Residential Site Investigation Report

Site Address: 10 Lagoon Sttreet and 75-77 Murray Street, Moruya NSW 2537

Client: NSW Land and Housing Corporation, Locked Bag 4009, Ashfield NSW 2131

(Our Reference: 34884-GR01_A)

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Project Name:	10 Lagoon Sttreet and 75-77 Murray Street, Moruya NSW 2537
Client:	NSW Land and Housing Corporation
Project No.	34884
Report Reference	34884-GR01_A
Date:	9.11.2020
Revision:	Revision A

Prepared by:	**Reviewed by:**
Williams	
Gareth Williams Geotechnical Technician	Luke Morris B.E. MIEAust CPEng (NPER) Director

1.0 INTRODUCTION

The following is a report on the geotechnical assessment of a residential site in accordance with AS2870-2011.

The purpose of the investigation is to provide guidance as to the expected foundation condition so that a suitable foundation design can be prepared for the proposed residential dwelling.

1.1 Terminology

The methods used in this report to describe the soil profiles, including visual classification of material types encountered, are in accordance with Australian standard AS1726-2017 “Geotechnical Site Investigations”.

1.2 Limitations

The geotechnical section of Barnson Pty Ltd has conducted this investigation and prepared this report in response to specific instructions from the client to whom this report is addressed. This report is intended for the sole use of the client, and only for the purpose which it is prepared. Any third party who relies on the report or any representation contained in it does so at their own risk.

1.3 Geotechnical Testing

Representative samples from the site were subjected to the following range of tests in accordance with relevant method of Australian Standard AS1289:

- Linear Shrinkage
- PH

NATA endorsed reports are attached in ***Appendix C***.

2.0 GENERAL DESCRIPTION OF SITE

The site is situated in a Residential area of Moruya NSW.

The site consists of moderate grass and weed cover with mature trees scattered over the site.

The site is sloping slightly to the north. The block has existing dwelling on block with vacant blocks in the vicinity.

Any trees noted to be within the building zone, should be removed and the excavation remaining should be backfilled with natural material and reinstated in layers to a minimum of 95% Standard Maximum Dry Density.

Plate 1 – North facing view.

Plate 2 – West facing view.

Plate 3 – South facing view.

3.0 METHOD OF INVESTIGATION

On the 13th of October 2020, a site investigation was carried out at 10 Lagoon Sttreet and 75-77 Murray Street, Moruya NSW.

A drill rig with a flight auger and tungsten tip was used to excavate 5 test holes. The supervising soil technician logged the soil profiles, which were recorded in the bore logs. Disturbed samples were taken from the depths shown in the bore logs. The bore logs are attached in ***Appendix B***.

The disturbed samples were returned to the Laboratory where Linear Shrinkage testing was conducted on the samples to correlate the material's Shrink Swell Index in accordance with AS2870-2011. The results of the Linear Shrinkage tests are attached in ***Appendix C.***

Dynamic Cone Penetrometer (DCP) testing was also performed on the site to evaluate the strength and consistency of the material present. The results of the Dynamic Cone Penetrometer tests are attached in ***Appendix B***.

4.0 SUB-SURFACE CONDITIONS

From the bore logs attached it can be seen that the soil encountered to the test end point was as follows:

4.1 Topsoil

A 0.2-0.4m thick layer of topsoil was encountered at the borehole locations. The topsoil consisted of loam.

4.2 Sub-Soil

Alluvial soils were encountered throughout the boreholes. These generally comprised of slightly moist sands and clays with trace's of gravel to the depths as shown in the borelogs attached in Appendix B.

4.3 Igneous Rock

Igneous Rock was encountered at borehole 2. The igneous rock was noted to be of a high strength. T.C Bit refusal and bouncing was encountered on all boreholes at a depth of 1.3m. Borelogs of the sub-surface profiles are attached in ***Appendix B*** providing all details of the profiles encountered.

4.4 Regional Geology

Reference to the New South Wales 1:1,000,000 Geological Map indicates the surrounding area consists of *"Granite, granodiorite, adamellite, minor gabbro diorite, porphyry."*.

Our investigation encountered alluvial soils overlying igneous rock.

4.5 Sub-Surface Bearing Capacity

- The allowable bearing capacity at depths ranging from 0.0m-0.5m is considered to be 100kPa.
- The allowable bearing capacity at depths ranging from 0.5m-3.0m is considered to be 100-350kPa.

All bearing capacities should be confirmed prior to the construction of any foundations as the above indicative values are as of the time of the investigation.

4.6 Soil Exposure Classification

Acidic ground conditions can be caused by dissolved "aggressive" carbon dioxide, pure and very soft waters, organic and mineral acids and bacterial activity.

pH testing was conducted on the site samples to determine if any acidic conditions were present in the soils encountered.

Table 1: pH Testing Results

Borehole No.	Sample Depth (m)	pH (w)	Exposure Classification
1	0.8	6.6	A1
2	0.8	6.8	A1
3	0.8	7.0	A1
4	0.8	5.4	A2
5	0.8	5.8	A1

These results show the exposure classification as per Table 5.2 AS2870-2011. Groundwater was not encountered during this investigation.

4.7 Seasonal Surface Movement

From the laboratory test results, as shown attached, an estimated ground surface movement (Ys) was calculated in accordance with AS2870-2011 (using a change in suction at the soil surface $\Delta\mu$ = 1.5pF and a depth of design suction change, Hs = 1.8m) being:

Ys = 30-35mm

The site has existing large trees and thus , it is our opinion that a **Site Classification of ʼP**ʼ should be adopted for the site in its present condition, with a soil classification of ʻMʼ

Reference is made to Appendix ʻHʼ of AS2870-2011, which gives guidance on the design of footings on reactive clay soils with the effect of trees. The footing design engineer will need to calculate the tree induced differential centre heave mound height (y_m) based on the tree height and distance of the proposed buildings from the tree or group of trees. This value should be used to design a suitable footing design in accordance with section 4 of the code.

5.0 RECOMMENDATIONS

5.1 Building Foundation

The recommended basic design philosophy for dealing with these soils is to cater for seasonal movements by appropriate foundation and structural design as per AS2870-2011. Therefore the foundations provided should be designed with guidance from AS2870-2011 for the site classification provided.

5.2 Foundations General

The possibility of other abnormal and localised moisture changes must be minimised by adherence to general design and site management practises as recommended in the attached CSIRO information service sheet, “Guide to Homeowners on Foundation Maintenance and Footing Performance”.

These recommendations assume that the footings will be founded in the natural soil or controlled fill, and that no topsoil or poor and uncompacted fill occurs beneath the footing beams or slab.

Finally, it must be emphasised that the recommended design approach accepts that minor aesthetic cracking may occur. The design philosophy is thus a compromise between economy and performance.

6.0 CONCLUSION

The testing methods adopted are indicative of the site's sub-surface conditions to the depths excavated and to specific sampling and/or testing locations in this investigation, and only at the time the work was carried out.

The accuracy of geotechnical engineering advice provided in this report may be limited by unobserved variations in ground conditions across the site in areas between and beyond test locations and by any restrictions in the sampling and testing which was able to be carried out, as well as by the amount of data that could be collected given the project and site constraints.

These factors may lead to the possibility that actual ground conditions and materials behaviour observed at the test locations may differ from those which may be encountered elsewhere on the site.

If the sub-surface conditions are found to differ from those described in this report, we should be informed immediately to evaluate whether recommendations should be reviewed and amended if necessary.

Appendix A – General Notes

GEOTECHNICAL INVESTIGATION GENERAL NOTES

This report contains the results of a geotechnical investigation conducted for a specific purpose and client. The results should not be used by other parties, or for other purposes, as they may contain neither adequate nor appropriate information. In particular, the investigation does not cover contamination issues unless specifically required to do so by the client.

TEST HOLE LOGGING

The information on the test hole logs (boreholes, test pits, exposures etc.) is based on a visual and tactile assessment, except at the discrete locations where the test information is available (field and/or laboratory results). The borehole logs include both factual data and inferred information. Reference should be made to the relevant sheets for the explanation of logging procedures (Soil and Rock Descriptions, Core Log Sheet Notes etc).

GROUNDWATER

Unless otherwise indicated, the water levels presented on the borehole logs are the levels of free water or seepage in the bore hole recorded at the given time of measuring. The actual groundwater level may differ from this recorded level depending on material permeability's (i.e. depending on response time of the measuring instrument). Further, variations of this level could occur with time due to such effects as seasonal, environmental and tidal fluctuations or construction activities. Confirmation of groundwater levels, phreatic surfaces or piezometric pressures can only be made by appropriate instrumentation techniques and monitoring programmes.

INTERPRETATION OF RESULTS

The discussion or recommendations contained within this report normally are based on a site evaluation from discrete borehole area. Generalised, idealised or inferred subsurface conditions (including any geotechnical cross-sections) have been assumed or prepared by interpolation and/or extrapolation of these data. As such these conditions are an interpretation and must be considered as a guide only.

CHANGE IN CONDITIONS

Local variations or anomalies in the generalised ground conditions do occur in the natural environment, particularly between discrete borehole locations. Additionally, certain design or construction procedures may have been assumed in assessing the soil-structure interaction behaviour of the site. Furthermore, conditions may change at the site from those encountered at the time of the geotechnical investigation through construction activities and constantly changing natural forces.

Any change in design, in construction methods, or in ground conditions as noted during construction, from those assumed or reported should be referred to this firm for appropriate assessment and comment.

GEOTECHNICAL VERIFICATION

Verification of the geotechnical assumptions and/or model is an integral part of the design process – investigation, construction verification and performance monitoring. Variability is a feature of the natural environment and, in many instances, verification of soil or rock quality, or foundation levels are required. There may be a requirement to extend foundation depths to modify a foundation system or to conduct monitoring as a result of this natural variability. Allowance for verification by geotechnical personnel accordingly should be recognised and programmed during construction.

FOUNDATIONS

Where referred to in the report, the soil or rock quality, or the recommendation depth of any foundation (piles, caissons footings etc.) is an engineering estimate. The estimate is influenced and perhaps limited, by the fieldwork method and testing carried out in connection with the site investigation, and other pertinent information as has been made available. The material quality and/or foundation depth remains, however, an estimate and therefore liable to variation. Foundation drawings, designs and specifications should provide for variations in the final depth, depending upon the ground conditions at each point of support, and allow for geotechnical verification.

REPRODUCTION OF REPORTS

Where it is desired to reproduce the information contained in our geotechnical report, or other technical information, for the inclusion in contract documents or engineering specification of the subject development, such reproductions should include at least all of the relevant test hole and test data, together with the appropriate standard description sheets and remarks made in the written report of a factual or descriptive nature.

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Appendix B – Borehole Logs

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BOREHOLE NUMBER 1

PAGE 1 OF 1

CLIENT NSW Land and Housing Corporation
PROJECT NAME Site Classification
PROJECT NUMBER 34884
PROJECT LOCATION 10 Lagoon Street, 75-77 Murray Street, Moruya NSW

DATE STARTED 13/10/20
COMPLETED 13/10/20
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Barnson
SLOPE 90°
BEARING ---
EQUIPMENT GT-10 Drill Rig
HOLE LOCATION Borehole 1
HOLE SIZE 90mm
LOGGED BY NR
CHECKED BY NR
NOTES

Method	Samples	Depth (m)	Graphic Log	Classification Symbol	Material Description	SPT Results	Additional Observations
Flight Auger & Tungsten Carbide (T.C) Bit					LOAM: dark brown		TOPSOIL
		0.2		CL	Sandy Silty CLAY: brown: slightly moist: hard: medium plasticity		ALLUVIAL
		0.5					
	Disturbed Sample LS = 12.0%						
		1.0		SC	Clayey SAND: trace gravel: pale brown: slightly moist: very dense: low plasticity		ALLUVIAL
		1.5					
	Disturbed Sample LS = 4.0%	2.0					
		2.5					
		3.0					

Borehole 1 terminated at 3m

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Dubbo NSW 2830
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BOREHOLE NUMBER 2

PAGE 1 OF 1

CLIENT NSW Land and Housing Corporation

PROJECT NAME Site Classification

PROJECT NUMBER 34884

PROJECT LOCATION 10 Lagoon Street, 75-77 Murray Street, Moruya NSW

DATE STARTED 13/10/20 **COMPLETED** 13/10/20

R.L. SURFACE

DATUM

DRILLING CONTRACTOR Barnson

SLOPE 90°

BEARING ---

EQUIPMENT GT-10 Drill Rig

HOLE LOCATION Borehole 2

HOLE SIZE 90mm

LOGGED BY NR

CHECKED BY NR

NOTES

Method	Samples	Depth (m)	Graphic Log	Classification Symbol	Material Description	SPT Results	Additional Observations
Flight Auger & Tungsten Carbide (T.C) Bit			░		LOAM: dark brown		TOPSOIL
		0.2	▨	CL	Sandy Silty CLAY: brown: slightly moist: hard: medium plasticity		ALLUVIAL
		0.5					
	Disturbed Sample LS = 15.0%						
		1.0	▨	SC	Clayey SAND: trace gravel: brown: slightly moist: very dense: low plasticity		ALLUVIAL
					Borehole 2 terminated at 1.3m		REFUSAL ON IGNEOUS ROCK
		1.5					
		2.0					
		2.5					
		3.0					

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BOREHOLE NUMBER 3

PAGE 1 OF 1

CLIENT NSW Land and Housing Corporation

PROJECT NAME Site Classification

PROJECT NUMBER 34884

PROJECT LOCATION 10 Lagoon Street, 75-77 Murray Street, Moruya NSW

DATE STARTED 13/10/20 **COMPLETED** 13/10/20

R.L. SURFACE

DATUM

DRILLING CONTRACTOR Barnson

SLOPE 90°

BEARING ---

EQUIPMENT GT-10 Drill Rig

HOLE LOCATION Borehole 3

HOLE SIZE 90mm

LOGGED BY NR

CHECKED BY NR

NOTES

Method	Samples	Depth (m)	Graphic Log	Classification Symbol	Material Description	SPT Results	Additional Observations
Flight Auger & Tungsten Carbide (T.C) Bit		0.4			Sandy SILT: brown		TOPSOIL
	Disturbed Sample LS = 12.0%	0.5 1.0		CL	Sandy Silty CLAY: brown: slightly moist: hard: medium plasticity		ALLUVIAL
	Disturbed Sample LS = 15.5%	1.5 2.0 2.5		CH	Sandy CLAY: trace gravel: slightly moist: hard: high plasticity		ALLUVIAL
		3.0		ML	SILT: grey: slightly moist: hard: low plasticity		ALLUVIAL

Borehole 3 terminated at 3m

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BOREHOLE NUMBER 4

PAGE 1 OF 1

CLIENT NSW Land and Housing Corporation
PROJECT NAME Site Classification
PROJECT NUMBER 34884
PROJECT LOCATION 10 Lagoon Street, 75-77 Murray Street, Moruya NSW

DATE STARTED 13/10/20 **COMPLETED** 13/10/20
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Barnson
SLOPE 90°
BEARING ---
EQUIPMENT GT-10 Drill Rig
HOLE LOCATION Borehole 4
HOLE SIZE 90mm
LOGGED BY NR
CHECKED BY NR
NOTES

Method	Samples	Depth (m)	Graphic Log	Classification Symbol	Material Description	SPT Results	Additional Observations
Flight Auger & Tungsten Carbide (T.C) Bit			⁙		Silty SAND: dark brown		TOPSOIL
		0.4	▨	CL	Sandy CLAY: trace gravel: pale brown: slightly moist: hard: medium plasticity		ALLUVIAL
		0.5	▨				
	Disturbed Sample LS = 13.5%		▨				
		1.0	▨				
		1.5	▨				
	Disturbed Sample LS = 7.5%	2.0	▨				
		2.5	▨				
		3.0	▨				

Borehole 4 terminated at 3m

BOREHOLE WITH SPT 34884-G01A-G05A.GPJ GINT STD AUSTRALIA.GDT 9/11/20

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BOREHOLE NUMBER 5

PAGE 1 OF 1

CLIENT NSW Land and Housing Corporation
PROJECT NAME Site Classification
PROJECT NUMBER 34884
PROJECT LOCATION 10 Lagoon Street, 75-77 Murray Street, Moruya NSW

DATE STARTED 13/10/20 **COMPLETED** 13/10/20
R.L. SURFACE
DATUM
DRILLING CONTRACTOR Barnson
SLOPE 90°
BEARING ---
EQUIPMENT GT-10 Drill Rig
HOLE LOCATION Borehole 5
HOLE SIZE 90mm
LOGGED BY NR
CHECKED BY NR
NOTES

Method	Samples	Depth (m)	Graphic Log	Classification Symbol	Material Description	SPT Results	Additional Observations
Flight Auger & Tungsten Carbide (T.C) Bit		0.5		ML	Sandy SILT: brown: slightly moist: very stiff to hard: low plasticity		ALLUVIAL
	Disturbed Sample LS = 14.0%	0.7		CL	Sandy Silty CLAY: brown: slightly moist: hard: medium plasticity		ALLUVIAL
		1.0		CL	Sandy CLAY: trace gravel: pale brown: slightly moist: hard: medium plasticity		ALLUVIAL
		1.5					
	Disturbed Sample LS = 10.5%	2.0					
		2.5					
		3.0					

Borehole 5 terminated at 3m

Appendix C – NATA Laboratory Reports

Material Test Report

Report Number: **34884-1**
Issue Number: 1
Date Issued: 20/10/2020
Client: NSW Land and Housing Corporation
Locked Bag 4009, Ashfield NSW 2131
Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709A
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 1, Depth: 800mm**
Material: Brown Sandy Silty CLAY

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Dubbo Laboratory
16 L Yarrandale Road Dubbo NSW 2830
Phone: 1300 BARNSON
Email: nreardon@barnson.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Nick Reardon
Laboratory Manager

NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	12.0		
Cracking Crumbling Curling	Curling		

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Material Test Report

Report Number:	**34884-1**
Issue Number:	1
Date Issued:	20/10/2020
Client:	NSW Land and Housing Corporation Locked Bag 4009, Ashfield NSW 2131
Contact:	Marcel Simor
Project Number:	34884
Project Name:	Site Classification
Project Location:	10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request:	3709
Sample Number:	D20-3709B
Date Sampled:	14/10/2020
Dates Tested:	14/10/2020 - 20/10/2020
Sampling Method:	AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location:	**Borehole 1, Depth: 2.0m**
Material:	Pale Brown Clayey SAND Trace Gravel

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NATA
WORLD RECOGNISED ACCREDITATION

Approved Signatory: Nick Reardon
Laboratory Manager

NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	4.0		
Cracking Crumbling Curling	None		

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Material Test Report

Report Number: **34884-1**
Issue Number: 1
Date Issued: 20/10/2020
Client: NSW Land and Housing Corporation
Locked Bag 4009, Ashfield NSW 2131
Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709C
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 2, Depth: 800mm**
Material: Brown Sandy Silty CLAY

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Approved Signatory: Nick Reardon
Laboratory Manager

NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	15.0		
Cracking Crumbling Curling	Curling		

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Laboratory Manager
NATA Accredited Laboratory Number: 9605

Report Number: **34884-1**
Issue Number: 1
Date Issued: 20/10/2020
Client: NSW Land and Housing Corporation
Locked Bag 4009, Ashfield NSW 2131
Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709D
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 3, Depth: 800mm**
Material: Brown Sandy Silty CLAY

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	12.0		
Cracking Crumbling Curling	Curling		

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Report Number: 34884-1
Issue Number: 1
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Client: NSW Land and Housing Corporation
Locked Bag 4009, Ashfield NSW 2131
Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709E
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 3, Depth: 2.0m**
Material: Pale Brown Clayey SAND Trace Gravel

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Laboratory Manager
NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	15.5		
Cracking Crumbling Curling	Curling		

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Issue Number: 1
Date Issued: 20/10/2020
Client: NSW Land and Housing Corporation
Locked Bag 4009, Ashfield NSW 2131
Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709F
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 4, Depth: 800mm**
Material: Pale Brown Clayey SAND Trace Gravel

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Approved Signatory: Nick Reardon
Laboratory Manager
NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	13.5		
Cracking Crumbling Curling	Curling		

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Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709G
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 4, Depth: 2.0m**
Material: Pale Brown Clayey SAND Trace Gravel

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Approved Signatory: Nick Reardon
Laboratory Manager

NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	7.5		
Cracking Crumbling Curling	Curling		

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Client:	NSW Land and Housing Corporation Locked Bag 4009, Ashfield NSW 2131
Contact:	Marcel Simor
Project Number:	34884
Project Name:	Site Classification
Project Location:	10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request:	3709
Sample Number:	D20-3709H
Date Sampled:	14/10/2020
Dates Tested:	14/10/2020 - 20/10/2020
Sampling Method:	AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location:	**Borehole 5, Depth: 800mm**
Material:	Brown Sandy Silty CLAY

DESIGN.PLAN.MANAGE
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Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Nick Reardon
Laboratory Manager

NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	14.0		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number: **34884-1**
Issue Number: 1
Date Issued: 20/10/2020
Client: NSW Land and Housing Corporation
Locked Bag 4009, Ashfield NSW 2131
Contact: Marcel Simor
Project Number: 34884
Project Name: Site Classification
Project Location: 10 Lagoon Street, 75 & 77 Murray Street, Moruya NSW
Work Request: 3709
Sample Number: D20-3709I
Date Sampled: 14/10/2020
Dates Tested: 14/10/2020 - 20/10/2020
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Sample Location: **Borehole 5, Depth: 2.0m**
Material: Pale Brown Clayey SAND Trace Gravel

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Laboratory Manager
NATA Accredited Laboratory Number: 9605

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	10.5		
Cracking Crumbling Curling	Curling		

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Results relate only to the items tested/sampled.

Appendix D - CSIRO Guide

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 perpends).

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.

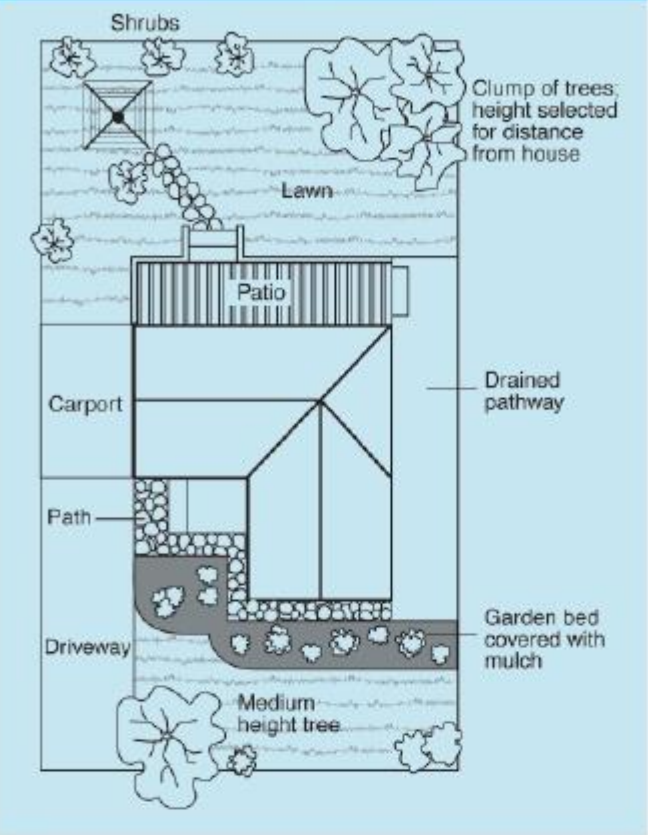
With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

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.

Gardens for a reactive site



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:

- 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.

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.

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