

# Preface

Offshore and land-based structures represent large capital investments. They are designed to withstand various types of environmental loads such as earthquakes, winds, ocean waves, tidal currents, and ice, and other loads due to explosions, machinery vibrations, dropped objects, and other factors. Many of them essentially induce dynamic and cyclic loading transferred into foundations. Therefore, understanding soil dynamics and foundation modeling is essential to ensure foundation and structural integrity and operational functionality. However, in spite of increased engineering knowledge, practical problems regarding foundation modeling and soil dynamics are in many cases handled unsuccessfully despite large expenditures. Moreover, even if engineers can perform sophisticated computer-based analysis tasks, many of them lack an actual understanding of the essential principles of soil dynamics and foundation modeling, and hence of the links between theory and applications. This leads to an insurmountable barrier when they are asked to validate/verify and provide insightful explanations of analysis results, or to further improve designs, which poses a significant safety hazard and can also result in significant economic loss.

With the objective of providing practical knowledge of foundation modeling and dynamic analysis, which is essential for both offshore and earthquake engineering, the book covers a wide range topics in this area, such as soil behavior, soil dynamics, seismic site-response analysis, soil–structure interactions, liquefactions, and modeling and assessment of shallow and deep foundations, considering various levels of detail and associated engineering challenges. Differences in soil and foundation modeling and response due to earthquake and ocean wave loading are also discussed. To facilitate the understanding and utilization of knowledge for each topic, general theory and principles are linked to their engineering applications. Moreover, recent developments in offshore foundation engineering such as anchor piles, suction piles, large-diameter piles, soil aging effects, and scours are also discussed. Special focus is placed on their engineering applications utilizing state-of-the-art knowledge.

Although offshore geotechnical principles are very similar to those of land-based structures, for offshore geotechnical engineering applications, soil conditions are often more difficult to measure and have larger uncertainties, site investigations are more expensive, and structural loads are usually more significant. Further, the focus of offshore geotechnical design is often placed on capacity control, while foundation stiffness remains important for the dynamic response of soil–foundation–structure systems.

Chapter 1 presents the basics of soil mechanics and behaviors, methods for testing soil strength, and their implications in geotechnical designs. Chapter 2 introduces the characteristics and modeling of soil properties under cyclic and dynamic loading, focused on treating soil nonlinearities. Chapters 3 and 4 present details of site-response analysis with a focus on how the response amplification and de-amplification of soil media are accounted for, and how to apply seismic excitations in a site-response analysis. Chapter 5 describes soil–structure interactions and analysis, which estimate the collective response of the entire soil–foundation–structure system to specified ground motions by accounting for effects of kinematic interaction (normally by site-response analysis), soil–foundation flexibility (foundation impedance), and inertia interaction (seismic structural analysis) and which can be performed by either direct or substructure approaches. Chapter 6 introduces various seismic testing methods including field testing, laboratory element testing, and model testing. Chapter 7 presents the causes and evaluation of soil liquefactions, followed by presentations of slope stability due to seismic loading presented in Chap. 8. Chapter 9 provides a general overview of offshore structures and their common and distinguishing features compared to those of land-based structures and also presents the hydrodynamic modeling to determine the ocean environmental loading in a seismic analysis. Chapters 10 and 11 present the theoretical background of seismic response spectrum and power spectrum and how earthquake loading is determined from a seismic hazard point of view. Chapters 12 and 13 present the bearing capacity assessment and modeling for shallow foundations. Chapters 14–26 discuss various aspects of pile foundations, such as pile capacity assessment, pile–soil interactions, large-diameter piles, pile group, grout connections, torsional behaviors of piles, scour, seismic assessment of piles, anchor piles, and suction piles. In Chap. 27, design issues for shallow and deep foundations, relevant international design codes, and hierarchy of codes and standards are briefly discussed.

The book is intended to serve as an introduction to the subject and also as a reference book with advanced topics. A balance between the theoretical and practical aspects is sought. All the chapters are addressed to practitioners who are looking for answers to their daily engineering problems, and to students and researchers who are looking for links between theoretical and practical aspects, and between phenomena and analytical explanations. It should also be of use to other science and engineering professionals and students with an interest in this subject.

The book is written in such a way that it can be followed by anyone with a basic knowledge of engineering dynamics and soil mechanics.

While the book does not seek to promote any specific “school of thought,” it inevitably reflects this author’s “best practice” and “working habits.” This is particularly apparent in the topics selected and the level of detail devoted to each of them, their sequences, the choices of mathematical treatments and symbolic notations, etc. The author hopes that this does not deter readers from seeking to find their own “best practice.”

Most of the chapters in this book can be covered in a two-day industry course in a brief manner, a one-week intensive course for either industry or academia, or a one-semester course in an elaborated form for graduate students.

In preparing such a text, it is rather difficult to acknowledge all the help given to the author. First, I am indebted to geotechnical, earthquake, and offshore engineering communities who have undertaken the extensive research and development that has led to accumulated knowledge, methods, and engineering applications in this field, on which this book is based. I would also like to thank individuals for assistance of various kinds, such as participation in book reviews, technical discussions, and research cooperation. These include (in alphabetical order) the following: Atilla Ansal (European Association for Earthquake Engineering), Kuvvet Atakan (University of Bergen), Gunnar Bremer (Aker Solutions), Ove Tobias Gudmestad (University of Stavanger), Yingcai Han (Fluor Canada), Nils-Christian Hellevig (Aker Solutions), Viggo Karlsen (Statoil), Amir M. Kaynia (Norwegian Geotechnical Institute), Steven L. Kramer (University of Washington), BM Lehané (The University of Western Australia), Conrad Lindholm (NORSAR), Lance Manuel (University of Texas at Austin), Peter Middendorp (Allnamics Geotechnical & Pile Testing Experts), George Mylonakis (University of Bristol), Laurens de Neef (CAPE Holland), Giuliano F. Panza (University of Trieste and China Earthquake Administration), John Michael Rotter (University of Edinburgh and Imperial College), Richard Snell (Oxford University), Douglas Stock (Digital Structures, Inc. Berkeley), Gary Torosian (GeoTesting Express, Inc.), and RJS Whitehouse (HR Wallingford). Furthermore, I would like to thank Norwegian Geotechnical Institute, Statoil, DongEnergy, BP, and DNV-GL for their cooperation on relevant engineering projects. Moreover, there are numerous others not named to whom I extend my sincere thanks.

This book has an extensive list of references reflecting both the historical and recent developments of the subject. I would like to thank all the authors in the references for their contribution to the area.

Most importantly, I dedicate this book to my parents Shufeng and Wangeng, my wife Jing, and daughter Danning; I conclude this preface with an expression of deep gratitude to them.

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