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INTERNATIONAL CENTRE FOR MECHANICAL SCIENCES

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MODERN ISSUES IN NON-SATURATED SOILS

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PREFACE

This monograph is a revised version of the notes for the Advanced School lectures given at the International Centre for Mechanical Sciences in Udine, September 19-23, 1994. The aim of the course was to provide a review of some of the most significant achievements in research on non-saturated soils, a material of a pre-eminent importance in civil engineering, agriculture and environmental engineering.

A phenomenological point of view based on fictitious continuity of the different constituents is adopted throughout this work, even if references to lower scale considerations may be made in different parts of the text. The different steps of the modelling of non-saturated soils are reviewed in Chapters 1 to 4. Chapters 5 to 11 are devoted to the analysis of a number of case studies.

In the introductory Chapter 1, non-saturated soils are considered in the broader context of heterogeneous media. Balance, equilibrium and non-equilibrium equations are presented using a generalized approach and in the light of the most recent achievements in irreversible thermodynamics. This approach covers all possible coupled phenomena in a single coherent model but leads to a complex set of equations. In conclusion, an automatic procedure is proposed for overcoming this complexity.

The behaviour laws proposed in Chapter 2 are based on the concept of yield surfaces as classically used in saturated soils. These laws are first extended to the case of non-saturated soils and then to non-isothermal conditions. The effects of non-saturation and temperature are incorporated in a generalized Cam-clay model, the simplest member of the family of critical state formulations. Some selected comparisons between model predictions and experimental results are presented.

Examples of experimental studies in the laboratory for studying coupled phenomena are presented in Chapter 3.

Numerical methods for solving complex thermo-hydro-mechanical coupling equations are presented in Chapter 4. Basic concepts and different strategies for discretization are examined and different numerical techniques are described. Fundamental problems of consistency, stability and convergence in linear and non-linear situations are discussed at length using a particular set of governing equations and a finite element method with estimation of numerical errors.

Finally, a broad review of applications covers domains such as water resources, road engineering, heat storage and consolidation, embankment dams, seismic behaviour and strain localisation in partially saturated soil, radioactive disposal and natural thermal reservoir.

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It would not have been possible to complete this joint research work without the facilities provided by the International Centre for Mechanical Sciences in Udine for both the organisation of the lectures and the publication of the monograph. The editors warmly thank all the organisers of the Centre, and especially the Rector, Professor Kaliszky, for their competence and hospitality.

Finally the constant help of M-A. Abellan has been deeply appreciated throughout the course and during preparation of the final manuscript.

For all the authors,
A. Gens
P. Jouanna
B. A. Schrefler

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