AIAA JOURNAL
Vol. 42, No. 2, February 2004

Book Review

BOOK REVIEWS published in this section reflect the opinions of their individual authors. They are not necessarily the opinions of the Editors of this journal or of AIAA.

Analysis and Optimization of Prismatic and Axisymmetric Shell Structures: Theory, Practice and Software

Ernest Hinton, Johann Sienz, and Mustafa Özakça, Springer, New York, 2003, 496 pp., $159.00

The nature of this interesting book is best understood by reading the Preface. It describes how a group was formed at the University of Wales in Swansea by Professor Ernie Hinton in the 1990s to focus on the combination of adaptive finite element analysis and shape optimization (ADOPT). In 1996, Professor Hinton started to plan a series of books publishing the work of the ADOPT group, and in 1999 he began to work on the present book. After he died at age 53 in November 1999, Dr. Sienz and Dr. Özakça, his colleagues and former Ph.D. students, completed this book.

With the focus on the contributions of the ADOPT research group come some strengths and limitations. The limitations include no treatment of nonisotropic or composite shells, very little on stiffened shells, only brief treatment of buckling with no accounting for imperfections, and almost entirely linear analysis throughout. Similarly, there is no mention of many other programs for design of shells of revolution, such as PANDA2 and VICONOPT.

The strengths of the book include a CD with Fortran software including nine computer programs and user documentation. There is a very large number of examples in the book that were apparently solved with these programs. There is clear exposition of the methods and algorithms used by these programs, with some information on alternative methods and algorithms. Besides the finite element methodology, the book also describes the finite strip and finite prism methodologies that are so efficient for prismatic and axisymmetric shells.

Therefore, the book should be useful for several audiences: First, for practitioners who can make use of the software, the book provides an excellent theoretical manual for these programs. Second, for researchers who develop shell optimization methodology, the book provides a wealth of test cases. The software would allow the researchers to reproduce most of the results and obtain additional information, which may not be available in the book or the papers where some of these examples were previously published. Finally, while not a textbook, the book may be a useful reference for courses on shell analysis and design.

The book includes five parts, with the last being on the accompanying CD:

Part I: Introduction includes three chapters. Chapter 1, Introduction, provides an overview for the book, including classification of shell structures, computer-aided curve and surface modeling tools, element technology, basic optimization algorithm, and a summary of main computer programs. Chapter 2, Structural Shape Definition and Automatic Mesh Generation, describes procedures used to define midsurface geometry, the automatic mesh generator, and their use for structural analysis and optimization. Chapter 3, Structural Optimization Methods and Algorithms, provides a brief overview of optimization algorithms with emphasis on gradient-based local search algorithms such as SQP, except for about 10 pages devoted to genetic algorithms. There is also substantial discussion of sensitivity analysis techniques, with special emphasis on overall finite differences and the semi-analytical method for linear static analysis.

Part II: Static Analysis and Optimization deals with the basic formulation of curved, variable-thickness, Mindlin–Reissner finite elements and finite strip shells of revolution and prismatic shells, which are idealized as effectively one-dimensional problems. Chapter 4, Basic Finite Element Formulation for Shells of Revolution, includes new finite element developments limited to axisymmetric response along with several benchmark examples. Chapter 5, Basic Finite Strip Formulation for Prismatic Shells, deals with linear elastic analysis of prismatic folded plate and shell structures supported by diaphragms at two opposite edges with the other two edges arbitrarily restrained for both straight and curved planforms. Benchmark examples and comparison with known solutions are also provided. Chapter 6, Structural Optimization of Shells of Revolution and Prismatic Shells, presents additional details on the implementation of the analytical and semi-analytical sensitivity calculation and then includes many examples. These start with thickness optimization of plates, box girders, cylindrical tanks, and spherical shells under transverse loads, followed by examples of shape optimization of cylindrical shells and plates with curved planforms.

Part III: Free Vibration Analyis and Optimization extends Part II to vibration analysis and optimization using the same shell formulation and one-dimensional finite element and finite strip analysis methods. Chapter 7, Basic Finite Element Formulation for Vibrating Axisymmetric Shells, presents methodology for the new finite elements and benchmark examples that establish accuracy, convergence, and efficiency. It also includes a

study of the vibration behavior of church and hand bells. Chapter 8, Finite Strip Formulation for Vibrating Prismatic Shells, provides similar demonstrations of accuracy and efficiency of families of C^0 strips. Chapter 9, Structural Shape Optimization of Vibrating Axisymmetric and Prismatic Shells, presents analytical and semi-analytical derivative calculations and gives examples. These include thickness optimization of plates and shells as well as shape optimization of shells, including bells.

Part IV: Dynamic and Buckling Analysis and Optimization completes the analysis and optimization problems for buckling problems and dynamic problems. Chapter 10, Buckling Analysis and Optimization of Plates and Shells, introduces into the analysis the geometric stiffness matrix, beginning with examples of plates and stiffened panels that are used to compare finite element and finite strip solutions. This is followed by thickness optimization examples of plates and stiffened panels. Chapter 11 is entitled Basic Dynamic Analysis of Plates, Solids of Revolution and Finite Prism Type Structures. This final chapter presents exact Navier-type solutions for rectangular simply supported plates based on double Fourier series and three-dimensional solutions for solids of revolution based on a finite prism method.

Part V: CD-ROM includes documentation, user instructions, and data files for several programs. These include two main programs. SANOPT-S deals with shells of revolution using the finite element method and prismatic shells under static conditions using the finite strip method. SANOPT-F deals with the free vibration and buckling analysis and optimization of the same structures. In addition there are seven auxiliary programs including the postprocessor SANOPT-P. Finally, the CD contains Windows binaries for free Gnu Fortran compiler g77 and Gnu PostScript interpreter.

Raphael Haftka
University of Florida