Journal of Applied Mechanics

Book Reviews

Mechanics of Solids With Applications to Thin Bodies. By G. Wempner. Martinus Nijhoff, 1982. 633 Pages. Price $79.00.

REVIEWED BY T. J. LARDNER[1]

This book was originally published by McGraw-Hill in 1973 and it has, I believe, stood the test of time well; I have had many occasions to refer to different sections in the book during the past nine years. A review of the book appeared in *Applied Mechanics Reviews* (AMR, Review No. 10535, 1976) and this reviewer agrees with the conclusions of the AMR review.

The principal goal of the book, according to the author ". . . is to build a bridge between the most fundamental concepts of continuous media and the practical theories of structures. Foundations are laid with a view toward their eventual role in the analysis of flexible bodies." This bridge at times appears strange when fundamental relations are derived and then applied to a simple structure; the reader new to solid mechanics may wonder if the formulation might be easier by direct approaches to the simple structure. Of course, easier methods do exist but the author stresses the importance of the general approach in his discussion. Further he does emphasize that the book ". . . is intended for *engineers* interested in the *applied* mechanics of solids." Chapter titles and a brief outline of some of them follows:

1. *Introduction.* A review of notation to be used in the book.
2. *Deformation.* The basic kinematic results for the deformation of a continuous solid are derived.
3. *Stress.* The basic concepts of internal forces are presented.
4. *Behavior of Materials.* The general theory of elasticity, the incremental theory of plasticity, and the linear theory of viscoelasticity are developed.
5. *Linear Theories of Isotropic Elasticity and Viscoelasticity.*
6. *Extension, Flexure, and Torsion of Rods.*
7. *Elastic Plates.*
8. *Mechanics of Curved Rods.* A useful chapter containing a number of results.
9. *Energy Principles.*
10. *Curvilinear Coordinates.*
10. *Differential Geometry of a Surface.*
12. *Theory of Shells.*

As can be seen from the chapter titles, the book covers a wide range of topics in the mechanics of solids. The derivations are carefully presented and clear. References up to the time of the original publication provide sources to the original works on a number of topics. This is a useful reference book and can be used effectively for an introductory graduate course in solid mechanics.

[1] Professor, Department of Civil Engineering, University of Massachusetts, Amherst, Mass. 01003.

Wave Propagation in Viscoelastic Media. Edited by F. Mainardi. Pitman Publishing, Marshfield, Mass. 272 Pages. Price $25.00.

REVIEWED BY T. C. T. TING[2]

This book is Volume 52 of *Research Notes in Mathematics* which contains 11 articles by lecturers who took part at the Euromech Colloquium 127 on "Wave Propagation in Viscoelastic Media," held at Taormina (Sicily, Italy) in April, 1980.

The authors and the titles of the articles are as follows: D. Graffi, "Mathematical models and waves in linear viscoelasticity," M. Hayes, "Viscoelastic plane waves," S. Zahorski, "Properties of transverse and longitudinal harmonic waves," L. Brun and A. Molinari, "Transient linear and weakly nonlinear viscoelastic waves," A. Jeffrey and J. Engelbrecht, "Waves in nonlinear relaxing media," T. B. Moodie, R. J. Tait, and J. B. Haddow, "Waves in compliant tubes," E. Strick, "Applications of linear viscoelasticity to seismic wave propagation," E. A. Trautenberg, K. Gebauer, and A. Sachs, "Numerical simulation of wave propagation in viscoelastic media with nonreflecting boundary," J. L. Sackman, "Prediction and identification in viscoelastic wave propagation," G. C. Gaunaurd, W. Madigosky, H. Überall, and L. R. Dragonette, "Inverse scattering and the response of viscoelastic and electromagnetic waves," and J. Brilla, "generalized variational principles and methods in dynamic viscoelasticity."

The problems of wave propagation in viscoelastic media are much more difficult to analyze than the associated problems in elastic media because of the history dependence nature of the stress-strain laws. The governing equations are in general in the form of integro-differential equations if the stress-strain laws are written in an integral form. If they are written in a differential form, one can obtain the governing equations in the form of differential equations but they are usually of higher order than the equations for elastic waves. Therefore, with few exceptions, only linear or one-dimensional problems can be treated analytically. This is reflected in this book in which most articles are concerned with linear and/or one-dimensional problems. With the exception of the article by Zahorsky, which deals with viscoelastic fluids and the article by Jeffrey and Engelbrecht, which discusses both fluids and solids, the articles deal with waves in viscoelastic solids. Moodie, Tait, and Haddow consider the wave propagation in

[2] Professor of Applied Mechanics, Department of Civil Engineering, Mechanics, and Metallurgy, University of Illinois at Chicago, Chicago, Ill. 60680.

a fluid-filled tube in which the tube can be elastic or viscoelastic but the fluid is assumed to be incompressible and inviscid. All articles are very mathematically and analytically oriented. Nevertheless, the articles cover a fairly wide range of wave propagation phenomena in viscoelastic media. In view of the fact that there are not many books available on viscoelasticity and even fewer on wave propagation in viscoelastic media, the appearance of this volume is welcome. It would serve as a useful reference for those who want to venture into this field.

Plane-Strain Slip-Line Fields for Metal-Deformation Processes. By. W. Johnson, R. Sowerby, and R. D. Venter. Pergamon Press, New York, 1982. 364 Pages. Price $45.00.

REVIEWED BY S. KOBAYASHI[3]

This monograph comprises the previous one *Plane-Strain Slip-Line Fields: Theory and Bibliography*, published by Edward Arnold in 1970, describes most of the advances in the field developed during the last decade, and includes references to many new papers which give results in specific problems.

The Introduction begins with a historical note on plane-strain slip-line fields, followed by a list of physical observations in working metal. In Chapter 2 certain basic aspects of the plasticity theory that are necessary for the development of the methods of solution of the two-dimensional problems are presented. Chapter 3 is concerned with the governing equations of the plane plastic flow of a rigid-perfectly plastic solid, and their solution method. It contains the method of characteristics, properties of slip-line net, hodograph, and the discussion on a complete solution. In Chapter 4 a number of boundary value problems are examined to show how solutions may be developed by a straightforward step-by-step procedure. Construction of slip-line fields, stress boundary conditions, and construction of hodographs are discussed. While Chapters 2, 3, and 4 have dealt with basic plasticity theory, Chapter 5 is devoted to the application of the theory to specific problems of plane plastic flow. Slip-line solutions to many metal deformation processes are presented. They include pressure vessels, compression, indentation, cutting, sheet drawing, extrusion, piercing, forging, machining, swaging, notched bar tension, bending, rolling, and blanking. The discussion is extended to the application of slip-line fields in the area of crack initiation and fracture. More than 500 references are listed in this chapter alone. In Chapter 6 a numerical computational procedure which is referred to as the matrix-operation method is presented in detail. The method was developed recently, and greatly facilitates the solution to problems of the indirect type where there are insufficient known starting conditions for the determination of the slip-line field (or hodograph). The procedure is based on a power series representation of the solution to the governing equations and a vector representation of slip-lines and a system of matrix operators. This chapter contains mathematical formulations for the procedure, matrix operator subroutines, and solution of direct-type and indirect-type problems. The final chapter is concerned with the plasticity problems for other than isotropic rigid-perfectly plastic materials under plane-strain conditions. The method of characteristics is described for plane stress and axisymmetric problems, and for materials such as clay, ice, and soils. Slip-line fields for anisotropic materials are given, and the problems of minimum weight frames, plastic bending of plates and the force-plane diagram for slip-line fields are shown as analogies with metal-forming operations.

This book is the most complete source book on the subject and contains the references in each chapter, totaling almost 900 references. The book indeed provides teachers and researchers with basic material and a bibliography of papers on the theory and application of plane-strain slip-line fields to metal deformation processes.

[3]Professor, Department of Mechanical Engineering, University of California, Berkeley, Calif. 94720. Fellow ASME

Impact Dynamics. By J. A. Zukas, T. Nicholas, H. F. Swift, L. B. Greszczuk, and D. R. Curran. Wiley, New York, 1982. 452 Pages. Price $47.50.

REVIEWED BY L. E. MALVERN[4]

This book grew out of a short course taught by the authors, but is more a reference book than a textbook. It covers a wide range from low-speed to hypervelocity impact of projectiles against targets, with emphasis on impacts causing damage.

J. A. Zukas wrote five of the 11 chapters. The first two introduce stress waves and some limitations of elementary theory. Chapter 5 is a well-illustrated comprehensive treatment (with some 160 references) of penetration and perforation of solids. Experimental methods and approximate analyses by force laws are discussed.

In Chapter 10, Zukas presents an authoritative discussion (with 90 references) of numerical simulation of impact phenomena. Several remarkable examples of successful calculation are reviewed, including spall prediction, ricochet, oblique impact by a long-rod penetrator, and the self-forming fragment. The last chapter catalogues available three-dimensional codes (72 references) and closes with a section on current developments. The most serious limitation is not cost or complexity of numerical simulation, but rather the inadequacy of models describing material behavior, especially failure models.

This critical problem of material behavior at high rates is addressed by T. Nicholas in Chapter 8, a comprehensive review of experimental methods (140 references) at strain rates up to about 10,000/sec. The split Hopkinson pressure bar or Kolsky aparatus is treated at length. Biaxial testing is mentioned, but few high-rate results are available. Rate-history effects and their modeling are considered.

At higher rates, inelastic wave analysis is needed to interpret the experiments, but this requires assumed constitutive properties and leads to an iterative procedure for properties determination that may not have a unique solution. Nicholas treats elastic-plastic stress waves in Chapter 4 (116 references).

Damage in composite materials, caused by low-velocity impact, is discussed by L. B. Greszczuk in Chapter 3. A theory is developed and applied for elastic impact of two bodies of revolution made of transversely isotropic and orthotropic materials, including laminated composite targets. Failure criteria are proposed, and a few experimentally observed failure modes presented.

Hypervelocity impact mechanics, at velocities where strength of projectile and target are sufficiently negligible that solids may be considered as fluid, is concisely and clearly treated by H. F. Swift in Chapter 6. Launchers include gas guns, explosive projectors, and electrical accelerators.

In Chapter 7 Swift authoritatively discusses cameras and related image-forming instruments and presents several interesting accounts of ingenious techniques.

[4]Professor, Engineering Sciences Department, University of Florida, Gainesville, Fla. 32611. Fellow ASME.