Preface

This book aims to provide an introduction to the basic concepts associated to constitutive models of engineering materials and to address key aspects related to their implementation in computer codes. A sound understanding of the material properties is essential for robust and effective material representations that can be used for a wide range of purposes and applications. The book places particular attention on exploiting inverse analysis techniques for the characterization of the material model parameters. Certainly, when dealing with simple constitutive models it might be easier and more efficient to rely on direct relationships that may exist between the measurements obtained from a standardized test and the sought material parameters. The use of inverse analysis techniques becomes competitive and more efficient when the aim is to minimize the amount of experimental tests carried out for calibration purposes, for example, by enriching the experimental information collected from the standard tests. Other advantages of exploiting inverse analysis techniques arise when dealing with more complex constitutive models, in which case it is generally difficult to separate the influence of different parameters from the experiment outputs and/or some parameters may not have a direct physical meaning. With these characterization techniques, it is usually possible to obtain representative parameters capable of describing the material behavior in scenarios that differ from those considered in the experiment performed for their identification. In this context, the selection of a constitutive model should aim at ensuring that the material representation is sufficiently refined to adequately capture the key features of the material response, relevant to the application considered, while keeping the model as simple as possible to simplify the identification of the material parameters.

Numerous simple examples are provided throughout the book to highlight the key challenges associated with the parameter identification for different constitutive models and how these can be addressed by either modifying or increasing the experimental results utilized in input of the inverse analysis procedure or by revising the selection of the constitutive model to limit the experimental information required for the parameter calibration while still providing an acceptable material description. Throughout the book, MATLAB® scripts are provided to assist the reader in gaining insight into the details of the computer implementations.

The main focus of the book is to deal with constitutive models that account for inelastic deformation. Such material representations are useful in a wide range of engineering problems when a material exhausts its elastic capacity. In general, the stress of a material that exhibits some degree of inelastic deformation depends on the current value of strain as well as on something else. In this book, we aim at introducing some of the possible representations that describe this something else and provide an overview of the main features exhibited by different typologies of inelastic constitutive models.

In the final part of the book, we introduce some of the key aspects associated to the modeling and characterization of particular classes of materials, such as metals, polymers, and shape memory alloys. These chapters consider simple and selected examples that aim at highlighting some of the key features related to the response of these materials. The selection of the examples does not intend to be exhaustive and reference is made to specialized textbook for a comprehensive review of the modeling of these materials. The illustrative examples presented aim at introducing sufficient information to create a connection between the areas of constitutive modeling, computer implementation, and parameter identification that are usually encountered when dealing with research and development of engineering materials and components.

Vladimir Buljak
Gianluca Ranzi