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Book Review

G.R. Liu, Z.C. Xi, Elastic Waves in Anisotropic Laminates, CRC Press, Boca Raton, FL, ISBN 0849310709, 2002 (472pp., price US$169.95).

Even though several books are available on elastic wave propagation in layered solids, the appearance of *Elastic Waves in Anisotropic Laminates* by G.R. Liu and Z.C. Xi is most welcome. The main feature of the book, which distinguishes it from the available monographs, is its emphasis on the introduction of efficient and innovative analytical–numerical techniques applicable to the study of linear elastic wave propagation in anisotropic laminates. Apart from laminated composite materials, which are usually understood under the name of laminated structures, three chapters are devoted to the study of functionally graded elastic and piezoelectric materials, the subjects of interest, e.g. to those involved in the study of smart structures and design of surface acoustic wave devices. The analytical–numerical techniques described in the book are applied to a very wide range of problems including: wave propagation in layered composites, wave scattering by cracks in laminated plates and cylinders, the calculation of the response of laminated plates using the so-called strip element method, some inverse problems of identification of the impact loads and material constants of laminates and new results on the wave phenomena in functionally graded elastic and piezoelectric materials.

The book is organized in such a way that chapters which use the same analysis approach are grouped together, starting with analytical- and moving on to numerical methods. Such a layout allows the chapters to be studied to a high extent independently, but may provoke a feeling of a lack of continuity of the exposition in a reader looking for a more classical textbook. Each of the eighteen chapters begins with a brief introduction describing the physical relevance of the subject studied and an overview of the previous research and references. A concise description of the equations governing the problem being studied in each chapter follows (but some prior familiarity with constitutive equations of composite materials will be of help to the reader) and the appropriate approach and the solution algorithm are discussed in detail. The reader gains confidence in the accuracy of the numerical algorithms used through the many comparisons with the results available in the literature. Finally, the element that I have found especially valuable, each chapter contains numerous plots of interesting and practical results with the discussion of their physical relevance.

The book begins with a chapter introducing the reader to the concepts of wave propagation. On the example of waves in a rod, the standard concepts of wave motion are introduced. Apart from the discussion of free propagation, the forced response to harmonic and transient excitation in an infinite and finite rod is discussed. The Fourier approach used throughout the book to study transient response is discussed with emphasis on the difficulties encountered when numerically calculating the inverse transform. Chapter 2 "Waves in Plates of Functionally Graded Materials"

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studies the propagation of waves in a plate of finite thickness with material properties changing continuously in the thickness direction. The propagation in the thickness direction is investigated and even though the problem is still one dimensional, its complexity is substantially greater than in the homogenous case. The solution is found using confluent hypergeometric functions. Chapters 3 and 4 deal with the exact solutions, respectively, for free propagation and forced transient waves in layered laminates. As almost everywhere in the book the analysis is based on the three-dimensional formulation of anisotropic elasticity. The effect of dispersion and anisotropy is discussed for composite laminates. Chapter 5 is devoted to the discussion of physical properties of waves in laminates. An approach to the calculation of the group velocity using the Rayleigh quotient is discussed and several numerical results are shown illustrating the directional dependence of the phase and group velocities in composite laminates.

Beginning with Chapter 6 the authors gradually introduce and apply various analytical–numerical methods applicable to the study of waves in anisotropic laminates. The novel analytical–numerical approaches advocated by the authors combine the numerical approximation in the thickness direction with different analytical techniques applied in other directions, thanks to which the methods used show advantages over the more classical numerical methods such as the finite element and the boundary element methods. Using the analytical–numerical approach, in Chapters 6 and 7 the authors study the wave propagation in composite rods. Chapter 8 discusses the analytical–numerical approach as applied to the study of transient waves in composite laminated plates. In Chapters 9 and 10 the approach of the previous chapter is generalized to the study of waves in elastic and piezoelectric functionally graded plates, for which the material properties display a continuous variation in the thickness direction. Strong surface waves are shown to exist in plates made of such materials. Chapter 11 introduces an efficient method of studying waves in anisotropic laminates—the strip element method. The approach is used in Chapters 12 and 13 to the study of wave scattering by cracks and flaws in composite laminates. Chapter 14 shows that some of the techniques developed in the book for the study of wave propagation can be applied with efficiency to the analysis of the vibration of composite structures. Using the classical laminated plate theory and the strip element method the authors calculate the transverse transient response of composite plates. In Chapters 15 and 16 the reader will find a short discussion of the characteristics of wave propagation in layered composite cylinders and their scattering by cracks. The final two chapters describe some special aspects of inverse problems of the identification of impact loads and material constants of composite laminates using the wave approaches developed in the earlier parts of the book. These two chapters introduce the reader to on-going research and describe some recent techniques such as the use of a genetic algorithm to the identification of material constants of laminated composites.

I do believe that thanks to the very wide range of subjects studied the book by G.R. Liu and Z.C. Xi will serve as a valuable text introducing a broad audience to wave phenomena in anisotropic laminates as well as up-to-date analysis tools used to study them. Another important advantage of the book is that some of the methods described in the text have been programmed and are available from the authors as proprietary computer codes.

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