

Numeric coding of rock, soil & defect descriptions

G.J. Cocks

Golder Associates, Sydney, Australia

ABSTRACT: Numeric coding of rock, soil and defect descriptions is a useful extension of the usual geological descriptive techniques. It provides a 'standard' description that is allied with a fuller written description and is more easily manipulated. Computer input of this coded description allows data analysis and correlation, especially into semi-discrete data sets. It is a flexible system that can be adapted to suit a variety of situations.

1. INTRODUCTION

Numeric coding of rock, soil and defect description is a useful extension of standard engineering geological and geotechnical site investigation description; it can be a fruitful exercise in all situations where a soil, rock or defect is described. In a full description of a discrete soil, rock or a defect, a series of descriptive terms should be included as a matter of course. For instance, a rock description will (or should!) include a description of the strength, weathering, colour, rock name, etc (as specified in AS1726-1993). It is believed that these various selected parameters are basic to any rock & soil material and defect description.

The system here presented aims to 'strip out' these routine components from the written description and present them in a standardised numeric format; the remainder of the valuable descriptive information is retained in the more usual written structure. Similar systems are routinely used for data collection on defects in rock mechanics studies.

This method does not and is not designed to in any way reduce the need for annotated sketches, photographs, cross-sections and the variety of other investigative tools and methods used (as described by Bell & Petinga (1984) and Stapledon (1984) amongst numerous others). Geotechnical site investigation is an exercise in applied geology; the observer needs to understand the site as a whole as well as being able to describe its various parts.

This paper attempts to presents a methodology of 'standardised' description that can be used in a variety of situations. It is believed that the system will be flexible enough to adapt to differing needs of various projects. It is however beyond the scope of this paper to be a comprehensive outline of soil, rock and defect description. The recent Australian Standard (AS1726-1993) fulfils this function for geotechnical site investigation, and the method presented here conforms to and is seen as being an extension of that same Standard.

2. USE OF THE PROPOSED NUMERIC DESCRIPTION CODING

The three tables for description presented within this paper are almost self-explanatory; that is, a practitioner of soil, rock & defect description should be able to immediately use them in a field situation. Each feature in turn is assigned a number corresponding to a descriptive category as presented in

the lower part of the information table (see Figures 1 to 3 for soil, rock and defects respectively). For instance, if the soil unit being described is deemed by the observer to be "firm" then a "3" would be placed in the ninth column (with the abbreviated title 'consist.'). This system is flexible in that columns can be removed or added for particular projects (for instance, the addition of a column recording depth might be useful in some situations); what the numeric coding describes can also be altered (for instance, it may be useful to more finely divide a defects spacing interval).

It is envisaged for field description of an outcrop of a series of rock, soils and/or defects a unique reference code (number, letter or symbol) would be assigned to each soil or rock material and/or defect; an annotated geological sketch (as per Stapledon (1984), etc) would show the relationship of all features and separate sheets would record the description (the description sheets also having the 'usual' place for job description, date, etc). Three reference sheets would include the numeric coding for the components of soil, rock and defect descriptions. For a borehole, etc a similar method would be used except that the unique reference code would be marked on the relevant place on the log. That is, the unique reference code would simply correlate the sketch, borelog, etc to the descriptive sheet; there is not and should not be any inference that this reference code is a means of describing a discrete geologic unit that occurs across two or more sites; a rock with a reference code of say '10' at two locations does not necessarily apply to the same stratigraphic unit.

For a soil mixture, a two section code may be used to describe a unit. For example, on the annotated sketch log might be "40% #1 clasts in a matrix of 60% #2", with #1 and #2 described separately on a rock and soil log respectively. Descriptions of soil layering, defects, fabric, organic content and nature, etc are important pieces of information and should be recorded in the written description.

The naming of rocks is described to some extent in AS1726-1993 and Appendix I of Smith & Minty (1979); otherwise a geology dictionary or text book can be used. The exactness of the rock type characterisation depends upon the needs of the project for which the work is being done. However, no list of rock names can be comprehensive or flexible enough to cover all project's needs, so the inclusion of "43 other" is necessary for use in some projects (i.e., for a trachyandesite, latite, metasiltstone, carbonate breccia, etc).

Describing defects in terms of spacing and persistence was first concisely put forward by the Geological Society Working Party (1972), and transferred to an Australian context by Smith & Minty (1979). The author has found that the ranges of spacing and persistence used by Bell & Petinga (1984) are the most useful and flexible in a variety of situations; however, an observer can of course adjust these ranges to suit his or her particular needs.

3. ADVANTAGES & DISADVANTAGES OF THE PROPOSED NUMERIC DESCRIPTION CODING

The proposed description coding system has a number of advantages:

- all of the 'standard' information is gathered; an empty "cell" on the description table is more immediately noticeable than a missed word within a full written description
- the 'standard' description provides a minimum level of descriptive information for each unit or defect at all locations and is an excellent starting point for a fuller written description
- once an observer 'learns the system', it can be quicker to use (i.e., a single digit is more easily written than 3 to 4 words)
- the system produces comparable result for each soil rock and defect description collected, allowing for a greater uniformity of data storage, presentation and comparison
- it allows for computer input, storage, manipulation and comparison (see §4). The data is then available to be used in a variety of different ways using the computer (e.g., a stereonet, a spreadsheet-drawn graph, etc).
- it enables more than one observer to gather uniform data at the same location

The system also has some disadvantages:

- in some situations it can be too inflexible; however the written description can reduce this
- an observer can get too caught up in the systematics of description and loose site of the overall aim — that is, a clear understanding of the geological and geotechnical situation. This can be reduced by training and experience
- there is a risk of transcription errors converting the data from the field sheets to the computer file as the numeric coding has no inherent 'check-ability'; this can be reduced by making sure that the collector of the data also inputs it to the computer (as suggested by Stapledon, 1984).

4. USE OF A COMPUTER

Computers are able to perform repetitive tasks quickly and consistent; as such, they are useful tools in analysing the patterns inherent in geologic materials and defects. This ability to quickly manipulate the data (and recognise that, for example, that the low angle defects with high persistence and a clay infill are generally sloping into the hillside) is very valuable; time or budget constraints may have meant this form of data correlation was not undertaken if the work needed to be done manually. Examples of this type of data analysis might include plotting strength versus depth down a borehole, comparing a defects orientation and infill with groundwater flow, and so on.

The ability to package individual materials or defects into (semi)discrete data sets makes analysis and design a smoother and more confident proposition (e.g., defect Set 'A' = potential basal rupture surfaces with clay infills and dip directions ranging from 178° to 186° and dips less than 12°; defect Set 'B' = potential crown release surfaces with sub-vertical dips and open to 15mm, etc).

As the data will usually be stored in a permanent electronic format, there is also the option of constantly re-evaluating the data as fresh information comes to hand, comparing a newly logged location with a previous location, even comparing a new job site with another in a similar geological setting, etc

As an example, the author was recently involved in the logging of defects in orientated core to aid in the stability analysis and consequent design of a road cut. Systematic descriptions was made of each defect, and its orientation using a system similar to that presented in Figure 3. Computer analysis of the data (using a spreadsheet and the stereonet program 'DIPS') enabled useful information on the nature of the defects to be noted within particular defect sets that would have been impractical using a 'manual' system.

5. SUMMARY

The numeric descriptive coding system presented in this paper is considered a useful extension of the standard method for describing soil, rock and defects. It is a system that is adaptable to the project in hand or can be used "off the shelf" for smaller jobs.

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Soil Description

Unique Reference Code	Major Div.	Major Sub.Div	Soil Name	UCS Symbol	Plastic.	Colour	Moist.	Consist.	Inferred Origin	Notes & Written Description

MAJOR DIVISION

- 1 boulders (> 200 mm)
- 2 cobbles (63 → 200 mm)
- 3 gravels (more than half of coarse fractions is greater than 2.36 mm)
- 4 sands (more than half of coarse fractions is less than 2.36 mm)
- 5 silts & clays (liquid limit < 50%)
- 6 silts & clays (liquid limit > 50%)
- 7 highly organic soils

MAJOR SUBDIVISION (IF APPLICABLE)

- 3/1 coarse (20 → 63 mm)
- 3/2 medium (6 → 20 mm)
- 3/3 fine (2.36 → 6 mm)
- 4/1 coarse (0.6 → 2.36 mm)
- 4/2 medium (0.2 → 0.6 mm)
- 4/3 fine (0.075 → 0.2 mm)

NAME

Based on particle size distribution and plasticity (e.g., "silty SAND with some clay" where "some" is 5→12% and "trace" is < 5%)

UNIFIED SOIL CLASSIFICATION (USC) SYMBOL

These are the standard symbols as described in the Australian Standard and elsewhere (i.e., GW, GP, GM, GC, SW, SP, SM, SC, ML, CL, CI, MH, CH, OH & Pt)

MOISTURE

- 1 dry
- 2 moist
- 3 wet

PLASTICITY

- 1 low plasticity ($\leq 35\%$)
- 2 medium plasticity ($> 35\%, \geq 50\%$)
- 3 high plasticity ($> 50\%$)

COLOUR

- 1 pink
- 2 red
- 3 yellow
- 4 brown
- 5 olive
- 6 green
- 7 blue
- 8 white
- 9 grey
- 0 black

Brackets after primary colour for secondary colour and/or modification
 A pale
 B dark
 C mottled

CONSISTENCY

Essentially cohesive soils:—

- 1 very soft
- 2 soft
- 3 firm
- 4 stiff
- 5 very stiff
- 6 hard

Essentially non-cohesive soils:—

- 7 very loose
- 8 loose
- 9 medium dense
- 10 dense
- 11 very dense

INFERRED ORIGINS

This column allows some interpretation of the origins of soil to be added to the descriptive sheet in the field. This might include terms like 'alluvial', 'colluvial', 'topsoil', 'A horizon', 'O₁ horizon', 'fill', etc. The vast range of possible inferred origins and the varying needs of often disparate projects make defining a formal set of names in this instance unnecessarily restrictive. The inferred origin is an interpretation that may need to be reviewed and changed during the course of the project.

Figure 1: Soil Description Table and Descriptive Numerals

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Rock Description

Unique Reference Code	Rock Name	Grain Size (mm)	Fabric	Colour	Strength	Weath.	Struct.	Notes & Written Description
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ROCK NAME (after Bell & Pettinga, 1984)

- Sedimentary, clastic
- 1 conglomerate
- 2 agglomerate
- 3 breccia
- 4 sandstone
- 5 siltstone
- 6 mudstone
- 7 tuff
- 8 claystone
- Sedimentary, chemical/organic
- 9 limestone
- 10 chert
- 11 other siliceous
- 12 coal
- 13 other carbonaceous
- 14 laterite
- 15 other ferrigneous
- 16 rock salt
- 17 gypsum
- 18 other saline
- Igneous, extrusive, silicic
- 19 rhyolite
- 20 obsidian
- 21 dacite
- Igneous, extrusive, intermediate
- 22 trachyte
- 23 andesite
- Igneous, extrusive, mafic
- 24 dolerite
- 25 basalt
- Igneous, extrusive, ultramafic
- 26 serpentinite

- Igneous, intrusive, silicic
- 27 granite
- 28 granodiorite
- Igneous, intrusive, intermediate
- 29 syenite
- 30 diorite
- Igneous, intrusive, mafic
- 31 gabbro
- Igneous, intrusive, ultramafic
- 32 peridotite
- 33 dunite
- Metamorphic, foliated
- 34 gneiss
- 35 schist
- 36 phyllite
- 37 slate
- 38 mylonite
- Metamorphic, massive
- 39 hornfels
- 40 marble
- 41 quartzite
- 42 amphibolite
- Other
- 43 other (specify in notes)

GRAIN SIZE

Grain size (in mm), often best done from a comparative chart.

FABRIC

- 1 finely layered (< 25 mm)
- 2 coarsely layered (25-100 mm)
- 3 massive (> 100 mm)
- 4 other (specify in notes)

COLOUR

(as per soils)

STRENGTH

- 1 EL extremely low
- 2 VL very low
- 3 L low
- 4 M medium
- 5 H high
- 6 VH very high
- 7 EH extremely high

WEATHERING

- 1 RS residual soil
- 2 XW extremely weathered
- 3 DW distinctly weathered
- 4 SW slightly weathered
- 5 FR fresh

STRUCTURE

- Sedimentary
- 1 massive ('layering' > 100 mm thick)
- 2 bedded
- 3 laminated ('layering' < 20 mm thick)
- Metamorphic
- 4 'massive'
- 5 foliated
- 6 banded, cleaved
- Igneous
- 7 'massive'
- 8 flow banded
- Other
- 9 none evident

Figure 2: Rock Description Table and Descriptive Numerals

Defect Descriptions

Unique Reference Code	Possible Set Nb.	Inferred Type	Spacing	Persist.	Strike	Dip°	Dip Direction (N,S,E,W)	Ground-Water	ISRM 'Code'	Infill or Coating	Material Forming Defect	Infill Thickness or Opening (mm)	Notes

POSSIBLE SET NUMBER

This is a possible set number assigned based on the interpretation of the data. This column might not be filled in until some data analysis (possibly with the aid of a stereonet) has been completed; indeed it might be left totally blank.

INFERRED TYPE

- 1 bedding
- 2 foliation
- 3 cleavage
- 4 joint
- 5 sheared zone ('R' to 'S' degree (see ASI726-1993) described in notes)
- 6 crushed seam/zone
- 7 decomposed seam/zone
- 8 infilled seam/zone

SPACING (from Bell & Pettinga, 1984)

- 1 extremely wide > 2 m
- 2 very wide 0.5 — 2 m
- 3 wide 200 — 500 mm
- 4 moderate 100 — 200 mm
- 5 close 25 — 100 mm
- 6 very close 5 — 25 mm
- 7 extremely close < 5mm

PERSISTENCE (from Bell & Pettinga, 1984)

- 1 very high > 10m
- 2 high 5 — 10m
- 3 moderate 2 — 5m
- 4 low 0.5 — 2 m
- 5 very low < 0.5m

STRIKE, DIP, DIP DIRECTION

This is of course the most crucial part of the defect description. An example might be 135/82°W Conversely DDIR, and DIP might be the column headers, with 225/82° being the resultant. Two columns might also be added (as per Bell & Pettinga, 1984) for error bounds on the defect measurement (e.g., ±5°).

GROUNDWATER (after Bell & Pettinga, 1984)

- 1 dry
- 2 seepage < 1 ml/sec
- 3 very low flow 1 — 10 ml/sec
- 4 low flow 10 — 100 ml/sec
- 5 moderate flow 0.1 — 1 l/sec
- 6 large flow 1 — 10 l/sec
- 7 very large flow > 10 l/sec

ISRM 'CODE' (from ISRM, 1978)

- I stepped; rough or irregular
- II stepped; smooth
- III stepped; slickensided
- IV undulating; rough or irregular
- V undulating; smooth
- VI undulating; slickensided
- VII planar; rough or irregular
- VIII planar; smooth
- IX planar; slickensided

COATING/INFILL

- 1 clean
- 2 stain
- 3 veneer
- 4 coating
- 5 infill

MATERIAL FORMING DEFECT

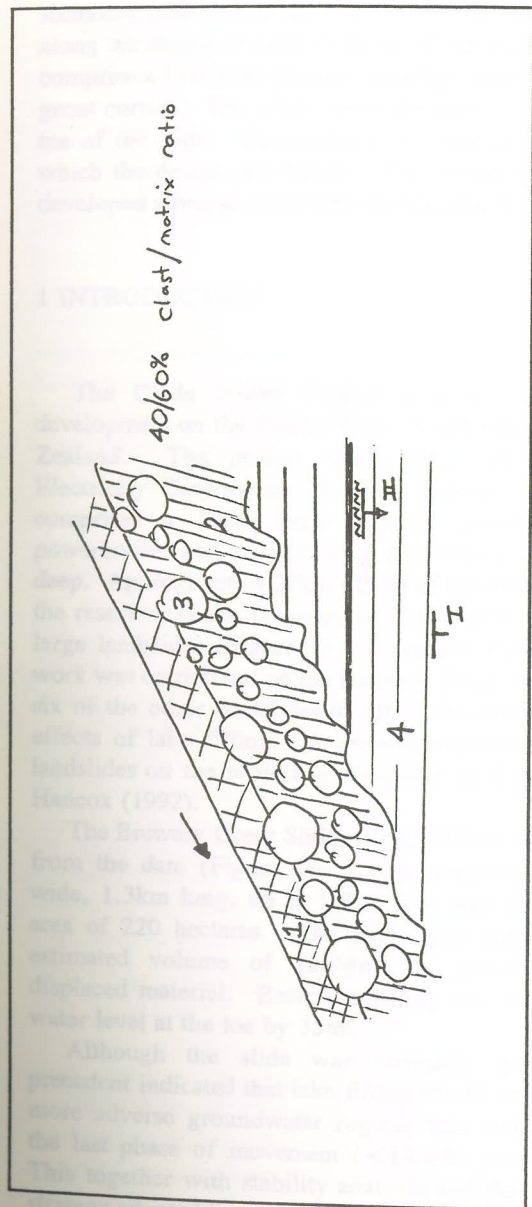
- 1 none
 - 2 iron stain / limonite
 - 3 zeolite
 - 4 crushed rock
 - 5 clay
 - 6 other (specify in notes)
- [NOTE: the material forming the defect can be (and often should be) described separately as a 'soil']

MATERIAL THICKNESS OR OPENING

Note in millimetres

Figure 3: Defect Description Table and Descriptive Numerals

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Location:

Unique Reference Code	Major Div.	Major Sub.Div	Soil Name	UCS Symbol	Plastic.	Colour	Moist.	Consist.	Inferred Origins	Notes & Written Description
1	5	/	Sandy SILT	OL	1	4	1	3	developed in situ	topsoil; well-developed; some organics
2	5	/	Sandy CLAY	CL	2	(2)4	2	3	"talus"	matrix of talus deposit is, colloidal

Unique Reference Code	Rock Name	Grain Size (mm)	Fabric	Colour	Strength	Weath.	Struct.	Notes & Written Description
3	4	0.3	2	3	3	2	2	"talus" clasts
4	4	0.3	2	4(3)	5	2(1)	2	

Unique Reference Code	Possible Set Nb.	Inferred Type	Spacing	Persist.	Strike°	Dip°	Dip Direction (N,S,E,W)	Ground-Water	ISRM 'Code'	Infill or Coating	Material Forming Defect	Infill Thickness or Opening (mm)	Notes
I		4	3	3+	016	42	E	1	VIII	1	1	0	regular spacing; distinct beds bedding shear; 'S' type
II		5	n/a	4	020	14	E	2	VII	5	5	10	

Figure 4: "Mock Example" of Log of Outcrop