ICE manual of geotechnical engineering

Volume II
Geotechnical Design, Construction and Verification

Edited by
John Burland
Imperial College London, UK
Tim Chapman
Arup Geotechnics, UK
Hilary Skinner
Donaldson Associates Ltd, UK
Michael Brown
University of Dundee, UK
Contents

Volume II
Foreword and endorsement xi
Preface xiii
List of contributors xv

SECTION 5: Design of foundations
Section Editor: A. S. O'Brien

Chapter 51: Introduction to Section 5
A. S. O'Brien

Chapter 52: Foundation types and conceptual design principles
A. S. O'Brien

Chapter 53: Shallow foundations
A. S. O'Brien and I. Farooq

Chapter 54: Single piles
A. Bell and C. Robinson

Chapter 55: Pile-group design
A. S. O'Brien

Chapter 56: Rafts and piled rafts
A. S. O'Brien, J. B. Burland and T. Chapman

Chapter 57: Global ground movements and their effects on piles
E. Ellis and A. S. O'Brien

Chapter 58: Building on fills
H. D. Skinner

Chapter 55: Pile-group design
A. S. O'Brien

Chapter 56: Rafts and piled rafts
A. S. O'Brien, J. B. Burland and T. Chapman

Chapter 57: Global ground movements and their effects on piles
E. Ellis and A. S. O'Brien

Chapter 58: Building on fills
H. D. Skinner
Chapter 59: Design principles for ground improvement 911
R. Easley

59.1 Introduction 911
59.2 General design principles for ground improvement 912
59.3 Design principles for void filling 913
59.4 Design principles for compaction grouting 914
59.5 Design principles for permeation grouting 916
59.6 Design principles for jet grouting 924
59.7 Design principles for vibrocompaction and vibroreplacement 929
59.8 Design principles for dynamic compaction 933
59.9 Design principle for deep soil mixing 934
59.10 References 937

Chapter 60: Foundations subjected to cyclic and dynamic loads 939
M. Srbulov and A. S. O'Brien

60.1 Introduction 939
60.2 Cyclic loading 939
60.3 Earthquake effects 940
60.4 Offshore foundation design 948
60.5 Machine foundations 950
60.6 References 951

SECTION 6: Design of retaining structures 955
Section Editor: A. Gaba

Chapter 61: Introduction to Section 6 957
A. Gaba

Chapter 62: Types of retaining walls 959
S. Anderson

62.1 Introduction 959
62.2 Gravity walls 959
62.3 Embedded walls 961
62.4 Hybrid walls 966
62.5 Comparison of walls 966
62.6 References 968

Chapter 63: Principles of retaining wall design 969
M. Devrient

63.1 Introduction 969
63.2 Design concepts 969
63.3 Selection of design parameters 973
63.4 Ground movements and their prediction 977
63.5 Principles of building damage assessment 979
63.6 References 980

Chapter 64: Geotechnical design of retaining walls 981
A. Pickles

64.1 Introduction 981
64.2 Gravity walls 981
64.3 Reinforced soil walls 988
64.4 Embedded walls 988
64.5 References 989

Chapter 65: Geotechnical design of retaining wall support systems 1001
S. Anderson

65.1 Introduction 1001
65.2 Design requirements and performance criteria 1001
65.3 Types of wall support systems 1002
65.4 Props 1003
65.5 Tied systems 1005
65.6 Soil berms 1006
65.7 Other systems of wall support 1008
65.8 References 1009

Chapter 66: Geotechnical design of ground anchors 1011
M. Turner

66.1 Introduction 1011
66.2 Review of design responsibilities 1014

66.3 The design of ground anchors for the support of retaining walls 1015
66.4 Detailed design of ground anchors 1017
66.5 References 1029

Chapter 67: Retaining walls as part of complete underground structure 1031
R. Ingram

67.1 Introduction 1031
67.2 Interfaces with structural design and other disciplines 1031
67.3 Resistance to lateral actions 1033
67.4 Resistance to vertical actions 1034
67.5 Design of bored piles and barrettes to support/resist vertical loading beneath base slab 1036
67.6 References 1037

SECTION 7: Design of earthworks, slopes and pavements 1039
Section Editor: Paul A. Nowak

Chapter 68: Introduction to Section 7 1041
P. A. Nowak

Chapter 69: Earthworks design principles 1043
P. A. Nowak

69.1 Historical perspective 1043
69.2 Fundamental requirements of earthworks 1043
69.3 Development of analysis methods 1044
69.4 Factors of safety and limit states 1044
69.5 References 1046

Chapter 70: Design of new earthworks 1047
P. A. Nowak

70.1 Failure modes 1047
70.2 Typical design parameters 1050
70.3 Pore pressures and groundwater 1053
70.4 Loadings 1055
70.5 Vegetation 1057
70.6 Embankment construction 1058
70.7 Embankment settlement and foundation treatment 1059
70.8 Instrumentation 1062
70.9 References 1063

Chapter 71: Earthworks asset management and remedial design 1067
B. T. McGinnity and N. Saffari

71.1 Introduction 1087
71.2 Stability and performance 1089
71.3 Earthwork condition appraisal, risk mitigation and control 1073
71.4 Maintenance and remedial works 1075
71.5 References 1085

Chapter 72: Slope stabilisation methods 1087
P. A. Nowak

72.1 Introduction 1087
72.2 Embedded solutions 1087
72.3 Gravity solutions 1088
72.4 Reinforced/ nailed solutions 1089
72.5 Slope drainage 1090
72.6 References 1091

Chapter 73: Design of soil reinforced slopes and structures 1093
S. Manceau, C. Macdiarmid and G. Horgan

73.1 Introduction and scope 1093
73.2 Reinforcement types and properties 1093
73.3 General principles of reinforcement action 1094
73.4 General principles of design 1096
Chapter 87: Rock stabilisation
R. Nicholson
87.1 Introduction 1295
87.2 Management solutions 1296
87.3 Engineered solutions 1297
87.4 Maintenance requirements 1301
87.5 References 1302

Chapter 88: Soil nailing construction
P. Ball and M. R. Gavins
88.1 Introduction 1303
88.2 Planning 1303
88.3 Slope/site preparation 1305
88.4 Drilling 1307
88.5 Placing the soil nail reinforcement 1306
88.6 Grouting 1307
88.7 Completion/finishing 1308
88.8 Slope facing 1310
88.9 Drainage 1311
88.10 Testing 1311
88.11 References 1312

Chapter 89: Ground anchors construction
J. Judge
89.1 Introduction 1313
89.2 Applications of ground anchors 1313
89.3 Types of ground anchors 1314
89.4 Ground anchor tendons 1316
89.5 Construction methods in various ground types 1316
89.6 Ground anchor testing and maintenance 1320
89.7 References 1321

Chapter 90: Geotechnical grouting and soil mixing
A. L. Bell
90.1 Introduction and background 1323
90.2 Permeation grouting in soils 1324
90.3 Soilfracture and compaction grouting 1327
90.4 Compaction grouting 1328
90.5 Jet grouting 1330
90.6 Soil mixing 1333
90.7 Verification for grouting and soil mixing 1338
90.8 References 1340

Chapter 91: Modular foundations and retaining walls
C. Wren
91.1 Introduction 1343
91.2 Modular foundations 1343
91.3 Off-site manufactured solutions – the rationale 1344
91.4 Precast concrete systems 1345
91.5 Modular retaining structures 1349
91.6 References 1349

SECTION 9: Construction verification
Section Editor: M. Brown and M. Devriendt

Chapter 92: Introduction to Section 9
M. Devriendt and M. Brown

Chapter 93: Quality assurance
D. Corke and T. P. Buckling
93.1 Introduction 1355
93.2 Quality management systems 1355
93.3 Geotechnical specifications 1356
93.4 Role of the resident engineer 1356
93.5 Self-certification 1356
93.6 Finding non-conformances 1357
93.7 Forensic investigations 1359
93.8 Conclusions 1360
93.9 References 1361

Chapter 94: Principles of geotechnical monitoring
J. Dunkelmann, A. Marr and J. Standing
94.1 Introduction 1363
94.2 Benefits of geotechnical monitoring 1363
94.3 Systematic approach to planning monitoring programmes using geotechnical instrumentation 1366
94.4 Example of a systematic approach to planning a monitoring programme: using geotechnical instrumentation for an embankment on soft ground 1370
94.5 General guidelines on execution of monitoring programmes 1372
94.6 Summary 1376
94.7 References 1376

Chapter 95: Types of geotechnical instrumentation and their usage
J. Dunkelmann
95.1 Introduction 1379
95.2 Instruments for monitoring groundwater pressure 1379
95.3 Instruments for monitoring deformation 1384
95.4 Instruments for monitoring load and strain in structural members 1389
95.5 Instruments for monitoring total stress 1392
95.6 General role of instrumentation, and summaries of instruments to be considered for helping to provide answers to various geotechnical questions 1393
95.7 Acknowledgement 1400
95.8 References 1402

Chapter 96: Technical supervision of site works
S. Glover and J. Chew
96.1 Introduction 1405
96.2 Reasons for supervision of geological works 1406
96.3 Preparing for a site role 1406
96.4 Managing the site works 1410
96.5 Health and safety responsibilities 1414
96.6 Supervision of site investigation works 1414
96.7 Supervision of piling works 1416
96.8 Supervision of earthworks 1417
96.9 References 1418

Chapter 97: Pile integrity testing
S. French and M. Turner
97.1 Introduction 1419
97.2 The history and development of non-destructive pile testing 1420
97.3 A Review of defects in piles in the context of NDT 1421
97.4 Low-strain integrity testing 1422
97.5 Cross-hole sonic logging 1437
97.6 Parallel seismic testing 1442
97.7 High-strain integrity testing 1442
97.8 The reliability of pile integrity testing 1448
97.9 Selection of a suitable test method 1448
97.10 References 1448

Chapter 98: Pile capacity testing
M. Brown
98.1 An introduction to pile testing 1451
98.2 Static pile testing 1452
98.3 Bi-directional pile testing 1458
98.4 High-strain dynamic pile testing 1460
98.5 Rapid load testing 1463
98.6 Pile testing safety 1467
98.7 Simple overview of pile testing methods 1487
98.8 Acknowledgements 1488
98.9 References 1488

Chapter 99: Materials and material testing for foundations
S. Pannington
99.1 Introduction 1471
99.2 Eurocodes 1471
99.3 Materials 1472
99.4 Verification 1472
99.5 Concrete 1472
Contents – volume II

99.6 Steel and cast iron
99.7 Timber
99.8 Geosynthetics
99.9 The ground
99.10 Aggregates
99.11 Grout
99.12 Drilling muds
99.13 Miscellaneous materials
99.14 Re-use of foundations
99.15 References

Chapter 100: Observational method
D. Patel
100.1 Introduction
100.2 Fundamentals of OM implementation and pros and cons of its use
100.3 OM concepts and design
1475
1477
1478
1479
1481
1482
1483
1484
1485
1486
1489
1491
1492
100.4 Implementation of planned modifications during construction
100.5 ‘Best way out’ approach in OM
100.6 Concluding remarks
100.7 References

Chapter 101: Close-out reports
R. Lindsey and M. Kemp
101.1 Introduction
101.2 Reasons for writing close-out reports
101.3 Contents of close-out report
101.4 Reporting on quality issues
101.5 Reporting on health and safety issues
101.6 Documentation systems and preserving data
101.7 Summary
101.8 References

Index to volumes I and II
1509