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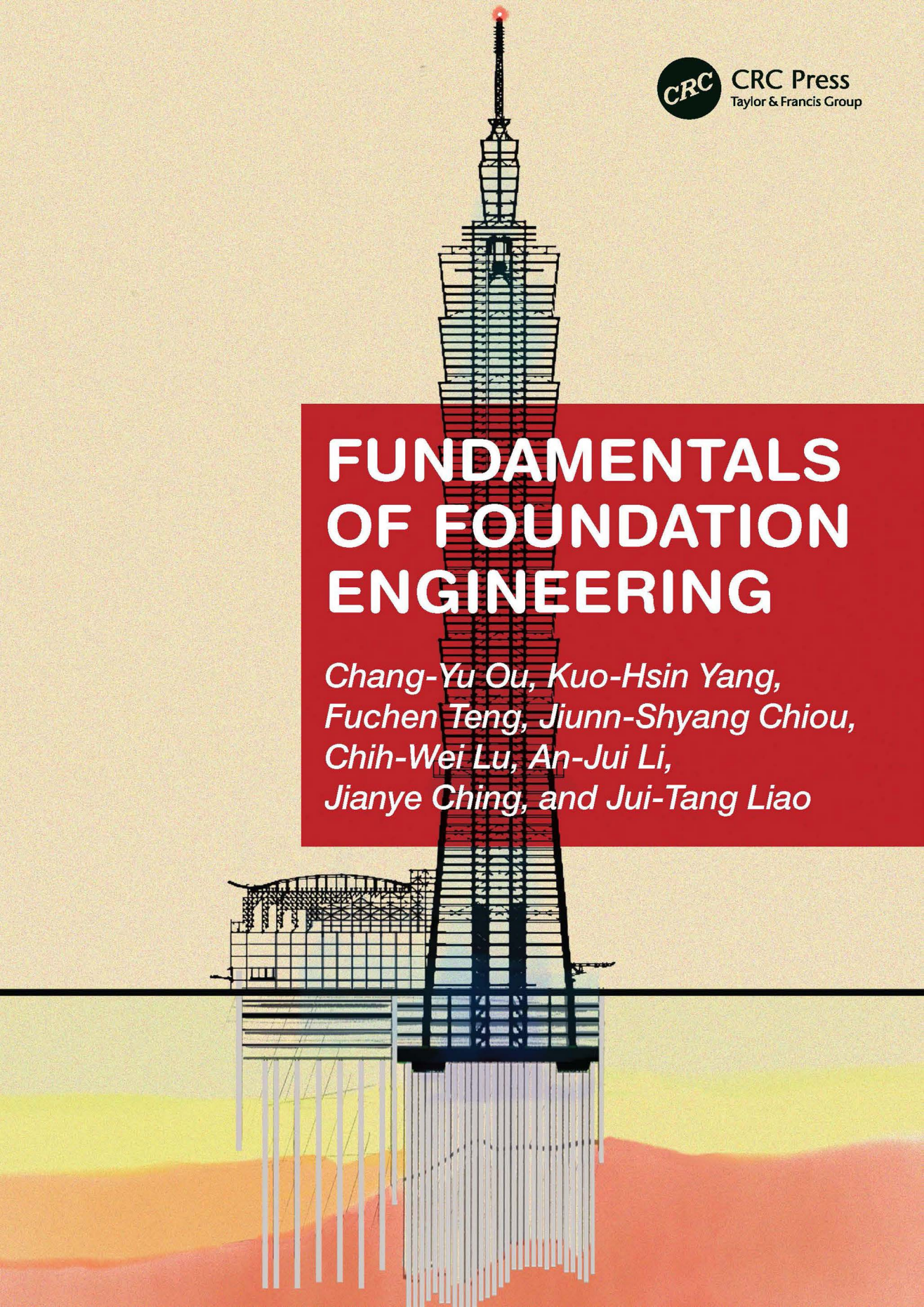

FUNDAMENTALS OF FOUNDATION ENGINEERING

Chang-Yu Ou, Kuo-Hsin Yang, Fuchen Teng, Jiunn-Shyang Chiou, Chih-Wei Lu, An-Jui Li, Jianye Ching, and Jui-Tang Liao

Fundamentals of Foundation Engineering

This book aims to introduce the principle and design of various foundations, covering shallow foundations, mat foundations, earth retaining structures, excavations, pile foundations, and slope stability. Since the analysis and design of a foundation are based on the soil properties under short-term (undrained) or long-term (drained) conditions, the assessment of soil properties from the geotechnical site investigation and the concept of drained or undrained soil properties are discussed in the first two chapters. Foundation elements transfer various load combinations from the superstructure to the underlying soils or rocks. The load transfer mechanisms, vertical stress or earth pressure distributions, and failure modes of each foundation type are clearly explained in this book. After understanding the soil responses subjected to the loadings from the foundation, the design methods, required factors of safety, and improvement measures for each foundation type are elaborated.

This book presents both theoretical explication and practical applications for readers to easily comprehend the theoretical background, design methods, and practical applications and considerations. Each chapter provides relevant exercise examples and a problem set for self-practice. The analysis methods introduced in the book can be applied in actual analysis and design as they contain the most up-to-date knowledge of foundation design. This book is suitable for teachers and students to use in foundation engineering courses and engineers who are engaged in foundation design to create a technically sound, construction-feasible, and economical design of the foundation system.

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Designed cover image: The Taipei 101, once the tallest building in the world, is located in Taipei City. Below the surface are thick soft clays with SPT-N values between 2 and 10, and below the clays are andesite formations. The foundation must carry the load of the 101-story tower above ground and the 6-story podium. In this case, pile foundations are used to transfer the load to the rock formation. The foundation and excavation is designed by Sino Geotechnology, Inc., Taiwan.

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Preface

The most important consideration in the design of a structure such as a building, bridge, retaining wall, or geotechnical structure is a stable foundation. An unstable foundation puts the safety of the entire structure at risk. The analysis and design of a foundation are closely related to the basic properties of soils, especially their drained and undrained behaviors. The method for analysis and design introduced in this book focuses particularly on the drained or undrained behavior of the target soil. Chapter 2 elucidates the concept and analysis methods for soils under drained and undrained conditions. The concept of drained or undrained properties associated with necessary soil parameters and analysis methods is also applied to the analysis and design methods presented in each chapter.

Since a large number of studies related to the analysis and design methods for foundation have been developed, this book is unable to cover them all. Therefore, for teaching purposes, only basic principles of analysis and design are provided in this book, followed by an introduction to their application. If students learn the principles of analysis and design from this book, then in future practical design work, they can perform a sound analysis or design considering relevant design codes.

Generally, the method for foundation design includes the allowable stress method, strength design method, and method considering various limit states. Chapter 2 explains the basic concepts of these design methods. Although the allowable stress method is a mainstream method in foundation design, the strength design method has been adopted to design upper structures. Obviously, it is not reasonable to adopt different design methods for the upper structure and foundation, especially considering the greater uncertainties involved in the soil parameters than in the parameters of structures. Consequently, an increasing number of country building codes adopt more rigorous strength design methods and even more advanced limiting state design methods. The limiting strength design method considers the design at various limiting states, for example, considering ultimate strength, deformation, or earthquakes.

To make it easy for students to understand the basic principles of basic analysis and design, each chapter introduces the basic principles of basic design from the perspective of the allowable stress method. If readers can understand the concepts of the strength design method and limit state design method, they will be able to understand the implications better behind the design codes when they must use them in actual design work.

The topics for foundation design cover a wide range, and relevant studies are becoming increasingly advanced. It is not easy for a single author to be an expert on every topic. Therefore, eight distinguished scholars from different fields contribute to the contents of this book. The book chapters and the contributing authors are arranged as follows. Chapter 1 is about geotechnical site investigation, written by Dr. Chih-Wei Lu and Dr. Jui-Tang Liao. Chapter 2

is about principles of foundation design, written by Dr. Chang-Yu Ou, Dr. Jianye Ching, and Dr. Jiunn-Shyang Chiou. Chapter 3 is about shallow foundations, written by Dr. Jiunn-Shyang Chiou. Chapter 4 is about lateral earth pressure, written by Dr. Chang-Yu Ou. Chapter 5 is about earth retaining structures, written by Dr. Kuo-Hsin Yang. Chapter 6 is about excavation, written by Dr. Chang-Yu Ou. Chapter 7 is about pile foundations, written by Dr. Fuchen Teng. And Chapter 8 is about slope stability, written by Dr. An-Jui Li. Each author is an expert in the field corresponding to the book chapter he wrote. All authors have tried their best to make the content of this book accessible, accurate, and current. All chapters in this book have been reviewed and approved by all authors.

About the authors

Chang-Yu Ou is a chair professor of the Department of Civil and Construction Engineering at National Taiwan University of Science and Technology (NTUST), Taipei, Taiwan. He received his doctoral degree from Stanford University, USA, in 1987. His areas of interest are deep excavations, soil behavior, soft ground tunneling, and ground improvement. He has published more than 200 journal and conference papers. He also has published two monograph books regarding deep excavations in English by Taylor & Francis in 2006 and 2022, respectively, and three deep excavation books in Chinese.

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