Geotechnical site investigation report

World Class End of Life Care
Tamworth Hospital, 31 to 35 Dean Street, Tamworth NSW

Ref: R44178g
Date: 2 July 2024

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Executive Summary

Background

A new palliative care facility is proposed for *Tamworth Hospital* 31 to 35 Dean Street, Tamworth NSW.

Proposed works for the site include excavations, bulk earthworks, retaining walls, new pavement and new building.

A geotechnical assessment is required to assist in the design of the new works.

Scope

Undertake an investigation to describe the soil and geotechnical limitations of the development area to assist in civil, structural and pavement design.

Investigation

Site inspections and subsurface investigations were undertaken by Barnson on 27 May and 28 May 2024. A dial before you dig search and cable scan were used to detect underground services.

The geotechnical properties of the soil were assessed by drilling 5 boreholes (BH1 to BH5) with a truck mounted EVH drilling rig fitted with a soil auger and TC bit to target depths ranging from 1m to 4m. Soil conditions were logged for each borehole including soil type, colour, depth, approximate depth of fill, moisture, evidence of historical groundwater, rock, consistency and plasticity.

Disturbed soil samples were collected from representative borehole layers and analysed for geotechnical parameters including Atterberg limits (liquid limit, plastic limit), pH, electrical conductivity (EC), bulk unit weight, and California Bearing Ratio (CBR).

Dynamic cone penetrometer (DCP) tests were undertaken next to representative boreholes to refusal depths. Soil consistency, shear strength, cohesion, friction angle, and estimated allowable bearing capacity were gauged by the analysis results, DCP tests, soil texture and drill rig penetration at the soil moisture conditions on the day of assessment.

The site has a land-use history as part of the Tamworth Hospital precinct. A building and trees were previously present within proposed area. Trees and structures were removed, and site landscaped in 2016. Removal details are unknown. The site has been levelled by historical fill placement.

Surface cover on the investigation area is landscaped gardens with areas of lawn on steeper slopes. A hardstand gravel pathway traverses the site. The lawn area was generally 100% surface cover. Small trees were present within the proposed development.

The soil profiles varied across the site. Fill material was identified in some boreholes up to 2m in depth. Natural subsoil generally included silty clay, sandy clay, sandy clay with weathered rock to the drilling depth. The clay subsoil has moderate to high plasticity with high linear shrinkage and plastic index.

The soil consistency and drill penetration ranged from firm to stiff in clay. Drill refusal on high strength rock was encountered at borehole location BH3 and BH4 at a depth of 3.5m and 4.0m. The depth of rock is variable across the site. Drill refusal on concrete was encountered at borehole location BH5 at a depth of 1.2m. The concrete is expected to be part of previous structure. The depth and location of the concrete may vary across the site.

The weathered rock material and high strength rock on the site are an excavation limitation and the depth is expected to vary.

Natural soils analysed from the boreholes contained high to very high liquid limit and plastic limit. The site classification is **Class P (abnormal conditions)** due to potential differential settlement from deep fill, removed trees and structures. The soils analysed are estimated to be in the highly reactive (H2) range with a design surface movement (*Ys*) of 60-65mm.

The soils analysed are not aggressive to foundations. The exposure classification for concrete is A1.

The CBR results for the natural subgrade samples collected ranged from 4% to 7%.

The estimated allowable bearing capacity of the soil on the site generally increased with depth ranging from approximately 150kPa in the sandy silty clay material to >300kPa into gravelly sandy clay material.

The assessment and results are based on conditions, soil profile and soil moisture identified at the borehole locations. Site conditions can vary due to fluctuations in seasonal factors and soil moisture. The site should be reassessed if surface or subsurface conditions differ from those described in the report.

Table of contents

1. Introduction

A new palliative care facility is proposed for *Tamworth Hospital* 31 to 35 Dean Street, Tamworth NSW. The site has a land-use history as part of the Tamworth Hospital precinct. The development will include excavation, bulk earthworks, retaining walls, new access road and new building.

A geotechnical investigation is required to assist in design of the development.

2. Objectives

Barnson Pty Ltd was commissioned by Health Infrastructure to undertake geotechnical investigations for the new palliative care facility is proposed for Tamworth Hospital at 31 to 35 Dean Street, Tamworth NSW.

The investigation includes:

- Summary of site and surface conditions
- Borehole drilling to depths of up to 4m or refusal
- Summary of subsurface conditions including groundwater and rock
- Collection of soil samples for laboratory analysis of geotechnical parameters
- In-situ dynamic cone penetration (DCP) tests to 2m or refusal
- Site classification including characteristic surface movement
- Foundation parameters including shear strength, bulk unit weight, allowable bearing capacities and footing types
- Assessment of soil aggressiveness
- California bearing ratio (CBR) of natural subgrade
- Pavement recommendations
- Earth pressure coefficient estimation and geotechnical parameters for retaining wall design
- Excavation limitations

3. Site location

The site is located at Tamworth Hospital, Lot 1 DP 1181268 31 to 35 Dean Street, Tamworth NSW. The site has a land-use history as part of the Tamworth Hospital precinct.

4. General site description

The majority of the site was formerly a part of the Tamworth hospital. A building and a few large to medium trees were located within the proposed area (Figure2). Demolition of the site commenced in 2016 and the site was landscaped. The site has been historically levelled by cut and fill placement.

5. Site condition and environment

5.1 Surface cover

Surface cover on the investigation area is landscaped gardens with areas of lawn on steeper slopes. A hardstand gravel pathway traverses the site. The lawn area was generally 100% surface cover. Small trees were present within the proposed development.

5.2 Topography

The site morphology is a mid-slope with an inclination of 3-5% southeast. The site elevation ranges from 418m in the north to 416m in the south of the investigation area.

5.3 Soils and geology

The investigation area is within the Orchard Creek Soil Landscape (NSW Government, nd).

Topsoil in the Orchard Creek Soil Landscape consists of a dark reddish brown to dark brown silty clay loam with a clear boundary change to a dark reddish brown to dark brown silty clay loam to 50cm over a medium clay to 300cm. The geological unit of the Orchard Creek Soil Landscape is the Baldwin Formation and the Yarrimie Formation. Parent rocks include quartz sandstone, lithic sandstone, conglomerate, ferruginous sandstone and red siltstone. Tertiary basalt also occurs on the site. (NSW Government, nd).

Natural sub soils observed on-site comprised reddish brown to yellowish brown and yellow sandy silty clay, sandy clay, and light medium clay. Sand and gravel occurred throughout the profiles.

5.4 Hydrology

5.4.1 Surface water

Surface water generally flows north to south towards the hospital building in the southern section of the site.

No drainage line is present in the investigation area. Peel River is situated approximately 1.1km to the south.

5.4.2 Groundwater

A search of the WaterNSW groundwater map identified four groundwater bores within 1.5Km of the site. Groundwater bore GW057928 is located approximately 200m south of the site and has water bearing zones of 26.2m to 26.5m and a final depth of 38m into basalt. Groundwater bore GW052834 is located approximately 200m southwest of the site and has a final depth of 34.5m into basalt and has water bearing zones of 24.5m to 34.0m.

No saturated soil groundwater ingress was encountered in the borehole profiles at the time of drilling. Mottled clays were detected from shallow depths indicating historical shallow seasonal groundwater flows.

6. Investigation methods

Site inspections and subsurface investigations were undertaken on 27 May and 28 May 2024. A dial before you dig search and cable scan were used to detect underground services prior to boreholes construction.

The areas assessed include the proposed building and pavement. The geotechnical properties of the soil were assessed by drilling 5 boreholes (BH1 to BH5) with a truck mounted EVH drilling rig fitted with a soil auger and TC bit to target depths ranging from 1m to 4m. Soil conditions were logged for each borehole including soil type, colour, depth, approximate depth of fill, moisture, evidence of historical groundwater, consistency, rock and plasticity.

Disturbed soil samples were collected from representative borehole layers and analysed for geotechnical parameters including Atterberg limits (liquid limit, plastic limit, plastic index, linear shrinkage), pH, electrical conductivity (EC), bulk unit weight and California Bearing Ratio (CBR). Natural subgrade soil samples were analysed for 4-day soak California Bearing Ratio (CBR) in proposed pavement areas. Pavement design recommendations will be made using Austroads guidelines.

Dynamic cone penetrometer (DCP) tests were undertaken next to representative boreholes to refusal depths. Soil consistency, shear strength, cohesion, friction angle and estimated allowable bearing capacity were gauged by the DCP tests, soil texture, laboratory analysis results and drill rig penetration at the soil moisture conditions on the day of assessment.

All testing depths undertaken for the assessment were relative to existing ground level on the day of investigation.

Boreholes, soil sampling was undertaken according to the Australian Standards 1726 and site classification in accordance with the Australian Standard 2870, by qualified field and laboratory personnel. Soil analysis was undertaken at the NATA accredited laboratory of Envirowest Testing Services.A schedule of sampling locations and the tests undertaken are given in Table 1.

Table 1. Sampling location, depths and tests undertaken

Borehole (Figure 1)	Approximate GPS location		Tests undertaken	Testing depths (m)	Investigation total depth (m)
1	-31.072756	150.924530	Soil properties description Atterberg limits CBR Bulk unit weight DCP	0 to 4.0 1.1, 3.0 0.6 to 1.5 1 to 1.5 0 to 0.9	4.0
2	-31.072770	150.924642	Soil properties description Atterberg limits CBR Bulk unit weight DCP	0 to 4.0 3.0 0.6 to 1.3 1.8 to 2.0 0 to 1.1	4.0
3	-31.072820	150.924721	Soil properties description Atterberg limits CBR Bulk unit weight DCP	0 to 3.5 1.7, 2.3 1.2 to 1.7 1.3 to 1.6 0 to 1.3	3.5(Refusal on rock)
4	-31.072783	150.924850	Soil properties description Atterberg limits CBR Bulk unit weight DCP	0 to 4.0 1.1, 2.3 1.2 to 1.6 1.4 to 1.6 0 to 0.9	4.0 (Refusal on rock)
5	-31.0728193	150.924720	Soil properties description	0 to 1.2	1.2(Refusal on concrete)

MDD – maximum dry density, OMC – optimum moisture content, DCP – dynamic cone penetrometer, CBR – California bearing ratio

7. Results

7.1.1 Site history

The site has a land-use history as part of the Tamworth Hospital precinct. A building and trees were previously present within proposed area. Trees and structures were removed, and site landscaped in 2016. Footing and tree removal details are unknown.

7.1.2 Site conditions

The investigation area occurs on a mid-slope. Surface cover on the investigation area is landscaped gardens with areas of lawn on steeper slopes. A hardstand gravel pathway traverses the site. The lawn area was generally 100% surface cover. Small trees were present within the proposed development during the time of investigation.

7.2 Soil profile and subsurface conditions

The borelogs are presented in Appendix 1. Report limitations are presented in Appendix 4.

Deep fill was identified at borehole location up to a depth of 2.0m at some of the borehole locations. Fill comprising various layers of gravely to clayey sand to gravelly to sandy clay with fine to coarse gravel. Abundant brick fragments and concrete gravels was identified to the fill depth at borehole locations. Depth of fill vary across the lot.

The natural soil profile comprising variable layers of sandy silty clay to silty sandy clay over gravelly to sandy clay with weathered rock to the drilling depth. the drilling depths. Fine grained sand and gravel were identified in natural soil profile. Natural soil colour varied from reddish brown to yellowish brown over brown and yellow to the drilling depth. The natural clay has medium to high plasticity. Soil moisture was generally less than plastic limit to equal to plastic limit to the drilling depth.

Drill refusal on high strength rock was encountered at borehole location BH3 and BH4 at a depth of 3.5m and 4.0m. The depth of rock is variable across the site.

Drill refusal on concrete was encountered at borehole location BH5 at a depth of 1.2m. The concrete is expected to be part of previous structure. The depth and location of the concrete may vary across the site.

7.3 Soil index tests

The clay soil at the borehole locations had high Liquid Limit and Linear Shrinkage. The soil index results are presented in Table 2 and Appendix 3.

Table 2. Soil index test summary

Borehole (Figure 1)	Depth (mm)	Liquid limit %	Linear shrinkage %	Soil description
BH1	1100	56	14.5	SILTY CLAY
BH1	3000	48	14.0	GRAVELLY SANDY CLAY
BH2	3000	43	12.5	SANDY CLAY
BH3	1700	78	17.5	SILTY CLAY
BH3	2300	70	17.0	SILTY CLAY
BH4	1100	62	16.0	SANDY CLAY
BH4	2300	49	14.0	SANDY CLAY

7.4 Soil aggressiveness

The laboratory results indicate all the soil samples collected were non-saline and EC_e less than 4dS/m (Table 3). The pH of the soil samples tested is presented in Table 3. The site is not located in a mapped acid sulphate soil prone area.

Table 3. pH, electrical conductivity analysis results and salinity rating

Borehole (Figure 1)	Depth (mm)	pH	Electrical conductivity (EC) (dS/m)	Electrical conductivity of a saturated extract (EC_e) (dS/m)	Salinity rating
BH1	600	7.9	0.03	0.24	Non-saline
BH2	600	8.5	0.01	0.15	Non-saline

7.5 Surface water and groundwater

Surface water is expected to be moderate in times of high rainfall. Surface water flows are a geotechnical constraint. No evidence of shallow seasonal groundwater flows was observed in the natural soil at the borehole locations. Groundwater flows are a geotechnical constraint.

7.6 Soil Consistency and Dynamic cone penetrometer (DCP) tests

The DCP testing and drill rig hydraulic penetration confirmed the consistency at borehole locations was

- BH1 – Soft to firm to 0.9m, firm to 2.5m and firm to stiff to the drilling depth
- BH2 – Loose to 0.5m and firm to 2m and firm to stiff to the drilling depth
- BH3 – Loose to 1.3m and firm to 2.4m and firm to stiff to the drilling depth and refusal at 3.5m
- BH4 – Loose to 0.4m soft to firm to 1.2m, firm to stiff to 2.3m and stiff to the drilling depth and refusal at 4.0m.
- BH5 – Very loose to 0.2m and soft to firm to 1.2m and refusal on concrete at 1.2m

7.7 Allowable bearing capacity

The estimated soil allowable bearing capacity was gauged by the DCP results, soil profile and drill rig hydraulic penetration.

The estimated allowable bearing capacity of the natural soil is outlined in Table 6.

The estimated geotechnical parameters for natural soil including undrained shear strength, cohesion, allowable shaft adhesion and allowable bearing capacity are outlined in Table 6.

7.8 California bearing ratio (CBR)

Soil was collected for CBR analysis from the subgrade depth in representative areas.

The CBR result for the sample collected are outlined in Table 4 and Appendix 5. Maximum dry density, field moisture, optimum moisture content and soil expansion (swell) are included in the laboratory report.

Table 4. CBR test result

Borehole (Figure 1)	Sample ID	Sample depth (mm)	Sample description	CBR (%)
BH1	O24-1528A	600-1500	Sandy Clay, Brown	4.0
BH2	O24-1528B	600-1300	Sandy Clay, Brown	7.0
BH3	O24-1528C	1200-1700	Silty Sandy Clay, Yellowish brown	4.5
BH4	O24-1528D	1200-1600	Silty Sandy Clay, Brownish Yellow	4.5

7.9 Bulk unit weight

Four subsoil samples were analysed for bulk unit weight at field moisture content (Table 6).

Table 5. Soil analysis results – bulk unit weight

Borehole (Figure 1)	Depth (mm)	Bulk unit weight γ (kN/m^3)
BH1	1000	18.91
BH2	1800	16.46
BH3	1300	17.24
BH4	1400	16.56

7.10 Surface water and groundwater

Surface water and groundwater generally flows south. Shallow seasonal groundwater is expected to occur on the site.

Evidence of historical elevated seasonal groundwater was not detected in the soil profile from shallow depths. Surface and subsurface water flows are a significant geotechnical constraint for construction and long-term moisture variances.

7.11 Removed trees and structure

Large trees and buildings were present with in proposed site formerly a part of Tamworth Hospital. Trees and structures were removed in 2016 during the construction of new building to the south. Removal details of footing and trees are unknown. Soil suction allowances attributed to trees (existing and removed) should be considered in design calculations.

8. Recommendations

8.1. Soil reactivity

The site has a site classification of **Class P (abnormal conditions)** due to potential differential settlement from deep fill, removed trees and footings within the building footprint. Natural soils analysed from the boreholes contained high liquid limit and plastic limit. The soils analysed are estimated to be in the highly reactive (H2) range with a design surface movement (*Ys*) of 60-65mm.

8.2 Exposure classification

The soil tested at the proposed site were non-saline with soil saturated extract electrical conductivity (EC_e) ranging from 0.15dS/m to 0.24dS/m. Soil pH was neutral to slightly alkaline (7.9 to 8.4 pH units) for the soil samples analysed. Exposure classification for concrete is A1 (Appendix 4).

8.3 Footing design parameters

Pile foundations shall be designed in accordance with and AS 2159. Pile type foundations should be founded below fill into natural subsoil with adequate bearing capacity. Fill is unsuitable for foundation Estimated design parameters are outlined in Table 6 for the proposed development.

Table 6. Soil parameter for engineering design for deep footings

Material (natural soil)	Depth (m)	Geotechnical design parameters							
		γ kN/m³	C*u* kPa	Ø deg	C' (kPa)	Ultimate shaft adhesion kPa	Allowable shaft adhesion kPa	Ultimate bearing capacity kPa	Allowable bearing capacity kPa
Silty clay	1.0	17.0	120	23	7	12	6	240	125
Sandy clay	2.0	17.5	200	24	7	48	25	480	250
Sandy clay or gravelly clay	3.0	18.5	>200	25	7	62	32	620	320
Weathered rock or rock	4.0	19.5	>200	30	-	96	50	960	500

γ - Bulk unit weight, C*u* – Undrained cohesion (shear strength), Ø – soil friction angle, C' – Effective cohesion (drained),

The site is subject to shallow seasonal groundwater flows resulting in wet soil and a reduction in shear strength which is a geotechnical constraint for foundations.

Pile foundation allowable bearing capacity was determined in accordance with AS 2159 with a geotechnical reduction factor of $\Phi_g = 0.45$. All foundations and piers should be inspected by a suitably qualified person to confirm geotechnical properties.

8.4 Retaining wall design parameters

Retaining walls should be designed in accordance with AS 4678. The geotechnical parameters are outlined in Table 6 and subsequent earth pressures are presented in Table 7.

Table 7. Earth pressure coefficients (non-sloping crest backfill)

Borehole (Figure 1)	Sample depth (m)	Stratum	γ kN/m³	Ø (deg)	Active (K_a)	At rest (K_o)	Passive (K_p)
1	1.0 to 1.5	Firm sandy to silty clay	18.8	22	0.455	0.625	2.198
2	1.8 to 2.0	Stiff sandy clay	16.5	26	0.492	0.660	2.032
3	1.3 to 1.6	Firm sandy to silty clay	17.2	24	0.422	0.593	2.371
4	1.4 to 1.6	Stiff sandy to silty clay	16.6	23	0.438	0.609	2.283

γ - Bulk unit weight, Ø – soil friction angle(derived)

No allowance has been made for wall friction, compaction pressures or surcharge effects. Drainage should be installed behind the wall to prevent hydrostatic pressures developing from seeping water. The design of the retaining walls should also include an assessment of potential wall deformation.

The use of heavy compaction equipment on backfill material against the retaining wall will result in earth pressures at levels greater than Table 6. Temporary wall propping should be undertaken if heavy compaction equipment is required.

Site inspections by a suitably qualified person are recommended during and after earthworks to confirm strata and subsurface conditions.

8.5 Excavation areas and subsoil properties

The subsoil profiles at borehole location varied including firm to stiff clay to the drilling depth with stiff weathered rock inclusion.

The weathered rock depth is likely to vary across the site and is a significant geotechnical limitation for excavations. Drill refusal on rock occurred at borehole locations BH3 and BH4 at a depth of 3.5m and 4.0m. Ripping or hammer may be required for excavations into the weathered rock and rock.

Drill refusal on concrete was encountered at borehole location BH5 at a depth of 1.2m. The concrete is expected to be part of previous structure. The depth and extent of the concrete is unknown.

Soil moisture on the day of drilling was dry (less than plastic limit) to greater than plastic limit. Shallow seasonal groundwater flows are a geotechnical limitation.

8.6 Pavement

8.6.1 Subgrade design strength

The design CBR value of the natural subgrade ranged from 4% to 7%.

8.6.4 Subgrade preparation

Subgrade preparation should include:

- Soft and wet subgrade is not suitable for subgrade. Mitigation measures may be required to improve the subgrade such as stabilisation or geogrid composite placement.

- All topsoil, vegetation including tree roots, wet material, soft soil, large particles, silty material, debris, and other foreign matter should be removed. Wet subgrade areas may require moisture reduction.

- The exposed subgrade should be compacted to 98% standard maximum dry density ratio (SMDD) ratio. The exposed compacted surface should be proof rolled to detect soft spots using a 12-tonne roller or equivalent.

- The subgrade design CBR ranges from 4% to 7%.

- Any soft, weak or saturated material should be removed and replaced by suitable fill material and compacted in maximum layers of 150mm, moisture content at time of compaction to be 60% - 90% optimum moisture content (OMC) and at least 98% standard maximum dry density ratio (SMDD) ratio.

- All service trenches and other excavations should be backfilled with suitable fill material and compacted in maximum layers of 150mm, moisture content at time of compaction to be 60% - 90%

optimum moisture content (OMC) and at least 98% standard maximum dry density ratio (SMDD) ratio.

- Pavement fill layers (select fill, subbase and base) shall be compacted in layers to at least 100% standard maximum dry density ratio (SMDD) ratio with moisture content at time of compaction to be close to optimum moisture content (OMC). Fill layers shall pass a proof roll.

8.6.5 Subgrade plasticity and expansion

Natural soils analysed from the boreholes contained high liquid limit and linear shrinkage. The natural soil has moderate to high expansive nature.

8.6.6 Expansive clay

The expansive nature of the natural clay is high in some locations of the proposed pavements as indicated by moderate to high CBR swell (expansion) and linear shrinkage. Pavement subgrade heaving and shape loss is probable due to moisture changes in the expansive clay. *Austroads (2012)* provides guidance on mitigation measures for expansive clays including:

- Construct the subgrade or fill material at a time when its soil suction (the ability of a soil to attract moisture) is likely to be near the long-term equilibrium value.
- Compact the soil close to Optimum Moisture Content (OMC).
- Provide a low-permeability lower subbase or select fill capping layer above the expansive soil. The minimum thickness of this layer should be the greater of 150 mm or two-and-a-half times the maximum particle size.
- Provide a minimum cover of material over the expansive soil for all pavement types. Material used to provide this layer should have swells of less than 2.5% and be placed at an appropriate moisture content to remain within this limit. The required thickness of cover increases with the traffic loading to reflect the better ride quality required on higher traffic volume roads.
- Ensure that the location of pavement drains is confined to the impermeable subbase and does not extend into the expansive soils. Drains located within expansive soils will cause fluctuations in the moisture content of the soil.
- Restrict the planting of shrubs and trees close to the pavement
- Provide – through appropriate design of the cross-section of the road – sealed shoulders and impermeable verge material. A seal width of 1 to 1.5 m is required outside the edge of the traffic lanes to minimise subgrade moisture changes under the outer wheel path.
- Use appropriate construction techniques when placing the expansive soil.
- Incorporate lime stabilisation to reduce the plasticity and increase the volume stability of the upper layer of the expansive clay subgrade.

8.7 Surface water and groundwater mitigation

Adequate surface and subsurface drainage are recommended to intercept groundwater reducing variation of soil moisture under the dwelling preventing excessive movement of the soil. Groundwater seepage may occur at the time of pile hole boring. The groundwater flows are expected to be significant in times of high rainfall.

8.8 Removed trees and structures

Differential settlement is possible in the areas of existing or removed foundations under new structural loads. Potential differential settlement is likely to occur due to existing foundation removal, excavation and backfill material on site. New footings are recommended to extend into natural undisturbed soil with adequate bearing capacity and below the zone of influence of the removed foundations and tree roots.

8.9 Geotechnical testing

Site inspections by a suitably qualified person are recommended during and after earthworks to confirm strata and subsurface conditions.

8.10 Filling and earthworks

Earthworks and fill placement techniques should be in accordance with AS3798. Foundations are recommended to extend into natural soil or socketed into rock below fill material with adequate bearing capacity.

8.11 Geotechnical testing

Pavement and footing excavations should be inspected by a suitably qualified person at the time of excavation and placement to confirm strata and accordance with design parameters. The specification, execution and control testing of earthworks and site preparation should be undertaken according to AS3798.

9. Limitations of the investigation

The engineering logs describe subsurface conditions only at a specific borehole location and inferred boundaries between geotechnical units may vary.

Ground conditions can vary over relatively short distances and it may be necessary to carry out additional investigations for specific excavation and building sites. Once specific proposals are known a geotechnical review should be undertaken and if necessary additional investigations commissioned to provide the level of information required for assessing design parameters. A geotechnical engineer should be engaged to review subsurface condition during construction stages to confirm that subsurface conditions are consistent with design assumptions.

This report has been prepared for the use of the client to achieve the objectives given the client requirements and cost constraints. The level of confidence of the conclusion reached is governed by the scope of the investigation and the availability and quality of existing data. Where limitations or uncertainties are known, they are identified in the report. No liability can be accepted for failure to identify conditions or issues which arise in the future and which could not reasonably have been predicted using the scope of the investigation and the information obtained.

The investigation identifies the actual subsurface conditions only at those points where samples are taken, when they are taken. Data derived through sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists who then render an opinion about overall subsurface conditions, the nature and extent of the investigation and its likely impact on the proposed buildings Actual conditions may differ from those inferred to exist, because no professional, no matter how well qualified, and no sub surface exploration program, no matter how comprehensive, can reveal what is hidden by earth, rock or time. The actual interface between materials may be far more gradual or abrupt than a report indicates. Actual conditions in areas not sampled may differ from predictions. It is thus important to understand the limitations of the investigation and recognise that Envirowest Consulting Pty Ltd are not responsible for these limitations.

10. References

AS 1289.6.3.2 Determination of the penetration resistance of a soil – 9kg Dynamic Cone Penetrometer Test

AS 2870 (2011) *Residential Slabs and Footings - Construction* (Standards Australia: Homebush)

AS 3798 (2007) *Guidance on earthworks for commercial and residential buildings* (Standards Australia: Homebush)

Austroads (2012) *Pavement design-A guide to the structural design of road pavements* (Austroads Inc, Sydney)

Austroads (2012) *Pavement design for light traffic-A supplement to the Austroads Pavement Design Guide* (Austroads Inc, Sydney)

Meyerhof GG, (1976) *Bearing Capacity and Settlement of Pile Foundations* (American Society of Civil Engineers)

NSW Government (nd) *eSpadev2* (https://www.environment.nsw.gov.au/eSpade2WebApp)

Terzaghi K, and Peck K B, (1967) *Soil Mechanics in Engineering Practice (*New York: John Wiley & Sons, Inc.)

Figures

Figure 1. Aerial image (SIXmaps 2011), Removed structure and tree location		
Tamworth Hospital, 31 to 35 Dean Street, Tamworth NSW		
	Envirowest Consulting Pty Ltd	
Job: R44178g	Drawn by: HT	Date: 26/6/2024

Legend

⊗ Borehole and DCP locations

Figure 2. Aerial image (Nearmap 2024) and borehole locations		
Tamworth Hospital, 31 to 35 Dean Street, Tamworth NSW		
	Envirowest Consulting Pty Ltd	
Job: R44178g	Drawn by: HT	Date: 26/6/2024

Appendices

Barnson

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Geotechnical Log - Borehole

1

Easting	: 301,993.33	**Location**	: Tamworth Hospital, Dean Street, North Tamworth NSW, Australia	**Job Number**	: 44178
Northing	: 6,560,483.33	**Logged By**	: HT	**Client**	: Health Infrastructure- Tamworth
Total Depth	: 4 m	**Date**	: 27/05/2024	**Project**	: Geotech

Drilling Method	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Consistency/Density	DCP graph	Samples: CBR	Samples: Disturbed sample	Samples: 5 kg disturbed	Remarks
Auger drill with TC bit	0.1	Non-Soil		PAV	Mulch							
		Fill		SP	Fill Gravelly SAND medium dense, dark brown, fine grained, fine to medium sized gravel, dry.	D	MD					
	0.4	Fill		CI	Fill Gravelly to sandy CLAY medium plasticity, soft to firm, dark brown, fine sized gravel, medium grained sand, organic, w > pl.	w > PL	S-F					
	0.9	Natural		CI	Natural Sandy to silty CLAY firm, medium plasticity, reddish brown, fine grained sand, with fine sized gravel, inorganic, w ≈ pl.	w ≈ PL	F		CBR	D	BD	
	1.2	Natural		CI	Natural Sandy to silty CLAY firm, medium plasticity, brownish yellow, fine grained sand, with fine sized gravel, inorganic, w < pl.	w < PL						
	2.1	Natural		CI	Natural Sandy to silty CLAY firm, medium plasticity, red, fine grained sand, inorganic, w < pl.							
	2.5	Natural		SC	Natural Gravelly to clayey SAND dense, medium plasticity clay, yellow, fine grained, medium sized gravel, with medium plasticity silt, moist.	M	D					
	2.8	Natural		CI	Natural Gravelly CLAY firm to stiff, medium plasticity, yellow brown, medium to coarse sized gravel, with medium plasticity silt, inorganic, w < pl.	w < PL	F-St			D		
	3.5	Natural		CI	Natural Gravelly to sandy CLAY stiff, medium plasticity, yellow, fine to medium sized gravel, fine grained sand, with medium plasticity silt, inorganic, w < pl.		St					
					1 Terminated at 4m (Target depth)							

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Geotechnical Log - Borehole

2

Easting	: 302,004.03	**Location**	: Tamworth Hospital, Dean Street, North Tamworth NSW, Australia	**Job Number**	: 44178
Northing	: 6,560,481.89	**Logged By**	: HT	**Client**	: Health Infrastructure- Tamworth
Total Depth	: 4 m	**Date**	: 27/05/2024	**Project**	: Geotech

Drilling Method	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Consistency/Density	DCP graph	Samples: CBR	Samples: Disturbed sample	Samples: 5 kg disturbed	Remarks
Auger drill with TC bit	0	Fill		SM	Fill Gravelly to silty SAND loose, dark brown to brown, fine grained, fine sized gravel, dry.	D	L					
	0.5	Fill		CL	Fill Gravelly to sandy CLAY low plasticity, firm, brown, fine sized gravel, fine grained sand, organic, w < pl.	w < PL	F		CBR			
	2	Natural		CI	Natural Gravelly to sandy CLAY firm to stiff, medium plasticity, yellow brown, fine to medium sized gravel, fine grained sand, with medium plasticity silt, inorganic, w < pl.		F-St				BD	
	2.8	Natural		CI	Natural Sandy CLAY firm to stiff, medium plasticity, yellow, fine grained sand, with fine to medium sized gravel, with medium plasticity silt, inorganic, w < pl.					D		
	3.5	Natural		SM	Natural Gravelly to silty SAND dense to very dense, yellow, fine grained, fine sized gravel, dry.	D	D-VD					
					2 Terminated at 4m (Target depth)							

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Geotechnical Log - Borehole

3

Easting	: 302,014.68	**Location**	: Tamworth Hospital, Dean Street, North Tamworth NSW, Australia	**Job Number**	: 44178
Northing	: 6,560,480.08	**Logged By**	: HT	**Client**	: Health Infrastructure- Tamworth
Total Depth	: 3.5 m	**Date**	: 27/05/2024	**Project**	: Geotech

Drilling Method	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Consistency/Density	DCP graph	Samples: CBR	Samples: Disturbed sample	Samples: 5 kg disturbed	Remarks
Augerdrill with TC bit	0.2	Fill		SP	Fill Gravelly SAND very loose, grey, fine grained, fine sized gravel, dry.	D	VL					
	1.2	Fill		CL	Fill Gravelly to sandy CLAY low plasticity, soft to firm, dark reddish brown, fine sized gravel, fine grained sand, organic, w < pl, abundant brick and concrete fragments .	w < PL	S-F					
	1.3	Fill		SC	Fill Clayey to silty SAND low plasticity clay, loose, dark grey, fine grained, dry.	D	L					
	2	Natural		CI	Natural Sandy to silty CLAY firm, medium plasticity, yellow, fine grained sand, inorganic, w < pl to w ≈ pl.	w < PL-w ≈ PL	F		CBR		BD	
	2.4	Natural		CI	Natural Sandy to silty CLAY firm, medium plasticity, red, fine grained sand, trace fine sized gravel, inorganic, w < pl.	w < PL				D		
	3.1	Natural		CI	Natural Sandy to silty CLAY firm to stiff, medium plasticity, yellow, fine grained sand, with fine sized gravel, inorganic, w < pl.		F-St					
		Natural		SC	Natural Gravelly to clayey SAND dense to very dense, medium plasticity clay, yellow, fine grained, fine sized gravel, trace low plasticity silt, dry, weathered rock .	D	D-VD					
					3 refusal at 3.5m (Refusal on rock)							

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Geotechnical Log - Borehole

4

Easting	**: 302,023.91**	**Location**	**: Tamworth Hospital, Dean Street, North Tamworth NSW, Australia**	**Job Number**	**: 44178**
Northing	**: 6,560,480.85**	**Logged By**	**: HT**	**Client**	**: Health Infrastructure- Tamworth**
Total Depth	**: 4.1 m**	**Date**	**: 27/05/2024**	**Project**	**: Geotech**

Drilling Method	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Consistency/Density	DCP graph	Samples: CBR	Samples: Disturbed sample	Samples: 5 kg disturbed	Remarks
Auger drill with TC bit	0.0	Fill		SP	Fill Gravelly SAND loose, dark brown, fine grained, fine sized gravel, with low plasticity silt, moist.	M	L					
	0.4	Fill		CI	Fill Gravelly to sandy CLAY medium plasticity, soft to firm, reddish brown, medium to coarse sized gravel, fine grained sand, with low plasticity silt, inorganic, w < pl, with brick and concrete gravels from 0.7.	w < PL	S-F			D		
	1.2	Natural		CI	Natural Sandy to silty CLAY firm to stiff, medium plasticity, brownish yellow, fine grained sand, with fine sized gravel, inorganic, w < pl.		F-St		CBR		BD	
	2.3	Natural		CI	Natural Clayey to sandy CLAY stiff, medium plasticity, yellow, fine grained sand, with fine sized gravel, with medium plasticity silt, inorganic, w < pl, weathered rock inclusions .		St			D		
					4 refusal at 4.1m (Refusal on hard rock)							

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Geotechnical Log - Borehole

5

Easting	: 302,011.60	**Location**	: Tamworth Hospital, Dean Street, North Tamworth NSW, Australia	**Job Number**	: 44178
Northing	: 6,560,476.67	**Logged By**	: HT	**Client**	: Health Infrastructure- Tamworth
Total Depth	: 1.2 m	**Date**	: 27/05/2024	**Project**	: Geotech

Drilling Method	Depth (m)	Soil Origin	Graphic Log	Classification Code	Material Description	Moisture	Consistency/Density	DCP graph (0 2 4 6 8 10 12 14 16 18 20 22 24 26)	Samples	Remarks
		Fill		SP	Fill Gravelly SAND very loose, grey, fine grained, fine sized gravel, dry.	D	VL			
	0.2	Fill		CL	Fill Gravelly to sandy CLAY low plasticity, soft to firm, dark reddish brown, fine sized gravel, fine grained sand, organic, w < pl, abundant brick and concrete fragments .	w < PL	S-F			
					5 refusal at 1.2m (Refusal on concrete)					

Material Test Report

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9 Cameron Place Orange NSW 2800
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Email: admin@envirowest.net.au

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Approved Signatory: Ethan Lewin
Laboratory Manager
NATA Accredited Laboratory Number: 15372

Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531A
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH1 , Depth: 1100mm**
Material: Silty clay, Yellow brown

Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	56		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**14.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

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Approved Signatory: Ethan Lewin
Laboratory Manager
NATA Accredited Laboratory Number: 15372

Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531B
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH1 , Depth: 3000mm**
Material: Gravelly sandy clay, yellow brown

Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	48		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**14.0**		
Cracking Crumbling Curling	Curling		

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Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531C
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH2 , Depth: 3000mm**
Material: Sandy clay, yellow

Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	43		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**12.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

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NATA Accredited Laboratory Number: 15372

Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531D
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH3 , Depth: 1700mm**
Material: Silty clay, yellow

Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	78		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**17.5**		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531E
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH3 , Depth: 2300mm**
Material: Silty sandy clay, Red

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Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	70		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**17.0**		
Cracking Crumbling Curling	Curling		

Material Test Report

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Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531F
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH4 , Depth: 2100mm**
Material: Silty sandy clay, brownish yellow

Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	62		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**16.0**		
Cracking Crumbling Curling	Curling		

Material Test Report

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NATA Accredited Laboratory Number: 15372

Report Number: **44178-2**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1531
Sample Number: O24-1531G
Date Sampled: 03/06/2024
Dates Tested: 03/06/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **BH4 , Depth: 2300mm**
Material: Sandy clay, Yellow

Atterberg Limit (AS 1289.3.1.2)		Min	Max
Sample History	Oven Dried		
Preparation Method	Dry Sieve		
Liquid Limit (%)	49		
Plastic Limit (%)			
Plasticity Index (%)			

Linear Shrinkage (AS 1289.3.4.1)		Min	Max
Moisture Condition Determined By	AS 1289.3.1.2		
Linear Shrinkage (%)	**14.0**		
Cracking Crumbling Curling	Curling		

Material Test Report

Report Number: **44178-1**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1528
Sample Number: O24-1528A
Date Sampled: 31/05/2024
Dates Tested: 31/05/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **CBR 1 , Depth: 600-1500mm**
Material: Sandy clay, Brown

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Approved Signatory: Ethan Lewin
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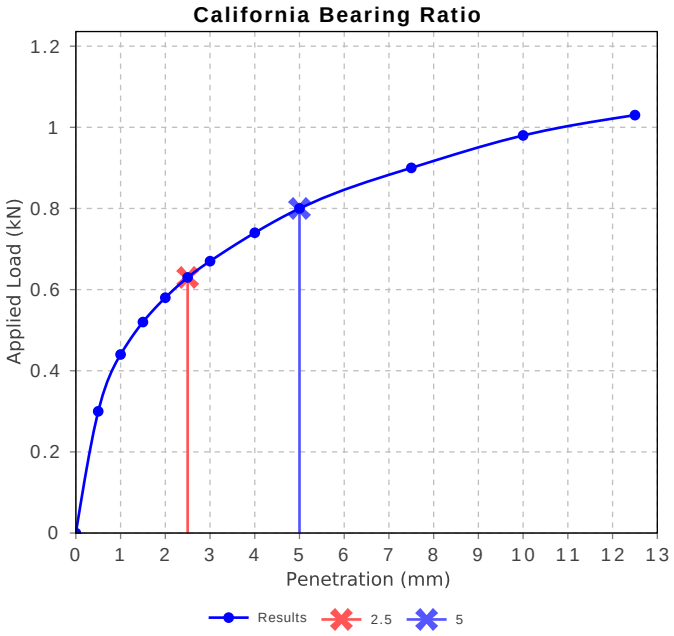
NATA Accredited Laboratory Number: 15372

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**5.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.63		
Optimum Moisture Content (%)	23.0		
Laboratory Density Ratio (%)	99.5		
Laboratory Moisture Ratio (%)	99.5		
Moisture Content at Placement (%)	22.7		
Moisture Content Top 30mm (%)			
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	144.7		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			



Material Test Report

Report Number: **44178-1**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1528
Sample Number: O24-1528B
Date Sampled: 31/05/2024
Dates Tested: 31/05/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **CBR 2 , Depth: 600-1300m**
Material: Sandy clay, Brown

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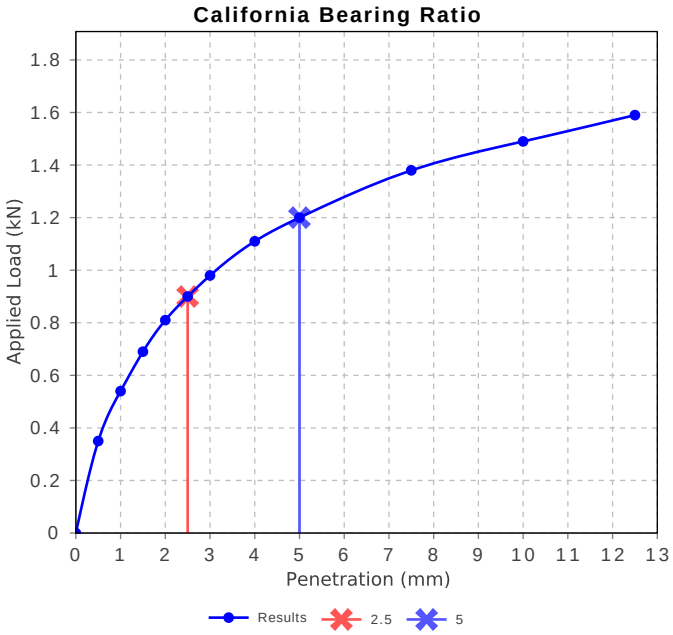
NATA Accredited Laboratory Number: 15372

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**7**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.77		
Optimum Moisture Content (%)	16.5		
Laboratory Density Ratio (%)	101.0		
Laboratory Moisture Ratio (%)	101.0		
Moisture Content at Placement (%)	16.6		
Moisture Content Top 30mm (%)	17.9		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	144.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			



Material Test Report

Report Number: **44178-1**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1528
Sample Number: O24-1528C
Date Sampled: 31/05/2024
Dates Tested: 31/05/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **CBR 3 , Depth: 1200-1700mm**
Material: Silty sandy clay, Yellow brown

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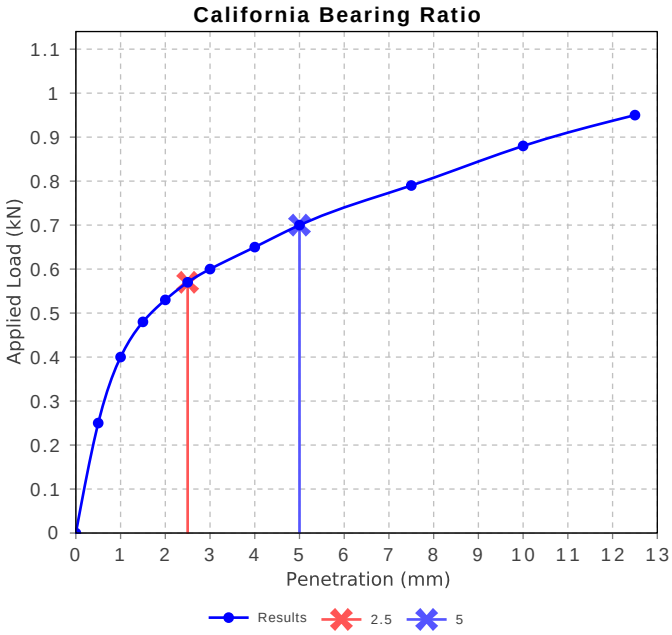
California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**4.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.66		
Optimum Moisture Content (%)	20.5		
Laboratory Density Ratio (%)	97.5		
Laboratory Moisture Ratio (%)	111.5		
Moisture Content at Placement (%)	22.7		
Moisture Content Top 30mm (%)	26.3		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	145.1		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			



Material Test Report

Report Number: **44178-1**
Issue Number: 1
Date Issued: 24/06/2024
Client: Health Infrastructure
Level 8, 77 Pacific Highway, North Sydney NSW 2060
Contact: Nina Cleary
Project Number: 44178
Project Name: Tamworth Hospital, Dean Street, Tamworth
Project Location: Tamworth Hospital, Dean Street, Tamworth
Work Request: 1528
Sample Number: O24-1528D
Date Sampled: 31/05/2024
Dates Tested: 31/05/2024 - 17/06/2024
Sampling Method: AS 1289.1.2.1 6.5.3 - Power auger drilling
Preparation Method: AS 1289.1.1 - Sampling and Preparation of Soils
Sample Location: **CBR 4 , Depth: 1200-1600mm**
Material: Silty sandy clay, Brown yellow

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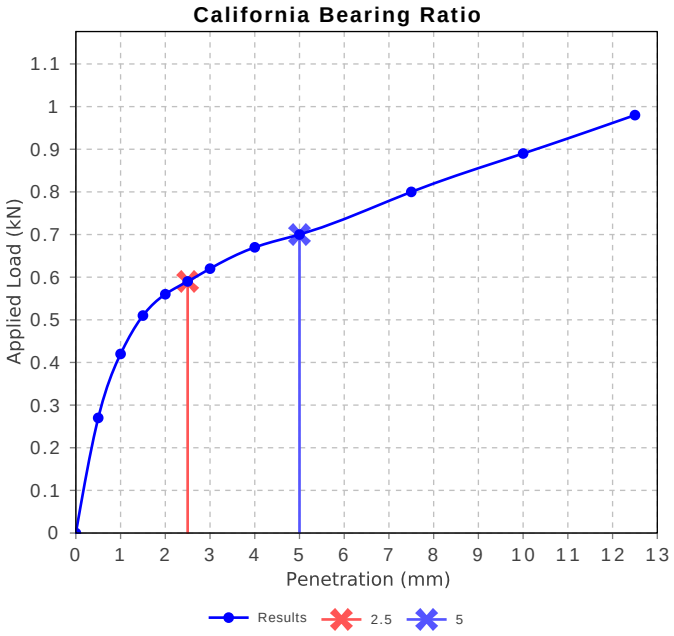
Approved Signatory: Ethan Lewin
Laboratory Manager
NATA Accredited Laboratory Number: 15372

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**4.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	Visual		
Maximum Dry Density (t/m^3)	1.63		
Optimum Moisture Content (%)	22.5		
Laboratory Density Ratio (%)	96.0		
Laboratory Moisture Ratio (%)	110.0		
Moisture Content at Placement (%)	24.7		
Moisture Content Top 30mm (%)	26.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours (h)	145.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)			



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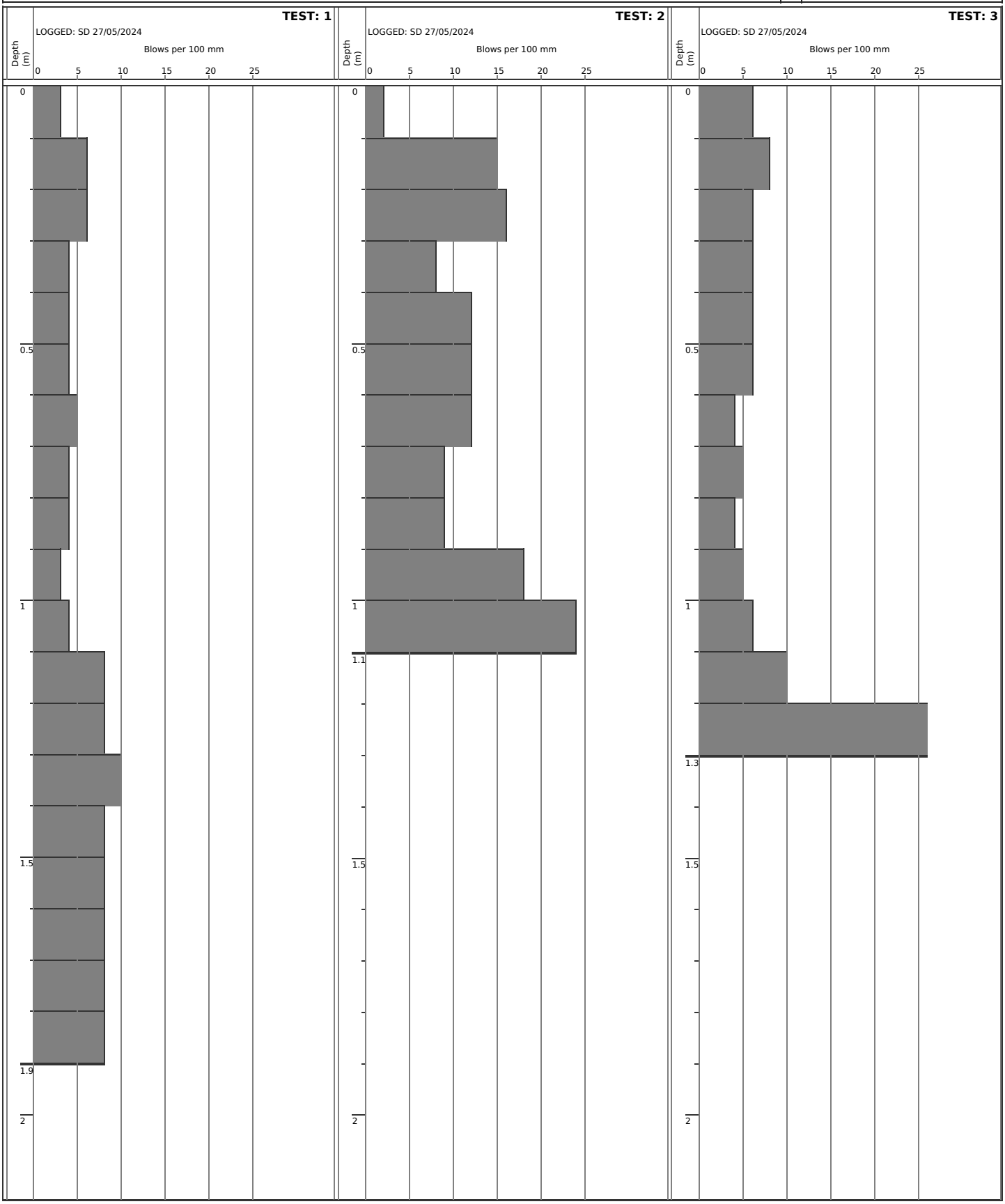
CLIENT	: Health Infrastructure- Tamworth	SHEET	: 1 OF 2
CONTRACTOR	: Barnson		
PROJECT	: Geotech		
LOCATION	: Tamworth Hospital, Dean Street, North Tamworth NSW, Australia		
PROJECT No.	: 44178		



Comments	Comments	Comments

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CLIENT	: Health Infrastructure- Tamworth		SHEET : 2 OF 2
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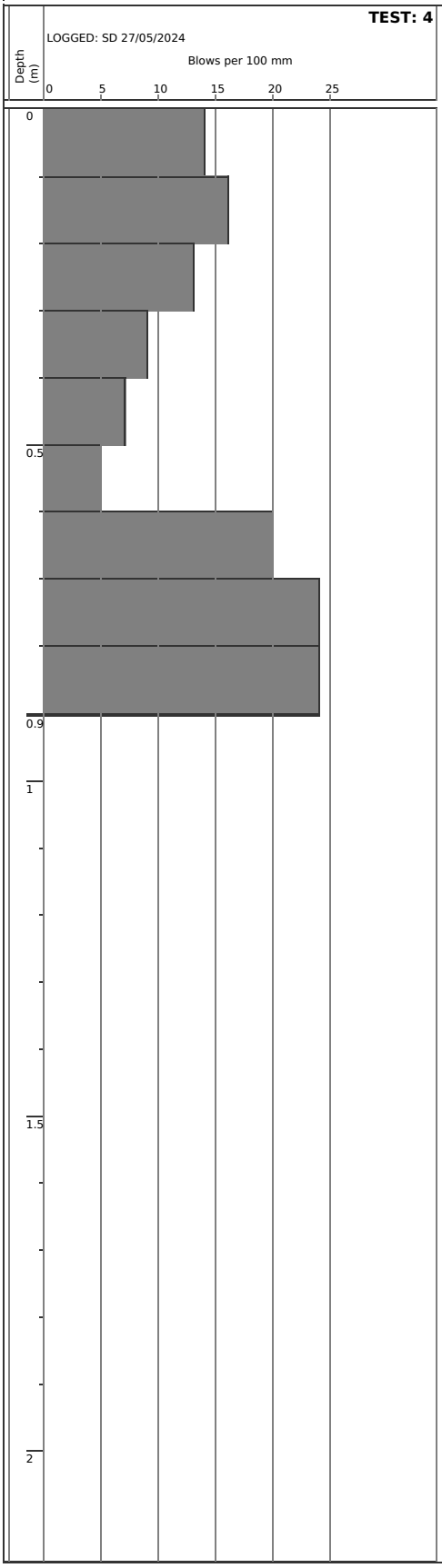
TEST: 4

LOGGED: SD 27/05/2024



Comments

Appendix 4. Aggressive soils, extract from Australian Standards, *AS 2870*

Exposure classification for concrete in saline soils

Saturated extract electrical conductivity (EC_e), *dS/m*	Exposure classification
<4	A1
4-8	A2
8-16	B1
>16	B2

Notes:

1. Guidance on concrete in saline soils can be found in CCAA T56
2. Exposure classifications are from AS 3600
3. The currently accepted method of determining the salinity level of the soil is by measuring the extract electrical conductivity (*EC*) of a soil and water mixture in deciSiemens per metre (dS/m) and using conversion factors that allow for the soil texture, to determine the saturated extract electrical conductivity (EC_e)
4. The division between a non-saline and saline soil is generally regarded as an EC_e value of 4dS/m, therefore no increase in the minimum concrete strength is required below this value

Exposure classification for concrete in sulphate soils

Exposure conditions			Exposure classification	
Sulphates (expressed as SO_4)*		pH	Soil conditions A**	Soil conditions B†
In soil (ppm)	In groundwater (ppm)			
<5,000	<1,000	>5.5	A2	A1
5,000-10,000	1,000-3,000	4.5-5.5	B1	A2
10,000-20,000	3,000-10,000	4-4.5	B2	B1
>20,000	>10,000	<4	C2	B2

* Approximately 100ppm SO_4 = 80ppm SO_3

** Soil conditions A – high permeability soils (e.g. sands and gravels) that are in groundwater

† Soil conditions B – low permeability soils (e.g. silts and clays) or all soils above groundwater

Minimum design characteristic strength (f_c') and curing requirements for concrete

Exposure classification	Minimum f_c' MPa	Minimum initial curing requirement
A1	20	Cure continuously for at least 3 days
A2	25	
B1	32	Cure continuously for at least 7 days
B2	40	
C1	≥50	
C2	≥50	

Minimum reinforcement cover for concrete

Exposure classification	Minimum cover in saline soils * mm	Minimum cover in sulfate soils ** (mm)
A1	See Clause 5.3.2	40
A2	45	50
B1	50	60
B2	55	65
C1	†	70
C2	†	85

* Where a damp-proofing membrane is installed, the minimum reinforcement cover in saline soils may be reduced to 30mm.

** Where a damp-proofing membrane is installed, the minimum reinforcement cover in sulfate soils may be reduced by 10mm.

† Saline soils have a maximum exposure classification of B2 as per Table 5.1.

Appendix 5. Important information about the report

Background

The intention of the Australian Standard 2870-1996, Residential slabs and footings is to provide guidance in the design of slabs and footings of residential building on commonly encountered foundations. The standard is also considered to provide useful guidance for commercial and industrial buildings. This involves (1) site classification, (2) structural design and construction and (3) site maintenance after construction. The classification assessment in this report is the first step in providing a footing system for a building, which will have a low risk of inadequate performance (Appendix B AS2870-1996). Even significant cracking to widths of over 3 mm usually presents only aesthetic rather than structural problems. Some minor problems should be expected during settlement or in periods of drought.

Classification

AS2870-1996 establishes a classification system whereby reactive sites (unaffected by filling) are designated slightly, moderately, highly or extremely reactive based on the range of ground surface movements anticipated and which are likely to have a less than 5% chance of being exceeded in the design life of the structure. Where the foundation conditions at a site need to consider aspects in addition to, or other than soil reactivity, the site is classified P.

It is neither possible nor economical to design for the extreme conditions that could occur in the foundation if a site is not properly maintained. The recommended foundation maintenance is described below. Some minor cracking and movement will occur in a significant proportion of houses, especially on reactive clays.

The method of subsurface investigation has been described in the attached report and it usually involves one or more boreholes or test pits in each lot. It may also involve the inspection of exposures in road cuttings and trenches. In making the assessment there is a risk that variations which may occur between tests or exposure locations may not be detected. The number of test pit locations undertaken is a professional estimate to provide a description of the general soil profile at the site. No subsurface investigation, no matter how comprehensive, can reveal all details and anomalies. Small local variations such as deep topsoil, fill associated with local grubbing of tree stumps and previous trenches or pits may be undetected. If subsoil conditions encountered during the footing excavation are different from those described in the report, reclassification may be necessary. The site should be reassessed and may require revision of the classification and footing design.

Most sites are not level and often require cutting and filling to provide a level platform for construction. AS2870-1996 specifies the classification should be revised if (a) the depth of the cut exceeds 0.5m, or (b) the depth of compacted fill exceeds 0.4 m for clay or 0.8 m for sand.

Foundation maintenance

All soils are affected by water. Silts are weakened by water and some sands can settle if heavily watered, but most problems arise on clay foundations. Clays swell and shrink due to changes in moisture. Sands, silts and clays should be protected from becoming extremely wet. Sites classified as M, H or E shall be maintained at essentially stable moisture conditions and extremes of wetting and drying prevented. This requires attention to the following:

(a) Drainage of the site. The site shall be graded and drained so that water cannot pond against or near the house. The ground immediately adjacent to the house shall be graded to a uniform fall of 50mm minimum away from the house over the first metre. The sub floor space for houses with suspended floors shall be graded or drained to prevent ponding, where this may affect the performance of the footing system. The site drainage requirement shall be maintained for the economic life of the building.
(b) Limitation on gardens. The buildings shall not interfere with the drainage requirements or the sub floor ventilation and weep hole drainage systems. Garden beds adjacent to the house should be avoided. Care should be taken to avoid over watering of gardens close to the house footings.
c) Restrictions on trees and shrubs. Planting of trees and shrubs should be avoided near the foundations of a house on reactive sites as they can cause damage, even at substantial distances, due to the drying of the clay. To reduce, but not eliminate the possibility of damage, trees should be restricted to a distance of 1 times the mature tree height for Class H and M, and 1.5 times mature tree height for Class E. Where groups of trees are involved, distances should be increased. Removal of trees from the site can also cause similar problems.
(d) Repair of leaks. Leaks in plumbing, including storm water and sewage should be repaired promptly.

Class P sites

The presence of fill, compressible soils at depth or slope may influence footing performance and these need to be considered in foundation design.

Appendix 6. Soil Descriptions and Abbreviations

These notes summarize abbreviations commonly used in borelogs and test pit reports

Classification code

GW well graded gravels, gravel sand, no fines
GP poorly graded gravels
GM silty gravel, poorly graded gravel silt sand
GC clayey gravels, poorly graded gravel sand clay
SW well graded sands, gravely sands, no fines
SP poorly graded sands, gravely sands, no fines
SM silty sands, poorly graded sand clay
SC clayey sands, poorly graded sand clay
CL inorganic clays, low plasticity, gravely clay, sandy clay, silty clay, lean clay
CI inorganic clays, medium plasticity, gravely clay, sandy clay, silty clay, lean clay
OL organic silt, organic silty clay, low plasticity
MI inorganic silts, fine sandy or silty soils with low plasticity
MH inorganic silts, fine sandy or silty soils with medium plasticity
CH inorganic clay, high plasticity, fat clays
OH organic clay medium to high plasticity
Pt peat, or other highly organic soils

Samples

U undisturbed
D disturbed
W water sample
B bulk
E environmental sample
VOC volatile organic compounds

Moisture

D Dry
M Moist, can be moulded
W Wet, free water on hands
PL plastic limit
LL liquid limit

Consistency (approx. shear strength in kPa)

Hand penetrometer or description:

VS very soft, exudes between fingers when squeezed (<25)
S soft, moulded by light finger pressure (25-50)
F firm, moulded slightly by fingers (50-100)
St stiff, cannot be moulded by fingers, indented by thumb (100-200)
VSt very stiff, indented with difficulty by thumb (200-300)
H Hard (>300)

Plasticity

NP non plastic
T trace
VL very low
L low
M medium

Density

VL very loose
L loose
M medium
D dense
VD very dense

H high
VH very high

Origin

An interpretation is provided based on observations of landform, geology and fabric, and many further include assignment of stratigraphic unit. Typical origin descriptions include

Residual Formed directly from in situ weathering with no visible structure or fabric of the parent rock or soil
Alluvial Deposited by streams and rivers (may be applied more generically as transported by water)
Topsoil Surficial soil, typically with higher levels of organic material. Topsoils buried by other transported soils are termed 'remnant topsoil'
Fill Any material which has been placed by anthropogenic process

Testing

PID Photoionization detectors
SPT Standard penetrometer test
CPT Cone penetrometer test
PP Pocket penetrometer
UCS Unconfined compressive strength
PSP Perth Sand Penetrometer
ASS Acid sulphate soils test
ECE Electrical conductivity of the saturated extract
CBR California bearing ratio
DPSH Dynamic probing super heavy

DCP Dynamic Cone Penetrometer Testing
The dynamic cone penetrometer test comprises the measurement of the soil resistance to a steel rod driven into the ground by a dropped weight. The DCP test is a simple manual test used in both sandy and clayey soils. The test is a measure of the shear strength of the soil at relatively shallow depth. The equipment uses a 9kg sliding weight with a drop height of 510mm. It is fitted with a conical tip. The equipment can be adjusted for a fall of 600mm and use of a blunt tip in accordance with AS1289.6.3.3.

Others

RQD Rock quality designation
TCR Temperature coefficient of resistance
PVC Polyvinyl chloride
UPVC Unplasticized polyvinyl chloride
TC Tungsten carbide
SFA Sectional flight auger

Degree of weathering

EW Extremely weathered
HW Highly weathered
MW Moderately weathered
SW Slightly weathered
Fs Fresh Staine