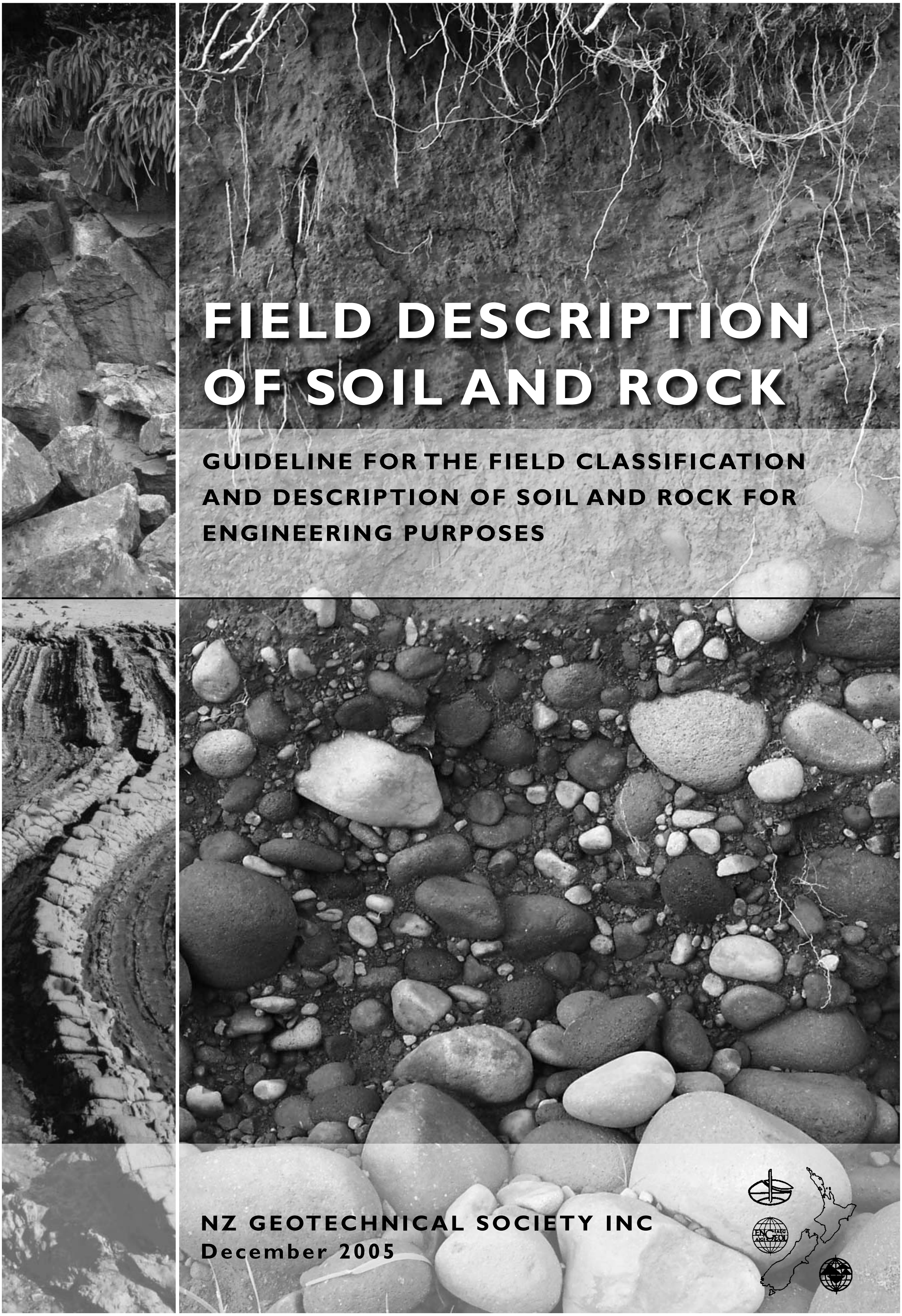

FIELD DESCRIPTION OF SOIL AND ROCK

GUIDELINE FOR THE FIELD CLASSIFICATION AND DESCRIPTION OF SOIL AND ROCK FOR ENGINEERING PURPOSES

NZ GEOTECHNICAL SOCIETY INC
December 2005

NZ GEOTECHNICAL SOCIETY INC

The New Zealand Geotechnical Society (NZGS) is the affiliated organisation in New Zealand of the International Societies representing practitioners in Soil Mechanics, Rock Mechanics and Engineering Geology. NZGS is also an affiliated Society of the Institution of Professional Engineers New Zealand (IPENZ).

The aims of the Society are:

- To advance the study and application of soil mechanics, rock mechanics and engineering geology among engineers and scientists
- To advance the practice and application of these disciplines in engineering
- To implement the statutes of the respective International Societies in so far as they are applicable in New Zealand.

Full members of the NZGS are affiliated to at least one of the following Societies:

- International Society for Rock Mechanics (ISRM)
- International Society for Soil Mechanics and Geotechnical Engineering (ISSMGE)
- International Society for Engineering Geology and the Environment (IAEG).

Members are engineers, scientists, technicians, contractors, students and others interested in the practice and application of soil mechanics, rock mechanics and engineering geology. Membership details are given on the NZGS website www.nzgeotechsoc.org.nz.

COVER PHOTOGRAPHS:
MAIN: Incised bank, Waiwhakaiho River, New Plymouth (courtesy Sian France)
UPPER LEFT: Basalt rock face, Mountain Road, Auckland (courtesy of Wayne Gunn)
LOWER LEFT: Sandstone/ mudstone exposed in shore platform, Auckland (courtesy of GNS Science)

Copy prepared by Karryn Muschamp
EDITORS: David Burns, Geoffrey Farqhuar, Mandy Mills, Ann Williams

FIELD DESCRIPTION OF SOIL AND ROCK

GUIDELINE FOR THE FIELD CLASSIFICATION AND DESCRIPTION OF SOIL AND ROCK FOR ENGINEERING PURPOSES

PREFACE

A draft method of soil description was produced by a working group of the New Zealand Geomechanics Society (now the New Zealand Geotechnical Society) in 1980. Members of the working Group were:

Dr S A L Read	New Zealand Geological Survey (now GNS Science)
Mr P J Millar	Tonkin & Taylor Ltd
Mr N S Luxford	Babbage Consultants Ltd
Mr A J Olsen	Worley Consultants Ltd (now Maunsell Ltd)

The draft was expanded to include a method for the description of rock in 1985, and published in 1988 as "Guidelines for the Field Description of Soils and Rocks in Engineering Use".

This 2005 revision has been prepared with the objectives of keeping pace with international practice, defining terms used in communicating soil and rock properties in New Zealand and giving emphasis to describing properties that are of engineering significance.

In particular, the soil description part of the Guideline has been revised to emphasize the distinction between classification and description. One notable change from the 1988 Guideline is the omission of Table 2.7 (USBR Unified Soil Classification Chart). This is in keeping with the 3rd edition of the USBR Earth Manual and changes to presentation of the Unified Soil Classification System in ASTM standards.

The rock description part of the Guideline has been simplified, and the section on weathering revised to make it more relevant to the range of rock types normally met in New Zealand. A more complete set of terms is provided to allow description of rock in both core and outcrop.

Contributors to the 2005 revision are:

David Burns	Maunsell Ltd
Steve Crawford	Tonkin & Taylor Ltd
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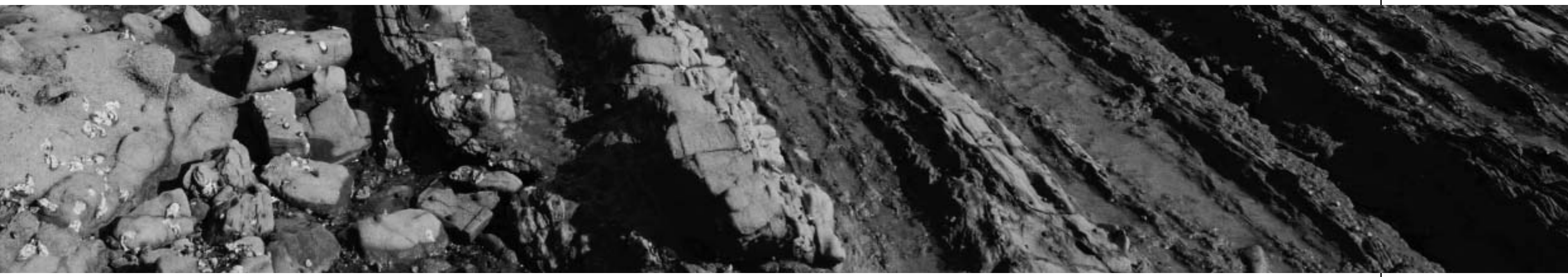
It is envisaged that in future the Guideline be reviewed and updated on a regular basis. To this end, all submissions on the Guideline should be registered with www.nzgeotechsoc.org.nz.

contents



1.0 INTRODUCTION

THE OVERALL AIM of a method of soil and rock description is to reduce the subjective nature and variability of descriptions of materials encountered during the investigation, design and construction of an engineering project. As such, the method is designed principally for use in the field where materials are described, and descriptions are recorded on logs. The logging forms and formats used vary according to the investigation method and the materials being investigated. This guideline is not intended to recommend forms for logging but to outline a methodology for the description of materials such that:

- All significant observable properties of soil and rock are described;
- Descriptions of a material consistently use the same terms; and
- Particular properties or groups of properties appear in the same relative position within any description, so that the user may rapidly locate them.

The system is therefore based on a list of applicable terms in a set sequence. The terms used in this document are often based on the results of standard laboratory tests (e.g. Atterberg limits). It should be emphasised however that such laboratory test results are given as a guide to the usage of terminology and that descriptions in the field should not wait for or rely on tests subsequently done in the laboratory. Where laboratory (and/or field) tests are performed, reference to the test or its results should be made on the logging form separate to the description. In compiling the guideline a wide variety of sources have been consulted. Although not referred to individually in the text, most are included in a selected bibliography at the end of this guideline.

There is overlap in the decision for describing a material as a soil or rock and this is largely determined by its geological setting. Soils are materials that can be separated by gentle mechanical means such as agitation in water. Rocks are harder more rigid aggregates of minerals connected by strong bonds. When weathering has reduced the strength of a rock to an unconfined compressive strength of less than 1 MPa (i.e. to that of a soil) and the parent rock fabric is visible, it should still be described as a soil but the rock description may also be given.

2.0 SOIL

2.1 OVERVIEW OF CLASSIFICATION AND DESCRIPTION

The terms classification and description have the following meanings in this document:

Classification: the identity of the material itself, i.e. what its composition and intrinsic properties are.

Description: the in-situ properties of the material, i.e. what it is like in its undisturbed state.

Classification systems used in soil mechanics, such as the Casagrande system, refer primarily to the material itself; they make only passing reference to the state in which the material exists in the ground.

Descriptive systems used in logging core, investigation pits etc, enable accurate accounts to be given of the state of the material in-situ. In some situations, for example where borrow sources are being investigated, or when only disturbed samples are available, then classification of the material itself is possible (and relevant), but description of its undisturbed state is not possible (or relevant).

A distinction between these two aspects is therefore made when describing a soil.

2.2 SOIL GROUPS

The framework for the classification and description of soil is provided in the following sections. For engineering purposes soil is grouped as shown in Table 2.1:

Table 2.1 Soil Groups

COARSE SOILS (granular soils or non-cohesive soils)		FINE SOILS (cohesive soils)		OTHER SOIL
Gravel	Sand	Silt	Clay	Organic Soils

The following notes give a brief outline of the engineering meaning attached to the above terms, and the basis on which they are identified or differentiated between.

2.2.1 Gravel and Sand

Gravel and sand comprise rock fragments of various sizes and shapes that may be either rock fragments or single minerals. In some cases there may be only a narrow range of particle sizes present, in which case the material is described as '*uniform*'. In other cases a broad range of particle sizes may be present and the material is described as '*well graded*' (refer Section 2.3.3.4).

2.2.2 Silt

Silt is intermediate between clay and fine sand. Silt is less plastic and more permeable than clay, and displays '*dilatant*' and '*quick*' behaviour. *Quick behaviour* refers to the tendency of silt to liquefy when shaken or vibrated, and *dilatancy* refers to the tendency to undergo volume increase when deformed. A simple test of patting a saturated soil sample in the hand can be undertaken to assess these properties and distinguish silt from clay.

2.2.3 Clay

Clay consists of very small particles and exhibits the properties of '*cohesion*' and '*plasticity*', which are not found in sand or gravel. *Cohesion* refers to the fact that the material sticks together, while *plasticity* is the property that allows the material to be deformed without volume change or rebound, and without cracking or crumbling.

2.2.4 Organic Soil

Organic soil is distinguished in Table 2.1 as a category different from coarse or fine soils, but should only be identified as such if the organic content is high and the material no longer behaves like a silt or clay. Soils containing small to moderate amounts of organic material still retain the properties of silts or clays and should be described within those categories.

2.2.5 Behaviour

Soil behaviour always depends to some extent on grain size and this forms a starting point for the engineering classification of soils. On this basis soils are categorised as in Table 2.2.

Table 2.2 Grain Size Criteria

TYPE	COARSE								FINE		ORGANIC
			Gravel			Sand					
	Boulders	Cobbles	coarse	medium	fine	coarse	medium	fine	Silt	Clay	Organic Soil
Size Range (mm)	200 60 20 6 2 0.6 0.2 0.06 0.002										Refer to Section 2.3.5
Graphic Symbol											

The properties of a coarse soil are closely related to particle size. For this reason, particle size is the sole criterion used in classifying coarse soils.

However, there is no clear relationship between properties and particle size in a fine soil; this is because the properties are influenced by both the *size* and *composition* of particles. For this reason, other methods, including physical manipulation of the soil (for visual description), and Atterberg Limit tests (for laboratory classification) are used to describe and classify them.

In most cases a soil consists of particle sizes spread over more than one category (e.g. sandy gravel). A sandy gravel is mainly gravel sizes but contains some sand.

It is important to understand the difference between the terms “clay” and “clay fraction” or “silt” and “silt fraction”. *Clay* is a descriptive term applied to a fine-grained soil that behaves like a clay (i.e. it has cohesion, plasticity, is not dilatant, and does not contain a noticeable amount of coarse material). *Clay fraction* is the proportion by weight of the particles in the soil finer than 0.002 mm. Similarly *silt* is a descriptive term for a material displaying the properties of a silt and *silt fraction* is the proportion by weight of the material between 0.002 mm and 0.06 mm.

The character of a mixed soil is largely dependent on the smallest constituents. Thus a soil containing 30 % sand, 40 % silt, and 30 % clay material is most likely to behave as a clay and would be termed a clay. Many clays contain less than 30 % clay fraction.

2.3 SYSTEMATIC CLASSIFICATION

2.3.1 Introduction

The basis for systematic classification is the Unified Soil Classification System (USCS), which is described in detail in many soil mechanics textbooks and ASTM D2488-00. It is not intended that the system be “followed to the letter” but that its general principles be adopted. The system provides for the use of group symbols (CH, GW etc), but the use of these is not encouraged in this guideline as this tends to force rather narrow, artificial limits to the classification process.

This guideline departs from the USCS in two areas:

- The basis for division into coarse and fine soils is a 35 % fines content, rather than 50 % as in the USCS (i.e. a Fine Soil has more than 35 % of grains finer than 0.06 mm and a Coarse Soil has less than 35 % of grains finer than 0.06 mm); and
- The division between sand and gravel is 2 mm, not 4.76 mm (the No. 4 sieve) as in the USCS.

The reasons for these differences (which follow British and Australian practice) are that:

- most soils with 35 % in the silt/clay size range are more likely to behave as fine soils rather than coarse soils; and
- 2 mm is more widely recognised as an appropriate boundary for sand/gravel differentiation than is 4.76 mm.

2.3.2 Distinction of Coarse Soils from Fine Soils

The first step in classification is to decide, from Figure 2.1, whether the soil falls into the coarse or fine category. The 0.06 mm size is considered to be the smallest size that can be seen with the naked eye, and it is also the size of the finest sieve used in particle size analysis.

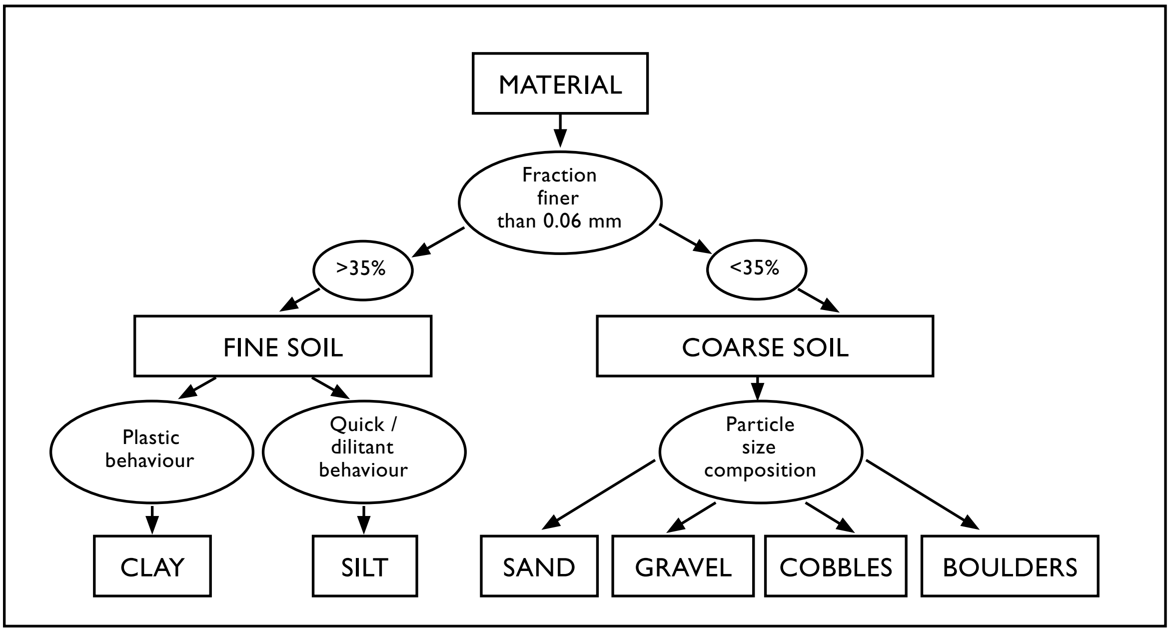


Figure 2.1 Soil Classification

If the material belongs in the fine soil category, it can be classified as silt or clay on the basis of behavioural characteristics – plasticity or quick and dilatant properties. If the material falls into the coarse soil category, it can be further divided into sand, gravel etcetera on the basis of particle size.

2.3.3 COARSE SOILS – classification

2.3.3.1 Introduction

If the soil falls into the coarse group, an estimate is made of the relative proportions of its principal constituents and an appropriate name given (Table 2.3).

In addition to the name given to the soil, further descriptive information should be given:

a) Proportions of particle sizes;
b) The maximum particle size;
c) Grading;
d) Particle shape;
e) Particle strength/hardness;
f) Other material;
g) Colour; and
h) Geological information.

2.3.3.2 Proportions of Particle Sizes

A material consisting mainly of gravel but containing significant sand would be classified as:
sandy GRAVEL.

In this case gravel is referred to as the major fraction and sand as the subordinate fraction. Some soils may also contain other material, for example clay. This is indicated by adding descriptive information to the soil name. The full classification might then become:
sandy GRAVEL with some clay.

With only a very small amount of clay the classification would be:
sandy GRAVEL with a trace of clay or slightly clayey sandy GRAVEL.

If the clay content is sufficient to influence behaviour, then proceed to Section 2.3.4.

Table 2.3 Proportional Terms Definition (Coarse Soils)

Fraction	Term	% of Soil Mass	Example
Major	(….) [UPPER CASE]	≥ 50 [major constituent]	GRAVEL
Subordinate	(….)y [lower case]	20–50	Sandy
Minor	with some … with minor …	12–20 5–12	with some sand with minor sand
	with trace of (or slightly)…	< 5	with trace of sand (slightly sandy)

Table 2.3 is an attempt to indicate this process, and define the terms some, minor, and trace. However the table will not always be directly applicable. For example, a soil could consist of 40 % gravel, 40 % sand and 20 % clay. This is clearly a coarse soil in terms of Figure 2.1, but does not have a "major" fraction. Its correct description would be either:
gravelly SAND, some clay, or
sandy GRAVEL, some clay.

In practice, it may appear as a *clayey GRAVEL* or *clayey SAND*, depending on the fineness of the gravel and sand, and the plasticity of the clay.

An attempt should be made to indicate whether any fines present in a coarse soil are silty or clayey in nature. This is not easy to do either in the field or the laboratory. Fines, which seem plastic and sticky, and cling to the large particles when the material is dried, are clayey. If they are not plastic and sticky, they are silty in nature.

2.3.3.3 Maximum Particle Size

Maximum particle size should be stated as a dimension in mm.

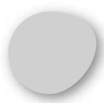
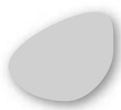
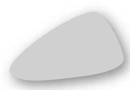
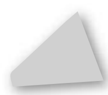
2.3.3.4 Grading

Gravels and sands should be described as *well graded* (a good representation of all particle sizes from largest to smallest), or *poorly graded* (a limited representation of grain sizes). *Poorly graded* materials may be further divided into *uniformly graded* (most particles about the same size), and *gap graded* (absence of one or more intermediate sizes within what otherwise would be a well graded material).

2.3.3.5 Particle Shape

Particle shape can be expressed in terms of *roundness* or *angularity* according to the scale shown in Table 2.4.

Table 2.4 Particle Shapes

Rounded	Subrounded	Subangular	Angular
			

The form of the soil particles may have an important effect on the mechanical properties of the soil mass. Particles can be further described as *equidimensional*, *flat*, *elongated*, *flat and elongated* or *irregular*.

2.3.3.6 Particle Strength/Hardness

Unless otherwise stated, it is assumed that grains of sand or gravel consist of hard, unweathered rock. If this is not the case, then information should be provided indicating the hardness of the grains, and the extent of weathering if this is a factor. Descriptions such as "*easily broken by hand*" or "*can be easily broken by a hammer blow*" are appropriate. The particle strength and weathering of gravel, cobbles and boulders can also be described using the rock descriptive terms given in, Section 3.0.

2.3.3.7 Other Material

Other material such as pieces of coal, shell, or traces of oils should be described. Strong odours should also be noted.

2.3.3.8 Colour

Colour should be described using the terms set out in Table 2.5. Colour may indicate the degree of weathering or the geological origin, and can be used to trace stratigraphic layers. Colour descriptions should focus on the main overall colour, rather than the fine details of colour variability. The choice of a colour from Column 3 in Table 2.5 can be supplemented by a term from Column 1 and/or Column 2 as appropriate.

Table 2.5 Colour Terms

1	2	3
light dark	pinkish reddish yellowish brownish greenish bluish greyish	pink red orange yellow brown green blue white grey black

2.3.3.9 Geological Information

Identify the dominant minerals or parent rock types and the geological unit, if known.

2.3.4 FINE SOILS – classification

2.3.4.1 Silt or Clay

If the soil is fine grained, it is examined to determine whether it is a silt or a clay. As already mentioned, the division into silt or clay is **not** made on the basis of particle size.

To distinguish between silts and clays, the best test to use is the "quick"/dilatancy test. A pat of soft soil (sufficiently wet to be almost sticky) is placed in the open palm of the hand and shaken, or vibrated horizontally. This is most effectively done by tapping the hand holding the soil, with the other hand. With a **silt**, "*quick*" behaviour appears (water will appear on the surface, giving it a shiny appearance), and will then disappear if the sample is squeezed or manipulated. During vibration, the sample tends to collapse and water runs to the surface. When it is manipulated the sample tends to dilate and draw water back into it. With a **clay**, these characteristics are not present. In the laboratory, the division into silt or clay can also be made on the basis of Atterberg Limit tests and use of the Plasticity Chart.

For example, a soil which behaves primarily as a clay, but also contains significant sand is classified as *Sandy CLAY.*

A soil that behaves primarily as a clay, but also displays some tendency towards silt behaviour could be classified as *Silty CLAY.*

The use of this terminology may not be strictly in accordance with the USCS, but it is more sensible to use such terminology than to force the soil into a category to which it does not belong.

In addition to the name given to the soil, the following descriptive information should be given:

a) Plasticity;
b) Presence of coarse material;
c) Colour; and
d) Geology.

In special circumstances, a field or laboratory classification of the particle size may be required, (e.g. when an estimate of the permeability of the soil is needed). In these cases the classification should be added to the field description of the soil and noted so that it is clear on what basis it has been made.

2.3.4.2 Plasticity

The most important property of a clay or silt is its plasticity. A *highly plastic* soil is one that can be moulded or deformed over a wide moisture content range, without cracking or showing any tendency to volume change. It also shows no trace of "quick" or dilatant behaviour.

To evaluate plasticity in the field it is necessary to remould the soil over a range of moisture contents.

The dry strength of the material is also a good guide to plasticity. *Highly plastic* clays will become 'rock hard' when dry, while those of *low plasticity* can be crumbled in the fingers.

2.3.4.3 Presence of Coarse Material (Sand or Gravel)

If the fine soil contains significant amounts of coarse material then this should be described. The guidelines in Table 2.3 for terminology applying to the subordinate or minor fraction can also be used in this case. For example, a soil is a *sandy CLAY* if the proportion of sand lies between 20 and 50 %, and a *CLAY*, *with trace sand*, if the proportion of sand is less than 5 %. Additional information on the nature of the coarse material should follow the guidelines given in Section 2.3.3.

2.3.4.4 Colour

Refer Section 2.3.3.8.

Unless of significance, the colour given should be the overall colour and not that of individual constituents. If appropriate, the distribution of colour may be described using the terms *mottled*, *banded*, *mixed*, or *speckled*. Where used, such terms should be written after the main colour e.g. brown, mottled yellow.

2.3.4.5 Geological Information

Refer Section 2.3.3.9.

2.3.5 ORGANIC SOILS

A small amount of dispersed organic matter can have a marked effect on plasticity and therefore on engineering properties. It may have a distinctive odour, a dark grey/ black or brown colour and a low density. If organic matter is present, the terms in Tables 2.6 or 2.7 should be used. The relative proportion of organics in a soil should be described as for inorganic soils (Table 2.3).

Table 2.6 Organic Soils

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However top-soil may occur at greater depth, having been buried by geological processes or man-made fill, and should then be termed a buried topsoil.
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidise rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. Can be further described according to its degree of decomposition and strength. *Firm*: Fibres already compressed together *Spongy*: Very compressible and open structure *Plastic*: Can be moulded in hand and smears in fingers *Fibrous*: Plant remains recognisable and retain some strength *Amorphous*: No recognisable plant remains

Table 2.7 Organic Descriptors

Term	Description
Rootlets	Fine, partly decomposed roots, normally found in the upper part of a soil profile or in a redeposited soil (e.g. colluvium or fill).
Carbonaceous	Discrete particles of hardened (carbonised) plant material.

Fine soils with larger amounts of organic matter usually plot below the A-line as organic silt. They have high liquid limits, sometimes up to several hundred percent. The liquid limit, plastic limit and plasticity index show a very marked drop on rewetting or remoulding following air or oven drying.

If a peat forms a horizon of major engineering significance, a fuller description using the scheme of von Post (Smart, 1986) may be appropriate.

2.4 DESCRIPTION OF IN-SITU (UNDISTURBED) CHARACTERISTICS

2.4.1 Introduction

The guidelines outlined above refer only to the material itself; they do not include information on the state in which it exists in the ground. Guidelines for description of the state in which a soil is found in the ground are provided in this section.

2.4.2 COARSE SOILS – description

2.4.2.1 Relative Density

Relative density refers to the "denseness", or degree of compactness of a coarse soil in the ground, and is expressed as the *density index*. The terms very loose through to very dense are used to describe this property. Table 2.8 provides a guide for relating descriptive terms to Standard Penetration Test (SPT) N-values and Dynamic Cone Penetrometer (Scala) values.

Table 2.8 Density Index (Relative Density) Terms

Descriptive Term	Density Index (R_D)	SPT N-value (blows / 300 mm)	Dynamic Cone (blows / 100 mm)
Very dense	> 85	> 50	> 17
Dense	65 – 85	30 – 50	7 – 17
Medium dense	35 – 65	10 – 30	3 – 7
Loose	15 – 35	4 – 10	1 – 3
Very loose	< 15	< 4	0 – 2

Note:
- No correlation is implied between Standard Penetration Test (SPT) and Dynamic Cone Penetrometer Test values.
- The SPT "N" values are uncorrected.

Particular care should be exercised in using the descriptors in coarse gravels. Where the above terms are used without test results, they should be written in inverted commas. Where no test results are available, a simple field assessment can be made using the terms *loosely packed* and *tightly packed*:

Loosely packed: Can be removed from exposures by hand or removed easily by shovel.

Tightly packed: Requires a pick for removal, either as lumps or as disaggregated material.

2.4.3 FINE SOILS – description

2.4.3.1 Soil Strength or "Consistency"

Table 2.9 provides a guide to the terms used to designate soil strength and related properties in fine soils.

Table 2.9 Consistency Terms for Cohesive Soils

Descriptive Term	Undrained Shear Strength (kPa)	Diagnostic Features
Very soft	< 12	Easily exudes between fingers when squeezed
Soft	12 – 25	Easily indented by fingers
Firm	25 – 50	Indented by strong finger pressure and can be indented by thumb pressure
Stiff	50 – 100	Cannot be indented by thumb pressure
Very stiff	100 – 200	Can be indented by thumb nail
Hard	200 – 500	Difficult to indent by thumb nail

The terms and strengths in Table 2.9 match those in AS1726:1993 but not those in BS5930:1999. Undrained shear strength can be determined using either field or laboratory tests. The most common field test in NZ is the hand held shear vane (refer NZGS, 2001).

2.4.3.2 Sensitivity

This is a measure of the loss of strength that occurs when the soil is disturbed or remoulded. Sensitivity is defined as the ratio of the undisturbed strength to the remoulded strength as outlined in Table 2.10.

Table 2.10 Sensitivity of Soil

Descriptive Term	Shear Strength Ratio $\frac{\text{undisturbed}}{\text{remoulded}}$
Insensitive, normal	< 2
Moderately sensitive	2 – 4
Sensitive	4 – 8
Extra sensitive	8 – 16
Quick	> 16

2.4.4 Structure (Applicable to Coarse and Fine Soils)

This refers to the presence or absence of bedding, or any other features such as faults, fissures, fractures, striations and slickensided surfaces as defined in Table 2.11.

Table 2.11 Soil Structure

Term	Description
Homogeneous	The total lack of visible bedding and the same colour and appearance throughout
Bedding	The presence of layers
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Polished	Fracture planes are polished or glossy
Slickensided	Fracture planes are striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensoidal	Discontinuous pockets of a soil within a different soil mass

2.4.5 Moisture Condition

Terms to describe the moisture condition of soil samples are given in Table 2.12.

Table 2.12 Moisture Condition

<table>
<tr><th>Condition</th><th>Description</th><th>Granular Soils</th><th>Cohesive Soils</th></tr>
<tr><td>Dry</td><td>Looks and feels dry</td><td>Run freely through hands</td><td>Hard, powdery or friable</td></tr>
<tr><td>Moist</td><td rowspan="2">Feels cool, darkened in colour</td><td rowspan="2">Tend to cohere</td><td>Weakened by moisture, but no free water on hands when remoulding</td></tr>
<tr><td>Wet</td><td>Weakened by moisture, free water forms on hands when handling</td></tr>
<tr><td>Saturated</td><td colspan="3">Feels cool, darkened in colour and free water is present on the sample</td></tr>
</table>

2.5 ORDER OF TERMS – SOIL

The descriptive sequence outlined in the preceeding sections seeks to place the most important items first and the least important at the end.

Examples are given in Tables 2.13 and 2.14

Table 2.13 Example of Description of a Coarse Soil

Main Paragraph	Example	Item
Subordinate fraction	sandy	Soil name
Major Fraction	fine to coarse GRAVEL	
Minor fraction	with minor silt and clay	
Colour	light greyish brown	Visual characteristics
Structure	bedded	
Qualifying Paragraph		
Strength	loosely packed	Soil mass qualifications
Moisture condition	dry	
Grading	well graded	
Bedding	subhorizontal, thick	
Plasticity		
Sensitivity		
Major fraction	gravel, subangular to subrounded greywacke	Soil fraction qualifications
Weathering of clasts	slightly weathered	
Subordinate fraction	sand, fine to coarse	
Minor fraction	silt and clay, slightly plastic	
Additional structures	few fine sand lenses	Additional information
Additional information	MT JOHN OUTWASH GRAVEL	

The example in Table 2.13 would be written:
Sandy fine to coarse GRAVEL with minor silt and clay; light greyish brown, bedded. Loosely packed; dry; well graded; bedding, subhorizontal, thick; subangular to subrounded, slightly weathered greywacke gravel; sand, fine to coarse; silt and clay, slightly plastic; few fine sand lenses (MT JOHN OUTWASH GRAVEL).

Table 2.14 Example of Description of a Fine Soil

Main Paragraph	Example	Item
Subordinate fraction	clayey	Soil name
Major Fraction	SILT	
Minor fraction	trace peat	
Colour	light grey, mottled black	Visual characteristics
Structure		
Qualifying Paragraph		
Strength	firm	Soil mass qualifications
Moisture condition	moist	
Grading		
Bedding		
Plasticity	low plasticity	
Sensitivity	moderately sensitive	
Major fraction		Soil fraction qualifications
Subordinate fraction		
Minor fraction		
Additional structures		Additional information
Additional information	HINUERA FORMATION	

The example in Table 2.14 would be written:
Clayey SILT, trace of peat; light grey, mottled black. Firm, moist, low plasticity, moderately sensitive, (HINUERA FORMATION).

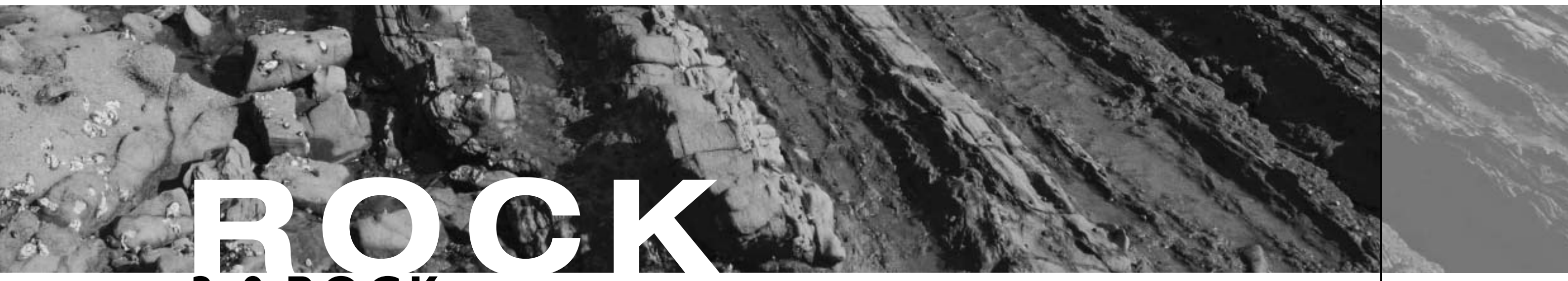
2.6 "DIFFICULT" SOILS

Some New Zealand soils do not fit easily into classification systems, and should not be forced to. Examples are volcanic ash found in various parts of the North Island, containing a high proportion of the clay mineral allophane and wind-deposited loess, found in many parts of the South Island.

Allophane soils normally plot well below the A-line on the Plasticity Chart, but their behaviour is not that of a silt. Allophane soils do not normally display the "quick" or dilatant behaviour associated with silt, but neither do they have the plasticity of a clay. In this case, it is perhaps best to describe the soil as a clayey SILT or a silty CLAY.

Some materials undergo considerable changes when taken from the ground and broken up. In their undisturbed state they may appear as firm or hard materials having little or no plasticity, but disturbance and remoulding changes them to soft, quite plastic materials. In some cases, they may appear to be essentially granular materials before disturbance, but afterwards are closer to silt or clay. This can result from breakdown of "bonds" between particles, or from breakdown of the particles themselves. The undisturbed material may appear to consist of discreet particles of sand or gravel size, but remoulding shows these to be so fragile that they break down into silt and clay material. In this situation the description is difficult, and it is recommended that two descriptions be made: one of the undisturbed sample and one of the disturbed sample.

Example: *sandy GRAVEL, loosely packed, breaks down to a sandy SILT, with some plasticity on remoulding.*



3.0 ROCK

3.1 INTRODUCTION

The order of terms used for describing rock is similar to that given for soils, however the description gives greater attention to the presence of discontinuities in the rock mass (fractures or defects) and the effects of weathering, both of these having a significant influence on the mechanical properties and behaviour of a rock mass.

A rock mass is made up of the rock material or rock substance (i.e. parent lithology) and the discontinuities. The presence of discontinuities influences the mechanical behaviour of the rock mass such that it is often different from that of the rock material, which has no discontinuities. This document provides guidelines for the description of a rock mass, not just the intact rock material comprising the rock mass. However it does not extend to mapping of the rock mass defects (e.g. irregularity surveys or stereonet projection), rock mass classification for the design of particular structures (e.g. Q-system of Barton) or the assessment of rock mass for material handling (e.g. correlation with seismic velocity for ripping or blasting).

3.2 COMPONENTS OF ROCK MASS DESCRIPTION

3.2.1 Colour

Colour should be described using the terms set out in Table 2.5. for soil description. Colour may indicate the degree of weathering or the geological origin, and can be used to trace stratigraphic layers. Colour descriptions should focus on the main overall colour, rather than the fine details of colour variability.

3.2.2 Weathering

'*Weathering is the process of alteration and breakdown of rock and soil materials at and near the Earth's surface by chemical decomposition and physical disintegration' (Geological Society Engineering Group Working Party Report, 1995).*

Of particular note in this definition is that weathering is described as a **process**. It is not a **method** for describing the engineering properties of a rock mass. As such, describing the state of weathering must never be a substitute for an adequate description of the intrinsic physical/mechanical properties of a rock mass using the standard descriptors set out in this guideline (e.g. strength, defects, fabric, rock type). If the degree of weathering cannot be determined, for example because the unweathered version of a particular rock type has not been seen, it is best left out of the description.

This guideline requires both the description of the effects of weathering, and, as far as possible, classification of the degree of weathering according to a scale.

However, it is recognised that the state of weathering of all rock masses (and 'soil' masses such as coarse alluvial and pyroclastic deposits) cannot be accurately described using a common weathering scale, and this should not be attempted if ambiguity results. What is important is to fully describe the effects of weathering.

There are many methods and scales for describing the weathering of rock masses. Many are general and attempt to cover a large range of rock types. They typically describe chemical weathering of jointed rock masses, concentrating on colour changes, strength changes and changes to rock fabric and texture. Few specifically include physical weathering effects. Others have been devised for specific rock types (e.g. Chandler and Apted, 1988). Some systems (e.g. BS5930:1999) include the state of weathering of the rock material (often referred to as rock condition) and the rock mass. The reader is referred to 'The Quarterly Journal of Engineering Geology', vol 28/3, August 1995 for a more complete discussion of weathering and some difficulties with existing descriptive methods.

Because this document is aimed at the overall description of a rock mass, a description of weathering which addresses both changes in the rock material and in the discontinuities is preferred. If there remains a significant difference in weathering of the defects as compared to the weathering category for the overall rock mass, then this should be pointed out as part of the description (e.g. 200 mm thick soil seam within a slightly weathered rock mass).

The effects of weathering are to be described using the standard soil and rock description terminology in terms of:

- colour and colour changes;
- strength and reduction of strength;
- condition of discontinuities and their infill; and
- weathering products.

While primarily applicable to rock masses it is intended that the effects of weathering on other geological materials such as alluvial and volcanic deposits also be routinely included in descriptions.

Based on the descriptions of weathering effects and products, the rock mass can be classified according to a general weathering scale (Table 3.1). Other scales may be used to aid classification and communication, particularly if the weathering environment is uncommon (e.g. desert/alpine). Any scale used must be clearly referenced. The general scale in Table 3.1 primarily recognises loss of strength, effect on defects and clasts, and weathering products.

In very general terms the boundary between a rock mass being more 'rock like' than 'soil like' is the boundary between moderately weathered and highly weathered.

Table 3.1 Scale of Rock Mass Weathering

Term	Grade	Abbreviation	Description
Unweathered (fresh)	I	UW	Rock mass shows no loss of strength, discolouration or other effects due to weathering. There may be slight discolouration on major rock mass defect surfaces or on clasts.
Slightly Weathered	II	SW	The rock mass is not significantly weaker than when unweathered. Rock may be discoloured along defects, some of which may have been opened slightly.
Moderately Weathered	III	MW	The rock mass is significantly weaker than the fresh rock and part of the rock mass may have been changed to a soil. Rock material may be discoloured, and defect and clast surfaces will have a greater discolouration, which also penetrates slightly into the rock material. Increase in density of defects due to physical disintegration process such as slaking, stress relief, thermal expansion/ contraction and freeze/thaw.
Highly Weathered	IV	HW	Most of the original rock mass strength is lost. Material is discoloured and more than half the mass is changed to a soil by chemical decomposition or disintegration (increase in density of defects/fractures). Decomposition adjacent to defects and at the surface of clasts penetrates deeply into the rock material. Lithorelicts or corestones of unweathered or slightly weathered rock may be present.
Completely Weathered	V	CW	Original rock strength is lost and the rock mass changed to a soil either by chemical decomposition (with some rock fabric preserved) or by physical disintegration.
Residual Soil	VI	RS	Rock is completely changed to a soil with the original fabric destroyed.

3.2.3 Fabric

Fabric refers to the arrangement of minerals and particles in the rock. The arrangement may be of similar mineral/particle sizes, composition or arrangement including showing a preferred orientation. For sedimentary rocks it is preferable to use the descriptors given in Table 3.4; in metamorphic rocks it refers to the development of foliation. General fabric terms are set out in Table 3.2.

Table 3.2 Description of Rock Mass Fabric

Term	Description
Fine fabric	< 25 mm
Coarse fabric	25 – 100 mm
Massive	No fabric observed

3.2.4 Bedding

The term bedded indicates the presence of layers. The latter can be qualified with terms to describe how visible the bedding is, such as indistinctly bedded, or distinctly bedded. Bedding inclination and bedding thickness should be included using terms defined in Tables 3.3 and 3.4.

Table 3.3 Bedding Inclination Terms

Term	Inclination (degrees from the horizontal)
Sub-horizontal	0 – 5
Gently inclined	6 – 15
Moderately inclined	16 – 30
Steeply inclined	31 – 60
Very steeply inclined	61 – 80
Sub-vertical	81 – 90

Table 3.4 Bedding Thickness Terms

Term	Bed Thickness
Thinly laminated	< 2 mm
Laminated	2 mm – 6 mm
Very thin	6 mm – 20 mm
Thin	20 mm – 60 mm
Moderately thin	60 mm – 200 mm
Moderately thick	0.2 m – 0.6 m
Thick	0.6 m – 2 m
Very thick	> 2 m

3.2.5 Strength

The strength term is based on a range of the uniaxial compressive strength (q_u) of the intact rock material comprising the rock mass. The means by which the strength term is selected in the field is given in Table 3.5, together with values of q_u and $I_s(50)$ (from the point load index strength test). The description of rock material strength using the terms strong and weak is preferred to the use of the terms high strength and low strength. The latter terms are considered as more appropriate to the description of rock mass strength.

Table 3.5 Rock Strength Terms

<table>
<tr><th>Term</th><th>Field Identification of Specimen</th><th>Unconfined uniaxial compressive strength q_u (MPa)</th><th>Point load strength $I_{s(50)}$ (MPa)</th></tr>
<tr><td>Extremely strong</td><td>Can only be chipped with geological hammer</td><td>> 250</td><td>>10</td></tr>
<tr><td>Very strong</td><td>Requires many blows of geological hammer to break it</td><td>100 – 250</td><td>5 – 10</td></tr>
<tr><td>Strong</td><td>Requires more than one blow of geological hammer to fracture it</td><td>50 – 100</td><td>2 – 5</td></tr>
<tr><td>Moderately strong</td><td>Cannot be scraped or peeled with a pocket knife. Can be fractured with single firm blow of geological hammer</td><td>20 – 50</td><td>1 – 2</td></tr>
<tr><td>Weak</td><td>Can be peeled by a pocket knife with difficulty. Shallow indentations made by firm blow with point of geological hammer</td><td>5 – 20</td><td rowspan="3"><1</td></tr>
<tr><td>Very weak</td><td>Crumbles under firm blows with point of geological hammer. Can be peeled by a pocket knife</td><td>1 – 5</td></tr>
<tr><td>Extremely weak (also needs additional description in soil terminology)</td><td>Indented by thumb nail or other lesser strength terms used for soils</td><td><1</td></tr>
<tr><td colspan="4">Note: No correlation is implied between q_u and $I_{s(50)}$</td></tr>
</table>

Commonly, rocks with q_u values in excess of 50 MPa are informally referred to as '*hard*' rocks and those less than 20 MPa (especially < 10 MPa) as '*soft*' rocks.

Although the boundary between soil and rock is commonly recognised as being between very weak and extremely weak (i.e. 1 MPa), rock descriptions may include materials with a strength of less than 1 MPa (e.g. Tertiary sandstone) and in such cases a soil description should also be included.

3.2.6 Discontinuities (or Defects)

The range of geological features that form discontinuities (or defects) in rock masses are summarised in Table 3.6.

Discontinuities such as joints, bedding and cleavage should be described where applicable in terms of their spacing, persistence, orientation, separation, tightness and roughness, as well as noting the presence of any coatings or infillings and the nature of these (eg slickensided or polished).

Larger discontinuities such as sheared or crushed zones should be described in terms of their orientation, continuity, aperture, spacing of any internal defects, condition of their walls, and the presence and nature of infillings, coatings and planes of preferential movement.

The full description of discontinuities requires attention to the following:

- Orientation
- Spacing
- Persistence
- Roughness
- Wall Strength
- Aperture
- Infill
- Seepage
- Sets
- Block size and shape.

3.2.6.1 Orientation

Attitude of the discontinuity in space. Described by the dip direction (azimuth) and dip of the line of steepest declination in the plane of the discontinuity.

Example: *dip direction/amount of dip (015°/35°) or strike and dip (105°/35°N).*

3.2.6.2 Spacing

Perpendicular distance between adjacent discontinuities. Spacing refers to the mean or modal spacing of a set of joints as defined in Table 3.7.

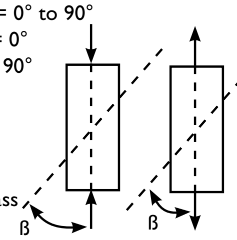
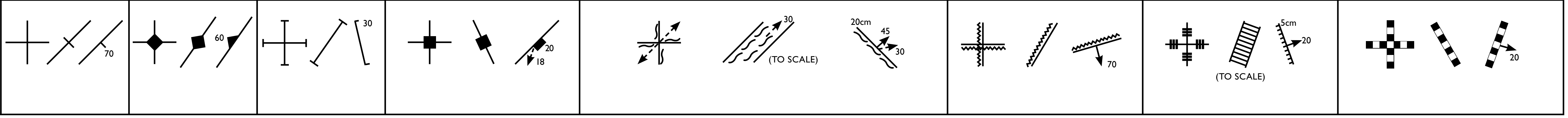
Table 3.7 Spacing of Defects or Discontinuities

Term	Spacing
Very widely spaced	>2 m
Widely spaced	600 mm – 2 m
Moderately widely spaced	200 mm – 600 mm
Closely spaced	60 mm – 200 mm
Very closely spaced	20 mm – 60 mm
Extremely closely spaced	<20 mm

3.2.6.3 Persistence

Discontinuity trace length to its termination in solid rock or against other discontinuities, as observed in an exposure. A crude measure of the areal extent or penetration of a discontinuity may br given. For major discontinuities, the plane may extend beyond the limits of the exposure and then the maximum trace length or area should be recorded.

Table 3.6 Range of Geological Features that Form Discontinuities (or defects) in Rock Masses

TERM[1] GENERAL	LAYERING (LAYER) [2]			FRACTURES AND FRACTURED ZONES		WEAK SEAMS OR ZONES		
SPECIFIC	BEDDING	FOLIATION	CLEAVAGE	JOINT	SHEARED ZONE	CRUSHED SEAM/ZONE	DECOMPOSED SEAM/ZONE	INFILLED SEAM/ZONE
PHYSICAL DESCRIPTION	Arrangement in layers, of mineral grains of similar sizes or composition, and/or arrangement of elongated or tabular minerals, near parallel to one another, and/or to the layers. Generally no microfractures	Discontinuous microfractures may be present, near parallel to the layering		A discontinuity or crack: planar curved or irregular across which the rock has little tensile strength. The joint may be open (filled with air or water) or filled by soil substances or by rock substance which acts as a cement. Joint surfaces may be rough, smooth or slickensided.	Zone, with roughly parallel planar boundaries, of rock material intersected by closely spaced (generally <50mm) joints and/or microscopic fracture (cleavage) planes. The joints are at small angles to the zone boundaries; they are slightly curved and divide the mass into unit blocks of lenticular or wedge shape. Their surfaces are smooth or slickensided. Type R ranging to Type S Joints tightly closed, cemented but cements (usually chlorite or calcite) are weaker than the rock substance. / Joints are cemented but either coated with soil substances or are open, filled with air and/or water.	Zone with roughly parallel planar boundaries, composed of disoriented, usually angular fragments of the host rock substance. The fragments may be of clay, silt, sand or gravel sizes or mixtures of any of these. Some minerals may be altered or decomposed but this is not necessarily so. Boundaries commonly slickensided.	Zone of any shape, but commonly with roughly parallel planar boundaries in which the rock material is discoloured and usually weakened. The boundaries with fresh rock are usually gradational. Geological structures in the fresh rock are usually preserved in the decomposed rock. "Weathered" and "altered" are more specific terms.	Zone, of any shape, but commonly with roughly parallel planar boundaries composed of soil substance. May show layering roughly parallel to the zone boundaries. Geological structures in the adjacent rock do not continue into the infill substance.
ENGINEERING PROPERTIES [3,4]	• Where uniformly developed in a rock substance any of these types of structure render that rock substance anisotropic in its behaviour under stress • Comprehensive strengths and initial shear usually { min when β = 30° to 45°; max when β = 0° to 90° • Tensile strength usually { max when β = 0°; min when β = 90° Deformation Modulus usually higher for β = 0° than for β = 90° When not uniformly developed, these structures represent defects in the rock mass i.e. as individual layers or layered zones. 			• Tensile strength low/zero • Sliding resistance depends upon properties of coatings or cement and/or condition of surfaces PARAMETERS c Cohesion of coating/cement/ wall-rock Ø Friction angle of coating/ cement/ wall-rock i Angle of roughness of surface k_n Normal stiffness k_s Tangential stiffness	• Rock properties, very fissile rock mass • When excavated forms GRAVEL / • SOIL properties, GRAVEL • Both types show extreme planar anisotropy. Lowest shear strength in direction of slickenslides, in plane parallel to boundaries.	• SOIL properties either cohesive or non-cohesive • Usually shows planar anisotropy; lowest shear strength in direction of slickensides in plane parallel to boundaries	• Extremely decomposed seam has SOIL properties usually cohesive but may be non-cohesive • Mostly very compact except when soluble minerals removed • Slightly to highly decomposed substances. ROCK properties but usually lower strengths than the fresh rock substance.	• SOIL properties, usually cohesive but may be non-cohesive.
				Engineering properties commonly different from place to place especially where the defect passes through several different rock substance types.				
EXTENT	Usually governed by the thickness and lateral extent of the rock substance or mass containing the defect.	May occur in a zone continuous through several different rock substance types.		From 10mm to 50m or more, depends on origin.	Generally large (50m to many km)		Weathered zones related to present or past land surface limited extent. Altered zones occur at any depth.	Usually small, limited to mechanically weathered zone. Can be great in rocks subject to solution.
ORIGIN (USUALLY CONTROLS EXTENT)	Deposition in layers	• Viscous flow • Crystal grown at high pressures and temperatures • Shearing under high confining pressure	• Shearing during folding or faulting • Consolidation compaction	• Shearing, extension or torsion failure, arising from faulting, folding relief of pressure, shrinkage due to cooling or loss of fluid	FAULTING • Shear failure by small displacements along a large number of near-parallel intersecting planes • The different strengths of types R and S are usually due to a) Different depths of rock cover at the time of faulting, or b) Later cementation, or c) Later mechanical weathering	• Failure by large movement within narrow zone • Generally formed at shallow depth (<3000m)	• Decomposition of minerals, removal or rupture of cement, due to circulation of mineralized waters usually along joints, sheared zones or crushed zones	• Cohesive soil carried into open joint or cavity as a suspension in water • Non-cohesive soil falls or washes in
DESCRIPTION REQUIRED	Bed thickness, grain types and sizes	Fabric description and spacing and extent of microfractures		Shape, aperture, surface condition, coating, filling, extent	Zone width, shape and extent			
	Ease of splitting and nature of fracture faces				Pattern of joints or micro-fractures and resulting shape and size of unit blocks. Standard description of joints.		Degree of Decomposition	
						Standard description of soil or rock substance		
ASSOCIATED DESCRIPTION ETC	Graded – , discord – , and slump-bedding; other primary structures: facing, attitudes and lineations	Attitude of planes and of any linear structure extent		Spacing, attitude of joint and/of slickenslides	Attitude of zone. Direction of slickenslides and amount, direction, and sense of displacement. Type of fault. History of past movements. Any modern activity. Likelihood of future movements. The terms "major" and "minor" fault are defined whenever used. The definitions are made on the basis of a) width and nature of the fault materials b) significance to the project.		Attitude of zone. Classify as weathered or altered if possible and determine origin, and defect or defects influencing decomposition.	Attitude of zone. Type of defect which is infilled, origin of infill substance.
		Allocate to set determine origin type						
MAP SYMBOLS (TO RIGHT SYMBOLS IN SEQUENCE HORIZONTAL, VERTICAL, DIPPING)								

NOTES

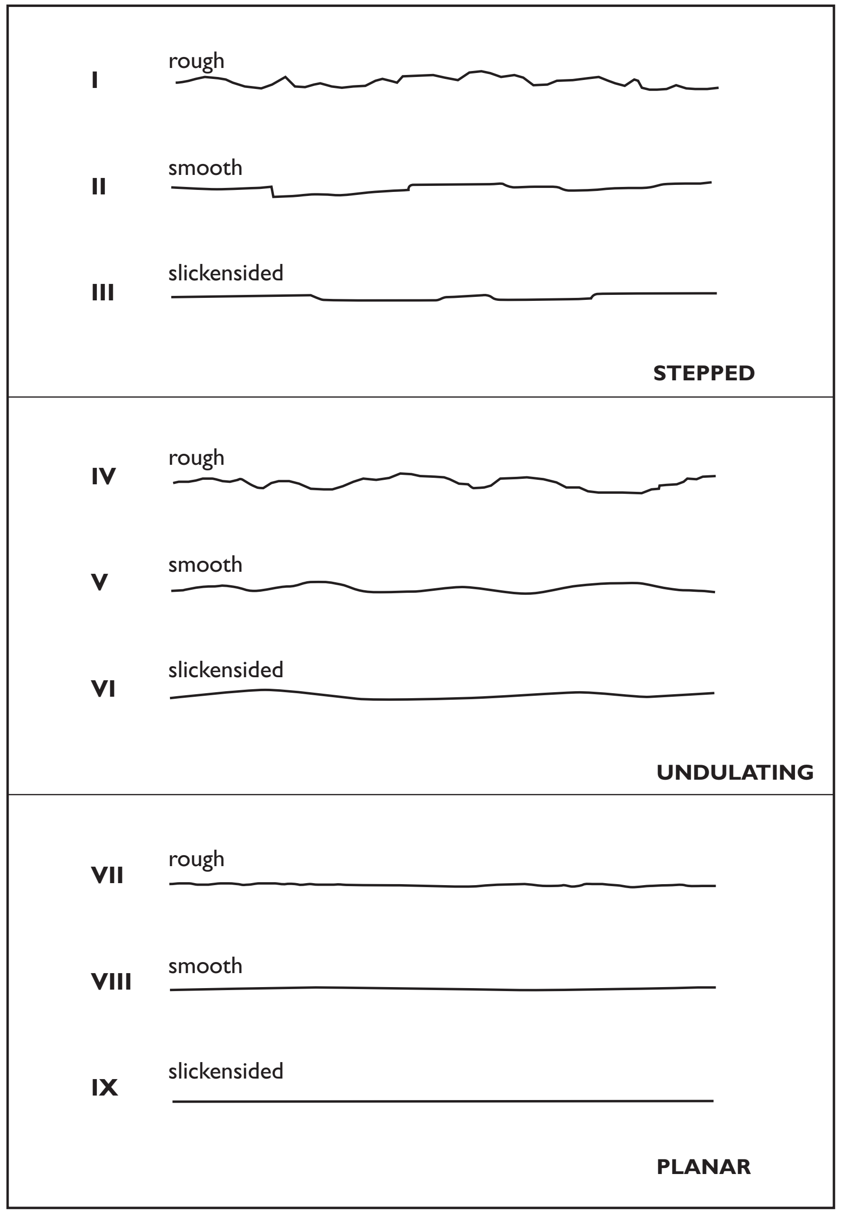
Adapted from Stapledon (1973).

1. The actual defect is described, not the process which formed or may have formed it e.g. "sheared zone" not "zone of shearing", the latter suggests a currently active process.
2. The terms "layering", "bedding" etc are used as the main headings on this portion of the table instead of "layer", "bed" etc. This is for convenience in descriptions and other notes, allowing them to refer to both rock substances and masses.
3. These notes refer to the engineering properties of the defect type, not those of the rock mass containing the defect.
4. In general each rock defect is more permeable than the substance in which it occurs, and the defect strength becomes lower with increase in water content/pressure.

3.2.6.4 Roughness

A discontinuity surface may be planar, undulating or stepped. Descriptive terms given in Table 3.8 occur at both small scale (tens of millimetres) and large scale (several metres). Both roughness and waviness contribute to the shear strength. Large scale waviness may also alter the dip locally.

Table 3.8 Roughness and Aperture



3.2.6.5 Wall Strength

Wall strength is the equivalent compressive strength of the adjacent rock walls of a discontinuity, and may be lower than the rock material strength due to the weathering or alteration of the walls. The shear strength of a discontinuity may be significantly affected by the condition or strength of the rock forming the walls of the discontinuity, particularly where infill is limited or the rock walls are in contact. An estimate of unconfined compressive strength can be obtained by using the Schmidt Hammer value (Deere & Miller 1966).

3.2.6.6 Aperture

The mean perpendicular distance between adjacent rock walls of a discontinuity, in which the intervening space is filled with air or water, as described in Table 3.9.

Table 3.9 Aperture of Discontinuity Surfaces

Term	Aperture (mm)	Description
Tight	Nil	Closed
Very Narrow	> 0 – 2	
Narrow	2 – 6	
Moderately Narrow	6 – 20	Gapped
Moderately Wide	20 – 60	Open
Wide	60 – 200	
Very Wide	> 200	

3.2.6.7 Infill

Material that separates the adjacent rock walls of a discontinuity and that is usually weaker than the parent rock. The infill may be soil introduced to the opening, minerals such as calcite or quartz, or clay gouge or breccia in a fault.

The width of an infilled discontinuity may, together with the roughness, be important in determining the resistance to shear along the discontinuity.

The infill material should be identified and described, and the strength of the infill assessed.

3.2.6.8 Seepage

Water flow and free moisture visible in individual discontinuities or in the rock mass as a whole should be described and if appropriate, the rate of flow estimated.

3.2.6.9 Number of Sets

Systematic discontinuity sets are parallel or sub-parallel sets of discontinuities that tend to be persistent. The number, orientation and spacing of sets will influence block size and shape.

Discontinuities that are irregular or have limited persistence, without arrangement into distinct sets are called non-systematic.

3.2.6.10 Block Size and Shape

The size of blocks bound by discontinuities can be described using the terms in Table 3.10.

Table 3.10 Description of Block Size in the Rock Mass

Term	Average Dimension
Very Small	< 60 mm
Small	60 – 200 mm
Medium	200 – 600 mm
Large	600 mm – 2 m
Very Large	> 2 m

The shape of blocks is dependent on the spacing of discontinuities and the relative persistence of the different discontinuity sets. On weathering, block shape alters by rounding of block edges. Terms given in Table 3.11 can be used to describe rock block shape.

Table 3.11 Rock Mass Block Shape

Block Shape	Discontinuity Arrangement
Polyhedral	Irregular discontinuities without arrangement into distinct sets, and of small persistence
Tabular	One dominant set of parallel discontinuities (eg bedding planes), with other non-continuous discontinuities; block length and width >> thickness
Prismatic	Two dominant sets of discontinuities orthogonal and parallel, with a third irregular set; block length and width >> thickness
Equidimensional	Three dominant orthogonal sets of discontinuities, with some irregular discontinuities
Rhomboidal	Three or more dominant, mutually oblique sets of discontinuities; oblique shaped equidimensional blocks
Columnar	Several (usually more than three) sets of continuous, parallel discontinuities crossed by irregular discontinuities; length >> other dimensions

3.2.6.11 Rock Name

The most common rock names are given in Table 3.12 although more common usage is limited to the names in uppercase. The table follows general geological practice, and the inclusion is intended as a guide only as geological training is required for satisfactory identification. It must be remembered that engineering properties cannot be inferred from rock names.

3.2.6.12 Additional Features and Geological Information

This includes all additional relevant information such as the name of the geological unit. Additional information may be particularly important when describing weathered rocks that have the properties of soils (e.g. residual soils). In such cases a description of the material as a soil (Section 2.0) should also be given.

Table 3.12 Common Rock Names

Grain size, mm	Bedded Rocks (mostly sedimentary)						Foliated rocks (mostly metamorphic)	Rocks generally with massive structure and crystalline texture (mostly igenous)					
More than 20	Grain size description		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix	At least 50% of grains are carbonate	At least 50% of grains are fine-grained volcanic rock		GNEISS Well developed but often widely spaced foliation sometimes with schistose bands	MARBLE	Grain size description	Pegmatite			
20 – 6 – 2	RUDACEOUS		BRECCIA Irregular rock fragments in a finer matrix	LIMESTONE and DOLOMITE (undifferentiated) Calcirudite	Fragments of volcanic ejecta in a finer matrix Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	SALINE ROCKS Halite	Migmatite Irregularly foliated: mixed schists and gneisses	QUARTZITE HORNFELS	COARSE	GRANITE[1]	Diorite[1,2] Granodiorite[1,2]	GABBRO[3] Amphibolite	Peridotite Serpen-tinite
0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals	Calcarenite	Cemented volcanic ash TUFF	Anhydrite Gypsum	SCHIST Well developed undulose foliation; generally much mica		MEDIUM	Microgranite[1]	Microdiorite[1,2] Micro-granodiorite[1,2]	Dolerite[3,4]	
0.2		Medium	QUARTZITE Quartz grains and siliceous cement ARKOSE Many feldspar grains										
0.06		Fine	GREYWACKE Many rock chips										
0.002	ARGILLACEOUS		MUDSTONE: SILTSTONE Mostly silt	Calcareous mudstone Calcisiltite	Fine-grained TUFF		Textural zones (II-IV) identified on basis of mineralogy and development of foliation		FINE	RHYOLITE[4,5,7] IGNIMBRITE[7]	ANDESITE[4,5,7] DACITE[4,5]	BASALT[4,5]	
Less than 0.002			MUDSTONE: CLAY STONE Mostly clay	Calcareous mudstone Calcilutite	Very fine-grained TUFF								
Amorphous or crypto-crystalline			Chert: occurs as nodules and beds in limestone and calcareous sandstone			COAL LIGNITE	MYLONITE found in fault zones, mainly in igneous and metamorphic areas			Obsidian[5]	Volcanic glass[7]		
			Granular cemented, except amorphous rocks				CRYSTALLINE			Pale ← Colour → Dark			
			SILICEOUS	CALCAREOUS	overlap with effusive igneous	CARBON-ACEOUS	SILICEOUS	mainly SILICEOUS		ACID Much quartz	INTER-MEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC

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.

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 recognise except by association. Any rock baked by contact metamorphism is described as a '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. Commonly strong and not porous when fresh, except in many cases for ignimbrite.

Mode of occurrence:

1. Batholiths
2. Laccoliths
3. Sills
4. Dykes
5. Lava flows
6. Veins
7. Effusive and ejecta

This table follows general geological practice but is intended as a guide only. Geological training is required for the satisfactory identification of rocks. Engineering properties cannot be inferred from rock names in the table.

3.3 ORDER OF TERMS – ROCKS

The rock description method given in this document is in one paragraph, using the sequence of terms given in Table 3.13. The whole sequence is written in the lower case except for the rock name. Terms in the sequence are separated by commas.

Table 3.13: Sequence of Terms

Weathering
Colour
Fabric
ROCK NAME
Strength
Discontinuities
[Additional features and geological information]

Examples are given in Tables 3.14 to 3.16.

Table 3.14: Example of Rock Description

Main Paragraph	Example	Item
Weathering	Unweathered	Visual characteristics
Colour	Grey	
Fabric	Foliated	
Rock Name	SCHIST	Rock name
Qualifying Paragraph		
Strength	Strong	Rock mass qualifications
Discontinuities	Foliation dips 20-25°, well-developed; several thin sheared zones along foliation. Steep joints moderately widely spaced.	
Geological Information	HAAST SCHIST Textural Zone 4	Additional information

The example in Table 3.14 should be written:
Unweathered, foliated, grey SCHIST; strong; foliation dips 20-25°, well developed, with several thin sheared zones along foliation. Joints steep and moderately widely spaced [HAAST SCHIST Textural Zone 4].

Table 3.15: Example of Rock Description

Main Paragraph	Example	Item
Weathering	Highly weathered	Visual characteristics
Colour	Light yellow-brown	
Fabric	Homogeneous	
Rock Name	SANDSTONE	Rock name
Qualifying Paragraph		
Strength	Very weak	Rock mass qualifications
Discontinuities	Joints closely spaced; very narrow to tight	
Geological Information	TORLESSE SUPERGROUP greywacke	Additional information

The example in Table 3.15 should be written:
Highly weathered, light yellow-brown, homogeneous SANDSTONE. Very weak; closely spaced joints very narrow to tight [TORLESSE SUPERGROUP greywacke].

Table 3.16: Example of Rock Description

Main Paragraph	Example	Item
Weathering	Slightly weathered	Visual characteristics
Colour	Blue-grey	
Fabric	Indistinctly bedded	
Rock Name	SILTSTONE	Rock name
Qualifying Paragraph		
Strength	Extremely weak	Rock mass qualifications
Discontinuities		
Geological Information	MANGAWEKA MUDSTONE	Additional information

The example in Table 3.16 should be written:
Slightly weathered, blue-grey, indistinctly bedded SILTSTONE; extremely weak [MANGAWEKA MUDSTONE].

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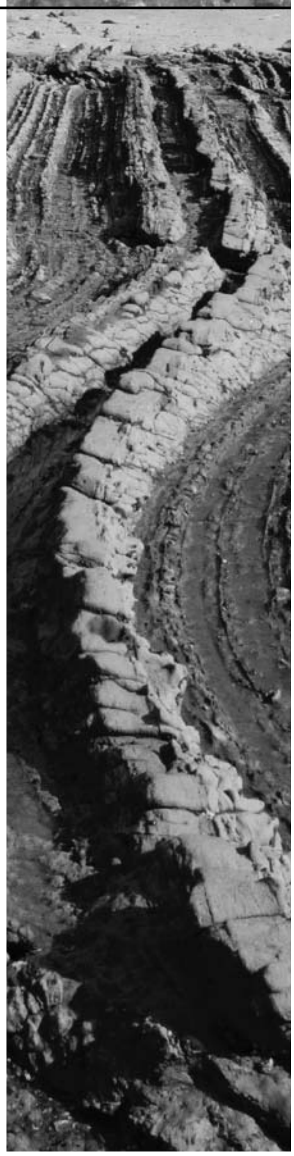

This guideline for the field classification and description of soil and rock for engineering purposes is prepared by members of the New Zealand Geotechnical Society for use by geo-practitioners in New Zealand.
The document draws from methods and standards published internationally and brings them together in a manner directly applicable to New Zealand conditions. The principal aim of the guideline is to reduce the variability of descriptions of materials encountered in investigation and construction of an engineering project by providing a range of defined terms from which an appropriate selection can be made. The guideline should be used in the field to check that as full a description as possible is given.