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BOOK REVIEWS

INTRODUCTION TO FINITE ELEMENT VIBRATION ANALYSIS, 1998, by M. Petyt, Cambridge University Press, xv + 558 pp. Price (paper-back) £35.00 (US$59.95). ISBN 0521-63417-2.

This book is the paperback edition of the hardback volume published in 1990. It appears to be the only book on the market which is devoted wholly to a description of the use of the finite element method in solving vibration problems. This concentration is well justified, given the versatility and power of the finite element method in predicting the response of general practical structures, as distinct from the limitations of analytical techniques.

The reader of the book is assumed to have prior knowledge of some fundamentals of vibration theory and of aspects of strength of materials, together with some familiarity with basic matrix algebra and the solution of sets of linear equations. However, it is important to note that the author does not assume that the reader has had any prior contact with the finite element method, whether in the context of dynamic or of static analysis. The finite element approach adopted throughout is the pure displacement approach which is introduced as a generalized Rayleigh–Ritz method.

The material of the book is arranged in a logical and systematic fashion. A modular style is adopted, which will help both the individual reader who wishes to concentrate on particular areas and the lecturer who may wish to use selected parts of the book in his course.

Basic material which forms the background for the later description of the finite element method is presented in the first two chapters. Chapter 1 is concerned with developing the equations of motion for a dynamical system and includes descriptions of the principle of virtual displacements, Hamilton's principle and Lagrange's equations. Chapter 2 presents statements of strain and kinetic energies and of virtual work of applied loading for various types of structural element, as well as considering the nature of damping and of boundary conditions.

Chapters 3–7 constitute a major (262 pages) core of material in which the properties (stiffness, mass and load matrices) of various types of finite element are developed in detail and applied. Attention is given to rods, shafts, beams (slender and shear deformable), plane and space frameworks, membranes, solids (axisymmetric and general), flat plates (classically thin and shear deformable), and stiffened and folded plate structures. The concepts of numerical integration, area co-ordinates and isoparametric formulations are included. The treatment is comprehensive, with the only significant omission being that of the advanced topic of curved shell analysis.

The next three chapters describe methods for the solution of the kinds of equations of motion that arise in dynamic finite element analysis. Chapter 8 deals

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with the analysis of free vibration, including a variety of popular methods for determining natural frequencies and modes, and giving consideration to reducing the number of degrees of freedom and to the solution of large eigenproblems. Chapters 9 and 10 present methods of predicting the response of structures to a dynamic loading which may be harmonic, periodic, transient or random in nature. Description is given of both modal analysis and direct techniques of solution, with damping effects included but with attention limited to linear behaviour.

The final chapter, Chapter 11, deals with computer analysis techniques and provides a broad description of the structure and facilities of commercial finite element packages and of their use. On this point, it bears mentioning that the book does not include any listings of computer programs for dynamic analysis.

Throughout the book the presentation of theoretical material is augmented by numerous worked examples and, with the exception of Chapters 10 and 11, the chapters conclude with problems for solution (mostly manual solution) by the reader. A copious list of references and a bibliography are provided for readers wishing to broaden their knowledge of the subject.

Petyt's book provides an excellent introduction to the use of the ubiquitous finite element method in solving dynamic problems. It is a well-written, clear, balanced and comprehensive text. It deals with a specialist topic but one that is of interest to numbers of undergraduate and postgraduate students and professional engineers in the realms of mechanical, aeronautical, civil and marine engineering. Anyone wishing to begin a study of this topic would do well to make a start with this very fine book.

D. J. DAWE

UNSTEADY AERODYNAMICS AND AEROELASTICITY OF TURBOMACHINES (PROCEEDINGS OF THE 8TH INTERNATIONAL SYMPOSIUM, STOCKHOLM, SWEDEN, SEPTEMBER 1997), 1998, T. H. Fransson, editor, Dordrecht: Kluwer Academic Publishers, xiv + 858 pp. Price: NL6 650.00, US$ 350.00, GBP 220.00. ISBN 0792350405.

The bound proceedings run to 845 pages, with a very wide range of topics covered, but all directed towards turbomachinery. It would be impossible to do justice to so much material in a brief review. The topics range from aeroelasticity, through to papers which are concerned with aerodynamic performance of compressors and turbines. Some are based on experimental measurements, others are numerical and a few are analytical in character. The papers give a good overview of the recent "state of the art" in many relevant areas. The geographical spread of authors is wide and many are familiar and famous names. Since the type face and layout varies from author to author the book appears to have been produced directly from copy provided by the authors — in almost every case the quality of presentation is very high.

N. A. CUMPSTY

FINITE-ELEMENT MODELLING OF UNBOUNDED MEDIA, 1996, by John P. Wolf and Chongmin Song. Chichester: John Wiley & Sons, xix +331 pp. Price £75, US$130. ISBN 0 471 961345.

This book is the first author's fourth on the topic of modelling of unbounded media. It contains innovative techniques developed by the authors.

The first chapter begins by describing the features of dynamic unbounded medium–structure interaction analysis. It is usual to model the structure and the irregular bounded medium, which may be non-linear, adjacent to the structure by means of the finite element method. However, difficulties arise with modelling the remaining regular unbounded medium. Previous attempts at using the boundary element method and the finite element method with transmitting boundaries are discussed. It is the aim of the book to develop three finite element-based procedures for unbounded media. The first procedure is based upon a similarity-based formulation whereby only a portion of the unbounded medium between two similar boundaries is modelled by using finite elements. This is used to formulate a relationship linking the unit-impulse response matrices (or the dynamic stiffness matrices) at the two interfaces. A variant of this method called the consistent infinitesimal finite-element cell method is obtained by taking the two similar boundaries close together and modelling the enclosed region with one layer of finite elements. The limit is then determined as the two surfaces approach one another. This method offers more advantages than the finite element and boundary element methods combined. The second procedure is referred to as the damping-solvent extraction method. A finite region of the unbounded medium adjacent to the structure is modelled with finite elements. Damping, which is not present in the actual medium, is introduced artificially to reduce the amplitude of outgoing waves and waves reflected from the outer boundary. This results in a dynamic stiffness matrix for the structure–medium interface which depends upon outgoing waves only. This matrix is then assumed to represent the unbounded medium with the same artificial damping. Finally, the influence of the introduced artificial damping is extracted. The third procedure is termed the doubly asymptotic multi-directional transmitting boundary method. A finite region of the unbounded medium is modelled using finite elements and suitable boundary conditions applied over the outer boundary to ensure waves are not reflected. The method described combines the advantages of the doubly asymptotic and multi-directional formulations. It is rigorous for the low-frequency limit and the high-frequency limit in the wave propagation direction perpendicular to the artificial boundary and at all the preselected angles. It is also highly accurate for plane waves at intermediate frequencies.

The remainder of the book is divided into three parts. Part 1, which consists of Chapters 2–10, addresses the similarity-based formulation in both the time and frequency domains. The damping-solvent extraction method is described in Chapters 11 and 12 in both the frequency and time domains. Finally, the formulation of the doubly asymptotic multi-directional transmitting boundary method in the time domain is given in Chapters 13 and 14.

The accuracy of all these methods is illustrated by applying them to a set of benchmark problems whose solutions are given in Appendix A. Appendix B gives a brief description of a computer program which covers all cases discussed in Chapters 5–10. The program can be obtained from the publishers free of charge.

The book assumes that the reader has a basic knowledge of the finite element method and of dynamic analysis. It is presented in a clear fashion and should appeal to those interested in engineering mechanics, earthquake engineering, ground vibration caused by transportation, acoustics, electromagnetism and computational mathematics. It is also suitable for advanced course in finite element methods and dynamic soil–structure interaction.

M. PETYT