Site Classification with Foundation Parameters

Proposed Dual Occupancy

68 Head St, Forster

Report Ref: G0667-SCFP-001-Rev0

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Project Details

Site Address:	68 Head St, Forster
Project Type:	Proposed Residential Development

Project no	Report type	Report no
G0667	SCFP	001

Report Register

Revision Number	Reported By	Reviewed By	Date
Rev0	DP	DS	03/09/24

We confirm that the following report has been produced for LJ & KL Stafford Nominees Pty Ltd, based on the described methods and conditions within.

For and on behalf of Hunter Civilab,

Daniel Soffer
Senior Geotechnical Engineer

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1 Introduction

At the request of LJ & KL Stafford Nominees Pty Ltd, Hunter Civilab (HCL) have undertaken a site classification in accordance with AS2870-2011 Residential Slabs and Footings for the proposed residential knockdown and dual occupancy development to be constructed at 68 Head St, Forster.

Details of the development have been supplied via email dated 13 August 2024. It is understood that the proposed development will involve construction of a three-story dwelling at the front of the Lot, and a detached two-story construction at the rear. Structural details have not been provided, however it is anticipated that both with a concrete slab on ground construction with a finishing floor level of RL4.0m, with minimal site regrading works required to build a level building pad.

The purpose of the investigation was to provide geotechnical comment and recommendations on the following:

- Desktop review of published geological and soil landscape mapping and review supplied plans and assessment of geotechnical conditions present informed by geomorphology mapping
- A geotechnical model of the site that includes the following (if encountered);
    - Presence of fill
    - Depth and characterisation of soil profiles
    - Depth to weathered rock
    - Identification of poor or potentially problematic ground conditions
    - Ground water levels
- An interpreted Geotechnical Long Section of the site
- Estimated surface movements calculated on the basis of the shrink-swell properties of the soil profile
- Site Classification to AS2870-2011 Residential Slabs and Footings;
- Foundation conditions including the presence of fill;
- Recommended foundation types to support the proposed structures within the subdivision, including:
    - Suitable shallow footing types and foundation design parameters (Allowable Bearing Capacity)
    - Bored pile design parameters and founding depths
- Earthworks advice including site preparation to support concentrated building loads, safe batter slopes and temporary support for excavations, excavation conditions and geotechnical suitability of excavated material for re-use as filling;
- Retaining wall design parameters; and
- Recommended safe temporary and permanent batter slopes.

This report provides details of the investigation, laboratory testing and provides recommendations for the proposed development.

2 Site Description

The site was located at 68 Head St, Forster, and was bordered by Head Street to the north, and residential housing on all remaining boundaries.

The site is situated on the lower slopes of a westerly plunging ridgeline 20mAHD. Surface slopes fell 1° to the east across the site and had a 5° fill batter to the front of the property that fell to the south. Drainage of the site was a combination of overland flow and surface infiltration into sandy topsoils. Vegetation at the time of the investigation was maintained grasses with no exposed soils and a small citrus tree to the rear.

A photograph showing the surface conditions at the site is shown below in

Figure 1.

Figure 1: Aerial image obtained via 'NearMaps' depicting the site and site setting

Figure 2: At the front of the property looking south

Figure 3: At the rear of the property looking north

3 Desktop Review

3.1 Geological & Soil Landscape Setting

Reference to the 1:100,000 Forster Coastal Quaternary Alluvial Mapping Sheet indicates that the site is underlain by the transition of Pleistocene aged backbarrier flat deposits to the south comprising marine sand, indurated sand, silt, clay, gravel, organic mud and peat and Holocene aged dune ridges and sandplaines to the north comprising marine sand, organic mud and peat.

3.2 Acid Sulfate Soils Risk Maps

Reference to the NSW Office of Environment and Heritage's online database 'ESPADE' indicates that the site lies in an area of low probability Acid Sulfate Soils occurring depths between 1 and 3m below ground level.

4 Fieldwork Methodology

Fieldwork was undertaken on 13 August 2024 and comprised a general site walk over and observation of the site and surrounding features. Two boreholes were drilled using hand auger techniques due to limited site access. The boreholes were logged and sampled by a Engineering Geologist from HCL in accordance with AS1726-2017, within the proposed development footprint.

5 Fieldwork Results

The subsurface soil conditions encountered at test locations are presented in detail in the borehole logs.

Table 5.1 - Summary of the soil unit depths encountered

Unit	Unit Description	Unit Depth (m)	
		BH1	BH2
Topsoil/Fill	Sandy SILT, low plasticity, dark brown to black	0.05	0.1
Fill	Silty SAND, medium density, brown to grey	-	0.5
Marine Sand	Clayey to Silty SAND, dark brown to black, very loose	0.65	--
Marine Sand	Clayey to Silty SAND, dark brown to black, medium dense, collapsable	1.0	≥1.35
Indurated SAND	Silty SAND, dark brown to black, dense to very dense	≥1.35*	-
	Groundwater	*0.7*	*0.5*

Note: ≥ Indicates that base of material layer was not encountered
- Indicates that the horizon was not encountered
* Indicates hand auger refusal on indurated sand

Groundwater was not encountered within the bore hole. It is further noted that groundwater conditions are dependent on factors such as soil permeability, and recent weather conditions and will vary with time.

Refer to **Annex A** for the borehole location plan and **Annex B** for detailed borehole logs.

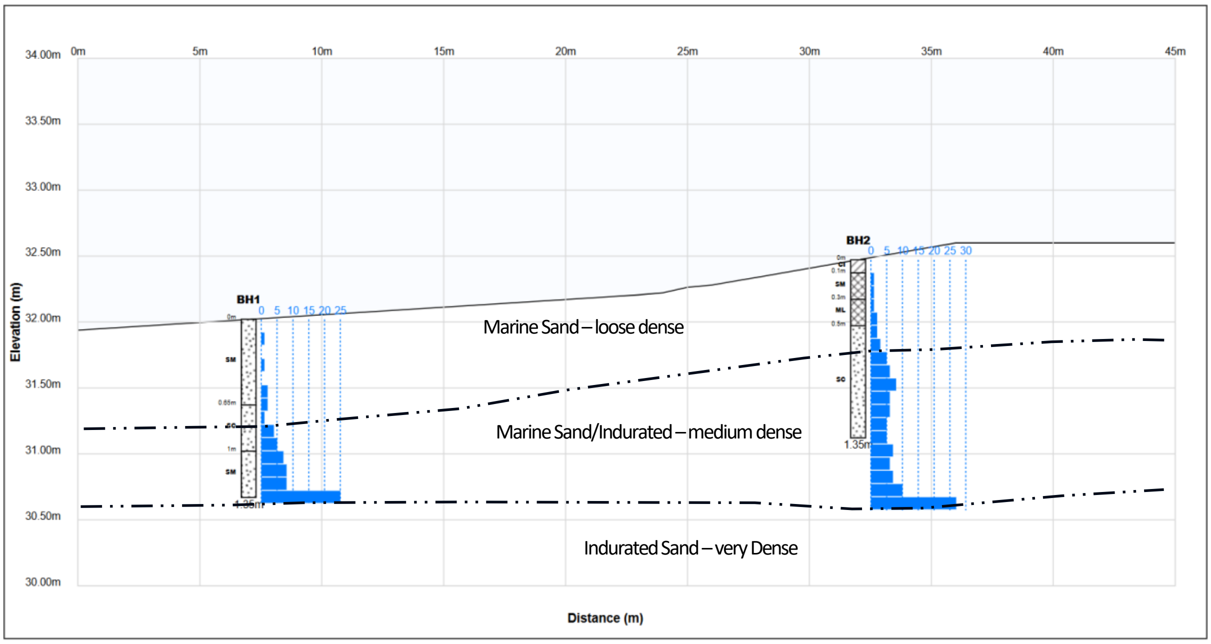

Figure 4. Geological long section of site

6 Site Classification

6.1 Background Information

Site classification is based off the characteristic surface movements encountered at the site due to the moisture variations within the soil profile. Characteristic surface movements are estimated in accordance with AS2870-2011 "Residential Slabs & Footings". Surface movement calculation take into consideration the depth of the soil profile layers, the soil reactivity and the soil suction depth.

The site classification based on characteristic surface movements are summarised below in **Table 6.1**.

Table 6.1 - Summary of AS2870-2011 characteristic surface movement and site classification

Characteristic Surface Movement (y_s) (mm)	Site Classification AS2870-2011	Underlying Soil / Geology
0	Class A	SAND or ROCK site (non-reactive)
0 – 20	Class S	CLAY (slightly reactive)
20 – 40	Class M	CLAY (moderately reactive)
40 – 60	Class H1	CLAY (highly reactive)
60 – 75	Class H2	CLAY (highly reactive)
> 75	Class E	CLAY (extremely reactive)

Sites subjected to deep-seated moisture change are modified with the addition of "-D". As defined by AS2870-2011 and other sites should be classified as a Class P (Problem) site. Sites classified as Class P have one or more of the following geotechnical related issues:

- inadequate bearing capacity
- expected excessive foundation settlement due to loading on the foundation
- significant moisture variations
- mine subsidence risk
- slope stability risk
- erosion issues
- greater than 0.8m of fill for sand sites and greater than 0.4m for other sites (in general)

6.2 Site Classification Recommendations

The site was assessed by a suitably qualified Senior Geotechnical to determine the Site Classification in accordance with AS2870-2011 "Residential Slabs & Footings". The Site Classification provides an indication of the characteristic surface movement due to shrink-swell properties of the underlying soils and ground moisture variations. The Site Classification provided is based on review of the subsurface profile and laboratory testing as well as an assessment of the site at the time of the investigation including

In assessing the expected shrink-swell related characteristic free surface movement (ys), the following has been adopted:

- Suction change at ground surface of pf 1.2;
- Depth of suction change of 1.5m;
- Investigation encountered a non-reactive aeolian and estuarine sand profile; and
- No trees will be present within 20m of the proposed building areas.

The density profile encountered up to 1.0m of very loose sand in BH1. In accordance with AS2870-2011, the site is classified as a **Class P** site due to insufficient bearing capacity (<100kPa). In accordance with AS2870-2011, residential footings on Class P sites must be designed in accordance with engineering principles based on specific site conditions. The preferred option on sites containing loose sands with inadequate bearing strength, is to extend structural foundations to found on a suitable underlying founding stratum with a bearing capacity of at least 100 kPa and the slabs connecting to the piers will need to be designed as a suspended structure. At this site, medium dense aeolian sand foundation material with 100 kPa bearing capacity was present at 1.0m below the ground surface in BH1 which can be achieved by screw piers or driven mini timber piers. The impact of vibration on neighbouring developments should be considered where driven timber piers are installed.

The site is occupied by an existing dwelling that is understood to be demolished. The foundation profile is likely to be disturbed and loosened during demolition of the existing dwelling.

The subsurface profile encountered non-reactive aeolian sands. Based on the existing profile encountered at the time of the field investigation, the expected shrink-swell related characteristic free surface movement (Ys) estimated for the profile encountered during the field investigations is 0mm.

Therefore, based on the subsurface conditions at the site and in accordance with AS2870-2011 "Residential Slabs & Footings", the site is classified as a **Class A** (Sand site, non-reactive).

6.2.1 Abnormal Moisture Effects

Abnormal moisture conditions in the foundation can be caused by the following:

- existing development
- leaking water services
- prolonged periods of draught or heavy rainfall
- trenches or other man-made water courses
- poor roof plumbing or obstruction to the roof plumbing system
- poor rainfall runoff control
- corroded gutters or downpipes

Abnormal moisture conditions specified above can cause adverse effects to the development's foundation such as:

- erosion significantly effecting the lateral and founding support of the structure's footing system;

- saturation of the founding material which can cause a significant decrease in the strength of the founding material
- shrinkage creating subsidence of the founding material and causing additional stresses within the building structure
- swelling which creates an upward force in the footings which causes additional stresses within the building structure

6.3 Footing Recommendations

The site is underlain by up to **1.0m of loose to medium sands**, as a mixture of fill and marine sourced sands encountered in **BH1** and **BH2**, with less than 100kPa allowable bearing capacity. The foundation profile in its current condition is unsuitable for the use of high-level footings in accordance with AS2870.

For the site to suitable for high level footings comprising pad, and / or strip footings, or a stiffened or waffle raft compactive effort would be required to be applied to the foundation profile to achieve a medium density (75% Relative Density or better), using a smooth drum roller and the profile assessed by a geotechnical engineer prior to placement of concrete. Once a consistent medium dense sand profile has been achieved and assessed by a geotechnical engineer, high level footings may be proportioned based on a maximum allowable bearing capacity of **100** kPa, below topsoil, or other deleterious material (e.g. root and footing affected soils, soft / loose soils, silt soils, uncontrolled fill etc).

Alternatively, where considered to be more practical, a piered foundation solution comprising screw piles founded, and supporting a suspended concrete slab founded in dense to very dense sand or better may be proportioned for a maximum allowable vertical capacity of **200** kPa. At this site, medium dense profiles were encountered at depths greater than **1.35m** below ground level.

The pull-out capacity for steel screw piles should be checked by designer. The pull-out capacity of steel screw piles should consider cylindrical or cone modes of failure.

Conventional uncased bored piles would not be suitable at this site due to the presence of groundwater and the likely borehole collapse upon withdrawal of the auger.

The footing systems must be designed by a structural engineer in accordance with engineering principles and AS 2870 - 2011 “Residential Slabs and Footings” for no less than the minimum requirements for the site classification and soil reactivity given above. Bearing pressures of all exposed foundation areas should be confirmed at the time of earthworks and prior to concrete pour by a qualified geotechnical engineer.

All footings, edge beams and internal beams should be founded on similar material outside or below the zones of influence resulting from existing or future service trenches, retaining walls or other subsurface structures.

All pile types should be suitably protected against decay or corrosion, taking account of the subsurface conditions, water table fluctuations and site-specific conditions (existing chemical concentrations at the site).

6.3.1 Footing Construction

Pile installation should be accompanied by appropriate verification inspections and testing, for example, load test results, pile driving records, grout pressure records, pile integrity testing, in keeping with the requirements of AS 2159-2009.

All footings should be excavated, cleaned and inspected by a qualified Geotechnical Engineer. Concrete should be poured with minimal delay. If delays in pouring mass concrete footings is anticipated, a concrete blinding layer should be provided to protect the foundation material.

Should softening of exposed foundation occur, the effected material should be over excavated and backfilled to design footing level by engineered fill or mass concrete.

6.3.2 Ongoing Footing Maintenance

Foundations including effective site drainage are required to be maintained over the life of the development to ensure footing performance. Refer to **Annex D** for the following:

- BTF 18-2011- CSIRO - Foundation Maintenance and Footing Performance – A Homeowner's Guide

6.4 Earthworks

Any earthworks conducted at the site should be controlled in accordance with AS3798-2007 and guided by the sections below.

6.4.1 Site Preparation

There may be difficulty maintaining the necessary level of compaction in sandy subgrade soils across the building foundation underlain aeolian sands. Density / compaction of the sandy areas may be maintained by limiting the area of exposed subgrade, regularly proof rolling using a 12T static smooth drum roller and maintaining moisture conditions by use of a water cart during dry periods.

Proposed foundation areas should be stripped to remove all vegetation, root affected soils, topsoil and existing fill down to design foundation level. Loose sands may be encountered in areas, and some over-excavation may therefore be required down to medium dense natural sand profiles, or better, for which an allowable bearing pressure of 100kPa can then be adopted.

The material in the exposed slab excavation will consist of natural sands which are likely to be moisture sensitive from incursion of groundwater or disturbance by construction equipment. At the time of the investigation, groundwater was encountered at 0.5m below ground level. It is therefore recommended that an allowance for the placement of a granular foundation replacement consisting of a 100mm to 300mm layer of granular fill such as **crusher dust**, or similar be included if compaction is difficult to achieve for high level footings.

It is recommended that the following be undertaken where controlled filling is to be undertaken:

- remove all topsoil, root effected zones, material assessed as unsuitable and other deleterious zones (noting the stripped soil is not considered suitable as engineered fill but may be considered for landscaping purposes)
- It is recommended that the building area is stripped using an excavator with a **mud** bucket to minimise disturbance of the sand profile. The exposed profile should then be static rolled with a smooth drum roller or similar
- The sand exposed at the base of the footings should be wetted down and compacted with a vibrating plate or roller to increase near surface compaction just prior to the placement of reinforcement and concrete
- the foundation area should then be assessed by an experienced geotechnical consultant using Perth Sand Penetrometer testing (PSPs) to assess if 100kPa has been achieved for high level footings. If identified, these areas should be over excavated under the direction of the geotechnical consultant and replaced with engineered fill

6.1 Fill Placement and Compaction Control

It is recommended that the following be undertaken where controlled filling is to be undertaken:

1) Following subgrade preparation, the exposed subgrade area should then be proof rolled under the supervision of an experienced geotechnical consultant and any soft spots / heaving areas identified. If identified these areas should be over excavated under the direction of the geotechnical consultant and replaced with engineered fill

2) Imported cohesive fill material is not recommended over the existing sand profile. Non-reactive granular fill

3) Where filling is required beneath structures is required, approved site won, and imported sand fill or crusher dust should be placed in layers not exceeding 200mm loose thickness and compacted to a minimum 75% Density Index with a smooth drum vibratory roller and addition of water to assist compaction. A grid of penetrometer tests should then be undertaken across the foundation area to confirm a density index of 75% in the foundation sands to at least 1.5m depth in accordance with frequency of tests in AS3789-2007 Guidelines on Earthworks for Residential and Commercial Developments.

4) All fill for the support of structures should be placed and compacted in accordance with the recommendations outlined in AS3798-2007 Guidelines on Earthworks for Residential and Commercial Developments, under Level 1 supervision.

6.1.1 Controlled Fill

Topsoil is not suitable for reuse as engineered fill. This material may be reused for landscaping purposes. Based on the encountered soil profile, visual observations and in-situ Perth Sand Penetrometer (PSP) testing, the Aeolian SAND material encountered at the site is deemed suitable for engineered fill, provided the fill is placed under strict moisture and compaction controls and adequate surface water drainage is maintained across the site.

The granular fill in the unsealed ring road and granular fill pad in the nursery is considered suitable for reuse as engineered fill or select fill.

If the sub-surface conditions encountered at the site during construction differ from those discussed in **Section 5**, then HCL should be consulted to determine if the material is suitable for controlled fill. Similarly, any won material imported from external sites should consult HCL to determine if the fill is suitable for controlled fill.

6.1.2 Compaction Criteria

Fill material should be compacted in near-horizontal uniform layers with a maximum compacted thickness of 300mm. It is important to ensure layers are placed in such a way that provides adequate drainage and prevent ponding during construction. The thickness of fill placed during construction should consider the compaction equipment available.

The moisture of the fill material should be controlled within a specified range of OMC to achieve the compaction criteria. In general, soils should be compacted within a moisture range of ±2% of OMC.

For residential developments the following compaction criteria applies:

- non-cohesive soils – 70% Minimum Density Index

Geotechnical inspections and testing should be performed in accordance with Level 1 procedures with reference to AS3798-2007.

6.1.3 Excavations Conditions

Excavation depths are not anticipated to exceed 0.5 m across the site to achieve final design levels. Excavation in sand profiles encountered at the site are considered as potentially unstable particularly when the excavations are below the water table and may require shoring / dewatering. Groundwater levels will fluctuate in response to climatic conditions and may be higher than the levels encountered during fieldwork.

Bored piers could be drilled using a 12-tonne excavator or greater with an attached auger. It is recommended that the bottom of bored pier holes should be cleaned out with the excavator fitted with a bucket attachment.

Excavations should be conducted in accordance with The Safe Work Australia "Excavation Work" Code of Practice October 2018.

https://www.safeworkaustralia.gov.au/doc/model-codes-practice/model-code-practice-excavation-work

Excavations can seriously affect the stability of adjacent buildings. Careful consideration must be taken to prevent the collapse of partial collapse of adjacent structures.

Construction material and equipment should not be placed within the zone of influence of an excavation unless a suitably qualified geotechnical engineer has designed ground support structures to withstand these loads. The zone of influence is dependent on the material encountered at the site and is the area in which possible failures can occur.

Refer to Council development guidelines before conducting any excavation works.

6.2 Batter Slopes

6.2.1 Temporary Batter Slopes

Battering of excavations within aeolian sand and fill that is placed above the groundwater table can be battered 1H:1V provided that:

- the depth does not exceed 0.5m in low lying areas and 1.0 m in elevated areas as described above
- they are open for no more than 24hrs
- no surcharge loading is applied to the surface within 2.5m of the excavation
- no one enters the excavation

Specific geotechnical assessment will be required where temporary excavations exceed 2m vertical height.

6.2.2 Permanent Better Slopes

Recommended permanent batter slopes in general are as follows:

- 4H:1V in excavated natural sand profiles else retained by an engineered retaining wall
- 3H:1V in placed Controlled Fill profiles else retained by an engineered retaining wall

Batter slopes should provide be protected against erosion by establishing vegetation cover or covering with Jute Mesh or similar. The optimum type of grass species selected to promote growth should be based on local climatic conditions and soil types. Also, regular watering during establishment and during dry weather periods along with initial fertilisation to promote growth is recommended.

Specific geotechnical assessment will be required where permanent batters exceed 1.0 m vertical height in elevated areas and 0.5 m in low lying areas.

7 Report Limitations

This report has been prepared by HCL for the specific site and purposes described within this report. HCL will accept no responsibility or liability for the use of this report by any third party, without the express consent of HCL or the Client, or for use at any other site or purpose than that described in this report.

This report and the services provided have been completed in accordance with relevant professional and industry standards of interpretation and analysis. This report must be read in its entirety without separation of pages or sections and without any alterations, other than those provided by HCL.

The scope of the investigation described in this report is based on information and plans provided to HCL by the Client as well as any additional limitations imposed by either the Client and / or site restraints.

Such limitations may include but are not limited to budget restraints, the presence of underground services or accessibility issues to a site. Where the report has been prepared for a specific design proposal the information and interpretation may not be relevant if the design proposal is changed. HCL should be consulted if site plans or design proposal is changed as the recommendations and / or opinions presented may not be suitable for the new revisions or variations made.

The conclusions, recommendations and opinions expressed within this report are subject to the specific conditions encountered and the limited geotechnical data gathered at the site during the time of the current investigation. The subsurface conditions and results presented in this report are indicative of the conditions encountered at the discrete sampling and testing locations within the site at the time of the investigation and within the depths investigated. Variations in ground conditions may exist between the locations that were investigated, and the subsurface profile cannot be inferred or extrapolated from the limited investigation conducted by HCL. For this reason, the report must be regarded as interpretative, rather than a factual document.

Subsurface conditions are subject to constant change and can vary abruptly because of human influences and /or natural geological and / or climatic processes and events. As such, conditions may exist at the site that could not be identified during or may develop after the current investigation has been conducted and as such, may impact the accuracy of this report. HCL should be contacted for further consultation and site re-assessment should sub-surface conditions differ from those conditions identified in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by HCL.

HCL recommends geotechnical reports older than 5 years from the date shown on the report, reports submitted for a previous (unrelated) development application on the site, or sites that have been altered by earthworks be reviewed by a qualified geotechnical consultant to confirm that the scope of the investigation undertaken for the report and the contents of the report are appropriate for the current development being proposed.

We are pleased to present this report and trust that the recommendations provided are sufficient for your present requirements. If you have any further questions about this report, please contact the undersigned.

For and on behalf of

Valley Civilab Pty Ltd, trading as Hunter Civilab

Reported by:	**Reviewed by:**
Drouin Pike	**Daniel Soffer**
Graduate Engineering Geologist	*Senior Geotechnical Engineer*
Bachelor of Geology	Bachelor of Engineering (Hon) (Civil)

Bachelor of Engineering (Hon) (Enviro)

References

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Annex A

Borehole Location Plan

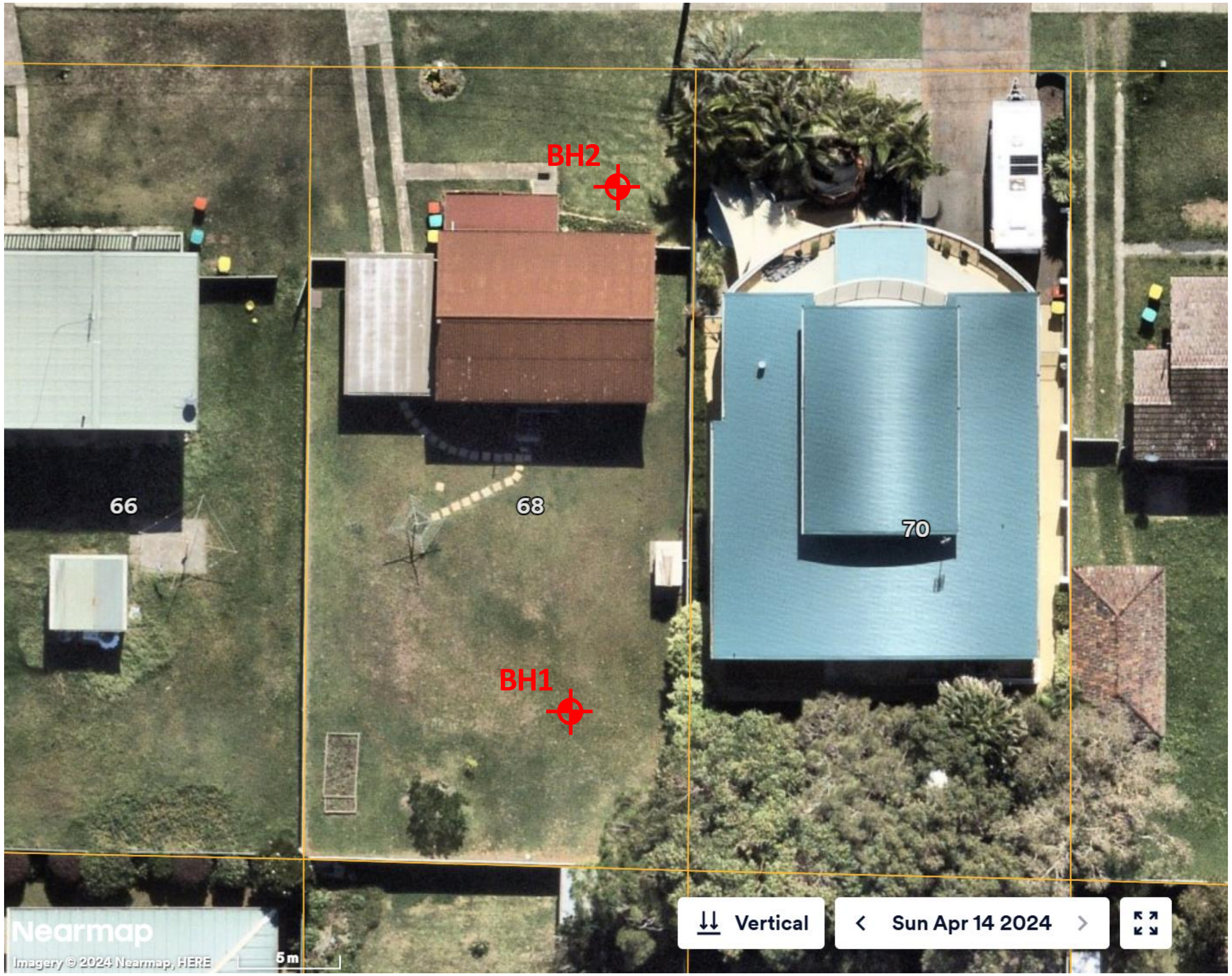

Figure 1 – Plan of the development at 68 Head St, Forster showing the approximate location of the Geotechnical boreholes.

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Annex B

1 Introduction

The following notes are provided to be used in conjunction with Hunter Civilab's report to explain the terms and abbreviations used throughout the report.

2 Material Descriptions

Descriptions of soil and rock are generally in accordance with the Unified Soil Classification System and Australian Standard AS1726-2017 – Geotechnical Site Investigations. The descriptions of soil and rock are based on field tests and observations and are independent of any laboratory test results. The data presented throughout this report is as factual as possible. However, some interpretations is unavoidable.

2.1 Unified Soil Classification Group Symbols

Soils are generally assigned one of the following unified soil classification group symbols:

Table 2.1 - Unified Soil Classification Group Symbols

Symbol	Description	Symbol	Description
CH	Organic clays of high plasticity	Pt	Peat and other highly organic soils
OL	Organic silts of low plasticity	CH	Inorganic clays of high plasticity
MH	Inorganic silts of high plasticity	CI	Inorganic clays of low plasticity
ML	Inorganic silts of low plasticity	CL	Inorganic clays of low plasticity
GC	Clayey gravels	SC	Clayey sands
GM	Silty gravels	SM	Silty sands
GP	Poorly graded gravels	SP	Poorly graded sands
GW	Well graded gravels	SW	Well graded sands

2.2 Soil Description

Soils are described in general accordance with AS1726-2017, Section 6.1:

Table 2.2 - Particle Size Definitions (AS1726-2017, Table 1)

Component	Subdivision	Size (mm)
BOULDERS		>200
COBBLES		63 - 200
GRAVEL	Coarse	19 - 63
	Medium	6.7 - 19
	Fine	2.36 - 6.7
SAND	Coarse	0.6 - 2.36
	Medium	0.21 - 0.6
	Fine	0.075 - 0.21
SILT		0.002 - 0.075
CLAY		<0.002

Table 2.3 - Descriptive Terms for Accessory Soil Components (AS1726-2017, Table 2)

Designation of Components	In Coarse Grained Soils				In Fine Grained Soils	
	% Fines	Terminology	% Accessory Coarse Fraction	Terminology	% Sand / Gravel	Terminology
Minor	≤ 5	Add 'trace clay / silt' to description where applicable	≤ 15	Add 'trace sand / gravel' to description where applicable	≤ 15	Add 'trace sand / gravel' to description where applicable
	> 5, ≤ 12	Add 'with clay / silt' to description where applicable	> 15, ≤ 30	Add 'with sand / gravel' to description where applicable	> 15, ≤ 30	Add 'with sand / gravel' to description where applicable
Secondary	> 12	Prefix soil name as 'Silty' or 'Clayey', as applicable	> 30	Prefix soil name as 'Sandy' or 'Gravelly', as applicable	> 30	Prefix soil name as 'Sandy' or 'Gravelly', as applicable

Table 2.4 - Descriptive Terms for Plasticity (AS1726-2017, Table 6)

Descriptive Term	Range of Liquid Limit for SILT	Range of Liquid Limit for CLAY
Non-Plastic	Not applicable	Not applicable
Low Plasticity	≤ 50	≤ 35
Medium Plasticity	Not applicable	> 35 and ≤ 50
High Plasticity	> 50	> 50

Table 2.5 - Moisture Condition (AS1726-2017, Clause 6.1.7 (a))

Material	Term	Abbreviation	Field Description Terms
Coarse Grained Soil	Dry	D	Non-cohesive and free-running
	Moist	M	Soil feels cool, darkened in colour; Soil tends to stick together
	Wet	W	Soil feels cool, darkened in colour; Soil tends to stick together, free water forms when handling
Fine Grained Soil	Moist, dry of plastic limit	w < PL	Hard and friable or powdery
	Moist, near plastic limit	w ≈ PL	Soil can be moulded at a moisture content approximately equal to the plastic limit
	Moist, wet of plastic limit	w > PL	Soil usually weakened and free water forms on hands when handling
	Wet, near liquid limit	w ≈ LL	Near liquid limit
	Wet, wet of liquid limit	w > LL	Wet of liquid limit

Table 2.6 - Consistency Terms for Cohesive Soils (AS1726-2017, Table 11)

Consistency	Abbreviation	Field Guide to Consistency
Very Soft	VS	Exudes between the fingers when squeezed in hand
Soft	S	Can be moulded by light finger pressure
Firm	F	Can be moulded by strong finger pressure
Stiff	St	Cannot be moulded by fingers
Very Stiff	VSt	Can be indented by thumb nail
Hard	H	Can be indented with difficulty by thumb nail
Friable	Fr	Can be easily crumbled or broken into small pieces by hand

Table 2.7 - Relative Density of Non-Cohesive Soils (AS1726-2017, Table 12)

Relative Density	Abbreviation	Density Index (%)
Very Loose	VL	$\leq$ 15
Loose	L	> 15 and $\leq$ 35
Medium Dense	MD	> 35 and $\leq$ 65
Dense	D	> 65 and $\leq$ 85
Very Dense	VD	> 85

Table 2.8 - Soil Origin (AS1726-2017, Clause 6.1.9)

Origin	Description
Residual Soil	Formed directly from in situ weathering of geological formations. These soils no longer retain any visible structure of fabric of the parent soil or rock material.
Extremely weathered material	Formed directly from in situ weathering of geological formations. Although this material is of soil strength, it retains the structure and / or fabric of the parent rock material.
Alluvial soil	Deposited by streams and rivers.
Estuarine soil	Deposited in coastal estuaries, and including sediments carried by inflowing rivers and streams, and tidal currents.
Marine soil	Deposited in a marine environment.
Lacustrine soil	Deposited in freshwater lakes.
Aeolian soil	Carried and deposited by wind.
Colluvial soil	Soil and rock debris transported down slopes by gravity, with or without the assistance of flowing water and generally deposited in gullies or at the base of slopes. Colluvium is often used to refer to thicker deposits such as those formed from landslides, whereas the term 'slopewash' may be use for thinner and more widespread deposits that accumulate gradually over longer geological timeframes.
Topsoil	Surface and / or near surface soils often, but not always, defined by high levels of organic material.
Fill	Material placed by anthropogenic processes.

2.3 Rock Description

Rocks are described in general accordance with AS1726-2017, Clause 6.2.

Table 2.9 - Rock Material Strength Classification (AS1726-2017, Table 19)

Strength	Abbreviation	Field Assessment
Very Low Strength	VLS	Material crumbles under firm blows with sharp end of pick; Can be peeled with sharp knife; Too hard to cut a triaxial sample by hand; Pieces up to 30mm thick can be broken by finger pressure.
Low Strength	LS	Easily scored with a knife; Indentations 1mm to 3mm show in the specimen with firm blows of the pick point; Has dull sound under the hammer; A piece of core 150mm long by 50mm diameter may be broken by hand; Sharp edges of core may be friable and break during handling.
Medium Strength	MS	Readily scored with a knife; A piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High Strength	HS	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; Rock rings under hammer.
Very High Strength	VH	Hand specimen breaks with pick after more than one blow; Rock rings under hammer.
Extremely High Strength	EH	Specimen required many blows with geological pick to break through intact material; Rock rings under hammer.

Note: Material with strength less than 'Very Low' shall be described using soil characteristics. The presence of an original rock structure, fabric or texture should be noted, if relevant.

Table 2.10 - Classification of Material Weathering (AS1726-2017, Table 20)

<table>
<tr><th colspan="2">Term</th><th colspan="2">Abbreviation</th><th>Definition</th></tr>
<tr><td colspan="2">Residual Soil</td><td colspan="2">RS</td><td>Material is weathered to such an extent that is has soil properties. Mass structure and material texture and fabric of original rock are no longer visible, but the soil has not been significantly transported. The material is described using soil descriptive terms.</td></tr>
<tr><td colspan="2">Extremely Weathered</td><td colspan="2">XW</td><td>Material is weathered to such an extent that is has soil properties. Mass structure and material structure and fabric of original rock are still visible. The material is described using soil descriptive terms.</td></tr>
<tr><td>Highly Weathered</td><td rowspan="2">Distinctly Weathered</td><td>HW</td><td rowspan="2">DW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable. Rock strength is significantly changed by weathering.</td></tr>
<tr><td>Moderately Weathered</td><td>MW</td><td>The whole of the rock material is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognizable, but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Slightly Weathered</td><td colspan="2">SW</td><td>Rock is partially discoloured with staining or bleaching along joints but shows little or no change of strength from fresh rock.</td></tr>
<tr><td colspan="2">Fresh</td><td colspan="2">FR</td><td>Rock shows no sign of decomposition of individual minerals or colour changes.</td></tr>
</table>

3 Drilling, In Situ Testing & Sampling Methodology

Table 3.1 - Drilling Methods

Abbreviation	Method
HA	Hand Auger
EX	Excavator bucket
AV	Auger drilling with steel 'V' bit
AT	Auger drilling with tungsten carbide bit
AB	Auger for bulk sampling
WB	Wash bore rotary drilling
NMLC	Rock coring using a NMLC core barrel
HQ	Rock coring using a HQ core barrel

Table 3.2 - Field Sampling and In Situ Testing Key

Abbreviation	In Situ Test
DCP	Dynamic Cone Penetrometer (blows/100mm)
PSP	Perth Sand Penetrometer (blow/100mm)
SPT	Standard Penetrometer Test
PP	Pocket Penetrometer Measurement (kPa)
3,4,5 (example)	SPT blows per 150mm
N=9 (example)	STP 'blow count number' over 300mm after initial 150mm seating
VS	Handheld Shear Vane Measurement (kPa)
CPT	Cone Penetrometer Test
IS50 (D) (A)	Point Load Index Value (reported in MPA) (D) = Diametric (A) = Axial

Abbreviation	Sample Type
U	Undisturbed Sample (50mm)
D	Disturbed Sample
B	Bulk Disturbed Sample
ES	Environmental Sample
W	Water Sample

4 Groundwater Observations

Table 4.1 - Water Comments Key

Water Comment	Symbol
Water Inflow	▶–
Water / drilling fluid loss	–◀
Measurement of standing water level	▼
Water Noted	▽

Hunter Civilab

Unit 3, 62 Sandringham Avenue Thornton NSW 2322

Phone: (02) 4966 1844

Geotechnical Log - Borehole

BH1

UTM	**: 56H**	**Drill Rig**	**:**	**Job Number**	**: G0667**
Easting (m)	**: 454,649.12**	**Driller Supplier**	**: Hunter Civilab**	**Client**	**: Cash**
Northing (m)	**: 6,439,408.79**	**Logged By**	**: Drouin Pike**	**Project**	**: 68 Head st, forster**
Ground Elevation	**: 6.75 (m)**	**Reviewed By**	**:**	**Location**	**: Forster NSW, Australia**
Total Depth	**: 1.35 m BGL**	**Date**	**: 13/08/2024**	**Loc Comment**	**:**

Drilling Method	Water	DCP	Testing: Pocket Penetrometer	Samples: Disturbed	Samples: Undisturbed	Samples: Bulk	Depth (m)	Graphic Log	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
		0					0.05		SM	Sandy SILT, low plasticity, dark brown to black mottled pale grey, fine to medium grained sand, with rootlets .	w < PL		Topsoil	
		1, 0, 1, 0, 2, 2	40				0.65		SM	Silty SAND, fine to coarse grained, dark brown to black mottled pale grey, siliceous sands, very low to low consistency	M	MD	MARINE – SAND	
	Water Table	1, 4, 5					1		SC	Clayey to silty SAND, fine to medium grained, black mottled pale grey, low plasticity clay, non - cemented	W	D	Indurated Sand	
		7, 8, 8, 25							SM	Silty SAND, fine to coarse grained, dark brown to black, non cemented		D-VD		
										BH1 refusal at 1.35m				

Hunter Civilab

Unit 3, 62 Sandringham Avenue Thornton NSW 2322

Phone: (02) 4966 1844

Geotechnical Log - Borehole

BH2

UTM	: 56H	Drill Rig	:
Easting (m)	: 454,652.68	Driller Supplier	: Hunter Civilab
Northing (m)	: 6,439,433.61	Logged By	: Drouin Pike
Ground Elevation	: 7.43 (m)	Reviewed By	:
Total Depth	: 1.35 m BGL	Date	: 13/08/2024

Job Number	: G0667
Client	: Cash
Project	: 68 Head st, forster
Location	: Forster NSW, Australia
Loc Comment	:

Depth (m)	Classification Code	Material Description	Moisture	Consistency	Soil Origin	Remarks
0 – 0.1	CI	Sandy CLAY, medium plasticity, dark brown mottled grey to pale grey, fine to medium grained sand, with grass roots .	w > PL		FILL/TOP SOIL:	
0.1 – 0.3	SM	FILL: Silty SAND, fine to coarse grained, medium dense, brown to grey mottled pale grey, with rootlets .	SLM	MD	Fill	
0.3 – 0.5	ML	FILL: Sandy SILT, fine to coarse grained sand, low plasticity, soft to firm, dark brown to black mottled pale grey, with rootlets .	w ≈ PL	S-F	Fill	
0.5 – 1.35	SC	Clayey to silty SAND, fine to medium grained, dark brown mottled pale grey, medium to high plasticity clay, increase sand content with depth	W-M	MD	MARINE – SAND	

Water: Water Table - Water table (at 0.5 m)

DCP (blows per 0.1 m, from 0 m): 0, 1, 1, 1, 2, 2, 3, 5, 6, 8, 6, 6, 5, 5, 7, 6, 7, 10, 27

BH2 Terminated at 1.35m (Hole collapse)

Annex C

Material Test Report

Report Number: **P24968-54**
Issue Number: 1
Date Issued: 19/08/2024
Client: Hunter Civilab
3/62 Sandringham Avenue, Thornton New South Wales 2322
Contact: Daniel Soffer
Project Number: P24968
Project Name: Geotechnical Consulting Services (MNC)
Project Location: 68 Head Street, Forster NSW
Client Reference: G0667
Work Request: 16178
Sample Number: 24-16178A
Date Sampled: 13/08/2024
Dates Tested: 15/08/2024 - 19/08/2024
Sampling Method: Sampled by Engineering Department
The results apply to the sample as received
Site Selection: Selected by Client
Sample Location: **BH1, Depth: 0.7-1.1m**
Material: Sand/Marine

Hunter Civilab
62 Sandringham Avenue Thornton NSW 2322
Phone: (02) 4966 1844
Email: office@huntercivilab.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: James Wyatt
Laboratory Manager
NATA Accredited Laboratory Number: 14975

Atterberg Limit (AS1289 3.1.2 & 3.2.1 & 3.3.1)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	Not Obtainable		
Plastic Limit (%)	Not Obtainable		
Plasticity Index (%)	**Non Plastic**		
Linear shrinkage could not be determined as the liquid limit could not be obtained and the material is non-plastic.			

Linear Shrinkage (AS1289 3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)			
Cracking Crumbling Curling			
Linear shrinkage could not be determined as the liquid limit could not be obtained and the material is non-plastic.			

Annex D

Foundation Maintenance and Footing Performance: A Homeowner's Guide

PUBLISHING

BTF 18-2011 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 2870-2011, 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, which may experience only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes

Notes

1. Where controlled fill has been used, the site may be classified A to E according to the type of fill used.
2. Filled sites. Class P is used for sites which include soft fills, such as clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soil subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.
3. Where deep-seated moisture changes exist on sites at depths of 3 m or greater, further classification is needed for Classes M to E (M-D, H1-D, H2-D and E-D).

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

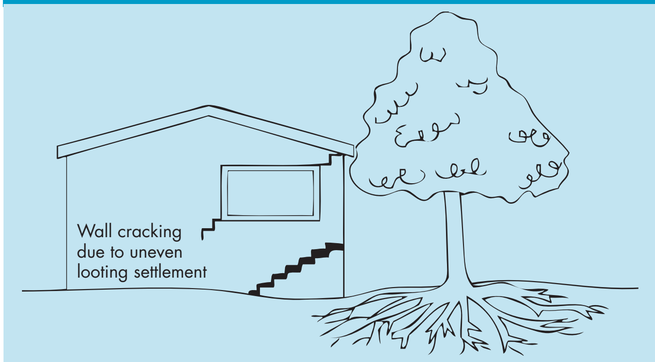
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the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

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.

Trees can cause shrinkage and damage



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 causes 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 2870-2011.

AS 2870-2011 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

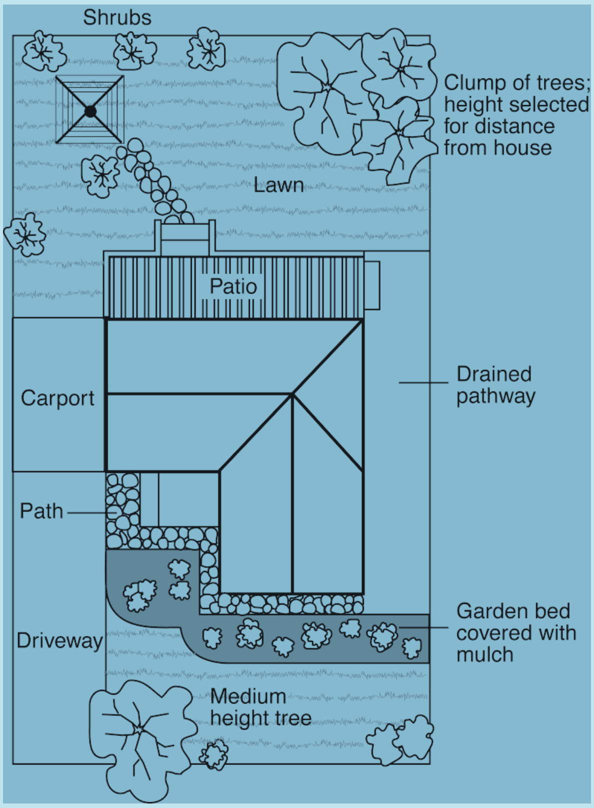
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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 should

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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.

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