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Book Review

Mechanics of Materials and Interfaces: The Disturbed State Concept, by Chandrakant S. Desai, CRC Press LLC, Boca Raton, Florida, USA 2001, 698 pp.

REVIEWED BY ANTONIO GENS[1]

Describing the behavior of materials as the interplay of two limiting states is a powerful concept likely to lead to elegant and economical (in terms of assumptions and parameters) formulations. This book presents a comprehensive development of such an approach, based on the Disturbed State Concept (DSC) pioneered by the author himself. Although many of the applications refer to civil engineering and geomechanics problems, the approach is general, and there are in fact application presented to a wide range of materials, from asphalt concrete to ceramic composites, metals, alloys in electronic packaging and silicon. The DSC approach is also applicable for modeling the behavior of interfaces and joints.

The Introduction chapter sets the contents of the book in a very broad context that reflects the philosophical outlook of the author. Although some of the paragraphs may perhaps surprise the reader of a technical book, it is worth paying attention to them because the considerations outlined there constitute a continuous thread running through all chapters.

The main body of the book can be divided in four blocks. In the first block, Chapters 2 to 4, the Disturbed State Concept is described in detail, from the definition of the basic elements of the theory to the general formulation of the DSC equations. The development is presented step by step with references to related theories such as Critical State, Self-Organized Critically or Continuum Damage models. An Appendix explores those relationships in more detail.

The second block comprises Chapters 5 to 8. After having presented the general formulation of the DSC, the approach is applied in the context of classical continuum theories such as Elasticity, Plasticity, Viscoelasticity and Viscoplasticity. The arrangement of these chapters follows a similar pattern, they start describing the classical models, the modifications introduced by the DSC approach are discussed afterwards and, finally, a variety of examples are presented. Regarding elastoplastic constitutive models, special attention is given to the HISS (hierarchical single surface) elastoplastic model including a detailed description of the incremental integration procedure and a great number of examples of validation concerning a large range of materials (metals, soils, rocks, concrete) under various loading conditions.

The third block of the book (Chapters 9 to 11) extends the DSC to other important areas of material behavior. Thus, Chapter 9 offers a common DSC framework for saturated and unsaturated materials. The disturbance function linking the two limit states accounts for the effects of varying suction in unsaturated materials. Chapter 10 deals with structured and stiffened materials, a type of materials for which the DSC approach appears especially suited. In addition to conventional bonded soils, reinforced and jointed materials are also considered in this chapter. Finally, in Chapter 11, the DSC is no longer applied to a continuum but to the behavior of joints and interfaces. Taking as the starting point the Thin-Layer Interface model, the DSC is incorporated to reproduce a wide variety of interface phenomena, including softening and cyclic loading. Obviously, the wide range of applications presented in this part of the book require some significant changes in the way the DSC is applied; but the basic principles remain visible throughout.

The last block of the book addresses complementary but important topics. In Chapter 12, the issues of localization, mesh dependency and instability are discussed, unavoidable topics when softening or degradation is such a characteristic feature of the proposed models. After reviewing various regularization techniques and non-local models, the author argues that the DSC approach provides a natural way of incorporating microcrack interaction effects that enable the formulation to deal successfully with the modeling of localization and the problem of mesh dependency. Several examples are given of the use of the technique. The relationship between instability and localization is also examined. Finally, Chapter 13 deals with the implementation of DSC models in computer procedures, a necessary step before solving boundary value problems of engineering significance. The algorithms are described in increasing order of complexity, introducing new model features at each step. A number of examples of static, repetitive and dynamic applications are presented related to geomechanics, structural mechanics, dynamics and liquefaction, pavement analysis, rock mechanics and chip-substrate systems in electronic packaging.

In addition to the theoretical descriptions, the book gives proper attention to practical details such as the integration of the constitutive laws, the implementation in computer codes and the physical interpretation and determination of parameters. In fact, there is an Appendix devoted to optimization techniques required for the efficient estimation of model parameters. The level of development of the models in the different areas considered is variable, reflecting the intensity of past and present research activity in each field. The overall impression, however, is of comprehensiveness and consistency with the basic principles outlined at the start of the book. Obviously, the DSC has proved very fertile and flexible for application to a very wide range of issues in the field of material behavior. It is likely that the approach will be extended to new types of materials from different disciplines, taking advantage of the general and unified nature of the DSC. For instance, it is found to be highly successful for characterizing materials and joints, and for computer design and reliability in electronic packaging, a high tech and important industrial area.

The book should appeal to the postgraduate student, researcher and practitioner interested in the theoretical and practical aspects of constitutive modeling and material science, not exclusively in the civil engineering field. Indeed it should also prove rewarding to those interested in the more basic philosophical concepts underlying some current developments in Engineering Science.

[1]Universidad Politechnica de Catalunya, Spain.

