Book review

Introduction to finite element vibration analysis, by Maurice Petyt, Cambridge University Press, Cambridge, UK (Second edition, 1998).

Since R. Clough coined the term "finite element method", there are many books devoted to this universal method of structural analysis. Many of these books contain a chapter on dealing with the FEM for vibration analysis. This book is exclusively devoted to the successful marriage between the vibration theory and the finite element method.

Vibration analysts do not have to know the FEM prior to engaging to reading and studying this book. Practicing engineers will certainly appreciate such an understanding of their needs. The book provides from A to Z introduction to the subject, so that the engineer could use the method actively.

One of the main strengths of the book lies in its modularity, so that one does not have to master entire book prior to being able to engage in rigorous solution of various problems.

The book presupposes the knowledge of strength of materials and basis of vibration theory (sorry, there are no "assume nothing" technical books, for the latter one ought to resort to the detective stories). Yet even then, the chapter 1 is a "reminder" of vibration fundamentals through the prism of deriving of equations of motion. Author mentions that "the success of the analysis is dependent upon the equations of motion being formulated correctly. This process will be less prone to errors if a routine procedure for formulating the equations can be established". Since the equation of motions can be derived from the energy functions, namely the strain and kinetic energies, the dissipation function and the virtual work done by the applied forces, same time ought to be spent on formulating these functions. This is done in the second chapter. The energy functions are derived for the axial torque, beam bending, deep beam bending, membrane, thin plate, thick plate, 3-D, and axisymmetric solid elements.

Chapter 3 introduces the FEM as a generalization of the Rayleigh-Ritz method. The method is illustrated by the solution of the clamped-free uniform rod's vibration frequencies. A single element and two element solutions, derivable by pencil and paper are compared with the exact solution available for this case. Fortunately, author does not stop here (as is often done), but introduces the non-uniform structures for which the FEM often is an only method of tackling the problem. Likewise, bending vibration of beams and vibration of plane frameworks are illustrated. Author then attacks the 3-D frameworks. Immediately the question of accuracy arises in the mind of the reader. The techniques for accomplishing this are discussed at length. Accuracy is indispensable from the degree of accuracy of the modeling itself. Naturally, the much-experienced author, who emerges to be a wonderful pedagogue, includes at this proper stage the effects of shear deformation and rotary inertia. To quote the author, "exact integration of the expressions for the inertia, stiffness and load matrices is often tedious, time consuming and prone to human error", and since "in some instances . . . it is impossible to carry out the integration exactly", the numerical integration is called for. This topic is discussed in Section 3.10. Symbolic manipulation packages could also be used for this purpose.

Chapters 4 and 6 deal with plate vibrations. Chapter 4 is devoted to in-plane motion, whereas chapter 6 is dedicated to flexural vibrations. These two chapters and then naturally integrated in chapter 7, discussing the stiffened plates and folded-plate structures. Chapter 5 treats vibration of solids. Various elements (rectangular, hexahedron, isoparametric hexahedron, and right pentahedron) are studied in detail.

Eighths chapter discusses, in detail, the solution of the linear eigen value problems, as resulted from the FE analysis. It includes both the standard and less known methods. Special emphasis in placed upon the solution of large eigenproblems, including bisection inverse iteration, subspace iteration, simultaneous iteration, and the Lanczos' method.

Thus the first eight chapters cover the free vibration analysis completely. Subsequent two chapters delve on the forced response, including the representation of viscous or structural dampings. For the transient response both the modal and the direct analysis are covered in much detail.

Tenth chapter is devoted to the stationary random vibration in the FE environment as well as the response

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spectrum methods and other pertinent topics. The last chapter deals with intricacies of the computer analysis technique.

Numerous problems are included to increase reader's grasp of the material covered, with answers provided so that the reader can check oneself.

To sum up this is an excellent and clear book, and constitutes a must for the vibration engineers. Both the researchers and the students in vibration will most benefit from this unique book.

The author ought to be congratulated with this impressive book, written with rare pedagogical and professional mastery.

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