

UR1987_30

1987/30. Stability assessment of a proposed subdivision at Flinders Street, Beauty Point.

D. J. Sloane

Abstract

Approximately half of a proposed subdivision area between Robert and Flinders Streets, Beauty Point, is zoned as a Landslip 'B' area. The Landslip 'B' area is moderate to steeply sloping (8°-14°), and morphological features suggest that part of the area may be an old landslide. Stability investigations have therefore been conducted in order to determine the suitability of the site for subdivision and subsequent building development. The remainder of the site has low slopes (7.5°-4°), and is therefore suitable for development.

Auger drilling, disturbed and undisturbed sampling, and a seismic survey have confirmed that the slopes are underlain by high plasticity (CH) clay which has possibly been previously disrupted.

Stability analysis of a selected slope profile indicates that the slope is marginally stable in the short term. The lowest acceptable value of the factor of safety is 1.3 at a pore pressure ratio of 0.2. It is therefore considered that the sloping area of land, zoned Landslip 'B', is unsuitable for building development. The remainder of the area is considered suitable for development.

Tunnel erosion has occurred in a small gully which traverses the site. Continued erosion will result in further tunnel collapse and eventual gullying. Building development must be arranged in order to avoid this erosion hazard, if successful rehabilitation cannot be undertaken.

INTRODUCTION

At the request of J. and K. Stone of the Astra Motel, Beauty Point, an investigation was conducted to determine the stability of an area of land between Robert and Flinders Streets. The owners have proposed to subdivide the area into three lots as shown on the site plan (fig. 1).

Approximately half of the area is classified as a 'Landslip B' area under Section 431A of the Local Government Act, Statutory Rule No. 107 of 1984.

A visual site inspection indicated that the steeply sloping section of the area was marginally suitable for subdivision and a geotechnical investigation was required to determine the overall stability of the site.

Three seismic spreads were fired on the site and two auger holes were drilled to a depth of 5.2 m. Disturbed and undisturbed drive tube samples were obtained for later laboratory determination of geomechanical properties and clay analysis.

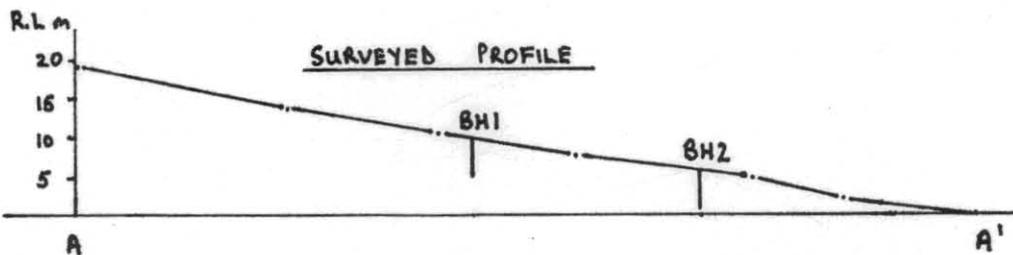
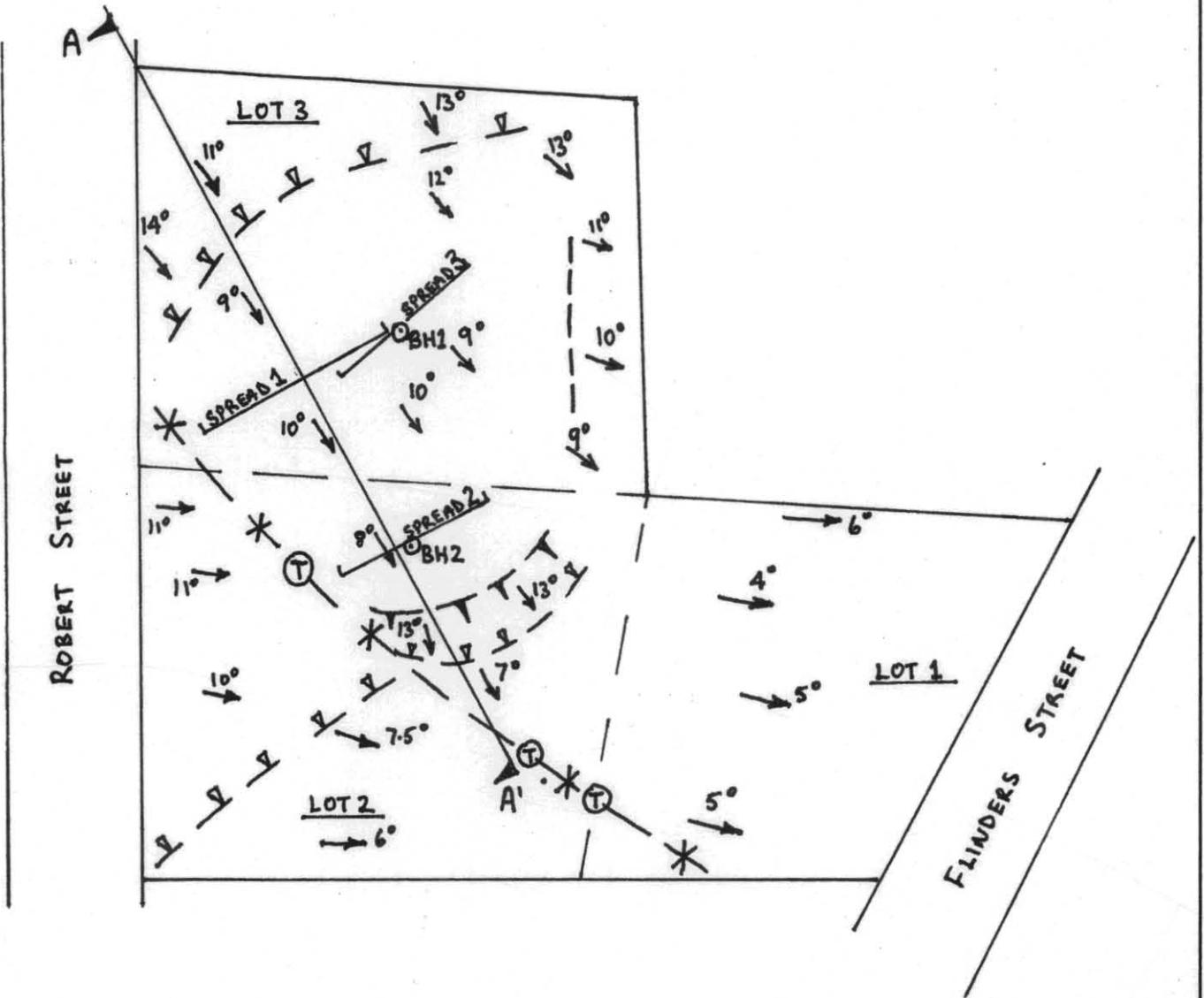
TOPOGRAPHY AND GEOLOGY

The area under investigation is situated towards the foot of the upper escarpment slopes at Beauty Point. Further to the north, in the township area, Tertiary gravel and sandy clay overlie basalt which crops out on the escarpment face. Soils derived from weathered basalt are exposed in an embankment adjacent to Robert Street to the west. Immediately to the

TASMANIA DEPARTMENT OF MINES SITE PLAN

2/11

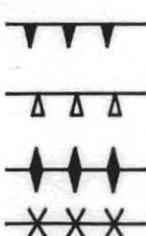
OWNER: J. STONE STREET/ROAD: FLINDERS ST GEOLOGIST: J. SLOANE
 SUBURB: TOWN/CITY: BEAUTY POINT DATE: 25/5/87



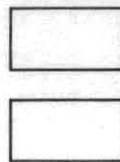
SCALE:

⊙ BH1 - Borehole

SPREAD 1 - SEISMIC SPREAD



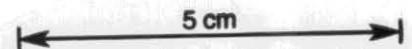
Convex break of slope
(profile form: )
 Concave break in slope
(profile form: )
 Ridge crest
 Gully ⊙ Collapsed tunnel



Suitable area for building
 Suitable area for septic outfall



Slope angle and direction



north, basalt boulders crop out on a small ridge, indicating that bedrock is probably present at shallow depth. The upper slopes of the proposed subdivision have occasional basalt boulders on the ground surface, but Tertiary sediments are expected to underlie most of the subdivision area.

The northern half of the area has slopes of between 8° and 14°. A moderate to steeply sloping section (11°-14°) occurs in the north-western corner of Lot 3, at the rear of a small terrace (8°-10°) which occurs over the remainder of the lot. At the lower edge of the terrace an arcuate, steeply sloping (13°) segment is present on Lot 2. The morphology of the area described above has features which may be associated with an old landslide. The remainder of Lot 2 and Lot 1 has low slopes (4°-7.5°).

A small gully bisects Lot 2 in a NW-SE direction. Tunnel erosion is evident along the base of this gully. Several circular holes have resulted from tunnel collapse. The gully runoff is contributed to by drainage from Robert Street to the west. The owner of the adjacent property to the south reports that flooding occurs adjacent to Flinders Street, with water both appearing out of and disappearing into holes in this area.

RESULTS OF AUGER DRILLING

Two auger holes have been drilled to a depth of 5.5 m. The bore logs are presented in Appendix 1. In summary, the materials encountered in the auger holes were high plasticity, greyish-yellow-brown clays (CH). A small intersection of sandy clay (CL) was encountered in hole S1 at a depth of 3.4 m. The undisturbed sample from hole S1 at a depth of 2.7 m has the texture of extremely weathered basalt. This basalt may be *in situ*, or may represent a weathered boulder or 'floater'. Most of the samples taken had a moisture content equal to or greater than the plastic limit. No free groundwater was encountered during drilling.

The two undisturbed, 70 mm square, drive tube samples indicated that the clays are fissured and sheared to some extent, with slickensided surfaces evident. Secondary clay cutans occur along many of the fissures, and iron mineral coating was observed in the sample from hole S1 at a depth of 5.2 metres. The fissure coatings and shear surfaces indicate that disruption of the sediments has occurred in the past, as well as groundwater movement through the fissures.

SEISMIC SURVEY RESULTS

The results of three seismic spreads are presented in Appendix 2. In summary, the results show that bedrock does not occur at shallow depth and clay or sandy clay extends to depths of at least 10 m from the ground surface.

The first layer velocities of 250 m/sec to 360 m/sec extend to depths varying between 0.9 m and 2.2 m, and are considered to represent unconsolidated material such as topsoil or clay and sandy clay with extensive dessication cracking.

The second layer velocities vary according to the position on the slope. Spreads 1 and 3 show calculated velocities between 900 m/sec and 1050 m/sec but lower down the slope the velocities are between 570 m/sec and 740 m/sec. This variation in velocity is related to the sediment density, water content, and the degree of fissuring.

The results from seismic spread 1 show a subvertical slow velocity seam, possibly up to five metres in thickness and located near the centre of the spread. The nature of this anomaly is uncertain but it may represent a gravel seam.

LABORATORY RESULTS

The results of laboratory testing by R. N. Woolley of the Department of Mines are presented below.

Hole No.	Depth (m)	Liquid Limit	Plastic Limit	Linear Shrinkage (%)	Angle of internal friction ϕ' r	Cohesion c'r (kPa)
1	2.5 - 2.7	94	25	22	21°	6.3
1	5.2 - 5.5	103	25	24	11°	2.6

X-RAY DIFFRACTION RESULTS

Hole No.	Depth (m)	Composition (%)
1	2.5 - 2.7	Kaolinite 60, halloysite 25, montmorillonite 10, talc 5
1	5.2 - 5.5	Kaolinite 70, montmorillonite 25, illite 5

Liquid and plastic limit results for the two samples are very similar. The results reflect the highly plastic nature of the clays. Linear shrinkage results indicate the high shrink-swell characteristics of the materials. These results can be taken as indicative of the clay properties over the entire site and must be carefully considered when designing the foundations of buildings to be constructed.

The laboratory results of undrained shearbox testing show marked variations. The sample of weathered basalt-derived clay from a depth of 2.5 m in hole S1 shows much higher results (ϕ' r = 21°, c'r = 6.3 kPa) than the lower sample from a depth of 5.2 m (ϕ' r = 11°, c'r = 2.6 kPa). The differences can be explained by the origin of the samples; the upper sample is composed of weathered basalt while the lower sample is a sedimentary clay. The difference in properties is also mirrored by the X-ray diffraction analysis results, which show that the upper sample contains 10% of the clay mineral montmorillonite but the lower sample has a 25% montmorillonite content. Montmorillonite has high shrink-swell characteristics and weak interlayer bonding in its structure. The presence of this clay mineral is usually conducive to slope failure.

STABILITY ANALYSIS

Stability analysis has been performed on the surveyed slope profile shown on Figure 1 and the analysis sheet presented in Appendix 3. The laboratory test results from undisturbed samples have been used in the analysis.

Cousins Charts and Bishop's simplified slip circle method have been used. The slip circle chosen for analysis passes through the toe of the steep slope segment on Lot 2 and through the break of slope at the rear of the terrace section on Lot 3. This slip circle has been chosen after careful examination of the morphology of the area.

Sheared and fissured clays have been observed at the base of auger hole S1 and therefore the laboratory determined properties of this clay have been used in the analysis. The shearing may represent a previous failure zone and these properties should also be used as any future failure is likely to involve the weakest materials. Residual values of cohesion and the angle of internal friction have been used as there is a high chance that previous instability has occurred.

The properties used in the stability analysis are shown on the computation sheet included in Appendix 3. The results are shown as Factors of Safety (FS) in relation to pore pressure ratios (ru). A pore pressure ratio of 0.5 occurs when the assumed slip is totally saturated and a ratio of 0.25 occurs when the slip is half saturated.

In summary, the lowest acceptable factor of safety is considered to be 1.3 at a pore pressure ratio of 0.2. If the pore pressure ratio is any higher then the factor of safety is considered unacceptable, assuming the given conditions and clay properties. It is considered that the pore pressure ratio of the analysed slip circle is unlikely to be always below 0.2 under natural conditions. Therefore the slope is considered to be only marginally stable in the short term. For long term stability the cohesion should perhaps be considered as zero, further reducing the factor of safety.

CONCLUSIONS

Approximately half of a proposed subdivision area between Robert and Flinders Streets, Beauty Point, is zoned as a Landslip 'B' area. The Landslip 'B' area is moderate to steeply sloping (8° - 14°), and morphological features suggest that part of the area may be an old landslide. Stability investigations have therefore been conducted in order to determine the suitability of the site for subdivision and subsequent building development. The remainder of the site has low slopes (7.5° - 4°) and is therefore suitable for development.

Auger drilling, disturbed and undisturbed sampling, and a seismic survey have confirmed that the slopes are underlain by high plasticity (CH) clay. Within the clay, secondary iron mineral and clay cutan deposition is associated with shear surfaces and fissures. These features suggest previous disruption of the sediments and groundwater movement within them.

Laboratory testing has confirmed the highly plastic nature and high linear shrinkage properties of the clays. Montmorillonite clay is also present in varying proportions.

Stability analysis of a selected slope profile indicates that the slope is marginally stable in the short term. The lowest acceptable value of the factor of safety is 1.3 at a pore pressure ratio of 0.2, when considering the suitability of the area for building development. An acceptable pore pressure ratio of 0.2 indicates that the slope would be required to be drained effectively to a depth of six metres from the ground surface. In practice, this level of drainage is not considered feasible.

It is therefore considered that the sloping area of land, zoned Landslip 'B', is unsuitable for building development. The remainder of the area, as indicated on Figure 1, is considered suitable for development. A reassessment of the subdivision layout could be made on the basis of the above advice.

In order to assess, contain and rehabilitate the tunnel erosion which has occurred in the small gully which traverses the site, advice should be obtained from the Department of Agriculture. Continued erosion will result in further tunnel collapse and eventual gullying. Building development must be arranged in order to avoid this erosion hazard, if successful rehabilitation cannot be obtained. It is considered that drainage from Robert Street contributes to the problem and the Beaconsfield Municipal Council should also examine the extent of tunnelling adjacent to, and possibly under Flinders Street.

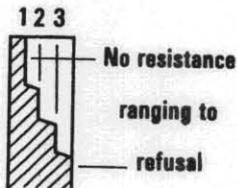
Wherever possible, trees and shrubs should be planted on the steeply sloping sections of the area. Investigations elsewhere in the world have demonstrated the benefits of vegetation in maintaining and preserving slope stability. Vegetation assists by root binding and groundwater transpiration, effectively lowering pore pressures and increasing cohesion.

[22 June 1987]

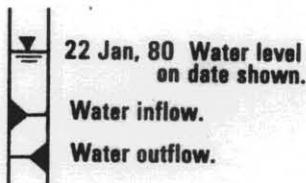
EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water



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. | |

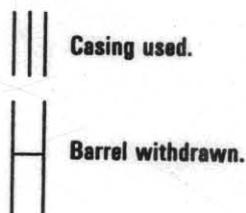
Notes: X on log is test result
— is range of results.

Density index

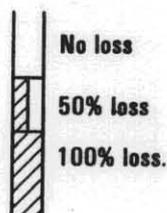
- | | | |
|----|---------------|----------|
| | | % |
| VL | Very loose. | 0 - 15 |
| L | Loose. | 15 - 35 |
| MD | Medium dense. | 35 - 65 |
| D | Dense. | 65 - 85 |
| VD | Very Dense | 85 - 100 |

Cored borehole log

Case - lift



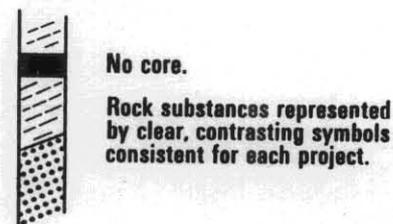
Fluid loss



Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 48 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.

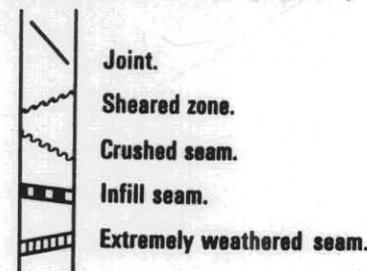
Strength

- | | | |
|----|-----------------|--|
| | | point load strength index $I_{s(100)}$ (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

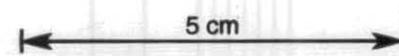
Significant defects shown graphically.



ENGINEERING LOG - BOREHOLE

project J. STONE	location FLINDERS - ROBERT ST., BEAUTY POINT
co-ordinates 484754425	drill type TRIEFUS
R.L. \approx 25m	drill method AUGER SCREW
inclination Vertical	drill fluid
bearing	hole commenced 24/3/87
	hole completed 24/3/87
	drilled by B.C.
	logged by D.J.S.
	checked by

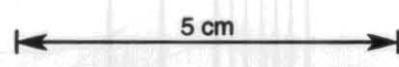
penetration	support	water	notes samples, tests	metres	R.L.	depth	graphic log	classification symbol	material soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency	density index	hand penetrometer kPa	structure, geology
1 2 3													25 50 100 200 400	
				0				SM	SILTY SAND: Brownish grey, medium quartz sand	D	L			AI SOIL HORIZON
			D	1				CH	CLAY: Brownish-grey, brown. High plasticity. Trace fine quartz sand. Trace limonite nodules to 5mm diameter.	M _h	PL	VSt		
			D	2				CH	CLAY: Greyish yellow brown. High plasticity. Trace fine sand. Some EW lithic fragments. Trace limonite nodules to 4mm diameter.	M _h	PL	VSt		
			D	3				CH	CLAY: Yellowish-brown, High plasticity. Trace fine sand.	M _h	PL	St		
			D	4				CH						
			D	5				CH						
			U70 □	5										
				6					END - 5.7m					



ENGINEERING LOG - BOREHOLE

project J. STONE	location FLINDERS- ROBERT ST., BEAUTY POINT	
co-ordinates 484754425	drill type TRIEFUS	hole commenced 24/3/'87
R.L. ≈ 25m	drill method AUGER SCREW	hole completed 24/3/'87
inclination Vertical	drill fluid	drilled by BC
bearing		logged by DJS
		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	structure, geology
			0		SM	SILTY SAND: Brownish grey, medium quartz sand	D	L			A1 SOIL HORIZON
			1		CH	CLAY: Greyish yellow brown - dull yellowish brown. High plasticity. Trace fine quartz sand. Trace limonite to 4mm	M<	VSt			
			2								
			3								
			4		CL	SANDY CLAY: Yellowish brown - greyish yellow brown. 15-20% medium - fine quartz sand. Moderate plasticity	M≈	VSt			
			5		CH	CLAY: Greyish yellow brown - yellowish brown. Trace fine sand. High plasticity.	M>	S-F			



APPENDIX 2

Summary of seismic spreads - J. and K. Stone, Beauty Point

SPREAD NO.	TRACE SYMMETRY	SHOT POINT	LAYER VELOCITY (m/sec)	LAYER THICKNESS (m)	DEPTH TO INTERFACE (m)	REMARKS
1	Symmetric. Central step - both ways	West	1. 310	1.8	1/2 = 1.8	Central step indicates slow subvertical seam 5? m at spread centre. Minimum possible depth to bedrock 10 m.
			2. 1000			
		East	1. 360	2.2	1/2 = 2.2	
			2. 1000			
2	Slightly assymmetric	West	1. 250	0.9	1/2 = 0.9	Minimum possible depth to bedrock 10.5 m
			2. 570			
		East	1. 310	2.2	1/2 = 2.2	
3	Slightly assymmetric	West	1. 310	1.6	1/2 = 1.6	Minimum possible depth to bedrock 9.4 m
			2. 1050			
		East	1. 300	1.0	1/2 = 1.0	
			2. 900			

30-10

