Book review

Unsaturated soils: A fundamental interpretation of soil behaviour. *E. J. Murray and V. Sivakumar.* Chichester: Wiley-Blackwell, 2010. 304 pp. ISBN 978-1-4443-3212-4. £69.99

Several geotechnical operations, such as compaction and excavation processes, are linked to the mechanics of unsaturated soils. As more than one third of the Earth's surface is arid or semi-arid, in addition to the less extreme cases of seasonal droughts and diurnal variations of the water table in soils, it is obvious that most soils are in a general state of partial water saturation. In other words, the pore space within soils is generally filled with water and air. Therefore the mechanics and physics of the considered soil are those of a three-phase porous material consisting of solid mineral and two immiscible fluid phases.

Even though most natural and engineered soils are only partially saturated with water, few books have been published in this research area. The study of the mechanics of unsaturated soils was initiated approximately 50 years ago as a natural extension of the knowledge developed in the conventional areas of the mechanics of (saturated) soils. The mechanics of saturated soils is based primarily on the concept of effective stress, and on consolidation theory. In the hydromechanical frameworks developed for saturated materials, the pore fluid (water) pressure mainly contributes to the mechanical behaviour through the field equations (consolidation theory). Its contribution to the constitutive behaviour of the solid skeleton is considered 'neutral' (no effect of the pore fluid pressure on the effective material compressibility or strength, for instance). When this particular assumption about soils saturated with a fluid under compression was no longer considered valid, the conventional theories needed to be revised. This major development was the first in defining the mechanics of unsaturated soils. The field equations were found to require an extension to address the effect of the degree of saturation on water permeability and on compressibility; the gas flow also had to be considered in some situations. The constitutive behaviour of the soil skeleton must incorporate the effect of gas pressure or, more specifically, its difference with respect to the liquid pressure, which is known as suction. In addition, the extension of the effective stress concept to unsaturated conditions revealed a need to take into account the important contribution of water retention behaviour, linking the degree of saturation to suction. In the past decade, the advancement of knowledge regarding the mechanics of unsaturated soils has been significant. Some fundamental issues have been solved, and important achievements have been made in certain areas. This book provides the reader with an exhaustive overview of the developments that have been achieved in the understanding, description and analysis of the mechanical behaviour of unsaturated soils. It represents a major contribution to the current state of knowledge of experimental testing and constitutive modelling of unsaturated soils.

As an introduction to the topic, a useful and well-presented introduction is presented to describe some of the physical properties of unsaturated soils. The book is then divided into two main parts: experiment and theory.

Unsaturated soil testing is covered in Chapters 2 and 3. Chapter 2 is dedicated to suction measurement and control. The chapter opens with a table summarising the most common available methods used to measure the suction component, suction range and equilibration time. Techniques and devices are succinctly described later in the chapter, indicating the main advantages and limitations related to their use. Chapter 3 describes soil-testing apparatuses, taking the suction explicitly into account as an independent variable. The reader is provided with a good overview of the topic. References to additional sources are disseminated throughout the text. However, some crucial aspects, such as the volume change assessment in triaxial testing, could have been addressed more deeply. More figures presenting the kinds of results that are attainable with the described devices would have enriched the chapter.

Chapter 4 deals with basic equations for stresses and strains in unsaturated conditions, as well as some constitutive models relating them. In an attempt to provide a rigorous description of unsaturated soil behaviour, the book delves into the thermodynamic aspects of the soil as a multiphase porous medium in the subsequent chapters. Chapter 5 begins with a good introduction to the thermodynamics of soil systems, including a description of the different phases and constituents and their interactions. The common thermodynamic principles and variables of state are presented. The chapter is then followed by a well-structured presentation of the laws of thermodynamics. This presentation, however, sometimes remains too general, without providing specific references to soil systems: hence it is comparable to similar material that has been addressed elsewhere in other thermodynamic textbooks. Specific applications are discussed for triaxial tests in Chapter 5 and then further extended in Chapter 6. These examples of triaxial tests afford a better understanding of the thermodynamic aspects of soil. In line with previous sections, the equilibrium condition, the mechanical behaviour and the conjugate variables for unsaturated soils are discussed in Chapters 7, 8 and 9 respectively. In these chapters, the stress state variables and conjugate pairs are further evaluated with respect to unsaturated soils. The concept of effective stress in saturated soils and its extension to unsaturated soils is also addressed. However, further review of recent work on the effective stress in unsaturated soils and, in particular, how it relates with retention behaviour and soil structure would have been very much appreciated. Finally, the mechanical behaviour of unsaturated soils has been discussed in detail within the framework of the critical-state concept using experimental results. In this respect, the link between the constitutive behaviour and the thermodynamic aspects is not straightforward, and could have been discussed in further detail.

To conclude, this is a well-thought-out and well-presented book. It provides postgraduate students, researchers and practitioners with a fundamental basis and knowledge of the behaviour of unsaturated soils. It deserves to be in every geotechnical engineer's library.

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