

Table of Contents

Preface	ix
Chapter 1. Introduction: Basic Concepts	1
1.1. Soils and rocks	1
1.2. Engineering properties of soils	3
1.3. Soils as an aggregation of particles	7
1.4. Interaction with pore water	9
1.5. Transmission of the stress state in granular soil	10
1.6. Transmission of the stress state in the presence of a fluid	14
1.7. From discrete to continuum	17
1.8. Stress and strain tensors	21
1.9. Bibliography	25
Chapter 2. Field Equations for a Porous Medium	27
2.1. Equilibrium equations	27
2.2. Compatibility equations	30
2.3. Constitutive laws	32
2.4. Geostatic stress state and over-consolidation	40
2.5. Continuity equation and Darcy's law	44
2.6. Particular cases	48
2.6.1. Dry soil	49
2.6.2. Saturated soil with still groundwater	50
2.6.3. Saturated soil with seepage: stationary conditions	50
2.6.4. Saturated soil with seepage: transient conditions	51
2.7. Bibliography	55

Chapter 3. Seepage: Stationary Conditions	57
3.1. Introduction	57
3.2. The finite difference method	60
3.3. Flow net	63
3.4. Excess pore pressure	65
3.5. Instability due to piping	67
3.6. Safety factor against piping	68
3.7. Anisotropic permeability	70
3.8. Transition between soils characterized by different permeability coefficients	74
3.9. Free surface problems	75
3.10. <i>In situ</i> methods for the permeability coefficient determination	77
3.11. Bibliography	81
Chapter 4. Seepage: Transient Conditions	83
4.1. One-dimensional consolidation equation	83
4.2. Excess pore pressure isochrones	86
4.3. Consolidation settlement	91
4.4. Consolidation settlement: approximated solution	93
4.5. Consolidation under different initial or boundary conditions	97
4.6. Load linearly increasing over time: under consolidation	101
4.7. Consolidation under axial symmetric conditions	104
4.8. Multidimensional consolidation: the Mandel-Cryer effect	106
4.9. Oedometer test and measure of c_v	114
4.10. Influence of the skeleton viscosity	118
4.11. Bibliography	123
Chapter 5. The Constitutive Relationship: Tests and Experimental Results	125
5.1. Introduction	125
5.2. Fundamental requirements of testing apparatus	127
5.3. Principal testing apparatus	130
5.3.1. The “true” triaxial test (TTA): Lamé’s ellipsoid and Mohr’s sickle	130
5.3.2. The (standard) triaxial apparatus	135
5.3.3. The oedometer	144
5.3.4. The biaxial apparatus	144
5.3.5. Direct shear box and simple shear apparatus (SSA)	147
5.3.6. Hollow cylinder	152

5.4. The stress path concept	157
5.5. Experimental results for isotropic tests on virgin soils	163
5.6. Experimental results for radial tests on virgin soils: stress, dilatancy relationship	167
5.7. Oedometric tests on virgin soil as a particular case of the radial test: earth pressure coefficient at rest	173
5.8. Drained triaxial tests on loose sands: Mohr-Coulomb failure criterion	174
5.9. Undrained triaxial tests on loose sands: instability line and static liquefaction	179
5.10. Drained tests on dense and medium dense sand: dilatancy and critical state	186
5.11. Strain localization: shear band formation	191
5.12. Undrained tests on dense and medium dense sands: phase transformation line	196
5.13. Sand behavior in tests in which the three principal stresses are independently controled: failure in the deviatoric plane	198
5.14. Normally consolidated and over-consolidated clays: oedometric tests with loading unloading cycles – extension failure.	201
5.15. Drained and undrained triaxial tests on normally consolidated clays: normalization of the mechanical behavior	208
5.16. Over-consolidated clays.	214
5.17. The critical state. Plasticity index	219
5.18. Natural soils: apparent over-consolidation – yielding surface	226
5.19. Soil behavior under cyclic loading: cyclic mobility and strength degradation.	230
5.20. Bibliography	236
Chapter 6. The Constitutive Relationship: Mathematical Modeling of the Experimental Behavior	241
6.1. Introduction	241
6.2. Nonlinear elasticity	242
6.3. Perfect elastic-plasticity	243
6.4. Yielding of metals	247
6.5. Taylor and Quinney experiments: the normality postulate	251
6.6. Generalized variables of stress and strain	258
6.7. Plastic strains for a material behaving as described by the Mohr-Coulomb criterion.	259
6.8. Drucker-Prager and Matsuoka-Nakai failure criteria	261
6.9. Dilatancy: non-associated flow rule	267
6.10. Formulation of an elastic-perfectly plastic law	269

6.11. Cam clay model	272
6.12. Reformulation of the Cam clay model as an elastic-plastic hardening model	282
6.13. Comparison between experimental behavior and mathematical modeling for normally consolidated clays	285
6.14. Lightly over-consolidated clays	290
6.15. Heavily over-consolidated clays	293
6.16. Subsequent developments and applications	298
6.17. Non-associated flow rule: the Nova-Wood model	301
6.18. Sinfonietta classica: a model for soils and soft rocks	309
6.19. Models for soils subjected to cyclic loading	315
6.20. Conceptual use of constitutive soil behavior models	318
6.20.1. Oedometric test	318
6.20.2. Unconfined undrained (UU) test	321
6.20.3. Shear modulus “anisotropy”	324
6.21. Bibliography	325
 Chapter 7. Numerical Solution to Boundary Value Problems	329
7.1. Introduction	329
7.2. The finite element method for plane strain problems	330
7.3. Earth pressures on retaining structures	344
7.4. Settlements and bearing capacity of shallow foundations	354
7.5. Numerical solution of boundary value problems for fully saturated soil	364
7.6. Undrained conditions: short-term bearing capacity of a footing	371
7.7. Short- and long-term stability of an excavation	380
7.8. Bibliography	389
 Postscript	391
 Index	395