GEOTECHNICAL INVESTIGATION

FOR

CHARLESTON HOMES PTY LIMITED

10 Courtley Road, Beacon Hill, New South Wales

Report No: 18/2839

Project No: 22184/0072D

September 2018

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DRAWING NO. 18/2839 – BOREHOLE AND PENETROMETER LOCATIONS

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1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out by STS GeoEnvironmental Pty Limited (STS) for a proposed new residential development to be constructed at 10 Courtley Road, Beacon Hill. We have been informed the development comprises demolition of the existing structures on the site prior to construction of a double storey residential dwelling. Due to the slope of the site construction of a new dwelling will require excavating up to 1.5 metres below existing ground surface levels. Further, we understand that the site is located within "Landslip Area B" as defined by Northern Beaches Council mapping. Sites within Area B require a Preliminary Landslip Assessment to be undertaken in accordance with Councils guidelines.

The purpose of the investigation was to:

- assess the subsurface conditions over the site,
- provide a Site Classification in accordance with AS2870,
- provide recommendations regarding the appropriate foundation system for the site including design parameters,
- provide parameters for the temporary and permanent support of the excavation,
- provide recommendations regarding vibration control during rock excavation, and
- provide a Preliminary Landslip Assessment.

The investigation was undertaken at the request of Charleston Homes Pty Limited.

Our scope of work did not include a contamination assessment.

2. FIEDLWORK DETAILS

The fieldwork consisted of a detailed site walkover together with the drilling of two (2) boreholes numbered BH1 and BH2, at the locations shown on Drawing No. 18/2839. Restricted site access dictated the borehole locations. The boreholes were drilled using a restricted access track mounted Christie drilling rig owned and operated by STS. Soils and weathered rock were drilled using rotary solid flight augers. Soil strengths were determined by undertaking Dynamic Cone Penetrometer (DCP) tests at each borehole location.

Fieldwork operations were undertaken by one of STS's senior geologists who also logged the subsurface conditions encountered.

The subsurface conditions observed are recorded on the borehole logs given in Appendix A. An explanation of the terms used on the logs is also given in Appendix A. Notes relating to geotechnical reports are also attached.

3. GEOLOGY AND SITE CONDITIONS

The Sydney geological series sheet at a scale of 1:100,000 indicates that the site is underlain by Triassic Age bedrock belonging to a subgroup of the Hawkesbury Sandstone formation. Bedrock within this subgroup comprises claystone, siltstone and laminite. The subgroup is underlain by Triassic Age Hawkesbury Sandstone. Bedrock within the Hawkesbury Sandstone formation comprises fine to medium grained quartz sandstone.

The site has an area of approximately 557m^2. At the time of the fieldwork, the site was occupied by a double level brick residential dwelling with tile roof, car port and concrete driveway. Site vegetation comprised grass, trees and shrubs. The surrounding buildings are residential in nature and comprise a mixture of single and double level brick residential dwellings.

The ground surface falls approximately 3 metres to the east.

4. SUBSURFACE CONDITIONS

When assessing the subsurface conditions across a site from a limited number of boreholes, there is the possibility that variations may occur between test locations. The data derived from the site investigation programme are extrapolated across the site to form a geological model and an engineering opinion is rendered about overall subsurface conditions and their likely behaviour regarding the proposed development. The actual condition at the site may differ from those inferred, since no subsurface exploration programme, no matter how comprehensive, can reveal all subsurface details and anomalies.

The subsurface conditions generally consist of fill overlying sandy clays and weathered sandstone. Fill materials were encountered across the site in both boreholes to depths of 0.2 to 0.3 metres. Natural sandy clays were encountered below the fill to depths of 0.5 to 1.6 metres. The consistency of the clays varies from firm to stiff to very stiff. Weathered sandstone underlies the site to the depth of auger refusal, 0.55 to 1.7 metres.

Groundwater seepage was observed during auger drilling of BH2 at the soil interface at a depth of 1.5 metres in BH2.

5. DISCUSSION

5.1. Site Classification to AS2870

The classification has been prepared in accordance with the guidelines set out in the "Residential Slabs and Footings" Code, AS2870 – 2011.

Because there are trees and buildings present, abnormal moisture conditions (AMC) prevail at the site (Refer to Section 1.3.3 of AS2870).

Because of the AMC present, the site is classified a *problem site (P).* Provided the recommendations given below are adopted and the footings bear in the underlying natural soils, the site may be reclassified *moderately reactive (M).*

5.2. Excavation Conditions and Support

Based on subsurface conditions observed in boreholes, the proposed bull excavation is expected to encounter fill, sandy clays, clayey sands and weathered sandstone. Excavators without assistance should be able to remove the soils and some of the weathered sandstone.

Excavators alone without assistance will not be able to remove any significant amount rock below the depth of auger refusal as shown on the borehole logs. Hydraulic breakers mounted on an excavator or jack hammers will be required to break up the majority of the rock below these depths before it can be removed using an excavator.

Particular care will be required to ensure that buildings or other developments on adjacent properties are not damaged when excavating the rock. The structures on the adjacent properties may be founded directly on the rock. Buildings founded directly on rock can often be very susceptible to damage from ground borne vibrations.

Excavations methods should be adopted which limit ground vibrations at the adjoining developments to not more than 10 mm/sec. Vibration monitoring will be required to verify that this is achieved. However, if the contractor adopts methods and/or equipment in accordance with the recommendations in Table 5.1 for a ground vibration limit of 5 mm/sec, vibration monitoring may not be required.

The limits of 5 mm/sec and 10 mm/sec are expected to be achievable if rock breaker equipment or other excavation methods are restricted as indicated in Table 5.1.

At all times, the excavation equipment must be operated by experienced personnel, according to the manufacturer's instructions and in a manner consistent with minimising vibration effects.

Use of other techniques (e.g. grinding, rock sawing), although less productive, would reduce or possibly eliminate risks of damage to property through vibration effects transmitted via the ground. Such techniques may be considered if an alternative to rock breaking is required.

Table 5.1 – Recommendations for Rock Breaking Equipment

Distance from adjoining structure (m)	Maximum Peak Particle Velocity 5 mm/sec		Maximum Peak Particle Velocity 10 mm/sec	
	Equipment	Operating Limit (% of Maximum Capacity)	Equipment	Operating Limit (% of Maximum Capacity)
1.5 to 2.5	Hand operated jackhammer only	100	300 kg rock hammer	50
2.5 to 5.0	300 kg rock hammer	50	300 kg rock hammer or 600 kg rock hammer	100 50
5.0 to 10.0	300 kg rock hammer or 600 kg rock hammer	100 50	600 kg rock hammer or 900 kg rock hammer	100 50

*Vibration monitoring is recommended for 10 mm/sec vibration limit.

It should be noted that vibrations that are below threshold levels for building damage may be experienced at adjoining developments.

It would be appropriate before commencing excavation to undertake a dilapidation survey of any adjacent structures that may potentially be damaged. This will provide a reasonable basis for assessing any future claims of damage.

It is of course important that the onsite excavations are adequately supported at all times and do not endanger the adjacent properties.

Temporary slopes in the soils and weathered rock may be constructed at a maximum angle of 1 to 1. Where this is not possible it will be necessary to provide temporary support. Support will probably need to be drilled and fixed into the rock below the base of the excavation.

When considering the design of the supports, it will be necessary to allow for the loading from structures in adjoining properties, any ground surface slope and the water table present. Where the structures in adjoining properties are within the zone of influence of the excavation, it will be necessary to adopt K_o conditions when designing the temporary support. Anchors or props can be used to provide the required support. If anchors extend into adjoining property, it will be necessary to obtain the permission of the property owners. Anchors should be installed into the weathered rock. When props or anchors are used for support, a rectangular earth pressure distribution should be adopted on the active side of the support. K_o should also be used to design the permanent support.

The following parameters are suggested for the design of the retaining wall system where there is a level ground surface:

Soil and Weathered Sandstone (To the depth of auger refusal on the borehole logs):

Active Earth Pressure Coefficient (K_a)	=	0.4
At Rest Pressure Coefficient (K_o)	=	0.55
Total (Bulk) Density	=	20 kN/m^3

Weathered Sandstone (Below the depth of auger refusal as shown on the borehole logs):

Earth Pressure Coefficient	=	0.1 or 10 kPa (whichever is lesser)
Passive Earth Pressure Coefficient (K_p)	=	4.5 (shale only)
Total (Bulk) Density	=	22 kN/m^3

Based on the observations during drilling, the basement excavation is not expected to encounter the groundwater table. However, some minor perched water seepage may flow into the excavation from the soil rock interface. The inflow rates are likely to be minor and therefore a sump and a pump should be sufficient to control the anticipated seepage.

5.3. Foundation Design

Footings that bear in firm to stiff natural clayey soils below any topsoil or fill may be proportioned using an allowable bearing pressure of 100 kPa. The minimum depth of founding must comply with the requirements of AS2870.

On Completion of bulk excavation, the materials exposed will likely comprise a mixture of weathered sandstone bedrock and natural clays/fill. Founding the structure on a combination of soils and bedrock may result in differential settlement occurring. We therefore recommend that the structures be uniformly founded within the underlying sandstone bedrock. An allowable bearing pressure of 800 kPa applies to footings founded in weathered shale. For piles an allowable adhesion of 80 kPa applies to the portion of the pile shaft within the weathered rock. These values may be increased to 1000 kPa and 100 kPa respectively when founding below the depth of auger refusal as shown on the borehole logs. It should be noted that piles will likely be required over parts of the site.

In order to ensure the bearing values given can be achieved, care should be taken to ensure that the base of excavations are free of all loose material prior to concreting. It is recommended that all footing excavations be protected with a layer of blinding concrete as soon as possible, preferably immediately after excavating, cleaning, inspection and approval. The possible presence of groundwater needs to be considered when drilling piles and pouring concrete.

5.4. Preliminary Landslip Assessment

The preliminary landslip carried out is based on Council's check list. The assessment follows:

- Does the site or adjacent properties have a history of slope instability – No.
- Are excavations or fills greater than 2 metres proposed – No.
- Is the site developed – Yes.
- Is fill greater than 1 metre present – No
- Are cuts/excavations greater than 2m high present – No.

Based on our observations and Council's check list a detailed landslip assessment will not be required.

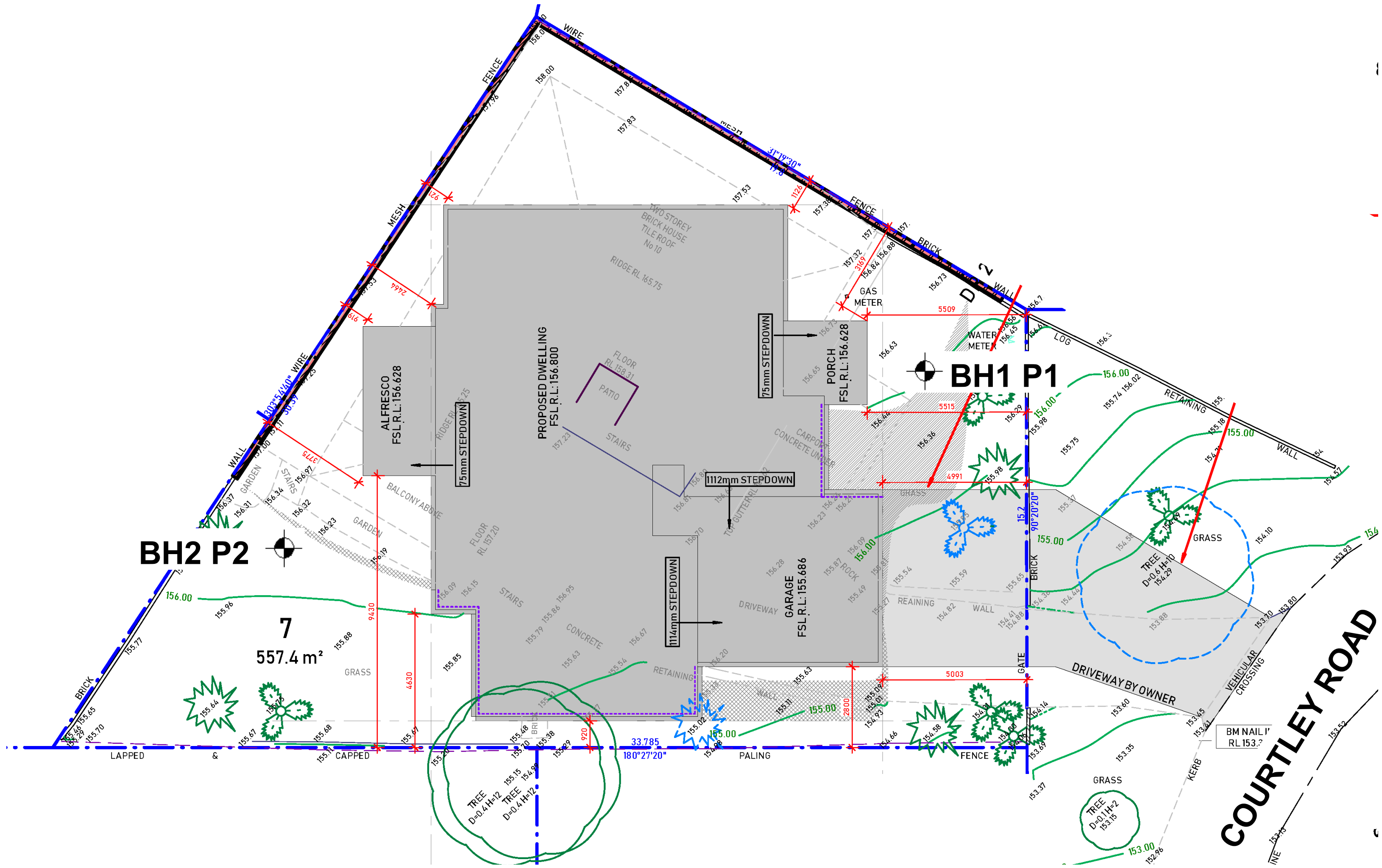
6. FINAL COMMENTS

During construction, should the subsurface conditions vary from those inferred above, we would be contacted to determine if any changes should be made to our recommendations.

The exposed bearing surfaces for footings should be inspected by a geotechnical engineer to ensure the allowable pressure given has been achieved.

Matt Green
Senior Engineering Geologist

Laurie Ihnativ,
Principal Geotechnical Engineer



STS GEOENVIRONMENTAL Pty. Ltd.	Scale: Unknown	Date: September 2018
Client: CHARLESTON HOMES		
GEOTECHNICAL INVESTIGATION 10 COURTLEY ROAD, BEACON HILL BOREHOLE AND PENETROMETER LOCATIONS		Project No. 22184/0072D Drawing No: 18/2839

NOTES RELATING TO GEOTECHNICAL REPORTS

Introduction

These notes have been provided to outline the methodology and limitations inherent in geotechnical reporting. The issues discussed are not relevant to all reports and further advice should be sought if there are any queries regarding any advice or report.

When copies of reports are made, they should be reproduced in full.

Geotechnical Reports

Geotechnical reports are prepared by qualified personnel on the information supplied or obtained and are based on current engineering standards of interpretation and analysis.

Information may be gained from limited subsurface testing, surface observations, previous work and is supplemented by knowledge of the local geology and experience of the range of properties that may be exhibited by the materials present. For this reason, geotechnical reports should be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Where the report has been prepared for a specific purpose (eg. design of a three-storey building), the information and interpretation may not be appropriate if the design is changed (eg. a twenty storey building). In such cases, the report and the sufficiency of the existing work should be reviewed by SMEC Testing Services Pty Limited in the light of the new proposal.

Every care is taken with the report content, however, it is not always possible to anticipate or assume responsibility for the following conditions:

- Unexpected variations in ground conditions. The potential for this depends on the amount of investigative work undertaken.
- Changes in policy or interpretation by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, SMEC Testing Services Pty Limited would be pleased to resolve the matter through further investigation, analysis or advice.

Unforeseen Conditions

Should conditions encountered on site differ markedly from those anticipated from the information contained in the report, SMEC Testing Services Pty Limited should be notified immediately. Early identification of site anomalies generally results in any problems being more readily resolved and allows re-interpretation and assessment of the implications for future work.

Subsurface Information

Logs of a borehole, recovered core, test pit, excavated face or cone penetration test are an engineering and/or geological interpretation of the subsurface conditions. The reliability of the logged information depends on the drilling/testing method, sampling and/or observation spacings and the ground conditions. It is not always possible or economic to obtain continuous high quality data. It should also be recognised that the volume or material observed or tested is only a fraction of the total subsurface profile.

Interpretation of subsurface information and application to design and construction must take into consideration the spacing of the test locations, the frequency of observations and testing, and the possibility that geological boundaries may vary between observation points.

Groundwater observations and measurements outside of specially designed and constructed piezometers should be treated with care for the following reasons:

- In low permeability soils groundwater may not seep into an excavation or bore in the short time it is left open.
- A localised perched water table may not represent the true water table.
- Groundwater levels vary according to rainfall events or season.
- Some drilling and testing procedures mask or prevent groundwater inflow.

The installation of piezometers and long term monitoring of groundwater levels may be required to adequately identify groundwater conditions.

Supply of Geotechnical Information or Tendering Purposes

It is recommended tenderers are provided with as much geological and geotechnical information that is available and that where there are uncertainties regarding the ground conditions, prospective tenders should be provided with comments discussing the range of likely conditions in addition to the investigation data.

APPENDIX A – BOREHOLE LOGS AND EXPLANATION SHEETS

STS GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Charleston Homes Project: 10 Courtley Road, Beacon Hill Location: Refer to Drawing No. 18/2839	Project: 22184/0072D Date : September 11, 2018 Logged: JK Checked By: LWI	**BOREHOLE NO.: BH 1** Sheet 1 of 1

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY SANDY CLAY: dark brown with light grey, fine grained, medium plasticity, trace of gravel/cobble FILL	CL	FIRM TO STIFF	M
			SANDY CLAY: orange brown with light brown, fine grained, medium plasticity, trace of gravel	CL	FIRM TO STIFF STIFF	M
		0.5	WEATHERED SANDSTONE: red brown, fine to medium grained		EXTREMELY LOW STRENGTH	D
			AUGER REFUSAL AT 0.55 M ON WEATHERED SANDSTONE			
		1.0				
		1.5				
		2.0				
		2.5				

D - disturbed sample U - undisturbed tube sample B - bulk sample WT - level of water table or free water N - Standard Penetration Test (SPT) S - jar sample	Contractor: STS Equipment: Mini Christie Hole Diameter (mm): 100
NOTES: See explanation sheets for meaning of all descriptive terms and symbols	Angle from Vertical (^{o}): Drill Bit: Spiral

STS GeoEnvironmental Pty Ltd

GEOTECHNICAL LOG - NON CORE BOREHOLE

Client: Charleston Homes Project: 10 Courtley Road, Beacon Hill Location: Refer to Drawing No. 18/2839	Project: 22184/0072D Date : September 11, 2018 Logged: JK Checked By: LWI	**BOREHOLE NO.: BH 2** Sheet 1 of 1

WATER TABLE	**SAMPLES**	**DEPTH** (m)	**DESCRIPTION OF DRILLED PRODUCT** (Soil type, colour, grain size, plasticity, minor components, observations)	**SYMBOL**	**CONSISTENCY** (cohesive soils) or **RELATIVE DENSITY** (sands and gravels)	**MOISTURE**
			SILTY SANDY CLAY: dark brown, fine grained, low plasticity, trace of gravel FILL	CL	SOFT TO FIRM	M
			SANDY CLAY: yellow brown, fine grained, medium plasticity, trace of gravel/cobbles	CL	FIRM TO STIFF	M
		0.5	SANDY CLAY: light grey with occasional orange brown and red brown, fine grained, medium plasticity	CL	STIFF	M-D
					VERY STIFF	
		1.0				
WT 12/09/18		1.5				WET
			WEATHERED SANDSTONE: light grey with occasional red brown, fine to medium grained		EXTREMELY LOW STRENGTH	M-D
			AUGER REFUSAL AT 1.7 M ON WEATHERED SANDSTONE			
		2.0				
		2.5				

D - disturbed sample	U - undisturbed tube sample	B - bulk sample
WT - level of water table or free water		N - Standard Penetration Test (SPT)
S - jar sample		

Contractor: STS
Equipment: Hand Auger
Hole Diameter (mm): 100
Angle from Vertical (^{o}):
Drill Bit: Spiral

NOTES: See explanation sheets for meaning of all descriptive terms and symbols

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Dynamic Cone Penetrometer Test Report

Project: 10 COURTLEY ROAD, BEACON HILL — Project No.: 22184/0072D
Client: CHARLESTON HOMES — Report No.: 18/2839
Address: PO BOX 146, Horsley Park NSW 2175 — Report Date: 12/09/2018
Test Method: AS 1289.6.3.2 — Page: 1 of 1

Site No.	P1	P2				
Location	Refer to Drawing No. 18/2839	Refer to Drawing No. 18/2839				
Starting Level	Surface Level	Surface Level				
Depth (m)	Penetration Resistance (blows / 150mm)					
0.00 - 0.15	1	1				
0.15 - 0.30	4	3				
0.30 - 0.45	3	5				
0.45 - 0.60	22	4				
0.60 - 0.75	Refusal	10				
0.75 - 0.90		10				
0.90 - 1.05		22				
1.05 - 1.20		Refusal				
1.20 - 1.35						
1.35 - 1.50						
1.50 - 1.65						
1.65 - 1.80						
1.80 - 1.95						
1.95 - 2.10						
2.10 - 2.25						
2.25 - 2.40						
2.40 - 2.55						
2.55 - 2.70						
2.70 - 2.85						
2.85 - 3.00						
3.00 - 3.15						
3.15 - 3.30						
3.30 - 3.45						
3.45 - 3.60						
3.60 - 3.75						

Remarks: * Pre drilled prior to testing

NATA Accredited Laboratory Number 2750
Accredited for compliance with ISO/IEC 17025
The results of tests, calibrations and / or measurements included in this document are traceable to Australian / national standards

Approved Signatory...
Laurie Ihnativ - Manager

Technician: JK

E1. CLASSIFICATION OF SOILS

E1.1 Soil Classification and the Unified System

An assessment of the site conditions usually includes an appraisal of the data available by combining values of engineering properties obtained by the site investigation with descriptions, from visual observation of the materials present on site.

The system used by SMEC in the identification of soil is the Unified Soil Classification system (USC) which was developed by the US Army Corps of Engineers during World War II and has since gained international acceptance and has been adopted in its metricated form by the Standards Association of Australia.

The Australian Site Investigation Code (AS1726-1981, Appendix D) recommends that the description of a soil includes the USC group symbols which are an integral component of the system.

The soil description should contain the following information in order:

Soil composition

- SOIL NAME and USC classification symbol (IN BLOCK LETTERS)
- plasticity or particle characteristics
- colour
- secondary and minor constituents (name estimated proportion, plasticity or particle characteristics, colour

Soil condition

- moisture condition
- consistency or density index

Soil structure

- structure (zoning, defects, cementing)

Soil origin

interpretation based on observation eg FILL, TOPSOIL, RESIDUAL, ALLUVIUM.

E1.2 Soil Composition

(a) Soil Name and Classification Symbol

The USC system is summarised in Figure E1.2.1. The primary division separates soil types on the basis of particle size into:

- Coarse grained soils - more than 50% of the material less than 60 mm is larger than 0.06 mm (60 µm).

- Fine grained soils - more than 50% of the material less than 60 mm is smaller than 0.06 mm (60 µm).

Initial classification is by particle size as shown in Table E1.2.1. Further classification of fine grained soils is based on plasticity.

TABLE E1.2.1 - CLASSIFICATION BY PARTICLE SIZE

NAME	SUB-DIVISION	SIZE
Clay (1)		< 2 µm
Silt (2)		2 µm to 60 µm
Sand	Fine Medium Coarse	60 µm to 200 µm 200 µm to 600 µm 600 µm to 2 mm
Gravel (3)	Fine Medium Coarse	2 mm to 6 mm 6 mm to 20 mm 20 mm to 60 mm
Cobbles (3)		60 mm to 200 mm
Boulders (3)		> 200 mm

Where a soil contains an appropriate amount of secondary material, the name includes each of the secondary components (greater than 12%) in increasing order of significance, eg sandy silty clay.

Minor components of a soil are included in the description by means of the terms “some” and “trace” as defined in Table E1.2.2.

TABLE E1.2.2 - MINOR SOIL COMPONENTS

TERM	DESCRIPTION	APPROXIMATE PROPORTION (%)
Trace	presence just detectable, little or no influence on soil properties	0-5
Some	presence easily detectable, little influence on soil properties	5-12

The USC group symbols should be included with each soil description as shown in Table E1.2.3

TABLE E1.2.3 - SOIL GROUP SYMBOLS

SOIL TYPE	PREFIX
Gravel	G
Sand	S
Silt	M
Clay	C
Organic	O
Peat	Pt

The group symbols are combined with qualifiers which indicate grading, plasticity or secondary components as shown on Table E1.2.4

TABLE E1.2.4 - SOIL GROUP QUALIFIERS

SUBGROUP	SUFFIX
Well graded	W
Poorly Graded	P
Silty	M
Clayey	C
Liquid Limit <50% - low to medium plasticity	L
Liquid Limit >50% - medium to high plasticity	H

(b) Grading

"Well graded"	Good representation of all particle sizes from the largest to the smallest.
"Poorly graded"	One or more intermediate sizes poorly represented
"Gap graded"	One or more intermediate sizes absent
"Uniformly graded"	Essentially single size material.

(c) Particle shape and texture

The shape and surface texture of the coarse grained particles should be described.

Angularity may be expressed as "rounded", "sub-rounded", "sub-angular" or "angular".

Particle **form** can be "equidimensional", "flat" or elongate".

Surface texture can be "glassy", "smooth", "rough", pitted" or striated".

(d) Colour

The colour of the soil should be described in the moist condition using simple terms such as:

Black	White	Grey	Red
Brown	Orange	Yellow	Green
Blue			

These may be modified as necessary by "light" or "dark". Borderline colours may be described as a combination of two colours, eg red-brown.

For soils that contain more than one colour terms such as:

- Speckled Very small (<10 mm dia) patches
- Mottled Irregular
- Blotched Large irregular (>75 mm dia)
- Streaked Randomly oriented streaks

(e) Minor Components

Secondary and minor components should be individually described in a similar manner to the dominant component.

*E1.3 **S**oil Condition*

(a) Moisture

Soil moisture condition is described as "dry", "moist" or "wet".

The moisture categories are defined as:
Dry (D) - Little or no moisture evident. Soils are running.
Moist (M) - Darkened in colour with cool feel. Granular soil particles tend to adhere. No free water evident upon remoulding of cohesive soils.

In addition the moisture content of cohesive soils can be estimated in relation to their liquid or plastic limit.

(b) Consistency

Estimates of the consistency of a clay or silt soil may be made from manual examination, hand penetrometer test, SPT results or from laboratory tests to determine undrained shear or unconfined compressive strengths. The classification of consistency is defined in Table E1.3.1.

TABLE E1.3.1 - CONSISTENCY OF FINE-GRAINED SOILS

TERM	UNCONFINED STRENGTH (kPa)	FIELD IDENTIFICATION
Very Soft	<25	Easily penetrated by fist. Sample exudes between fingers when squeezed in the fist.
Soft	25 - 50	Easily moulded in fingers. Easily penetrated 50 mm by thumb.
Firm	50 - 100	Can be moulded by strong pressure in the fingers. Penetrated only with great effort.
Stiff	100 - 200	Cannot be moulded in fingers. Indented by thumb but penetrated only with great effort.
Very Stiff	200 - 400	Very tough. Difficult to cut with knife. Readily indented with thumb nail.
Hard	>400	Brittle, can just be scratched with thumb nail. Tends to break into fragments.

Unconfined compressive strength as derived by a hand penetrometer can be taken as approximately double the undrained shear strength ($q_u = 2\ c_u$).

(c) Density Index

The insitu density index of granular soils can be assessed from the results of SPT or cone penetrometer tests. Density index should not be estimated visually.

TABLE E1.3.2 - DENSITY OF GRANULAR SOILS

TERM	SPT N VALUE	STATIC CONE VALUE q_c (MPa)	DENSITY INDEX (%)
Very Loose	0 - 3	0 - 2	0 - 15
Loose	3 - 8	2 - 5	15 - 35
Medium Dense	8 - 25	5 - 15	35 - 65
Dense	25 - 42	15 - 20	65 - 85
Very Dense	>42	>20	>85

E1.4 Soil Structure

(a) Zoning

A sample may consist of several zones differing in colour, grain size or other properties. Terms to classify these zones are:

Layer - continuous across exposure or sample
Lens - discontinuous with lenticular shape
Pocket - irregular inclusion
Each zone should be described, their distinguishing features, and the nature of the interzone boundaries.

(b) Defects

Defects which are present in the sample can include:

- fissures
- roots (containing organic matter)
- tubes (hollow)
- casts (infilled)

Defects should be described giving details of dimensions and frequency. Fissure orientation, planarity, surface condition and infilling should be noted. If there is a tendency to break into blocks, block dimensions should be recorded

E1.5 Soil Origin

Information which may be interpretative but which may contribute to the usefulness of the material description should be included. The most common interpreted feature is the origin of the soil. The assessment of the probable origin is based on the soil material description, soil structure and its relationship to other soil and rock materials.

Common terms used are:

"Residual Soil" - Material which appears to have been derived by weathering from the underlying rock. There is no evidence of transport.

"Colluvium" - Material which appears to have been transported from its original location. The method of movement is usually the combination of gravity and erosion.

"Landslide Debris" - An extreme form of colluvium where the soil has been transported by mass movement. The material is obviously distributed and contains distinct defects related to the slope failure.

"Alluvium" - Material which has been transported essentially by water. usually associated with former stream activity.

"Fill" - Material which has been transported and placed by man. This can range from natural soils which have been placed in a controlled manner in engineering construction to dumped waste material. A description of the constituents should include an assessment of the method of placement.

E1.6 Fine Grained Soils

The physical properties of fine grained soils are dominated by silts and clays.

The definition of clay and silt soils is governed by their Atterberg Limits. Clay soils are characterised by the properties of cohesion and plasticity with cohesion defines as the ability to deform without rupture. Silts exhibit cohesion but have low plasticity or are non-plastic.

The field characteristics of clay soils include:

- dry lumps have appreciable dry strength and cannot be powdered
- volume changes occur with moisture content variation
- feels smooth when moist with a greasy appearance when cut.

The field characteristics of silt soils include:

- dry lumps have negligible dry strength and can be powdered easily
- dilatancy - an increase in volume due to shearing - is indicted by the presence of a shiny film of water after a hand sample is shaken. The water disappears upon remoulding. Very fine grained sands may also exhibit dilatancy.
- low plasticity index
- feels gritty to the teeth

E1.7 Organic Soils

Organic soils are distinguished from other soils by their appreciable content of vegetable matter, usually derived from plant remains.

The soil usually has a distinctive smell and low bulk density.

The USC system uses the symbol Pt for partly decomposed organic material. The O symbol is combined with suffixes "O" or "H" depending on plasticity.

Where roots or root fibres are present their frequency and the depth to which they are encountered should be recorded. The presence of roots or root fibres does not necessarily mean the material is an "organic material" by classification.

Coal and lignite should be described as such and not simply as organic matter.