



# Manual of Soil Laboratory Testing

## Volume 1: Soil Classification and Compaction Tests

Third Edition

K. H. Head, *MA (Cantab), C. Eng, FICE, FGS*



Whittles Publishing



CRC Press  
Taylor & Francis Group

# Summary Contents

<b>Preface</b> .....	v
<b>Acknowledgements</b> .....	vi
<b>1 Scope and general requirements</b> .....	1
1.1 Introduction .....	1
1.2 Laboratory equipment .....	6
1.3 Techniques .....	22
1.4 Care of samples .....	32
1.5 Preparation of disturbed samples for testing .....	34
1.6 Safety in the laboratory .....	40
1.7 Calibration .....	45
<b>2 Moisture content and index tests</b> .....	53
2.1 Introduction .....	53
2.2 Definitions .....	54
2.3 Theory .....	54
2.4 Applications .....	64
2.5 Moisture content tests .....	68
2.6 Liquid and plastic limit tests .....	74
2.7 Shrinkage tests .....	97
2.8 Empirical index tests .....	107
2.9 Soil suction .....	110
<b>3 Density and particle density</b> .....	116
3.1 Introduction .....	116
3.2 Definitions .....	117
3.3 Theory .....	118
3.4 Applications .....	129
3.5 Density tests .....	131
3.6 Particle density tests .....	141
3.7 Limiting density tests .....	149
<b>4 Particle size</b> .....	159
4.1 Introduction .....	159
4.2 Definitions .....	160
4.3 Theory .....	160
4.4 Applications .....	166
4.5 Practical aspects .....	170
4.6 Sieving procedures .....	177
4.7 Sedimentation theory .....	206
4.8 Sedimentation procedures .....	210

<b>5</b>	<b>Chemical tests</b> .....	240
5.1	Introduction .....	240
5.2	Definitions and data .....	247
5.3	Theory .....	249
5.4	Applications .....	259
5.5	Tests for pH .....	261
5.6	Sulphate content tests .....	267
5.7	Organic content tests .....	279
5.8	Carbonate content tests .....	285
5.9	Chloride content tests .....	296
5.10	Miscellaneous tests .....	304
<b>6</b>	<b>Compaction tests</b> .....	309
6.1	Introduction .....	309
6.2	Definitions .....	311
6.3	Theory .....	311
6.4	Applications .....	320
6.5	Compaction test procedures .....	323
6.6	Moisture condition tests .....	346
6.7	Chalk crushing value .....	359
6.8	Compactability test for graded aggregates .....	361
<b>7</b>	<b>Description of soils</b> .....	365
7.1	Introduction .....	362
7.2	Definitions .....	368
7.3	Identification of soils .....	369
7.4	Description of coarse (granular) soils .....	373
7.5	Description of fine soils .....	375
7.6	Description of other soil types .....	380
	<b>Appendix: Units, Nomenclature and laboratory equipment</b> .....	387
A1	Metric (SI) units .....	388
A2	Nomenclature .....	393
A3	Useful data .....	395
A4	Comparison of BS and ASTM sieve aperture sizes .....	396
A5	Inventory of equipment.....	397
	<b>Index</b> .....	405

# Summary of test procedures

<i>Test designation</i>	<i>Section</i>	<i>Abbreviated reference*</i>
<i>Chapter 2</i>		
Moisture content:		
Oven drying	2.5.2	BS: Part 2: 3.2
Sand-bath	2.5.3	(BS 1377: 1975**)
Saturation moisture content of chalk	2.5.4	BS: Part 2: 3.3
Liquid limit:		
Cone penetrometer	2.6.4	BS: Part 2: 4.3
One-point penetrometer	2.6.5	BS: Part 2: 4.4
Casagrande	2.6.6	BS: Part 2: 4.5
One-point Casagrande	2.6.7	BS: Part 2: 4.6
Plastic limit	2.6.8	BS: Part 2: 5.3
Shrinkage limit:		
TRL method	2.7.2	BS: Part 2: 6.3
ASTM method	2.7.3	BS: Part 2: 6.4
Linear shrinkage	2.7.4	BS: Part 2: 6.5
Puddle clay	2.8.2	Nixon (1956)
Free swell	2.8.3	Gibbs & Holtz (1956)
Sticky limit	2.8.4	Terzaghi & Peck (1948)
Soil suction (filter-paper method)	2.9	BRE Info. Paper IP4/93
<i>Chapter 3</i>		
Density:		
Measurement	3.5.2	BS: Part 2: 7.2
Tube	3.5.3	Soil Mechanics
Water displacement	3.5.4	BS: Part 2: 7.4
Immersion in water	3.5.5	BS: Part 2: 7.3
Particle density:		
Small pycnometer	3.6.2	BS: Part 2: 8.3
Gas jar	3.6.4	BS: Part 2: 8.2
Large pycnometer	3.6.5	BS: Part 2: 8.4
Maximum density:		
Sands	3.7.2	BS: Part 4: 4.2
Silty soils	3.7.3	Soil Mechanics
Gravelly soils	3.7.4	BS: Part 4: 4.3
Minimum density:		



Sands	3.7.5	BS: Part 4: 4.4
Gravelly soils	3.7.6	BS: Part 4: 4.5
<i>Chapter 4</i>		
Sieving:		
Dry: simple	4.6.1	BS: Part 2: 9.3
Dry: composite	4.6.2	BS: Part 2: 9.3
Dry: very coarse soils	4.6.3	BS: Part 2: 9.3
Wet: fine soils	4.6.4	BS: Part 2: 9.2
Wet: gravelly soils	4.6.5	BS: Part 2: 9.2
Wet: cohesive soils	4.6.6	BS: Part 2: 9.2
Wet: cohesive soils with large particles	4.6.7	Soil Mechanics
Sedimentation:		
Pipette	4.8.2	BS: Part 2: 9.4
Hydrometer	4.8.3	BS: Part 2: 9.5
<i>Chapter 5</i>		
pH value:		
Indicator papers	5.5.1	Supplier
Electrometric	5.5.2	BS: Part 3: 9
Colorimetric	5.5.3	(BS 1377: 1975**)
Lovibond	5.5.4	Supplier
Sulphate content:		
Total sulphates—acid extraction	5.6.2	BS: Part 3: 5.2
Water-soluble sulphates—extraction	5.6.3	BS: Part 3: 5.3
Groundwater	5.6.4	BS: Part 3: 5.4
Gravimetric analysis	5.6.5	BS: Part 3: 5.5
Ion-exchange analysis	5.6.6 & 5.6.7	BS: Part 3: 5.6
Organic content:		
Dichromate oxidation	5.7.2	BS: Part 3: 3.4
Peroxide oxidation	5.7.3	(BS 1377: 1975**)
Carbonate content:		
Rapid titration	5.8.2	BS: Part 3: 6.3
Gravimetric	5.8.3	BS: Part 3: 6.4
Calcimeter: standard	5.8.4	Collins (1906)
simplified	5.8.5	Collins (1906)
Chloride content:		
Qualitative	5.9.2	BS: Part 3: 7.2.3.3
Water-soluble	5.9.3	BS: Part 3: 7.2
Mohr's method	5.9.4	Bowley (1995)
Acid soluble	5.9.5	BS: Part 3: 7.3
Total dissolved salts	5.10.2	BS: Part 3: 8.3

Loss on ignition	5.10.3	BS: Part 3: 4.3
Indicator papers	5.10.4	Supplier
<i>Chapter 6</i>		
Light compaction (1 litre mould)	6.5.3	BS: Part 4: 3.3
Heavy compaction (1 litre mould)	6.5.4	BS: Part 4: 3.5
Compaction in CBR mould	6.5.5	BS: Part 4: 3.4 & 3.6
ASTM compaction	6.5.7	ASTM D 698 & D 1557
Compaction by vibration	6.5.9	BS: Part 4: 3.7
Harvard miniature compaction	6.5.10	ASTM STP 479
Moisture Condition Value:		
MCV as received	6.6.3	BS: Part 4: 5.4
Moisture Condition Calibration (MCC)	6.6.4	BS: Part 4: 5.5
Rapid Assessment	6.6.5	BS: Part 4: 5.6
Chalk Crushing Value	6.7.2	BS: Part 4: 6.4
Compactability of aggregates	6.8	Pike (1972); Pike and Acott (1975)

\* BS implies BS 1377: 1990 unless otherwise stated

\*\* Superseded standard

ASTM: American Society for Testing and Materials

BRE : Building Research Establishment

Supplier: Supplier's or manufacturer's instruction leaflets