Preface

Nowadays composite materials play a very important role in all types of engineering structures, such as aerospace, automotive, underwater structures, medical productions, electronic, and sports equipments. Computational mechanic analysis is the base of the dramatic development of composite materials. Composite structures can be studied by using two basic analysis schemes: micromechanical methods and macromechanical methods. In general, micro-mechanical analysis is aimed at predicting and understanding the average properties in terms of the detailed microscopic behavior of the material, rather than generating accurate design data; while macromechanical analysis draws mainly on the results obtained from physical and mechanical testing of unidirectional composites. If we need to analyze the macro and microresponse simultaneously, multiscale analysis methods are necessary. This book is focused on the macromechanical analysis and multiscale analysis of composite engineering structures. In the early days of laminated composites, the technique used for analyzing conventional plates was extended to analyze these new structures. The zig-zag effects and C_z^0-Requirements poses a serious challenge to the early traditional analytical methods. Although the composite analysis theories have made great progress, there are still many challenges because of the complex characteristics and wide applications of composites: their complex integrated molding process, complex anisotropic constitutive relations, complex damage mechanism, complex multiphysical loading, and complex multiscale effective, namely C^5 challenges. Unfortunately, it is almost impossible to accurately consider all the challenges using the existing refined analysis methods.

The author and his research team have focused on solving the basic mechanical problems in composite engineering structures, especially the theories of composite laminated beams, plates, and shells; they are called the composite laminated theories in this book. The research team has developed a composite structure analysis software system, with a total code of more than 200,000 lines. The software system has a large number of solvers based on shear deformation theories, state space theory, the layerwise method, extended layerwise method, computational continua, multipoint multilevel grid refinement method, and taking the fracture, damage, multiscale and multiphysics analysis problems as its advantages. Analysis objects of this software system include: beams, plates, shells, stiffened plates and shells, sandwich plates and shells, and multilayer sandwich plates and shells. Loading types include: mechanic, thermal, electric, chemical, and their coupling loading. The software system adopts advanced storage and solution technologies, and requires less memory and hard disk than commercial software. For some specific challenging engineering problems, the efficiency and accuracy of the proposed software are better than these of the commercial software as well.

As there is a dramatic increase in the use of composite materials, the number of students taking courses in composite mechanics has steadily increased in recent years, and the students are drawn to these courses from a variety of disciplines. The courses offered at universities and the books published on composite materials are of three types: material science, mechanics, and design. The present book belongs to the mechanics category. The motivation for the present book has come from many years of the author's research in laminated composite structures and from the fact there does not exist a book that contains a detailed coverage of various laminate theories, analytical solutions, finite element models, and their applications in structural engineering problems. The book is largely based on the author's original work on refined theories of laminated composite plates and shells, and the analytical and finite element solutions he and his collaborators have developed over the last two decades. The novelty of this book is that the existing most important analysis methods and their codes are introduced, and mainly focus on fracture and damage analysis, together with multiscale analysis and multiphysics analysis.

This textbook is unique in three respects:

- Theory and implementation. The text provides a detailed exposition of the state-of-the-art composite analysis theories and their insertion into engineering applications of typical structure forms and problems;
- Hands-on experience. Included with this textbook is an academic version of the composite analysis codes, which includes more than 200,000 lines of code;
- Engineering problems. Many structural engineering problems are studied numerically. A lot of benchmark examples are designed and detailed numerical results are presented.

Due to a broad spectrum of application areas, this course is intended to be of interest and used to a varied audience, including:

- Graduate students and researchers in academia and government laboratories who are interested in acquiring fundamental skills that will enable them to advance the state-of-the-art in the field;
- Practitioners in civil, aerospace, and automotive industries who are engaged in analysis, design, and optimization of composite structures;
- Commercial software vendors who are interested in extending their product portfolios and tapping into new markets.

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