

This introductory course on soil mechanics presents the key concepts of stress, stiffness, seepage, consolidation, and strength within a one-dimensional framework. Consideration of the mechanical behaviour of soils requires us to consider density alongside stresses, thus permitting the unification of deformation and strength characteristics. Soils are described in a way which can be integrated with concurrent teaching of the properties of other engineering materials. The book includes a model of the shearing of soil and some examples of soil-structure interaction which are capable of theoretical analysis using one-dimensional governing equations. The text contains many worked examples, and exercises are given for private study at the end of all chapters. Some suggestions for laboratory demonstrations that could accompany such an introductory course are sprinkled through the book.

David Muir Wood has taught soil mechanics and geotechnical engineering at the universities of Cambridge, Glasgow and Bristol since 1975 and has contributed to courses on soil mechanics in many countries around the world. He is the author of numerous research papers and book chapters. His previous books include *Soil behaviour and critical state soil mechanics* (1990) and *Geotechnical modelling* (2004). He was co-chairman of the United Kingdom GeotechniCAL computer-aided learning project.

Cover photo: Alum Bay, Isle of Wight. Copyright David Muir Wood.

Cover design: Alice Soloway

CAMBRIDGE
UNIVERSITY PRESS
www.cambridge.org

ISBN 978-0-521-74135-3



9 780521 741353

Contents

<i>Preface</i>	<i>page ix</i>
1 Introduction	1
1.1 Introduction	1
1.2 Soil mechanics	2
1.3 Range of problems/applications	2
1.4 Scope of this book	10
1.5 Mind maps	11
2 Stress in soils	12
2.1 Introduction	12
2.2 Equilibrium	12
2.3 Gravity	13
2.4 Stress	16
2.5 Exercises: Stress	18
2.6 Vertical stress profile	19
2.6.1 Worked examples	21
2.7 Water in the ground: Introduction to hydrostatics	23
2.7.1 Worked example: Archimedes uplift on spherical object	26
2.8 Total and effective stresses	28
2.8.1 Worked examples	32
2.9 Summary	37
2.10 Exercises: Profiles of total stress, effective stress, pore pressure	37
3 Density	40
3.1 Introduction	40
3.2 Units	40
3.3 Descriptions of packing and density	41
3.3.1 Volumetric ratios	43
3.3.2 Water content	44
3.3.3 Densities	44

3.3.4 Unit weights	46
3.3.5 Typical values	46
3.4 Measurement of packing	47
3.4.1 Compaction	50
3.5 Soil particles	52
3.6 Laboratory exercise: particle size distribution and other classification tests	56
3.6.1 Sieving	56
3.6.2 Sedimentation	57
3.6.3 Particle shape	61
3.6.4 Sand: relative density	61
3.7 Summary	62
3.8 Exercises: Density	64
3.8.1 Multiple choice questions	64
3.8.2 Calculation exercises	65
4 Stiffness	67
4.1 Introduction	67
4.2 Linear elasticity	67
4.3 Natural and true strain	70
4.4 One-dimensional testing of soils	70
4.4.1 Hooke's Law: confined one-dimensional stiffness ♣	72
4.5 One-dimensional (confined) stiffness of soils	74
4.6 Calculation of strains	78
4.6.1 Worked examples: Calculation of settlement	79
4.7 Overconsolidation	82
4.7.1 Worked examples: Overconsolidation	84
4.8 Summary	87
4.9 Exercises: Stiffness	87
5 Seepage	90
5.1 Introduction	90
5.2 Total head: Bernoulli's equation	90
5.3 Poiseuille's equation	96
5.4 Permeability	99
5.4.1 Darcy or Forchheimer?	102
5.5 Measurement of permeability	104
5.6 Permeability of layered soil	106
5.7 Seepage forces	108
5.8 Radial flow to vertical drain	111
5.9 Radial flow to point drain	112
5.10 Worked examples: Seepage	113
5.10.1 Example: flow through soil column	113
5.10.2 Example: effect of changing reference datum	116

5.10.3 Example: pumping from aquifer	117
5.10.4 Example: flow into excavation	119
5.11 Summary	121
5.12 Exercises: Seepage	123
6 Change in stress	127
6.1 Introduction	127
6.2 Stress change and soil permeability	127
6.3 Worked examples	130
6.3.1 Example 1	130
6.3.2 Example 2	131
6.3.3 Example 3	133
6.4 Summary	134
6.5 Exercises: Change in stress	136
7 Consolidation	138
7.1 Introduction	138
7.2 Describing the problem	140
7.3 Parabolic isochrones	142
7.4 Worked examples	149
7.4.1 Example 1: Determination of coefficient of consolidation	149
7.4.2 Example 2	152
7.4.3 Example 3	154
7.4.4 Example 4	155
7.5 Consolidation: exact analysis ♣	155
7.5.1 Semi-infinite layer	159
7.5.2 Finite layer	161
7.6 Summary	165
7.7 Exercises: Consolidation	167
8 Strength	169
8.1 Introduction	169
8.2 Failure mechanisms	169
8.3 Shear box and strength of soils	171
8.4 Strength model	173
8.5 Dilatancy	174
8.6 Drained and undrained strength	177
8.7 Clay: overconsolidation and undrained strength	179
8.8 Pile load capacity	181
8.9 Infinite slope	185
8.9.1 Laboratory exercise: Angle of repose	191
8.10 Undrained strength of clay: fall-cone test	193
8.11 Simple model of shearing ♣	195
8.11.1 Stiffness	196

8.11.2 Strength	197
8.11.3 Mobilisation of strength	197
8.11.4 Dilatancy	198
8.11.5 Complete stress:strain relationship	199
8.11.6 Drained and undrained response	200
8.11.7 Model: summary	203
8.12 Summary	203
8.13 Exercises: Strength	205
9 Soil-structure interaction	208
9.1 Introduction	208
9.2 Pile under axial loading ♣	211
9.2.1 Examples	215
9.3 Bending of an elastic beam ♣	216
9.4 Elastic beam on elastic foundation ♣	220
9.5 Pile under lateral loading ♣	224
9.6 Soil-structure interaction: next steps	226
9.7 Summary	227
9.8 Exercises: Soil-structure interaction	227
10 Envoi	230
10.1 Summary	230
10.2 Beyond the single dimension	231
Exercises: numerical answers	232
<i>Index</i>	237