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Published by
Excellent Publishers



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Ground Improvement Techniques Principles, Design and Practice

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ISBN : **978-81-69623-04-9**

Page(s) : **290, xiv**

Price : **Rs.1800/-**

Published Year : **November, 2026**

Published by : **Excellent Publishers**
No. 38/48, Second street, Ellappa Nagar
Kanchipuram – 631501, Tamilnadu, India.
Cell +91-9842641794
excellentpublishers2013@gmail.com
www.excellentpublishers.com



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PREFACE

Dear Reader,

Ground improvement is no longer a last resort for difficult sites. It is now one of the first options an engineer considers when a structure must be built on poor ground. Highways, railways, ports, industrial estates and urban developments in India are increasingly built on soft marine clays, loose sands, expansive black cotton soils and filled land, where shallow foundations are inadequate and deep foundations are costly. Preloading with vertical drains, stone columns, dynamic compaction, deep soil mixing, grouting and geosynthetic reinforcement allow such sites to be used safely and economically. The civil engineer of today must therefore understand not only how these techniques work, but also how to select, design, specify and verify them.

This book has been written to meet that need. It draws on my 26 years of teaching civil engineering students, and it follows the path of a real ground improvement project. It begins with the problematic soils that create the need for improvement, the mechanisms by which soils are improved, and the site investigation on which every design depends. It then treats each major technique in turn and shows how the techniques are applied to foundations, highways and railways, dams and slopes, and coastal and marine works. The final chapters deal with monitoring and quality control, design calculations, case histories, recent advances and a framework for selecting the most suitable method.

Throughout the book, I have tried to keep the theory rigorous yet accessible, to explain the reasoning behind each design equation, and to illustrate it with worked examples based on typical field situations. Relevant Indian Standards and IRC guidelines are cited wherever they apply, and Indian ground conditions receive particular attention. Each chapter closes with a summary, review questions ranging from short-answer to numerical problems, and references for further reading.

The book is intended for B.Tech and M.Tech students of civil and geotechnical engineering. It will also serve practising engineers, consultants and contractors as a ready reference. Suggestions from teachers, students and practitioners for improving future editions will be gratefully received.

I thank the Management, the Principal and my colleagues in the Department of Civil Engineering for their constant encouragement, my students whose questions shaped much of this book, and my family for their patience and support during its preparation. I am also grateful to the publisher for bringing out the book in its present form.

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About the Book

Ground Improvement Techniques is a comprehensive textbook on the methods used to improve the engineering behaviour of weak and problematic soils. It treats ground improvement as a complete engineering process: identifying the problem soil, investigating the site, selecting and designing the technique, controlling construction and verifying performance. The 22 chapters are arranged in four parts:

- **Fundamentals (Chapters 1–4):** problematic soils, mechanisms of improvement and site investigation.
- **Techniques (Chapters 5–13):** mechanical densification, preloading and vertical drains, stone columns, grouting, stabilization with additives, geosynthetics, electro-osmosis and thermal methods, deep soil mixing and vibro techniques.
- **Applications (Chapters 14–17):** foundations, highways and railways, dams, embankments and slopes, and coastal and marine works.
- **Practice (Chapters 18–22):** monitoring and quality control, design procedures, case studies, recent advances and selection guidelines.

Key Features

- Clear explanation of the mechanisms behind every technique: densification, consolidation and drainage, cementation, reinforcement and thermal effects.
- More than 70 worked examples, and nine complete design examples covering preloading with vertical drains, stone columns beneath a storage tank, vibro-compaction for liquefaction mitigation, basal reinforcement, deep mixing, permeation grouting and vacuum preloading.
- Over 90 figures and nearly 50 tables that summarise design data, soil suitability and comparisons between methods.
- Case histories, including the Second Bangkok International Airport, Kansai International Airport, the Leaning Tower of Pisa and the Muar Flats trial embankment.
- Emphasis on Indian practice, with reference to Indian Standards and IRC guidelines, black cotton soils and soft marine clays.
- Recent advances: bio-mediated improvement, nanomaterials, low-carbon binders, carbon assessment, digital monitoring and machine learning.
- A practical selection framework with screening tables, a decision flowchart, weighted comparison, a checklist and guidance on managing ground risk.
- Review questions in every chapter (short-answer, descriptive and numerical), and appendices on Indian Standards, notation, record formats, design charts, ten laboratory experiments and a glossary.

The book is designed for B.Tech and M.Tech students of civil and geotechnical engineering, and will be equally useful to practising engineers, consultants and contractors engaged in the design and construction of ground improvement works.

Table of Contents

Chapter 1 Introduction to Ground Improvement 1
1.1 Definition and Scope 1
1.2 Need for Ground Improvement 2
1.3 Objectives of Ground Improvement 3
1.4 Historical Development 4
1.5 Classification of Ground Improvement Techniques 5
1.6 Factors Influencing the Choice of Technique 7
1.7 Ground Improvement in Indian Practice 8
1.8 Ground Improvement Projects: Stages and Participants 8
1.9 Organisation of This Book 9

Chapter 2 Problematic Soils and Their Engineering Behaviour 12
2.1 What Makes a Soil Problematic? 12
2.2 Expansive Soils 13
2.3 Soft Clays and Organic Soils 17
2.4 Loose Sands and Liquefaction 20
2.5 Collapsible Soils 22
2.6 Marine and Coastal Deposits 23
2.7 Fills and Other Special Soils 24
2.8 Summary of Problems and Treatments 25
2.9 Heave Prediction and Field Identification 25

Chapter 3 Principles and Mechanisms of Ground Improvement 30
3.1 The Effective Stress Principle 30
3.2 Densification 31
3.3 Consolidation and Drainage 32
3.4 Reinforcement and Load Sharing 34
3.5 Cementation and Chemical Modification 36
3.6 Thermal and Electrical Mechanisms 37
3.7 Matching Mechanisms to Soils 37
3.8 Stress Distribution Beneath Loaded Areas 38

Chapter 4 Site Investigation for Ground Improvement Projects 42
4.1 Purpose of Investigation for Ground Improvement 42
4.2 Planning the Investigation 43
4.3 Boring and Sampling 44
4.4 In Situ Tests 45
4.5 Laboratory Tests 48
4.6 Ground Model and Parameter Selection 49
4.7 Investigation for Verification 49
4.8 Reporting 49
4.9 Shear Wave Velocity and Sample Quality 50

Chapter 5 Mechanical Densification Methods 53
5.1 Compaction Theory 53
5.2 Surface Compaction 55
5.3 Dynamic Compaction 56
5.4 Rapid Impact Compaction 60
5.5 Explosive Compaction 60
5.6 Comparison of Densification Methods 60
5.7 Field Practice: Trials, Special Materials and Vibration 61

Chapter 6 Preloading and Vertical Drains 65
6.1 Principle of Preloading 65
6.2 Strength Gain and Staged Construction 67
6.3 Vertical Drains 68
6.4 Theory of Radial Consolidation 69
6.5 Installation of Prefabricated Vertical Drains 71
6.6 Vacuum Consolidation 72
6.7 Monitoring and Design Summary 73
6.8 Secondary Compression, Well Resistance and the Drainage Blanket 73

Chapter 7 Stone Columns and Sand Compaction Piles 77
7.1 Applications and Materials 77
7.2 Installation Methods 77
7.3 Mechanisms of Improvement 78
7.4 Failure Modes 78
7.5 Ultimate Capacity of a Single Column 79
7.6 Capacity of Column Groups and Composite Ground 80
7.7 Settlement of Column-Improved Ground 80
7.8 Consolidation, Liquefaction Mitigation and Special Columns 81
7.9 Sand Compaction Piles 82
7.10 Design Parameters, Quality Control and Testing 83
7.11 Stability of Embankments on Column-Improved Ground 83

Chapter 8 Grouting Techniques 87
8.1 Classification of Grouting Methods 87
8.2 Grout Materials 88
8.3 Permeation Grouting 89
8.4 Compaction Grouting 92
8.5 Jet Grouting 93
8.6 Fracture and Compensation Grouting 94
8.7 Rock and Fissure Grouting 94
8.8 Quality Control and Environmental Aspects 94
8.9 Grout Mix Tests, Rock Permeability and Cut-off Efficiency 95

Chapter 9 Soil Stabilization with Additives 99
9.1 Modification and Stabilization 99
9.2 Lime Stabilization 100
9.3 Cement Stabilization 102
9.4 Fly Ash, Slag and Other By-products 104

9.5 Other Chemical Stabilizers 106
9.6 Selection of Stabilizer 106
9.7 Durability: Sulphates and Organic Matter 107
9.8 Laboratory Mix Design 107
9.9 Construction 109
9.10 Drying Wet Soils with Quicklime 110

Chapter 10 Reinforced Soil and Geosynthetics 113
10.1 Types of Geosynthetics 113
10.2 Functions 114
10.3 Properties and Design Strength 115
10.4 Reinforced Soil Walls 115
10.5 Reinforced Slopes 119
10.6 Embankments on Soft Ground 119
10.7 Geosynthetics in Pavements 121
10.8 Drainage, Filtration and Containment 121
10.9 Quality Control 121
10.10 Further Applications: Filters, Unpaved Roads and Geocells 121

Chapter 11 Electro-osmosis and Thermal Methods 125
11.1 Electrokinetic Phenomena in Soil 125
11.2 Theory of Electro-osmosis 126
11.3 Applications of Electro-osmosis 127
11.4 Artificial Ground Freezing 130
11.5 Thermal Stabilization by Heating 132
11.6 Comparison 133
11.7 Groundwater Lowering for Construction 134

Chapter 12 Deep Soil Mixing Methods 138
12.1 Development and Classification 138
12.2 Binders and Dosage 140
12.3 Properties of Mixed Soil 141
12.4 Applications and Patterns 142
12.5 Design 142
12.6 Execution and Quality Control 144
12.7 Applications, Advantages and Limitations 145
12.8 Laboratory Mix Design and Strength Evaluation 146

Chapter 13 Vibro-Replacement and Vibroflotation 150
13.1 Development 150
13.2 Equipment 150
13.3 Vibroflotation (Vibro-compaction) 152
13.4 Vibro-replacement 155
13.5 Process Control and Verification 156
13.6 Comparison 156
13.7 Column Diameter from Stone Consumption, and Dynamic Replacement 157

Chapter 14 Ground Improvement for Foundations 160
14.1 Ground Improvement as a Foundation Option 160
14.2 Performance Requirements 161
14.3 Shallow Foundations on Improved Ground 162
14.4 Rafts and Large Flexible Structures 164
14.5 Piles and Improved Ground 166
14.6 Foundations on Expansive Soils 167
14.7 Remediation of Existing Foundations 167
14.8 Design Procedure 168
14.9 Settlement of Footings on Granular Soil Before and After Densification 168

Chapter 15 Ground Improvement for Highways and Railways 172
15.1 Subgrade Requirements 172
15.2 Subgrade Improvement 173
15.3 Embankments on Soft Ground 175
15.4 Bridge Approaches and Transitions 177
15.5 Railway Formations 178
15.6 Quality Control and Monitoring 179
15.7 Widening of Existing Embankments 179
15.8 Practice on Black Cotton Soils 180

Chapter 16 Ground Improvement for Dams, Embankments and Slopes 183
16.1 Seepage Through and Beneath Water-retaining Structures 183
16.2 Filters 186
16.3 Foundation Treatment for Dams 187
16.4 Slope Stability 187
16.5 Erosion Control 189
16.6 Monitoring 190
16.7 Slurry Trench Cut-off Walls and Uplift Control 191

Chapter 17 Ground Improvement in Coastal and Marine Areas 194
17.1 Marine Ground Conditions 194
17.2 Land Reclamation 195
17.3 Treatment of Soft Marine Clay 197
17.4 Port and Harbour Structures 198
17.5 Coastal Protection 200
17.6 Environmental Considerations 200
17.7 Monitoring 200
17.8 Geotextile Tubes and Containers 200
17.9 Liquefaction of Hydraulic Fill 201

Chapter 18 Monitoring and Quality Control 204
18.1 Purposes of Monitoring 204
18.2 Planning an Instrumentation Programme 205
18.3 Geotechnical Instruments 205
18.4 Interpretation of Settlement and Pore Pressure Data 207
18.5 Quality Control During Construction 210
18.6 Verification Testing and Acceptance Criteria 211

18.7 Documentation and Reporting 212
18.8 Monitoring Stability and Adjacent Structures 212

Chapter 19 Design Procedures and Calculations 216
19.1 General Design Procedure 216
19.2 Design Criteria and Factors of Safety 217
19.3 Selection of Design Parameters 218
19.4 Design Example 1: Preloading with Vertical Drains for a Warehouse 218
19.5 Design Example 2: Stone Columns beneath a Storage Tank 220
19.6 Design Example 3: Vibro-compaction for Liquefaction Mitigation 221
19.7 Design Example 4: Basal Reinforcement for an Embankment 222
19.8 Design Example 5: Deep Mixing at a Bridge Approach 223
19.9 Design Example 6: Permeation Grouting for Underpinning 223
19.10 Design Example 7: Comparison of Alternatives 224
19.11 Design Example 8: Vacuum-assisted Preloading 224
19.12 Design Example 9: Densification of Fill for a Light Industrial Building 226

Chapter 20 Case Studies from Field Projects 230
20.1 Learning from Case Histories 231
20.2 Transport Infrastructure on Soft Clay: Preloading with PVDs 231
20.3 Vacuum Preloading for an Oil Storage Station 232
20.4 Stabilisation of the Leaning Tower of Pisa 233
20.5 Reclaimed Land and Long-term Settlement 234
20.6 Performance of Improved Ground in Earthquakes 235
20.7 Field Experience with Dynamic Compaction 236
20.8 Industrial Facilities and Storage Tanks 236
20.9 Illustrative Case: Highway on Black Cotton Soil 236
20.10 An Embankment Built to Failure: The Muar Flats Trial 238
20.11 Summary of Lessons 238

Chapter 21 Recent Advances in Ground Improvement 241
21.1 Developments in Established Techniques 241
21.2 Bio-mediated Ground Improvement 242
21.3 Nanomaterials 243
21.4 Sustainable Ground Improvement 244
21.5 Digital Technologies and Artificial Intelligence 247
21.6 Readiness of Emerging Techniques 249

Chapter 22 Selection Guidelines and Decision Framework 251
22.1 The Selection Process 251
22.2 Screening by Soil Type 252
22.3 Screening by Objective 252
22.4 Screening by Depth 253
22.5 Decision Flowchart 253
22.6 Constraints, Cost and Time 254
22.7 Combining Techniques 256
22.8 Practical Guidelines 256
22.9 Selection Checklist 257

22.10 Managing Ground Risk 258

Appendix A: Indian Standards and Guidelines 262

Appendix B: Notation and Abbreviations 264

Appendix C: Test and Monitoring Record Formats 266

Appendix D: Design Charts and Tables.....269

Appendix E: Laboratory Experiments 272

E.1 Effect of Compactive Effort on the Compaction Curve 272
E.2 Free Swell and Swelling Pressure of an Expansive Soil 272
E.3 Lime Requirement by the pH Method.....273
E.4 Unconfined Compressive Strength of Stabilized Soil 273
E.5 California Bearing Ratio of Treated and Untreated Subgrade 274
E.6 Consolidation Characteristics of a Soft Clay.....274
E.7 Radial Consolidation with a Central Drain 275
E.8 Model Load Test on a Stone Column.....275
E.9 Grout Properties and Groutability of Sand.....276
E.10 Index Properties of Geotextiles 276

Appendix F: Glossary.....278

Subject Index.....284

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Published by
Excellent Publishers
Kancheepuram, Tamilnadu, India
www.excellentpublishers.com
Mobile no. +91-9842641794
email id: excellentpublishers2013@gmail.com

EXCELLENT PUBLISHERS

ISBN 978-81-69623-04-9
9 788169 623049