AIAA JOURNAL
Vol. 33, No. 9, September 1995

Book Reviews

Acoustic and Elastic Wave Scattering Using Boundary Elements

J. J. do Rego Silva, Computational Mechanics Publications, Billerica MA, 1994, 152 pp., $69.00

Boundary element method (BEM) or boundary integral equation method (BIEM) has become a powerful tool of solving engineering problems. Many researchers around the world have been actively participating in applications, improvements of accuracy of computation, as well as in addressing theoretical questions such as the uniqueness and existence of solutions. This field has been developing intensively since the '60s, when digital computers became available for solving engineering problems requiring extensive numerical computation. Since then many conferences and symposia on BEM/BIEM have been held with published proceedings. Much work on this field has been done by university researchers and graduate students. Advances in BEM/BIEM can be found in conference proceedings, journals and degree theses. There are now some good textbooks on the subject and the number is increasing steadily. However, the book reviewed here, authored by J. J. do Rego Silva, is a research monograph that is suitable as a reference for a graduate level course on BEM.

The book, which is apparently based on a Ph.D. dissertation at Southampton University, consists of five chapters on advanced topics on BEM. A basic knowledge of BEM is assumed by the author. The book is unique because it deals with both mathematical and practical aspects of BEM. In spite of its small size (134 pages), the author has managed to pack many useful results in the book. Chapter 1 is an introduction to the remaining four chapters of the book as well as a brief history of applications of BEM/BIEM to problems of acoustics and elastodynamics. Chapter 2 presents a new family of boundary elements that consists of continuous, discontinuous, and transition elements for efficient numerical integration of both regular and singular integrals. A good discussion of the need for development of such a family of boundary elements in applications is given here. Numerical implementation of BEM for the Helmholtz equation with Dirichlet, Neumann, and mixed boundary conditions is also presented in this chapter. Some applications in acoustics, such as the sound from a pulsating sphere, as well as elastic wave propagation for which analytic solutions are available, are given at the end of this chapter using the new family of boundary elements.

In Chapter 3, the author considers hypersingular boundary element formulations. These formulations typically involve divergent integrals whose interpretation is based on Hadamard's concept of the finite part of divergent integrals. One application of the hypersingular formulation is in exterior problems of acoustics where there is a difficulty with uniqueness of the solution at some frequencies. Here a composite boundary integral formulation consisting of a linear combination of a standard and hypersingular boundary integral equations can be used as proposed, for example, by Burton and Miller in the early '70s. The main contribution of this chapter is the rigorous evaluation of the finite part of a hypersingular integral associated with the Green's function of the Helmholtz equation. The necessary mathematical theorems are stated here as needed. Additionally, the implementation of the results in the boundary element codes is also discussed. Some applications to scattering of sound waves from thin bodies and Stokes flow in ducts are presented here.

Chapters 4 and 5 consider improved formulations for three-dimensional acoustic and elastic wave propagation, respectively. The main idea behind these formulations comes from O. I. Panich who addressed the question of the solvability of exterior electromagnetic wave propagation problems based on an integral equation approach. Both these chapters are at a higher level than the earlier chapters and require careful reading. A knowledge of integral operator theory is helpful, although the author has avoided abstract reasoning common in some advanced monographs on the subject. In Chapter 4 a proof of the existence and uniqueness of the solution of the Neumann problem for Helmholtz's equation, based on Panich's formulation, is given in detail. A similar proof of the Navier–Cauchy equations for steady state elastodynamics is given in Chapter 5. Other aspects of Panich's method such as smoothness requirements of the density function are discussed in these chapters. Numerical implementation of the method together with some examples are presented in these chapters.

The author has a clear style of writing and reasoning and cites the appropriate references in the discussions. The list of references at the end of the book is comprehensive. Unfortunately, this book has no subject or author indices to help the reader. Some of the figures, such as spheres, are badly drawn and do not resemble the intended shape (e.g., Fig. 2.21). Nevertheless, the reviewer believes that this book is valuable for graduate students and researchers of BEM/BIEM and recommends it as a worthwhile addition to their libraries.

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