Engineer's quick reference guide

FOR GROUND INVESTIGATION

www.rsk.co.uk

RSK

RSK'S SERVICES

- Site investigation
- Drilling
- Risk assessment
- Remediation options appraisal
- Remedial design
- Laboratory testing
- Expert witness
- Due diligence
- Waste management
- Air and noise quality
- Earthworks modelling
- Civil and structural engineering

STANDARDS AND CODES OF PRACTICE

Example standards and codes of practice	
BS 5930:2015	Code of practice for ground investigations
BS 10175:2011	Investigation of potentially contaminated sites – Code of practice
–	UK Specification for Ground Investigation
BS EN 1997	Eurocode 7: Geotechnical design (parts 1 and 2)
BS EN ISO 14688	Geotechnical investigation and testing – Identification and classification of soil (parts 1 and 2)
BS EN ISO 14689	Geotechnical investigation and testing – Identification and classification of rock (part 1)
BS EN ISO 22475	Geotechnical investigation and testing – Sampling methods and groundwater measurements (Parts 1–3)
BS EN ISO 22476	Geotechnical investigation and testing – Field testing (parts 1–12)
BS EN ISO 22282	Geotechnical investigation and testing – Geohydraulic testing (parts 1–6)
BS 1377:1990	Methods of test for soils for civil engineering purposes (parts 1–9)
BS EN ISO 17892	Geotechnical investigation and testing – Laboratory testing of soil (multiple parts)

Note: Where standards have been amended (e.g. BS 10175:2011 + A1:2013), the amendment number and date have been omitted from the above list for clarity. Information obtained from British Standards © BSI.

Drilling rigs and investigation equipment

CABLE PERCUSSION DRILLING RIGS

Cable percussion drilling

- Suitable for drilling soil and weak rock
- Able to penetrate most rocks only short distances
- Borehole depths of up to 90 m achievable in suitable ground (*30 m for limited-access rig*)

Dando 2000	
Mass (unladen)	1700 kg
Working height	6.65 m
Length during transit	7.5 m
Height during transit	1.75 m
Usual delivery method	Towed by 4WD vehicle
Working space requirements	Preferably 10 × 3 m

Dando 2500	
Mass (unladen)	1995 kg
Working height	6.83 m
Length during transit	8.45 m
Height during transit	1.8 m
Usual delivery method	Towed by 4WD vehicle
Working space requirements	Preferably 10 x 3 m

CABLE PERCUSSION DRILLING RIGS

Borehole diameter

- 150 mm, 200 mm, 250 mm or 300 mm (*for full-sized rigs*)
- 150 mm and 200 mm (*for limited-access rigs*)

Dando 3000	
Mass (unladen)	1850 kg
Working height	6.55 m
Length during transit	8.5 m
Height during transit	1.88 m
Usual delivery method	Towed by 4WD vehicle
Working space requirements	Preferably 10m x 3m

Limited-access (cut down) rig	
Note: This rig is electrically operated by a portable generator and uses a 5-kVA, 440-V supply.	
Working height	2.2 (min.) to 4.5 m (max.)
Usual delivery method	4WD towed trailer
Working space requirements	2 x 6 m (max.)

ROTARY DRILLING RIGS

- Suitable for forming boreholes through soil and rock
- Drilling techniques include rotary coring, rotary percussive (open hole) drilling, dynamic sampling and flight augering
- All rigs MUST include a safety cage around the rotating drill string to prevent personnel access to rotating parts

Comacchio 200 series	
Maximum depth (in suitable ground)	60 m
Mass (unladen)	2400–2700 kg
Working height	4.5 m
Length during transit	4.5 m
Height during transit	2.1 m
Usual delivery method	4WD towed trailer

Comacchio 300 series	
Maximum depth (in suitable ground)	60 m
Mass (unladen)	3000 kg
Working height	4.5 m
Length during transit	4.5 m
Height during transit	2.1 m
Usual delivery method	4WD towed trailer

ROTARY DRILLING RIGS

- Maximum borehole diameter is dependent on rig type, drilling method, ground conditions and depth
- The 200 and 300 series models are typically suitable for forming holes up to 120–150 mm diameter
- The 400 and 600 series rigs are typically suitable for forming holes up to 150–300 mm diameter
- The 400 and 600 series rigs are also suitable for rotary wireline coring to depths of up to 250 m

Comacchio 400 series	
Maximum depth (in suitable ground)	120 m
Mass (unladen)	6000 kg
Working height	7.4 m
Length during transit	6.1 m
Height during transit	2.5 m
Usual delivery method	Rigid lorry

Comacchio 600 series	
Maximum depth (in suitable ground)	200 m
Mass (unladen)	8000–10,000 kg
Working height	8.0 m
Length during transit	5.34/7.33 m
Height during transit	2.5/3.0 m
Usual delivery method	Rigid or articulated lorry (low loader)

TRACKED DYNAMIC (WINDOW AND WINDOWLESS) SAMPLING RIGS

- Suitable for forming small diameter boreholes (~100 mm diameter) in most soil, excluding dense sand or gravel, or coarser soil
- The tracked rigs can undertake standard penetration tests (SPT) and dynamic probing.

Archway Dart	
Mass (unladen)	960 kg
Working height	2.4 m*
Length during transit	2.36 m
Height during transit	1.27 m
Usual delivery method	4WD towed trailer

*Drill rods can be extended above this

Dando Terrier	
Mass (unladen)	1126 kg
Working height	2.85 m*
Length during transit	2.7 m
Height during transit	1.48 m
Usual delivery method	4WD towed trailer

*Drill rods can be extended above this

HAND-HELD DYNAMIC (WINDOW AND WINDOWLESS) SAMPLING AND TRIAL PITTING

Hand window sampler

- The sample tubes are driven into the ground using a jackhammer
- The hammer is usually powered by a hydraulic power pack (hydraulic breaker)
- The sample tubes are then removed from the ground by a pair of hydraulic rams operated from the same power pack

Trial pitting with mechanical excavator

- The depths achievable depend on the excavation technique, plant used and ground conditions
- Typical dimensions for JCB 3CX: height: ~3.0 m (cab), ~3.8 m (backhoe arm)*

Width	2.35 m*
Length	5.6 m
Mass	7700–8400 kg

*Dimensions are when backhoe and front bucket are in stowed positions

COMMON ROTARY CORING SYSTEMS

Comparison of common rotary coring systems

Barrel	Hole diameter (mm)	Core OD standard (mm)	Core OD linered (mm)	Casing			
				Type	OD (mm)	ID (mm)	Weight (kg)
T2-76	76.3	61.7	58.7	HW	114	102	25
T2-86	86.3	71.7	68.7	101 metric	98	89	16
HWF	99.2	76.2	73.0	116 metric	113	104	20
T6-H	99.2	79.0	76.0	116 metric	113	104	20
HWAF	99.5	70.9	68.7	116 metric	113	104	20
T6-101	101.3	79.0	76.0	116 metric	113	104	20
T2-101	101.3	83.7	80.7	116 metric	113	104	20
412	107.2	74.4	73.0	PW	139	127	39
T6-116	116.3	93.0	90.0	PW	139	127	39
PWF	120.6	92.1	87.0	PW	139	127	39
T6-131	131.0	108.0	105.0	PW	139	127	39
SWF	146.0	112.8	107.0	SW	168	151	47
Geobore-S	146.0	n/a	102.0	Geobore-S	146	n/a	35

Weights are approximate.

Soil sampling and in situ testing

SAMPLING CATEGORIES AND CLASSES

(From BS EN 22475-1 and BS EN 1997-2)

Category	Definitions
A	Samples of quality class 1 or 2 can only be obtained by using category A sampling methods. The intention is to obtain samples in which no or only slight disturbance of the soil structure has occurred during the sampling procedure or in handling of the samples. The water content and the void ratio of the soil correspond to that in situ. No change in constituents or in the chemical composition of the soil has occurred. Certain unforeseen circumstances, such as varying of geological strata, can lead to lower sample quality classes being obtained. *(Section 6.2.2)*
B	By using category B sampling methods, this will preclude achieving a sampling quality class better than 3. The intention is to obtain samples containing all the constituents of the in situ soil in their original proportions and the soil has retained its natural water content. The general arrangement of the different soil layers or components can be identified. The structure of the soil has been disturbed. Certain unforeseen circumstances, such as varying of geological strata, can lead to lower sample quality classes being obtained. *(Section 6.2.3)*
C	By using category C sampling methods, this will preclude achieving a sampling quality class better than 5. The soil's structure in the sample has been totally changed. The general arrangement of the different soil layers or components has been changed so that the in situ layers cannot be identified accurately. The water content of the sample may not represent the natural water content of the soil layer sampled. *(Section 6.2.4)*

Soil properties/quality class	1	2	3	4	5
Unchanged soil properties					
Particle size	•	•	•	•	
Water content	•	•	•		
Density, density index, permeability	•	•			
Compressibility, shear strength	•				
Properties that can be determined					
Sequence of layers	•	•	•	•	•
Boundaries of strata – broad	•	•	•	•	
Boundaries of strata – fine	•	•			
Atterberg limits, particle density, organic content	•	•	•	•	
Water content	•	•	•		
Density, density index, permeability	•	•			
Compressibility, shear strength	•				
Quality classes of soil samples for laboratory testing and sampling categories to be used					
Sampling category according to EN ISO 22475-1 (table 1)	A				
			B		
					C

SOIL SAMPLERS

(From BS EN 22475-1)

Examples of sampling methods with respect to the sampling category in different soils				
Soil type	Suitability depends on, for example	Sampling method		
		Category A	Category B	Category C
Clay	Stiffness or strength, sensitivity, plasticity	PS-PU OS-T/W-PU[b] OS-T/W-PE[a] OS-TK/W-PE[a, b] CS-DT, CS-TT LS, S-TP, S-BB	OS-T/W-PE OS-TK/W-PE CS-ST HSAS AS[a]	AS
Silt	Stiffness or strength, sensitivity, groundwater surface	PS OS-T/W-PU[b] OS-T/W-PE[a] OS-TK/W-PE[a, b] LS, S-TP	CS-DT, CS-TT OS-TK/W-PE HSAS	AS CS-ST
Sand	Sizes of the particles, density, groundwater surface	S-TP OS-T/W-PU[b]	OS-TK/W-PE[b] CS-DT, CS-TT HSAS	AS CS-ST
Gravel	Sizes of the particles, density, groundwater surface	S-TP	OS-TK/W-PE[b] HSAS	AS CS-ST
Organic soil	State of decay	PS OS-T/W-PU[b] S-TP	CS-ST HSAS AS[a]	AS

[a] Can be used only in favourable conditions

[b] See also 6.4.2.3 of BS EN 22475-1 for the detailed geometry

KEY

OS-T/W-PU: Open-tube samplers, thin walled/pushed
OS-T/W-PE: Open-tube samplers, thin walled percussion
OS-TK/W-PE: Open-tube samplers, thin walled percussion
PS: Piston samplers
PS-PU: Piston samplers, pushed
LS: Large samplers
CS-ST: Rotary core drilling, single tube
CS-DT, CS-TT: Rotary core drilling, double or triple tube
AS: Augering
HSAS: Hollow stem augering
S-TP: Sample from trial pit
S-BB: Sample from borehole bottom

ENVIRONMENTAL SAMPLING

Guidance on appropriate methods for the collection of samples of soil and water for contamination analysis is given in BS 10175 Investigation of potentially contaminated sites – Code of practice.

Care must be taken when collecting soil and water samples for contamination analysis to avoid cross-contamination. Samples must be taken in appropriate containers that are determined by the analyses to be undertaken. The containers may include plastic tubs and bottles, borosilicate glass jars and bottles, and glass vials.

Samples must be kept cool and out of sunlight usually within cooler boxes containing ice packs. They must be despatched to the laboratory on the day of collection to minimise sample holding times. For some analyses, the sample containers will contain preservatives to reduce degradation of the contaminant of interest. Failure to follow correct handling, storage and transportation procedures can result in deviating (non-conforming) samples that may no longer be accepted by regulators as being representative of site conditions.

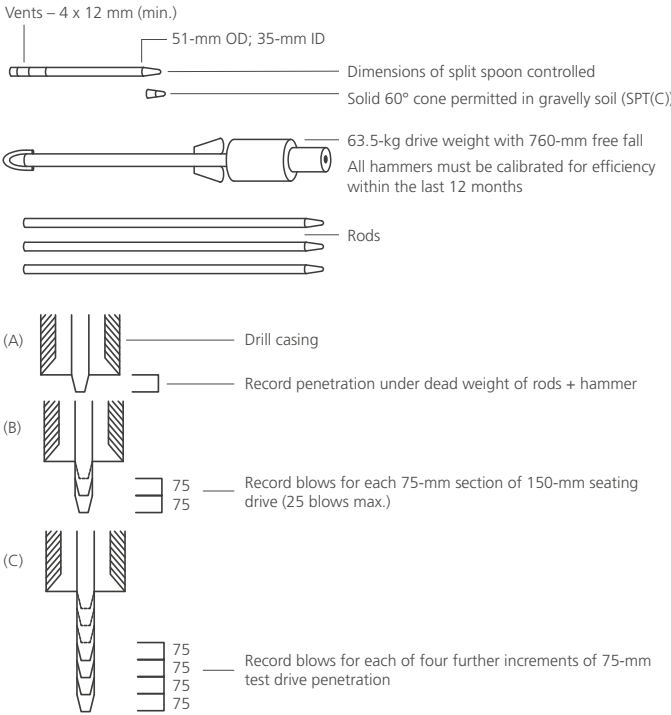
Envirolab, RSK's in-house chemical testing laboratory, can offer advice on, provide sample containers for and undertake chemical contamination testing. www.envlab.co.uk

envirolab

Envirolab
Sandpits Business Park
Mottram Road
Hyde SK14 3AR
UK
Tel: +44 (0)161 368 4921
Fax: +44 (0)161 368 5287
Email: ask@envlab.co.uk

STANDARD PENETRATION TEST (SPT)

Test carried out in accordance with BS EN ISO 22473 Part 3 as follows



If blows in (B), seating drive, reach 25, measure penetration and proceed to test drive (C)

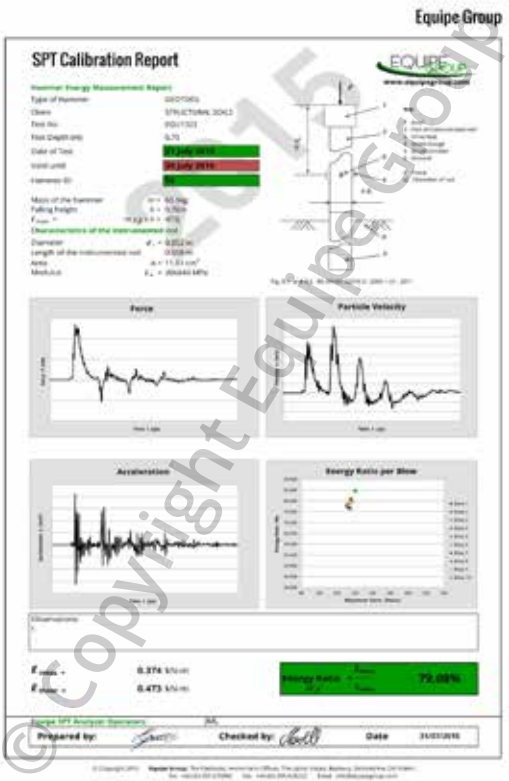
If blows in (C), test drive, reach 50 (or 100 in 'soft rock'), cease test. Measure test drive penetration

The following must be recorded:

- water level in borehole at time of start of test
- level of bottom of borehole casing

SPT CERTIFICATION

Energy losses occur owing to, for example, friction at the hammer (velocity loss compared with the free fall) or during the hammer's impact on the anvil. Therefore, the energy ratio, *Er*, of the equipment used has to be known if the *N* values are going to be used for the quantitative evaluation of foundations or for the comparison of results. A certificate of calibration of the Er-value immediately below the driving head or anvil shall be available.



Example of SPT hammer calibration certificate

BOREHOLE TESTING

Borehole vane test

Purpose

To measure the peak and residual in situ shear strength of fine ('cohesive') soil within boreholes

Method

The current test method is detailed in BS 1377 Part 9, and is suitable for very soft to firm, intact, saturated fine ('cohesive' soil). A vane of cruciform shape is lowered on extension rods to the base of the borehole and pushed at least three borehole diameters into the intact soil beneath. The rods are connected to a calibrated torque measuring instrument at ground level and slowly rotated until sufficient torque is applied to shear the soil under test

Borehole packer permeability test

Purpose

To measure the acceptance in situ by rock of water under pressure, which, in effect, give a measure of permeability

Method

The test method currently in use in the UK is given in BS 22282 part 3. Packers most commonly consist of a rubber duct tube that can be inflated against the side of a borehole using pressurised gas to create a seal within the borehole through which groundwater cannot pass. Water is pumped through the duct into the rock beneath and measurements made of water flow and applied pressure over time. A double packer arrangement can be used to isolate a specific part of a borehole for testing

IN SITU TESTING

Tests carried out in accordance with BS 1377 Part 9 except where noted

California bearing ratio (CBR)

Purpose

To measure parameters for the structural design or assessment of pavements and working platforms

Method

Carried out by one technician using small, hand-operated, vehicle-mounted equipment. A hardened steel plunger is inserted into the test surface at a constant rate of penetration and the applied stress is measured

Plate loading test

Purpose

To investigate and test the load-settlement characteristics of a soil

Method

Carried out by one technician using a steel plate and a hydraulic jack. The jack pushes against a kentledge such as the underside of a mechanical excavator. The vertical deformation of the ground under load is assessed by measuring the settlement of the plate over time under different applied loads

Sand replacement test

Purpose

To determine the in situ density of natural or re-compacted soil; it is commonly used to assess the density of recently placed fill

Method

Carried out by one technician using hand-portable, unpowered equipment. A 200-mm-diameter hole is hand excavated to a maximum depth of 250 mm. Dried, graded sand is poured into the hole and the weight of the sand is compared with that of the excavated soil

IN SITU TESTING

Tests carried out in accordance with BS 1377 Part 9 except where noted

Nuclear density gauge
Purpose
To determine the in situ density of natural or re-compacted soil; it is commonly used to make a rapid on-site assessment of the density of recently placed fill
Method
The nuclear density gauge utilises sealed radioactive sources that emit ionising radiation. The gauge is placed on the surface or is a plunger pushed into the ground and the radiation reaching the detector within the unit is measured

Soakaway testing
Purpose
To measure the drainage characteristics of the ground by filling a test pit with water and measuring the change in water level over time
Method
Carried out in accordance with BRE Digest 365. A test pit is excavated to the design depth and filled with clean water supplied from a bowser, tanker, hydrant or similar. The change in water level is measured. The pit is allowed to run dry or is pumped dry on completion of the test and then backfilled

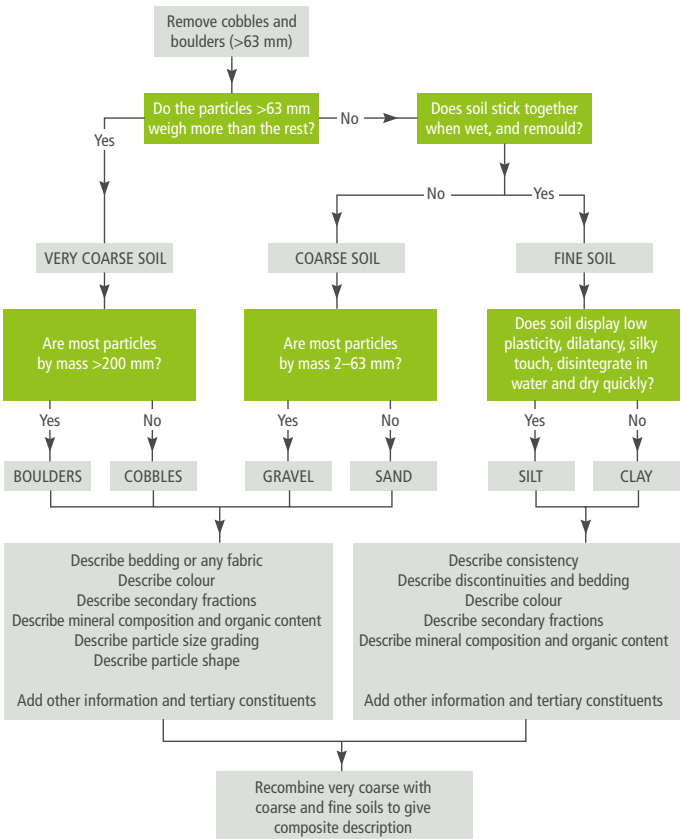
Percolation testing
Purpose
To measure the drainage characteristics of the ground for drainage field design by filling a 300-mm-square test pit with water and measuring the change in water level over time
Method
Carried out in accordance with CIRIA Report 156. A 300-mm-square test pit is excavated and filled with clean water. The change in water level over time is measured. The pit is allowed to run dry or is pumped dry on completion of the test and then backfilled

- Mackintosh probes
- Hand vane and pocket penetrometer
- DCP TRL CBR, Mexecone
- Schmidt hammer
- Inclinometer, extensometer, piezometers
- Falling and rising head tests, soakaway test

Soil description

GENERAL IDENTIFICATION AND DESCRIPTION OF SOIL

(BS 5930:2015 – Figure 6)

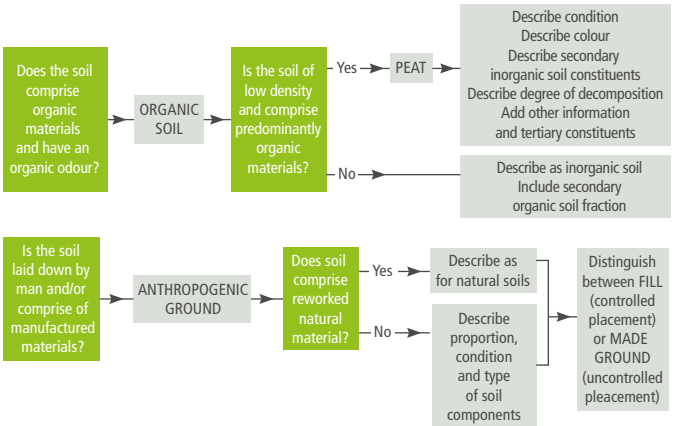


ORGANIC SOIL AND MADE GROUND

(BS 5930:2015 – Tables 20 and 21 and Figure 6)

Types of peats	
PEAT	Accumulates in situ in a mire. Predominantly plant remains, usually dark brown or black, distinctive smell, low bulk density. Can include disseminated or discrete inorganic particles
Fibrous PEAT	Plant remains clearly recognisable and retain some tensile strength. Water and no solids on squeezing
Pseudo-fibrous PEAT	Mixture of fibres and amorphous paste. Turbid water and <50% solids on squeezing
Amorphous PEAT	No recognisable plant remains, mushy consistency. Paste and >50% solids on squeezing
HUMUS/ TOPSOIL	Plant remains, living organisms and their excretions together with inorganic constituents

Description of condition of peats	
Term	Definition of condition
Firm	Fibres compressed together
Spongy	Very compressible. Open structure
Plastic	Can be moulded in hand. Smears fingers



CONSISTENCY, STRENGTH AND RELATIVE DENSITY

(BS 5930:2015 – Tables 8, 9 and 10)

Consistency	
Term	Consistency description definition (after BS EN ISO 14688-1:2002, 5.14)
Very soft	Finger easily pushed in by up to 25 mm. Exudes between fingers
Soft	Finger easily pushed in by up to 10 mm. Moulds with light finger pressure
Firm	Thumb makes impression easily. Cannot be moulded by fingers. Rolls in the hand to a 3-mm-thick thread without breaking or crumbling
Stiff	Can be indented slightly by thumb. Crumbles on rolling a 3-mm-thick thread but can then be remoulded into a lump
Very stiff	Can be indented by thumb nail. Cannot be moulded. Crumbles under pressure

Strength	
Term	Undrained strength classification definition s_u, in kPa (from BS EN ISO 14688-2:2004, 5.3, Table 5)
Extremely low	<10
Very low	10–20
Low	20–40
Medium	40–75
High	75–150
Very high	150–300

Relative density in boreholes	
Term	Classification based on uncorrected SPT N values
Very loose	0–4
Loose	4–10
Medium dense	10–30
Dense	30–50
Very dense	>50
Where relative density term has been determined from SPT N values, the density term is put at the start of a soil description	

RELATIVE DENSITY IN OBSERVATION PITS AND TRIAL PITS

(BS 5930:2015 – Table 11)

Assessment of field density[1]			
Density term	Excavation by spade or pick[2]	Penetration of light horizontal blows of geological pick	Penetration of geological pick by pushing
Very loose	Very easy to excavate with a spade	100 mm (full depth)	75 mm–100 mm (full length)
Loose	Fairly easy to excavate with a spade or to penetrate with a crowbar	50 mm–100 mm	25 mm–75 mm
Medium dense	Difficult to excavate with a spade or to penetrate with a crowbar	25 mm–50 mm	10 mm–25 mm
Dense	Very difficult to penetrate with a crowbar. Requires a pick for excavation	5 mm–25 mm	2 mm–10 mm
Very dense	Difficult to excavate with a pick	<5 mm	<2 mm

[1]If the field density is assessed using these methods, the density term MUST be placed in the second (or later) sentence of the soil description, AFTER the principal soil type, and include the test method used to make the assessment. Density terms obtained in this way must NEVER be confused with those obtained from SPTs

[2]See BRE, 1993

SECONDARY ORGANIC MATTER IN INORGANIC SOIL

Terms for description of secondary organic matter in an inorganic soil			
Term	Colour	Organic content	Weight % of dry mass (based on BS EN ISO 14688-2)
Slightly organic	Grey	Low organic content	2–6
Organic	Dark grey	Medium organic content	6–30
Very organic	Black	High organic content	>30

BEDDING AND STRUCTURE

Bedding and structure		
Thickness term	Spacing term	Thickness or spacing
Very thickly	Extremely wide	>6 m
Very thickly	Very wide	2 m–6 m
Thickly	Wide	600 mm–2 m
Medium	Medium	200 mm–600 mm
Thinly	Close	60 mm–200 mm
Very thinly	Very close	20 mm–60 mm
Thickly laminated (sedimentary) Narrowly (metamorphic and igneous)	Extremely close	6 mm–20 mm
Thinly laminated (sedimentary) Very narrowly (metamorphic and igneous)	Extremely close	>6 mm

COLOUR

Colour		
Lightness (tertiary descriptor)	Chroma (secondary descriptor)	Hue (primary descriptor)
Light Dark	Reddish Pinkish Orangish Yellowish Brownish Greenish Bluish Greyish	Red Pink Orange Yellow Cream Brown Green Blue White Grey Black
The above terms for lightness, chroma and hue may be used in combination for colour description		

ODOUR

(BS 5930:2015 – Table 19)

Terms for description of odours	
Category	Descriptive terms
Camphor	Bitter Mothballs Acrid
Musk	Penetrating Pungent
Floral	Wide range of terms, not likely to be used often in made ground
Peppermint	Sweet Minty
Ether	Solvent Acetone Medicinal
Vinegar	Sharp Acetic Pungent Rancid
Putrid	Rotten egg Rotten cabbage Fishy Disagreeable, sweet Sulphurous
Hydrocarbon	Organic Petrol Diesel Oil Asphalt Tar

PRINCIPAL SOIL TYPE

Principal soil type	Particle size		Behaviour	
Clay		<0.002 mm	FINE SOIL – sticks together when wet and remoulds	Plastic when wet, dry lumps can be broken not powdered, dries out slowly
Silt	Fine Medium Coarse	0.002–0.0063 mm 0.0063–0.02 mm 0.02–0.063 mm		Feels silky, dries out quickly, not very plastic, coarse silt visible to the naked eye
Sand	Fine Medium Coarse	0.063–0.2 mm 0.2–0.63 mm 0.63–2 mm	COARSE SOIL – does <u>not</u> stick together when wet and remould	Visible to the naked eye, little or no cohesion, size can be described
Gravel	Fine Medium Coarse	2–6.3 mm 6.3–20 mm 20–63 mm		Visible to the naked eye, no cohesion, size and shape can be described
Cobbles		63–200 mm	VERY COARSE SOIL	Difficult to recover from boreholes
Boulders		200–630 mm		Usually only seen in trial pits
Large boulders		>630 mm		

SECONDARY AND TERTIARY FRACTIONS

Term	Principal soil type	Approximate proportion of secondary constituent	
		Coarse soil	Coarse and/ or fine soil
Slightly clayey or silty and/or sandy or gravelly	Sand and/ or gravel		<5%
Clayey or silty and/or sandy or gravelly			5–20%[1]
Very clayey or silty and/or sandy or gravelly			>20%[1]
Very sandy and/or gravelly	Silt or clay[3]	>65%[2]	
Sandy and/or gravelly		35–65%	
Slightly sandy and/or gravelly		<35%	

[1]Or described as fine soil depending on assessed engineering behaviour
[2]Or described as coarse soil depending on assessed engineering behaviour
[3]Can be silty CLAY or clayey SILT

COBBLES AND BOULDERS

(where <50% of soil)

Classification of very coarse soil		
Fraction	Percent by mass	Term
Boulders	<5	Low boulder content
	5–20	Medium boulder content
	>20	High boulder content
Cobbles	<5	Low cobble content
	5–20	Medium cobble content
	>20	High cobble content

ANGULARITY

Angularity terms		
Term	High sphericity	Low sphericity
Very angular		
Angular		
Subangular		
Subrounded		
Rounded		
Well rounded		

COBBLES AND BOULDERS

(where >50% of soil)

Deposits containing >50% boulder- and cobble-sized particles		
Fraction	Main name	Estimated boulder or cobble content of very coarse fraction
Over 50% of material is very coarse (>63 mm)	BOULDERS	Over 50% is of boulder size (>200 mm)
	COBBLES	Over 50% is of cobble size (200–63 mm)
The term large boulder has no upper size limit, so dimensions should be given wherever available		

Proportion of cobbles in a boulder deposit (or vice versa)	
Term	Secondary constituent by weight
BOULDERS with occasional cobbles	Up to 5% cobbles
BOULDERS with some cobbles	5–20% cobbles
BOULDERS with many cobbles	20–50% cobbles
COBBLES with many boulders	20–50% boulders
COBBLES with some boulders	5–20% boulders
COBBLES with occasional boulders	Up to 5% boulders

Very coarse soil with secondary finer material	
Term	Composition
BOULDERS (or COBBLES) with a little finer material*	Up to 5% finer material
BOULDERS (or COBBLES) with some finer material*	5–20% finer material
BOULDERS (or COBBLES) with much finer material*	20–50% finer material
*The description of "finer material" is made in accordance with 33.4.2 to 33.4.6, ignoring the very coarse fraction; the principal soil type name of the finer material can also be given in capital letters, e.g. COBBLES with some sandy CLAY.	

SOIL DESCRIPTION SUMMARY TABLE (PART 1)

Field identification and description of soils (BS 5930:2015, Table 7, part 1)						
SOIL GROUP	Very coarse soils			Coarse soils		
PRINCIPAL SOIL TYPE	BOULDERS		COBBLES	GRAVEL		
Particle size (mm)	Large boulder >630	Boulder 630–200	Cobble 200–63	Coarse 63–20	Medium 20–6.3	Fine 6.3–2.0
Visual ID	Only seen complete in pits or exposures. Difficult to recover whole from boreholes			Easily visible to naked eye; particle shape can be described; grading can be described		
Density/ Consistency	No terms defined Qualitative description of packing by inspection and ease of excavation			Classification of relative density on the basis of N value (Table 10), or field assessment using hand tests may be made (Table 11)		
Discontinuities	Describe spacing of features such as fissures, shears, partings, isolated beds or laminae, desiccation cracks, rootlets, etc. Fissured: Breaks into blocks along unpolished discontinuities Sheared: Breaks into blocks along polished discontinuities					
Bedding	Describe thickness of beds in accordance with geological definition. Alternating layers of materials are Inter-bedded or Inter-laminated and should be described by a thickness term if in equal proportions, or by a thickness of and spacing between subordinate layers where unequal					
Colour	HUE can be preceded by LIGHTNESS and/or CHROMA			Light–dark: Red, Pink, Orange, Yellow, Cream, Brown, Green, Blue, White, Grey, Black		
Secondary constituents	For mixtures involving very coarse soils see 33.4.4.2			Term in coarse soils	Slightly (sandy) (b)	Sandy (b)
				Proportion secondary (a)	<5%	5-20% (c)
Mineralogy	Terms can include: glauconitic, micaceous, shelly, organic, calcareous. For example: slightly (glauconitic), (glauconitic), very (glauconitic)					
Particle shape	Very angular/Angular/Subangular/Subrounded/Rounded/Well-rounded A dominant shape can be described, for example: Cubic/Flat/Elongate					
PRINCIPAL SOIL TYPE	LARGE BOULDERS	BOULDERS		COBBLES	GRAVEL	
Tertiary constituents	Example terms include: shell fragments, pockets of peat, gypsum crystals, pyrite nodules, calcareous concretions, flint gravel, brick fragments, rootlets, plastic bags					
Geological unit	Name in accordance with published geological maps, memoirs or sheet explanations					

Notes: a) Percentage coarse or fine soil type assessed excluding cobbles and boulders
b) Gravelly or sandy and/or silty or clayey c) Can be described as fine soil depending on mass behaviour

SOIL DESCRIPTION SUMMARY TABLE (PART 2)

Field identification and description of soils (BS 5930:2015, Table 7, part 2)

Coarse soils			Fine soils		
SAND			SILT		
Coarse 2.0–0.63	Medium 0.63–0.2	Fine 0.2–0.063	Coarse 0.063–0.02	Medium 0.02–0.0063	Fine 0.0063–0.002
Visible to naked eye; no cohesion when dry; grading can be described			Only coarse silt visible with hand lens; exhibits little plasticity and marked dilatancy; slightly granular or silky to the touch; disintegrates in water; lumps dry quickly; possesses cohesion but can be powdered easily between fingers		

		Term	Very soft	Soft
		Field test	Finger easily pushed in up to 25 mm. Exudes between fingers	Finger pushed in up to 10 mm. Moulded by light finger pressure
Scale of spacing of discontinuities	Term	Very widely	Widely	Medium
	Mean spacing (mm)	>2000	2 000–600	600–200
Scale of bedding thickness	Term	Very thickly bedded	Thickly bedded	Medium bedded
	Mean thickness (mm)	>2000	2 000–600	600–200

Light–dark: Reddish, Pinkish, Orangish, Yellowish, Brownish, Greenish, Bluish, Greyish

Very (sandy) (b)	SAND AND GRAVEL		Term in fine soils	Slightly (sandy) (d)	Sandy (d)	Very (sandy) (f)
>20% C	~ 50%		Proportion secondary (a)	<35%	35–65% (e)	>65% (e)

Carbonate content: slightly calcareous – weak or sporadic effervescence from HCl, calcareous – clear but not sustained effervescence from HCl, highly calcareous – strong, sustained effervescence from HCl

SAND	SILT

Qualitative proportions can be given: with rare, with occasional, with numerous, frequent, abundant
Proportions are defined on a site or material specific basis, or subjectively

For example: RIVER TERRACE DEPOSITS, GLACIAL SAND AND GRAVEL, MADE GROUND, LANGLEY SILT MEMBER, WEATHERED CHARMOUTH, MUDSTONE FORMATION, CLAY-WITH-FLINTS

Notes: d) Gravelly and/or sandy e) Can be described as coarse soil depending on mass behaviour
f) Gravelly or sandy

SOIL DESCRIPTION SUMMARY TABLE (PART 3)

Field identification and description of soils (BS 5930:2015, Table 7, part 3)					
SOIL GROUP	Fine soils				
PRINCIPAL SOIL TYPE	CLAY				
Particle size (mm)	<0.002				
Visual ID	Dry lumps can be broken but not powdered between the fingers; dry lumps disintegrate under water but more slowly than silt; smooth to the touch; exhibits plasticity but no dilatancy; sticks to the fingers and dries slowly; shrinks appreciably on drying usually showing cracks				
Density/ Consistency	Term	Firm	Stiff	Very stiff	
	Field test	Thumb makes impression easily. Cannot be moulded by fingers. Rolls to thread	Can be indented slightly by thumb. Crumbles in rolling thread. Remoulds	Can be indented by thumb nail. Cannot be moulded, crumbles	
Discontinuities	Term	Closely	Very closely	Extremely closely	
	Mean spacing (mm)	00–60	60–20	<20	
Bedding	Term	Thinly bedded	Very thinly bedded	Thickly laminated	Thinly laminated
	Mean thickness (mm)	200–60	60–20	20–6	<6
Colour	Colours may be mottled. More than 3 colours is multicoloured				
Secondary constituents	Silty CLAY Clayey SILT	Terms used to reflect secondary fine constituents where this is important			
Mineralogy	Organic soils contain secondary finely divided or discrete particles of organic matter, often with distinctive smell, might oxidize rapidly. For example: slightly organic – grey/organic – dark grey/very organic – black				
PRINCIPAL SOIL TYPE	CLAY				
Tertiary constituents	As parts 1 and 2				
Geological unit	For example: LOWESTOFT FORMATION, EMBANKMENT FILL, ALLUVIUM, TOPSOIL, LAMINATED BEDS, WOOLWICH FORMATION, SHERWOOD SANDSTONE GROUP				

WORD ORDER AND EXAMPLE DESCRIPTIONS

General soil description – word order (BS 5930:2015)

Note: Tables and clause numbers referred to below are those in BS 5930:2015

A. Mass characteristics comprising state and structure (see 33.3):
   1) relative density/consistency;
   2) discontinuities;
   3) bedding;

B. Material characteristics comprising nature and state (see 33.4);
   1) colour;
   2) composite soil types: particle grading and composition; shape and size;
   3) tertiary constituents either before or after the principal soil type as appropriate;
   4) principal soil type (name in capitals, e.g. SAND), based on grading and plasticity shape;

C. Stratum name: geological formation, age and type of deposit (see 33.5); classification (optional)

RSK company approach

1. All terms describing particle shape and size go **after** the principal soil type, **after** the full stop
2. Secondary and tertiary **size** fractions are listed in order of particle size, not **proportion**; for example, in 'silty sandy slightly gravelly CLAY', the term 'sandy' will always occur before 'gravelly' no matter how much of each there is
3. Topsoil should generally be described as a normal soil and the word should be (TOPSOIL) added in brackets at the end of the description

WORD ORDER AND EXAMPLE DESCRIPTIONS

Example descriptions

A. MADE GROUND: Firm brown slightly sandy gravelly CLAY. Sand is fine to coarse. Gravel is angular fine to coarse brick and concrete fragments. Occasional pieces of wire, rubber and plastic

B. Stiff orangish brown silty slightly sandy CLAY. Occasional rootlets. (TOPSOIL)

C. Plastic dark brown clayey PEAT. Strong (natural organic?) odour

D. Very stiff extremely closely fissured brown mottled red and grey silty CLAY with a low cobble content. Cobbles are tabular angular of mudstone up to 100 mm across

E. Dense multicoloured (grey, white, orange and brown) very clayey very sandy GRAVEL. Sand is fine to coarse. Gravel is well rounded to subrounded fine to medium flint

F. Grey COBBLES with occasional boulders and much sandy GRAVEL. Sand is coarse. Gravel is subangular fine to coarse of sandstone. Cobbles and boulders are angular up to 400 mm across of sandstone

G. Firm closely fissured yellowish brown CLAY (LONDON CLAY FORMATION)

H. Medium dense light greyish brown slightly clayey sandy GRAVEL with a low cobble content. Sand is fine to coarse. Gravel is subrounded fine to coarse of mixed lithologies. Cobbles are subrounded of strong sandstone. (RIVER TERRACE DEPOSITS)

I. Greenish brown gravelly slightly glauconitic SAND. Sand is fine to coarse. Gravel is rounded fine to medium of black flint. Assessed as loose as fairly easy to excavate with a spade. (HARWICH FORMATION – BLACKHEATH MEMBER).

J. Firm to stiff brown slightly sandy slightly gravelly CLAY with occasional lenses (5 mm by 15 mm to 15 mm by 50 mm) of yellow silty sand. Gravel is subangular to subrounded fine and medium of various lithologies (GLACIAL TILL)

Rock description

ROCK DESCRIPTION

General description: word order (BS 5930:2015)

To be applied to rocks in natural outcrops, cores and excavations

A. Material characteristics:
   1. Strength
   2. Structure
   3. Colour
   4. Texture
   5. Grain size
   6. Rock name (in capitals, e.g., SANDSTONE)

B. General information:
   1. Additional information and minor constituents
   2. Geological information

C. Mass characteristics:
   1. State of weathering
   2. Discontinuities
   3. Fracture state

Rock strengths from BS EN ISO 14689 (table 5)

Term	Field identification	Unconfined compressive strength (MPa)
Extremely weak	Indented by thumbnail. Gravel sized lumps crush between finger and thumb	0.6–1.0
Very weak	Crumbles under firm blows with points of geological hammer; can be peeled by a pocket knife	1–5
Weak	Can be peeled by a pocket knife with difficulty; shallow indentations made by firm blows with point of geological hammer	5–25
Medium strong	Cannot be scraped or peeled with pocket knife; specimen can be fractured with single firm blow of geological hammer	25–50
Strong	Specimen requires more than one blow of geological hammer to fracture it	50–100
Very strong	Specimen requires many blows of geological hammer to fracture it	100–250
Extremely strong	Specimen can only be chipped by geological hammer	>250

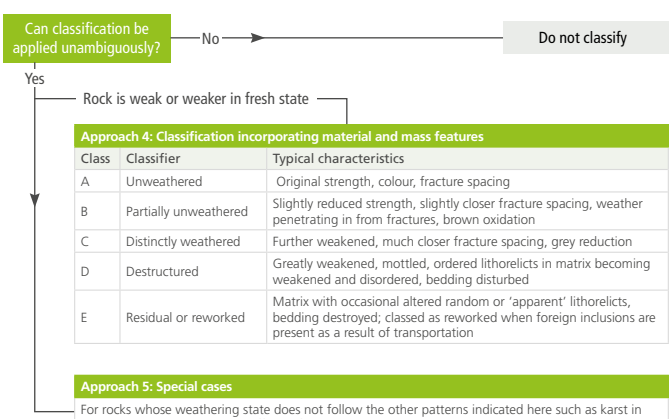
ROCK DESCRIPTION

Description and classification of weathering rock (BS 5930:2015, Figure 9)

Standard descriptions should always include comments on the degree and nature of any weathering effects at material or mass scales. This may enable subsequent classification and provide information for separating rock into zones of like character. Typical indications of weathering include

- changes in colour
- changes in fracture state
- a reduction in strength
- the presence, character and extent of weathering products.

These features should be described using standard terminology, quantified as appropriate, together with non-standard English descriptions as necessary to describe the results of weathering. At the mass scale, the distribution and proportions of the variously weathered materials (for example, core stone versus matrix) should be recorded.



Approach 4: Classification incorporating material and mass features

Class	Classifier	Typical characteristics
A	Unweathered	Original strength, colour, fracture spacing
B	Partially unweathered	Slightly reduced strength, slightly closer fracture spacing, weather penetrating in from fractures, brown oxidation
C	Distinctly weathered	Further weakened, much closer fracture spacing, grey reduction
D	Destructured	Greatly weakened, mottled, ordered lithorelicts in matrix becoming weakened and disordered, bedding disturbed
E	Residual or reworked	Matrix with occasional altered random or 'apparent' lithorelicts, bedding destroyed; classed as reworked when foreign inclusions are present as a result of transportation

Approach 5: Special cases

For rocks whose weathering state does not follow the other patterns indicated here such as karst in carbonates and the particular effects of arid climates

ROCK DESCRIPTION (PART 1)

Description of rock (tables on pages 137–138 from BS 5930, Table 27)

Grain size (mm)	Bedded rocks (mostly sedimentary)					
Grain size boundaries approximate	Grain size description	CONGLOMERATE Rounded boulders cobbles and gravel cemented in a finer matrix Breccia Irregular rock fragments in a finer matrix	At least 50% of grains are of carbonate		At least 50% of grains are of grained volcanic rock	SALINE ROCKS
20 –	RUDACEOUS		LIMESTONE and DOLERITE (undifferentiated)	Calcirudite	Fragments of volcanic ejects in a finer matrix Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	HALITE
6.3 –						
2 –	ARENACEOUS Coarse	SANDSTONE Angular or rounded grains commonly cemented by clay, calcite or iron minerals Quartzite Quartz grains and siliceous cement Arkose Many feldspar grains Greywacke Many rock chips		Calcarenite	Cemented volcanic ash	ANHYDRITE
0.63 –	Medium					GYPSUM
0.2 –	Fine				TUFF	
0.063 –	ARGILLACEOUS	SILTSTONE Mostly silt	Calcareous mudstone	Calcisiltite	Fine-grained TUFF	
0.002 –		MUDSTONE		Calcilutite	Very fine-grained TUFF	
Amorphous or crypto-crystalline		Flint: occurs as bands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone		CHALK		COAL LIGNITE
		Granular cemented – except amorphous rocks				
		SILICEOUS	CALCAREOUS		SILICEOUS	CARBONACEOUS

Sedimentary rocks

Granular cemented rocks vary greatly in strength, some sandstones are stronger than many igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils.

Calcareous rocks contain calcite (calcium carbonate), which effervesces with dilute hydrochloric acid.

ROCK DESCRIPTION (PART 2)

Igneous rocks: generally massive structure and crystalline texture

Grain size description				
COARSE	GRANITE[1]	DIORITE[1,2]	GABBRO[1,2]	Pyroxe-nite Perido-tite
	These rocks are sometimes porphyritic and are then described, for example, as porphyritic granite			
MEDIUM	MICRO-GRANITE[1]	MICRO-DIORITE[1,2]	DOLERITE[3,4]	
	These rocks are sometimes porphyritic and are then described as porphyries			
FINE	RHYOLITE[4,5]	ANDESITE[4,5]	BASALT[5]	
	These rocks are sometimes porphyritic and are then described as porphyries			
Amorphous or crypto-crystalline	OBSIDIAN[5]	VOLCANIC GLASS		

Increasing grain size

Colour: Pale → Dark

ACID (much quartz)	INTER-MEDIATE (some quartz)	BASIC (Little or no quartz)	ULTRA BASIC

Metamorphic rocks

Foliated	Massive
GNEISS Well-developed but often widely spaced foliation sometimes with schistose bands Migmatite Irregular foliated: mixed schists and gneisses	MARBLE QUARTZITE GRANULITE HORNFELS
SCHIST Well-developed undulose foliation: generally much mica	AMPHIBOLITE SERPENTINE
PHYLLITE Slightly undulose foliation; sometimes spotted SLATE Well-developed plane cleavage (foliation) MYLONITE Found in fault zones, mainly in igneous and metamorphic areas	
CRYSTALLINE	
SILICEOUS	Mainly SILICEOUS

Igneous rocks

Composed of closely interlocking mineral grains, strong when fresh, not porous.
Occurrence: 1. batholiths, 2. laccoliths, 3. sills, 4. dykes, 5. lava flows, 6. veins.

Metamorphic rocks

Generally classified according to fabric and mineralogy rather than grain size. 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. Most fresh metamorphic rocks are strong but fissile.

ROCK DESCRIPTION (PART 1)

Terminology and checklist for rock discontinuity description (BS 5930:2015, Table 30)

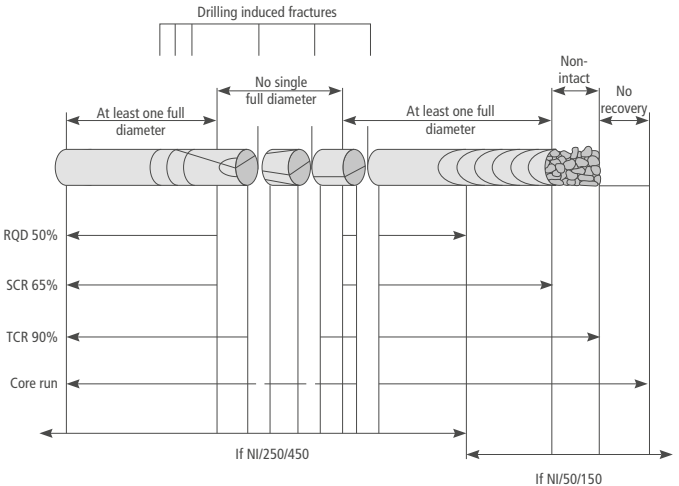
Orientation	Discontinuity spacing	Persistence	Type of termination	Roughness
Dip amount only in cores		Discontinuous	Cannot normally be described in cores	**Intermediate scale (cm) and small scale (mm)**
				Stepped
		Continuous in cores		Rough
				Smooth
				Striated
	Extremely wide >6 m		Termination	
	Very wide 2–6 m			**Undulating**
	Wide 600 mm–2 m	Very high >20 m		Rough
Take number of readings of dip direction/dip e.g. 015/18°	Medium 200 mm–600 mm	High 10 m–20 m	x (outside exposure)	Smooth
				Striated
	Close 60 mm–200 mm	Medium 3 m–10 m		**Planar**
			r (within rock)	Rough
				Smooth
	Very close 20 mm–60 mm	Low 1 m–3 m		Striated
Report as range and on stereo net if appropriate	Extremely close <20 mm	Very low 1<m	d (against discontinuity)	**Large scale (m)**
				Waviness
	Take number of readings and state minimum, mode and maximum.			Curvature
			Record also size of discontinuity	Straightness
				Measures amplitude and wavelength of feature

ROCK DESCRIPTION (PART 2)

Terminology and checklist for rock discontinuity description (BS 5930:2015, Table 30)

Wall strength	Apeture	Filing	Seepage	Number of sets
Schmidt hammer	Cannot normally be described in cores		Cannot be described in cores	Can be described or summarised in cores where sets of different dip are present
Point load test				
		Clean		
	Extremely wide >1 m	Surface staining (colour)		
	Very wide 0.1 m–1 m		Moisture on rock surfaces	
Other index tests	Wide 0.01 m–0.1 m	Soil infilling (described in accordance with Clause 33)	Dripping water	
	Moderately wide 2.5 mm–10 mm		Water flow measured per time unit on an individual discontinuity or set of discontinuities	
	Open 0.5 mm–2.5 mm	Mineral coatings (e.g. calcite chlorite, gypsum etc.)		Record orientation and spacing of sets to each other and all details for each set
	Partly open 0.25 mm–2.5 mm	Other (specify)	Small flow 0.05 l/s–0.5 l/s	
	Tight 0.1 mm–0.25 mm		Medium flow 0.5 l/s–5 l/s	
Visual assessment		Record width and continuity of infill		
	Very tight <0.1 mm		Large flow >5 l/s	

ROCK DESCRIPTION

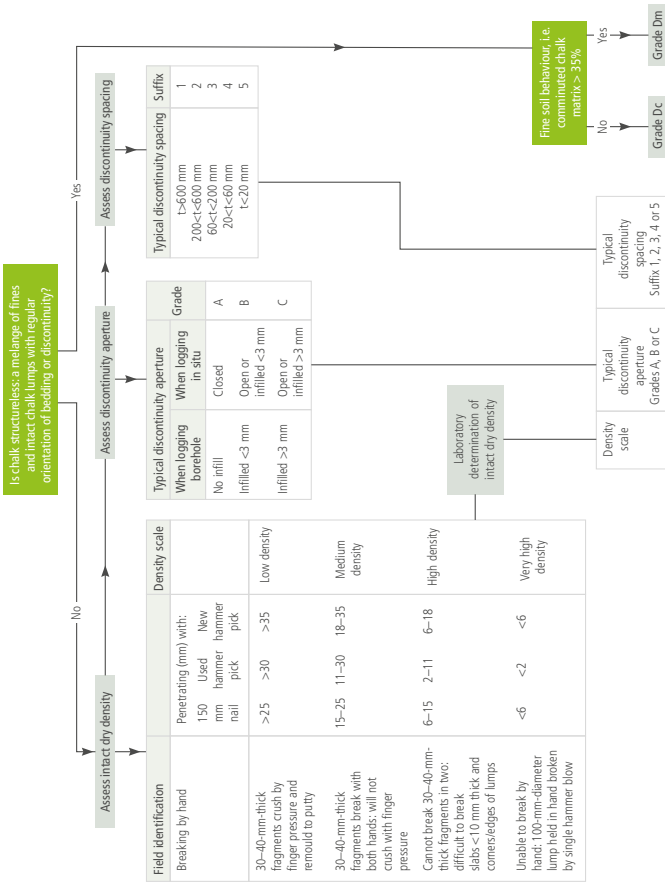


Application of fracture state terms for rock core (BS 5930:2015)

Standard indices definitions (BS 5930:2015)	
TCR (%)	Length of core recovered (solid and non-intact) expressed as a ratio of the length of core run
SCR (%)	Length of solid core recovered expressed as a ratio of the length of core run. Solid core has a full diameter, uninterrupted by natural discontinuities, but not necessarily a full circumference and is commonly measured along the core axis or other scan line
RQD (%)	Length of solid core each pieces longer than 100 mm expressed as a ratio of the length of core run
Fracture index	Count of the number or spacing of fractures over an arbitrary length of core of similar intensity of fracturing recorded as minimum/mode/maximum. Commonly reported as Fracture Spacing (If, mm) or as Fracture Index (FI, number of fractures per metre). Where core is non-intact in the ground, the abbreviation NI may be used
NOTE The total core recovery (TCR) records the proportion of core recovered and is read with the description, solid core recovery (SCR) and rock quality designation (RQD). The TCR of itself gives little information on the character of the core or the rock from which it was recovered. This measurement is required to ensure that all depth related records such as boundaries, markers and samples are correct	

CHALK DESCRIPTION

Source: CIRIA Report C574 Engineering in chalk *(2002), Part 4*



EXAMPLE ROCK DESCRIPTIONS

Example descriptions

A. Extremely weak light greenish grey partially weathered MUDSTONE. Fracture set 1: fractures are extremely closely to very closely spaced horizontal planar rough tight or open <1 mm and infilled with brown clay. Fracture set 2: fractures are incipient extremely closely spaced blocky

B. Medium weak very thinly bedded reddish brown fine and medium grained SANDSTONE. Rare light grey siltstone inclusions up to 5 mm across. Fractures are very closely spaced dipping 5–10° undulating rough stained black

C. Weak to medium strong narrowly to medium banded reddish brown fresh PHYLITE with medium strong extremely closely spaced fine to medium grained psammite. Fractures are extremely closely to medium spaced dipping 35–45° undulating rough open 2 mm and infilled with sand, and planar smooth tight with no infill. Brown staining on fractures

D. Structureless CHALK composed of firm yellowish white sandy slightly gravelly SILT with a low cobble content. Sand is fine to coarse chalk. Gravel is angular fine to coarse very weak low density chalk. Cobbles are angular very weak low density chalk with occasional flints (Grade Dm)

E. Weak medium density white with frequent black speckles CHALK. Fractures are very closely spaced open and infilled up to 5 mm with white silt size chalk (medium density Grade C4)

Laboratory testing

LABORATORY TESTING (PART 1)

Guide to basic laboratory testing (BS 1377)

	Type of test	Derived parameters	Suitable sample type required	Suitable soil types	Mass required based on		
					Fine grained soil	Medium grained soil	Coarse grained soil
Classification tests	Moisture content	Moisture content	D, U	C, S, G	50 g	350 g	4 kg
	Atterberg limits (LL/LP)	Liquid limit (%) Plastic limit (%) Plasticity index (%)	D, U	C, S	500 g	1 kg	2 kg
	Density (linear)	Density (mg/m^3)	U	C, S	500 g	1 kg	2 kg
	Particle size description (PSD)	Particle size distribution by weight	D, B	All	150 g	3 kg	17 kg
Compaction tests	California bearing ratio (CBR)	CBR value	U*, B	All	6 kg	6 kg	12 kg
	Compaction (heavy/4.5 kg)	Maximum density and optimum moisture content	B	All	10 kg	25 kg	50 kg
	Compaction (light/2.5 kg)		B	All	10 kg	25 kg	50 kg
	Compaction (vibrating hammer)		B	All	50 kg	50 kg	50 kg

Fine grained soil = <2 mm (includes clay, silt, sand)
Medium grained soil = 2–20 mm (includes fine and medium)
Coarse grained soil = 20–75 mm (includes coarse gravel)

U = Undisturbed sample (U100)
B = Bulk disturbed sample
D = Small disturbed sample

LABORATORY TESTING (PART 2)

Guide to basic laboratory testing (BS 1377)			
**Approx. duration of test	Reporting of results	Test comments	Additional comments
2 days	Tabulated in summary of classification tests (can be plotted versus depth if required)	The natural moisture content is generally the condition of the material on receipt at the laboratory	
5 days (owing to drying method this may be longer)	Tabulated in summary of classification tests and also plotted on A-Line (BS 5930: 2015)	Only the sample passing a 425-µm sieve is used	Can be carried out as a one- or four-point test. The four-point test is more accurate. Moisture content is not included as part of the test but must also be undertaken
2 days	Tabulated in summary of classification tests		
3 days	Plotted on particle size distribution curve and also tabulated		A sedimentation test can be carried out on the material passing the 63-µm sieve. This is generally a dependent option (based on the percentage passing the 63-µm sieve)
2 days	Tabulation of results Plot of load versus penetration	Only the sample passing a 20-mm sieve is used (may not be appropriate if retained >25%). Can be carried out on a recompacted specimen or an undisturbed sample recovered in a CBR mould. Normally, a surcharge of up to 10 kPa (-16 kg) can be applied	
4 days	Density versus moisture content plot	Only sample passing a 20-mm sieve is used in a litre mould or 37.5-mm in a CBR (approx. 2.3-L) mould but may not be appropriate if >30% larger than 20 mm. Only material below 20 mm can be used if a CBR test is to be performed. For samples that are susceptible to crushing, these quantities need to be at least doubled. The vibrating hammer test is normally applicable only to non-cohesive materials. Unless a particle density test is scheduled, an assumed or assessed value is used for air voids calculation (usually 2.65 mg/m^3)	
4 days			
4 days			
U* = Undisturbed sample recovered in test-specific moulds and not U100 tube samples ** Includes preparation and drying time where applicable			

LABORATORY TESTING (PART 3)

Guide to basic laboratory testing (BS 1377)

	Type of test	Derived parameters	Suitable sample type required	Suitable soil types	Mass required based on		
					Fine grained soil	Medium grained soil	Coarse grained soil
Strength tests	Undrained unconsolidated triaxial (UU)	Shear strength/ cohesion – c_u	U	C	6 kg	6 kg	12 kg
	Consolidated undrained triaxial (CU)	Effective cohesion, c' Effective angle of shear resistance, Φ	U	C	6 kg	6 kg	12 kg
	Consolidated drained triaxial (CD)		U	C	6 kg	6 kg	12 kg
	Laboratory vane	Shear strength/ cohesion,c_u	U	C	100-mm diameter >100-mm long		
	Small shear box	Effective cohesion,c' Effective angle of shear resistance, Φ	U*, B	All	1 kg	2 kg	n/a
	Large shear box		U*, B	All	35 kg	35 kg	35 kg
Consolidation	Oedometer consolidation	Coefficient of volume compressibility, m_v Coefficient of consolidation, c_v	U	C	500 g	1 kg	2 kg
Chemical	pH and sulphate	pH value and sulphate content	D, B, U	All	150 g	600 g	4 kg

Fine grained soil = <2 mm (includes clay, silt, sand)
Medium grained soil = 2–20 mm (includes fine and medium)
Coarse grained soil = 20–75 mm (includes coarse gravel)

U = Undisturbed sample (U100)
B = Bulk distributed sample
D = Small disturbed sample

LABORATORY TESTING (PART 4)

Guide to basic laboratory testing (BS 1377)

**Approx. duration of test	Reporting of results	Test comments	Additional comments
2 days	Tabulated on summary table	Tests are generally carried out on U100 or U38 samples (3 x 38 mm samples can be prepared from U100 sample). Test can be single stage (no confining pressure), multistage (three confining pressures) or three tests on 3 x U38 samples (three confining pressures)	Scheduling requires the cell confining pressure(s), either one pressure for a single stage test or three pressures for a multistage test
Minimum 5 days	Tabulation of all input and derived data Plot of Mohr's circles (shear stress versus normal effective stress)	As for the above plus side drains are normally fitted unless material's type of test schedule precludes this (vertical drains unless spiral specified). Saturation can be incremental cell and back pressure or at constant moisture content (cell pressure only). Consolidation can be undertaken with various drainage conditions but normally to top with pore pressure measured at centre base. Failure criteria are peak deviatoric stress (CU/CD), peak stress ratio (CU), constant shear stress and pore pressure (CU) constant shear stress and volume (CD)	
Minimum 5 days			
1 day	Summary table of results	Soft to firm cohesive samples only. Laboratory vane is more accurate and more expensive than hand-held methods	
3–5 days	Tabulation of all input and derived data Plot of Mohr's circles (shear stress versus normal effective stress)	Undisturbed specimen or recompacted from disturbed samples or loosely poured cohesionless soil. Small shear box has maximum particle size 2 mm in a 60- or 100-mm square box with height 20–25 mm. Large shear box has maximum particle size 20 mm (sometimes extended to 37.5 mm) in a nominally 300-mm square mould with height up to 150 mm. Specifications allow for tests in inundated or dry box conditions depending on engineering considerations. For samples susceptible to crushing, the quantities need to be multiplied by the number of sets to be tested. Shearing rates are based on consolidation parameters derived in the test	Specimen size, recompaction/ remoulding details (if required). Normal stresses (usually set of three). Peak only or peak and residual strengths. Inundated or dry box. Any specific requirements, e.g., reversal method
3–5 days			
1 day per loading stage	Plot of void ratio versus pressure Tabulated results	Undisturbed or recompacted specimen. Maximum particle size 4 mm. Nominally 75 mm diameter, 20 mm high	Loading/unloading pressures, usually four to six
5 days	Summary table of results	All sample except gravel greater than 2 mm is crushed and used, although gypsum larger than 2 mm is representatively crushed and included. Check expression of results and units used (normally sulphate in % or g/l, but also in mg/l)	Specify acid or water soluble extract. Any dependent options for BRE SD1

U* Undisturbed samples recovered in test-specific moulds and not U100 tube samples

**Includes preparation and drying time where applicable

Additional information

ENVIRONMENTAL MONITORING

RSK provides a range of construction-focused site monitoring and testing services that are responsive, cost-effective and of the highest quality.

Our fully qualified and experienced environmental technicians visit a site and carry out any monitoring or sampling before arranging delivery of the samples to our state-of-the-art laboratories. All our field staff are equipped to enable them to carry out gas, flow, vapour and water monitoring to current national specifications. All work is carried out under the ISO 9001, ISO 14001 and OHSAS 18001 standards.

Our analytical laboratory is staffed by very experienced chemists and accredited to BS EN 17025 and MCERTS.

COMPLEMENTARY SERVICES

RSK provides many services complementary to site investigations. Further details can be found at www.rsk.co.uk

RSK SafeGround – PAS128 standard utility surveys: from large-scale mapping projects to clearance of discrete locations before intrusive site investigation works www.safe-ground.co.uk/index.html

Ecology – Undertaking habitat and protected species surveys to inform clients of ecological constraints and obtaining development licences to facilitate works as required www.rsk.co.uk/services/esia/ecology.html

Geophysics – Applying near-surface geophysical techniques to site investigation, including surface mapping and borehole methods www.rsk.co.uk/geosciences.html

Envirolab – A UKAS-accredited laboratory (No. 1247) providing specialist analytical services for a variety of organic and inorganic analyses in a diverse range of matrices www.envlab.co.uk

Materials and structures – Provides a comprehensive range of UKAS-accredited on-site and laboratory tests on hardened concrete and other construction materials for quality assurance and structural investigations www.rsk.co.uk/services/sustainability/building-sciences/construction-materials-evaluation-and-testing.html

Asbestos and legionella – A full range of consultancy services to keep you compliant from surveys and air testing to risk assessments and tank cleaning www.rsk.co.uk/services/compliance/asbestos-and-water-hygiene

RemedX – cutting-edge, design-led remediation contracting solutions. Experience of all aspects of remediation fieldwork from small projects through to the management of multi-million pound programmes www.remedx.co.uk

TOOL AND EQUIPMENT WEIGHTS

Tool and equipment weights, kg			
Cable percussion kit		Rotary drilling kit	
6-in. casing 1.5 m	59	PW casing 1.5 m	33
8-in. casing 1.5 m	78	PW core barrel	50
10-in. casing 1.0 m	63	PW core barrel	48
10-in. casing 1.5 m	95	SWF core barrel	70
12-in. casing 1.0 m	75	NWY drill rod 1.5 m	15
12-in. casing 1.5 m	113	Box of 1.5 m P core	23
6-in. clay cutter	55	Box of 1.5 m S core	45
8-in. clay cutter	82	Other items	
6-in. casing head	13	Breaker and gun	88
8-in. casing head	17	1 m^3 (1000 L) of water	1000
6-in. bailer	57	Bag of cement	25
8-in. bailer	86	Bag of sand/ballast	25
U4 hammer/slider	80	Bag of bentonite	25
Top swivel weight	80		
Intermediate weight	95		
SPT hammer	105		
SPT rod 1.0 m	10		
Note: Figures quoted are approximate only and may vary with manufacture, etc.			

BOREHOLE VOLUMES AND BACKFILL

Borehole/grout volumes				
Hole diameter (mm)	Volume per metre depth		Volume of annulus where 63-mm OD (50-mm ID) standpipe installed	
	m^3	Litres	m^3	Litres
300	0.071	71	0.069	68
250	0.049	49	0.047	46
200	0.031	31	0.029	28
150	0.018	18	0.016	15
128	0.013	13	0.011	10
101	0.008	8	0.006	5

	Bentonite pellet quantities for sealing standpipe (kg/m)					
	Borehole diameter (mm)					
Installation pipe inner diameter (mm)	100	125	150	200	250	300
0	9	13	19	35	54	78
19	8	13	19	34	54	77
38	7	12	18	33	52	76
50	6	11	17	32	51	75
100			9	24	44	67
125				18	38	61
150				11	30	54
175					22	46
200					12	36

Note: Bentonite pellets – quantity is needed to backfill boreholes with standpipes

Pipe diameter is left-hand column

Estimated quantities based on an assumed packing density of 11 kg/m^3, and a pipe OD that is 110% of pipe ID

WHO IS RSK?

RSK is a multidisciplinary environmental and engineering consultancy that has been operating across Europe, the Middle East and Africa for over 25 years. The company offers comprehensive site investigation services through a sound knowledge of all aspects of geotechnical and geoenvironmental engineering. All the required services are in-house, including drilling using a fleet of rigs, service tracing, laboratory testing and remediation contracting.

The company also provides associated services such as ecology, environmental impact assessment, civil and structural engineering, aerial surveys, waste management, and permitting.

RSK has an accredited and integrated safety, health, environmental and quality management system aligned with ISO 9001, ISO 14001 and OHSAS 18001.

CONTACT US

RSK

www.rsk.co.uk

Belfast +44 (0)28 90 660993
Bristol +44 (0)117 947 1000
Castleford +44 (0)1977 552255
Coventry +44 (0)24 7650 5600
Derby +44 (0)1332 542740
Dublin +353 (0)1 400 3609
Glasgow +44 (0)141 418 0471
Helsby +44 (0)1928 726006
Hyde (Envirolab) +44 (0)161 368 4921
Hemel Hempstead +44 (0)1442 437500
Manchester +44 (0)161 236 2757
Southampton +44 (0)1794 329276
Tonbridge +44 (0)1732 833111

Published November 2015

GROUND ENGINEERING AWARDS 2015

WINNER
GROUND INVESTIGATION PROJECT OF THE YEAR