REPORT ON SLOPE STABILITY ASSESSMENT
LOT 5 OF PROPOSED SUBDIVISION OF
LOT 4 ON DP 1054848
STOTT STREET - BILAMBIL HEIGHTS

For

(Messrs Jim and Les Dickinson)

(December 2003/January 2004)
Job No. NO/03/699

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REPORT ON SLOPE STABILITY ASSESSMENT
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1.0 INTRODUCTION

Maiden Geotechnics is pleased to present herein, a report on slope stability assessment of Lot 5 of proposed subdivision of Lot 4 on DP 1054848 on Stott Street, Bilambil, as commissioned by Messrs Jim and Les Dickinson for the partially fulfilment of the subdivision development application requirements.

The scope of work includes establishment of the existing ground conditions for the modelling and assessment of the long-term stability of the slopes, and to advise on precautionary measures for ensuring and/or maintaining the stability of the slopes for future buildings and other engineering structures.

The report also examines the suitability of various footing systems for the support of future buildings across the site, and classification of the site in accordance with the Australian Standard AS2870 – 1996.

2.0 EXISTING SITE FEATURES

Stott Street in Bilambil Heights is just under 0.5km from Piggabeen Road through Skyline Drive. The subject site is made up of two sections as shown on the site plan provided. The two sections are herein referred to Site A and Site B. Site A extends westward from Stott Street, and is directly opposite a new Aged Care Facility, which was under construction and near completion at the time of this investigation.

It is 165.8 metres long along Stott Street, and approximately 75 and 230 metres wide, respectively at the northern and southern ends. The ground surface slopes gently at an estimated grade of 1 in 18 into a steep escarpment at the western extremities. At the time of this investigation, the site was sparsely vegetated at the northern half. The southern half was being used for fruit farming.

Site B is situated behind the aged care facility at the eastern side. Access is by a private community road from Stott Street cul-de-sac. It measures approximately 25m, and 50m and 100m at the northern and southern ends, and the mid-sections respectively.

It extends some 150m in the north-south direction.

The site overlooks the Tweed River and slopes at an estimated surface grade of 1 in 5 towards the east. The ground surface was heavily vegetated at the time of this investigation.

3.0 INVESTIGATION TECHNIQUES

3.1 Field Tests

Fifteen (15) test pits, eleven at Site A and four at Site B were excavated across the two sites to determine the subsurface conditions. The test pit were either terminated on refusal or extended to the maximum reach of the excavation machine. The maximum depths varied between 1.1 and 2.7 metres. Hitachi Zaxis 30U mini-excavator was used for the test pits excavation.

In-situ tests included dynamic cone penetrometer (DCP) tests at selected test pit locations, and pocket penetrometer tests on the sides of the test pits. The test pits locations are shown the site plan (figure A1) and presented as part of the appendix. An experienced geotechnical engineer supervised the fieldwork.

3.2 Laboratory Tests

Laboratory classification tests, i.e. determination of Atterberg limits, linear shrinkage and in-situ moisture contents, were conducted on representative samples. The detailed test results are also contained in the appendix. A summary is presented in table 3.1 below.

Table 3.1 – Summary of Laboratory Classification Tests Results

Test Pit No.	Depth (m)	LL (%)	PL (%)	PI (%)	LS (%)	M/C (%)
3	1.6	67	31	36	13.5	23.6
4	1.0	69	36	33	14.5	-
5	1.2	77	34	43	17	32.5
11	1.0	58	37	21	16.5	33.3

4.0 GROUND CONDITIONS

4.1 Regional Geology

The site is situated within the meta-sedimentary Neranleigh-Fernvale Beds. The main rock units include shales and sandstones, and some basalt and argillaceous rocks.

4.2 Results of Test Pits Excavations

4.2.1 Fill

Significant amount of fill was identified at the locations of test pits 4, 5, 6A, 6B, 7, 8 and 9. At the locations of test pit 6A, 6B and 7, the fill consisted of rotten vegetation and other organics. At other locations, the fill material included imported "soft" shale fragments and silty clays of similar characteristics as the residual soil. The silty clays and shale fragments appeared to have been controlled filled. The estimated fill depths at the various test pits locations are summarised in table 4.1.

Table 4.1 – Estimated fill depths at the test pit locations

Location (Test Pit No.)	Approximate Fill Depth (m)
4	1.0
5	0.6
6A	2.0
6B	1.0
7	2.2
8	1.5
9	0.5
10	0.3

4.2.2 Residual Soil

The residual soil consists of silty clays and clayey silt of high plasticity and generally very stiff to hard in consistencies. Bedrock was not intercepted at the test pits termination depths. The soil profiles were generally dry or slightly moist, with the in-situ moisture contents generally falling within the plastics limits. No seepage was observed in any of the test pits excavation. The attached test pit logs contained the detailed sub-surface stratification.

5.0 STABILITY EVALUATION

5.1 Analyses

Qualitative and quantitative analyses of the overall site slopes stability assessments are presented, herein. The quantitative analyses were carried out on a typical cross sections across Site A and Site B. The sections were analysed with the slide (version 2.2) slope stability software. The analyses were based on Bishop's simplified methodology the analysis covered both the short-term (total stress analysis) and the long-term (effective stress analysis) conditions.

The analytical sections were derived from the surface contours provided, and the sub-surface profile identified on the test pit logs. Available contours from aerial photographs have been adopted at the western extremities of Site A, and the steep slope along the eastern boundary of Site B.

The design parameters used in the geotechnical models were based on previous experience and reported information on similar materials and strength characteristics. A range of values was investigated. The values summarised in table 5.1 are those used to derive the final stability plots contained in the appendix of this report.

Table 5.1 – Adopted Parameters for the Slope Stability Analyses

Material	Cohesion (kPa)	Friction Angle (Deg.)	Bulk Density (kn/m^3)
Compacted fill	5	26	20
Soft organic clay fill	0	15	18
Very stiff to hard residual clay	10	30	20

For the short-term condition, cohesion values of 100 kPa for the compacted fill and 200 kPa for the residual soil, and friction angle of 0 degrees were adopted. A seismic coefficient of 0.6 was incorporated in all the analyses.

5.2 Results of Stability Analyses

5.2.1 Stablility of Site A

Outside the organic fill (area of test pits 6, 6A & 7) the minimum factor of safety is in excess of 2.0. Across the organic fill, the minimum factor of safety for the long-term is below unity. However, the long-term factor of safety can be brought to 2.0 or higher if the organic fill is replaced with compacted clayey fill. For the short term analysis, the minimum factors of safety are also in excess of 2 outside the "organic-fill" area.

5.2.2 Stability of Site B

The minimum factors of safety for Site B is in excess of 3.0 for the short-term conditions, and greater than 2.0 for the long-term.

6.0 DISCUSSION

6.1 General

The factors of safety against failure of the existing slopes are generally in excess of 2.0 and hence, adequate for the proposed development to proceed. The following specific issues, however, need to be addressed to ensure adequate stability of the entire site.

6.2 Organic fill – Site A

The organic fill identified at the areas of test pits 6, 6A & 7 should be removed and replaced with compacted clay fill. The imported fill shall be of low to medium plasticity clays/gravelly clays/sandy clay, and should be compacted to dry density ratio of not less than 100% (standard).

6.3 Stockpile – Site B

The existing stockpile between the subject site and the aged care facility is not likely to be stable in the long-term. It is, however, understood that the entire stockpile shall be removed upon completion of the age care facilities.

It is recommended that this office be contacted for the inspection of the excavation works to ensure that adequate stable batter slopes are maintained.

7.0 SITE CLASSIFICATION

The ultimate site classification of each allotment shall depend on the ground conditions at the time of construction. Any modification to the existing site conditions, either through excavation or filling, shall invariably alter the site classification assigned herein.

It is therefore recommended that individual allotments classified prior to undertaking documentations. For the preliminary site assessment, an overall site classification of Class H is assigned to Site A and Site B.

8.0 FOUNDATIONS

Beam and pier foundation systems are recommended for major buildings across the site. Slab-on-ground footing systems shall be suitable provided that bored piers penetrating the natural soil profile, and founded at least 2.0m below the existing ground surface, is provided beneath the main beams. Isolated columns may be supported on pad footings, which should be founded at least 0.3m into the natural soil profile.

The following allowable bearing pressures are recommended for the footing design.

Slab-on-ground	100 kPa
Pad	150 kPa
Piers	300 kPa

9.0 DRAINAGE

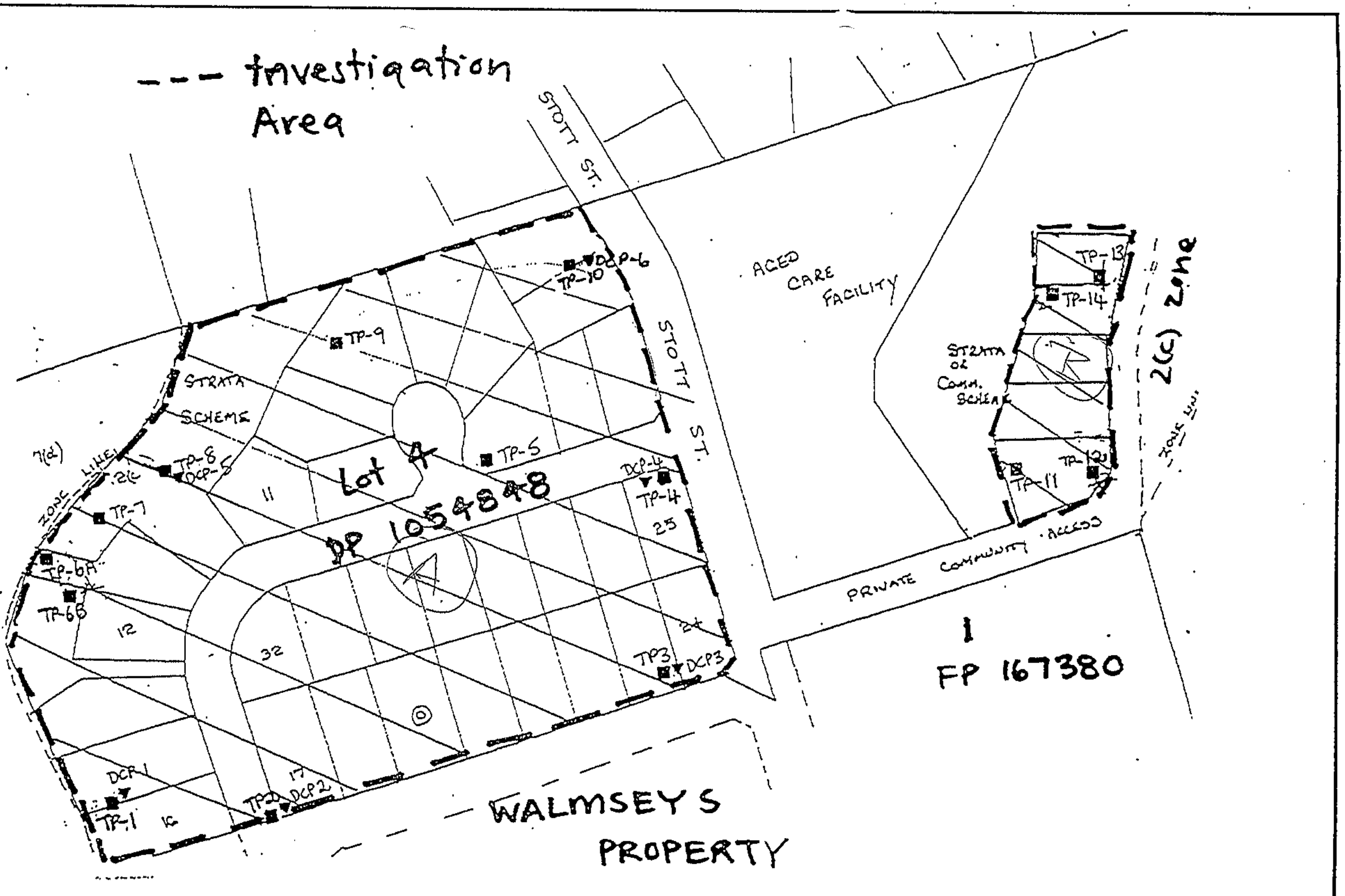
The site is susceptible to surface runoff and sub-surface infiltration. Adequate site drainage should include interception of sub-surface infiltration during major rainfall events. This may be achieved by extending perimeter spoon drains by at least 200mm into the natural soil profile. Cut-off spoon drains should be provided along the northern, southern and eastern sides (at Site A) and the northern, southern and western sides at Site B.

Should you have any queries or require any additional information, please do not hesitate to contact Ohene K. Yeboah at this office.

For and on behalf of Maiden Geotechnics

Ohene K. Yeboah (C.P.Eng.)
M.I.E.Aust., M.ASCE, R.P.E.Q.
B.Sc.(Hons. Civil), M.Eng.Sc.(Melb.),
Grad.Dip.Comp.(Monash)
Director

APPENDIX



MAIDEN GEOTECHNICS	▨ DENOTES APPROX, TEST PITS	Job No: NO/03/699	Scale : -	LOT 2 & 4 STOTT STREET BILAMBIL HEIGHTS	SKETCH NO/03/699 SK1
	▼ DENOTES APPROX. DCP LOCATIONS	Drawn Provided	Date : 18/12/2003		
		Checked : O.K.Y	Review :		

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	1
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING Depth(m)	INSITU TESTING Results	COMMENTS
0.2 0.5 0.7		Silty CLAY (CH), high plasticity, stiff, red, moist. Contains boulders.	stiff		D @ 0.0-0.5m	
1.0 1.6		CLAY (CI), medium plasticity, hard, grey mottling red, moist. Highly fissured.	hard			
2.0 2.5		CLAY (CI), medium plasticity, hard, brown, dry. Highly fissured.	hard		D @ 2.0m	
2.7		CLAY (CI), low plasticity, hard, brownish grey (hollow), dry.	hard		D @ 2.5m	
3.0 4.0		Total depth = 2.7m 1.7				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	2
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.2 0.5 0.7		Silty CLAY (CH), high plasticity, stiff, red, moist. Contains boulders.	stiff			
1.0 2.0 2.1		Silty CLAY (CI), medium plasticity, hard, reddish brown to brown, dry. Contains lenses of sandstone conglomerates.	hard			
3.0 4.0		Total depth = 2.1m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	3
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.1	▨	Fill - Clayey GRAVEL(GC), medium dense, coarse grained, dark brown, dry.	medium dense			
0.2 0.5	▤	Clayey SILT(MH), high plasticity, hard, brown, dry.	hard			
1.0	☰	CLAY (CI), medium plasticity, hard, greenish grey, dry.	hard		D @ 1.0m PP>600kPa	
1.5	‖	CLAY (CI-CH), medium to high plasticity, hard, red mottling grey, dry.	hard		D @ 1.6m PP>600 kPa	
2.0		Total depth = 2.0m				
3.0						
4.0						

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
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D = Disturbed Sample
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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	4
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.1 0.2 0.5	▨	Fill - Clayey GRAVEL(GC), medium dense, coarse grained, dark brown, dry.	medium dense			
1.0 2.0	▥	Silty CLAY (CI-CH), medium to high plasticity, hard, pale brown, dry.	hard		PP>600kPa D @ 1.0m	
2.1 3.0 4.0		Total depth = 2.0m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	5
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.2 0.5 0.6		Fill - Silty CLAY (CI), medium plasticity, stiff, red/brown, dry.	stiff			
1.0		Clayey SILT (MH), high plasticity, very stiff, reddish brown, moist.	very stiff		PP>600kPa	
1.5 2.0 2.3		Silty CLAY (CH), high plasticity, hard, blueish grey, moist.			D @ 1.0m	
3.0 4.0		Total depth = 2.3m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
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PT = Penetration Test

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PS = Piston Sample

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	6A
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.2 0.5 0.6	▤	FILL - Clayey SILT (MH), high plasticity, loose, reddish brown, dry.	loose			
1.0 1.5 2.0	▓	FILL - Organic, rotten vegetation, soft. Boulders encountered immediately beneath the rubbish.	soft			
2.1	▥	Silty CLAY (CH), high plasticity, hard, blueish grey, moist.	hard			
3.0 4.0		Total depth = 2.1m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.** NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:** 6B
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.** Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING Depth(m)	INSITU TESTING Results	COMMENTS
0.2 0.5		FILL - Silty CLAY (CH), medium to high plasticity, loose, dark brown, dry. Contains rotten vegetation	loose			
1.0 1.5 2.0		Silty CLAY (CH), medium plasticity, hard, dark brown, dry. Highly fissured.	hard			
2.1 3.0 4.0		Total depth = 2.1m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
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D = Disturbed Sample
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CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	7
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING Depth(m)	INSITU TESTING Results	COMMENTS
		FILL - Silty CLAY (CI), medium plasticity, loose, red brown, dry.	loose			
0.2						
0.5						
0.9						
1.0		FILL - Silty CLAY (CI) and old vegetation rubbish, medium plasticity, loose, brown, dry.	loose			
1.5						
2.0						
2.2		Silty CLAY (CI), medium plasticity, stiff, brown, moist.	stiff			
2.5						
3.0		Total depth = 2.5m				
4.0						

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

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TEST PIT LOG

CLIENT	Mr Jim Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	8
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.2 0.5 0.9 1.0 1.5		FILL - Gravelly CLAY (CL), low plasticity, medium dense, brown, dry.	medium dense			
2.0 2.5		Silty CLAY (CI-CH) medium to high plasticity, hard, red, moist. Moisture content < Plastic limit.	hard			
3.0 4.0		Total depth = 2.3m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
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TEST PIT LOG

CLIENT Jim & Les Dickinson
Job No. NO/03/699
PROJECT Stability Assessment Proposed Subdivision
Test Pit No: 9
LOCATION Lot 2 DP961928 & Lot 4 DP1054848
Stott Street, Bilambil Heights
Test Pit Incl. Vertical
Page 1 of 1

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
		FILL - Silty CLAY (CI), medium plasticity, medium dense, red, dry. Contains minor gravels.	medium dense			
0.2						
0.5		Silty CLAY (CI) medium plasticity, hard, red, moist. Moisture content < Plastic limit.	hard			
1.0						
1.5						
2.0						
2.3						
		Total depth = 2.3m				
3.0						
4.0						

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

MAIDEN GEOTECHNICS

GOLD COAST
Unit 3-5/9 Brendan Drive NERANG
Phone: (07) 5596 2122 Fax: (07) 5596 1650

BRISBANE
14 Musgrave Avenue COOPERS PLAINS
Phone: (07) 3875 2488 Fax: (07) 3875 1915

Postal Address: PO Box 2079 Nerang East, Qld 4211, Australia Email: gmaiden@winshop.com.au

TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	10
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING Depth(m)	INSITU TESTING Results	COMMENTS
0.2 0.3		FILL - Silty CLAY (CI), medium plasticity, loose/firm, reddish brown, dry.	loose/firm			
0.5 0.6		Silty CLAY (CI) medium plasticity, very stiff, red, moist.	very stiff			
1.0		Silty CLAY (CI), medium plasticity, hard, greenish grey, moist.	hard			
1.2		Silty CLAY (CI), high plasticity, stiff, pink mottling grey, moist. MC>PL	stiff			
1.5 2.0 2.4		Silty CLAY (CI), high plasticity, very stiff, greenish grey, moist. Moisture Content >Plastic Limit	very stiff			
2.5 3.0						

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	11
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.2	▦	TOPSOIL - Clayey SILT(MH), dark brown.				
0.5 1.0 1.5 2.0	▥	Silty CLAY (CH) high plasticity, hard,dark brown, dry.	hard			
2.5 3.0 4.0		Total Depth = 2.0m				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

MAIDEN GEOTECHNICS

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	12
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
0.2		TOPSOIL - Clayey Silt (MH), dark brown.				
0.5 1.0 1.5 2.0		Silty CLAY (CH), high plasticity, hard, dark brown, dry.	hard			
2.5 3.0 4.0		Total Depth = 2.0m.				

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	Job No.	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	Test Pit No:	13
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	Test Pit Incl.	Vertical
	Stott Street, Bilambil Heights	Page 1 of 1	

Logged By: O.K.Y. Date: 13/11/2003 Checked By: O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
	▦	TOPSOIL - Clayey SILT(MH), high plasticity, brown, moist.				
0.2	‖‖	CLAY (CH) high plasticity, hard, brown, moist.	hard			
0.5	‖‖					
1.0	‖‖					
1.5	‖‖					
2.0		Total Depth = 2.0m				
2.5						
3.0						
4.0						

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

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TEST PIT LOG

CLIENT	Jim & Les Dickinson	**Job No.**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**Test Pit No:**	14
LOCATION	Lot 2 DP961928 & Lot 4 DP1054848	**Test Pit Incl.**	Vertical
	Stott Street, Bilambil Heights	**Page 1 of 1**	

Logged By: O.K.Y. **Date:** 13/11/2003 **Checked By:** O.K.Y.

DEPTH (m)	GRAPHIC LOG	PROFILE DESCRIPTION	CONSISTENCY	INSITU TESTING		COMMENTS
				Depth(m)	Results	
	▦	TOPSOIL - Clayey SILT(MH), high plasticity, brown, moist.				
0.2	▥	CLAY (CH) high plasticity, hard, brown, moist.	hard			
0.5	▥					
1.0	▥					
1.5	▥					
2.0		Total Depth = 2.0m				
2.5						
3.0						
4.0						

DRILL TYPE: Hitachi Zaxis 304 mini excavator

Groundwater: NIL

U50 = Undisturbed 50mm diameter Tube Sample
SPT = Standard Penetration Test
D = Disturbed Sample
S = Vane Shear Value (kPa)
PP = Pocket Penetrometer Reading (kPa)
PT = Penetration Test

"V" Bit Refusal - Maximum Depth of Penetration by "V" Bit
"T/C" Bit Refusal - Maximum Depth of Penetration by "T/C" Bit
PS = Piston Sample

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DYNAMIC CONE PENETROMETER TEST

CLIENT Jim & Les Dickinson
JOB NO: NO/03/699
PROJECT Stability Assessment Proposed Subdivision
DATE: 13/11/2003
LOCATION Lots 2 DP961928 & Lot 4 DP1054848
PAGE NO: 1 of 1
Stott Street, Bilambil Heights
Tested By: V.V.
Checked By: O.K.Y.

TEST NUMBER DCP-1 (adjacent to TP-1)
TEST LOCATION Refer to attached site plan

DEPTH (m)	BLOWS	DEPTH (m)	BLOWS		
0.1	6	3.2	11		
0.2	7	3.3	11		
0.3	7	3.4	10		
0.4	8	3.5	8		
0.5	8	3.6	8		
0.6	8				
0.7	10				
0.8	10				
0.9	12				
1.0	14				
1.1	12				
1.2	12				
1.3	6				
1.4	6				
1.5	12				
1.6	10				
1.7	11				
1.8	13				
1.9	17				
2.0	18				
2.1	14				
2.2	11				
2.3	10				
2.4	10				
2.5	11				
2.6	10				
2.7	10				
2.8	9				
2.9	8				
3.0	10				
3.1	11				

SOIL DESCRIPTION: REFER BOREHOLE LOGS

MAIDEN GEOTECHNICS

GOLD COAST
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Phone: (07) 5596 2122 Fax: (07) 5596 1650

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DYNAMIC CONE PENETROMETER TEST

CLIENT Jim & Les Dickinson
JOB NO: NO/03/699
PROJECT Stability Assessment Proposed Subdivision
DATE: 13/11/2003
LOCATION Lots 2 DP961928 & Lot 4 DP1054848
Stott Street, Bilambil Heights
PAGE NO: 1 of 1
Tested By: V.V.
Checked By: O.K.Y.

TEST NUMBER	DCP-2 (adjacent to TP-2)	DCP-3 (adjacent to TP-3)			
TEST LOCATION	Refer attached site plan	Refer attached site plan			
DEPTH (m)	BLOWS	BLOWS	DEPTH (m)	BLOWS	
0.1	4	14	3.2	14	
0.2	8	9	3.3	14	
0.3	9	10	3.4	13	
0.4	10	9	3.5	13	
0.5	11	9	3.6	13	
0.6	16	9			
0.7	10	12			
0.8	9	15			
0.9	22	16			
1.0	22	17			
1.1	17	16			
1.2	9	17			
1.3	17	19			
1.4	20	14			
1.5	22	17			
1.6	22	11			
1.7	32	10			
1.8		15			
1.9		12			
2.0		8			
2.1		8			
2.2		8			
2.3		9			
2.4		12			
2.5		17			
2.6		17			
2.7		16			
2.8		13			
2.9		12			
3.0		12			
3.1		14			

SOIL DESCRIPTION: REFER BOREHOLE LOGS

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DYNAMIC CONE PENETROMETER TEST

CLIENT	Jim & Les Dickinson	**JOB NO:**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**DATE:**	13/11/2003
LOCATION	Lots 2 DP961928 & Lot 4 DP1054848	**PAGE NO:**	1 of 1
	Stott Street, Bilambil Heights		

TEST NUMBER	**DCP-4 (adjacent to TP4)**
TEST LOCATION	Refer attached site plan

DEPTH (m)	BLOWS	DEPTH (m)	BLOWS		
0.1	2	3.2	9		
0.2	8	3.3	8		
0.3	6	3.4	8		
0.4	5	3.5	9		
0.5	6	3.6	9		
0.6	13				
0.7	12				
0.8	6				
0.9	7				
1.0	8				
1.1	7				
1.2	9				
1.3	11				
1.4	9				
1.5	11				
1.6	10				
1.7	9				
1.8	12				
1.9	11				
2.0	11				
2.1	12				
2.2	12				
2.3	11				
2.4	11				
2.5	10				
2.6	9				
2.7	10				
2.8	10				
2.9	8				
3.0	8				
3.1	9				

SOIL DESCRIPTION: REFER BOREHOLE LOGS

MAIDEN GEOTECHNICS

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DYNAMIC CONE PENETROMETER TEST

CLIENT	Jim & Les Dickinson	**JOB NO:**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**DATE:**	13/11/2003
LOCATION	Lots 2 DP961928 & Lot 4 DP1054848	**PAGE NO:**	1 of 1
	Stott Street, Bilambil Heights		
TEST NUMBER	**DCP-5 (adjacent to TP8)**		
TEST LOCATION	Refer attached site plan		

DEPTH (m)	BLOWS				
0.1	4				
0.2	4				
0.3	5				
0.4	10				
0.5	8				
0.6	5				
0.7	7				
0.8	11				
0.9	7				
1.0	6				
1.1	4				
1.2	4				
1.3	5				
1.4	4				
1.5	8				
1.6	6				
1.7	6				
1.8	5				
1.9	5				
2.0	6				
2.1	7				
2.2	9				
2.3	13				
2.4	20				
2.5	33				
2.6	29				
2.7	31				
2.8					
2.9					
3.0					
3.1					

SOIL DESCRIPTION: REFER BOREHOLE LOGS

MAIDEN GEOTECHNICS

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DYNAMIC CONE PENETROMETER TEST

CLIENT	Jim & Les Dickinson	**JOB NO:**	NO/03/699
PROJECT	Stability Assessment Proposed Subdivision	**DATE:**	13/11/2003
LOCATION	Lots 2 DP961928 & Lot 4 DP1054848	**PAGE NO:**	1 of 1
	Stott Street, Bilambil Heights		
TEST NUMBER	DCP-6 (adjacent to TP10)		
TEST LOCATION	Refer attached site plan		

DEPTH (m)	BLOWS	DEPTH (m)	BLOWS		
0.1	0	3.2	8		
0.2	2	3.3	8		
0.3	7	3.4	8		
0.4	6	3.5	7		
0.5	3	3.6	7		
0.6	2				
0.7	2				
0.8	3				
0.9	6				
1.0	5				
1.1	4				
1.2	4				
1.3	6				
1.4	6				
1.5	6				
1.6	6				
1.7	7				
1.8	7				
1.9	7				
2.0	6				
2.1	7				
2.2	5				
2.3	6				
2.4	6				
2.5	8				
2.6	7				
2.7	8				
2.8	8				
2.9	8				
3.0	7				
3.1	7				

SOIL DESCRIPTION: REFER BOREHOLE LOGS

Maiden Geotechnics
CONSULTING GEOTECHNICAL ENGINEERS

PLASTICITY OF SOIL REPORT

Form No: R008
Revision 07/03

Client: *Jim & Les Dickenson*
Project: *Stott St. Bilambil Heights*
Date Sampled: *13/11/2003*
Sampling location: *TP 11 at 1.0m*
Sample Description: *Silty Clay-Dark Brown*

Job No.: *NO/03/699*
Document No: *35841*
Issue Date: *03/02/2004*
Registered Sample No: *996236*

HISTORY OF SAMPLE

☐ Natural State
☐ Air Dried
☒ Oven Dried (45 - 50 C)
☐ Unknown

☐ Wet Seived
☒ Dry Seived

Curing Time 24Hrs

TEST METHOD

Liquid Limit
☐ AS1289 3.1.1 Four point Casagrande Method
☒ AS1289 3.1.2 One point Casagrande Method (Subsidiary Method)
☐ AS1289 3.9.1 Drop Cone Method

lastic Limit
☒ AS1289 3.2.1 Plastic Limit of Soil

lasticity Index
☒ AS1289 3.3.1 Plasticity Index of Soil
☐ AS1289 3.3.2 Plasticity Index of Soil Cone Method

Linear Shrinkage
☒ AS1289 3.4.1 Linear Shrinkage of Soil

Moisture Content
☒ AS1289 2.1.1 Moisture Content (Oven)

RESULTS

IQUID LIMIT	**58 %**
LASTIC LIMIT	**37 %**
LASTICITY INDEX	**21 %**
INEAR SHRINKAGE	**16.5 %**
SITU MOISTURE CONTENT	**33.3 %**

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Authorised Signatory
Ohene K. Yeboah

Maiden Geotechnics
CONSULTING GEOTECHNICAL ENGINEERS

PLASTICITY OF SOIL REPORT

Form No: R008
Revision 07/03

Client: *Jim & Less Dickenson*
Project: *Stott St. Bilambil Heights*
Date Sampled: *13/11/2003*
Sampling location: *TP3 at 1.6m*
Sample Description: *Clay- Red mottling grey*
Job No.: *NO/03/699*
Document No: *35842*
Issue Date: *03/02/2004*
Registered Sample No: *996235*

HISTORY OF SAMPLE

☐ Natural State
☐ Air Dried
☒ Oven Dried (45 - 50 C)
☐ Unknown

☐ Wet Seived
☒ Dry Seived

Curing Time 24Hrs

TEST METHOD

Liquid Limit
☐ AS1289 3.1.1 Four point Casagrande Method
☒ AS1289 3.1.2 One point Casagrande Method (Subsidiary Method)
☐ AS1289 3.9.1 Drop Cone Method

Plastic Limit
☒ AS1289 3.2.1 Plastic Limit of Soil

Plasticity Index
☒ AS1289 3.3.1 Plasticity Index of Soil
☐ AS1289 3.3.2 Plasticity Index of Soil Cone Method

Linear Shrinkage
☒ AS1289 3.4.1 Linear Shrinkage of Soil

Moisture Content
☒ AS1289 2.1.1 Moisture Content (Oven)

RESULTS

LIQUID LIMIT	**67 %**
PLASTIC LIMIT	**31 %**
PLASTICITY INDEX	**36 %**
LINEAR SHRINKAGE	**13.5 %**
NSITU MOISTURE CONTENT	**23.6 %**

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Ohene K. Yeboah

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PLASTICITY OF SOIL REPORT

Form No: R008
Revision 07/03

Client: *Jim & Les Dickenson*
Project: *Stott St. Bilambil Heights*
Date Sampled: *13/11/2003*
Sampling location: *TP5 at 1.2m*
Sample Description: *Silty Clay- Bluish Gray*

Job No.: *NO/03/699*
Document No: *35843*
Issue Date: *03/02/2004*
Registered Sample No: *996238*

HISTORY OF SAMPLE

☐ Natural State
☐ Air Dried
☒ Oven Dried (45 - 50 C)
☐ Unknown

☐ Wet Seived
☒ Dry Seived

Curing Time 24Hrs

TEST METHOD

Liquid Limit
☐ AS1289 3.1.1 Four point Casagrande Method
☒ AS1289 3.1.2 One point Casagrande Method (Subsidiary Method)
☐ AS1289 3.9.1 Drop Cone Method

Plastic Limit
☒ AS1289 3.2.1 Plastic Limit of Soil

Linear Shrinkage
☒ AS1289 3.4.1 Linear Shrinkage of Soil

Plasticity Index
☒ AS1289 3.3.1 Plasticity Index of Soil
☐ AS1289 3.3.2 Plasticity Index of Soil Cone Method

Moisture Content
☒ AS1289 2.1.1 Moisture Content (Oven)

RESULTS

LIQUID LIMIT	77 %
PLASTIC LIMIT	34 %
LASTICITY INDEX	43 %
INEAR SHRINKAGE	17 %
NSITU MOISTURE CONTENT	32.5 %

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Ohene K. Yeboah

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PLASTICITY OF SOIL REPORT

Form No: R008
Revision 07/03

Client:	*Jim & Les Dickenson*	**Job No.:**	*NO/03/699*
Project:	*Stott St. Bilambil Heights*	**Document No:**	*35853*
Date Sampled:	*13/11/2003*	**Issue Date:**	*03/02/2004*
Sampling location:	*TP4 at 1.0m*	**Registered Sample No:**	*996340*
Sample Description:	*Silty Clay - Pale Brown*		

HISTORY OF SAMPLE

- ☐ Natural State
- ☐ Air Dried
- ☒ Oven Dried (45 - 50 C)
- ☐ Unknown

- ☐ Wet Seived
- ☒ Dry Seived

Curing Time 24Hrs

TEST METHOD

Liquid Limit
- ☐ AS1289 3.1.1 Four point Casagrande Method
- ☒ AS1289 3.1.2 One point Casagrande Method (Subsidiary Method)
- ☐ AS1289 3.9.1 Drop Cone Method

Plastic Limit
- ☒ AS1289 3.2.1 Plastic Limit of Soil

lasticity Index
- ☒ AS1289 3.3.1 Plasticity Index of Soil
- ☐ AS1289 3.3.2 Plasticity Index of Soil Cone Method

Linear Shrinkage
- ☒ AS1289 3.4.1 Linear Shrinkage of Soil

Moisture Content
- ☐ AS1289 2.1.1 Moisture Content (Oven)

RESULTS

IQUID LIMIT	69 %
LASTIC LIMIT	36 %
LASTICITY INDEX	33 %
INEAR SHRINKAGE	14.5 %

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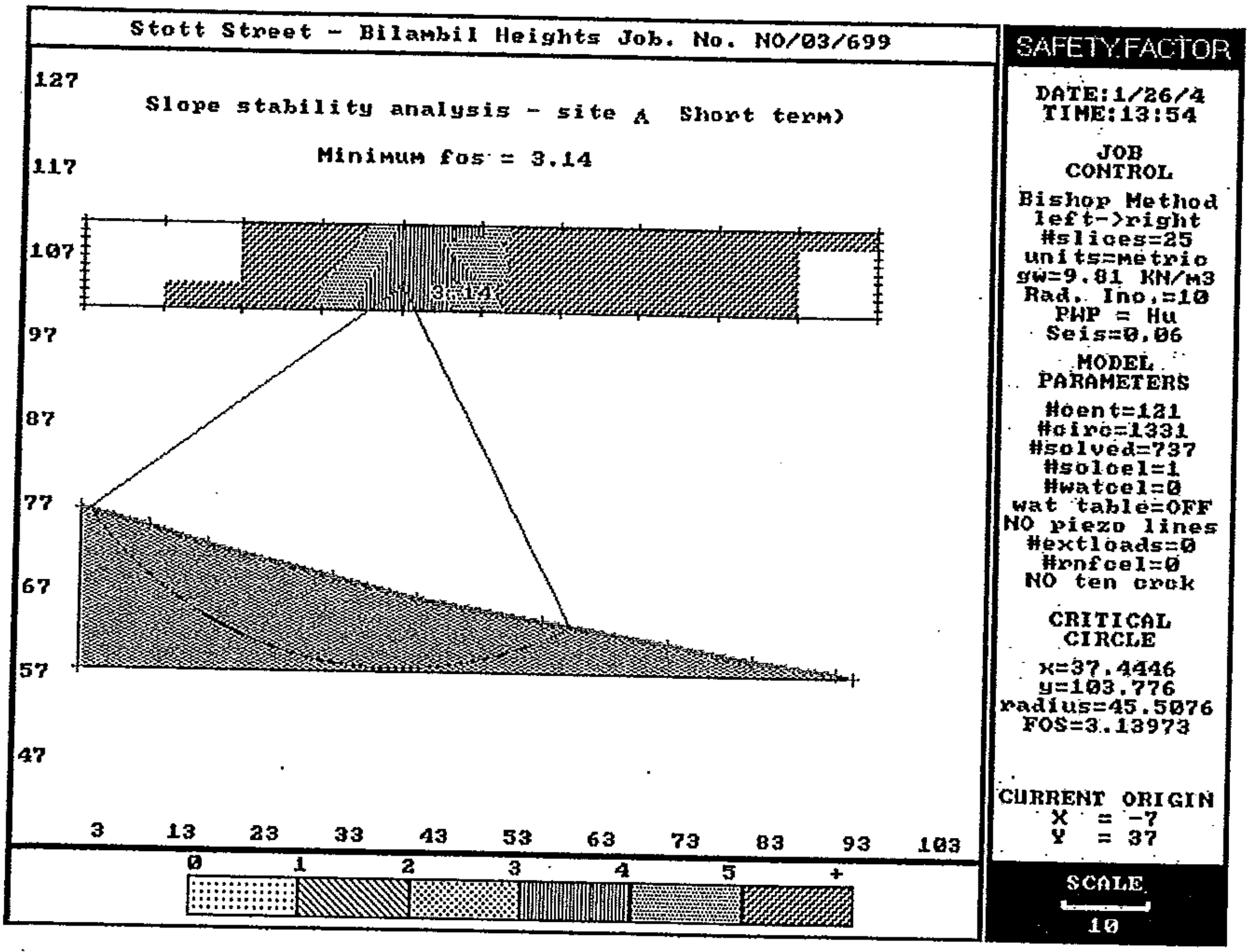
Authorised Signatory

Ohene K Yeboah



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Stott Street - Bilambil Heights Job. No. NO/03/699

Slope stability analysis - site A  Short term)

Minimum fos = 3.14
```

```
SAFETY.FACTOR

DATE:1/26/4
TIME:13:54

JOB
CONTROL

Bishop Method
left->right
#slices=25
units=metric
gw=9.81 KN/m3
Rad. Inc.=10
PWP = Hu
Seis=0.06

MODEL
PARAMETERS

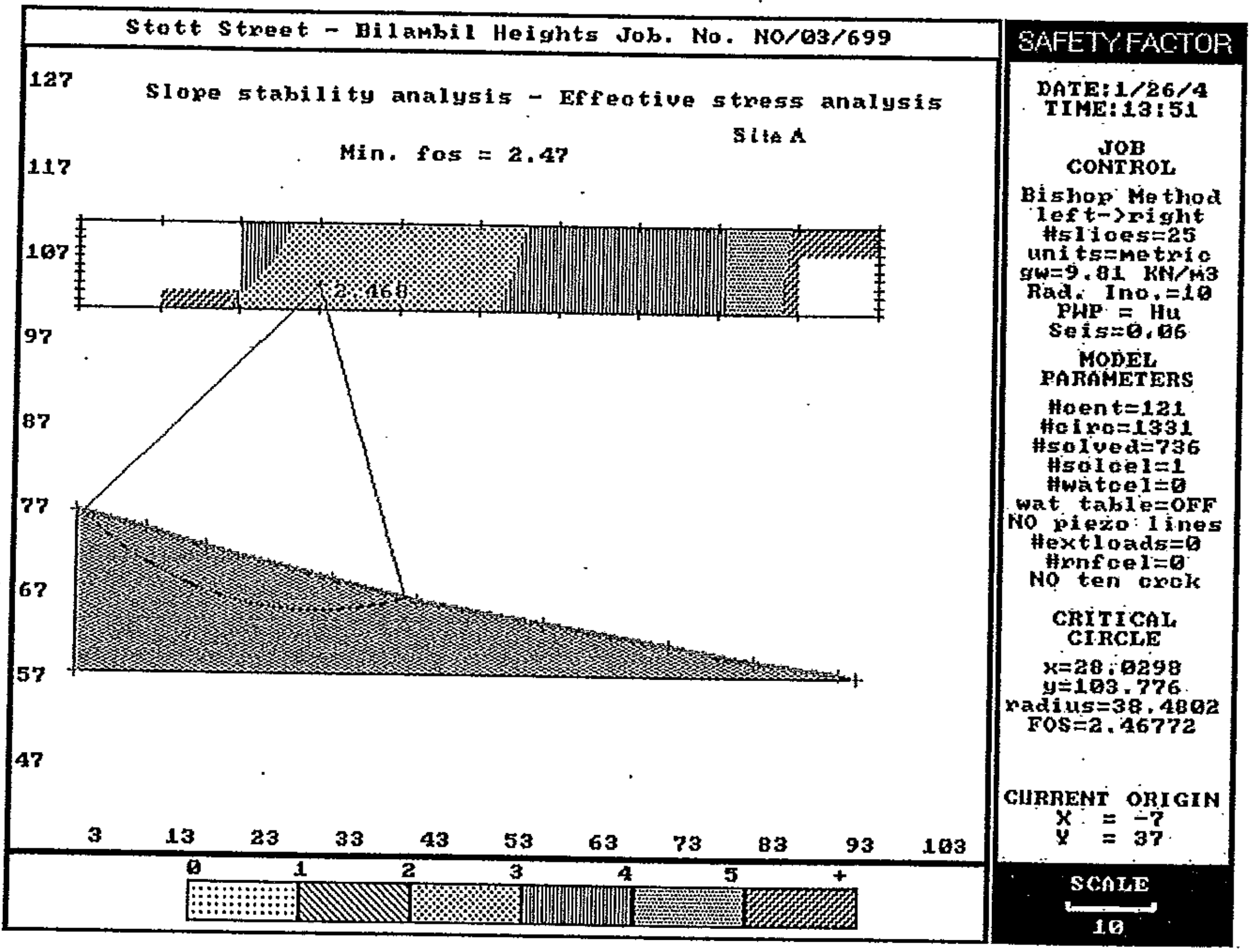
#cent=121
#circ=1331
#solved=737
#solcel=1
#watcel=0
wat table=OFF
NO piezo lines
#extloads=0
#rnfcel=0
NO ten crck

CRITICAL
CIRCLE

x=37.4446
y=103.776
radius=45.5076
FOS=3.13973

CURRENT ORIGIN
X  = -7
Y  = 37

SCALE
10
```



Stott Street - Bilambil Heights Job. No. NO/03/699

Slope stability analysis - Effective stress analysis

Site A

Min. fos = 2.47

```
SAFETY FACTOR

DATE:1/26/4
TIME:13:51

JOB
CONTROL

Bishop Method
left->right
#slices=25
units=metric
gw=9.81 KN/M3
Rad. Inc.=10
PWP = Hu
Seis=0.06

MODEL
PARAMETERS

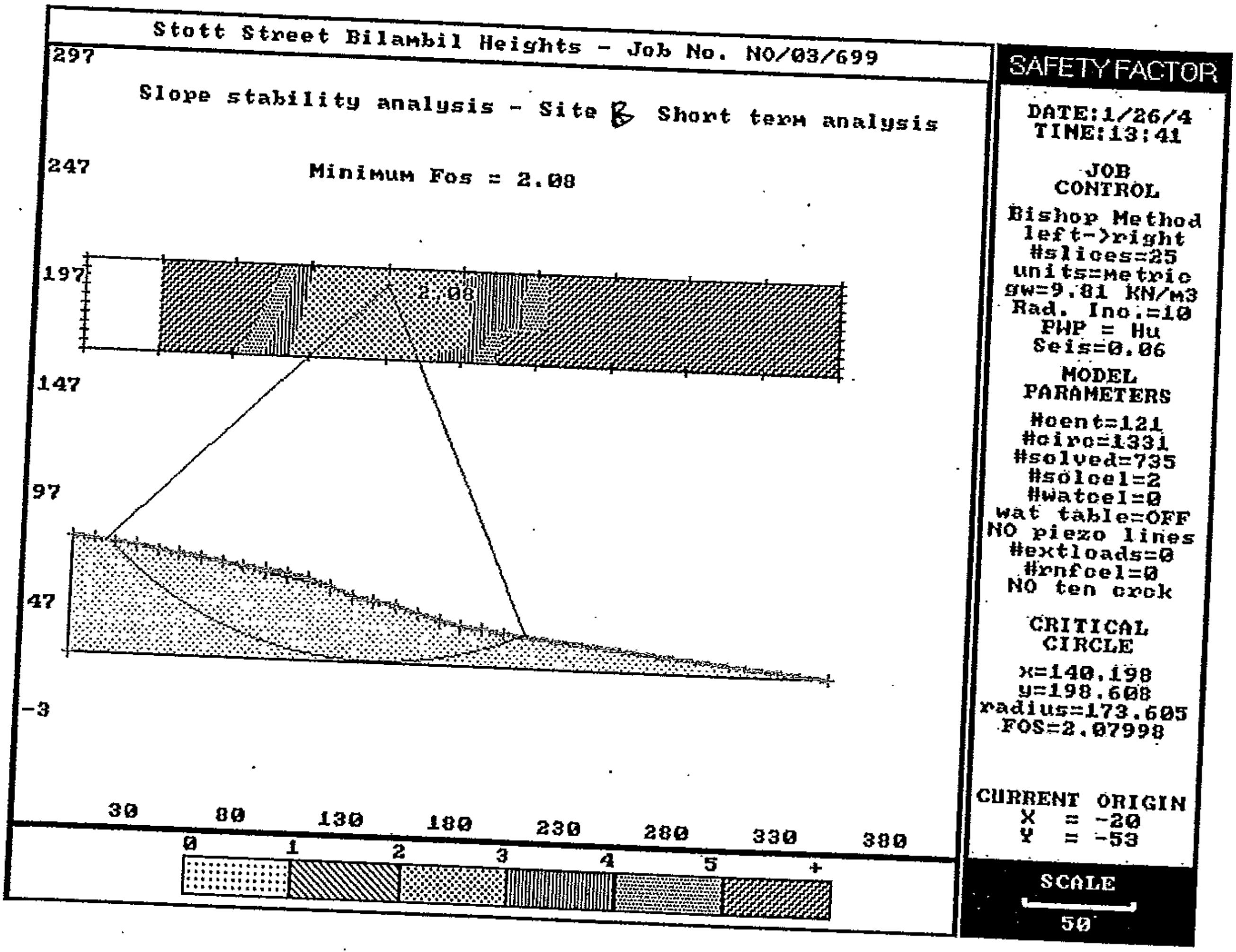
#cent=121
#circ=1331
#solved=736
#solcel=1
#watcel=0
wat table=OFF
NO piezo lines
#extloads=0
#rnfcel=0
NO ten crck

CRITICAL
CIRCLE

x=28.0298
y=103.776
radius=38.4802
FOS=2.46772

CURRENT ORIGIN
X = -7
Y = 37

SCALE
10
```



Stott Street Bilambil Heights - Job No. NO/03/699

Slope stability analysis - Site B Short term analysis

Minimum Fos = 2.08

SAFETY FACTOR

DATE:1/26/4
TIME:13:41

JOB
CONTROL

Bishop Method
left->right
#slices=25
units=metric
gw=9.81 KN/m3
Rad. Inc.=10
PWP = Hu
Seis=0.06

MODEL
PARAMETERS

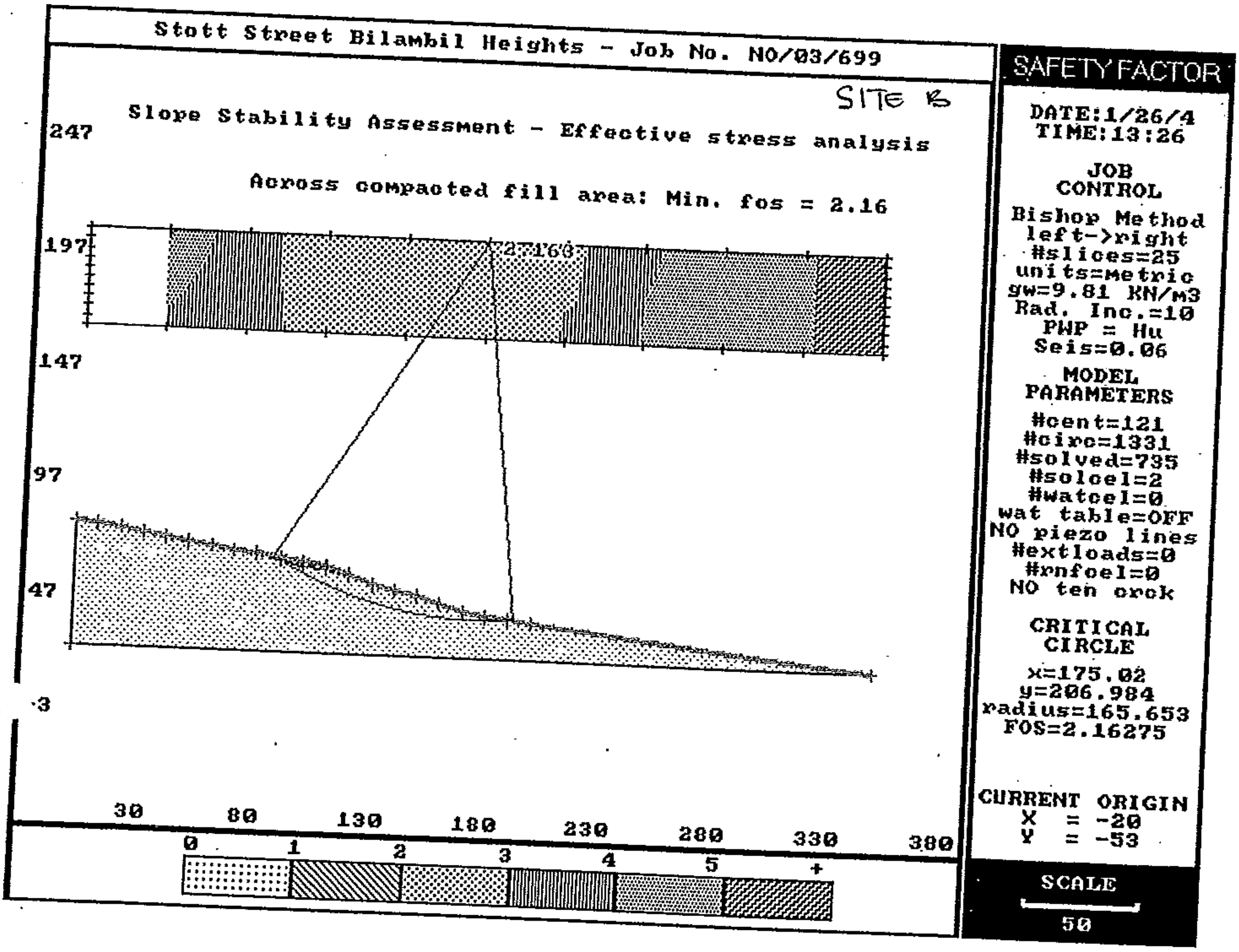
#cent=121
#circ=1331
#solved=735
#solcel=2
#watcel=0
wat table=OFF
NO piezo lines
#extloads=0
#rnfcel=0
NO ten crck

CRITICAL
CIRCLE

x=140.198
y=198.608
radius=173.605
FOS=2.07998

CURRENT ORIGIN
X = -20
Y = -53

SCALE
50



Stott Street Bilambil Heights - Job No. NO/03/699

SITE B

Slope Stability Assessment - Effective stress analysis

Across compacted fill area: Min. fos = 2.16

SAFETY FACTOR

DATE:1/26/4
TIME:13:26

JOB
CONTROL

Bishop Method
left->right
#slices=25
units=metric
gw=9.81 KN/m3
Rad. Inc.=10
PWP = Hu
Seis=0.06

MODEL
PARAMETERS

#cent=121
#circ=1331
#solved=735
#solcel=2
#watcel=0
wat table=OFF
NO piezo lines
#extloads=0
#rnfcel=0
NO ten crck

CRITICAL
CIRCLE

x=175.02
y=206.984
radius=165.653
FOS=2.16275

CURRENT ORIGIN
X = -20
Y = -53

DESCRIPTION & CLASSIFICATION OF SOILS & ROCKS FOR GEOTECHNICAL PURPOSES

GENERAL

The description and classification of soils and rocks contained in this report are based on the definitions and systems contains in the Australian Standard AS1726 - 1993, SAA Geotechnical Site Investigation Code and the Unified soil classification System.

SOILS

Description of soil is based on an assessment of representative samples as may be recovered from boreholes, test pits and other sample sources.

Soils are classified on the basis of the grain sizes as follows:

Soil Type	Particle Size (mm)
CLAY	<0.002
SILT	0.002 - 0.06
SAND:	0.06 - 2.0
fine grained	0.06 - 0.2
medium grained	0.2 - 0.6
coarse grained	0.6 - 2.0
GRAVEL:	2.0 - 60.0
fine grained	2.0 - 6.0
medium grained	6.0 - 20.0
coarse grained	20.0 - 60.0
COBBLES	60 - 200
BOULDERS	>200

Soil Name:

Where a soil contains 50 percent or more of fine materials (grain sizes ≤0.06), it is described as a clay or silt; and sand or gravel if the proportion of fine material is less than 50%.

In the field, these percentages can only be estimated. If accurate determinations are requires, laboratory tests are necessary and should be requested.

As most natural soils are part combinations of various constituents, the primary soil is described and modified by minor components as follows:

Fine Grained Soils		Coarse Grained Soils	
% Coarse	Modifier	% fines	Modifier
≤15	"trace" (may be omitted)	≤5	"trace" (may be omitted)
15 - 30	"with sand/gravel" as applicable	5 - 12	"with clay/silt" as applicable
>30	"sandy/gravelly" as applicable	>12	"silty/clayey" as applicable

Group Symbols:

Group symbols for soil classification are allocated as shown on Table 1.

Moisture Conditions

(i) "Dry" (D) - Cohesive soils; hard and friable or powdery, well dry of plastic limit.
Granular soils; cohesionless and free-running.

(ii) "Moist" (M) - Soil feels cool, darkened in colour.
Cohesive soils can be moulded. Granular soils tend to cohere.

(iii) "Wet" (W) - Soil feels cool, darkened in colour.
Cohesive soils usually weakened and free water forms on hands when handling.
Granular soils tend to cohere.

Colour

The colour of the soil is described in the "moist" conditions using simple terms like: black, white, grey, red, brown, orange, yellow, green or blue. These terms may be modified as necessary by "pale", "dark" or "mottled". Borderline colours may be described as a combination of these colours (eg. red-brown).

Where a soil consists of a primary colour with a secondary mottling, it is described in the following fashion:
(Primary Colour) mottled (Secondary Colour) [eg. grey mottled red-brown clay]

Where a soil consists of two colours present in roughly equal proportions, the colour description is as follows: mottled (first colour) and (second colour) [eg. mottled brown and red-brown clay]

A mixture of distinct colours may be described as, for example, mottled red-grey.

Cohesive Soils

Cohesive soils are further classified by the plasticity as follows:

	Liquid Limit(%)
low plasticity	≤35
medium plasticity	35 > ≤ 50
high plasticity	>50

Consistency for cohesive soils is based on the shear strength of the soil, which is generally estimated from experience, by hand held penetrometers or from insitu tests, eg. Standard Penetration tests.

The following terms are normally used:

	Shear Strength(kPa)	**Field Guide**
very soft	< 12	exudes between the fingers when squeezed in hand
soft	12 - 25	can be moulded by light finger pressure
firm	25 - 50	can be moulded by strong finger pressure
stiff	50 - 100	cannot be moulded by fingers, can be idented by thumb
very stiff	100 - 200	can be indented by thumb nail
hard	>200	can be indented with difficulty by thumb nail

	Unconfined Compressive Strength (kPa)	SPT N-Values
very soft	<24	0 - 2
soft	24 - 50	2 - 5
firm	50 - 100	5 - 10
stiff	100 - 200	10 - 20
very stiff	200 - 400	20 - 30
hard	>400	>30

Non-Cohesive Soils

The consistency of non-cohesive is based on the relative density or density index determined by the Standard Penetration tests (SPT) or any other form of penetration testing. The terms used are as follows:

Term	Relative Density (%)	SPT N-Values (blows/300mm)
very loose	≤ 15	< 5
loose	15 - 35	5 - 10
medium dense	35 - 65	10 - 30
dense	65 - 85	30 - 50
very dense	> 85	> 50

ROCK

Aid to identification of rocks for engineering purposes:

Table 2 :	Sedimentary Rock
Table 3 :	Metamorphic and Igneous Rock
Table 4 :	Texture and Fabric of Rock
Table 5 :	Strength of Rock Material
Table 6 :	Rock Material Weathering Classification
Table 7 :	Roughness Classification

Rock Mass Properties

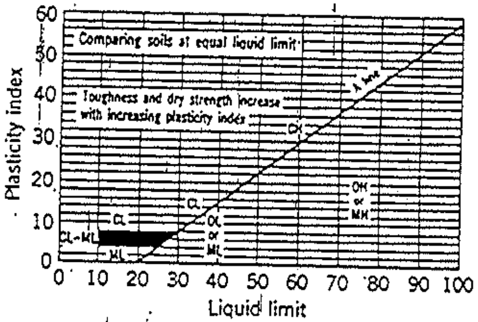
Sedimentary Rocks:

thinly laminated	<6 mm
laminated	6 - 20mm
very thinly bedded	20 - 60mm
thinly bedded	60 - 200mm
medium bedded	200 - 600mm
thickly bedded	600 - 2000mm
very thickly bedded	>2000mm

Coating or Infilling:

Clean :	no visible coating or infilling
stain :	no visible coating or infilling but surface discoloured by mineral staining
veneer :	a visible coating or infilling of soil or mineral substance but unable to be measured (less than 1mm) If discontinuities over the plane, patchy veneer.
coating :	a visible coating or infilling of soil or mineral substance, greater than 1mm thick. Describe composition and thickness.

Table 1 Unified Soil Classification

<table>
<tr><td colspan="6">Field Identification Procedures
(Excluding particles larger than 75 μm and basing fractions on estimated weights)</td><td>Group Symbols[a]</td><td>Typical Names</td><td>Information Required for Describing Soils</td><td colspan="4">Laboratory Classification Criteria</td></tr>
<tr><td rowspan="8">Coarse-grained soils
More than half of material is <i>larger</i> than 75 μm sieve size[b]</td><td rowspan="16">(The 75 μm sieve size is about the smallest particle visible to naked eye)</td><td rowspan="4">Gravels
More than half of coarse fraction is larger than 4 mm sieve size</td><td rowspan="2">Clean gravels (little or no fines)</td><td colspan="3">Wide range in grain size and substantial amounts of all intermediate particle sizes</td><td><i>GW</i></td><td>Well graded gravels, gravel-sand mixtures, little or no fines</td><td rowspan="8">Give typical name: indicate approximate percentages of sand and gravel; maximum size; angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbols in parentheses
For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics
Example:
<i>Silty sand</i>, gravelly; about 20% hard, angular gravel particles 12 mm maximum size; rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength; well compacted and moist in place; alluvial sand; (<i>SM</i>)</td><td rowspan="17">Use grain size curve in identifying the fractions as given under field identification</td><td rowspan="8">Determine percentages of gravel and sand from grain size curve
Depending on percentage of fines (fraction smaller than 75 μm sieve size) coarse grained soils are classified as follows:
Less than 5% <i>GW, GP, SW, SP</i>
More than 12% <i>GM, GC, SM, SC</i>
5% to 12% <i>Borderline</i> cases requiring use of dual symbols</td><td colspan="2">$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4
$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3</td></tr>
<tr><td colspan="3">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td><i>GP</i></td><td>Poorly graded gravels, gravel-sand mixtures, little or no fines</td><td colspan="2">Not meeting all gradation requirements for <i>GW</i></td></tr>
<tr><td rowspan="2">Gravels with fines (appreciable amount of fines)</td><td colspan="3">Nonplastic fines (for identification procedures see <i>ML</i> below)</td><td><i>GM</i></td><td>Silty gravels, poorly graded gravel-sand-silt mixtures</td><td>Atterberg limits below "A" line, or <i>PI</i> less than 4</td><td rowspan="2">Above "A" line with <i>PI</i> between 4 and 7 are <i>borderline</i> cases requiring use of dual symbols</td></tr>
<tr><td colspan="3">Plastic fines (for identification procedures, see <i>CL</i> below)</td><td><i>GC</i></td><td>Clayey gravels, poorly graded gravel-sand-clay mixtures</td><td>Atterberg limits above "A" line, with <i>PI</i> greater than 7</td></tr>
<tr><td rowspan="4">Sands
More than half of coarse fraction is smaller than 4 mm sieve size</td><td rowspan="2">Clean sands (little or no fines)</td><td colspan="3">Wide range in grain sizes and substantial amounts of all intermediate particle sizes</td><td><i>SW</i></td><td>Well graded sands, gravelly sands, little or no fines</td><td colspan="2">$C_U = \frac{D_{60}}{D_{10}}$ Greater than 6
$C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3</td></tr>
<tr><td colspan="3">Predominantly one size or a range of sizes with some intermediate sizes missing</td><td><i>SP</i></td><td>Poorly graded sands, gravelly sands, little or no fines</td><td colspan="2">Not meeting all gradation requirements for <i>SW</i></td></tr>
<tr><td rowspan="2">Sands with fines (appreciable amount of fines)</td><td colspan="3">Nonplastic fines (for identification procedures, see <i>ML</i> below)</td><td><i>SM</i></td><td>Silty sands, poorly graded sand-silt mixtures</td><td>Atterberg limits below "A" line or <i>PI</i> less than 5</td><td rowspan="2">Above "A" line with <i>PI</i> between 4 and 7 are <i>borderline</i> cases requiring use of dual symbols</td></tr>
<tr><td colspan="3">Plastic fines (for identification procedures, see <i>CL</i> below)</td><td><i>SC</i></td><td>Clayey sands, poorly graded sand-clay mixtures</td><td>Atterberg limits below "A" line with <i>PI</i> greater than 7</td></tr>
<tr><td rowspan="8">Fine-grained soils
More than half of material is <i>smaller</i> than 75 μm sieve size</td><td colspan="5">Identification Procedures on Fraction Smaller than 380 μm Sieve Size</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="9" colspan="3">
Plasticity chart
for laboratory classification of fine grained soils</td></tr>
<tr><td rowspan="4" colspan="2">Silts and clays liquid limit less than 50</td><td>Dry Strength (crushing characteristics)</td><td>Dilatancy (reaction to shaking)</td><td>Toughness (consistency near plastic limit)</td></tr>
<tr><td>None to slight</td><td>Quick to slow</td><td>None</td><td><i>ML</i></td><td>Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity</td><td rowspan="7">Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; colour in wet condition, odour if any, local or geologic name, and other pertinent descriptive information, and symbol in parentheses
For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, moisture and drainage conditions
Example:
<i>Clayey silt</i>, brown; slightly plastic; small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (<i>ML</i>)</td></tr>
<tr><td>Medium to high</td><td>None to very slow</td><td>Medium</td><td><i>CL</i></td><td>Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays</td></tr>
<tr><td>Slight to medium</td><td>Slow</td><td>Slight</td><td><i>OL</i></td><td>Organic silts and organic silt-clays of low plasticity</td></tr>
<tr><td rowspan="3" colspan="2">Silts and clays liquid limit greater than 50</td><td>Slight to medium</td><td>Slow to none</td><td>Slight to medium</td><td><i>MH</i></td><td>Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts</td></tr>
<tr><td>High to very high</td><td>None</td><td>High</td><td><i>CH</i></td><td>Inorganic clays of high plasticity, fat clays</td></tr>
<tr><td>Medium to high</td><td>None to very slow</td><td>Slight to medium</td><td><i>OH</i></td><td>Organic clays of medium to high plasticity</td></tr>
<tr><td colspan="4">Highly Organic Soils</td><td colspan="3">Readily identified by colour, odour, spongy feel and frequently by fibrous texture</td><td><i>Pt</i></td><td>Peat and other highly organic soils</td></tr>
</table>

From Wagner, 1957.

[a] *Boundary classifications.* Soils possessing characteristics of two groups are designated by combinations of group symbols. For example *GW–GC*, well graded gravel-sand mixture with clay binder.

[b] All sieve sizes on this chart are U.S. standard.

Field Identification Procedure for Fine Grained Soils or Fractions

These procedures are to be performed on the minus 380 μm sieve size particles. For field classification purposes, screening is not intended, simply remove by hand the coarse particles that interfere with the tests

Dilatancy (Reaction to shaking):

After removing particles larger than 380 μm sieve size, prepare a pat of moist soil with a volume of about 8000 mm³. Add enough water if necessary to make the soil soft but not sticky.

Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing assist in identifying the character of the fines in a soil.

Very fine clean sands give the quickest and most distinct reaction whereas a plastic clay has no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

Dry Strength (Crushing characteristics).

After removing particles larger than 380 μm sieve size, mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying, and then test its strength by breaking and crumbling between the fingers. This strength is a measure of the character and quantity of the colloidal fraction contained in the soil. The dry strength increases with increasing plasticity.

High dry strength is characteristic for clays of the CH group. A typical inorganic silt possesses only very slight dry strength. Silty fine sands and silts have about the same slight dry strength, but can be distinguished by the feel when powdering the dried specimen. Fine sand feels gritty whereas a typical silt has the smooth feel of flour

Toughness (Consistency near plastic limit)

After removing particles larger than the 380 μm sieve size, a specimen of soil about 12 mm cube in size, is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3 mm in diameter. The thread is then folded and re-rolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity, and crumbles when the plastic limit is reached.

After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.

The tougher the thread near the plastic limit and the stiffer the lump when it finally crumbles, the more potent is the colloidal clay fraction in the soil. Weakness of the thread at the plastic limit and quick loss of coherence of the lump below the plastic limit indicate either inorganic clay of low plasticity, or materials such as kaolin-type clays and organic clays which occur below the A-line.

Highly organic clays have a very weak and spongy feel at the plastic limit.

TABLE 2
AN AID TO IDENTIFICATION OF ROCKS FOR ENGINEERING PURPOSES — (sedimentary rocks)

(tables 2 & 3 follow general geological practice, but are intended as a guide only)

<table>
<tr><th>Grain size mm</th><th colspan="10">Bedded rocks (mostly sedimentary)</th></tr>
<tr><td>More than 20</td><td colspan="2">Grain size description</td><td colspan="2" rowspan="2">CONGLOMERATE
Rounded boulders, cobbles and gravel cemented in a finer matrix
Breccia
Irregular rock fragments in a finer matrix</td><td colspan="4">At least 50% of grains are of carbonate</td><td>At least 50% of grains are of fine-grained volcanic rock</td><td rowspan="3">SALINE ROCKS
Halite
Anhydrite
Gypsum</td></tr>
<tr><td>20
6
2</td><td colspan="2">RUDACEOUS</td><td colspan="2" rowspan="2">LIMESTONE and DOLOMITE (undifferentiated)</td><td colspan="2">Calcirudite*</td><td>Fragments of volcanic ejecta in a finer matrix
Rounded grains
AGGLOMERATE
Angular grains
VOLCANIC BRECCIA</td></tr>
<tr><td>0.6
0.2
0.06</td><td>ARENACEOUS</td><td>Coarse
Medium
Fine</td><td colspan="2">SANDSTONE
Angular or rounded grains, commonly cemented by clay, calcitic or iron minerals
Quartzite
Quartz grains and siliceous cement
Arkose
Many feldspar grains
Greywacke
Many rock chips</td><td colspan="2">Calcarenite</td><td>Cemented volcanic ash
TUFF</td></tr>
<tr><td>0.002</td><td colspan="2" rowspan="2">ARGILLACEOUS</td><td rowspan="2">MUDSTONE
SHALE
Fissile</td><td>SILTSTONE
Mostly silt</td><td rowspan="2">Calcareous mudstone</td><td rowspan="2"></td><td>Calcisiltite</td><td rowspan="2">CHALK</td><td>Fine-grained TUFF</td><td rowspan="2"></td></tr>
<tr><td>Less than 0.002</td><td>CLAYSTONE
Mostly clay</td><td>Calcilutite</td><td>Very fine-grained TUFF</td></tr>
<tr><td>Amorphous or crypto-crystalline</td><td colspan="2"></td><td colspan="6">Flint: occurs as bands of nodules in the chalk
Chert: occurs as nodules and beds in limestone and calcareous sandstone</td><td></td><td>COAL
LIGNITE</td></tr>
<tr><td></td><td colspan="2" rowspan="2"></td><td colspan="8">Granular cemented — except amorphous rocks</td></tr>
<tr><td></td><td colspan="2">SILICEOUS</td><td colspan="4">CALCAREOUS</td><td>SILICEOUS</td><td>CARBONACEOUS</td></tr>
<tr><td></td><td colspan="10">SEDIMENTARY ROCKS
Granular cemented rocks vary greatly in strength, some sandstones are stronger than many igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils.
Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid.</td></tr>
</table>

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* A more detailed classification is given in Clark, A.R. and Walker, B.F. *Geotechnique*, 1977, 27(1), 93-99.

GMP

TABLE 3
AN AID TO IDENTIFICATION OF ROCKS FOR ENGINEERING PURPOSES
(METAMORPHIC & IGNEOUS ROCKS)

Obviously foliated rocks (mostly metamorphic)		Rocks with massive structure and crystalline texture (mostly igneous)						Grain size mm
Grain size description			Grain size description	Pegmatite			Pyroxenite	More than 20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands Migmatite Irregularly foliated: mixed schists and gneisses	MARBLE QUARTZITE Granulite HORNFELS	COARSE	GRANITE[1] These rocks are sometimes porphyritic and are then described, for example, as porphyritic granite	Diorite[1,2]	GABBRO[3]	Peridotite	20 6 2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica	Amphibolite Serpentine	MEDIUM	Microgranite[3] These rocks are sometimes porphyritic and are then described as porphyries	Microdiorite[3,4]	Dolerite[3,4]		0.6 0.2 0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted' SLATE Well developed plane cleavage (foliation)		FINE	RHYOLITE[4,5] These rocks are sometimes porphyritic and are then described as porphyries	ANDESITE[4,5]	BASALT[4,5]		0.002 Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian[5]	Volcanic glass			Amorpho or crypto-crystallin
CRYSTALLINE				Pale	colour ←——————→		Dark	
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	

METAMORPHIC ROCKS

Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognise except by association. Any rock baked by contact metamorphism is described as a 'hornfels' and is generally somewhat stronger than the parent rock.

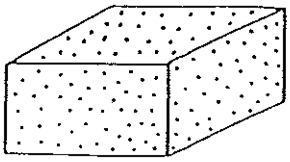
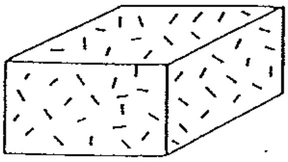
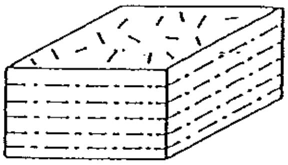
Most fresh metamorphic rocks are strong although perhaps fissile.

IGNEOUS ROCKS

Composed of closely interlocking mineral grains. Strong when fresh; not porous

Mode of occurrence: 1 Batholiths; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava flows; 6 Veins

TABLE 4
TEXTURE & FABRIC OF ROCK

Geological description	Diagram	Fabric type
Massive		Effectively homogeneous and isotropic. Bulky or equidimensional grains uniformly distributed.
		Effectively homogeneous and isotropic. Elongated or tabular grains uniformly distributed, randomly orientated
Layered (bedded foliate cleaved)		Effectively homogeneous with planar anisotropy. Elongated or tabular grains or pores in a layered arrangement

NOTES

1 The symbols in this Table are not standard symbols for any one soil or rock type, they represent diagrammatically the shape of mineral grains or pores.

2 'Effectively' means that for practical engineering purposes tests give acceptable coefficients of variation.

TABLE 5
STRENGTH OF ROCK MATERIAL

Term	Letter symbol	Point load index (MPa) I_{50}	Field guide to strength
Extremely low	EL	≤0.03	Easily remoulded by hand to a material with soil properties
Very low	VL	>0.03 ≤0.1	Material crumbles under firm blows with sharp end of pick, can be peeled with knife, too hard to cut a triaxial sample by hand. Pieces up to 3 cm thick can be broken by finger pressure
Low	L	>0.1 ≤0.3	Easily scored with a knife, indentations 1 mm to 3 mm show in the specimen with firm blows of the pick point, has dull sound under hammer. A piece of core 150 mm long 50 mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling
Medium	M	>0.3 ≤1.0	Readily scored with a knife, a piece of core 150 mm long by 50 mm diameter can be broken by hand with difficulty
High	H	>1 ≤3	A piece of core 150 mm long by 50 mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer
Very high	VH	>3 ≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer
Extremely high	EH	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer

TABLE 6
ROCK MATERIAL WEATHERING CLASSIFICATION

Term	Symbol	Definition
Residual soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported
Extremely weathered rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded, in water
Distinctly weathered rock	DW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually be ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering products in pores
Slightly weathered rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh rock	FR	Rock shows no sign of decomposition or staining

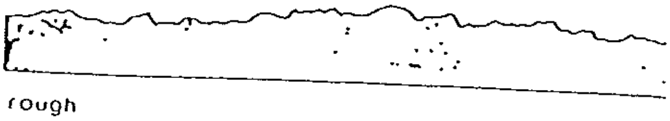
GMP

TABLE 7
TYPICAL ROUGHNESS PROFILES
(after ISRM Commission 1978)

Class

I

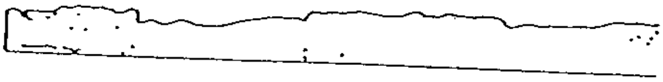
Stepped



rough

Class

II



III

smooth

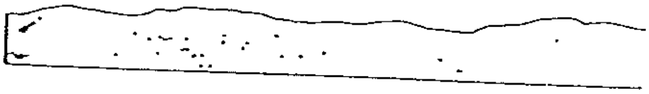
slickensided

IV

Undulating

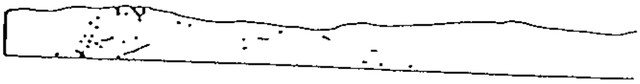
V

rough



smooth

VI



slickensided

VII

Planar

rough

VIII

IX

smooth

slickensided