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Book Reviews

Finite Element Analysis for Composite Structures

L. T. Tenek and J. Argyris, Kluwer Academic Publishers, Dordrecht, The Netherlands, 1998, 339 pp., $169.00

This book consists of nine chapters, two of which, Chapters 5 and 6, constitute 68% of the book. A brief review of each chapter follows.

The first chapter discusses the basic concept of continuum mechanics, including analysis of stress and strain and the principles of strain energy, virtual work, and stationary energy. A brief chapter on the history of finite element analysis with citations of contributors to the technology base follows. Chapter 3 focuses on a discussion of the natural mode method and natural stiffness method for a number of selected elements, including beams, truss triangles, and tetrahedral elements, and Chapter 4 presents a brief verbal description of composite materials and composite laminates.

The greater part of the book is composed of just two chapters, 5 (86 pp.) and 6 (124 pp.). In them an in-depth discussion of beam, plate, and shell elements is presented. Some simple analytical models for comparing isotropic and composite beam behavior are introduced, along with a discussion of symmetrical and asymmetrical bending with shear *correction* factors. Included in the discussion are several simple examples for composite and sandwich beam, plate, and shell members subjected to both mechanical and thermal loads.

There follows, in Chapter 7, a brief discussion of the computational efficiency of the finite element methodology developed, focusing on a specific example presented in Chapter 6, that of a cylindrical composite shell. Then in Chapter 8 a discussion is presented of the nonlinear analysis of anisotropic shells based on the natural mode method and the cylindrical arc-length method, along with numerical examples for isotropic and composite shells.

Chapter 9, which completes the body of the book, describes the programming aspects of the computer program included with the text. A basic knowledge of Fortran 77 and of the underlying principles and methods developed in the text is sufficient to follow the structure of the computer program.

Two appendices are also included. Appendix A examines the geometry of a beam element in space, and Appendix B outlines a model computer program for evaluating the static and buckling analysis of isotropic and composite material beams, frames, and three-dimensional beam assemblies.

This book is coauthored by a respected pioneer in the area of finite element analysis and as such provides a useful contribution to the literature. The reader should be aware that the book is written in a style that may require dedicated reading for clarity. Although the title of the text is focused on finite element method analysis of composite structures, the amount of material in Chapter 4 dedicated to composites is sparse, and the use of classical lamination theory in Chapter 6 is considered as well-understood material. The number of references to the growing textbook literature on composites is also sparse, the current book containing but three references.

This text, as described by the authors, presents "an adventure into the computer analysis of 3D composite structures using the finite element method (FEM)." As such, it should be useful to active researchers in this area and to researchers and students who have had a basic course in the mechanics of composites as well as some basic finite element method analysis.

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Impact on Composite Structures

S. Abrate, Cambridge University Press, London, 1998, 289 pp., $64.95

The author, who developed his reputation in the field of impact of composite structures through his review papers, is one of the few individuals qualified to write a book of this nature. It represents excellent coverage of pertinent areas within a restricted number of pages. He doesn't dwell for too long on specific topics and nicely describes the overall problems related to structural impact.

Chapter 1 is an introduction to the layout of the book, and Chapter 2 describes the contact law that is important in evaluating the effects of impact. A recent book by Sierakowski and Chaburvedi[1] is an excellent reference.

In Chapter 3, the author presents the beam, plate, and shell equations of motion with several examples related to different composite structural elements. Also included is a helpful review of the important ideas of structural motion that are useful in understanding impact events. The impact modeling section gives the reader a good feel for the overall problem. This chapter is the most useful part of the text.

Chapter 4 is a compilation of common impact test procedures. It might have been more useful if Fig. 4.1 showed actual diagrams of the specific devices. It should be noted that the pendulum-controlled device allows for very small impact energy. Some actual microphotographs of tensile and shear cracks developed under the impact point would have been helpful. In the second part of the chapter, a discussion of the development of delamination is given for a composite plate specimen.

Chapter 5 attempts to trace the damage within a composite material target using certain numerical approximations. The author gives a value of 20 m/s, within a graphite/epoxy plate, for the lower bound on the consideration of through-the-thickness wave propagation effects on the engineering property limitation. Above this value, one should consider strain rate for establishing constitutive relationships.

Chapter 6 discusses the effect impact has on the general mechanical properties of laminated composite structures, such as compression, tension, shear, and bending. For the most part, discussion is related to experimental findings leading to specific algorithms.

Chapter 7, on ballistics, is really not needed. Certain terminology is defined, e.g., transition velocity, that leads to an appreciation of the general area, but not mentioned are efforts being carried out at certain research laboratories that should be consulted by interested readers. For example, research reported by Anderson and Walker[2] at Southwest Research Institute and by Aidum and Addessio[3] at Los Alamos National Laboratory will help familiarize a reader with the field of ballistic impact.

Chapter 8 is related to the repair of composites damaged by impact. Understanding of the specific details listed, e.g., Figs. 8.5–8.7, would be improved if the drawings were three dimensional. They are not informative enough as they presently exist.[4]

Chapter 9 is on the impact of sandwich structures. This scenario has many features that are very different from the monolithic composite structure. The author does a nice job in presenting these areas. The work by Herup[5] would be a useful addition to the list of references.

References

[1]Sierakowski, R. L., and Chaburvedi, S. K., *Dynamic Loading and Characterization of Fiber-Reinforced Composites*, Wiley, New York, 1997.

[2]Anderson, C. E., and Walker, J. O., "An Examination of Long-Rod Penetration," *International Journal of Impact Engineering*, Vol. 1, No. 1, 1991, pp. 481–501.

[3]Aidum, J. D., and Addessio, F. L., "An Enhanced Cell Model with Nonlinear Elasticity," *Journal of Composite Materials*, Vol. 30, No. 2, 1996, pp. 248–280.

[4]Dedward, K. T., "Joining of Composite Materials," STP 749, American Society for Testing and Materials, 1981.

[5]Herup, E. J., "Low Velocity Impact on Composite Sandwich Plates," Ph.D. Dissertation, U.S. Air Force Inst. of Technology, AFIT/DS/ENY 96-II, Dayton, OH, 1996.

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