Book review

Thermo-poroelasticity and Geomechanics. A. P. S. Selvadurai and A. P. Suvorov. Cambridge, UK: Cambridge University Press, 2017. 268 pp. ISBN 978-1-107-14289-3, £69.99

Geotechnical engineers are increasingly facing new challenges that involve multi-physics couplings in soil and rocks. Among these challenges, energy production and storage represent a significant proportion. Examples include the extraction of non-conventional hydrocarbons, deep geothermal energy production, very low-energy geostructures, compressed air energy storage, heat storage in salt caverns, carbon dioxide geological storage and so on. These applications all have the peculiarity to involve temperature changes, which could affect fluid transfers and the mechanical behaviour of the geomaterials involved (soils, reservoir rocks, caprock, etc.).

In the context of this description, it is possible to envisage that the profession of geotechnical engineer could assume a central role, from an engineer's perspective. Geotechnical engineers are indeed in a position to contribute significantly to solving these societal and environmental issues. However, to tackle such complex problems, which involve coupled thermo-hydro-mechanical (THM) phenomena, the engineer and the scientist require accurate modelling tools and advanced theories.

There are many codes that can deal with geomechanics in the research world, and some of them have been transferred to the industrial world. However, they are not all well suited for a given application, nor are they always fully validated. Furthermore, an engineer interested in a particular problem might not be willing, or indeed have the need or the capabilities to solve a complex problem numerically from scratch. Actually, even if there is such a need, it is always good practice to start with a simplified problem, by reducing the geometrical complexity or the material non-linearities of the original application.

In such a context is where this book becomes useful. It is aimed at providing analytical solutions for coupled problems involving THM phenomena. In *Thermo-poroelasticity and Geomechanics*, the authors have provided a book that will prove to be useful for both engineers and researchers working in non-isothermal problems involving geomaterials. The variety of applications used in this book illustrates the wide interest that it should attract. It will eventually be useful for graduate students and professors of geomechanics who are interested in analytical solutions for various simple (although not only simple) problems that could be studied in classrooms. People interested in computational geomechanics will also appreciate this book, because it provides a way to check carefully the numerical issues associated with any numerical

model, such as mesh refinement, size of the geometrical model and so on.

The first chapter of this book sets the context in which the authors are interested by giving half a dozen applications where THM couplings play a key role. As the target applications involve rocks and other stiff materials, the authors locate the theoretical framework within the mechanics of porous materials, namely, poromechanics, or thermo-poromechanics, since non-isothermal evolutions are considered.

In the second chapter, the authors present the constitutive relations that form the core of future analytical developments. The authors pragmatically reduce the scope of the theoretical framework to thermo-poroelasticity. This choice appears to be judicious, because it allows the derivation of analytical solutions in the subsequent chapters. Even though such a choice implies severe limitations in some applications that involve large and irreversible deformation, working within an elastic framework is acceptable in many cases.

Chapter 3 focuses on one-dimensional (1D) problems and progressively shows the importance of several aspects, such as the effects of solid phase and liquid phase compressibility in hydro-mechanical and then THM problems. Section 3.8 presents an overview of how finite elements can be applied to THM problems. Without providing a detailed description of the method, the authors succeed in presenting the most relevant aspects.

In chapters 4–8, the authors expose the analytical solutions for some well-chosen particular problems with increasing geometrical complexity, starting from the rigid 1D cavity. Various geometries are treated: solid cylinder, cylindrical cavity in an infinite medium, solid sphere and spherical cavity in an infinite medium. The last chapter is purely numerical and deals with glaciation problems.

In conclusion, this book is an answer to the adage that a good numerical modeller should know the results before running the simulation. In an effort to justify the analytical solutions derived in this work, the authors consistently compare their solutions to computational results obtained using commercial software. Proper use of this book will, however, be the other way around: the analytical solutions provided here should be used as reference solutions to obtain first estimates or to validate the implementation of in-house numerical codes to solve coupled thermo-poromechanics problems. In this sense, it will attract the interest of a large community working in geomechanics, from the graduate student to the researcher and the geotechnical engineer.

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