Nepean Geotechnics

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Geotechnical Investigation Report

Proposed New K-12 School

**Eileen O'Connor School,
84 Gavenlock Road, Mardi NSW**

Report No. R23169. Rev2

Prepared for:

Stanton Dahl Architects

7 April 2025

Planning Secretary’s Environmental Assessment Requirements

Development Details

Application No:	SSD-67173718
Project Name:	New Eileen O’Connor Catholic School
Location:	84 Gavenlock Road, Mardi NSW 2259 Lot 9 Section 4 DP3368 within Central Coast
Applicant:	Catholic Schools Broken Bay

The following documentation has been prepared to support the State Significant Development Application for the above project and in accordance with the Planning Secretary’s Environmental Assessment Requirements (SEARS) dated 19th February 2024 as follows:

	Issue and Assessment Requirements	Relevant Section of this Report
12	**Ground and Water Conditions:**	
	Assess potential impacts on soil resources and related infrastructure and riparian lands on and near the site, including soil erosion, salinity and acid sulfate soils.	Sections 3,5,6,7, and 11
	Provide a Surface and Groundwater Impact Assessment that assesses potential impacts on: • surface water resources (quality and quantity) including related infrastructure, hydrology, dependent ecosystems, drainage lines, downstream assets and watercourses. • groundwater resources in accordance with the Groundwater Guidelines.	

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Appendices

1. Introduction

This report presents the results of a geotechnical investigation undertaken for the proposed construction of the Eileen O'Connor Catholic School at 84 Gavenlock Road, Mardi NSW. The job was undertaken in accordance with Nepean Geotechnics general terms of engagement.

We understand that the proposed upgrade works comprise the construction of new teaching blocks, on-grade carparks and associated facilities at the north-western portion of the school site. Conceptual design drawings were provided which shows the footprint of proposed structures at the site. It is understood that the proposed new buildings will be two storey with a maintenance level.

The objective of the investigation was to assess the subsurface soil conditions across the site and provide comments on site classification in accordance with AS2870, bearing capacity of exposed material, subgrade conditions and other geotechnical restrictions.

2. Site Description

The investigation area is located at the north-western portion of the school site and occupies an approximate area of 12,840 m^2. The site has frontage to Keefers Glen along the western boundary and is bordered by a series of residential dwellings to the north. To the south and east, there are existing building within the subject school site and further south are building of the existing St. Peter Catholic School. The site was vacant at the time of investigation, however, there was a relatively large farm dam at the northern portion of the site. Site vegetation was limited to grasses and trees along the boundaries. It's noted that the vegetation within the existing dam area consist of trees, shrubs and weeds.

The site had a difference in elevation of approximately 3 – 4 metres from the highest portions along the southern boundary towards the northern boundary.

The general site conditions at the time of the field work have been illustrated in the following photographs:

Photograph 1 – General site conditions, looking north

Photograph 2– Location of BH2 – looking east

Photograph 3– A view of the existing dams and vegetation – looking north

3. Geology

According to the Gosford-Lake Macquarie 1:100 000 Geological Series Sheet the site is underlain by Quaternary aged sediments consisting of gravels and sands. According to the mapping, the site is situated close to a geological boundary with the Clifton Subgroup (Rnp) formation of Narrabeen group consisting of claystone, siltstone and fine-grained lithic sandstone.

4. Field Works

The field work comprised drilling of four boreholes (BH1 – BH4) to a maximum depth of 7.0 m. A shallow borehole was drilled for the recovery of bulk samples for undertaken a laboratory California bearing ratio (CBR) test. The boreholes were drilled using a Hilux mounted Christie Engineering drilling rig equipped with solid flight augers.

Dynamic cone penetrometer (DCP) tests were carried out at each borehole location, to provide an indication of the penetration resistance of the near-surface soils. An experienced geotechnical engineer attended site for a walkover assessment and borehole logging. A marked up site plan showing the approximate borehole locations is provided in Appendix A.

5. Subsurface Conditions

The surface material in the boreholes comprised minor toposils to approximate depths of 0.1 – 0.2 m. Surface topsoils were underlain by sands, silty sands and clayey sands of loose to medium density to an average depth of 1.0 m. Below this depth, clayey sands in dense conditions were present in the boreholes. The subsurface material below approximate depth of 1.0 included seams of gravelly silty sands with trace coarse gravels which continued to the termination depth of boreholes.

The boreholes were drilled to a depth of 7.0 m in BH1, 6.0 m in BH2 and BH3 and a depth of 3.0 m in BH4.

Significant water seepage was observed at approximate depth of 2.8 m in BH2 at the northern portion of the existing dam. The subsurface material in BH1 and BH3 appeared dry to moist. However, the granular soils below a depth of 2.5 m in BH4 appeared moist to wet. The observed seepage may be attributed to the recent rainfall prior to the investigation or some leakage from the existing dam. It is noted that the groundwater level in granular soils may vary from time to time and depending on the climatic conditions.

6. Laboratory Test Results

A sample of natural clayey material was collected and sent to a NATA accredited soil laboratory for Atterberg Limits test to assist in the classification of natural soils. A summary of test results is provided in Table 1 below.

Table 1: Summary of Atterberg Limits Test Results

Sample Location & Depth	Liquid Limit (%)	Plasticity Index (%)
BH1 / 0.8 m	33	18

The results suggest the natural clays below the surface are of low to moderate potential for movement as a result of moisture variations.

A bulk sample of natural residual material (CBR1) was collected and delivered to a NATA accredited laboratory for California Bearing Ratio (CBR) tests to evaluate subgrade design parameter. The test was carried out on samples compacted to a density ratio of 100% of the Standard maximum dry density and soaked for four days. A summary of the results is presented in Table 2 below.

Table 2: Summary of California Bearing Ratio (CBR) Test Result

Sample No.	Depth (m)	Material	Maximum Dry Density (tonne/m^3)	Optimum Moisture Content (%)	CBR
CBR1	0.5 – 1.0	Silty Sands/Clayey Sands	1.98	8.6	11

The test reports are provided in Appendix C.

7. Soil Classification

Due to presence of existing dam and trees and a potential for abnormal moisture conditions, the site will be classified 'Class P' in accordance with AS2870 – 2011 *'Residential Slabs & Footings*'. Based on the subsurface material encountered and laboratory test result, a ground surface movement equivalent to 'Class M – Moderately Reactive' may be considered for the site in accordance with AS2870 – 2011 *'Residential Slabs & Footings'*, provided the footings are extended into the natural soils or controlled fill material placed in a controlled manner.

8. Site Preparation

Based on the site observations, the site preparation works would likely involve some cutting and filling to approximate depth of 1 m for levelling the slab areas.

All future site preparation work should generally be carried out in accordance with AS3798-2007 '*Guidelines on Earthworks for Commercial and Residential Developments*'. Fill material shall be placed under the Level 1 testing and supervision requirements as outlined in AS3798. The fill layers shall be proof rolled and tested by the geotechnical testing authority to confirm the above compaction criteria are met. The fill layers need to compacted to a minimum dry density ratio of 98% standard compaction (or minimum density index of 75% for cohesionless soils as suggested in Table 5.1 of AS3798).

It is understood that the existing farm dam at the northern portion of the site shall be backfilled to the design level for the proposed Eileen O'Connor Catholic School. The backfilling shall be undertaken upon pumping out any ponded water.

After discharging the ponded water, all vegetation, any near surface silt and saturated soils shall be stripped to expose the underlying dense sands or stiff sandy clays. The depth of the dam is unknown at this time. The exposed surface shall be proof rolled in the presence of a geotechnical engineer prior to placing any fill material. A bridging layer may be required if any isolated soft spots are identified or over excavation of the dams is not feasible due to water seepage. The bridging layer consist of a minimum 500 mm layer of coarse ballast type gravels wrapped in geofabrics.

It is necessary to box into the existing dry surface at the edge of each fill layer to allow for keying the fill material into the natural soils or previously placed fill layers.

Backfill material shall be placed under level 1 supervision as outlined in AS3798. Site won material may be used for backfilling the dam area. However, any organic materials/topsoils or saturated material from the dam shall be spread and dried out. These materials may be used for landscaping purposes after moisture conditioning.

9. Safe Batters and Retaining Walls

Unsupported excavations shall be battered safely to maintain the stability of the site during the construction and enable a safe entry for workers. Temporary batter slope of 2(H): 1(V) may be adopted for cut batters in near surface loose to medium dense sands in dry conditions.

Where required, retaining walls may be designed based on the following estimated design parameters:

Table 2: Retaining Wall Design Parameters

Material	Bulk Unit Weight (kN/m^3)	Earth Pressure Coefficient			Elasticity Modulus (MPa)
		At rest (K_0)	Active (Ka)	Passive (Kp)	
Clayey Sands/Sandy clays	20	0.55	0.35	2.5	8
Extremely to highly weathered Rock	22	0.1			50

The above parameters are estimated values and have been adopted from the available literatures.

The values are for horizontal ground surface behind the retaining walls. Granular material shall be placed directly behind the retaining walls. Efficient drainage shall be provided by placing perforated drainage pipes along the bottom of the wall. The effect of water pressure needs to be considered in the design of retaining walls where there is a potential for the saturation of backfill material and residual soil.

In order to minimize the effects of erosion and long term stability of the site, surface soil will need to be protected, by directing surface runoff away from the construction areas and behind the retaining walls. The developed site should be maintained in accordance with the 'Foundation Maintenance and Footing Performance: A Homeowner's Guide', a copy of which is provided in Appendix C. The guide suggests site maintenance practices to assist in minimising the foundation movements and keeping the cracking within acceptable limits.

10. Footings

The near surface topsoils, loose sands or uncontrolled filling material are not suitable to support the footings of proposed structures. High level pad/strip footings or shallow piers founded on the natural clayey sands of medium density or stiff clayey soils may be designed based on an allowable bearing capacity of 100 kPa. All footings and piers shall be extended to the similar material to avoid any differential settlement between the foundation material. Higher bearing capacities should be applicable to the dense natural sands or weathered rock. An allowable bearing capacity of 250 kPa may be adopted for bored piers extended into the underlying dense natural clayey sands below approximate depths of 1.5 m in the boreholes.

Seepage was encountered at approximate depth of 2.8 m in BH2 and may be encountered during the drilling of piles through the granular soils at the northern portion of the site. Due to presence of loose granular soils and potential for seepage in parts of the site, cast in-site bored piles may not be suitable option and consideration should be given to alternative piling techniques such as steel screw piles or continuous flight auger (CFA) piles.

If steel screw piles are adopted, the piles shall be constructed by contractors with experience in the same geological conditions. A copy of this report and borehole logs may be provided to the contractor to assist them in the planning and design of the piles. The design and constructions of screw piles shall be undertaken by the contractor using the design working loads for the piles.

Settlements up to 20 mm may be expected for the footings founded in the loose to medium dense sands.

All piers and footings will need to be inspected by a qualified geotechnical engineer during construction to confirm the foundation material are suitable for the estimated design parameters.

11. Subgrade Conditions

The laboratory testing on the near surface subgrade material returned a CBR value of 11 %. It is assumed that minor filling will be required for levelling the pavement areas on the western portion of the site. The fill material will need to be placed in a controlled manner in accordance with the testing requirements of AS3798 – 2007 '*Guidelines on Earthworks for Commercial and Residential Developments*'. A design CBR value of 3.0 % may then be used for pavement design purposes, subject to proof roll testing and inspection of exposed subgrade by a geotechnical engineer.

The subgrade materials should be compacted to a minimum density ratio of 100% of the Standard maximum dry density. Base and subbase course materials should be compacted and tested to a minimum density ratio of 98% of the Modified maximum dry density.

12. General Notes

Our professional services were performed, our findings obtained, and our recommendations prepared in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties, either expressed or implied.

The geotechnical report was prepared for the use of the owner in the design of the subject project and should be made available to potential contractors for information on factual data only. This report should not be used for contractual purposes as a warranty of interpreted subsurface conditions such as those indicated by the interpretive borehole logs, cross-sections, or discussion of subsurface conditions contained herein.

The analyses, conclusions and recommendations contained in the report are based on site conditions as they presently exist and assume that the boreholes are representative of the subsurface conditions of the site. If, during construction, subsurface conditions are found which are significantly different from those observed in the boreholes, or assumed to exist in the excavations, Nepean Geotechnics should be advised immediately to review these conditions and review recommendations where necessary. If there is a substantial lapse of time between the submission of this report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, this report should be reviewed to determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse.

The borehole logs are our opinion of the subsurface conditions revealed by periodic sampling of the ground as the field work progressed. The soil descriptions and interfaces between strata are interpretive and actual changes may be gradual.

The logs and related information depict subsurface conditions only at these specific locations and at the particular time designated on the logs. Soil conditions at other locations may differ from conditions occurring at these borehole locations. Also, the passage of time may result in a change in the soil conditions at these borehole locations.

Groundwater levels often vary seasonally. Groundwater levels reported on the borehole logs or in the body of the report are factual data only for the dates shown.

Unanticipated soil conditions are commonly encountered on construction sites and cannot be fully anticipated by merely taking soil samples or boreholes. Such unexpected conditions frequently require that additional expenditures be made to attain a properly constructed project.

Nepean Geotechnics cannot be responsible for any deviation from the intent of this report including, but not restricted to, any changes to the scheduled time of construction, the nature of the project or the specific construction methods or means indicated in this report; nor can our firm be responsible for any construction activity on sites other than the specific site referred to in this report.

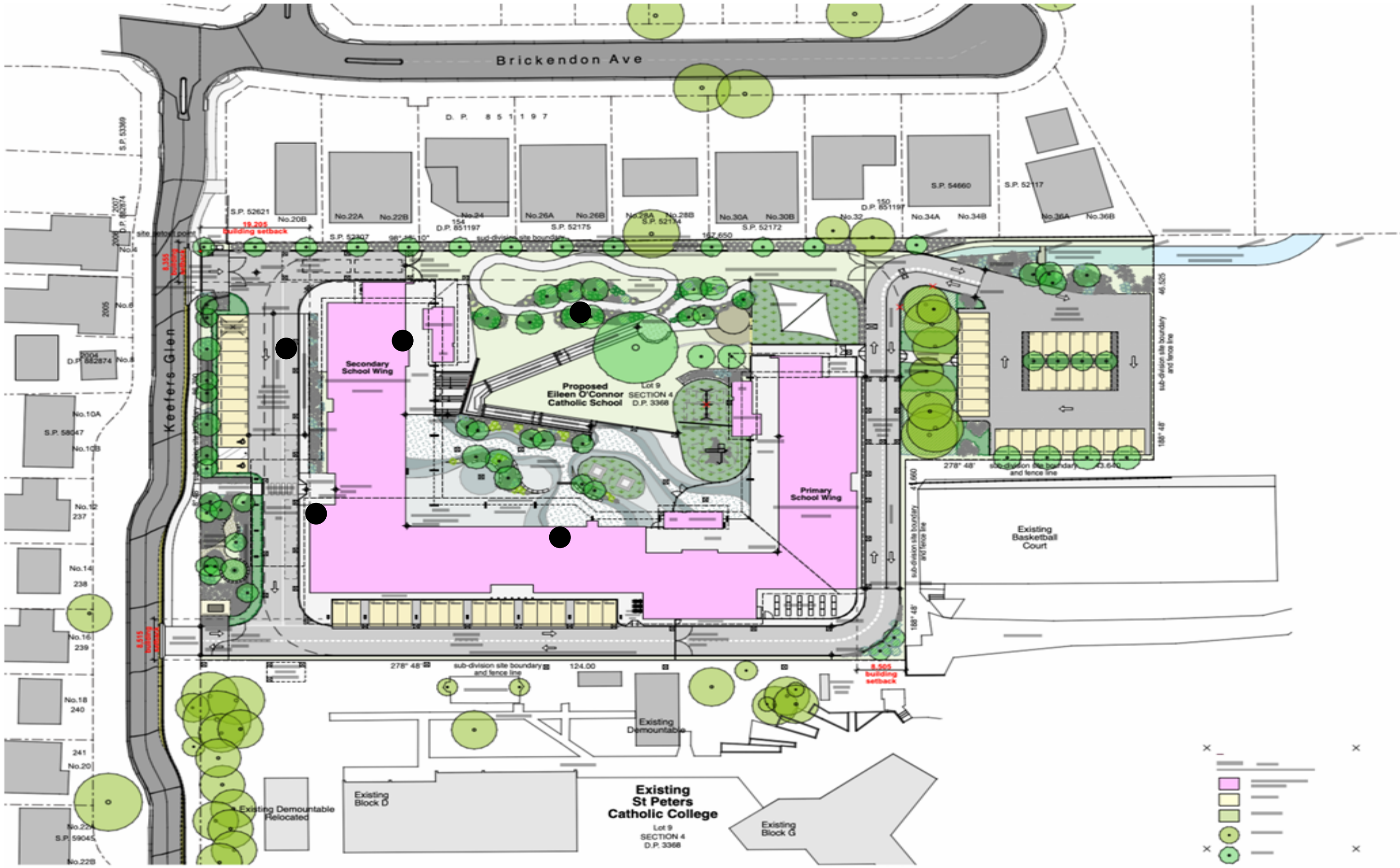
We trust the above is sufficient for your requirements. Please do not hesitate to contact the undersigned should you require further information or need to discuss any aspect of this report.

Yours sincerely,

Rasoul Machiani (MIEAust/CPEng/NER)
Senior Geotechnical Engineer
For and on behalf of Nepean Geotechnics

Appendix A

Approximate Borehole Locations



Approximate Borehole Locations ●

Proposed New K-12 School	**Project No:**	**R23169**
Eileen O'Connor School	**Date:**	**22 August 2023**
84 Gavenlock Road, Mardi NSW		

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Appendix B

Soil & Rock Descriptions Sheets

Borehole Logs (BH1 – BH4 and CBR1)

Photographs of Subsurface Material

Nepean Geotechnics

Soil & Rock Descriptions

The methods of descriptions and classifications used by Nepean Geotechnics in this report are in general accordance with Australian Standard AS1726 -1993 as detailed in the following tables:

Soil Classification

Grading

Term		Particle Size(mm)
Coarse Grained Soils (more than 50% of material is larger than 0.075mm)	Boulders	>200
	Cobbles	63 – 200
	Gravels	2.36 – 63
	Sand	0.075 – 2.36
Fine Grained Soils (more than 50% of material is smaller than 0.075mm)	Silt	0.002 – 0.075
	Clay	<0.002

Consistency (Cohesive Soils)

Term	Undrained Shear Strength (kPa)	Field Guide to Consistency
Very soft	≤ 12	Exudes between the fingers when squeezed in hand
Soft	>12 ≤25	Can be moulded by light finger pressure
Firm	>25 ≤50	Can be moulded by strong finger pressure
Stiff	>50 ≤100	Can not be moulded by fingers/can be indented by thumb
Very stiff	>100 ≤200	Can be indented by thumb nail
Hard	>200	Can be indented with difficulty by thumb nail

Consistency (Non-Cohesive Soils)

Term	Density Index (%)
Very loose	≤ 15
Loose	>15 ≤35
Medium dense	>35 ≤65
Dense	>65 ≤85
Very dense	>85

Rock Classification

Strength of Rock Material

Term	Letter Symbol	Point Load Index, Is_{50} (MPa)	Filed Guide to Strength
Extremely low	EL	≤0.03	Easily remoulded by hand to a material with soil properties
Very low	VL	>0.03 ≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; pieces up to 3 cm thick can be broken by finger pressure
Low	L	>0.1 ≤0.3	Easily scored with a knife; indentations 1 – 3 mm show in the specimen with firm blows of the pick point; a piece of core 150 mm long may be broken by hand
Medium	M	>0. 3 ≤1.0	Readily scored with a knife; a piece of core 150 mm long can be broken by hand with difficulty
High	H	>1 ≤3	A piece of core 150 mm long cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer
Very high	VH	>3 ≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer

Rock Material Weathering Classification

Term	Letter Symbol	Filed Guide to Strength
Residual soil	RS	Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported
Extremely weathered	XW	Rock is weathered to such an extent that has 'soil' properties (i.e. either disintegrated or can be remoulded in water)
Highly weathered	HW	Rock strength usually changed by weathering. The rock may be highly discoloured, usually be ironstaining. Porosity may be increased by leaching, or may be decreased due to deposition of weathering in pores
Slightly weathered	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock
Fresh rock	FR	Rock shows no sign of decomposition or staining

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Borehole Log

Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH1
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	1 of 2

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger			2 2				SM	Silty SAND dark grey, moist, loose, with rootlets	M	L		Topsoil
			3 3 4				SP	Silty SANDS/SANDS grey/dark grey, dry to moist, loose to medium dense	D/M	L/MD		Natural
			4 7			0.5	SM	Silty SANDS light brown, dry to moist, medium dense	D/M	MD		Natural
			Refusal				SC	Gravelly Silty SAND brown/light brown mottled, dry to moist dense, with coarse gravels/trace XW rock	D/M	D		Natural
						1.0 1.5	SC	Clayey SANDS brown/light brown, moist to wet, medium dense to dense, with trace gravels	M/W	MD/D		Natural
						2.0 2.5 3.0	SC	Clayey SANDS/Sandy CLAYS light grey/brown mottled, moist to wet, dense/stiff, with trace fine to coarse gravels	M/W	D/St		Natural
						3.5 4.0	SC	Clayey SANDS light grey/brown mottled, moist, dense with seams of sandy clays/trace fine gravels	M/W	D		Natural

Rig: Utility mounted Christie Engineering drill rig

Water Observations: N/A

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Borehole Log

Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH1
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	2 of 2

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger						5.0 5.5	SC	Clayey SANDS light grey/brown mottled, moist, dense with seams of sandy clays/trace fine gravels	M/W	D		Natural
						6.0 6.5	CI	Gravelly Sandy CLAY light grey, moist, stiff to very stiff, with seams of extremely weathered rock	M	V-St		Residual
						7.0 7.5 8.0 8.5		End of Borehole				

Rig: Utility mounted Christie Engineering drill rig

Water Observations: N/A


Samples of Subsurface Material - BH1

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Borehole Log

Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH2
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	1 of 2

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger			1 2				SM	Silty SAND dark grey, moist/wet, loose, with rootlets	M/W	L		Topsoil
			2 2 3 3 4 4			0.5	SP	Silty SANDS/SANDS grey/light grey, dry to moist, loose to medium dense to dense	D/M	L/MD		Natural
			5 6 8 10			1.0	SC	Clayey SANDS light grey, dry to moist, medium dense to dense	M	MD/D		Natural
			Refusal			1.5 2.0	SC	Clayey SANDS/Sandy CLAYS light grey/brown mottled, moist, dense with trace fine gravels	M	D		Natural
	▼					2.5 3.0	SC	Gravelly Clayey SANDS light grey/brown mottled, moist to wet, dense, with seams of coarse gravels	M	D		Natural
						3.5 4.0	SC	Clayey SANDS light grey/brown mottled, moist, dense with seams of sandy clays/trace fine gravels	M/W	D		Natural

Rig: Utility mounted Christie Engineering drill rig

Water Observations: seeapge below 2.8 m

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Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH2
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	2 of 2

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger						5.0 5.5	SC	Clayey SANDS light grey/brown mottled, moist, dense with seams of sandy clays/trace fine gravels	M/W	D		Natural
						6.0 6.5 7.0 7.5 8.0 8.5		End of Borehole				

Rig: Utility mounted Christie Engineering drill rig

Water Observations: seeapge below 2.8 m

Samples of Subsurface Material – BH2

Subsurface Material and seepage conditions– BH2

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Borehole Log

Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH3
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	1 of 2

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger			2 2				SM	Silty SAND dark grey, moist, loose, with rootlets	M	L		Topsoil
			3 3 5			0.5	SP	Silty SANDS/SANDS grey/dark grey, dry to moist, loose to medium dense	D/M	L/MD		Natural
			7 7				SM	Silty SANDS light brown, dry to moist, medium dense	D/M	MD		Natural
			15 Refusal			1.0	SC	Clayey SANDS light grey/grey/brown, dry to moist, medium dense to dense	M	MD/D		Natural
						1.5	CI	Sandy CLAYS light grey/light brown mottled, dry to moist, stiff to very stiff	D/M	Stiff		Natural
						2.0 2.5 3.0	SC	Gravelly Sandy CLAYS light grey/light brown mottled, dry to moist, stiff to very stiff, with trace fine gravels/extremely weathered rock	D/M	V-St		Natural
						3.5 4.0	SC	Clayey SANDS light grey/brown mottled, moist, dense with seams of sandy clays/trace fine gravels	M/W	D		Natural

Rig: Utility mounted Christie Engineering drill rig

Water Observations: N/A

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Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH3
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	2 of 2

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger							SC	Clayey SANDS light grey/brown mottled, moist, dense with seams of sandy clays/trace fine gravels	M/W	D		Natural
						5.0						
						5.5						
						6.0		End of Borehole				
						6.5						
						7.0						
						7.5						
						8.0						
						8.5						

Rig: Utility mounted Christie Engineering drill rig

Water Observations: N/A


Samples of Subsurface Material – BH3

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Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	BH4
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	1 of 1

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger			2, 2				SM	Silty SAND dark grey, moist, loose, with rootlets	M	L		Topsoil
			3, 3, 4, 4, 4			0.5	SP	Silty SANDS/SANDS grey/dark grey, dry to moist, loose to medium dense	D/M	L/MD		Natural
			7, 7, 10, 10, 10			1.0	SC	Clayey SANDS light grey/grey, dry to moist, medium dense to dense	M	MD/D		Natural
			11, Refusal			1.5	SC	Gravelly Silty SAND grey/light brown mottled, dry to moist dense, with coarse gravels/trace XW rock	D/M	D		Natural
						2.0	SC	Clayey SANDS light grey/brown mottled, dry to moist, dense, with trace fine gravels	M	D		Natural
						2.5	SC	Clayey SANDS light grey/brown mottled, moist to wet, dense, with trace fine gravels	M/W	D		Natural
						3.0		End of Borehole				
						3.5						
						4.0						

Rig: Utility mounted Christie Engineering drill rig

Water Observations: seepage below 2.2 m

Samples of Subsurface Material – BH4

Nepean Geotechnics Pty Ltd
ABN 45 626 934 389
15 Henry Place, Narellan Vale NSW 2567
Email: info@nepeangeotechnics.com.au
Phone: 0447 280 042

Borehole Log

Client:	Stanton Dahl Architects	**Surface Level:**	N/A	**Job No. :**	R23169
Project:	Proposed New K-12 School	**South:**	Refer to site	**Borehole:**	CBR1
Location:	Eileen O'Connor School	**Easting:**	plan	**Date:**	22-August-2023
	84 Gavenlock Road, Mardi	**Logged/Checked by:**	RM	**Sheet:**	1 of 1

Method	Groundwater	Sample	Dynamic Cone Penetrometer	SPT	RL	Depth (m)	Classification Symbol	Material Description	Moisture Content	Consistency/Relative Density	Pocket Penetrometer (kPa)	Origin
Solid Flight Auger							SM	Silty SAND dark grey, moist, loose, with rootlets	M	L		Topsoil
						0.5	SP	Silty SANDS/SANDS grey/dark grey, dry to moist, loose to medium dense	D/M	L/MD		Natural
		B				1.0	SC	Clayey SANDS light grey/grey, dry to moist, medium dense to dense	M	MD/D		Natural
						1.5	SC	Gravelly Silty SAND grey/light brown mottled, dry to moist dense, with coarse gravels	D/M	D		Natural
						2.0		End of Borehole				
						2.5						
						3.0						
						3.5						
						4.0						

Rig: Utility mounted Christie Engineering drill rig

Water Observations: N/A

Appendix C

Laboratory Test Reports

Geo-Logic Solutions
Geotechnical & Environmental Testing

Unit 3 /112 Fairfield Street, Fairfield East NSW 2165
www.geo-logic.com.au
ABN: 57 621 548 294
PH: 0402 597 452
Email samer@geo-logic.com.au

ATTERBERG LIMITS & LINEAR SHRINKAGE REPORT- AS & RMS

Client:	**Nepean Geotechnics P/L**	Project Number:	**L1080/ 23169**
Project:	**Material Testing**	Report Date:	**30/08/2023**
Location:	**84 Gavenlock Road, Mardi NSW**	Page:	**1 of 1**

TEST METHOD	Liquid Limit	Plastic Limit	Plasticity Index	Linear Shrinkage
	AS1289 3.1.1 ☐	AS1289 3.2.1 ☑	AS1289 3.3.1 ☑	AS1289 3.4.1 ☐
	AS1289 3.1.2 ☑	RMS- T109 ☐	RMS- T109 ☐	RMS- T113 ☐
	RMS- T108 ☐	Sample Procedure:	Sampled by Client	
Sample No/ID:	**R23169**			
Sample Location & Depth:	BH1/0.8m - 1.0m			
Sample Date:	22/08/2023			
Sample Description:	Sandy Clay - Brown/ Grey			
Sample History: (eg. Oven dried, air dried	Oven Dried			
Laboratory Test Date	24/08/2023			

Atterberg Limits Test Results

Liquid Limit %	33			
Plastic Limit %	15			
Plasticity Index %	18			

Linear Shrinkage Test Results

Linear Shrinkage %				
Linear Shrinkage Mould Length (mm)				
Cracking: Y/N				
Crumbling: Y/N				
Curling: Y/N				
Preperation Method				

NOTES:
Moisture Content:
BH1=14.4%, (Test Method AS1289.2.2.1- Oven Dried)

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing
ACCREDITATION NO. 20097

Approved Siginatory:
Samer Ghanem

Date: 30/08/2023

Sign:

Geo-Logic Solutions
Geotechnical & Environmental Testing

Unit 3 /112 Fairfield Street, Fairfield East NSW 2165
www.geo-logic.com.au
ABN: 57 621 548 294
PH: 0402 597 452
Email: samer@geo-logic.com.au

CALIFORNIA BEARING RATIO

Client:	**Nepean Geotechnics P/L**	Project Number:	**L1080/ 23169**
Project:	**Material Testing**	Report Date:	**30/08/2023**
Location:	**84 Gavenlock Road, Mardi NSW**	Page:	1 of 1

TEST METHODS USED

Moisture/ Density Ratio	Moisture Content	Laboratory Compaction	Sampling & Preperation	CBR Test Method
AS1289 5.4.1 ☑	AS1289 2.1.1 ☑	AS1289.5.1.1 (STD) ☑	AS1289 1.2.1 ☑	AS1289 6.1.1 ☑
RMS T117 ☐	RMS- T120 ☐	AS1289.5.2.1 (MOD) ☐	RMS- T105 ☐	RMS- T117 ☐
		RMS- T111 (STD) ☐	Sampled By Client ☑	
		RMS- T112 (MOD) ☐	Not covered under scope	

SAMPLE/ TEST INFORMATION

Sample No/ID & Date Sampled:	**CBR1**	**22/08/2023**		
Sample Location:	Sampled by Client			
Elevation/ RL:	0.5m			
Sample Soak Period: (days)	4			
Sample Description:	Sandy Clay - Brown/ Grey			

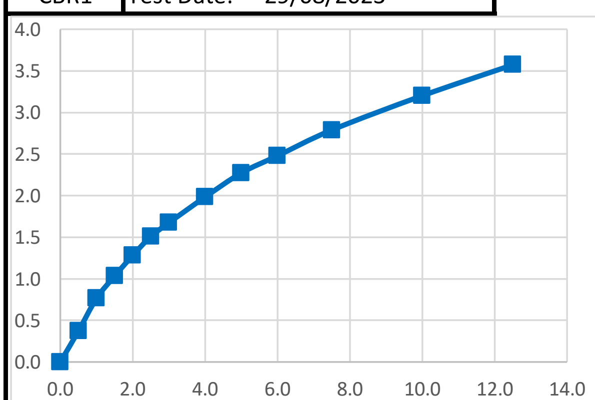
LABORATORY COMPACTION & OVERSIZE MATERIAL RESULTS

Laboratory Density Ratio: (%)	100.0			
Laboratory Moisture Ratio : (%)	100.0			
Maximum Dry Density: (t/m3)	1.98			
Optimum Moisture Content: (%)	8.6			
***Material retained on AS 19mm sieve: (%)**	Wet Basis	0.0		

MOISTURE CONTENT/ SHRINK/ SWELL

Moisture Content After Soak: (%)	Top 30mm	11.5		
	Remainder	9.7		
Moisture Content Before Soak (%)	8.6			
Swell after Soak: (%)	0.6			
CALIFORNIA BEARING RATIO VALUE: (%)	5mm	Penetration	**11.0**	

CBR1	Test Date: 29/08/2023



NOTES:
*=Not Included in Tesing Process

NATA
WORLD RECOGNISED ACCREDITATION

Accredited for compliance with ISO/IEC 17025 - Testing

Accreditation No. 20097

Approved Signatory:	*Samer Ghanem*
Date:	*30/08/2023*
Sign:	

Appendix D

Foundation Maintenance and Footing Performance (CSIRO)

Foundation Maintenance and Footing Performance: A Homeowner's Guide

BTF 18 replaces Information Sheet 10/91

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

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

Soil Types

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

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

Causes of Movement

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

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

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

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

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

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

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

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

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

GENERAL DEFINITIONS OF SITE CLASSES

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

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

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

Unevenness of Movement

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

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

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

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

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

Effects of Uneven Soil Movement on Structures

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

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

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

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

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

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

Trees can cause shrinkage and damage

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

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

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

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

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

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

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

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

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

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

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

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

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

Water Service and Drainage

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

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

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

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

Prevention/Cure

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

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

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

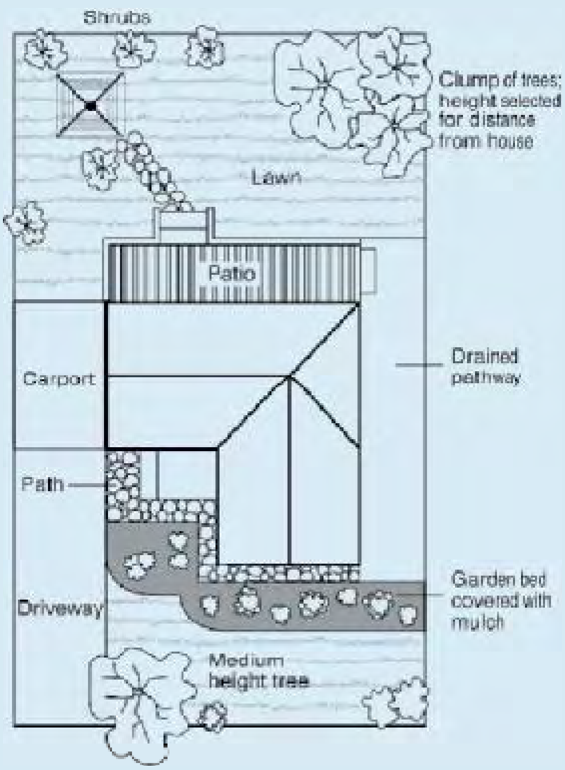
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

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

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

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

Gardens for a reactive site



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

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

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

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

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

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

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

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

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

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

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

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

Remediation

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

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

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

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