GEOTECHNIQUE® PTY LTD

ABN 64 002 841 063

Job No: 14602/1
Our Ref: 14602/1-AA
4 February 2020

Mr James Millard
88 Idaline Street
COLLAROY PLATEAU NSW 2097
Email: james_millard@hotmail.com

Attention: Mr J Millard

Dear Sir

re: **Proposed Development**
88 Idaline Street, Collaroy Plateau
Limited Geotechnical Investigation

This letter report provides the results of a limited geotechnical investigation at the above site. The work was commissioned by Mr J Millard in a signed confirmation of engagement dated 22 January 2020, and was carried out as per our email dated 23 January 2020.

Proposed Development
We understand that the development will include the demolition of the existing house and the construction of a new dwelling, including a basement and a swimming pool. Basement excavation is understood to be up to about 3.0m deep.

A limited geotechnical investigation was required to assess sub-surface conditions across the site in order to provide geotechnical recommendations with respect to the proposed development, and recommendations on excavation conditions and vibrations limits.

Based on our experience in the Northern Sydney region, the subsurface profile at the proposed development site is anticipated to comprise a sequence of silty sand / sandy silt and bedrock. The depth to bedrock was likely to vary from about 1.0m to 3.0m from the existing ground surface. This limited investigation included hand drilling of two shallow boreholes. This report provides assessments and recommendations based on results of the investigation.

Field Work
Field work for the geotechnical investigation was carried out on 24 January 2020, and consisted of the following:

- A walk over survey to assess existing site conditions and site stability with regard to the proposed development.
- Reviewing services plans obtained from “Dial Before You Dig” to determine approximate locations of any services across the proposed development site.

- Scanning proposed borehole locations for underground services to ensure that services would not be damaged during field work. We engaged a specialist services locator for this purpose.
- Hand drilling of two boreholes at the locations shown on the attached Drawing No 14602/1-AA1. All boreholes were terminated at shallow depths of 0.8m to 0.9m due to refusal to hand drilling on sandstone bedrock or boulders. Engineering logs and explanatory notes are also attached.
- Dynamic Cone Penetration (DCP) tests were conducted adjacent to the boreholes to assess strength characteristics of sub-surface soils.
- Recover representative soil samples for visual classification.
- Measure depths to groundwater level in boreholes, if encountered.

Regional Geology

Reference to the Geological Map of Sydney (Scale 1:100,000) indicates the residual soils within the site to be underlain by Hawkesbury Sandstone comprising medium to coarse grained quartz sandstone, very minor shale and laminite lenses.

Reference to the Soil Landscape Map of Sydney (Scale 1:100,000) indicates that the site is located within the Gymea soil landscape area and typically consists of shallow, highly permeable sands associated with rock outcrop.

Site Conditions

The proposed development site is rectangular and measures approximately 43.0m by 13.5m. The site is bound by Acacia Street to the north, Idaline Street to the east, and existing residential developments to the south and west. Topography of the site is generally flat, with a gentle slope to the east. Currently, there is a single dwelling in the centre portion of the site. There are several matured trees and bushes scattered across the site.

Sub-surface Conditions

Sub-surface materials encountered in the boreholes are detailed in the attached engineering logs and summarised in Table 1 below.

Table 1 – Subsurface Profiles Encountered in Boreholes

Borehole No	Termination Depth	Depth of Topsoil	Natural	Bedrock
BH1	0.9	0.0-0.1	0.1-0.9	0.9*
BH2	0.8	0.0-0.1	0.1-0.8	0.8*

** Assessed from DCP refusal*

Natural	Silty Sand, fine grained, brown, with grass roots
Bedrock	Sandstone, fine to medium grained, grey/yellow, medium strength, slightly weathered (interpreted)

Groundwater or seepage was not encountered to the terminated depths of the boreholes. However, it should be noted that groundwater/seepage level might vary due to rainfall, temperature, and other factors not evident during field work.

DISCUSSION AND RECOMMENDATIONS

Slope Stability Assessment

Site factors such as slope angles, thickness of insitu soils, and strength of sub-surface materials and concentrations of water generally govern the stability of a site. "Practice Note Guidelines for Landslide Risk Management" prepared by Australian Geomechanics Society (Reference 1) recommend that the landslide risk of a site is assessed on the basis of the likelihood of a landslide event and the consequences of that event.

Applying the guidelines and based on the site inspection and sub-surface conditions encountered in the boreholes, the site for the proposed alterations and additions is assessed as follows:

- Qualitative Measures of Likelihood - For the existing site conditions, it is our assessment that an event of a slope failure (including soil, floaters and debris slide or flow) is "Unlikely", which means a slope failure might occur under very adverse circumstances, with indicative annual probability of $\approx 10^{-4}$. The likelihood of slope failure might increase if construction of the residence results in unstable cut and fill slopes. Therefore, design and construction of the proposed residence should ensure that the likelihood of slope failure is not increased.
- Qualitative Measures of Consequences to Property - It is our assessment that the consequences of slope failure in the site to the property would be "Medium", resulting in moderate damage to some structures, or a significant part of the site requiring large reinstatement/stabilisation works.

Based on the above Qualitative Measures, the site for the proposed residence is assessed to have a "Low Risk" to the property, before and after completion of the residence, provided excavations are appropriately battered or retained. The definitions of the risk levels are provided in Reference 1 and an extract is presented below.

Risk Level		Implication
VH	Very High Risk	Extensive detailed investigation and research, planning and implementation of treatment options, essential to reduce risk to acceptable levels; might be too expensive and not practical.
H	High Risk	Detailed investigation, planning and implementation of treatment options required to reduce risk to acceptable levels.
M	Moderate Risk	Tolerable, provided treatment plan is implemented to maintain or reduce risks. Might be accepted. Might require investigation and planning of treatment options.
L	Low Risk	Usually accepted. Treatment requirements and responsibility to be defined to maintain or reduce risk.
VL	Very Low Risk	Acceptable. Manage by normal slope maintenance procedures.

Based on the above, the development at the site is considered suitable, providing:

- Construction works are carried out in accordance with Northern Beaches Council's general guidelines.
- Cut and fill slopes are minimised, and all cut and fill slopes are battered appropriately or retained by engineered retaining walls.
- All footings are founded on bedrock (not floaters) encountered at the site.

Excavation Conditions

We understand that the excavation for the construction of the pool and garage will reach to depths of 3m. The sandstone bedrock and boulders exposed at the site are generally of medium to high strength, therefore excavation would be difficult and might require larger equipment such as a rock saw, rock hammer, rippers, etc.

Selection of excavation equipment should be based on site access, strength of sub-surface materials and the likely impact of vibration to structures (building, houses, roads, etc.) in the vicinity of the excavation. Contractors should be able to make their own judgement when tendering for excavation works based on existing site conditions and experience in such circumstances.

Acceptable vibration is based on the nature and state of neighbouring structures, which will have to be established by a dilapidation survey. As a general guide, the acceptable maximum peak particle velocity in a residential area would range from about 5mm/s to 10mm/s.

In order to keep the vibration limit within 5mm/s, the following can be considered in selection of a hammer and carrier (excavator).

Equipment	Carrier Weight	Safe Working Distance*
Hand operated jack hammer	-	2m nominal
250kg hammer operated at 100% capacity	5 to 12 tonnes	10m
250kg hammer operated at 50% capacity	5 to 12 tonnes	5m
550kg hammer operated at 50% capacity	8 to 15 tonnes	10m

** From neighbouring structures*

However, we recommend that a saw cutter is used to cut on the boundaries (garage), and a hammer to break the rock into small pieces for removal.

It is recommended that a contiguous retaining wall is used if the excavation is less than 3m from an adjacent property or public asset.

Batter Slopes and Retaining Structures

Cut slopes during and after proposed development works should be battered for stability or retained by engineered retaining structures. Recommended batter slopes for stability of cut and fill slopes in fill, residual soils and sandstone bedrock are presented below in Table 2.

TABLE 2

Material	Temporary (Horizontal : Vertical)		Permanent (Horizontal : Vertical)	
	Exposed	Protected	Exposed	Protected
Sands (≈1m)	1.5:1.0	1.0:1.0	2.5:1.0	2.0:1.0
Bedrock – Very low to low strength	1.0:1.0	0.75:1.0	1.5:1.0	1.0:1.0
Bedrock – Medium to high strength	Vertical	Vertical	Vertical	Vertical

Vertical excavations in medium to high strength sandstone, where required, will have a very low risk of instability. However, some local rock bolting and shotcreting might be required depending on the relative orientation of rock discontinuities (bedding partings, fractures, and joint systems) and excavation faces.

Therefore, we recommend that the excavation is progressively inspected (at 1m depth intervals) by a Geotechnical Engineer to identify any instability and recommend suitable remedial measures.

Slopes steeper than those listed in Table 2 would need to be retained by engineered retaining structures.

Footings
All footings for the proposed alterations and additions should be founded on stable sandstone bedrock (not floaters). Footings founded on sandstone bedrock can be designed for an allowable bearing pressure of 1,000kPa. Bored piers might be required in areas where depth to bedrock is deep. Bored piers should be socketed at least 0.3m in sandstone bedrock to mobilise the above recommended bearing pressure.

Total settlement of footings founded on sandstone bedrock is estimated to be about 1% for minimum footing dimension. Differential settlement is expected to be about 50% for total settlement. It is important that footings are founded on similar material to minimise differential movement.

Floor Slabs
Floor slabs can be founded on bedrock or suspended on footings. It is important that slabs are founded on similar material to minimise differential movement.

Limitations
As the recommendations presented in this report are based on information from two hand drilled boreholes and site observations, actual sub-surface conditions across the site might differ from those expected (interpreted). If such differences are encountered during construction, we recommend that this office is contacted for further advice. This can also occur with groundwater conditions, especially after climatic changes.

If you have any questions, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

pp
RAM RAVI-INDRAN
Geotechnical Engineer

Attached Drawing 14602/1-AA1 – Borehole Locations
Excavation Logs & Explanatory Notes

Reference
1) Australian Geomechanics - “Practice Note Guidelines for Landslide Risk Management (2007)”

Imagery ©2020 NearMap.com

N

LEGEND

- Borehole

0 4 8 12 16 20m

Scale 1:400

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NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing

Mr James Millard
Proposed Basement
88 Idaline Street
Collaroy Plateau

Borehole Locations

Drawing No: 14602/1-AA1
Job No: 14602/1
Drawn By: MH
Date: 31 January 2020
Checked By: NK

File No: 14602-1
Layers: 0, AA1

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engineering log - borehole

Client : MR JAMES MILLARD
Project : PROPOSED BASEMENT
Location : 88 IDALINE STREET, COLLAROY PLATEAU

Job No. : 14602/1
Borehole No. : BH1
Date : 24/01/2020
Logged/Checked by: NK/RR

drill model and mounting : HAND AUGER **slope :** **deg.** **R.L. surface :**

hole diameter : 100 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
	DRY				CONE 1 1 1 1 1 2 5 8 18	0		SM	TOPSOIL: Silty Sand, fine grained, brown, with grass roots Silty SAND, fine grained, brown	D	L		
					Refusal	0.5 1 1.5 2 2.5 3 3.5 4 4.5			Borehole No 1 terminated at 0.9m due to refusal on possible sandstone				

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engineering log - borehole

Client : MR JAMES MILLARD
Project : PROPOSED BASEMENT
Location : 88 IDALINE STREET, COLLAROY PLATEAU

Job No. : 14602/1
Borehole No. : BH2
Date : 24/01/2020
Logged/Checked by: NK/RR

drill model and mounting : HAND AUGER **slope :** **deg.** **R.L. surface :**

hole diameter : 100 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
	DRY				CONE 1 1 2 2 2 5 5 19	0 0.5		SM	TOPSOIL: Silty Sand, fine grained, brown, with grass roots Silty SAND, fine grained, brown	D	L		
					Refusal	1 1.5 2 2.5 3 3.5 4 4.5			Borehole No 2 terminated at 0.8m due to refusal on possible sandstone				

Log Symbols & Abbreviations (Non-cored Borehole Log)

Log Column	Symbol/Value		Description
Drilling Method	V-bit TC-bit RR DB BB		Hardened steel 'V' shaped bit attached to auger Tungsten Carbide bit attached to auger Tricone (Rock Roller) bit Drag bit Blade bit
Groundwater	Dry 		Groundwater not encountered to the drilled or auger refusal depth Groundwater level at depths shown on log Groundwater seepage at depths shown on log
Environment Sample	GP G P		Glass bottle and plastic bag sample over depths shown on log Glass bottle sample over depths shown on log Plastic bag sample over depths shown on log
PID Reading	100		PID reading in ppm
Geotechnical Sample	DS DB U_{50}		Disturbed Small bag sample over depths shown on log Disturbed Bulk sample over depths shown on log Undisturbed 50mm tube sample over depths shown on log
Field Test	N=10 3,5,5 N=R 10,15/100		Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration. 'R' represents refusal to penetration in hard/very dense soils or in cobbles or boulders. The first number represents10 blows for 150mm penetration whereas the second number represents 15 blows for 100mm penetration where SPT met refusal
	DCP/PSP	5 6 R/10	Dynamic Cone Penetration (DCP) or Perth Sand Penetrometer (PSP). Each number represents blows per 100mm penetration. 'R/10' represents refusal after 10mm penetration in hard/very dense soils or in gravels or boulders.
Classification	GP GW GM GC SP SW SM SC ML MI MH CL CI CH		Poorly Graded GRAVEL Well graded GRAVEL Silty GRAVEL Clayey GRAVEL Poorly graded SAND Well graded SAND Silty SAND Clayey SAND SILT / Sandy SILT / clayey SILT, low plasticity SILT / Sandy SILT / clayey SILT, medium plasticity SILT / Sandy SILT / clayey SILT, high plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, low plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, medium plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, high plasticity
Moisture Condition Cohesive soils Cohesionless soils	 M<PL M=PL M>PL D M W		 Moisture content less than Plastic Limit Moisture content equal to Plastic Limit Moisture content to be greater than Plastic Limit Dry - Runs freely through hand Moist - Tends to cohere Wet - Tends to cohere

Consistency Cohesive soils	Term	Undrained shear strength, C_u (kPa)	Hand Penetrometer (Qu)
VS	Very Soft	≤12	<25
S	Soft	>12 ≤25	25 – 50
F	Firm	>25 ≤50	50 – 100
St	Stiff	>50 ≤100	100 – 200
VSt	Very Stiff	>100 ≤200	200 – 400
H	Hard	>200	>400

Density Index Cohesionless soils	Term	Density Index, I_D (%)	SPT 'N' (blows/300mm)
VL	Very Loose	≤15	≤5
L	Loose	>15 ≤35	>5 ≤10
M	Medium Dense	>35 ≤65	>10 ≤30
D	Dense	>65 ≤85	>30 ≤50
VD	Very Dense	>85	>50

Hand Penetrometer	100 200	Unconfined compressive strength (q_u) in kPa determined using pocket penetrometer, at depths shown on log
Remarks	 Residual Alluvium Colluvial Aeolian Marine	Geological origin of soils Residual soils above bedrock River deposited Alluvial soils Gravity deposited Colluvial soils Wind deposited Aeolian soils Marine Soils

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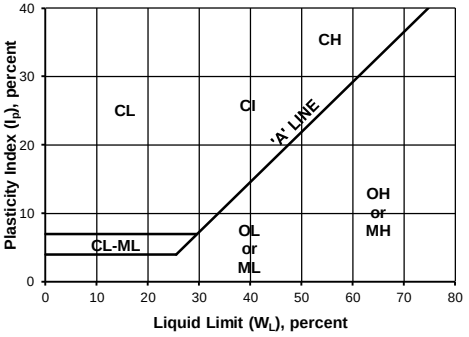
AS1726 – Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification				
	BOULDERS	200						% (2) < 0.075mm	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
	COBBLES	63										
COARSE GRAINED SOILS (more than half of material less 63mm is larger than 0.075mm)	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	Coarse 20	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>4	between 1 and 3	1. Identify lines by the method given for fine grained soils 2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.075mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Medium 6	GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line or I_p>7	-	-	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)	Coarse 0.6	SW	Well-graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>6	between 1 and 3	
		Medium 0.2	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Fine 0.075	SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
			SC	Clayey sand, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line of I_p>7	-	-	
FINE GRAINED SOILS (more than half of material less than 63mm is smaller than 0.075mm)					**Dry Strength**	**Dilatancy**	**Toughness**					
	SILTS & CLAYS (liquid limit < 50%)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to low	Quick to slow	None	More than 50% passing 0.075mm	Below 'A' line			
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium		Above 'A' line			
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low		Below 'A' line			
	SILTS & CLAYS (liquid limit > 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Low to medium	Slow to none	Low to medium		Below 'A' line			
			CH	Inorganic clays of medium to high plasticity, fat clays	High to very high	None	High		Above 'A' line			
			OH	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium		Below 'A' line			
	HIGHLY ORGANIC SOILS		Pt	Peat and highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture			Effervesces with H_2O_2				

Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'

Log Symbols & Abbreviations (Cored Borehole Log)

Log Column	Symbol	Description
Core Size		Nominal Core Size (mm)
	NQ	47
	NMLC	52
	HQ	63
Water Loss	◀	Complete water loss
	◁	Partial water loss
Weathering	FR	Fresh — Rock shows no sign of decomposition or staining
	SW	Slightly Weathered — Rock is slightly discoloured but shows little or no change of strength from fresh rock
	DW	Distinctly Weathered — Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased by deposition of weathering products in pores
	EW	Extremely Weathered — Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrate or can be remoulded, in water
	RS	Residual Soil — Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but soil has not been significantly transported
Strength		Term — Point Load Strength Index (I_{s50}, MPa)
	EL	Extremely Low — ≤0.03
	VL	Very Low — >0.03 ≤0.1
	L	Low — >0.1 ≤0.3
	M	Medium — >0.3 ≤1
	H	High — >1 ≤3
	VH	Very High — >3 ≤10
	EH	Extremely High — >10
Defect Spacing		Description — Spacing (mm)
		Extremely closely spaced — <20
		Very closely spaced — 20 to 60
		Closely spaced — 60 to 200
		Medium spaced — 200 to 600
		Widely spaced — 600 to 2000
		Very widely spaced — 2000 to 6000
		Extremely widely spaced — >6000
Defect Description		
Type	Bp	Bedding parting
	Fp	Foliation parting
	Jo	Joint
	Sh	Sheared zone
	Cs	Crushed seam
	Ds	Decomposed seam
	Is	Infilled seam
Macro-surface geometry	St	Stepped
	Cu	Curved
	Un	Undulating
	Ir	Irregular
	Pl	Planar
Micro-surface geometry	Ro	Rough
	Sm	Smooth
	Sl	Slickensided
Coating or infilling	cn	clean
	sn	stained
	vn	veneer
	cg	coating

AS1726 – Identification of Sedimentary Rocks for Engineering Purposes

Grain Size mm		Bedded rocks (mostly sedimentary)									
More than 20	20	Grain Size Description				At least 50% of grains are of carbonate				At least 50% of grains are of fine-grained volcanic rock	
	6	RUDACEOUS		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)		Calcirudite		Fragments of volcanic ejecta in a finer matrix	SALINE ROCKS
	2			Breccia Irregular rock fragments in a finer matrix						Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	Halite Anhydrite
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals				Calcarenite		Cemented volcanic ash	Gypsum
	0.2		Medium	Quartzite Quartz grains and siliceous cement						TUFF	
	0.06		Fine	Arkose Many feldspar grains Greywacke Many rock chips							
	0.002	ARGILLACEOUS		MUDSTONE	SILTSTONE Mostly silt	Calcareous Mudstone		Calcisiltite	CHALK	Fine-grained TUFF	
	Less than 0.002			SHALE Fissile	CLAYSTONE Mostly clay			Calcilutite		Very fine-grained TUFF	
Amorphous or crypto-crystalline				Flint: occurs as hands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone							COAL LIGNITE
				Granular cemented – except amorphous rocks							
				SILICEOUS		CALCAREOUS				SILICEOUS	CARBONACEOUS
				SEDIMENTARY ROCKS Granular cemented rocks vary greatly in strength, some sandstones are stronger than many Igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid						

AS1726 – Identification of Metamorphic and Igneous Rocks for Engineering Purposes

Obviously foliated rocks (mostly metamorphic)		Rocks with massive structure and crystalline texture (mostly igneous)						Grain size (mm)
Grain size description			Grain size description	Pegmatite			Pyrosenite	More than 20
		MARBLE						20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands	QUARTZITE	COARSE	GRANITE	Diorite	GABBRO	Peridorite	6
	Migmatite Irregularly foliated: mixed schists and gneisses	Granulite HORNFELS		These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica	Amphibolite	MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
		Serpentine		These rocks are sometimes phorphyritic and are then described as porphyries				0.2
								0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted'		FINE	RHYOLITE	ANDESITE	BASALT		0.002
	SLATE Well developed plane cleavage (foliation)			These rocks are sometimes phorphyritic and are then described as porphyries				Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian	Volcanic glass			Amorphous or cryptocrystalline
CRYSTALLINE				Pale<----------->Dark				
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	
METAMORPHIC ROCKS Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognize except by association. Any rock baked by contact metamorphism is described as 'hornfels' and is generally somewhat stronger than the parent rock Most fresh metamorphic rocks are strong although perhaps fissile			IGNEOUS ROCKS Composed of closely interlocking mineral grains. Strong when fresh; not porous Mode of occurrence : 1 Batholith; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava Flows; 6 Veins					