fill(?) to a depth of about 0.5 m, moderately dense plastic clay and sandy clay from 0.5 m to about 1.6 m, and more dense material below this depth.

Hand penetrometer testing

A series of hand penetrometer tests were performed on clay at the base of the foundation trench. Exposed plastic clay gave values of between 100 and 125 kPa, but freshly exposed material had a bearing strength of 200 kPa.

HOUSE CRACK DISTRIBUTION AND DISPLACEMENT

Crack distribution is shown on Figure 1. Major cracks are considered to be those wider than 0.5 mm. Crack displacements and displacement directions are also indicated. Some cracking is also listed in Locke's report.

The owner's main cause for concern is a large crack along a vertical construction joint on the southern wall. The construction joint has a gradual separation from closed at ground floor slab level to about 25 mm wide at roof level, approximately five metres from the ground. Other cracks are as follows:

South wall

(1) Cracking at base of construction joint around sewerage pipes from WC extending to foundation level

(2) Cracking from construction joint to above WC and bathroom windows

(3) Minor cracking below bathroom window and also along damp proof course adjacent to garage.

East wall

(4) Laundry entrance - south wall crack from top corner of window. Approximately 4 mm horizontal and vertical separation. Also mid-wall crack.

(5) Lintel angle above laundry entrance at southern wall intersection, supporting first floor brickwork, shows 6 mm horizontal separation from first floor slab and approximately 4 mm vertical separation.

(6) Cracking of first floor brickwork above laundry entrance extending to underside of first floor window.

(7) Northern end. Cracking below ground floor window with maximum of one millimetre separation. Also cracks above window extending to living room window on first floor.

North wall

(8) Minor crack below ground floor bedroom 1 window.

(9) Minor crack along construction joint below bedroom 2 window.

Garage

(10) 3 mm to 5 mm east-west separation - junction of house and garage wall in corner of carport.

(11) North-west corner of garage wall. Crack at lower corner - 5 mm vertical separation.

(12) 2 mm east-west separation of brick at top of wall above (11).

(13) Fascia indicates 6 mm east-west separation due to roof movement at south-west corner.

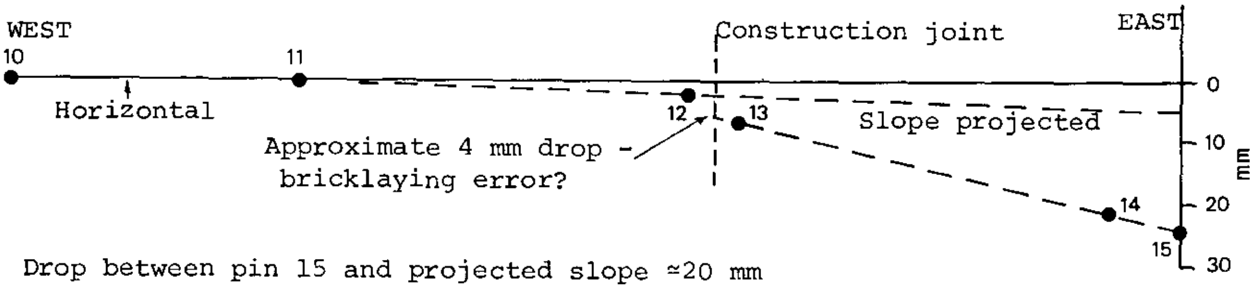
(14) Cracking below garage window on south wall. Window frame separated from brickwork. 5 mm east-west separation of brick course above window, 2-5 mm separation of brick course below window.

(15) Major cracking at junction of east garage wall to southern house wall adjacent to doorway. 5 mm north-south separation of door frame and same separation of brickwork above door lintel. Flashing at garage roof - south house wall junction indicates total separation of about 10 mm.

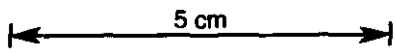
BRICKWORK SURVEY

Two horizontal lines of steel pins were driven into the south wall brickwork, at ground floor and first floor levels. The ground floor line was continued around the house. Plotted brick course lines shown (figs. 2 and 3) are an average of at least four courses, with measurements taken up to ten courses above and below the survey line. This method was used to average out any bricklaying errors. Course measurements were, in fact, very consistent.

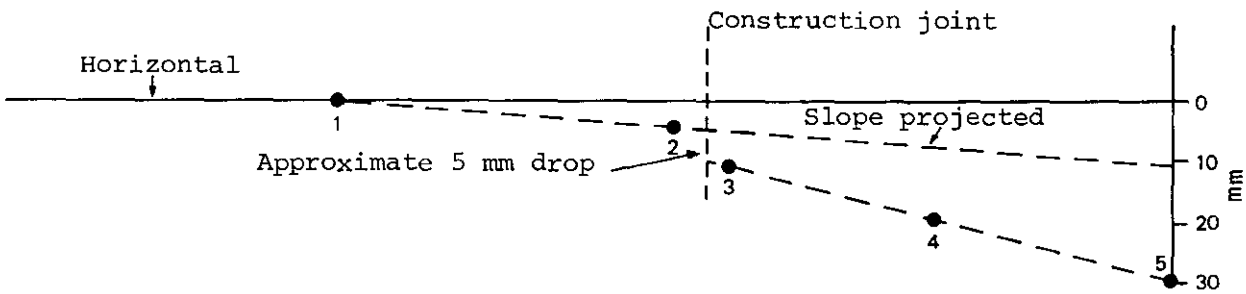
A theodolite was used to measure the verticality of the sides of the *(a) South wall - first floor survey line*



Drop between pin 15 and projected slope ≈20 mm
Subtract drop across construction joint of 4 mm
South-east corner settlement approximately 16 mm



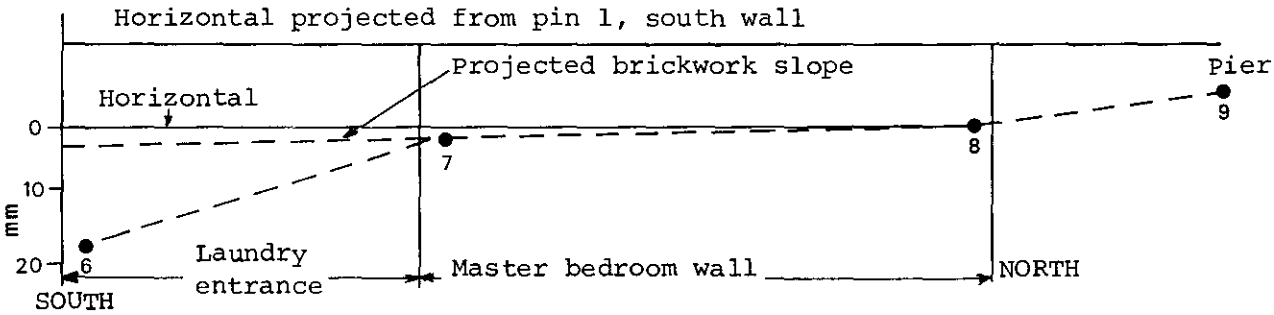
(b) South wall - ground floor survey line



Drop between pin 5 and projected brickwork slope ≈20 mm
Subtract drop across construction joint of 5 mm
South-east corner settlement approximately 15 mm

For pin locations see Figure 1.

(c) East wall - ground floor survey line



Approximate drop of south-east corner (pin 6) from horizontal drawn along main section of east wall ≈16 mm.

Many assumptions have been made concerning bricklaying error and projected slopes of brickwork. The resultant discrepancies between the horizontal and brick courses are approximate, but reasonably consistent and show a south-east corner settlement of about 15 mm.

Figure 2. *Brick course surveys*

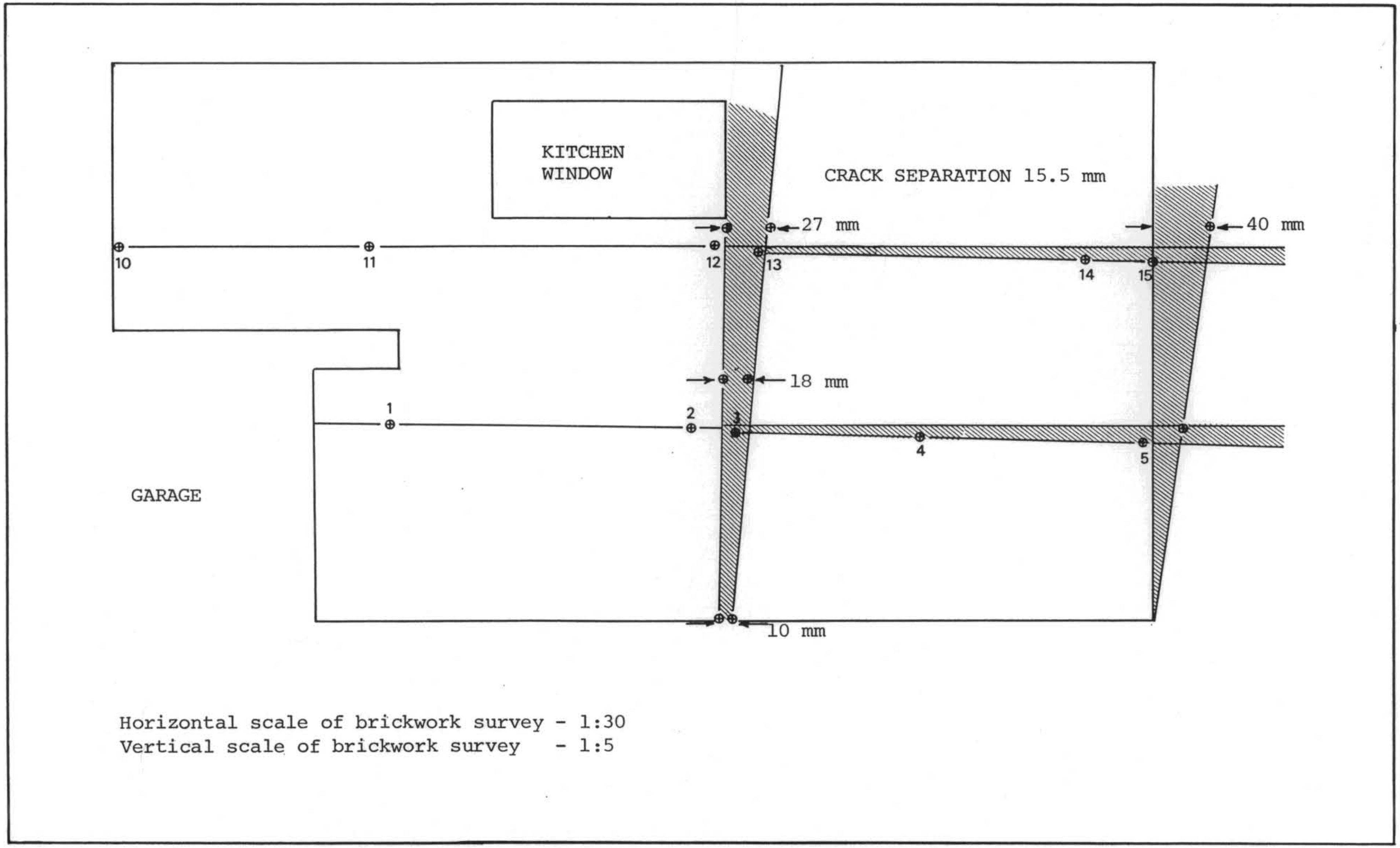


Figure 3. *Diagrammatic representation of vertical and horizontal brickwork survey, south wall section.*

5 cm

main construction joint crack and also the south-eastern corner. The results are shown on Figure 3. Both sides of the main construction joint are off-vertical by varying amounts with displacement to the east. Measurements taken below the kitchen window (pins 12 and 13) indicate that the western side of the joint is about 7 mm off-vertical, with the eastern side about 25 mm off-vertical. Part of these measurements may be attributed to bricklaying error, but the magnitude of the measurements indicates that the wall on the eastern side has rotated to the east compared with the western section. The south-eastern corner of the building is about 40 mm off-vertical where measured at the first floor survey line, with displacement to the east. Part of this displacement is undoubtedly bricklaying error as the eastern part of the wall has remained intact, but there is a discrepancy of 15 mm in measurements taken at the construction joint to those taken at the south-east corner.

The construction joint has been constructed by butting bricks together with approximately 10 mm of mortar between. Flexible mastic has been subsequently applied to the joint. This has become brittle with age and subsequently cracked. Removal of part of the mastic shows that the construction joint mortar has separated from the brickwork by 15.5 mm at the underside of the kitchen window. A plastic indicator and glass microscope slide were attached to the construction joint during March 1981. Towards the end of winter in August or September 1981 the glass slide had cracked and the telltale indicated a closure of approximately 3 mm. When measured after summer during May 1982 the gap had again opened approximately 3 mm.

In summary, the main south wall construction joint shows a separation of 15.5 mm where accurately measured below the kitchen window, approximately 3.5 m from ground level. The gap reduces in width to closure at ground floor slab level. From this level, a brickwork crack propagates to the west, across to the WC drain pipe and down to foundation level (fig. 4). Foundation failure is likely to have occurred at this point. The construction joint appears to open and close seasonally by about 3 mm, closing during winter and opening during summer. The sides of this joint are not vertical and measurements indicate that the eastern side wall has rotated compared with the western side, the hinge point being located at foundation level close to the WC drain pipe.

The results of the brick course surveys are shown in Figures 2 and 3. The essential features are an eastward slope of between one and five millimetres for brickwork on the western side of the construction joint and an eastward slope of between 25 and 30 mm on the eastern side of the joint. The eastern wall shows corresponding measurements. The main, master bedroom, section has virtually horizontal courses but across the laundry entrance the brickwork on the south-eastern corner shows a drop of about 20 mm.

The remainder of the building shows displacements attributed to bricklaying errors of ±6 mm.

FOUNDATIONS

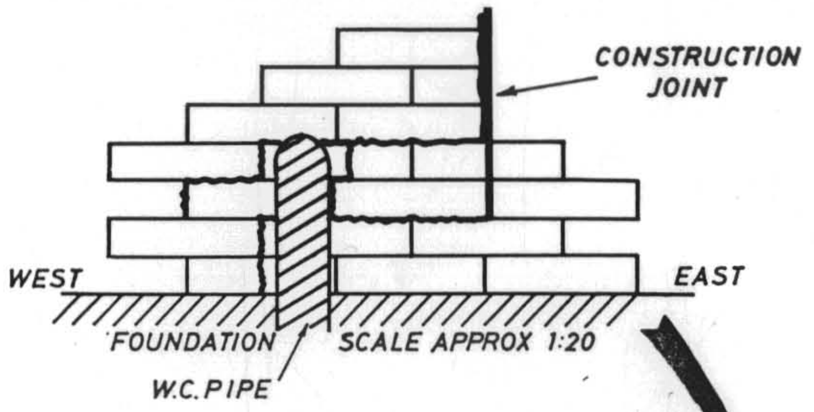
The owner of the house has exposed a large part of the south wall foundations. These have been carefully measured and are shown in Figure 4. The house plans (fig. 1) indicate that the footings along this wall should be type 'A' - 2'0" (0.6 m) wide by 15" (0.38 m) deep with No. 6 trench mesh top and bottom. The foundations vary in thickness from 0.14 m to 0.33 m, with a large proportion being approximately 0.2 m thick. If it is assumed that the concrete block walls are centrally placed on the foundation, then the foundation should project 6" (0.15 m) out from the base of the wall.

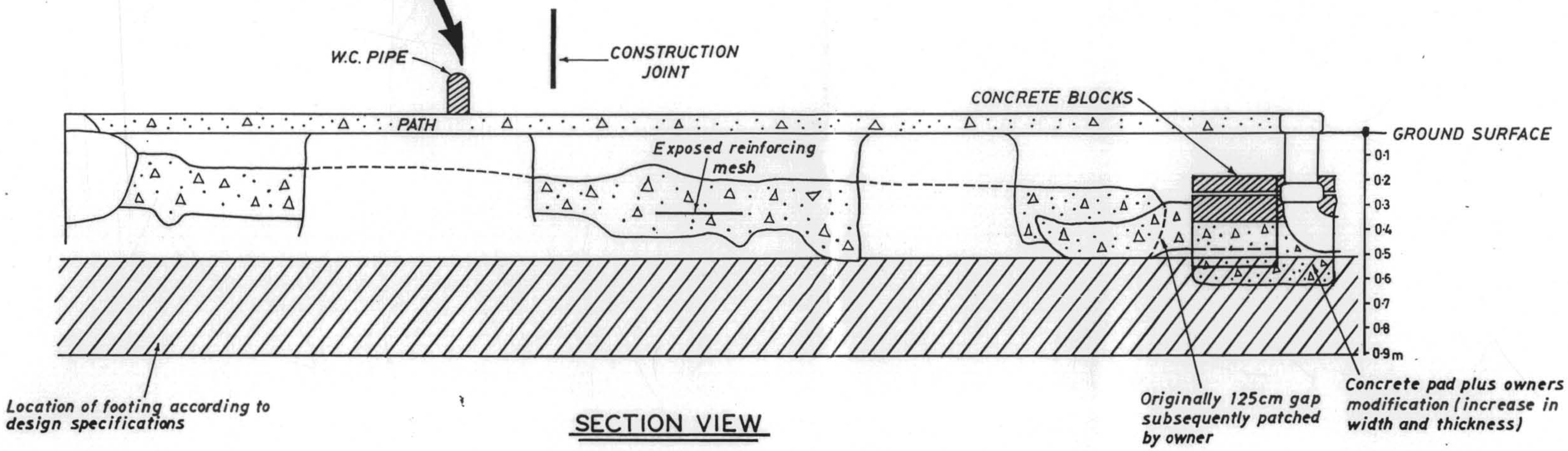
SOUTH WALL FOUNDATION

HORIZONTAL SCALE 1:25

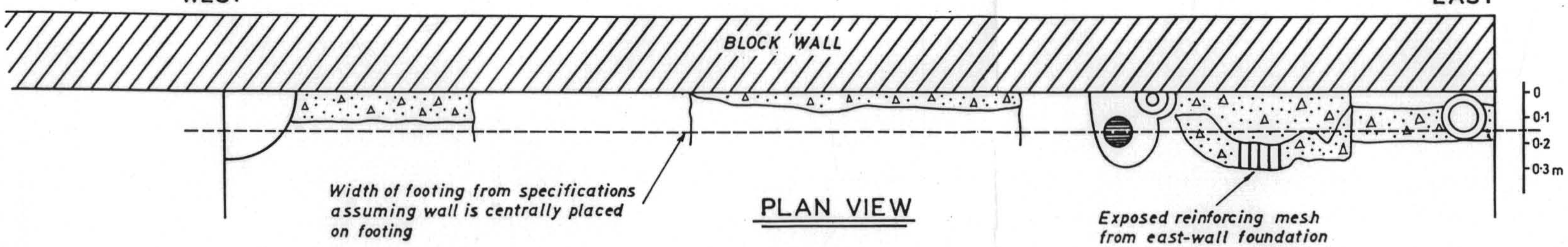
5 cm

DETAIL OF CRACK PROPAGATION FROM MAIN CONSTRUCTION JOINT





SECTION VIEW



PLAN VIEW

Most of the foundation does not project this far and in the area of the WC drain pipe there is no projection at all. Some of the foundation has been removed in order to place the drain pipes, and initial footing damage may have been caused in this area, especially as the main construction joint crack propagates across to foundation level at this point. The foundation is also thinnest at this point. Reinforcing is exposed and rusting in the central part of the wall and also at the intersection of the east wall foundation. Only a lower layer of trench mesh can be seen and using a small pipe and wire detector only this layer can be detected. A concrete saw cut is needed to confirm that only one layer is present. The foundation under the south-eastern corner has been constructed of concrete block, with a small pad of concrete below. At the junction of the concrete block part of the foundation to the *in situ* poured reinforced concrete section, a gap approximately 120 mm in width had been left with trench mesh also exposed. This gap has subsequently been filled by the owner who has also increased the width of the footing.

The plans also specify that the footings should be at a minimum depth of 3'0" (0.9 m) if they are on clay, and the footings are shown at this depth on the plans. The footings are in fact only at about half this depth.

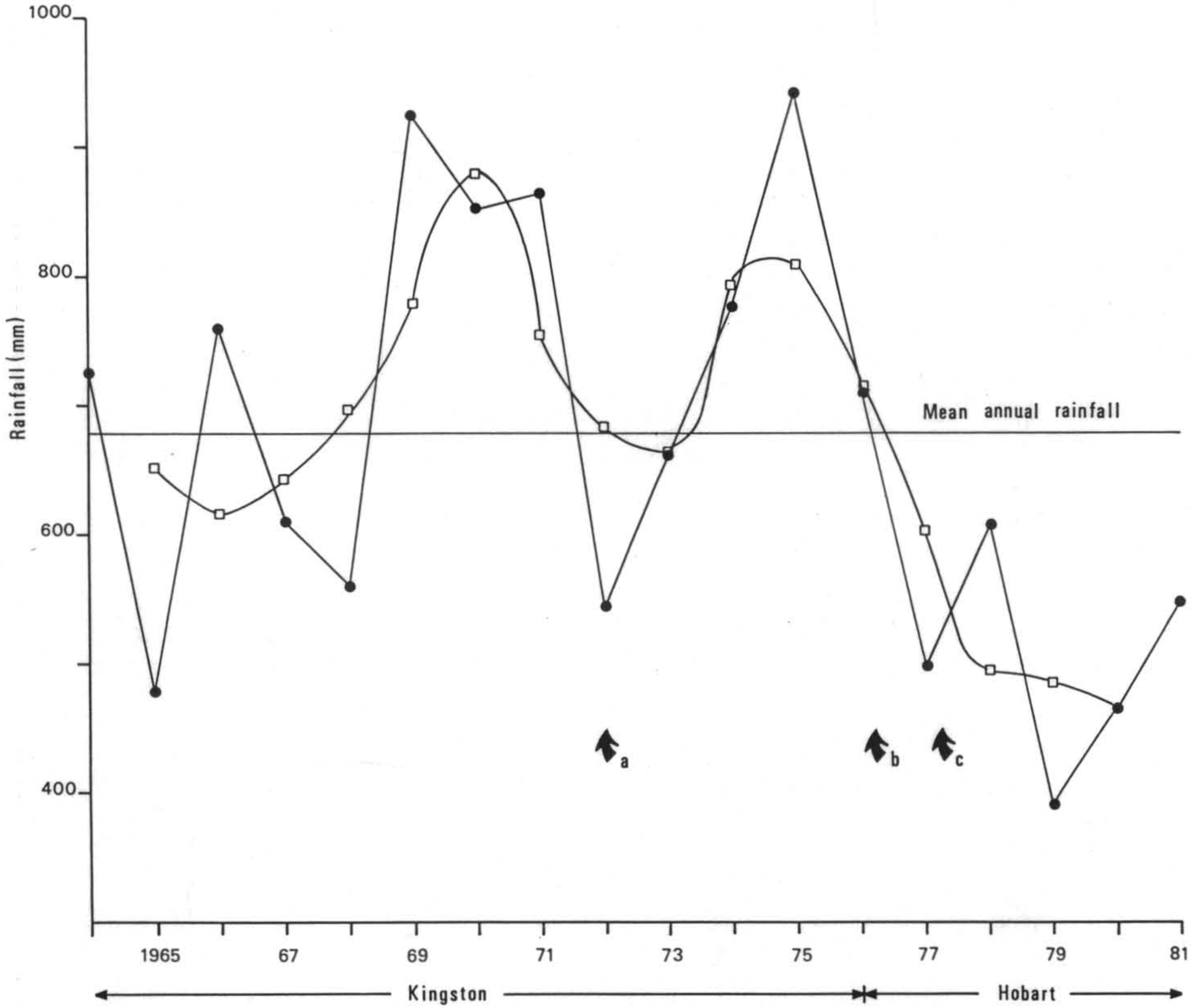
PRECIPITATION

Dry conditions have prevailed over most of Tasmania, especially the south-east, for the past six years. Rainfall figures for Hobart show that the past three or four years have been about 150 mm below the average of around 670 mm (fig. 5). Figure 5 also shows a smoothed curve generated by running means over a three year period which indicates broad rainfall trends clearly. This dry period has resulted in numerous requests for investigations of cracked buildings by this Department and others. These problems are undoubtedly related to dry conditions and their effect on expansive soils. These climatic conditions are probably a major factor in the house cracking at this site as most problems were initially noticed in the summer of 1977, at the beginning of the dry spell, despite the fact that the pipe leak under the slab occurred at the beginning of 1976.

ANALYSIS OF RESULTS

There are two theories as to the cause of cracking and separation of the main construction joint of the south wall. The first theory is related to the leaking pipe beneath the ground floor slab of the bathroom which occurred during January of 1976. The subsequent increase in moisture content of the clay beneath the slab and around the foundation could cause swelling with a resultant heave of the centre of the south wall in the area of the construction joint. This would result in the type of separation observed, open at the top of the construction joint tapering to closure at foundation level. The amount of heave would need to be about 7 to 9 mm to produce the measured separation. Other house cracks observed could be related to this movement.

The second theory is that the western side of the construction joint has remained relatively stable, but foundation failure has occurred due to settlement of the eastern corner. Foundation failure is likely to have occurred in the area of the WC drain pipe where the foundation is thinnest and possibly damaged. The foundation is not continuous to the eastern corner, and has probably only been reinforced at the base. There is some evidence of 0.3 m of sandy loam fill in the area of the corner which may have also contributed to settlement. The higher clay content of materials



• Yearly rainfall total
□ Smoothed profile, 3 year running mean

Note:
(a) House built
(b) Pipe leak
(c) Stairwell wall cracked, south wall crack noticed.

Kingston records cease 1976, Hobart figures used 1976 to 1981. Hobart average is slightly less than Kingston.

Figure 5. *Graph of annual rainfall, Kingston - 1964 to 1981.*

5 cm

28-10

10/27

below the foundation of the corner is also probably responsible for the seasonal opening and closing of the construction joint as seasonal shrink and swell of the clay occurs. This clay also contains sodium montmorillonite. The pipe leak below the ground floor slab may have initiated movement, but could have been caused by the initial movement itself. As the construction joint is covered with mastic initial movement would not have been noticed as the mastic remained flexible. Only after the mastic became brittle and other cracks occurred would the construction joint crack have become noticeable.

The brickwork survey favours the second theory, that of south-eastern corner settlement. If the construction joint separation was caused by central wall heave, then the brick courses should slope away from the joint and show a 10 mm drop over the distance to the wall corner. The survey indicates that all the brickwork of the south wall slopes down towards the east with the main slope occurring in brickwork on the eastern side of the construction joint, thereby indicating a drop of the south-eastern corner of about 25 mm. The variations in brickwork on the western side of the construction joint are within normal bricklaying errors of ±6 mm. If the slope of brickwork on the western wide is considered to be consistent error and is projected to the south-eastern corner and removed from the overall measured drop of the courses, then the south-eastern corner could be considered to have dropped by about 18 mm. If the construction joint separation is restored, purely by rotation of the wall on the eastern side about a hinge point at foundation level at the base of the joint, the south-eastern corner will be raised approximately 19 mm.

The south wall brickwork will consequently be restored close to the horizontal as will the eastern side of the construction joint. The south-eastern corner will also be partially restored to the vertical, although it would still remain about 25 mm off the vertical, an amount which must be considered as bricklaying error. The rotation of the eastern section of the south wall will also restore the east wall brickwork to the horizontal, as the brickwork survey indicates a 17 mm drop of mortar courses across the laundry entrance.

It should be noted that the above measurements are approximate. Assumptions have been made as to vertical and horizontal bricklaying errors. Measurements do appear to be of the right order and the restoration of the construction joint separation by rotating the eastern block of the south wall will restore brick course measurements close to the horizontal. It therefore appears that there is good evidence to indicate settlement of the south-eastern corner of the house rather than heave in the central part of the southern wall. Crack distribution around the laundry entrance, inside the laundry, WC, and master bedroom are consistent with this movement, although not of the same magnitude due to the method of house construction. Internal blockwork is placed on the floor slab and therefore the outer wall leaf is virtually free to move independently of the internal walls. Cracking and displacements described in Locke's report concerning stairwell wall cracks and roof displacement can also be explained by roof movements associated with south-east corner settlement. There does seem to be an absence of major cracking in the east wall, to account for the amount of settlement. The only explanation is that the movement has been taken up progressively by the major cracks observed, together with minor cracks. Some flexing is also possible and some minor cracking may not be observed unless a very detailed inspection of all mortar joints is conducted. Even if the magnitude of settlement is incorrect and there is a central wall heave component in the construction joint separation, the evidence still indicates some settlement of the south-eastern corner, especially since there is seasonal opening and closing of the joint. The foundation of the south wall is likely to have failed in the region of the WC drain pipe, approximately 0.5 m to the west of the construction joint. The foundation is also thinnest in this area and the reinforcing mesh is exposed and appears to have only been placed at the bottom of the foundation, providing little resistance to the type of movement described above. The foundation may also have been cracked during placement of the WC drain pipe, as part of the foundation has been removed to provide access for this pipe.

Cracking of the garage may also be caused by foundations not being built to specifications. The main problem is associated with the garage moving away from the house by approximately 10 mm. The cause is related to the expansive clay and dry conditions over the past few years. The foundations are also separate from the house foundations, thereby allowing freedom of movement between the garage and house. This type of cracking is expected in most structures designed in this way and is not necessarily a sign of structural weakness. The magnitude of the cracking is, however, disconcerting to the owner and may, as in the case of the south wall, be related to foundation construction which is not to specification.

CONCLUSIONS AND RECOMMENDATIONS

The main construction joint crack on the southern wall appears to have been largely caused by settlement of the south-eastern corner. Failure of the foundation has probably occurred in the area of the WC drain pipe, approximately 0.5 m to the west of the construction joint. Here the foundation is thinnest and has been damaged in order to place the drain pipe. This point of failure has acted as a hinge for wall movement, with the eastern side rotating about this point as settlement of the south-eastern corner occurred. Relative settlement of the corner must be about 19 mm to produce the measured separation of the construction joint. A survey of brick courses on the southern and eastern walls tends to confirm movement of this order. Crack patterns inside the house can be related to the movement postulated. A relative eastward movement of the house roof with associated cracking and displacement of eaves quad has been produced in the same way.

The foundations of the south wall have not been built to design specifications and are inadequate compared with current standards. They are not as wide, about one half as thick and about one half as deep as specified. It also appears that the top layer of trench mesh has been omitted. The footings are not continuous along the southern wall with the last 0.75 m of the eastern corner largely composed of concrete blocks. Reinforcing is exposed and rusting in some areas. The foundation construction is undoubtedly related to house damage observed.

The foundations are underlain by plastic, expansive clay which has high linear shrinkage properties. Seasonal moisture variations in such materials undoubtedly cause shrinking and swelling which is considered responsible for the seasonal opening and closing of the construction joint. Rainfall during the past five years has been well below average and this has resulted in a general shrinkage of expansive clay, causing numerous problems with cracking buildings elsewhere. The dry conditions are considered to be a major factor in the development of cracking in the house under investigation, the inadequate foundations being unable to withstand these conditions. Excavation for the house construction has been minimal, however there may be up to 0.3 m of sandy fill in the south-eastern corner and along part of the eastern wall. The presence of sandy fill under the south-eastern corner could be responsible for the corner settlement.

Cracking between the house and garage is expected, as the garage foundations are independent. The magnitude of cracking is large and may be related to inadequate foundations in this area. Here again, the unusually dry conditions and underlying expansive clay are considered to be the cause.

It is suggested that a structural engineer be consulted as to the best remedial methods to restore the stability of the south wall. It is likely that the least expensive solution is underpinning the south wall foundation. From the investigation, the most suitable founding materials occur at a depth of about 1.7 m, at which depth seasonal moisture variations would be small. Once the wall is underpinned and stabilised other associated cracks *etc*. can be cosmetically repaired. All earthernware drainage pipes should be checked for leakage or possibly replaced by flexible PVC pipes. An area of paving should be placed along the south and eastern walls to prevent ingress of water adjacent to the foundations. Further monitoring of the construction joint and horizontal survey lines should continue. Seasonal moisture profiles should also be determined.

[27 July 1982]

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TASMANIA DEPARTMENT OF MINES

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration

1 2 3

No resistance

ranging to

refusal

Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undistributed 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

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

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. CM1

sheet 1 of 1

15/27

project	C. Meech	location	4 Carinya Street, Blackmans Bay
co-ordinates	EN260384	drill type	75 mm hand auger
		drill method	Auger screw
R.L.	≃50 m		
inclination	vertical	drill fluid	
bearing			

hole commenced	20.5.82
hole completed	20.5.82
drilled by	R. Woolley
logged by	D.J. Sloane
checked by	D.J.S.

notes samples, tests	depth (metres)	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components)	moisture condition	consistency density index	structure, geology
	0 – 0.2 – ~0.32	SM	SILTY SAND: Brownish black. Medium to fine quartz sand.	M	L	Topsoil and fill(?)
D (0.6), D (1.0)	0.4, 0.6, 0.8, 1.0	CH	CLAY: High plasticity. Dull yellow-orange. Some fine to medium quartz sand. Lenses(?) or minor layers of (CL) sandy clay. Bright yellowish brown.	M	St	
D (1.3), D (1.7)	1.2, 1.4, 1.6, 1.8	CL	SANDY CLAY: Moderate plasticity. Mottled light grey to bright yellowish brown to dull yellow-orange. To 40% medium quartz sand. Trace muscovite mica.	M	St	
D (1.9)	1.8 – 2.0	SC	CLAYEY SAND: Medium quartz sand. Bright yellowish brown to dull yellow-orange. Some reddish brown mottles. Trace mica.	M	Fb	

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. CM2

sheet 1 of 1

16/27

project	C. Meech	location	4 Carinya Street, Blackmans Bay

co-ordinates	EN260384	drill type	75 mm hand auger	hole commenced	20.5.82
		drill method	Auger screw	hole completed	20.5.82
R.L.	≈50 m			drilled by	R. Woolley
inclination	vertical	drill fluid		logged by	D.J. Sloane
bearing				checked by	D.J.S.

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
				0		SM	SILTY SAND: Brownish black. Medium to fine quartz sand. Some silt.				Topsoil and fill?
				0.2							
				0.4		CH	CLAY: High plasticity. Yellowish brown to dull yellowish brown. Approx. 20% medium quartz sand.	M	VSt		
			D	0.6							
				0.8			Some CL SANDY CLAY layers and lenses with up to 40% medium quartz sand.	M	St		
				1.0							
			D	1.2							
				1.4							
			D			SC	CLAYEY SAND: Medium quartz sand. Bright yellowish brown to greyish yellow-brown. Approx. 20%-30% clay - highly plastic fines. Trace mica increasing with depth.	M	Fb		
				1.6							
				1.8							
							Reddish brown mottling.				
			D	2.0							

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. CM3

sheet 1 of 1

17/27

project	C. Meech	location	4 Carinya Street, Blackmans Bay

co-ordinates	EN260384	drill type	75 mm hand auger	hole commenced	20.5.82
		drill method	Auger screw	hole completed	20.5.82
R.L.	≃50 m			drilled by	R. Woolley
inclination	vertical	drill fluid		logged by	D.J. Sloane
bearing				checked by	D.J.S.

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
				0 – 0.52		SM	SILTY SAND: Brownish black. Medium to fine quartz sand. Some silt.				Topsoil and fill(?)
			D (0.78), D (1.0)	0.52 – 1.08		CH	CLAY: High plasticity. Yellowish brown-dull yellowish brown. Some medium to fine quartz sand.	M	St		
			D (1.24)	1.08 – 1.56		CH-CL	SANDY CLAY-CLAYEY SAND: Medium to low plasticity. Dull yellow-orange to bright yellowish brown. Approx. 50% medium to fine quartz sand.	M	St		
			D (1.67), D (1.98)	1.56 – 2.0		SC	CLAYEY SAND: Medium to fine quartz sand. Bright yellowish brown to dull yellow-orange. Trace mica. Mottled bright reddish brown.	M	Fb		

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. CM4
sheet 1 of 1

18/27

project C. Meech
location 4 Carinya Street, Blackmans Bay

co-ordinates EN260384
drill type 75 mm hand auger
drill method Auger screw
hole commenced 20.5.82
hole completed 20.5.82
R.L. ≈50 m
drilled by R. Woolley
inclination vertical
logged by D.J.Sloane
drill fluid
bearing
checked by D.J.S.

notes samples, tests	metres depth	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency density index	structure, geology
	0 – 0.4	SM	SILTY SAND: Brownish black. Medium to fine quartz sand. Some silt.	M	L	
D	0.4 – 0.8	CL-CH	CLAYEY SAND-SANDY CLAY: Bright yellowish brown. Approx. 50% fine to medium quartz sand. 50% plastic fines.	M	F	
D, D	0.8 – 1.6	CH	CLAY: high plasticity. Yellowish brown to bright yellowish brown. Some medium to fine quartz sand.	M	VSt	
D, D	1.6 – 2.0	SC	CLAYEY SAND: Light grey to light yellow-orange. Medium to fine quartz sand. Trace mica. Plastic fines.	M	Fb	

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. CM5

sheet 1 of 1

ENGINEERING LOG – BOREHOLE

project	C. Meech	location	4 Carinya Street, Blackmans Bay
co-ordinates	EN260384	drill type	75 mm hand auger
		drill method	Auger screw
R.L.	≃50 m		
inclination	vertical	drill fluid	
bearing			
hole commenced	5.7.82	hole completed	5.7.82
drilled by	C. Meech	logged by	D.J. Sloane
checked by	D.J.S.		

notes samples, tests	depth (metres)	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency density index	structure, geology
	0 – 0.4	SM	SILTY SAND: Brownish black. Medium to fine quartz sand. Some silt.	M	L	
D	0.4 – 0.8	CH	SANDY CLAY: High plasticity. Bright yellowish brown. Approx. 15% medium quartz sand.	M	VSt	
D, D, D, D	0.8 – 1.4	SC	CLAYEY SAND: Yellowish brown to bright yellowish brown medium quartz sand. Approx. 30%-40% plastic fines. Trace mica (at ~1.3)	M	VSt	
D, D	1.4 – 2.0	SC	CLAYEY SAND: Light grey to light yellow-orange. Medium fine quartz sand. Trace mica. Approx. 15% plastic fines. Minor (CH) clay lenses or layers.	M	Fb	

Column headings also printed: penetration 1 2 3, support, water, R.L., graphic log, hand penetrometer kPa 25 50 100 200 400

Depth marks: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0

Samples (D) at approx. 0.5, 0.8, 1.0, 1.3, 1.4, 1.5, 2.0 m

20/27

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. CM6

sheet 1 of 1

project C. Meech — location 4 Carinya Street, Blackmans Bay

co-ordinates	EN260384	drill type	75 mm hand auger	hole commenced	5/7/82
		drill method	Auger screw	hole completed	5/7/82
R.L.	≈50 m			drilled by	C. Meech
inclination	vertical	drill fluid		logged by	D.J. Sloane
bearing				checked by	D.J.S.

notes samples, tests	depth (metres)	classification symbol	material (soil type: plasticity or particle characteristics, colour, secondary and minor components.)	moisture condition	consistency density index	structure, geology
	0 – 0.3	SM	SILTY SAND: Brownish black. Medium to fine quartz sand. Some silt.	M	L	
D	0.3 – 0.68	SC	CLAYEY SAND: Bright yellowish brown. Medium to fine quartz sand, some silt. Approx. 20% plastic fines.	M	D	
D	0.68 – 1.0	CH	SANDY CLAY: High to moderate plasticity. Bright yellowish brown to dull yellow-orange. Approx. 20% medium sand.	M	VSt	
D, D	1.0 – 1.79	SC	CLAYEY SAND: Bright yellowish brown to light grey. Approx. 20%-30% plastic fines. Medium quartz sand. Some lenses(?) or thin layers of high plasticity, dull yellowish brown (CH) clay.	M	VSt	
D	1.79 – 1.93	CH	CLAY: High plasticity. Light grey to light yellow-orange. Approx. 10% medium quartz sand.	M	St	
D	1.93 – 2.0	SC	CLAYEY SAND: Bright yellowish brown to light yellow-orange. 20% highly plastic clay fines.	M	Fb	

Depth marks: 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, 1.4, 1.6, 1.8, 2.0

TASMANIA DEPARTMENT OF MINES

5 cm

ENGINEERING LOG – BOREHOLE

borehole no. CM7

sheet 1 of 1

21/27

project	C. Meech		location	4 Carinya Street, Blackmans Bay	
co-ordinates	EN260384	drill type	75 mm hand auger	hole commenced	5.7.82
		drill method	Auger screw	hole completed	5.7.82
R.L.	≈50 m			drilled by	C. Meech
inclination	vertical	drill fluid		logged by	D.J. Sloane
bearing				checked by	D.J.S.

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
				0		SM	SILTY SAND: Brownish black. Medium to fine quartz sand. Some silt.	M	L		Topsoil
				0.2							
				0.4		CH	SANDY CLAY: High to moderate plasticity. Yellowish brown. Approx. 15% medium quartz sand.	M	VSt		
			D	0.6							
				0.8							
				1.0		SC	CLAYEY SAND: Dull yellow-orange to bright yellowish brown. Medium quartz sand. Approx. 20%-30% plastic clay fines. Some lenses(?) and/or layers of CH clay.	M	Fb		
			D								
				1.2							
			D	1.4			Becoming mottled - light yellow-orange and light grey.				
				1.6							
			D				Trace muscovite mica.				
				1.8							
			D	2.0							

APPENDIX 2

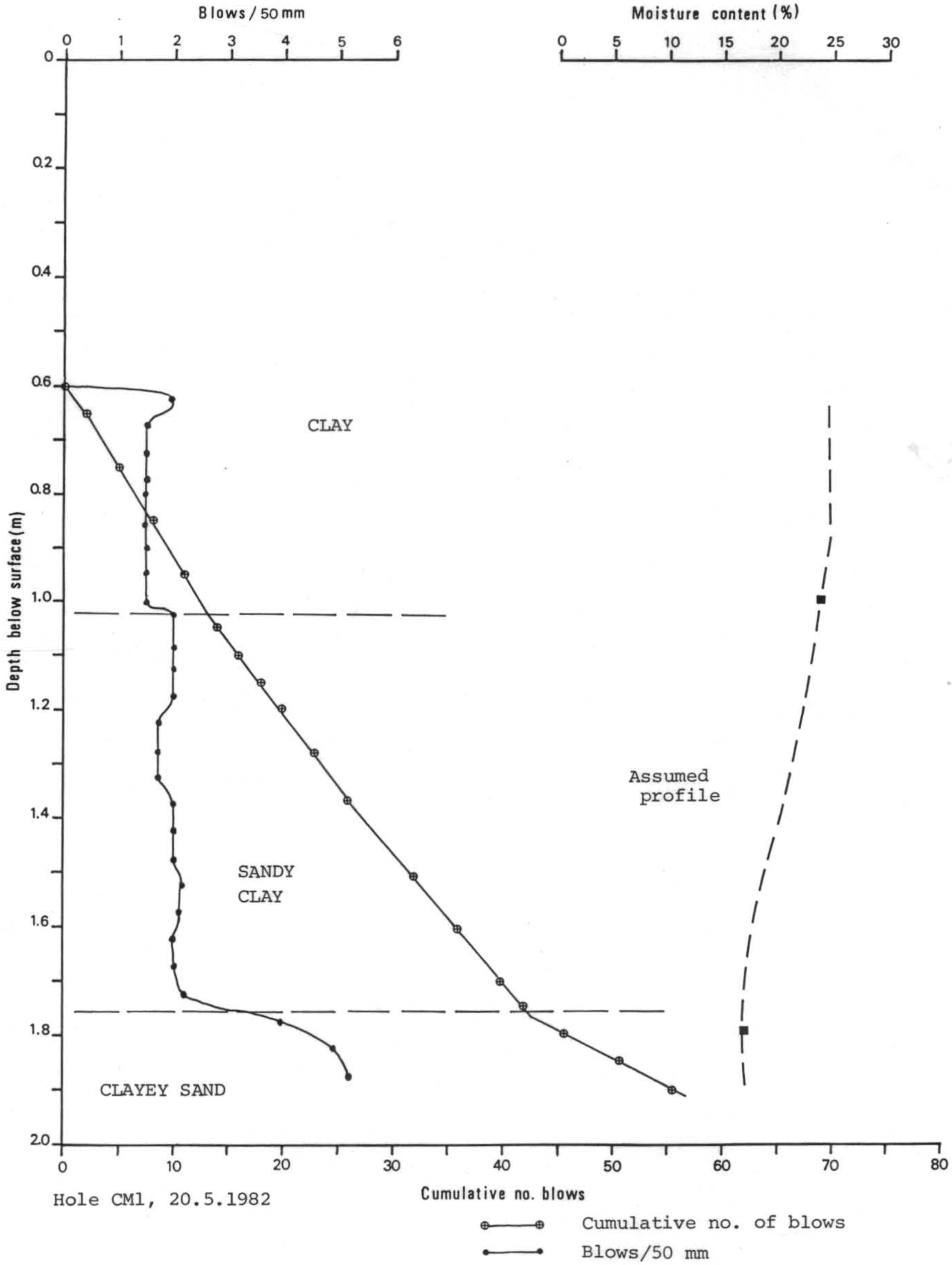
Penetrometer probe and laboratory test results

SLIDING WEIGHT PENETROMETER RESULTS

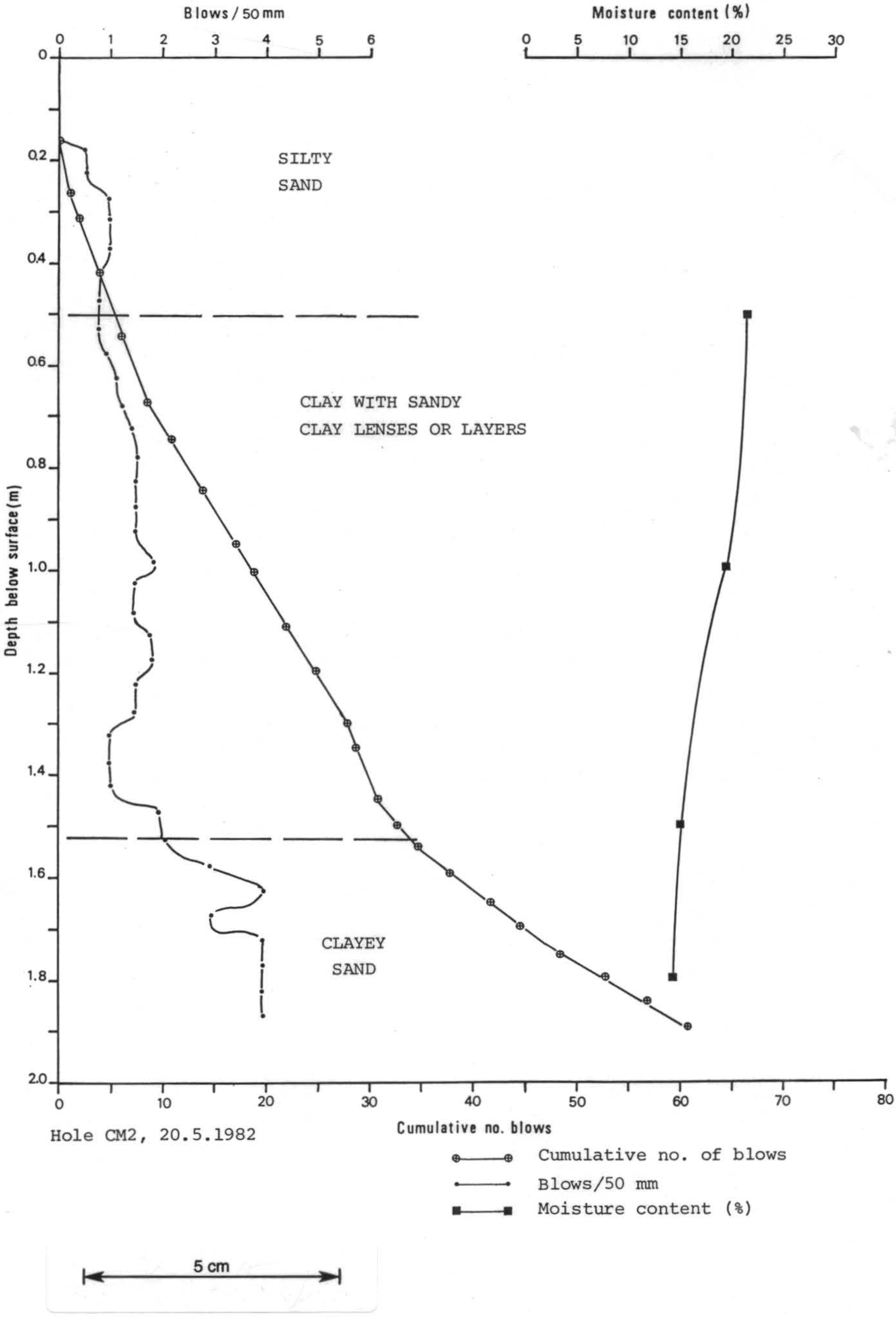
Weight	9.1 kg	Cone angle	15°
Fall distance	0.5 m	Cone diameter	20 mm

Graphs show number of blows to drive penetrometer cone 50 mm and also shows cumulative number of blows to a particular depth. Moisture profiles have also been included on the graphs.

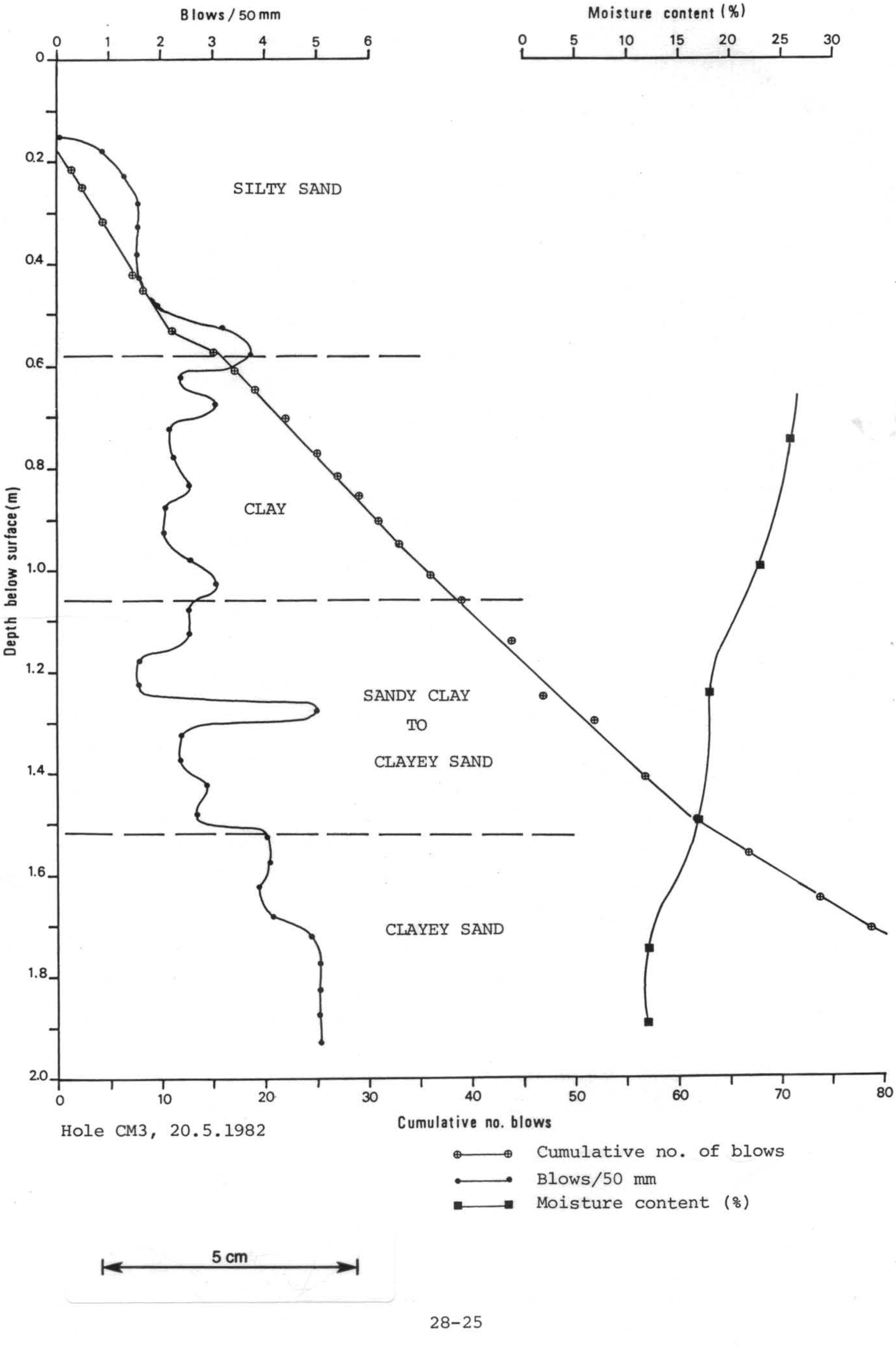
Hole number	Depth (m)	Moisture content (%)	Liquid limit (%)	Plastic limit (%)	Linear shrinkage (%)	Clay type
CM1	1.0	24	69	24	17	Illite, kaolinite, Ca montmorillonite
	1.8	17				
CM2	0.5	22				
	1.0	20	67	23	16	Kaolinite, illite, Ca montmorillonite
	1.5	16	59	25	13	
	1.8	15				
CM3	0.75	26	70	23		
	1.0	23	65	22	15	Kaolinite, illite, Na montmorillonite
	1.25	18				
	1.5	17	48	20		Kaolinite, illite, Na montmorillonite
	1.75	13				
	1.9	13				
CM4	0.5	25				
	1.0	24				
	1.3	20				
	1.55	18				
	1.8	16				



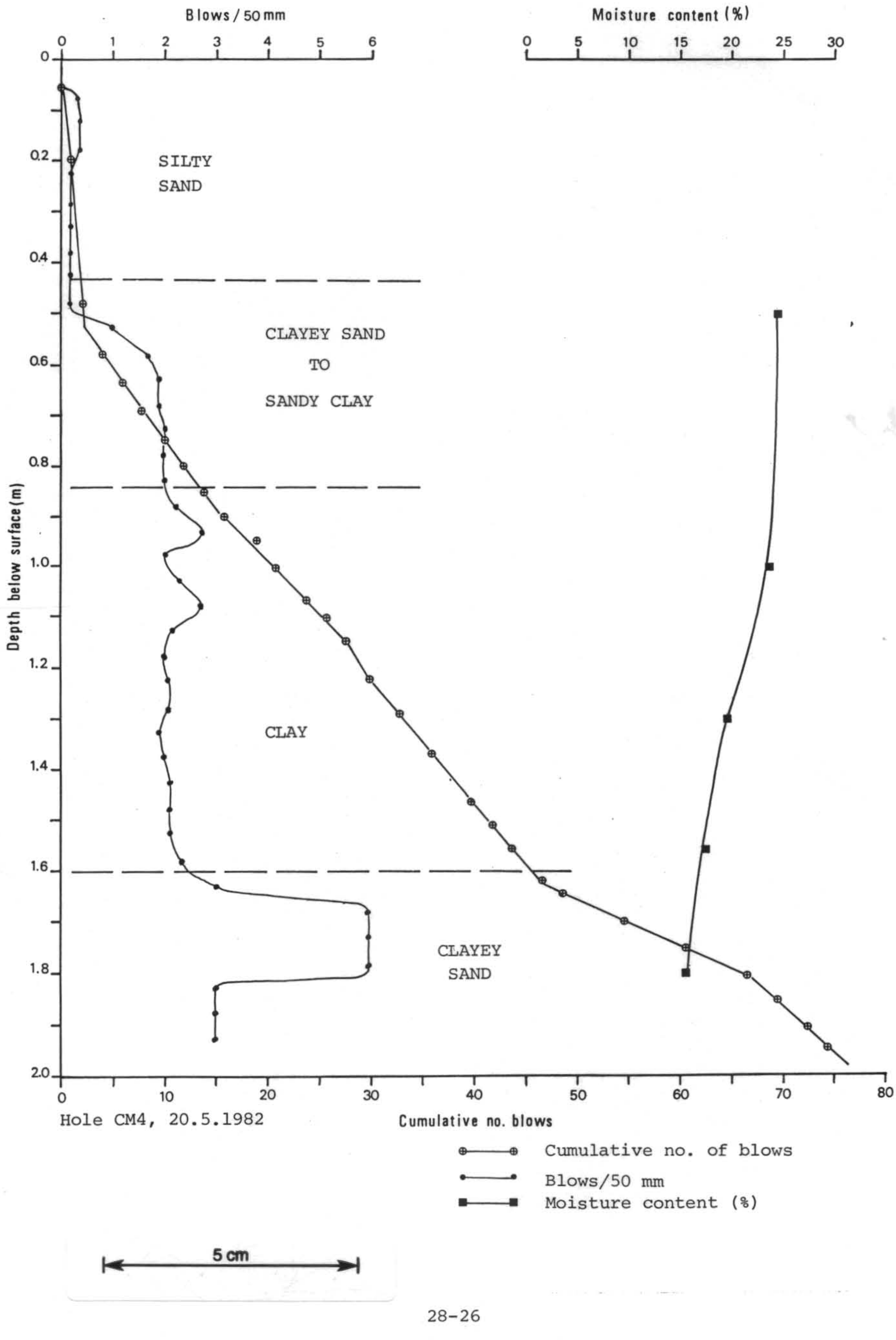
Hole CM1, 20.5.1982



Hole CM2, 20.5.1982



Hole CM3, 20.5.1982



Hole CM4, 20.5.1982

NORTH
SOUTH
East Wall of Laundry
Shows Cracking on South Wall of Laundry Entrance
EAST (REAR)
WEST (FRONT)
SECTION 'A-A'
KITCHEN
LOUNGE
BATH
BED 1.
Flashing Separation
SITE 1/16" = 1'0"
CARINYA STREET
NORTH
Indicates Location of Main Internal Cracks
LIVING
DINING
KITCHEN
LOUNGE
LANDING
MASTER BED
LAUNDRY
BEDROOM 1.
PASSAGE
BATHROOM
BEDROOM 2
ENTRY
CARPORT
GARAGE
CM1
CM2
CM3
CM4
CM5
CM6
CM7
FOOTINGS
ROOF
1ST FLOOR
GROUND FLOOR
FOOTING
5 cm
LIGTH SCALE WORKING DRAWING
BESSER BLOCK HOUSE
FOR MR. & MRS. C.A. MEECH
AT LOT 167 CARINYA STREET
BLACKMANS BAY TASMANIA
M033/1
DAVID KELLY
ARCHITECT
43 BRISBANE STREET
HOBART 7000
TELEPHONE

Figure 1.