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Book Review:

MODEL UNCERTAINTIES IN FOUNDATION DESIGN

Chong Tang and Kok-Kwang Phoon. Boca Raton, FL: CRC Press (an imprint of Taylor & Francis Group), 2021. 589pp.
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Chang-Yu Ou [1*]

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Unlike structural materials (*e.g.,* steel/concrete), naturally occurring geo-materials (*e.g.,* soil/rock) are not manufactured to meet prescribed quality specifications and in general, their engineering properties have a higher degree of variability. Furthermore, site profiles (*e.g.,* stratigraphy and engineering properties) are often spatially variable. Geotechnical data from a site investigation are usually multivariate, uncertain and unique, sparse, incomplete, and potentially corrupted with "X" denoting the spatial/temporal dimension – MUSIC-X (Phoon *et al.* 2019). This is the typical limit of our knowledge of the ground and oftentimes the engineer relies heavily on engineering judgment to make decisions in the presence MUSIC-X data. Because of this complex site condition, complicated soil-structure interaction behavior, and construction effects, almost all models (analytical and numerical) are an approximation of reality. Inevitably, the predicted response (*e.g.,* capacity and deformation) will deviate from observation or measurement (*e.g.,* load-displacement curve from a load test). Such a deviation is conveniently characterized as the ratio of measured-to-calculated value, called a model factor. According to ISO2394:2015 (General principles on reliability of structures), characterization of geotechnical variability and model factor are identified as two critical elements in the development of reliability-based design in geotechnics. Some design codes present the resistance factor as a function of the degree of site and model understanding, which refer to these 2 elements respectively.

The focus of the book is statistical evaluation of model factor. Chapter 1 of this book reviewed the role of data in the evolution of geotechnical design and the status of digital transformation in geotechnics. This book is of value to research and practice. First, it compiled the largest load test database to date, covering various foundation types in a wide range of ground conditions (clay, silt, sand, gravel, and rock) – shallow foundation (Chapter 4), offshore spudcan in layered soils (Chapter 5), driven and drilled shaft (Chapter 6), and helical pile (Chapter 7). The database can be used by researchers to develop more accurate design methods. Particularly in the context of big data era, it will fuel data-driven research in geotechnics that has received increasing attention in the literature recently. Also, the database can be used by designers to evaluate and improve the geotechnical design for foundations in their projects (*e.g.,* acceptance tool for pile installation). It can improve the effectiveness of communications among the designer, field engineer, and contractor to reduce the construction downtime. Second, this book characterized the mean and coefficient of variation (COV) of model factor in the calculation of foundation capacity and settlement (Chapters 4 to 7) that can be used directly for load and resistance factor design (LRFD) calibration. Chapter 8 presented a comprehensive survey of the performance databases for other geo-structures (*e.g.,* soil nail/mechanically stabilized earth walls, slope, plate/anchor, braced excavation) and the associated mean and COV values. As model factor assessment based on database is intrinsically tied to geotechnical variability, bias in design model, load test interpretation, and measurement error, the resulting COV can provide designers with the degree of their site and model understanding. On this basis, a practical three-tier scheme is proposed to classify this total uncertainty, which will provide an empirical basis for code developers to calibrate resistance factors in LRFD as a function of the degree of site and model understanding.

Because of an in-depth review of design methods, load test databases, and statistical coverage, this book is a valuable complement to classical textbooks of foundation engineering (Teng 1962; Peck *et al.* 1974; Salgado 2008) and several books exploring the use of risk-informed decision making in geotechnics (Baecher and Christian 2003; Fenton and Griffiths 2008; Phoon 2008; Phoon and Ching 2015; Phoon and Retief 2016). Moreover, the book can be used as a text to educate the next generation of geotechnical engineers on how to make data-driven decisions and to understand the role of engineering judgment in a more rational risk management context (Phoon 2017).

[1*] Chair Professor (corresponding author), Department of Civil and Construction Engineering, National Taiwan University of Science and Technology, Taipei 106335, Taiwan (ou@mail.ntust.edu.tw).

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