

GEOTECHNICAL INVESTIGATION REPORT
PRELIMINARY DEVELOPMENT ASSESSMENT
LOT CLASSIFICATION & PAVEMENT CONDITIONS

715-717 Appin Road, Gilead NSW 2560

Prepared for
Meadowvale Developments Pty Ltd

Reference No. G646

June 2023

DOCUMENT CONTROL REGISTER

Document Information	
Reference No.	G646
Document No.	1
Report Title	Geotechnical Investigation & Preliminary Assessment
Site Address	715-717 Appin Road, Gilead NSW 2560
Prepared for	Meadowvale Developments Pty Ltd

Document Review Details			
Revision No.	Issue Date	Description	Issued By
0	14/06/2023	Initial Issue	Ben Buckley
A	12/09/2023	Client Revision	Ben Buckley
–	–	–	–

Distribution Register		
Method	Custodian	Issued to
Electronic	Ben Buckley	Foundation Earth Sciences Office
Electronic	Peter Alevizos	Meadowvale Developments Pty Ltd

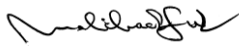
Authorisation and Release			
–	Signature	Name	Date
Author		Lubos Melicharek	13/09/2023
Author		Ben Buckley	13/09/2023

TABLE OF CONTENTS

1.0 INTRODUCTION	5
2.0 AVAILABLE INFORMATION	6
3.0 FIELDWORK AND LABORATORY TESTING.....	7
4.0 GROUND CONDITIONS	7
4.1 Ground Profile	7
4.2 Groundwater	8
4.3 Soils Laboratory Testing	9
5.0 DISCUSSIONS AND RECOMMENDATIONS	9
5.1 Preliminary Site Lots Classification.....	9
5.2 Topsoil Layer with Site Preparation and Temporary Batter Slopes	11
5.3 Stormwater Drainage and Groundwater Management	12
5.4 Foundations.....	13
5.5 Preliminary Site Stability Assessment	14
5.6 Preliminary Pavement Design Parameters	15
5.7 Earthworks and Subgrade Preparation	15
6.0 CONCLUSIONS	16
7.0 LIMITATIONS	18
8.0 REFERENCES	18

LIST OF TABLES

Table 1: Summary of Details of the Site	5
Table 2: Summary of Ground Profile within Test Pits TP1 to TP5 inclusive	8
Table 3: Summary of Ground Profile within Test Pits TP6 to TP10 inclusive	8
Table 4: Summary of Atterberg Limits (LL, PI, LS), Shrink Swell Index (Iss) and CBR Tests	9
Table 5: Preliminary Site Lot Classification	11
Table 6: Maximum Temporary Batter Slope.....	12
Table 7: Foundation Design Parameters	13

APPENDICES

- Appendix A:** Site Plan
- Appendix B:** Test Pit Logs
- Appendix C:** Results of Dynamic Cone Penetrometer Tests
- Appendix D:** Results of Soils Laboratory Testing
- Appendix E:** Guide to Home Owners

1.0 INTRODUCTION

The purpose of this geotechnical investigation was to provide generalised geotechnical assessment model of the site providing subsurface conditions, groundwater and stability of the site, topsoil thickness, earthworks recommendations, bedrock depths, and preliminary site lot classifications together with pavement design parameters. The site will contain low and medium density housing, local roads and conservation areas. This geotechnical report has been prepared to assist in the rezoning application of the site to accommodate the proposed residential development. Details of the site are summarised in Table 1.

Table 1: Summary of Details of the Site

Site	Details
Location	715-717 Appin Road, Gilead, NSW 2560
Lot / DP	Lot 1 [717 Appin Rd] & Lot 4 [715 Appin Rd] in DP602888
Local Council	City of Campbelltown
Site Area	Approximately 72.3ha
Shape & Slope	Rectangular approximate shape of relatively low hills topography and undulating terrain with dams and creek valley
Existing Structures	The site currently has two residential dwellings and gas and services easement, trees and water ponding dams and creek
Closest Watercourse	Woodhouse Creek, passing through the eastern portion of the site
Special Features	The site has easement at the western part and 'Avoided Land' area
Neighbouring Properties	East - Appin Road then vacant land grassed rural areas West - Vacant land rural properties then Nepean River South - Vacant land and rural residential properties North - Rural residential grassed and forest properties
Geology Map	Wollongong 1:250,000 Geological Series Sheet SI 56-9 (Second edition 1966) from NSW Department of Mines, Sydney, N.S.W.
Primary Geology	Rwl – Wianamatta Group, "Shale with some sandstone beds."
Secondary Geology	Rh – Triassic Age Hawkesbury Sandstone, comprising "Quartz sandstone with some shale."

2.0 AVAILABLE INFORMATION

Foundation Earth Sciences (“FES”) was appointed by Meadowvale Developments Pty Ltd (“client”) to undertake a geotechnical field investigation as per the proposed scope. This FES report describes assessed field geotechnical and geological site conditions, proposed residential lots assessment, with further details and all geotechnical aspects pertaining to this site and summarising Geotechnical Site Investigation (GI) undertaken by FES for the property at 715-717 Appin Road, Gilead NSW (“the site”).

The site is currently occupied by two residential dwellings with mainly grassed areas, trees and dams, with access via a gravel driveway at the existing rural residential area of Appin Road, Gilead. It is understood that the site is proposed to be developed for residential and community development purposes. This geotechnical report forms a part of the requirement for a Land Capability Assessment to confirm the suitability of the land for residential housing and designed open space areas purposes.

Following information was made available to Foundation Earth Sciences (“FES” or “Foundation ES”) during the preparation of this geotechnical report:

- Preparatory design information for DA lodgement within Campbelltown City Council (“Council”) area to support the rezoning of the land parcels to enable urban development. The Greater Macarthur Plan 2040 with recent exhibition under issued ‘Campbelltown Interim Development Order No. 15’.
- Drawing Concept Plans, A, B, and B – Design, prepared by e8urban Pty Ltd, Drawing “Concept A, Concept B & Concept B – Design Issues”, Concept drawn 12th April 2023, Sketch No. SK-0031 to SK-0033.
- GLN Request for Services, containing information and requested geotechnical report study objectives, dated 15th March 2023, and prepared for Omayya, Meadowvale, Gilead. GLN Planning specified scope of work to be undertaken for this site.

3.0 FIELDWORK AND LABORATORY TESTING

Following scope of work was carried out as a part of the site field investigation undertaken by FES during combined (PSI and GI) sampling and testing on 17th May 2023:

- Review of Dial-Before-You-Dig (“DBYD”) plans and services locating.
- Mechanical excavation of ten (10) geotechnical test pits, identified as TP1 to TP10.
- Excavating and collecting environmental samples during the investigation works.
- Dynamic Cone Penetrometer (“DCP”) testing in the field at the selected two (2) locations, in order to assess strength and consistency of the natural soils on the site.
- Laboratory testing of pavement reactivity of natural residual clays on the site with a California Bearing Ratio (“CBR”) testing on recovered soil samples, together with Atterberg Limits soil testing and Shrink-Swell Index tests on selected samples.

The approximate locations of the test pits excavated are shown on a “Site Plan” and attached as Appendix A. The test pit logs combined are attached as Appendix B.

The results of DCP tests, together with the results of CBR tests, Atterberg Limits and Shrink-Swell Index tests are annexed as Appendix C, D, with Guide to Home-Owners attached as Appendix E respectively.

4.0 GROUND CONDITIONS

4.1 Ground Profile

Ground profiles encountered within the test pits are listed below, with the depths of the encountered ground profiles. Following ground profiles encountered are summarised further in Table 2 and Table 3.

However, reference should be made to the test pits logs TP1 to TP10 inclusive.

- TOPSOIL Layer – Silty Clay, brown, low to medium plasticity, with organic matter, moist. Appears generally of firm consistency and with grass roots.
- RESIDUAL SOILS – Silty Clay, brown, red/orange, and yellow/grey, high plasticity, with gravel and trace of sand, moist. Appears generally of very stiff to hard consistency.
- ROCK – Shale and Sandstone, extremely weathered to highly weathered, grey/brown (shale) and red/orange (sandstone), dry to moist. Extremely low to low strength.

Table 2: Summary of Ground Profile within Test Pits TP1 to TP5 inclusive

Unit	Depth (m)				
	TP1	TP2	TP3	TP4	TP5
Topsoil	0.0 – 0.2	0.0 – 0.2	0.0 – 0.1	0.0 – 0.2	0.0 – 0.2
Residual Soil	0.2 – 1.1	0.2 – 0.9	0.1 – 1.0	0.2 – 1.6	0.2 – 1.1
Bedrock	1.1 – 1.2	0.9 – 1.0	1.0 – 1.1	1.6 – 1.7	–

Table 3: Summary of Ground Profile within Test Pits TP6 to TP10 inclusive

Unit	Depth (m)				
	TP6	TP7	TP8	TP9	TP10
Topsoil	0.0 – 0.2	0.0 – 0.2	0.0 – 0.2	0.0 – 0.3	0.0 – 0.3
Residual Soil	0.2 – 0.8	0.2 – 0.9	0.2 – 0.5	–	0.3 – 1.2
Bedrock	0.8 – 0.9	0.9 – 1.1	0.5 – 0.7	0.3 – 0.7	1.2 – 1.3

4.2 Groundwater

Groundwater seepage was not observed during the excavating of the test pits TP1 to TP10 inclusive, and prior to backfilling of these test pits. The standpipes were not installed in the test pits or at close vicinity, as this was not planned or required at this stage of the project.

Groundwater levels in general may fluctuate, and it should be noted further that groundwater levels, expected at greater depths in the underlying rock profiles, may also be subject to

seasonal variations, local rainfalls, prevailing weather conditions and future developments of the areas and landforms across the neighbouring potential residential land sites.

4.3 Soils Laboratory Testing

Soils samples recovered on the site were tested for CBR, Emerson class and for soils reactivity. Emerson Class 5. or Class 6. soils were confirmed on site. Results of Shrink Swell Index (Iss) and Atterberg Limits tests, together with CBR test results are summarised in Table 4.

Table 4: Summary of Atterberg Limits (LL, PI, LS), Shrink Swell Index (Iss) and CBR Tests

Test Pit (Sample Depths)	Liquid Limit (%)	Plasticity Index (%)	Linear Shrinkage (%)	Iss (%)	CBR (%)
TP1 0.3-0.5m	60	39	15.5	1.9	-
TP3 0.4-0.6m	63	38	15.5	-	6.0
TP5 0.3-0.6m	68	41	15.5	1.1	6.0
TP6 0.6-0.8m	27	7	5.0	-	-
TP10 0.6-0.8m	66	37	16.5	-	6.0

5.0 DISCUSSIONS AND RECOMMENDATIONS

5.1 Preliminary Site Lots Classification

Laboratory testing of the soil samples, evaluation of soils reactivity potential, and preliminary assessment of individual lots classification was carried out in accordance with Australian Standard AS 2870-2011. It is noted that the entire development site was mapped as a part of large area generally located within the South Campbelltown Mine Subsidence District.

Also noted that the areas with natural creek and water dams are to be excluded, as these will create biodiversity separate land area in the eastern portion of the site. Gas and transmission

lines traverse the western portion of the land, and this affected area will also be excluded from the residential development, thus following lot classifications will not apply to these designated areas. Lastly it may be possible that some of the proposed residential lots can be affected by external design factors and historical references.

Based on the laboratory testing and the prior acquired geotechnical knowledge of the wider development area, the preliminary lots classification of areas with residual soils beneath the topsoil (fill) layers is assessed to be "Class H1". This means "Highly reactive clay or silt sites, which may experience high ground movement from moisture changes". The proposed lots after the topsoil removal, or with less than 400mm thick imported fill layers can be then classified as "Class H1".

The lots with rock encountered at the shallow depths less than 0.5m, as encountered in TP9 area, can be classified as "Class A" rock site with little or no ground movement from moisture changes.

It is expected that site earthworks and detailed design of the residential lots will change the final topography of newly created residential blocks, and as such, detailed site and lots classification are recommended to be carried out at the final stage of the proposed residential development on this site.

Preliminary and general site lot classification of the proposed lots is summarised in Table 5. It is recommended that potential individual home owners, after the project completion, are also made aware of the recommendations given by the CSIRO publication, "Guide to Home Owners on Foundation Maintenance and Footing Performance" annexed as Appendix E.

It is also recommended that these individual home owners comply with the safe distance from buildings requirements for proposed plants, trees and shrubs from their dwelling to ensure no impact to foundation system of their newly constructed dwellings.

Table 5: Preliminary Site Lot Classification

Lot Address (Gilead, NSW 2560)	New Lot Number (DP602888)	Lot Class
717 Appin Road	Lot 1	H1, A
715 Appin Road	Lot 4	H1

5.2 Topsoil Layer with Site Preparation and Temporary Batter Slopes

It is understood from preliminary design and drawing concept plans that single dwellings and associated structures are proposed predominantly on most of the site residential lots. However, medium density residential development is also planned potentially encompassing multi-storey units and large buildings, with communal areas and driveway access, together with car parking areas. Earthworks to be undertaken for these sized development areas will be feasible with large excavators, backhoes or other type of machinery, and it is expected that the foundations and founding slabs for large buildings will be prepared with the substantial cuts (up 1m to 3m depths) into the natural ground and slopes on the site. This may require stability of the building sites to be provided with temporary or permanent slopes and retaining walls to be built on the proposed lots.

Topsoil layers found across the entire site area, except for buildings, creek, dams and watercourses, were generally found to be in order of 200mm to a maximum 300mm or 400mm thickness. The topsoil (topsoil/fill) layer was assessed comprising mainly natural silty clay soils of low to medium plasticity, with grass roots and organic matter. The topsoil was assessed clean and without foreign materials and from geotechnical perspective suitable for re-use as a gardening soil or for re-agriculture purposes. Topsoil layers are strictly not suitable and cannot be used as a structural fill on this site or any other site when exported.

Temporary batter slopes can be generally considered in the boundaries, where neighbouring structures and road carriageways are located outside the zone of influence and sufficient space exists in between the building site and excavation boundaries. Recommended potential maximum temporary batter slopes for the excavated cut sides are provided in Table 6.

Temporary batter slopes should be supported by suitable earth retaining structures designed for the proposed buildings. Area in between the batter slope and proposed earth retaining structures should be backfilled with suitable materials. Drainage system shall be installed as per structural design drawings prior to commencement of the backfilling process.

Table 6: Maximum Temporary Batter Slope

Ground Profile	Temporary Batter Slope (Horizontal: Vertical)
Fill	2: 1
Residual Soil	1.5: 1
Shale or Sandstone Rock	1: 1

Note: Excavations should be carried out in stages with maximum excavation height of 2.0m. Inspections of batter slopes of each stage should be carried by project geotechnical engineer to confirm stability of the batter slopes.

Backfilling can be carried out using granular type material compacted in layers not exceeding 150mm thickness to 95% Standard Maximum Dry Density, provided some settlement can be tolerated and there are no structures, pavements or services founded within the backfill. If the temporary batter slopes are not considered stable or suitable, then a shoring system consisted of a soldier pile wall system with concrete panels with piles spaced about 1m may be considered suitable for the excavations of the proposed buildings.

5.3 Stormwater Drainage and Groundwater Management

It should be noted groundwater conditions of this entire site may vary and change with climate and development variations. Based on the site field investigation results, it is anticipated that limited, if any groundwater seepages are potentially likely to be encountered during the proposed buildings and multi-storey units' foundation excavations.

If seepages are potentially encountered, then the groundwater within the residual soils and extremely weathered rock profile can be controlled by sump and pump method system with regular discharging. Open space areas, gas and transmission easements, as well as 'Avoided Land' areas around Woodhouse Creek zone are not part of this groundwater assessment.

5.4 Foundations

The foundation levels of the proposed single residential dwellings and/or the proposed units' buildings and their concrete slab footings are anticipated to be within the high reactivity natural clays or within bedrock geology consisting of extremely weathered low to very low strength shale or sandstone rock strata ground profile. Topsoil layers or any potential loose fill materials must be fully stripped and removed from the designed building envelopes prior to foundation preparations.

It is expected the foundation systems for the proposed structures may be likely either shallow or piled foundation systems extending and socketing into suitable shale or sandstone bedrock layers. Table 7 provides preliminary geotechnical design parameters recommended for shallow and pile foundations.

Table 7: Foundation Design Parameters

Ground Profile	Allowable End Bearing Capacity (kPa)	Allowable Shaft Adhesion Compression (kPa)
Fill	N/A	N/A
Residual Soils	150	10
Shale or Sandstone Rock	600	60

Piles will also be used to increase the resistance against the lateral seismic and wind loads. Shallow and pile foundations can be designed in accordance with Australian Standards AS2870-2011 and AS2159-2009, respectively.

It is recommended, and this applies to all foundation slabs and all designed units' buildings and associated structures, that all foundations are to be founded on the same stratum, either rock or clay, in order to minimise and avoid any potential future differential settlements, due to high reactivity of the residual soil's profiles found on this development site. Detail designs of the foundation systems for all structures to be built on the entire site should be carried out by structural engineer and potentially reviewed by geotechnical engineer, with inspections

carried out at the foundation excavations to confirm appropriate foundation materials, and to ensure the serviceability bearing pressures can be achieved. Foundation excavations must be cleaned, all wet soil and rock spoils and debris removed prior to the concrete placement.

5.5 Preliminary Site Stability Assessment

Based on the ground conditions, observed site features and its topography, also confirmed geological profiles and preliminary details of the proposed residential general development, and in accordance with the results of the site detailed investigation, the sites of Lot 1 and Lot 4 in DP602888 are not to be considered as potentially prone to landslide or excessive slope movements. The site has a relatively steeper profile from the western 'crest' areas towards the eastern side Woodhouse Creek area, with slopes generally from the west towards the east to the creek, and from Appin Road eastern boundary towards the west to the creek, traversing the site at about 500m to 600m distance from Appin Road. The slopes are then gentle at the eastern portion towards the eastern site boundary, and all the site area is with trees and covered with grass, without signs of extreme erosion or slope instability. Rock is at the relatively shallow depths uphill towards the western boundary, and it is not anticipated that the general site area will exhibit signs of instability.

Soils potential to dispersion and erosion was preliminary assessed as low and residual soils found across the site preliminary assessed as not prone to pinhole dispersion. This assessment does not apply to the area of Woodhouse Creek between TP3 and TP4, as the existing dams and watercourse were not investigated and tested due to 'Avoided Land' designation. There may be potential for dispersive soils in the expected alluvial soils profile found in this particular land segment of the site but with no detrimental effect on whole site development.

The site earthquake classification, in accordance with Australian Standard AS 1170.4-2007, can be preliminary designated as "Rock" (Class Be) for design of foundations and retaining walls embedded in the underlying bedrock. This is subject to confirmation with the design of foundation systems for the proposed buildings and structures extended and socketed into the underlying bedrock geology. The Hazard Factor (Z) assessed is then stated as 0.08.

5.6 Preliminary Pavement Design Parameters

Results of CBR tests carried out on samples from TP3, TP5 and TP10 indicate that CBR value applicable to site high reactivity gravelly residual silty clays of high plasticity is 6.0%. Where a shallow rock layer was encountered (less than 0.5m depth in TP9) natural gravelly clays or silty clays CBR value is expected to be of higher values. This shallow rock area is regarded, in accordance with the preliminary concept drawings, generally not representative of the areas where most of the proposed access roads may be constructed. Potentially steeper gradients of some of the preliminary designed roads and access to the lots may also become a limiting factor for the pavement design.

It is therefore recommended a **CBR** value of **6.0%** to be adopted preliminary for the site pavement thickness designs.

After preparation of the subgrade layers, it is advisable that in-situ CBR testing may be carried out prior to construction of proposed access roads and carparks to confirm the design CBR value recommended in this report and to avoid any issues that may result from potential variation in assessed strength of the prepared subgrade. Pavement thickness design should be complemented by the provision of adequate surface and subsurface drainage system and then shall be constructed in accordance with the Campbelltown City Council specifications.

5.7 Earthworks and Subgrade Preparation

Earthworks and subgrade preparation on this site to be carried out in accordance with Council specifications and Australian Standard AS 3798-2007. However, as a general procedure some brief comments are provided below for the proposed pavements and access roads areas:

- Fill materials or topsoil or any unsuitable materials should be removed from the site.
- Excavated clay soils for reuse as engineering fill should be stockpiled separately.

- Exposed surface after excavation should be treated to adjust its moisture condition to not to vary more than 2% from its Optimum Moisture Content (“OMC”) and then compacted using at least 12t vibratory roller or compactor to design density ratio.
- Exposed surface shall be tested then with field density testing and if soft or loose areas found during the proof rolling with a smooth drum roller, these should be treated with moisture and then recompacted or replaced with appropriate imported fill material.

Final surface of the cut areas and every layer of the fill areas should be treated with moisture and compacted to design parameters to achieve the adequate strength for the proposed development. The general recommendation for the compaction of fill layers is listed below:

- Moisture content of fill materials on site to be treated to $\pm 2\%$ of OMC of these soils.
- Minimum density ratio of 95% of the standard maximum dry density for the proposed building envelopes areas, as required in general for the residential developments.
- Placement of loose thickness of fill should not exceed 250mm prior and during the compaction works with no larger than 20mm to 40mm particles to be present.

General recommendation for suitability of imported materials for fill layers:

- The materials should be clean (i.e., free of contaminants, deleterious or organic material), free of inclusions of >60mm particles in size.
- Material with excessive moisture content should not be used and be avoided.
- The materials should satisfy the Australian Standard AS 3798-2007.

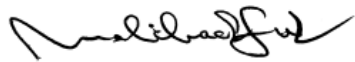
6.0 CONCLUSIONS

This report presents the findings of the site field geotechnical investigation and site lot preliminary classification and pavement design, together with geotechnical comments and provided geotechnical recommendations for the proposed residential development at site 715-717 Appin Road, Gilead, NSW referenced as a preparatory stage conceptual document.

The report considers that the proposed development is feasible for this site in Gilead if the geotechnical recommendations provided in this report are considered in the design and construction of the site residential development.

For and on behalf of Foundation Earth Sciences

Prepared by



Lubos Melicharek

Senior Geotechnical Engineer

CPEng & NER (Civil & Geotechnical Engineering)

Reviewed by



Ben Buckley

Director

7.0 LIMITATIONS

The assessment of the subsurface profile within the proposed development area and the recommendations presented in this report are based on the information available to date. The recommendations and advice presented in this report on soil and rock conditions are to be considered as indicative only as limited areas were assessed on this site to date. Site assessment prior to design of the proposed development is to be undertaken in order to confirm the conditions of founding materials across the whole site in which this geotechnical assessment based above recommendations.

Anecdotal site evidence and all information provided by client is assumed to be relevant and to the best of knowledge be appropriate for its interpretation. There is a high probability that the actual geotechnical and groundwater conditions across the site may differ or vary from the inferred geotechnical assumptions and derivations on which our recommendations are presented in this report. In that case, Foundation Earth Sciences should be contacted for further advise and review of the information provided in this report.

Foundation Earth Sciences does not accept any liabilities for the conditions not provided and/or accessible during the preparation of this report. Any ensuring liability resulting from use of this report by third parties cannot be transferred to Foundation Earth Sciences.

8.0 REFERENCES

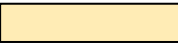
1. Australian Standard – AS1726-1993 “Geotechnical Site Investigation”.
2. Australian Standard – AS 1170.4-2007 “Structural Design Actions – Part 4: Earthquake actions in Australia”.
3. Australian Standard – AS 2870-2011 “Residential slabs and footings”.
4. Australian Standard – AS 2159-2009 “Piling - Design and installation”.

Appendix A

Site Plan

Feature No	Details



Legend
Site Location Pipeline Area Test Pits TP Locations   



DRAWN RW/LM	Site Plan
Appendix A	Meadowvale Developments Pty Ltd
Job FES G646	715 & 717 Appin Road, Gilead NSW

Appendix B

Test Pit Logs

PROJECT: PSI, Salinity & GI

Checked By : MS/LM

Datum : m AHD

Slope : ---

VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

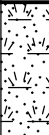
CLIENT NAME: Meadowvale Developments Pty Ltd **JOB NUMBER:** E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW **PROJECT:** PSI, Salinity & GI

Date Started : 17/05/2023 **Completed :** 17/05/2023 **Logged By :** RW/KV **Checked By :** MS/LM

Testpit Location : Refer to Site Plan **Surface RL :** 196 **Datum :** m AHD

Equipment : 5 Tonne Excavator **Testpit Size :** 2m x 0.5m **Slope :** ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	195.8	0.20			FILL / TOPSOIL, Silty Clay, low plasticity, light brown with organic matter	M	[F]	0.0-0.1	[Topsoil] PSI Sample, No HC smell, No Staining or No fibro fragments observed	0.5
			0.5		CH	Silty CLAY, high plasticity, red/orange and brown/yellow, with some coarse gravel and trace of fine to coarse sand	M	VSt-H	0.4-0.5	[Residual Soil] Salinity Sample, No HC smell, No Staining or No fibro fragments observed	
			0.70					H			
			0.90				M				
			1.0			SANDSTONE, highly weathered, orange/yellow and red, very low to low strength	M			[Bedrock]	
		195.0	1.00			Testpit TP 2 terminated at 1.00m				Bucket Refusal	1.0
			1.5								1.5
			2.0								2.0

Comments:

D - Dry
 M - Moist
 W - Wet
 VS - Very Soft
 S - Soft
 F - Firm
 St - Stiff
 VSt - Very Stiff
 H - Hard
 VL - Very Loose
 L - Loose
 MD - Medium Dense
 D - Dense
 VD - Very Dense

CLIENT NAME: Meadowvale Developments Pty Ltd **JOB NUMBER:** E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW **PROJECT:** PSI, Salinity & GI

Date Started : 17/05/2023 **Completed :** 17/05/2023 **Logged By :** RW/KV **Checked By :** MS/LM

Testpit Location : Refer to Site Plan **Surface RL :** 186 **Datum :** m AHD

Equipment : 5 Tonne Excavator **Testpit Size :** 2m x 0.5m **Slope :** ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	185.9	0.10			FILL / TOPSOIL, Silty Clay, low plasticity, light brown, with organic matter	M	[F]	0.0-0.1	[Topsoil] PSI Sample, No HC smell, No Staining or No fibro fragments observed	
		185.5	0.50		CH	Silty CLAY, high plasticity, red/orange and brown, with fine to coarse gravel and trace of sand	D	VSt-H		[Residual Soil]	
								H	CBR, Atterberg Sample & 0.4-0.5	Salinity & GI Sample, No HC smell, No Staining or No fibro fragments observed	0.5
		185.0	1.00			SANDSTONE, highly weathered, orange/yellow and brown/red, very low strength	D			[Bedrock]	1.0
		184.9	1.10			Testpit TP 3 terminated at 1.10m				Bucket Refusal	
			1.5								1.5
			2.0								2.0

Comments:

D - Dry	VS - Very Soft	VL - Very Loose
M - Moist	S - Soft	L - Loose
W - Wet	F - Firm	MD - Medium Dense
	St - Stiff	D - Dense
	VSt - Very Stiff	VD - Very Dense
	H - Hard	

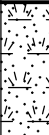
CLIENT NAME: Meadowvale Developments Pty Ltd JOB NUMBER: E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW PROJECT: PSI, Salinity & GI

Date Started: 17/05/2023 Completed: 17/05/2023 Logged By: RW/KV Checked By: MS/LM

Testpit Location: Refer to Site Plan Surface RL: 177 Datum: m AHD

Equipment: 5 Tonne Excavator Testpit Size: 2m x 0.5m Slope: ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	176.8	0.20			FILL / TOPSOIL, Silty Clay, low to medium plasticity, brown, with organic matter	M	[F]		[Topsoil]	
									0.1-0.2	PSI Sample, No HC smell, No Staining or No fibro fragments observed	
		176.4	0.60		CH	Silty CLAY, high plasticity, orange and red/brown, with fine to coarse gravel	D	St-Vst		[Residual Soil]	
			0.5						0.4-0.5	Salinity Sample, No HC smell, No Staining or No fibro fragments observed	0.5
		176.0	1.00					H			1.0
		175.4	1.60			SANDSTONE, highly weathered, orange and yellow/red, very low to low strength	D			[Bedrock]	
		175.3	1.70			Testpit TP 4 terminated at 1.70m				Bucket Refusal	
			2.0								2.0

Comments:

D - Dry
M - Moist
W - Wet
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

PROJECT: PSI, Salinity & GI

Checked By : MS/LM

Datum : m AHD

Slope : ---

VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

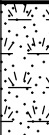
CLIENT NAME: Meadowvale Developments Pty Ltd **JOB NUMBER:** E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW **PROJECT:** PSI, Salinity & GI

Date Started : 17/05/2023 **Completed :** 17/05/2023 **Logged By :** RW/KV **Checked By :** MS/LM

Testpit Location : Refer to Site Plan **Surface RL :** 193 **Datum :** m AHD

Equipment : 5 Tonne Excavator **Testpit Size :** 2m x 0.5m **Shore :** ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	192.8	0.20			FILL / TOPSOIL, Silty Clay, low to medium plasticity, brown, with organic matter and some shale fragments	M	[F]		[Topsoil]	0.5
									0.1-0.2	PSI Sample, No HC smell, No Staining or No fibro fragments observed	
		192.6	0.40		CH	Silty CLAY, high plasticity, brown/red, with fine to coarse gravel	M	VSt		[Residual Soil]	
									0.3-0.4	Salinity Sample, No HC smell, No Staining or No fibro fragments observed	
										GI Sample, No HC smell, No Staining or No fibro fragments observed	
		192.2	0.80		CI	Gravelly CLAY / Silty CLAY, medium plasticity, grey and brown, fine to coarse gravel, with shale fragments	M	H			0.5
						SHALE/SANDSTONE, highly weathered, light grey and brown/red, very low to low strength	D-M			[Bedrock]	
		192.1	0.90			Testpit TP 6 terminated at 0.90m				Bucket Refusal	1.0
			1.0								
			1.5								1.5
			2.0								2.0

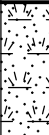
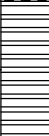
Comments:

 D - Dry
M - Moist
W - Wet

 VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

 VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

CLIENT NAME: Meadowvale Developments Pty Ltd **JOB NUMBER:** E3041, E3041-2 & G646
SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW **PROJECT:** PSI, Salinity & GI
Date Started : 17/05/2023 **Completed :** 17/05/2023 **Logged By :** RW/KV **Checked By :** MS/LM
Testpit Location : Refer to Site Plan **Surface RL :** 171 **Datum :** m AHD
Equipment : 5 Tonne Excavator **Testpit Size :** 2m x 0.5m **Slope :** ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	170.8	0.20			FILL / TOPSOIL, Silty Clay, low to medium plasticity, brown, with organic matter	M	[F]	0.0-0.1	[Topsoil] PSI Sample, No HC smell, No Staining or No fibro fragments observed	
			0.5		CH	Silty CLAY, high plasticity, orange/brown and grey, trace of fine to medium gravel	D	VSt-H	0.4-0.5	[Residual Soil] Salinity Sample, No HC smell, No Staining or No fibro fragments observed	0.5
			0.70					H			
			0.90			SHALE, extremely weathered, grey and brown, extremely low to very low strength	D			[Bedrock]	1.0
		169.9	1.10			Testpit TP 7 terminated at 1.10m				Bucket Refusal	2.0

Comments:

D - Dry
 M - Moist
 W - Wet
 VS - Very Soft
 S - Soft
 F - Firm
 St - Stiff
 VSt - Very Stiff
 H - Hard
 VL - Very Loose
 L - Loose
 MD - Medium Dense
 D - Dense
 VD - Very Dense

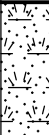
CLIENT NAME: Meadowvale Developments Pty Ltd **JOB NUMBER:** E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW **PROJECT:** PSI, Salinity & GI

Date Started : 17/05/2023 **Completed :** 17/05/2023 **Logged By :** RW/KV **Checked By :** MS/LM

Testpit Location : Refer to Site Plan **Surface RL :** 183 **Datum :** m AHD

Equipment : 5 Tonne Excavator **Testpit Size :** 2m x 0.5m **Slope :** ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	182.8	0.20			FILL / TOPSOIL, Silty Clay, low to medium plasticity, brown, with organic matter	M	[F]	0.0-0.1	[Topsoil] PSI Sample, No HC smell, No Staining or No fibro fragments observed	0.5
		182.5	0.50		CH	Silty CLAY, high plasticity, red/brown, trace of fine to coarse gravel	D	VSt	0.3-0.4	[Residual Soil] Salinity Sample, No HC smell, No Staining or No fibro fragments observed	
						SHALE, extremely weathered, grey/brown, extremely low to very low strength	D			[Bedrock]	
		182.3	0.70			Testpit TP 8 terminated at 0.70m				Bucket Refusal	2.0

Comments:

D - Dry	VS - Very Soft	VL - Very Loose
M - Moist	S - Soft	L - Loose
W - Wet	F - Firm	MD - Medium Dense
	St - Stiff	D - Dense
	VSt - Very Stiff	VD - Very Dense
	H - Hard	

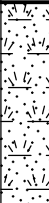
CLIENT NAME: Meadowvale Developments Pty Ltd JOB NUMBER: E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW PROJECT: PSI, Salinity & GI

Date Started : 17/05/2023 Completed : 17/05/2023 Logged By : RW/KV Checked By : MS/LM

Testpit Location : Refer to Site Plan Surface RL : 167 Datum : m AHD

Equipment : 5 Tonne Excavator Testpit Size : 2m x 0.5m Slope : ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	166.7	0.30			FILL / TOPSOIL, Silty Clay, low to medium plasticity, brown, with organic matter	M	[F]		[Topsoil]	0.5
									0.1-0.2	PSI Sample, No HC smell, No Staining or No fibro fragments observed	
						SHALE, extremely weathered, grey/brown, extremely low to very low strength	D			[Bedrock]	
									0.5-0.6	Salinity Sample, No HC smell, No Staining or No fibro fragments observed	
		166.3	0.70			Testpit TP 9 terminated at 0.70m				Bucket Refusal	2.0

Comments:

D - Dry
M - Moist
W - Wet

VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

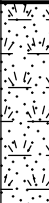
CLIENT NAME: Meadowvale Developments Pty Ltd **JOB NUMBER:** E3041, E3041-2 & G646

SITE ADDRESS: 715 & 717 Appin Road, Gilead NSW **PROJECT:** PSI, Salinity & GI

Date Started : 17/05/2023 **Completed :** 17/05/2023 **Logged By :** RW/KV **Checked By :** MS/LM

Testpit Location : Refer to Site Plan **Surface RL :** 168 **Datum :** m AHD

Equipment : 5 Tonne Excavator **Testpit Size :** 2m x 0.5m **Slope :** ---

Method	Water	RL (m)	Depth (m)	Graphic Log	Classification Symbol	Material Description	Moisture	Consistence	Samples Tests Remarks	Additional Observations	Depth (m)
E	Not encountered	167.7	0.30			FILL / TOPSOIL, Silty Clay, low to medium plasticity, brown, with organic matter	M	[F]		[Topsoil]	
									0.1-0.2	PSI Sample, No HC smell, No Staining or No fibro fragments observed	
		167.2	0.80		CH	Silty CLAY, high plasticity, red/brown, trace of coarse gravel	D	VSt-H		[Residual Soil]	
			1.0					H			
		166.8	1.20			SHALE, extremely weathered, grey/brown, extremely low to very low strength	D			[Bedrock]	
		166.7	1.30			Testpit TP 10 terminated at 1.30m				Bucket Refusal	
			1.5								
			2.0								

Comments:

D - Dry	VS - Very Soft	VL - Very Loose
M - Moist	S - Soft	L - Loose
W - Wet	F - Firm	MD - Medium Dense
	St - Stiff	D - Dense
	VSt - Very Stiff	VD - Very Dense
	H - Hard	

Appendix D

Results of Dynamic Cone Penetrometer Tests

Results of Dynamic Cone Penetration Tests

Client:	Meadowvale Developments Pty Ltd	Ref No:	G646
Project:	Geotechnical Investigation & Preliminary Assessment	Test Date:	17/05/2023
Location:	715 & 717 Appin Road, Gilead NSW	Sheet:	1 of 1

Depths (mm)	Test No.				Depths (mm)	Test No.			
	DCP1 (TP10)	DCP2 (TPH1)	-	-		-	-	-	-
0-100	3	1			0-100				
100-200	5	2			100-200				
200-300	6	3			200-300				
300-400	11	5			300-400				
400-500	9	5			400-500				
500-600	10	10			500-600				
600-700	12	7			600-700				
700-800	15	11			700-800				
800-900	14	23			800-900				
900-1000	13	Terminated			900-1000				
1000-1100	12				1000-1100				
1100-1200	Terminated				1100-1200				
1200-1300					1200-1300				
1300-1400					1300-1400				
1400-1500					1400-1500				
1500-1600					1500-1600				
1600-1700					1600-1700				
1700-1800					1700-1800				
1800-1900					1800-1900				
1900-2000					1900-2000				
2000-2100					2000-2100				
2100-2200					2100-2200				
2200-2300					2200-2300				
2300-2400					2300-2400				
2400-2500					2400-2500				
2500-2600					2500-2600				
2600-2700					2600-2700				
2700-2800					2700-2800				
2800-2900					2800-2900				
2900-3000					2900-3000				
3000-3100					3000-3100				
3100-3200					3100-3200				
3200-3300					3200-3300				
3300-3400					3300-3400				
3400-3500					3400-3500				
3500-3600					3500-3600				
3600-3700					3600-3700				
3700-3800					3700-3800				
3800-3900					3800-3900				
3900-4000					3900-4000				

Note: Refer to Site Plan for the test TP locations
Groundwater not encountered

Appendix D

Results of Soils Laboratory Testing



Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling
Unit 12/1 Bounty Close, Tuggerah NSW 2259
Ph: 1300 137 038 Fax: 1300 136 038

REPORT OF THE SOAKED C.B.R. OF A SOIL

CLIENT: Foundation Earth Sciences
PROJECT: Geotechnical Site Investigation
TEST LOCATION: 715 - 717 Appin Rd, Gilead

Job No.: LC8931-1a
Date: 30/05/2023
Page: 1 of 1

Sample No.: MT2
Sampling Location: TP3
Depth: 0.4 - 0.6m
Date Sampled: 17/05/2023
Sample Description: Silty Clay with rock fragments, Red Brown

Sampling Methods:
AS1289 1.2.1 ☐
Sampled by Others ☒

TEST METHOD: AS1289.6.1.1

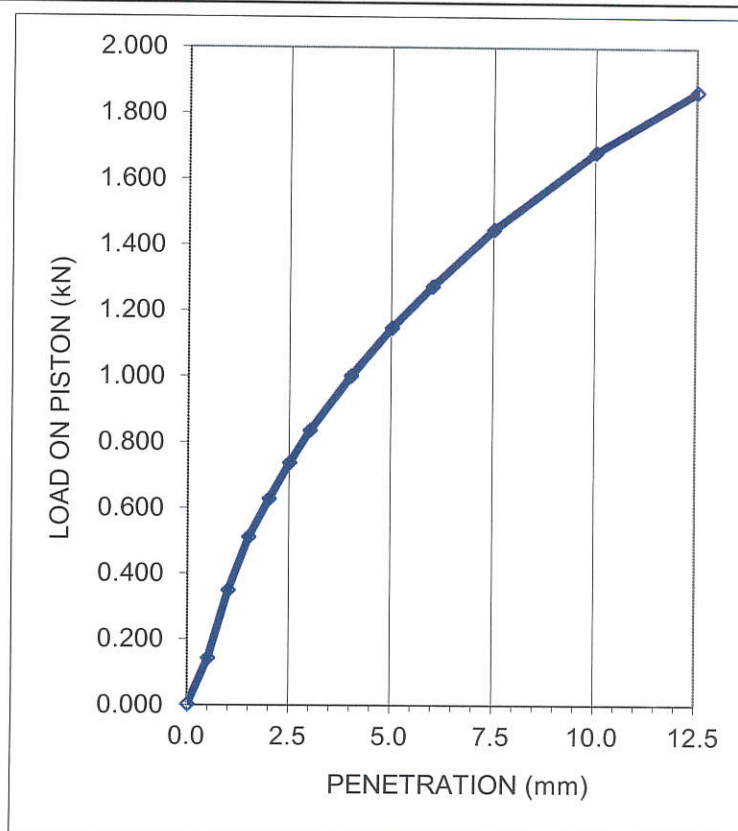
Compaction Type: **Standard**
Maximum Dry Density (t/m³): **1.59**
Optimum Moisture Content (%): **23.6**

Remarks:

FES job no G646

TEST CONDITIONS

CONDITION OF SPECIMEN	SOAKED (4 DAYS)
SURCHARGE (kg)	4.5
PERCENTAGE RETAINED 19mm (%) (Not Included in Sample)	2.4
MOISTURE CONTENT - TOP 30mm (%)	26.9
MOISTURE CONTENT - Remainder (%)	24.8
SWELL/CONSOLIDATION (%)	1.5
LABORATORY MOISTURE RATIO (%)	98.5
LABORATORY DENSITY RATIO (%)	100.5
CBR PENETRATION IN mm	5.0
CBR VALUE %	6.0



TESTED BY: **R Hoveling**

DATE: **26-05-2023**

APPROVED BY: **M Hoveling**

ISSUED: **30-05-2023**

TEST METHODS: **AS1289 2.1.1, 5.1.1 (Standard)**

Authorised Signature: *M Hoveling*

NATA Accredited Laboratory Number: 5452

-Accredited for compliance with ISO/IEC 17025 - Testing.
-This document shall not be reproduced except in full.





Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling
Unit 12/1 Bounty Close, Tuggerah NSW 2259
Ph: 1300 137 038 Fax: 1300 136 038

REPORT OF THE SOAKED C.B.R. OF A SOIL

CLIENT: Foundation Earth Sciences
PROJECT: Geotechnical Site Investigation
TEST LOCATION: 715 - 717 Appin Rd, Gilead

Job No.: LC8931-1b
Date: 30/05/2023
Page: 1 of 1

Sample No.: MT3
Sampling Location: TP5
Depth: 0.3 - 0.6m
Date Sampled: 17/05/2023
Sample Description: Silty Clay with some rock fragments, Brown

Sampling Methods:
AS1289 1.2.1 ☐
Sampled by Others ☒

TEST METHOD: AS1289.6.1.1

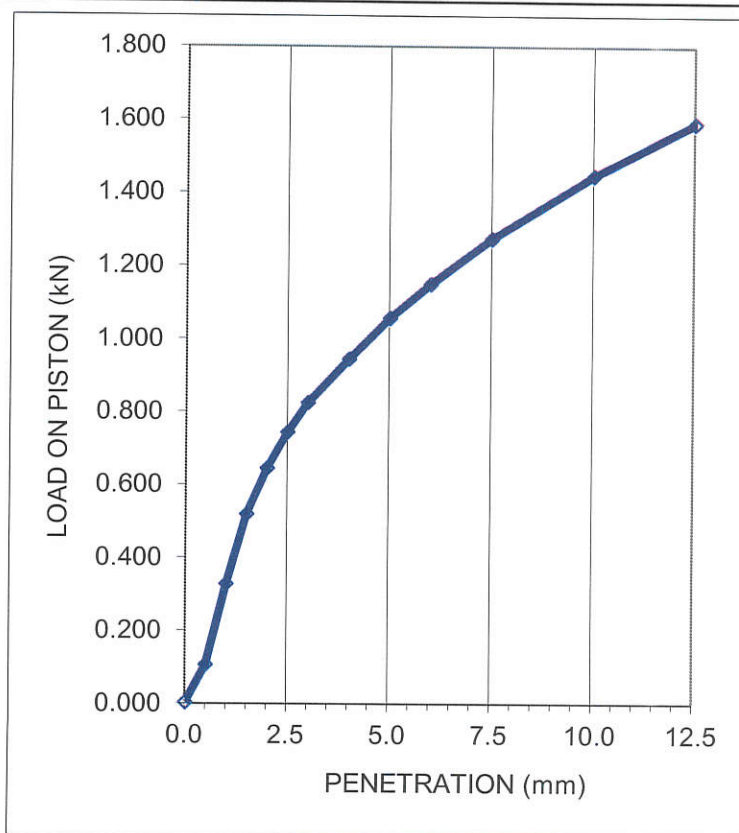
Compaction Type: **Standard**
Maximum Dry Density (t/m³): **1.51**
Optimum Moisture Content (%): **27.1**

Remarks:

FES job no G646

TEST CONDITIONS

CONDITION OF SPECIMEN	SOAKED (4 DAYS)
SURCHARGE (kg)	4.5
PERCENTAGE RETAINED 19mm (%) (Not Included in Sample)	0.0
MOISTURE CONTENT - TOP 30mm (%)	30.1
MOISTURE CONTENT - Remainder (%)	28.7
SWELL/CONSOLIDATION (%)	1.0
LABORATORY MOISTURE RATIO (%)	100.0
LABORATORY DENSITY RATIO (%)	100.0
CBR PENETRATION IN mm	5.0
CBR VALUE %	6.0



TESTED BY: **R Hoveling**

DATE: **26-05-2023**

APPROVED BY: **M Hoveling**

ISSUED: **30-05-2023**

TEST METHODS: **AS1289 2.1.1, 5.1.1 (Standard).**

Authorised Signature: *M Hoveling*

NATA Accredited Laboratory Number: 5452

-Accredited for compliance with ISO/IEC 17025 - Testing.
-This document shall not be reproduced except in full.





Aargus Pty Ltd ACN: 050 212 710
Environmental - Remediation - Engineering - Laboratories - Drilling
Unit 12/1 Bounty Close, Tuggerah NSW 2259
Ph: 1300 137 038 Fax: 1300 136 038

REPORT OF THE SOAKED C.B.R. OF A SOIL

CLIENT: Foundation Earth Sciences
PROJECT: Geotechnical Site Investigation
TEST LOCATION: 715 - 717 Appin Rd, Gilead

Job No.: LC8931-1c
Date: 30/05/2023
Page: 1 of 1

Sample No.: MT5
Sampling Location: TP10
Depth: 0.6 - 0.8m
Date Sampled: 17/05/2023
Sample Description: Silty Clay with some gravel, Dark Brown

Sampling Methods:
AS1289 1.2.1 ☐
Sampled by Others ☒

TEST METHOD: AS1289.6.1.1

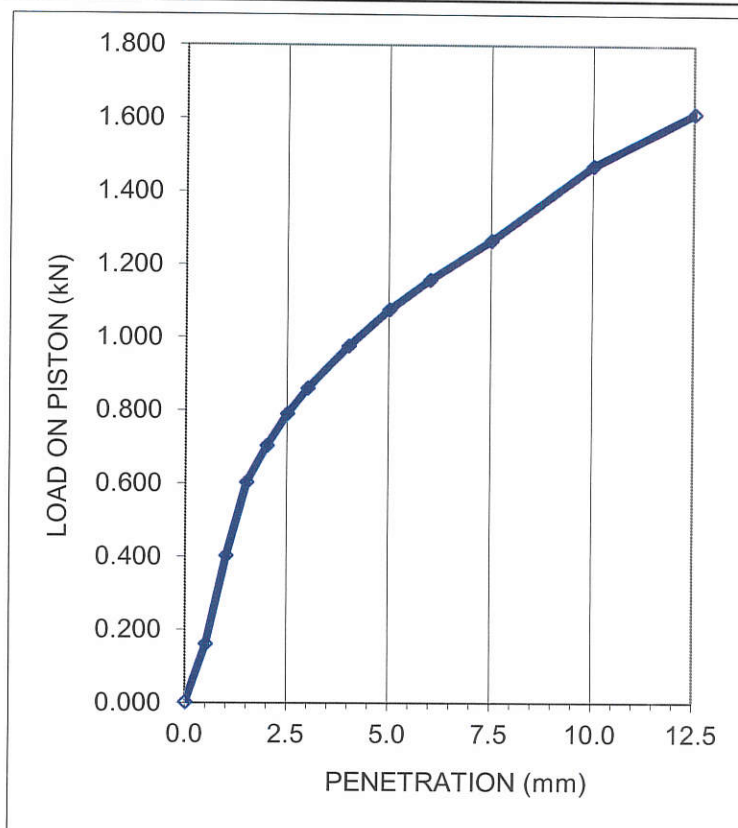
Compaction Type: **Standard**
Maximum Dry Density (t/m³): **1.41**
Optimum Moisture Content (%): **30.0**

Remarks:

FES job no G646

TEST CONDITIONS

CONDITION OF SPECIMEN	SOAKED (4 DAYS)
SURCHARGE (kg)	4.5
PERCENTAGE RETAINED 19mm (%) (Not Included in Sample)	0.0
MOISTURE CONTENT - TOP 30mm (%)	32.8
MOISTURE CONTENT - Remainder (%)	31.7
SWELL/CONSOLIDATION (%)	1.0
LABORATORY MOISTURE RATIO (%)	97.5
LABORATORY DENSITY RATIO (%)	101.0
CBR PENETRATION IN mm	5.0
CBR VALUE %	6.0



TESTED BY: **R Hoveling**

DATE: **26-05-2023**

APPROVED BY: **M Hoveling**

ISSUED: **30-05-2023**

TEST METHODS: **AS1289 2.1.1, 5.1.1 (Standard)**

Authorised Signature: *M Hoveling*

NATA Accredited Laboratory Number: 5452

-Accredited for compliance with ISO/IEC 17025 - Testing.
-This document shall not be reproduced except in full.





Aargus Pty Ltd ACN: 050 212 710

Environmental - Remediation - Engineering - Laboratories - Drilling

Unit 12 1 Bounty Close, Tuggerah NSW 2259

Ph: (02) 4353 0332 Fax: (02) 4353 0221

ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client	Foundation Earth Sciences	Job Number	LC8931-1d
Project	Geotechnical Site Investigation	Date	30-05-2023
Location	715 - 717 Appin Rd, Gilead	Page	1 of 2

SAMPLE DETAILS				
Sample Number	MT1	MT2	MT3	MT4
Date Sampled	17-05-2023	17-05-2023	17-05-2023	17-05-2023
Sample Location / Source	TP1	TP3	TP5	TP6
Layer\Depth	0.3 - 0.5m	0.4 - 0.6m	0.3 - 0.6m	0.6 - 0.8m
Material Description	Slightly Silty Clay with some rock fragments, Red Brown	Silty Clay with some rock fragments, Red Brown	Slightly Silty Clay with some rock fragments, Brown	Gravelly Silty Clay, Grey Brown
Sample History	Air Dried	Air Dried	Air Dried	Air Dried
Method of Preparation	Dry Sieved	Dry Sieved	Dry Sieved	Dry Sieved
Shrinkage Mould Length mm	250	250	250	254

TEST METHOD		TEST RESULTS			
Liquid Limit					
AS1289 3.1.2	☒ %	60	63	68	27
RMS (NSW) T108	☐				
Plastic Limit					
AS1289 3.2.1	☒ %	21	25	27	20
RMS (NSW) T109	☐				
Plasticity Index					
AS1289 3.3.1	☒ %	39	38	41	7
RMS (NSW) T109	☐				
Linear Shrinkage					
AS1289 3.4.1	☒ %	15.5	15.5	17.5	5.0
RMS (NSW) T113	☐				
Cracking Occurred	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
Crumbling Occurred	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒
Curling Occurred	Yes ☒ No ☐	Yes ☒ No ☐	Yes ☐ No ☒	Yes ☐ No ☒	Yes ☐ No ☒

Notes: FES Job no: G646

Accredited for compliance with ISO/IEC 17025 - Testing This document shall not be reproduced, except in full. Accreditation No. 5452	Approved Signatory	Mark Hoveling
	Date	30-05-2023



Aargus Pty Ltd ACN: 050 212 710

Environmental - Remediation - Engineering - Laboratories - Drilling

Unit 12 1 Bounty Close, Tuggerah NSW 2259

Ph: (02) 4353 0332 Fax: (02) 4353 0221

ATTERBERG LIMITS AND LINEAR SHRINKAGE TEST REPORT

Client	Foundation Earth Sciences	Job Number	LC8931-1d
Project	Geotechnical Site Investigation	Date	30-05-2023
Location	715 - 717 Appin Rd, Gilead	Page	2 of 2
SAMPLE DETAILS			
Sample Number	MT5		
Date Sampled	17-05-2023		
Sample Location / Source	TP10		
Layer\Depth	0.6 - 0.8m		
Material Description	Silty Clay with rock fragments, Dark Brown		
Sample History	Air Dried		
Method of Preparation	Dry Sieved		
Shrinkage Mould Length	mm 254		
TEST METHOD		TEST RESULTS	
Liquid Limit			
AS1289 3.1.2 ☒ %	66		
RMS (NSW) T108 ☐			
Plastic Limit			
AS1289 3.2.1 ☒ %	29		
RMS (NSW) T109 ☐			
Plasticity Index			
AS1289 3.3.1 ☒ %	37		
RMS (NSW) T109 ☐			
Linear Shrinkage			
AS1289 3.4.1 ☒ %	16.5		
RMS (NSW) T113 ☐			
Cracking Occurred	Yes ☐ No ☒	Yes ☐ No ☐	Yes ☐ No ☐
Crumbling Occurred	Yes ☐ No ☒	Yes ☐ No ☐	Yes ☐ No ☐
Curling Occurred	Yes ☐ No ☒	Yes ☐ No ☐	Yes ☐ No ☐
Notes:		FES Job no: G646	
 Accredited for compliance with ISO/IEC 17025 - Testing This document shall not be reproduced, except in full. Accreditation No. 5452		Approved Signatory Mark Hoveling <i>M Hoveling</i> Date 30-05-2023	



Aargus Pty Ltd ACN: 050 212 710

Environmental - Remediation - Engineering - Laboratories - Drilling

Unit 12 1 Bounty Close, Tuggerah NSW 2259

Ph: (02) 4353 0332 Fax: (02) 4353 0221

SHRINK SWELL INDEX REPORT SHEET

Client	Foundation Earth Sciences	Job Number	LC8931-1e
Project	Geotechnical Site Investigation	Date	30-05-2023
Location	715 - 717 Appin Rd, Gilead	Page	1 of 1

TEST INFORMATION

Test Number	MT1	MT3		
Date Sampled	17-05-2023	17-05-2023		
Test Location	TP1	TP5		
Depth	0.3 - 0.5m	0.3 - 0.6m		
Material Description	Slightly Silty Clay with rock fragments, Brown & Grey	Slightly Silty Clay, Brown		

SHRINK TEST

Field Moisture Content	%	16.6	16.2		
Extent of Crumbling (See Notes)		N	Mi		
Extent of Cracking (See Notes)		Mi	Mi		

SWELL TEST

Field Moisture Content	%	19.8	19.9		
Moisture Content After Soak	%	26.4	24.3		
Estimated Signific Inert Inclusions	%	20	0		

SHRINK SWELL INDEX

AS1289 7.1.1

Shrink Swell Index	(Iss)	1.9	1.1		
--------------------	-------	-----	-----	--	--

Notes: FES job no G646

Abbreviations: N = Nil, Mi = Minor, Med = Medium, Maj = Major



Accredited for compliance with ISO/IEC 17025-Testing
This document shall not be reproduced, except in full.
Accreditation No. 5452

Approved Signatory Mark Hoveling

M Hoveling

Date 30-05-23

Appendix E

Guide to Home Owners

Foundation Maintenance and Footing Performance: A Homeowner's Guide



CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth

Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation

Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpend).

Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay

Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots

In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself

Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures

Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures

Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures

Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.

Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.

- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing

Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage

In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

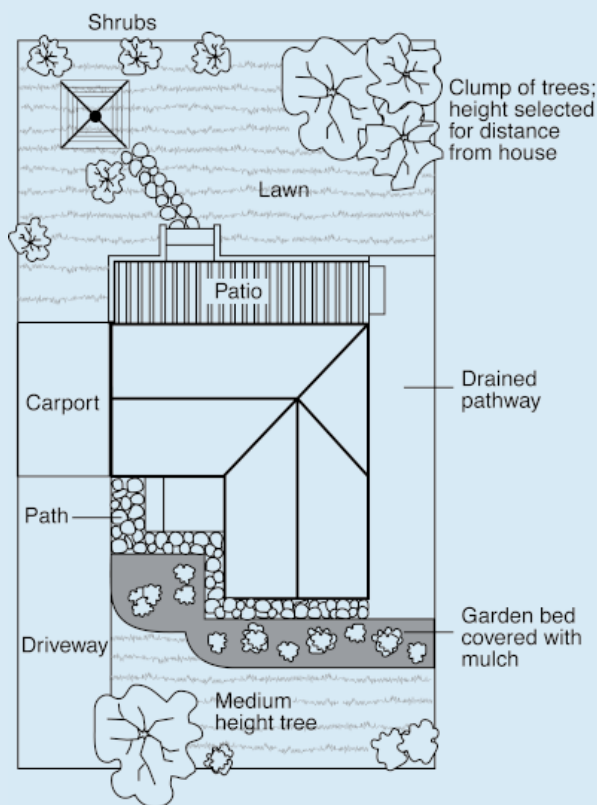
Protection of the building perimeter

It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

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 depend on number of cracks	4

Gardens for a reactive site



- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

The information in this and other issues in the series was derived from various sources and was believed to be correct when published.

The information is advisory. It is provided in good faith and not claimed to be an exhaustive treatment of the relevant subject.

Further professional advice needs to be obtained before taking any action based on the information provided.

Distributed by

CSIRO PUBLISHING PO Box 1139, Collingwood 3066, Australia

Freecall 1800 645 051 Tel (03) 9662 7666 Fax (03) 9662 7555 www.publish.csiro.au

Email: publishing.sales@csiro.au

© CSIRO 2003. Unauthorised copying of this Building Technology file is prohibited