Annex C

Geotechnical Report
(Chandler Geotechnical 2003)

Chandler Geotechnical Pty Ltd. ▲▼▲▼▲▼▲▼▲▼▲▼
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Project 22170
30 May 2003

"WALDEL PARK"
PROPOSED RESIDENTIAL SUBDIVISION
BELLE O'CONNOR STREET
SOUTH WEST ROCKS

1. INTRODUCTION

This report presents the findings of a geotechnical investigation for a proposed subdivision located along Belle O'Connor Street, South West Rocks. The work was carried out for Hadlow Design Services.

The purpose of the geotechnical investigation was to undertake the following based on the results of the fieldwork and laboratory testing:-

- assess subsurface conditions
- provide an indication as to likely site classifications with regard to foundation soil reactivity (shrink/swell) in accordance with AS2870-1996 (Ref 1)
- provide representative subgrade CBR values in vicinity of proposed roads
- assess for presence of potential acid sulphate soils at proposed detention basin site

The results of the field work and laboratory testing are appended to this report.

2. SUBSURFACE CONDITIONS

The site can be divided into three general areas according to the typical subsurface conditions as reported in the test pits.

North-Eastern Corner (Pits 4, 5 & 6)
This section of the site is generally below about RL 5.0 and is low lying wetland. Subsurface conditions in this area comprise slopewash in the form of silty clay underlain by sands and clayey sands. The surface water in this location is perched on the silty clay immediately below the topsoil. The sands encountered in the vicinity of test pit 5, below the silty clay slopewash,are permeable and removal of this material during construction of the detention basin should improve the drainage properties of the low lying areas of the site.

South-Eastern Corner (Pits 14 to 16 and Pit 18)
This area generally comprises an organic topsoil layer of around 200mm to 300mm thickness overlying residual silty clay. The silty clay is of weathered mudstone origin and the plasticity ranges from medium to high. Slopewash of varying thickness was encountered between the topsoil layer and the residual silty clay layer in test pits 15, 16 and 18.

Remainder Of Site (Pits 1 to 3, 7 to 13)
This area is associated with the higher and better drained parts of the site. Subsurface conditions comprise topsoil to depths of around 200mm to 300mm thickness overlying orange/brown residual sandy clay. Slopewash material of up to 0.4m thickness was encountered between these two layers in some of the test pits. The orange/brown sandy clay layer tends to be underlain by extremely to highly weathered siltstone/mudstone at varying depths.

3. COMMENTS

3.1 Proposed Development

We understand the development comprises the subdivision of Lot 21 Pt. Lot 2, DP6545213 into 225 allotments.

The subdivision will comprise the following:-
- 225 residential lots
- Approximately 3 kilometres of roadworks
- A detention basin and associated drainage facilities

3.2 Site Classification

Site classification of foundation soil reactivity provides an indication of the propensity of the ground surface to move with seasonal variation in moisture.

Nine (9) "undisturbed" 50mm diameter tube samples were collected from varying locations around the site representing differing foundation conditions. Laboratory reactivity testing was carried out on six of the samples and copies of these test reports are appended in this report.

Based on procedures presented in AS2870-1996 "Residential slabs and footings - construction" (Ref 1), the typical profiles revealed in the test pits and the results of laboratory testing a range of site classifications from "Class S" to "Class H" will exist across the site with the majority of the lots being in the "Class M" category.

It is understood that significant filling of up to 1.2 metres is proposed for the lower sections of the development. Subgrade preparation and earthworks procedures should be carried out in accordance with AS3798-1996 "Guidelines on earthworks for commercial and residential developments" (Ref 2).

Lot specific site classifications should be carried out upon completion of the earthworks prior to building construction.

3.3 Site Preparation & Lot Filling

Site preparation for the building areas will require clearance of vegetation and surface organic matter followed by excavation of topsoil.

Following stripping of topsoil it is suggested the exposed surface be proof rolled using a minimum 10 tonne roller to identify any "soft" areas that may exist. Any "soft" spots encountered should be either tyned, dried and uniformly recompacted or excavated and replaced with compacted material.

Any filling placed on lots to achieve design levels should be placed in layers not exceeding 250mm compacted thickness. The filling should be compacted to a minimum dry density ratio of 98% of Standard compaction.

Inspection and testing should be carried out in accordance with AS3798-1996 Appendix B (REF 2).

3.4 Pavement Thickness

Five of the bulk samples collected from the test pits within the proposed development and one sample from Belle O'Connor Street were tested for Californian Bearing Ratio (CBR) to give an indication of existing subgrade conditions. Test Reports are appended in this report and summarised below:-

Location	Depth	Laboratory CBR (%)
Test Pit 1	0.3 - 0.6m	11
Test Pit 4	0.3 - 0.6m	2½
Test Pit 10	0.25 - 0.55m	25
Test pit 13	0.3 - 0.6m	1½
Test Pit 15	0.3 - 0.6m	11
Belle O'Connor	0.3 - 0.6m	11

Based on the CBR values obtained it can be anticipated that subgrade conditions across the site will be variable. The low CBR value of 1½% on the material taken from test pit 13 suggests that in some areas subgrade improvement may be necessary. Over excavation during boxing out and replacement with better quality material (select subgrade) in some areas may be required.

More intensive sampling and testing should be carried out along the proposed road alignments either at design stage or following boxing out to identify specific subgrade conditions as a range of pavement thickness will be required based on subgrade CBR and design traffic loadings.

Final design CBR values adopted will also depend upon the extent of site regrading carried out. Where clay subgrade is exposed subsoil drainage should be provided along both sides of the road.

For Belle O'Connor Street adopting a design CBR value 11% and a traffic loading of 1x10^6 ESA a 250mm minimum pavement thickness will be required.

3.5 Acid Sulphate Testing

Based on the initially supplied lot layout plan it is understood that a detention basin is proposed for the north-eastern corner of the site. The floor of the detention basin is to be cut to a depth of about 2.0 metres

Samples were collected from test pit 5, the location of the proposed detention basin, at 0.5 metre depth intervals and analysed for acid sulphate potential. Two samples from test pit 15 were also tested.

Test results show the material to be NOT potential acid sulphate soil.

3.6 Erodability

Subsurface conditions in the detention basin area (test pit 5) include clayey sand to a depth of 1.1 metres overlying sand and silty sand to the depth of proposed excavation. Based on the material encountered in test pit 5 the walls of the detention basin can be considered to have severe erodability rating dur to the non cohesive nature of the material.

3.7 Excavatability

The fieldwork was carried out using a 5 Tonne mini excavator. All test pits within the area of the proposed development were taken to a minimum depth of 2.0 metres. Refusal on bedrock or boulders did not occur in any of the test pits and rock was not encountered in any of the test pits.

4 COMMENTS

Site investigations as above are based on the information obtained from the test pits and on the results of laboratory testing and have involved some interpolation between data points. In the event that conditions encountered during construction are different

to those presented in this report it is recommended further geotechnical advice be sought.

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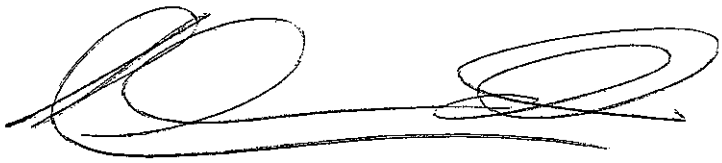

Steve Chandler
Managing Director

REFERENCES

1. Australian Standard AS2870-1996 "Residential slabs and footings - construction"

2. Australian Standard AS3798-1996 "Guidelines on earthworks for commercial and residential developments"

APPENDIX

Test Pit Reports
Test Pits 1 to 19

CBR Reports
Report 22170-1 to 22170-6

Reactivity Test Reports
Report 22170-7 to report 22170-12

Acid Sulphate Soil Analysis
Southern Cross University Report E0352

CSIRO Sheet 10-91

Test Pit Location Plan

Chandler Geotechnical Pty Ltd

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NDSL

TEST PIT No: 1
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, grey brown, sands fine to medium grained.
0.50	"B" 0.3 - 0.6m (PM 4658) "U" 0.5 - 0.9m (PM 4677)	RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, mc > wp.
1.00		RESIDUAL. Extremeley weathered siltstone/sandstone with soil like properties, as silty sandy clay, mottled orange/grey/red/yellow, fines of low plasticity, sands fine to medium grained, mc < wp.
1.50		Becoming less weathered with depth.
2.00		
		Test Pit terminated 2.0 metres.
2.50		
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NDSL

TEST PIT No: 2
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, grey brown, sands fine to medium grained.
0.50	"B" 0.2 - 0.5m (PM 4659)	SLOPEWASH. Clayey silty sand, dark grey/brown, sands fine to medium grained, fines of low to medium plasticity, mc , wp.
1.00	"U" 0.6 - 0.9m (PM 4681)	RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, mc > wp.
1.50		RESIDUAL. Extremeley weathered siltstone/sandstone with soil like properties, as silty sandy clay, mottled orange/grey/purple, fines of low plasticity, sands fine to medium grained, mc < wp.
2.00		
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
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LOCATION: South West Rocks

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LEVEL: NDSL

TEST PIT No: 3
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey/black, sands fine to medium grained.
0.50	"B" 0.3 - 0.6m (PM 4660)	RESIDUAL. Silty sandy clay, orange & grey, medium to high plasticity, sands fine to medium grained, mc > wp.
1.00		RESIDUAL. Silty clay, pale grey with some orange staining, medium plasticity, sands fine to medium grained, mc > wp.
1.50		
2.00		
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER: None encountered.
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
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LOCATION: South West Rocks

PROJECT NO: 22170
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LEVEL: NSL

TEST PIT No: 4
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Clayey silty sand, black, sands fine to medium grained, organic
0.50	"B" 0.3 - 0.6m (PM 4661) "U" 0.5 - 0.9m (PM 4679)	SLOPEWASH. Silty clay, pale grey, medium to high plasticity, sands fine grained, mc > wp.
1.00		COLLUVIUM/SLOPEWASH. Clayey sand, grey with some orange mineral staining, sands fine to coarse grained, trace of fine gravel, with some seams of sandy clay at varying depths, moist to wet.
1.50		
2.00		
		Test Pit terminated 2.0 metres.
2.50		
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER: None encountered.
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

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DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 5
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, black, sands fine to medium grained, organic.
0.50	"D" PM 4684 0.3 - 0.5m	SLOPEWASH. Silty clay, pale grey, medium to high plasticity, sands fine grained, mc > wp.
1.00	"D" PM 4685 0.7 - 1.0m	COLLUVIUM/SLOPEWASH. Clayey sand, pale grey, fine to medium grained, fines of low plasticity, mc > wp.
1.50	"D" PM 4686 1.2 - 1.4m	SAND. pale grey white, medium grained, clean, wet. (Some water inflow through this lense.)
2.00	"D" PM 4687 1.8 - 2.1m	Silty sand, pale grey with some orange staining, sands fine to medium grained, non plastic fines.
2.50	"D" PM 4688 2.4 - 2.7m	Clayey sand, grey, sands fine to medium grained, fines of low to medium plasticity, mc >> wp.
3.00		Test Pit terminated 2.7 metres.
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER: Some inflow between 1.1 to 1.5 metres.
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

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LEVEL: NSL

TEST PIT No: 6
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, black, sands fine to medium grained, organic
0.50	"U" 0.6 - 0.8m (PM 4678)	SLOPEWASH. Silty clay, pale grey, medium to high plasticity, sands fine grained, mc > wp.
1.00		Clayey silty sand, pale grey, sands fine to medium grained, fines of low to medium plasticity, mc < wp.
1.50		
2.00		
2.50		Test Pit terminated 2.1 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 7
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, grey, sands fine to medium grained.
0.50		SLOPEWASH. Silty sand, grey, sands fine to medium grained, non plastic.
1.00	"U" 0.7 - 1.0m (PM 4676)	RESIDUAL. Sandy clay, mottled orange & grey, medium to high plasticity, sands fine to coarse grained, mc > wp.
1.50		RESIDUAL. Gravelly sandy clay, mottled orange & grey, medium plasticity, sands fine to coarse grained, gravel fine to medium weathered siltstone, mc > wp.
2.00		Test Pit terminated 2.0 metres.
2.50		
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER: None encountered.
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

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DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 8
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey, sands fine to medium grained.
0.50	"B" 0.2 - 0.5m (PM 4662)	SLOPEWASH. Gravelly clayey sand, grey, sands fine to medium grained, fines of low to medium plasticity, mc > wp.
1.00	"B" 0.5 - 0.8m (PM 4663)	RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, mc > wp.
1.50		RESIDUAL. Sandy clay, mottled orange & grey, medium to high plasticity, sands fine to medium grained, mc > wp.
2.00		Extremeley weathered mudstone, pale grey with some orange mineral staining.
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

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DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 9
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey, sands fine to medium grained.
	"B" 0.25 - 0.5m (PM 4664)	Clayey silty sand / silty sandy clay, orange brown, sands fine to medium grained, fines of low to medium plasticity, mc > wp.
0.50		RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, mc > wp.
1.00		
1.50		RESIDUAL. Extremely weathered siltstone with soil like properties, as silty sandy clay, orange, fines of low to medium plasticity, sands fine to medium grained, mc < wp.
2.00		
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
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PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 10
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey, sands fine to medium grained.
0.50	"B" 0.25 - 0.55m (PM 4665)	Clayey silty sand /silty sandy clay, yellow brown, sands fine to medium grained, fines of low to medium plasticity, mc > wp.
1.00		RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, trace of fine gravel, mc > wp.
1.50		
2.00		
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER: None encountered.
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

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LEVEL: NSL

TEST PIT No: 11
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey, sands fine to medium grained.
0.50	"B" 0.2 - 0.5m (PM 4665) "U" 0.4 - 0.7m (PM 4680)	RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, trace of fine gravel, mc > wp.
1.00		
1.50		RESIDUAL. Extremely weathered rock with soil proerties as clayey sand, sands fine to coarse grained, fines of low to medium plasticity, mc > wp.
2.00		
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
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TEST PIT REPORT

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LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 12
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, pale grey, sands fine to medium grained.
		Clayey silty sand, orange brown, sands fine to medium grained, fines of low to medium plasticity, mc > wp.
0.50		RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, mc > wp.
1.00		RESIDUAL. Extremely weathered siltstone/mudstone with soil like properties, as silty sandy clay, orange, fines of low to medium plasticity, sands fine to medium grained, mc < wp.
1.50		
2.00		As above becoming less weathered with depth with some seams of fractured siltstone.
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

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TEST PIT REPORT

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PROJECT NO: 22170
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LEVEL: NSL

TEST PIT No: 13
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey/black, sands fine to medium grained.
0.50	"B" 0.3 - 0.6m (PM 4667) "U" 0.4 - 0.7m (PM 4675)	RESIDUAL. Sandy clay, orange brown, medium to high plasticity, sands fine to medium grained, trace of fine gravel, mc > wp.
1.00		RESIDUAL. Silty clay, pale grey white, low to medium plasticity, sands fine grained.
1.50		
2.00		
2.50		Test Pit terminated 2.0 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
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TEST PIT REPORT

CLIENT: W & M Walls
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LEVEL: NSL

TEST PIT No: 14
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey/black, sands fine to medium grained.
0.50	"U" 0.5 - 0.9m (PM 4674)	RESIDUAL. Silty clay, pale grey white, medium to high plasticity, sands fine grained, mc > wp.
1.00		Becoming less plastic with depth.
1.50		Becoming extremely weathered mudstone.
2.00		Some patches of orange mineral staining below 1.8 metres.
		Test Pit terminated 2.0 metres.
2.50		
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

Chandler Geotechnical Pty Ltd

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2 / 22 Blackbutt Road Port Macquarie NSW 2444 Phone (02)65810142 Fax (02)65810129

TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 15
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, black, sands fine to medium grained, organic
0.50	"B" 0.3 - 0.6m (PM 4648) "D" 0.5 - 0.7m (PM 4689)	SLOPEWASH. Clayey sand,grey, sands fine to coarse grained, fines of low to medium plasticity, mc > wp.
1.00	"D" 1.0 - 1.2m (PM 4690)	RESIDUAL. Silty clay, pale grey, low to medium plasticity, sands fine to medium grained, mc > wp.
1.50		Becoming extremely weathered mudstone.
2.00		Some orange mineral staining.
2.50		Test Pit terminated 2 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 16
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, black, sands fine to medium grained, organic
0.50	"B" 0.2 - 0.6m (PM 4669)	SLOPEWASH. Clayey sand,grey, sands fine to coarse grained, fines of low to medium plasticity, mc > wp.
1.00		RESIDUAL. Silty clay, pale grey, low to medium plasticity, sands fine to medium grained, mc > wp.
1.50		Becoming extremely weathered mudstone.
2.00		Some orange mineral staining.
2.50		Test Pit terminated 2 metres.
3.00		
3.50		

RIG: Mini Excavator
GROUND WATER: None encountered.
REMARKS:

LOGGED: SC

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waidell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 17
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, dark grey, sands fine to medium grained.
0.50		SLOPEWASH. Clayey sand,grey, sands fine to coarse grained, fines of low to medium plasticity, mc > wp.
1.00	"U" 0.7 - 1.0m (PM 4673)	RESIDUAL. Silty clay, mottled orange & grey, low to medium plasticity, sands fine to coarse grained, mc > wp.
1.50		
2.00		
2.50		Test Pit terminated 2 metres.
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER: None encountered.
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 18
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		TOPSOIL. Silty sand, black, sands fine to medium grained, organic.
0.50		SLOPEWASH. Silty clay, grey, medium to high plasticity, sands fine to medium grained, mc > wp.
1.00		SLOPEWASH. Clayey sand / sandy clay, grey, sands fine to medium grained, fines of medium to high plasticity, mc > wp.
1.50		Clayey sand, pale grey with some orange staining, sands fine to medium grained, fines of low plasticity, mc < wp.
2.00		Test Pit terminated 2.0 metres.
2.50		
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER:
REMARKS:

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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TEST PIT REPORT

CLIENT: W & M Walls
PROJECT: Waldell Park
LOCATION: South West Rocks

PROJECT NO: 22170
DATE: 9.4.03
LEVEL: NSL

TEST PIT No: 19
METHOD OF ADVANCE: Excavator

DEPTH METRES	SAMPLES TESTS	DESCRIPTION OF STRATA (SOIL TYPE, STRENGTH, MOISTURE, COLOUR, ORIGIN)
		Crushed Rock, (DGS40).
		FILLING. Silty sand, pale grey brown, sands fine to medium grained, fines of low to medium plasticity.
0.50	"B" 0.3 - 0.6m (PM 4670)	RESIDUAL. Sandy clay, orange brown, low to medium plasticity, sands fine to medium grained, mc < wp.
		Test Pit terminated 0.6 metres.
1.00		
1.50		
2.00		
2.50		
3.00		
3.50		

RIG: Mini Excavator
LOGGED: SC
GROUND WATER:
REMARKS: Belle O'Connor Street.

SAMPLES & TESTS

D Disturbed sample U Undisturbed tube sample
B Bulk sample pp pocket penetrometer

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CALIFORNIA BEARING RATIO

CLIENT:	W & M Walls	**PROJECT NO:**	22170
ADDRESS:	C/- PO Box 86 South West Rocks	**REPORT NO:**	22170-1
PROJECT:	Walldell Park	**DATE:**	23.4.03
LOCATION:	South West Rocks		

Sample No:	**PM 4658**
Sample description:	**Sandy CLAY, orange/brown.**
Sample location:	**Test Pit 1, 0.3 - 0.6 metres.**
Date sampled:	**9.4.03**

TEST PROCEDURES

Date Tested:	**22.4.03**
Test Method:	**AS1289, 6.1.1**
Duration of soaking:	**4 Days**
Compaction level % :	**98.9%**
Compactive effort:	**Standard**
Drop of rammer (mm):	**300mm**
Mass of rammer (kg):	**2.7kg**
Surcharge (kg):	**4.5kg**

TEST RESULTS:

Field moisture content %:	**18.9%**
Maximum dry density (kg/m3):	**1,750 kg/m³**
Optimum moisture content %:	**17.5%**
Dry density prior to soaking (kg/m3):	**1,730 kg/m³**
Dry density after soaking (kg/m3);	**1,725 kg/m³**
Moisture content moulded % :	**17.9%**
Moisture content after soaking % :	**19.5%**
Top 30mm after test %	**19.2%**
Swell after soaking % :	**0.3%**

C.B.R.VALUES: **2.5mm penetration % : 11**

5.0mm penetration % : 11

02/03

Approved Signatory: S Chandler Laboratory No 9849

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CALIFORNIA BEARING RATIO

CLIENT: W & M Walls
ADDRESS: C/- PO Box 86
South West Rocks

PROJECT: Walldell Park

LOCATION: South West Rocks

PROJECT NO: 22170

REPORT NO: 22170-2

DATE: 23.4.03

Sample No:	**PM 4661**
Sample description:	**Silty CLAY, pale grey.**
Sample location:	**Test Pit 4, 0.3 - 0.6 metres.**
Date sampled:	**9.4.03**

TEST PROCEDURES

Date Tested:	**22.4.03**
Test Method:	**AS1289, 6.1.1**
Duration of soaking:	**4 Days**
Compaction level % :	**98.2%**
Compactive effort:	**Standard**
Drop of rammer (mm):	**300mm**
Mass of rammer (kg):	**2.7kg**
Surcharge (kg):	**4.5kg**

TEST RESULTS:

Field moisture content %:	**36.5%**
Maximum dry density (kg/m3):	**1,650 kg/m³**
Optimum moisture content %:	**18.0%**
Dry density prior to soaking (kg/m3):	**1,620 kg/m³**
Dry density after soaking (kg/m3);	**1,590 kg/m³**
Moisture content moulded % :	**17.8%**
Moisture content after soaking % :	**20.7%**
Top 30mm after test %	**24.1%**
Swell after soaking % :	**1.8%**

C.B.R.VALUES: **2.5mm penetration % :** **2½**

5.0mm penetration % : **2**

02/03

Approved Signatory: S Chandler Laboratory No 9849

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CALIFORNIA BEARING RATIO

CLIENT:	W & M Walls	**PROJECT NO:**	22170
ADDRESS:	C/- PO Box 86 South West Rocks	**REPORT NO:**	22170-3
PROJECT:	Walldell Park	**DATE:**	23.4.03
LOCATION:	South West Rocks		

Sample No:	**PM 4665**
Sample description:	**Gravelly silty sandy clay**
Sample location:	**Test Pit 10, 0.25 - 0.55 metres.**
Date sampled:	**9.4.03**

TEST PROCEDURES

Date Tested:	**22.4.03**
Test Method:	**AS1289, 6.1.1**
Duration of soaking:	**4 Days**
Compaction level % :	**100.0%**
Compactive effort:	**Standard**
Drop of rammer (mm):	**300mm**
Mass of rammer (kg):	**2.7kg**
Surcharge (kg):	**4.5kg**

TEST RESULTS:

Field moisture content %:	**12.3%**
Maximum dry density (kg/m3):	**1,980 kg/m³**
Optimum moisture content %:	**9.5%**
Dry density prior to soaking (kg/m3):	**1,980 kg/m³**
Dry density after soaking (kg/m3);	**1,980 kg/m³**
Moisture content moulded % :	**9.9%**
Moisture content after soaking % :	**10.9%**
Top 30mm after test %	**10.7%**
Swell after soaking % :	**0.0%**

C.B.R.VALUES: **2.5mm penetration % : 19**

5.0mm penetration % : 25

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CALIFORNIA BEARING RATIO

CLIENT:	W & M Walls	**PROJECT NO:**	22170
ADDRESS:	C/- PO Box 86 South West Rocks	**REPORT NO:**	22170-4
PROJECT:	Walldell Park	**DATE:**	23.4.03
LOCATION:	South West Rocks		

Sample No:	**PM 4667**
Sample description:	**Sandy CLAY, orange brown.**
Sample location:	**Test Pit 13, 0.3 - 0.6 metres.**
Date sampled:	**9.4.03**

TEST PROCEDURES

Date Tested:	**22.4.03**
Test Method:	**AS1289, 6.1.1**
Duration of soaking:	**4 Days**
Compaction level % :	**99.5%**
Compactive effort:	**Standard**
Drop of rammer (mm):	**300mm**
Mass of rammer (kg):	**2.7kg**
Surcharge (kg):	**4.5kg**

TEST RESULTS:

Field moisture content %:	**24.9%**
Maximum dry density (kg/m3):	**1,630 kg/m³**
Optimum moisture content %:	**21.5%**
Dry density prior to soaking (kg/m3):	**1,620 kg/m³**
Dry density after soaking (kg/m3);	**1,530 kg/m³**
Moisture content moulded % :	**21.2%**
Moisture content after soaking % :	**25.2%**
Top 30mm after test %	**28.9%**
Swell after soaking % :	**6.1%**

C.B.R.VALUES: **2.5mm penetration % : 1½**

5.0mm penetration % : 1½

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CALIFORNIA BEARING RATIO

CLIENT:	W & M Walls	**PROJECT NO:**	22170
ADDRESS:	C/- PO Box 86 South West Rocks	**REPORT NO:**	22170-5
PROJECT:	Walldell Park	**DATE:**	23.4.03
LOCATION:	South West Rocks		

Sample No:	**PM 4668**
Sample description:	**Clayay SAND, grey.**
Sample location:	**Test Pit 15, 0.3 - 0.6 metres.**
Date sampled:	**9.4.03**

TEST PROCEDURES

Date Tested:	**22.4.03**
Test Method:	**AS1289, 6.1.1**
Duration of soaking:	**4 Days**
Compaction level % :	**99.2%**
Compactive effort:	**Standard**
Drop of rammer (mm):	**300mm**
Mass of rammer (kg):	**2.7kg**
Surcharge (kg):	**4.5kg**

TEST RESULTS:

Field moisture content %:	**16.0%**
Maximum dry density (kg/m3):	**1,960 kg/m³**
Optimum moisture content %:	**10.0%**
Dry density prior to soaking (kg/m3):	**1,940 kg/m³**
Dry density after soaking (kg/m3);	**1,940 kg/m³**
Moisture content moulded % :	**10.8%**
Moisture content after soaking % :	**12.3%**
Top 30mm after test %	**12.4%**
Swell after soaking % :	**0.3%**

C.B.R.VALUES: **2.5mm penetration % : 10**

5.0mm penetration % : 11

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CALIFORNIA BEARING RATIO

CLIENT: W & M Walls
ADDRESS: C/- PO Box 86
South West Rocks

PROJECT: Walldell Park

LOCATION: South West Rocks

PROJECT NO: 22170

REPORT NO: 22170-6

DATE: 23.4.03

Sample No:	**PM 4670**
Sample description:	**Sandy CLAY, orange brown.**
Sample location:	**Belle O'Connor Street, (Test Pit 19), 0.3 - 0.6m**
Date sampled:	**9.4.03**

TEST PROCEDURES

Date Tested:	**22.4.03**
Test Method:	**AS1289, 6.1.1**
Duration of soaking:	**4 Days**
Compaction level % :	**100.0%**
Compactive effort:	**Standard**
Drop of rammer (mm):	**300mm**
Mass of rammer (kg):	**2.7kg**
Surcharge (kg):	**4.5kg**

TEST RESULTS:

Field moisture content %:	**15.3%**
Maximum dry density (kg/m3):	**1,720 kg/m³**
Optimum moisture content %:	**17.0%**
Dry density prior to soaking (kg/m3):	**1,720 kg/m³**
Dry density after soaking (kg/m3);	**1,715 kg/m³**
Moisture content moulded % :	**17.2%**
Moisture content after soaking % :	**18.9%**
Top 30mm after test %	**18.5%**
Swell after soaking % :	**0.3%**

C.B.R.VALUES: **2.5mm penetration % : 10**

5.0mm penetration % : 11

Approved Signatory: S Chandler Laboratory No 9849

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SOIL REACTIVITY TEST
DETERMINATION OF SHRINK SWELL INDEX

CLIENT : W & M Walls
ADDRESS : C/- PO Box 86
South West Rocks

DATE : 23.4.03

PROJECT NO : 22170

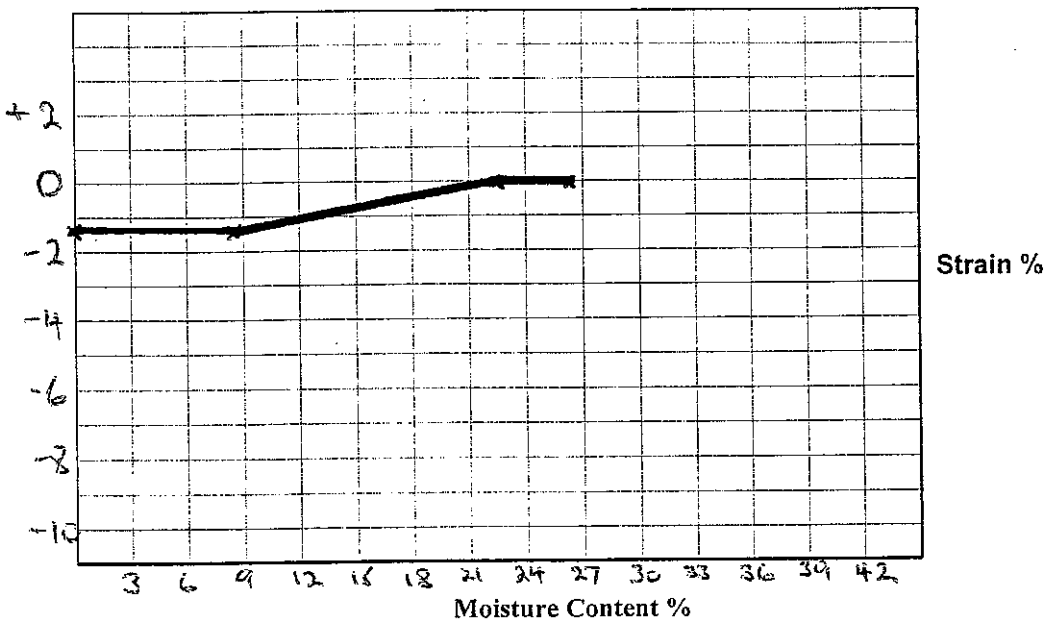
PROJECT : Waldell Park

REPORT NO : 22170-7

SAMPLE LOCATION : Test Pit 1, 0.5 - 0.9 metres.

SAMPLE DESCRIPTION : Sandy CLAY, orange brown, medium to high plasticity, sands fine to medium grained, mc > wp.

CORE SHRINKAGE TEST	SWELL TEST
Moisture content - air dried 8.4%	Pocket penetrometer - initial 350kPa
Shrinkage - air dried 1.3%	Pocket penetrometer - final 240kPa
Field Moisture content - oven dried 22.5%	Moisture content - final 26.2%
Shrinkage - oven dried 1.3%	Swell under load 0.0%



Shrink - swell index (Iss) 0.72

Test Method AS 1289.7.1.1-1992

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SOIL REACTIVITY TEST
DETERMINATION OF SHRINK SWELL INDEX

CLIENT : W & M Walls
ADDRESS : C/- PO Box 86
South West Rocks

DATE : 23.4.03

PROJECT NO : 22170

PROJECT : Waldell Park

REPORT NO : 22170-8

SAMPLE LOCATION : Test Pit 6, 0.3 - 0.6 metres.

SAMPLE DESCRIPTION : Silty CLAY, grey, medium to high plasticity, sands fine grained, mc > wp. Slopewash.

CORE SHRINKAGE TEST

Moisture content - air dried 15.7%

Shrinkage - air dried 7.0%

Field Moisture content - oven dried 30.9%

Shrinkage - oven dried 7.8%

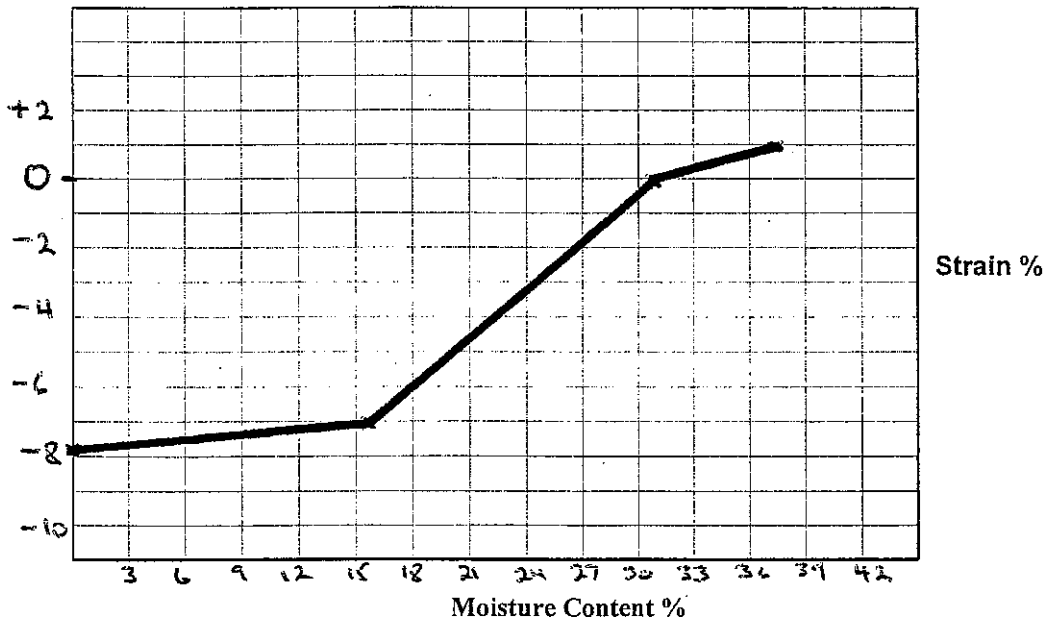
SWELL TEST

Pocket penetrometer - initial 280kPa

Pocket penetrometer - final 180kPa

Moisture content - final 37.5%

Swell under load 1.0%



Shrink - swell index (Iss) 4.60 Test Method AS 1289.7.1.1-1992

Approved Signatory: S Chandler Laboratory No 9849

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SOIL REACTIVITY TEST
DETERMINATION OF SHRINK SWELL INDEX

CLIENT : W & M Walls
ADDRESS : C/- PO Box 86
South West Rocks

DATE : 23.4.03

PROJECT NO : 22170

PROJECT : Waldell Park

REPORT NO : 22170-9

SAMPLE LOCATION : Test Pit 7, 0.7 - 1.0 metre.

SAMPLE DESCRIPTION : Gravelly sandy CLAY, mottled orange & grey, medium to high plasticity, sands fine to coarse grained, gravel fine to medium, mc > wp. Residual.

CORE SHRINKAGE TEST

Moisture content - air dried 6.5%

Shrinkage - air dried 3.3%

Field Moisture content - oven dried 15.7%

Shrinkage - oven dried 3.3%

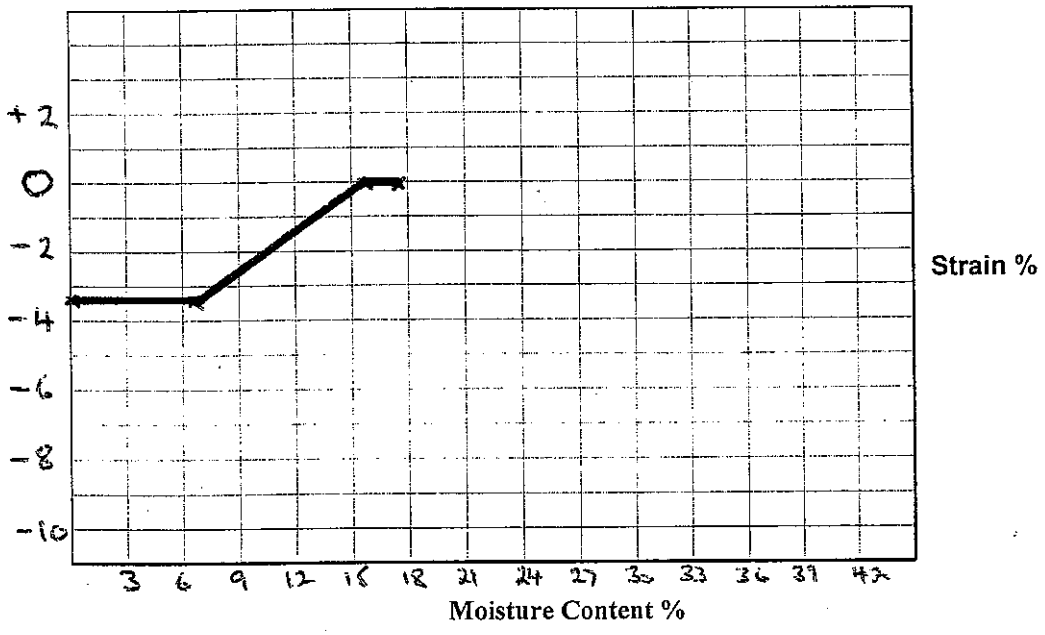
SWELL TEST

Pocket penetrometer - initial 250kPa

Pocket penetrometer - final 220kPa

Moisture content - final 17.4%

Swell under load 0.0%



Shrink - swell index (Iss) 1.83

Test Method AS 1289.7.1.1-1992

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SOIL REACTIVITY TEST
DETERMINATION OF SHRINK SWELL INDEX

CLIENT : W & M Walls
ADDRESS : C/- PO Box 86
South West Rocks

DATE : 23.4.03

PROJECT NO : 22170

PROJECT : Waldell Park

REPORT NO : 22170-10

SAMPLE LOCATION : Test Pit 13, 0.4 - 0.7 metres.

SAMPLE DESCRIPTION : Sandy CLAY, orange brown, medium to high plasticity, sands fine to medium grained, trace of fine gravel, mc > wp.

CORE SHRINKAGE TEST

Moisture content - air dried 10.0%

Shrinkage - air dried 4.1%

Field Moisture content - oven dried 24.9%

Shrinkage - oven dried 4.1%

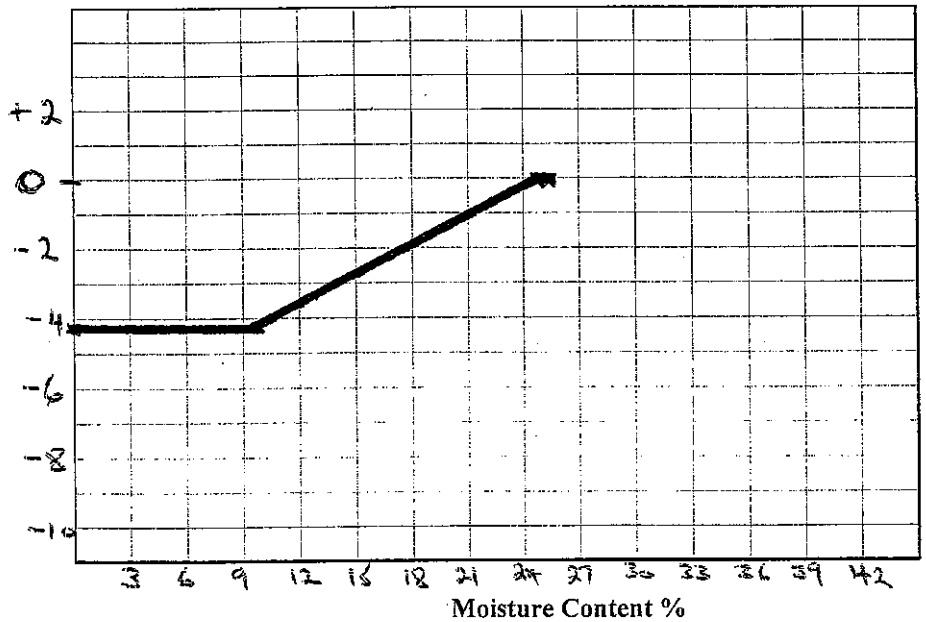
SWELL TEST

Pocket penetrometer - initial 250kPa

Pocket penetrometer - final 180kPa

Moisture content - final 25.2%

Swell under load 0.0%



Shrink - swell index (Iss) 2.28

Test Method AS 1289.7.1.1-1992

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SOIL REACTIVITY TEST
DETERMINATION OF SHRINK SWELL INDEX

CLIENT : W & M Walls
ADDRESS : C/- PO Box 86
South West Rocks

DATE : 23.4.03

PROJECT NO : 22170

PROJECT : Waldell Park

REPORT NO : 22170-11

SAMPLE LOCATION : Test Pit 14, 0.5 - 0.9 metres.

SAMPLE DESCRIPTION : Silty CLAY, pale grey, medium to high plasticity, sands fine grained, mc > wp. Residual.

CORE SHRINKAGE TEST

Moisture content - air dried 14.4%

Shrinkage - air dried 7.2%

Field Moisture content - oven dried 30.0%

Shrinkage - oven dried 8.2%

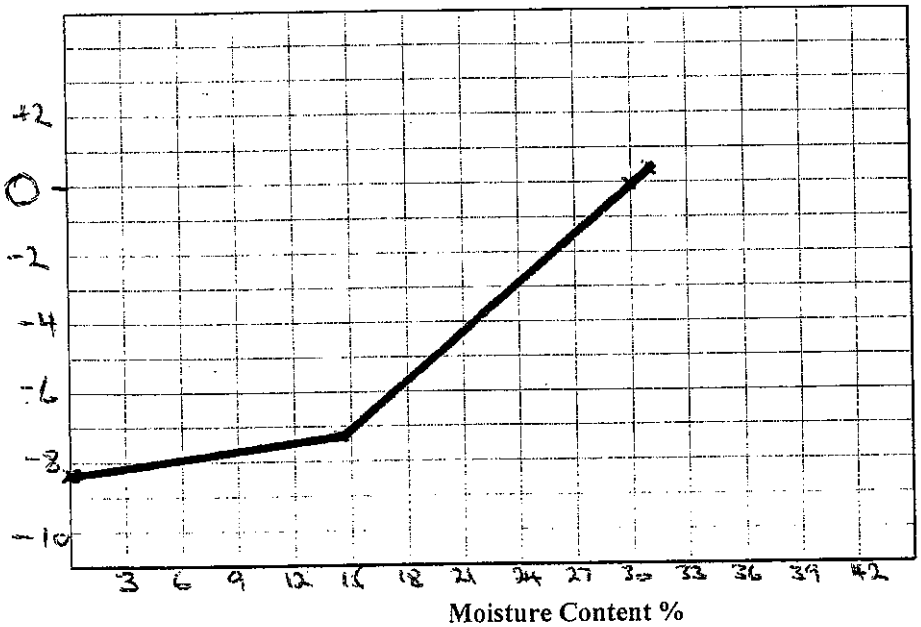
SWELL TEST

Pocket penetrometer - initial 150kPa

Pocket penetrometer - final 100kPa

Moisture content - final 31.0%

Swell under load 0.4%



Shrink - swell index (Iss) 4.67 Test Method AS 1289.7.1.1-1992

Approved Signatory: S Chandler Laboratory No 9849

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SOIL REACTIVITY TEST
DETERMINATION OF SHRINK SWELL INDEX

CLIENT : W & M Walls
ADDRESS : C/- PO Box 86
South West Rocks

DATE : 23.4.03

PROJECT NO : 22170

PROJECT : Waldell Park

REPORT NO : 22170-12

SAMPLE LOCATION : Test Pit 17, 0.7 - 1.0 metres.

SAMPLE DESCRIPTION : Silty sandy CLAY, mottled orange & grey, low to medium plasticity, sands fine to coarse grained,

CORE SHRINKAGE TEST

Moisture content - air dried 4.4%

Shrinkage - air dried 2.0%

Field Moisture content - oven dried 16.3%

Shrinkage - oven dried 2.0%

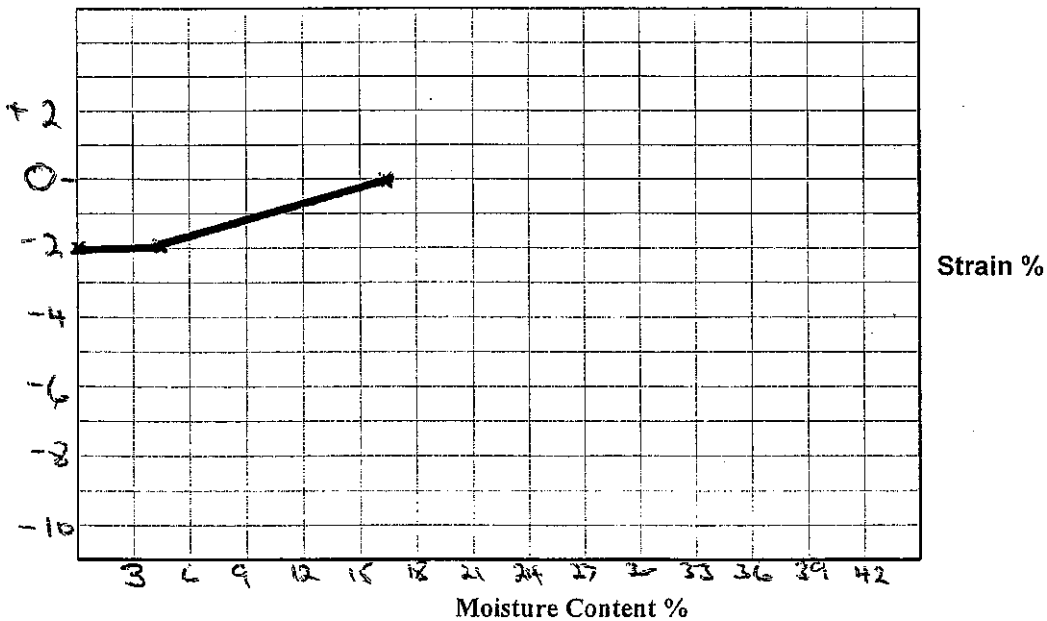
SWELL TEST

Pocket penetrometer - initial 500kPa

Pocket penetrometer - final 400kPa

Moisture content - final 16.3%

Swell under load 0.0%



Shrink - swell index (Iss) 1.11 Test Method AS 1289.7.1.1-1992

Approved Signatory: S Chandler Laboratory No 9849

7/02

RESULTS OF ACID SULPHATE SOIL ANALYSIS

7 soil samples supplied by Chandler Geotechnical P/L on 17th April, 2003 - Lab. Job No. E0352
Analysis requested by Steve Chandler. **Your Job No.: 22170.**

Sample Site	Texture (note 9)	Reduced Inorganic Sulphur (% chromium reducible S) (note 2)	Lab. Bulk Density tonne DW/m^3 (note 5)	Neutralising Calculation Kg Lime/m^3 (note 6 & 7)	COMMENTS RE: Classification as potential acid sulphate soil (ASS) (based on %Scr results)
				(based on %CRS)	
PM4684	fine	0.009	1.29	0.4	**NOT** Potential ASS
PM4685	coarse	0.004	1.77	0.2	**NOT** Potential ASS
PM4686	coarse	0.003	1.47	0.1	**NOT** Potential ASS
PM4687	coarse	0.007	1.83	0.4	**NOT** Potential ASS
PM4688	medium	0.007	1.61	0.4	**NOT** Potential ASS
PM4689	medium	0.007	1.72	0.4	**NOT** Potential ASS
PM4690	medium	0.012	1.89	0.7	**NOT** Potential ASS

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)

2 - Samples analysed by the **'Chromium Reducible Sulphur' technique (S_{cr} - Method 22B)**

3 - Methods from Stone, Y. Ahern CR, and Blunden B (1998). **Acid Sulphate Soil Manual 1998.** ASSMAC, Wollongbar, NSW.

4 - Total carbon and total sulphur determined using a LECO CNS 2000 analyser

5 - Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)

6 - Neutralising Requirement (based on NAGP, chromium reducible sulphur **or** total sulphur) = Kg H_2SO_4/tonne x bulk density

7 - The neutralising requirement does not include a safety margin for complete neutralisation (a factor of 1.5 is often recommended)

8 - Conductivity 1 dS/m = 1 mS/cm = 1000 μS/cm

9 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays

.. Denotes analysis not performed

checked: .....

CSIRO

Improving the Built Environment
information sheet

Sheet No. 10–91 Revised August 1996

Guide to home owners on foundation maintenance and footing performance (updated for AS 2870–1996)

Introduction

This guide was prepared by Dr P.F. Walsh, formerly of CSIRO and now with the University of Newcastle, with advice from the Standards Australia Committee on Residential Slabs and Footings, to provide guidance to home owners on their responsibilities for the care of clay foundations, and to discuss the performance that can be expected from a footing system. (The ground that supports a house is called a foundation, and the concrete structure that transfers the load to this foundation is the footing system.)

The best information about the design and construction of footing systems is contained in the Australian Standard AS 2870 'Residential Slabs and Footings'. The Standard gives a system of site classification, prescribed footing and slab designs, and construction methods that provide an excellent footing system for Australian houses. However, a warning is given that the chance of a footing failure is higher if extreme site conditions are permitted to occur, viz.:

- growth of trees too close to a footing;
- excessive or irregular watering of gardens adjacent to the house;
- lack of maintenance of site drainage; and
- failure to repair plumbing leaks.

The Standard further states that compliance with this guide is a way to avoid extreme site conditions.

Clay foundations are the cause of major problems for houses. Clays are very fine-grained soils that are plastic and sticky when wet, and hard and strong when dry. All clays swell or shrink to some degree as they become wet or dry out. 'Reactive' clays swell or shrink to such an extent that foundation movements can damage houses.

All house sites are classified. Reactive-clay sites are classified as S, M, H or E, in order of increasing reactivity. Proper maintenance of such clay sites requires that the moisture content of the clay should be kept reasonably constant.

Some minor cracking of masonry walls on reactive clay sites is almost inevitable despite proper design, construction and maintenance. Very slight cracks (up to 1 mm wide) could be expected in most houses. Larger cracks (up to 5 mm) may occur in some houses with properly designed and constructed footings if reactive clay sites have been subject to large changes of moisture. Cracks larger than 5 mm are regarded as significant damage.

Non-reactive sites – sands, silts and certain clays of class A or S – need only be protected from becoming extremely wet. This requires adequate attention to site drainage and prompt repair of plumbing leaks.

Further information on these topics is given in the following sections. The guide has been updated to be consistent with the revised edition of AS 2870 (1996).

Site classification

AS 2870 requires all sites to be classified. The emphasis has been placed on reactive clays that swell and shrink with changes of moisture content, because these are the most common cause of problems. The classification system is fairly complicated but, as a general guide, the following may be helpful in understanding the system for clay sites.

S Clays that have not given trouble in the past.

M Moderately reactive clays that may cause minor damage to brick houses on old-style light strip footings. Moderately reactive clays are common.

H Highly reactive clays that often damage houses, paths and fences.

E Extremely reactive clays that frequently damage houses even with strong footings. Generally rare in major cities except Adelaide. Other occurrences include outback NSW, Darling Downs, Geelong and Horsham.

Since the precautions necessary depend on the reactivity of the site, the owner should check the classification that is shown on the house plans.

The maintenance of the building and the site is the responsibility of the owner, and so the owner should be familiar with the requirements of this guide.

Care of clay foundations

All clays move with changes of moisture content, so the aim is to minimise such changes in the clay by:

- draining the site;
- keeping gardens and trees away from the house;
- adequate but moderate garden watering; and
- repairing plumbing leaks.

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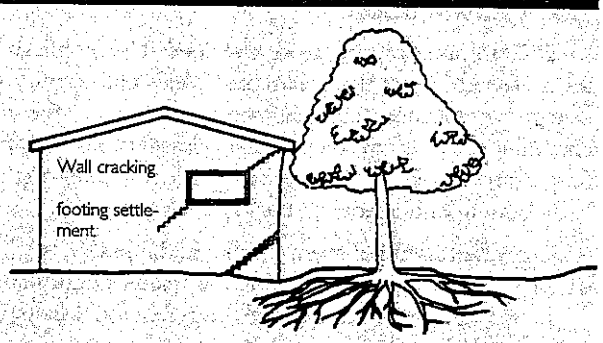
 ISSN 0314-5956

On a reactive-clay site there are some restrictions on the way the owner can safely develop the garden around the house. These restrictions apply mainly to brick houses. In most cases, only minimal precautions are justified for framed houses clad with timber or sheeting.

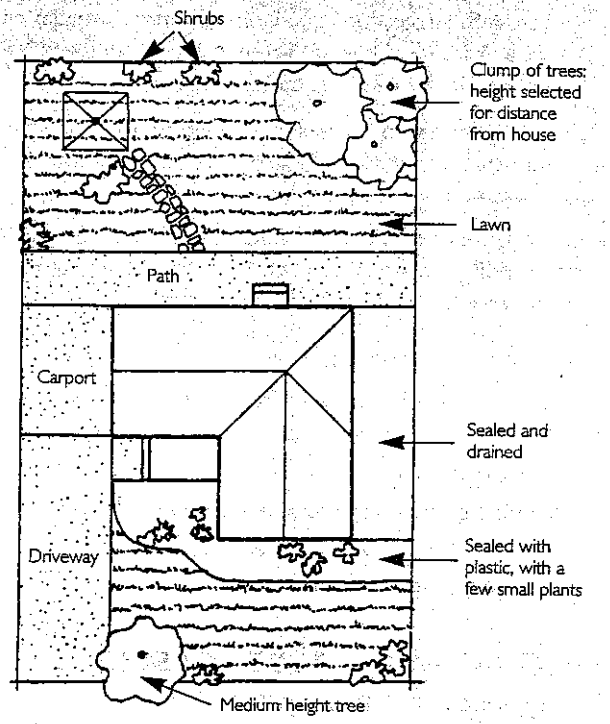
The site must be well drained. Under no circumstances should water be allowed to lie against the house or even near the house. The ground immediately next to the house should be graded away with a slope of about 50 mm over the first metre. Suitable surface drains should be provided to take the surface water away from the house. Where topsoil is brought in, it should not interfere with the site drainage, nor should it raise the ground level enough to block the weepholes in the brick walls or any subfloor vents. Even the subfloor of houses with timber floors should be drained so that water does not collect under the house.

Large garden beds are best not located near the house. This will avoid the possibility of introducing too much moisture to the foundation clay by overwatering. The zone near the house should be planned for paths or covered with gravel and plastic sheeting. Small shrubs may be planted at reasonable spacings.

Trees cause shrinkage and damage



Gardens for reactive site



Gardens and lawns should be watered adequately but not excessively. Uniform, consistent watering can be important to prevent damage to the foundation during dry spells such as droughts or dry summers.

Trees and large shrubs require substantial amounts of water, and if the soil near the tree dries out, the roots will extend in search of soil moisture. Tree watering is important in late summer and in drought. The use of slow-drip watering systems may be appropriate. It has also been found useful to drill holes near trees and fill them with gravel to allow water better access to the tree roots. Otherwise, clays will shrink as they dry, and a house may settle as shown below.

Removal of large trees creates the opposite problem. As soil moisture is gradually restored, clays swell and may lift shallow footings.

Many factors determine the extent of clay drying by trees. The more important include soil type, and the size, number and species of trees. Trees obtain moisture from roots that spread sideways, and the drying zone is influenced by the extent of these roots. For single trees, the drying zone is usually half to twice the tree height, but the zone may be larger for groups or rows of trees. Although it is known that the species can influence the extent and severity of the drying zone, little definite information is available. Some Australian trees are particularly efficient in extracting water from very dry soils and can be more dangerous than non-Australian species that use large amounts of water in normal conditions. The effect of tree drying on the amount of movement is also related to the reactivity of the clay. To minimise the risk of damage, trees (especially groups of trees) should not be planted near the house on a reactive clay site, and the following limits are recommended:

$d = 1.5\,h$ for Class E sites

$d = 1\,h$ for Class H sites

$d = 0.75\,h$ for Class M sites

where d is the distance of the tree from the house, and h is the eventual mature height of the tree. These values should be increased by 50% if the trees are in a dense group. These rules mean that on the average suburban block, trees that grow higher than 8–9 m are often impractical unless the owner accepts the risk of some damage to the house. If large trees are desired, it may be practical to adopt a specially designed footing system, e.g. a piled footing system.

A leak in the plumbing can cause the footings of a house on a reactive clay to move. The water seeps into the clay causing it to swell and push the footing system upwards. Any obvious leaks in stormwater, drainage or sewerage pipes should be investigated. Leaking water pipes can be detected by turning off all the taps and checking if the water meter records any flow.

The above restrictions may seem onerous for new home owners, but lack of site maintenance on a reactive clay can cause damage to the house. The whole issue should be kept in some perspective. The damage to houses caused by reactive clays is mostly unsightly cracks in the brickwork. In the typical Australian brick-veneer house, the brickwork does not support the structure. It is the timber frame that

ırries the walls and roof loads, so brick cracks do not affect .e structural safety of the house.

owners choose to disregard some of the above restrictions ıd, say, plant large trees all around the house, they should ɔt blame the builder, the engineer or the Council if the ɔuse suffers some cracking.

erformance of footing systems

l building materials move. Concrete and timber shrink, ıicks grow, and so on. Many building practices have been ɔlved to reduce the damage that such movements cause, ıd the minor difficulties that arise are usually repaired .thout significant problems.

here footings are designed by an engineer, the basis of the ɜsign is the limitation of any vertical movement that might ɔcur between the centre of the wall and a line joining the ıds of the wall. This is termed the differential movement .d lim'' are given in AS 2870 for various forms of house nstr n. For example, a masonry veneer house with ticulation joints is designed for a movement limit of 30 m. The amount of this movement at a house can be ecked using a level or even a string line along a brick urse in the wall. If the vertical differential movement is ɜs than the prescribed limit then the footing system has ɜrformed up to standard.

asonry wall cracking can have many causes other than ɔting movement, including bricks growing as they absorb ɔisture, the structural or shrinkage movements of the ıme within the veneer skin or even accidental damage .ring construction. If the cracking is less than a few milli-ɜtres it is virtually impossible to determine the cause. ɜrtainly if there is no evidence of excessive differential ɔvement then footings should not be regarded as the cause the cracking.

ɔwever, it must be accepted that on reactive clay sites, rticularly Class H and E, some movement is likely and for ne s ive houses cracking may occur even for footings rform. within expectations. In order to set realistic ɔectations, AS 2870 contains Appendix C which is ɜluded in this report.

e performance requirement of AS 2870 suggests that tegory 0 to 1 damage may be expected for houses on a ıctive-clay site, but that the damage is of little ısequence. Category 2 damage (isolated cracks up to 5 mm le) is clearly not satisfactory, but it still does not constitute nificant failure and could be expected to occur under ɜrse environmental conditions.

r these categories of damage, it is the intention of AS 2870 .t consequent repairs are part of the normal house intenance, although during the warranty period this may the responsibility of the builder.

netheless, to ensure that the damage does not proceed to ıore serious state, the owner should take some action.

Check that the recommendations on site treatment, drainage, garden arrangement, trees etc., have been observed.

Keep a record of the crack width against the time of the year. If the damage is as high as Category 2 and seems to be increasing, the owner should consult the builder who may be able to offer more specific advice. If this does not prove satisfactory, the owner should engage a consulting engineer who specialises in house footings.

- Engage a plumber to check for leaks if this is suspected to be the cause.
- Replace soil moisture in dry spells by watering. Such watering can be more effective if holes or trenches are dug into the clay. The holes or trenches should be filled with compacted crushed rock or gravel and moderately watered. Some trees may need to be removed or kept pruned.

Complete stability is difficult to achieve, so repairs to damaged walls should include methods that will disguise further movements. Extra joints should be included in external masonry walls and further cracking in internal walls can be concealed by flexible paints, wall paper or panelling. Repairing of cracks with brittle fillers should be avoided unless the cracks have stabilised.

For the more serious categories of damage, the steps to be taken are similar, but there should be little delay in seeking advice. Remedial action for significant failure may still only include attention to stabilising moisture conditions as described above, but could also involve constructing a concrete path or a wall in the ground to stop drying of the foundation clay. Walls may even be designed to span over sagging footings or to cantilever beyond sagging footings. Underpinning is usually not satisfactory in reactive clays.

Experience indicates that lack of maintenance is responsible for many failures. Even with proper design and site maintenance the occasional failure may still occur because footing behaviour is so complex.

Shrinkage of concrete floors

Concrete needs water. Firstly to allow the fresh concrete to flow, and secondly to develop strength during its first few weeks. As a slab starts to dry, it shrinks and tries to contract. Some of this movement is restrained or resisted by friction on the bottom of the slab and by the beams in the ground. This restraint causes tension or stretching forces in the slab and these forces are often large enough to crack the slab.

Shrinkage cracking is almost inevitable and does not represent failure. Most owners never notice the cracks because they often do not occur until after the carpets are laid. Cracks under brittle or sensitive floor coverings are of concern, but the risk of damage can be reduced by using flexible mortars and glues for fixing slate and tiles etc. Also it helps to delay installing the floor covering until after the shrinkage has occurred. The length of delay should be at least three months after the slab has started to dry (i.e. from the time the slab is last wet from rain or during construction).

Adhesive-fixed floor coverings

A concrete slab takes a long time to dry. For example, under temperate conditions a slab will take about three months to dry. Moisture in the concrete can interfere with the bond or break down the adhesive used to attach floor coverings. However, a range of adhesives is available for various floor coverings and these should perform quite well on slabs that have been allowed to dry sufficiently. If there is any doubt, the moisture condition of the slab should be assessed before coverings are placed.

Conclusion

This guide has been prepared to advise owners on how to care for the foundation of their houses and what to expect from a well-designed footing system. The main concern with foundation maintenance is to prevent the foundation soil becoming too wet or too dry, and a variety of recommendations are given to achieve this.

Further information

Cameron, D. A. & Earl, I. 1982, *Trees and Houses: A Question of Function*, Cement & Concrete Association, Melbourne.

Cameron, D. A. & Walsh, P. F. 1984, *Damage to Buildings on Clay Soils*, Technical Bulletin 5.1, Australian Council of National Trusts.

CSIRO 1995, *House Cracking in Drought Periods*, Information Sheet No. 10–88, CSIRO Australia, Division of Building, Construction and Engineering, Melbourne.

Martin, K. G., Lewis, R. K., Palmer, R. E. & Walsh, P. F. 1983, *Floor Coverings on Concrete Slab-on-ground*, CSIRO Australia, Division of Building Research Report, Melbourne.

Disclaimer

Appendix C of As 2870

Table C1 **Classification of damage with reference to walls**

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depends on number of cracks	4

Table C2 **Classification of damage with reference to concrete floors**

Description of typical damage	Approximate crack width limit in floor	Change in offset from a 3 m straight edge centred over defect (see Note 5)	Damage category
Hairline cracks, insignificant movement of slab from level	<0.3 mm	<8 mm	0
Fine but noticeable cracks. Slab reasonably level	<1.0 mm	<10 mm	1
Distinct cracks. Slab noticeably curved or changed in level	<2.0 mm	<15 mm	2
Wide cracks. Obvious curvature or change in level	2–4 mm	15–25 mm	3
Gaps in slab. Disturbing curvature or change in level	4–10 mm	>25 mm	4

Notes:

1 Crack width is the main factor by which damage to walls is categorised. The width may be supplemented by other factors, including serviceability, in assessing category of damage.

2 In assessing the degree of damage, account shall be taken of the location in the building or structure where it occurs, and also of the function of the building or structure.

3 Where the cracking occurs in easily repaired plasterboard or similar clad-framed partitions, the crack width limits may be increased by 50% for each damage category.

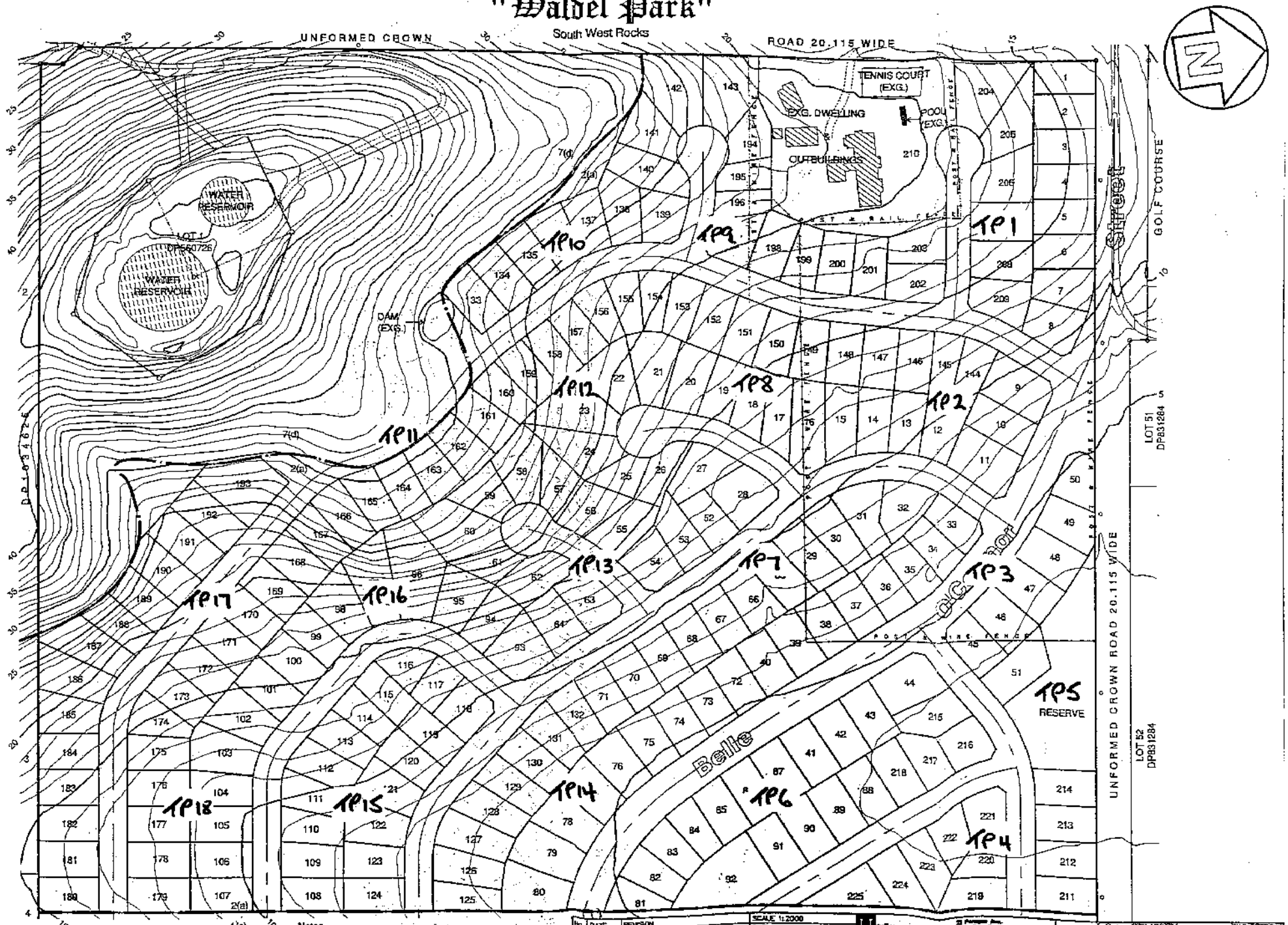
4 Local deviation of slope, from the horizontal or vertical, of more than 1/100 will normally be clearly visible. Overall deviations in excess of 1/150 are undesirable.

5 Account should be taken of the past history of damage in order to assess whether it is stable or likely to increase.

6 The straight edge is centred over the defect, usually, and supported at its ends by equal height spacers. The change in offset is then measured relative to this straight edge.

"Waldel Park"

South West Rocks



Concept Plan

Scale 1:2000

Notes

1. Dimensions, areas & easement locations subject to final survey & Council approval.

2. ——— Denotes Zone boundary

No.	DATE	REVISION

SCALE 1:2000
DATUM : AHD
DRAWN BY : C.A.B.
APPROVED : L.M.
DATE : 8th MAY 2003

L.G.A. KEMPSEY
PROPOSED SUBDIVISION
LOT 21 PL LOT 2 DP845213 Belle O'Connor St.
South West Rocks
W.R. & M.E. WALLS

FILE REFERENCE 50493-02C
AMENDMENT No