

FIFTH EDITION

FUNDAMENTALS OF GEOTECHNICAL ENGINEERING



BRAJA M. DAS | NAGARATNAM SIVAKUGAN



Fundamentals of Geotechnical Engineering

Fifth Edition

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The cover photograph by Rohini Sivakugan is of the Shin-Meishin Expressway construction near Kyoto, Japan. This section connects Kobe and Takatsuki. The construction site is closer to Takatsuki.

To Janice, Rohini, Joe,
Valerie and Elizabeth



Preface

Principles of Foundation Engineering and *Principles of Geotechnical Engineering* were originally published with 1984 and 1985 copyrights, respectively. These texts were well received by instructors, students, and practitioners alike. Depending on the needs of the users, the texts were revised and are presently in their eighth editions. These texts have also been translated in several languages.

Toward the latter part of 1998, there were several requests to prepare a single volume that was concise in nature but combined the essential components of *Principles of Foundation Engineering* and *Principles of Geotechnical Engineering*. In response to those requests, the first edition of *Fundamentals of Geotechnical Engineering* was published in 2000. This text includes the fundamental concepts of soil mechanics as well as foundation engineering, including bearing capacity and settlement of shallow foundations (spread footings and mats), retaining walls, braced cuts, piles, and drilled shafts.

New to This Edition

This fifth edition has been revised and prepared based on comments received from several reviewers and users without changing the philosophy on which the text was originally prepared. Professor Nagaratnam Sivakugan of James Cook University, Australia, has joined as a co-author of this edition. As in the previous editions, SI units are used throughout the text. This edition consists of 20 chapters and an appendix. The major changes from the fourth edition include the following:

- About forty additional photographs have been added.
- A number of additional example problems and homework problems have been added in each chapter.
- Each chapter has some critical thinking problem(s) added to the homework problem set.

- An interactive digital version of this text is now available. Please see the MindTap description on page xix.
- In Chapter 2 on “Soil Deposits—Origin, Grain-Size, and Shape” a discussion has been added for the U.S. sieve size designations. Details for the British standard sieves and the Australian standard sieves have also been added.
- In Chapter 3 on “Weight-Volume Relationships and Plasticity,” a table for various unit-weight relationships has been added.
- Chapter 4 on “Soil Classification” has a new section on visual identification of soils.
- In Chapter 5 on “Soil Compaction,” some recently published correlations for maximum dry unit weight and optimum moisture content has been added. Also added in this chapter is a brief description on various ground improvement methods.
- Chapter 9 on “Consolidation” now has a new section on the effects of initial excess pore water pressure distribution on $U-T_v$ relationships. Also added to this chapter is a discussion on the construction time correction of consolidation settlement.
- A number of recently published correlations for effective stress friction angle (ϕ') and cohesion (c') for cohesive soils has been added to Chapter 10 on “Shear Strength of Soils.” Also included in this chapter are several correlations for the undrained shear strength of remolded clays with liquidity index.
- Chapter 12 on “Subsurface Exploration” now has a section on field instrumentation.
- In Chapter 13 on “Slope Stability,” an analysis to evaluate the factor of safety of clay slopes with the undrained cohesion increasing with depth has been added. This chapter now also has a discussion on the mass procedure for stability analysis of homogeneous clay slopes ($\phi = 0$) with earthquake forces.
- Chapter 15 has been renamed as “Retaining Walls, Braced Cuts, and Sheet Pile Walls.” Analyses of cantilever sheet pile walls and anchored sheet pile walls have been added to this chapter.
- The bearing capacity of strip foundation under eccentrically inclined load has been discussed in greater detail in Chapter 16 on “Shallow Foundations—Bearing Capacity.”
- An improved method for elastic settlement calculation of shallow foundations on granular soil taking into consideration the variation of soil stiffness with stress level has been added to Chapter 17 on “Settlement of Shallow Foundations.”
- A new chapter (Chapter 20) on “Load and Resistance Factor Design (LRFD)” has been added to the text.

Instructor Resource Materials

A detailed *Instructor's Solutions Manual* and Lecture Note PowerPoint slides are available for instructors through a password-protected Web site at www.cengagebrain.com.

MindTap Online Course and Reader

This textbook is also available online through Cengage Learning's MindTap, a personalized learning program. Students who purchase the MindTap have access to the book's multimedia-rich electronic Reader and are able to complete homework and assessment material online, on their desktops, laptops, or iPads. Instructors who use a Learning Management System (such as Blackboard, Canvas, or Moodle) for tracking course content, assignments, and grading, can seamlessly access the MindTap suite of content and assessments for this course.

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Additionally, students can listen to the text through ReadSpeaker, take notes in the digital Reader, study from or create their own Flashcards, highlight content for easy reference, and check their understanding of the material through practice quizzes and automatically-graded homework. The MindTap for *Fundamentals of Geotechnical Engineering* also includes algorithmically generated problems, providing an endless pool for student practice and assessment.

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- Alierza Bayat, University of Alberta
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- Tim Anderson, Product Director
- Mona ZefTEL, Senior Content Developer

Thanks are also due to Janice Das for her continuous help in the development of the original text and its subsequent four editions.

It is also fitting to thank Rose P. Kernan of RPK Editorial Services. She has been instrumental in shaping the style and overseeing the production of this edition of *Fundamentals of Geotechnical Engineering* as well as all previous editions.

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