Items Authored by Han, Weimin

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Han, Weimin(1-IA); Reddy, B. Daya(SA-CAPE-MAM)
Plasticity. (English. English summary)
Mathematical theory and numerical analysis. Interdisciplinary Applied Mathematics, 9.
Springer-Verlag, New York, 1999. xiv+371 pp. \$69.95. ISBN 0-387-98704-5
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This book offers a nice and modern presentation of some mathematical and numerical methods applied in plasticity. It provides complete results on quasistatic processes for a class of elastoplastic materials with hardening that have been developed during the last years, to a large degree by the authors. The purpose of the book is threefold, namely: to introduce the reader to the constitutive theory of elastoplastic solids; to provide the variational analysis of related initial and boundary value problems; to present the numerical analysis of these problems. This aim determines the structure of the book, which consists of Preface, Part I, Part II, Part III, Bibliography and Index.

Part I contains a review of topics in continuum mechanics, thermodynamics, linear elasticity and the convex-analytic setting of elastoplasticity. This part provides a detailed introduction on theoretical aspects of the small-strain models of elastoplastic materials with hardening assumptions. The emphasis is on the advantages to be gained by placing the constitutive models in a convex-analytic context. In particular, it is shown that the flow rule can be written in terms of either the dissipation function or the yield function. This treatment leads to two alternative yet equivalent models, which are dual to each other. Mathematicians unfamiliar with plasticity theory will find in Part I an introduction that is well written, self-contained and accessible.

Part II of the monograph is concerned with the variational analysis of a quasistatic initial-boundary value problem for elastoplastic materials. It begins with a review of some topics from functional analysis and function spaces; then some classical results on elliptic and parabolic variational inequalities are presented. Particular attention is paid to weak formulations of initial-boundary value problems. Then, the quasistatic problem for elastoplastic materials is considered and set into two variational formulations: the primal variational problem, in which the unknowns are the displacement and internal variable fields, and the dual problem, in which the main unknowns are the generalized stresses. For the primal problem, an existence and uniqueness result is obtained, via an abstract existence and uniqueness result for evolutionary variational inequalities in a real Hilbert space. The continuous dependence of the solution on the input data is also obtained and a stability result is proved. The well-posedness of the dual variational problem is proved using an equivalence result. It is also obtained via a direct analysis which is of interest in its own right.

Part III is devoted to a treatment of the approximation of the variational problems presented in Part II. It begins with an introduction to basic aspects of the finite element method and finite element interpolation theory, including issues relative to convergence and error estimates. Then, the approximation by the finite element method of variational equations and inequalities is presented. Particular attention is paid to the error analysis for numerical solution of the abstract variational inequality used in the study of the primal problem of plasticity, for which time-discrete and fully discrete approximations are considered. These abstract results are then used in the derivation of error estimates for various numerical schemes approximating the solution of the primal variational problem of elastoplasticity. For this problem convergence results under basic regularity assumptions on the solutions are presented and predictor-corrector algorithms in the implementation of numerical schemes are considered. The difficulty caused by nondifferentiable terms is removed both with a

regularization technique and with a numerical integration method. Similar results including error estimates under sufficient assumptions on the solution, convergence under basic regularity assumptions on the solutions and analysis of some predictor-corrector methods in the study of the dual problem are also presented.

The book shows the range and the flexibility of a functional and numerical approach to partial differential equations occurring in elastoplasticity with hardening. It gives a valuable summary of the state of the theory, which appears to be fairly mature. The mathematical results on the variational and numerical analysis of the elastoplastic problems presented in this book are original and of substance. They lay the necessary groundwork for numerical applications in practical problems in industry and technology. The book is professionally written and will be a useful reference to researchers and students interested in mathematical and numerical problems of plasticity. It represents a major contribution in the area of continuum mechanics and numerical analysis.

Reviewed by Mircea Sofonea

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