The "new" British and European standard guidance on rock description. A critique by Steve Hencher.

Note: It is recommended that the reader sees this month's Talking Point (page seven) in conjunction with this article.

Changes have been made to UK national standards for the description and classification of soil and rock for engineering purposes, some of which, I believe, are highly undesirable.

The document entitled *Eurocode 7: Geotechnical Design Part 1: General Rules* has the status of a British Standard – BS EN 1997-1:2004 and was published on 22 December 2004. In the national foreword to the document it is noted that, following its publication, there is a period of two years allowed for a "national calibration period" followed by a three-year "coexistence period".

It is stated that at the end of this coexistence period (presumably 22 December 2009) various British Standard (BS) publications relating to geotechnical practice will be withdrawn. This includes BS 5930:1999, the British code of practice for site investigations that provides guidance on soil and rock description for engineering purposes, among other things.

In the meantime a changed version of *BS 5930:1999 Incorporating Amendment 1* was published on 31 December 2007 with the various amendments clearly identified. In explanation it is stated that: "Amendment 1 to this standard (primarily to Section 6) removes text superseded by BS EN ISO 14688-2:2004 and BS EN ISO 14689-1:2003". These new documents deal with soil and rock description. It is also stated in the amended version of BS 5930 that: "As a code of practice, this British Standard takes the form of guidance and recommendations in contrast to specifications such as BS EN ISO 14688-1:2002, BS EN ISO 14688-2:2004 and BS EN ISO 14689-1:2003, which take the form of requirements" (emphasis added).

In summary, Eurocode 7 now rules and British Standards such as BS 8004:1986 Code of practice for foundations and BS 5930:1999 are to be withdrawn or reissued so there is no conflict with new European documents. In terms of soil and rock description the BS EN ISO 14688 and 14689 documents take precedence over Section 6 of BS 5930:1999, which appears to be a done deal.

Baldwin et al (2007) list the changes in rock and soil description requirements in a general way but without comment on technical merit. However, there are difficulties with the new guidance and many of the changes are poorly considered, sometimes retrograde and sometimes incorrect. An opportunity to improve matters has been missed.

History

The need for systematic description and classification of soils and rocks for civil engineering purposes has long been recognised. Unfortunately, in the 1960s and 1970s several international bodies and societies took it upon themselves to come up with a system – sometimes using the same terms to describe different things. Behind this there was a need for national standards and changes, brought about as the various original schemes were tried and tested in practice.

In 1984 a conference organised by the Engineering Group of the Geological Society of London devoted itself to discussing the then current British Code of Practice for Site Investigations, BS 5930:1981. The published proceedings ran to over 400 pages. A new version of BS 5930 was produced in 1999 – a much improved document that was used as a specification for ground investigation.

The terms and definitions employed were adopted within other BS documents and textbooks, for example, in defining design parameters. Compatible codes of practice and other guideline documents were developed elsewhere (such as Geoguide3 of the Geotechnical Control Office in Hong Kong (GCO, 1988) and CP4:2003 Code of Practice for Foundations in Singapore).

Other authoritative guideline documents such as ISRM (1978) had different scopes, and while there are some conflicts in terminology, these do not really matter, provided the practitioner is aware of the potential pitfalls and that care is taken to declare in documents what system and terminology is being employed.

The new EN documents

The new BS EN ISO documents published in 2002 to 2004 are now binding in the UK. It is understood they were prepared by committees with representatives from different countries in Europe. As indicated earlier and demonstrated below, the resulting *BS EN ISO 14689-1:2003 Geotechnical investigation and testing – Identification and classification of rock – Part 1: Identification and description* (the EN) is flawed.

The following discussion will consider parts of this document paragraph by paragraph. It should be borne in mind that the aim of a standardised description of soils and rocks for engineering purposes is to ensure repeatability and accuracy of communication. This means that those in the design office or tendering for a contract can understand clearly the ground conditions at site.

Clause	Comment
"Geological maps related to the project shall be used for the designation of rocks."	This is poor advice let alone specification. Many maps do not deal with geology at the scale and in the detail required for site-specific investigation. The author has experience of reviewing reports where the "geology" for a site has simply been summarised or interpreted from available published maps, whereas the actual site geology is considerably different. This clause encourages poor practice and incorrect engineering geological modelling.

Para 4.1 Rock Identification

Clause	Comment
"Rock material colour may be described using colour charts of an approved type."	The BS 5930:1999 advice was more detailed, for example, encouraging reporting of colour changes due to oxidation or desiccation. In terms of the colour charts that might be used, Munsell charts were specifically referred to in the BS which, while expensive and perhaps over the top for most descriptions, were designed with soil description in mind. The new reference to the use of colour charts "of an approved type" brings to mind the case where a colleague showed me a driller's log describing "blush" granite. We pondered over this for a while wondering whether he meant "bluish"? It turned out that blush was the best match for the weathered granite according to a lipstick guide that the driller had obtained conscientiously from the local beauty parlour…

Para 4.2.1 Colour

Para 4.1 Rock Identification (see table)

Para 4.2 Description of rock material

Para 4.2.1 Colour (see table)

Para 4.2.4 Weathering and alteration effects

The EN does not recommend any system of weathering grade classification for materials (intact weathered rock samples), which, in my opinion, is a retrograde step. This will be discussed further with Paragraph 4.3.4.

Para 4.2.6 Stability of rock material (see table)

Para 4.2.7 Unconfined compressive strength

Definition of terminology for ranges of unconfined compressive strength (UCS) has always been a problem with different sets of terms in use.

It has been decided for the EN to adopt the scale recommended in ISRM (1978) rather than that long used in the UK, Hong Kong and elsewhere.

"Weak" rock, for example, is now defined with a UCS of 5MPa to 25MPa, whereas the term was used to describe much weaker rock with a UCS of 1.25MPa to 5MPa in BS 5930:1999. "Moderately strong" rock now has a UCS of 25MPa to 50MPa compared with 12.5MPa to 25MPa in BS 5930:1999.

These changes conform to ISRM recommendations. However, there are disadvantages. For example:

1. Regarding the dropping of the 12.5 MPa boundary, generally rock of lower strength can be broken by hand whereas higher strength rock cannot. In engineering we commonly distinguish "soil" from "rock" using the hand breakage test, which is also the boundary between highly and moderately weathered rock – grades IV and III (GCO, 1988; BS 5930:1999).
2. Textbooks will have to be changed. For example Tomlinson (2001) in Table 2.3 suggests a presumed bearing value of > 1000kPa for "weak" limestone with discontinuity spacing > 600mm. This is based on the old definition of "weak" and needs revision.
3. The recommendations for bearing capacity for "weak and broken rocks" in *BS 8004:1986 Code of practice for foundations* were based on the old scale of UCS definition. The original BS figures have been redrawn and included in Appendix G of *Eurocode 7 BS EN 1997-1:2004* but are otherwise unchanged, that is to say, the old UK strength definitions of strength are still used. The Eurocode will have to be edited and reissued to comply with the new definitions for rock strength.

4.3 Rock Mass

4.3.3.2 Measurement of dip and dip direction

The amended BS 5930:1999 (2007) still has the same incorrect example in Table 13 ("dip direction/dip e.g. 015/018") as in the original but now has additional errors. Also the statement that number of sets "cannot be described in cores" might have been reconsidered for the new document because it is incorrect.

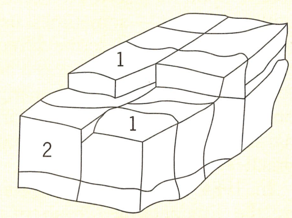
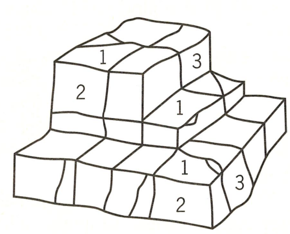
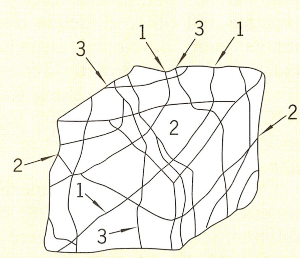
4.3.3.3 Discontinuity spacing and block shape (see table)

Definitions of spacing are as previously defined in BS 5930:1999, but it is now mandatory that, among other things, "the method of measurement (in core) shall be reported". However, it is not clear what that means in practice. A new series of figures has been introduced to describe rock mass structure, but these are not very illuminating as illustrated above.

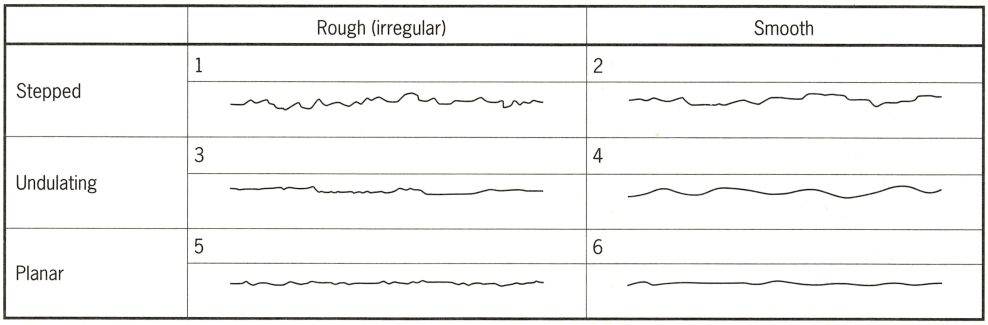
Without wishing to be overcritical, what is to be gained by using such terms, let alone insisting on their use? The table is poorly reasoned out, does not cover all struc-

Clause	Comment
It is a requirement of the EN that "the degradation of rock material when it is exposed to a new water or atmospheric environment should be assessed where the relevant conditions shall be determined". Three new terms are introduced: ""Stable, Fairly stable and Unstable."	This requirement is incomprehensible. It is also unclear whether this is mandatory for each encountered material – it would be hoped not because it would take a very long time and probably not be very productive. It is not known where the definitions of these three new terms have come from but they relate to the behaviour of samples submerged in water for 24h hours. "Fairly stable" includes material that "slakes" as distinguished from "Unstable" material where the "specimen disintegrates". Apart from the difficulty of distinguishing between disintegration and slaking this is a misuse and highjacking of the term "slakes", which is used in GCO (1988) and BS 5930:1999 to mean disintegration or disaggregation of a rock in a few minutes rather than 24 hours. The slake test has been used widely to distinguish "completely weathered or completely decomposed" from "highly weathered or decomposed material" since Moye introduced the test in 1955. This is a distinction of importance to tunnelling and other works in weathered rocks because of the potential for slakeable material to collapse and flow (see, for example, the discussions by Shirlaw 2003 and Knill 2003). If the authors of this document wished to introduce some new classification then they should have done so without redefining terms already used in geotechnical engineering to mean something else.

Para 4.2.6 Stability of rock material

Prismatic blocks "Two dominant sets of discontinuities (1 and 2) approximately orthogonal and parallel, with a third irregular set; thickness of blocks much less than length or width."		Comment: how are thickness, length and width defined? Blocks in the figure do not seem to tally with the descriptive criteria. Why is the third direction not identified (clearly shown as master joints in the sketch).
Equidimensional "Three dominant sets of discontinuities (1,2 and 3) approximately orthogonal, with occasional irregular joints""		Comment: how does this sketch differ substantially from the one above?
Rhomboidal "Three (ore more) dominant, mutually oblique, sets of joints (1, 2 and 3) giving oblique-shaped, equidimensional blocks""		Comment: apart from the typo, the sketch looks rather unrealistic and it is difficult to recognise that the blocks illustrated are 'oblique and equidimensional.

4.3.3.3 Discontinuity spacing and block shape. Note: images redrawn from the originals



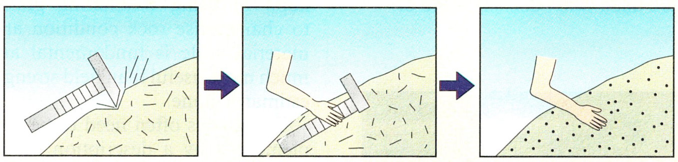
Key

1 stepped rough surface
2 stepped smooth surface
3 undulating rough surface
4 undulating smooth surface
5 planar rough surface
6 planar smooth surface

4.3.3.5 Roughness. Note: image redrawn from the original

Box 1: Prescriptive weathering classifications for rock that is strong or stronger in its fresh state

Prescriptive classification for uniform materials
(Terms are often used at a mass scale where zones are essentially uniform - zones 1 or 6 from next table)



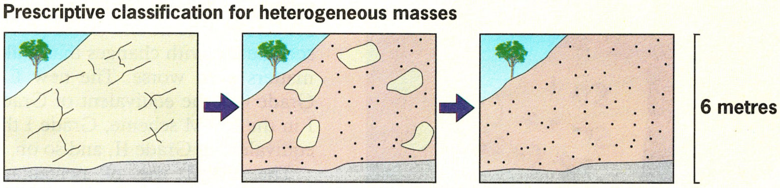
Grades		
I	Fresh	Rock
II	Discoloured	Rock
III	Weakened	Rock
IV	Broken by hand	Soil
V	Slakes in water	Soil
VI	No parent rock fabric	Soil

Approach 2 grading is used for classification of different strength uniform materials that can be sampled in boreholes or in the field and tested in the laboratory

This exposure near Busan, Korea is predominantly grades II, III and IV materials

The Approach 3 zonal scheme can be used to separate mixed volumes of different materials and assign design parameters on project scale. This scheme is more flexible and better defined than the ISRM, 1978 and new EN schemes

Prescriptive classification for heterogeneous masses



Zones	
1	100% rock
2	>90% rock
3	50-90% rock
4	30-50% rock
5	<30% rock
6	100% soil
Rock: grades I to III	
Soil: grades IV to VI	

Approaches 2 and 3 from BS5930:1999 (now defunct for the UK). Figures are from Hencher, 2000, modified from Anon, 1995.

tural geological conditions and is badly drawn.

Surely, in the desire to provide guidance at some best practice level, the scheme of description suggested by the ISRM (1978) might have been recommended.

Alternatively, consideration might have been given to adopting the geological strength index table (GSI) of Marinos and Hoek (2000), versions of which have been available for more than 20 years and which do have some direct end use for assessing rock mass properties.

4.3.3.4 Persistence of discontinuities

Discontinuities are defined earlier in the EN and described at 4.3.3.1 by "the tensile or shear strength across or along the surface is lower than that of the intact material", which, of course, includes any faint incipient bedding, cleavage or schistosity in a rock – that is, not only mechanical fractures.

At 4.3.3.4 it states that "the linear extent of discontinuities from their inception to their termination in solid rock mass or against other discontinuities has to be measured in metres". This is a daunting task and what, it is wondered, is the inception point of a discontinuity?

4.3.3.5 Roughness (see table)

No reference is made to Joint Roughness Coefficient (JRC), which is in common use for characterising the roughness of rock joints, or to practical measurement of roughness using plates or other profile measuring devices.

Again, reference might have been made to ISRM (1978), which deals with the subject well. Instead, a new series of profiles have been produced that are unhelpful and misleading (see above).

If these are to be used at all, profile 2 should be in profile 1, profile 2 in profile 3 and maybe profile 1 in profile 3, although it may equally be put in profile 5. A scale should also have been provided.

It is instructed that the term "slickensided" should only be used where there is clear evidence of shear displacement along the discontinuity. This is a rather purist geological direction and difficult to prove in practice, especially in core samples.

It is a poor directive that does not offer some alternative for describing important features that a
re often indicative of faulted ground and which are highly significant in terms of low shear strength and geological structure.

Indeed, there is no useful advice in this document on the description of discontinuity surface features ("fractography").

4.3.4 Weathering of the rock mass
One of the major criticisms at the 1984 conference was that the weathering classification scheme recommended in BS5930:1981 – the same as recommended by ISRM (1978), – does not work well in practice and conflicts with other well-established classifications.

The detailed evidence and reasoning may be found in Martin and Hencher (1986). That scheme is poorly defined, coarse and inflexible. No guidance was given in the 1981 document on the weathering classification of intact weathered rock samples, despite this being the scale at which logging and testing is conducted (Martin and Hencher, 1986; Cragg and Ingman, 1995).

Also, the weathering classification terminology recommended for rock masses by BS5930:1981 was the same as used elsewhere for intact weathered materials, which was, and is, an obvious source for confusion.

Following these criticisms the Engineering Group of the Geological Society of London formed a working party that reported with a recommended method for description and classification of weathered rock (Anon, 1995). Drafts of this report were widely circulated and discussed. Findings were adopted within BS5930:1999 and the application of Approaches 2 and 3 in that document are illustrated in Box 1.

Those recommendations do not conflict with systems for rock weathering classification used in Hong Kong and elsewhere where weathering is an important factor in geotechnical engineering, and were soon taken as the basis for revisions in Singapore (*CP4:2003 Code of Practice for Foundations*).

New schemes, totally compatible with the recommendations of Anon (1995) and BS5930:1999, have since been developed for local conditions in countries such as Malaysia (Mohamed et al, 2006), and BS 5930:1999 is used as a standard for soil and rock description for ground investigations internationally without difficulty.

The "new" European Scheme

All this is now in chaos. The new EN has reverted to something similar to the old 1981 standard but with such confusing changes that it does not seem to correlate to any other published scheme.

It also adopts the same terms as used in other classifications but defines them differently. That this has not been openly debated or peer reviewed is, to my mind, a step backwards and one that may have dire consequences.

Most readers of *GE* will not immediately appreciate the problems here, partly because weathering and weathering classification is generally not a day-to-day concern for UK conditions other than for chalk, marls and so on – rocks unaffected by the recent changes.

So, are weathering classifications really useful at all given the current confusion? Some of the reasons why they are are set out in Box 2.

In Hong Kong, for example, the Geotechnical Engineering Office is dealing with thousands of hazardous slopes cut in weathered rocks. Here there is considerable experience and expertise with engineering in weathered rock, and the shorthand of using weathering grades to characterise rock condition at a material scale is fundamental and much more useful than field strength estimates alone.

The grades often need to be supplemented by a description of the condition of disintegration and density, but nevertheless a good feel for the engineering properties may be obtained from weathering grade alone. Figure 1 illustrates weathered granite being logged and classified using material weathering grades.

The new EN provides no guidance on material weathering grades for rocks that are strong or stronger in their fresh state (viz. previous Approach 2 in BS 5930:1999) but nevertheless states that "in logging cores, the distribution of weathering grades may be recorded". How this is to be done is not clear considering that the new "grades" are for mixtures of stronger and weaker materials. These are old, old problems that were recognised long ago and were addressed carefully in Anon (1995) prior to the revisions of BS 5930:1999.

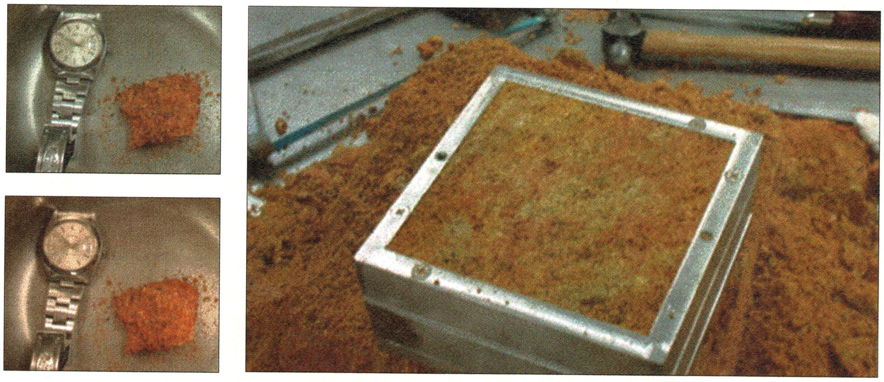
Instead, the new EN reverts to requiring a mass classification scheme to be used similar to the BS 5930:1981 scheme and ISRM (1978) scheme but with changes that make matters even worse. The new EN Grade 0 is the equivalent of Grade I in the ISRM scheme, Grade I the equivalent of Grade II, and so on.

The ISRM use of percentage of "soil" and "rock" in defining Grades III and IV has been dropped and instead it must now be judged on the percentage of rock mass that "shows some sign of disintegra-

Box 2: Why do we need weathering classifications?

Material Scale
Weathered rocks - especially at the weaker end are difficult to sample and test without serious disturbance.
Good data are precious and need to be used at more than one location.
Weathering grading of materials can be quite objective provided index tests are used when defining state of weathering.

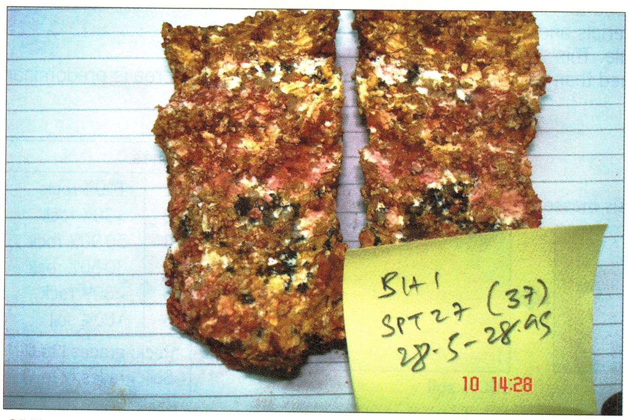
No slaking after 2 minutes submersion in water – therefore grade IV



Grade IV meta sandstone being prepared for testing in Leeds Direct Shear Box (details of box design in Ebuk et al, 1993).

Mass Scale
When defining a ground model for design and analysis, zones of similar engineering properties need to be defined. Weathering zone classifications can be a good place to start.

Zonal schemes can be useful for general observation and rapid communication and can be particularly useful for prescriptive design when developed specifically to suit the particular range of profiles developed at a particular location (say along a road development).



SPT sample of Grade V granite, Singapore. For example of the usefulness of material scale grade correlations see Irfan, 1996 tion or decomposition". Without wishing to be overly pedantic, it is wondered how one might identify whether more than 50% of a rock mass is "disintegrated"? This classification is at best not very useful and at worst impossible to apply in practice.

Having examined and described many rocks in the UK and abroad I cannot recall any profile to which this classification could be applied unambiguously or helpfully. It certainly is not generally applicable in preference to Approach 3 of the BS 5930:1999 or the scheme used in Hong Kong (GCO, 1988).

But if people have been apparently using such a scheme for years, and seem happy with it, then why should we be concerned?

First, I doubt that they have been applying this scheme. I see references to the ISRM scheme in published papers but not this proposed scheme. Second, and more importantly, the ISRM (1978) scheme is often not used as defined – people think they know what it recommends but then go and do something else (see discussion in Martin and Hencher, 1986).

Strengths and densities of samples are measured in the laboratory and then weathering grades assigned to those small samples, while it is professed that the mass classification scheme is being employed. Even worse, some authors try to force the mass scheme on to small samples by estimating the percentage of decomposed minerals and treating that as the "soil" percentage. This is the kind of poor practice that occurs when no guidance is given on defining material weathering grades.

Annex A (informative)

The table offered as an aid to the identification of rock types ("for the engineer with limited geological knowledge") was quite a good idea when first introduced. It indicated to the geologist the kind of level of petrological definition that a civil engineer might be interested in.

The hope that many civil engineers could distinguish these rocks independently is rather misplaced judging from years of teaching civil engineering undergraduates to "spot the rock" at Imperial College London and at the University of Leeds.

But the table has its uses, even though I have serious reservations about civil engineers preparing their own geological models. What is upsetting is that the table from BS 5930 has been changed so it is now incorrect. For example, granite and diorite are now both described as massive with quartz, feldspars, micas and dark minerals. The old BS chart distinguished these rocks on the basis of them containing much quartz (granite) and some quartz (diorite) and on the basis of colour. This is correct. Hatch et al (1961) note regarding diorites that "normally these rocks do not contain quartz but in the more acid varieties accessory quartz may occur". This distinction was made by the original treatment in BS 5930 but is lost in the EN.

It is acknowledged that this is a minor and perhaps trivial point, unlikely to result in settlement of a building or collapse of a slope, but it is of concern that what was correct has been revised to be incorrect.

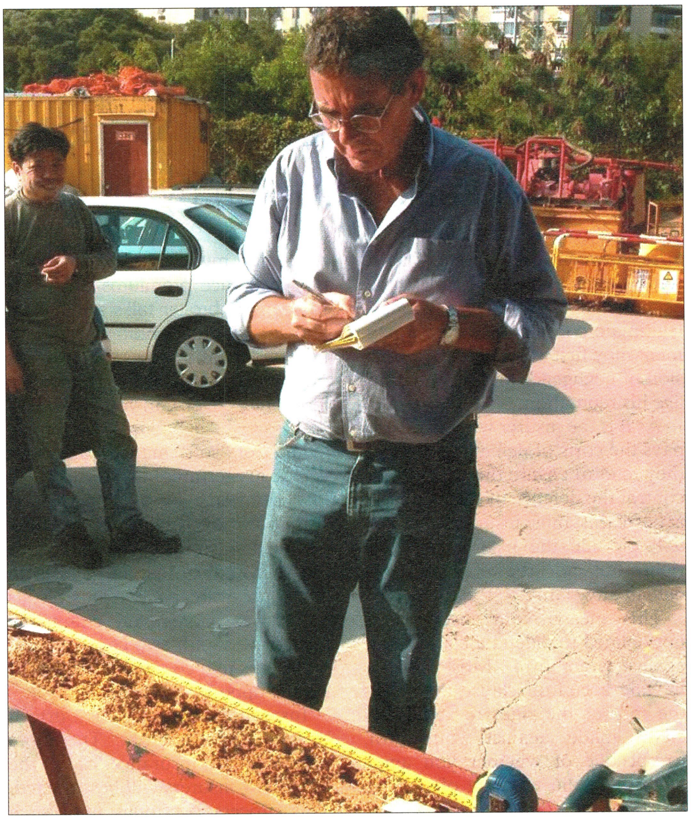


Figure 1: Weathered granite Mazier sample being logged at material grade scale in Hong Kong

Conclusions

In my view, a retrograde step has been taken regarding rock description and classification. An opportunity to provide improved guidance in the EN has been lost, indeed the new document is flawed and should not be used.

Malaysia and Singapore, and no doubt other countries, will no longer be able to specify use of BS 5930 as a basic standard for ground investigation because the normal logging shorthand of weathering grades is not part of the revised BS. Apologists will argue that the BS allows for other schemes to be used but this misses the point – the BS used to contain good advice in this respect; the new set of documents does not.

The knock-on effects to other standards, documents and design practice have not been researched fully here.

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