Preface

Due to the nature of anisotropy, composite materials are usually modeled as anisotropic elastic solids. Therefore, the researchers and engineers interested in composite materials are usually advised to get acquainted with *anisotropic elasticity*. However, only three books related to anisotropic elasticity have been published in the literature. Two of them were written in Russian by Professor S.G. Lekhnitskii and were originally published in 1947 and 1950. Their English translations were published later in 1963 and 1968. These two books are the classical books of anisotropic elasticity and have great contributions for the follow-up research. In the present book, I arrange one chapter named *Lekhnitskii formalism* introducing the classical method presented in these two books. The third book about anisotropic elasticity was written by Professor T.C.T. Ting and was published in 1996. A great contribution of Ting's book is the presentation of another systematic approach – *Stroh formalism*. Due to its importance, the Stroh formalism together with its related discussions introduced in Ting's book is summarized in Chapter 3 of this book. Owing to the publication of Lekhnitskii's and Ting's books, during the last half century numerous new advances have been achieved. Therefore, I think it is a proper time to update this topic by publishing a new book entitled *Anisotropic Elastic Plates*.

As structural elements, anisotropic elastic plates find wide applications in modern technology. The *plates* here are considered to be subjected to not only in-plane loads but also transverse loads. In other words, both plane problem and plate bending problem as well as stretching–bending coupling problem are all treated in this book. In addition to the introduction of the theory of anisotropic elasticity, several important subjects have also been discussed in this book such as interfaces, cracks, holes, inclusions, contact problems, piezoelectric materials, thermal stresses, and boundary element analysis.

Most of the materials presented in this book can be found in the journal papers written by me and my co-workers, and some others are edited from the books and journal papers written by the other researchers. Even some notations have been unified in Lekhnitskii's and Ting's books, the notations used in the new advancements including my own works are still quite varied. Without a unified notation system, it is difficult for a beginner to study the subject. Therefore, in this book all the materials collected from the published results have been rewritten using a unified notation

system and some useful Appendices are provided for the symbols, sign convention, formalisms, and problem solutions.

Elasticity and *mechanics of composite materials* are two important fundamental courses for senior undergraduate students and beginning graduate students in aerospace, civil, naval and mechanical engineering, applied mechanics, and engineering science. Several textbooks have been written for the studies of these two courses. I believe this book is helpful for engineers and scientists who want to have an advanced knowledge of the theory of elasticity and mechanics of composite materials. This book is appropriate to be a university textbook for the courses such as *anisotropic elasticity*, *advanced elasticity*, and *advanced mechanics of composite materials.* It is also a good reference book for the standard courses such as *elasticity*, *mechanics of composite materials*, *fracture mechanics*, *plates and shells*, and *boundary element method* and for the advanced courses such as *micromechanics*, *contact mechanics*, *smart materials and structures*, and *thermal elasticity*.

Special features:

1. **This book connects *anisotropic elasticity* and *mechanics of composite materials.***
   This book provides a systematic complex variable approach covering both plane problem and plate bending problem as well as stretching–bending coupling problem. The advancement of the stretching–bending coupling problem started nearly 15 years ago and hence has never been introduced in any book related to anisotropic elasticity or mechanics of composite materials. Most of the books related to anisotropic elasticity discuss only plane problem, whereas the books related to mechanics of composite materials discuss mainly the plate bending problem. Thus, we need a systematic approach to connect these two related topics.
2. **This book connects *anisotropic elasticity* and *fracture mechanics.***
   Most of the crack problems are discussed in the books entitled *Fracture Mechanics*. Not too many books related to elasticity have special chapters named *Cracks* or *Holes* or *Inclusions* or *Wedges & Interface Corners*. I believe the arrangement of these chapters is helpful for the readers to understand the connection between elasticity and fracture mechanics.
3. **This book connects *theoretical treatment* and *numerical analysis.***
   Most of the books related to elasticity introduce mainly the theoretical treatment of elastic deformable solids and leave the numerical analysis to special books such as finite element method or boundary element method. To let the readers see more clearly about the connection between theoretical treatment and numerical analysis, we arrange a chapter named *boundary element analysis* in this book. The boundary elements introduced in this chapter involve both two-dimensional problems and stretching–bending coupling problems.
4. **Several special topics are discussed through one systematic approach**
   In addition to cracks, holes, inclusions, wedges & interface corners, the topics such as *contact problems*, *thermoelastic problems*, *piezoelectric materials*, and

holes/cracks/ inclusions in laminates, which are important in the engineering practice, are discussed separately in the specific chapters. Through these chapters the readers can understand how to apply the method introduced in this book to treat these special and interesting problems.

5. **Collection of problem solutions**
   In contrast to isotropic elastic materials that have only two elastic constants, anisotropic elastic materials may have as many as 21 elastic constants. Therefore, how to express the solutions for the problems of anisotropic elasticity in a simple and systematic way is really a big problem. Thus, even for one simple conventional problem, there may be several different kinds of mathematical expressions appeared in the literature. This also causes trouble for engineers to utilize the existing solutions, if they have difficulty in understanding the derivation details. *In this book, more than 100 problem solutions are collected in Appendix D*. To avoid the confusion caused by the symbols, *Appendix A* is provided in this book that describes the symbols, sign convention, and units. Moreover, to help the readers see clearly the unified expression used in this book, the summary of Stroh formalism is provided in *Appendix C*. Each problem collected in Appendix D is described with aid of a simple figure, and its solution is expressed in terms of the same symbol system. I believe through this collection most of the engineers and scientists can take advantage of these solutions freely and easily even they do not have enough time to understand their derivation details.

I wish to express my gratitude to my Ph.D. thesis adviser, Professor T.C.T. Ting. I am very fortunate to get into the field of anisotropic elasticity through his guidance. Several new advances of anisotropic elasticity have been achieved due to the publication of his book. Hope that the present book can also help the researchers go further. I also want to express my gratitude to my mentors, Professor C.S. Yeh of National Taiwan University and Professor W.H. Chen of National Tsing-Hua University for their guidance during my studies for B.S. and M.S. degrees. In particular, since part of this book was written during my sabbatical leave, I am grateful to Professors K. Kishimoto (Tokyo Institute of Technology), M. Omiya (Keio University), N. Miyazaki (Kyoto University), T. Ikeda (Kyoto University), Y.W. Mai (Sydney University), T. Aoki (Tokyo University), and T. Yokozeki (Tokyo University), who have helped me during my staying in their departments. Special thanks also to my assistant H.E. Shen, my former student Y.C. Liang, and my present students C.Z. Tan, T.L. Kuo, Y.C. Chen, and H.Y. Huang who helped me draw part of figures presented in this book. I would also like to thank my friends C.C. Ma, K.C. Wu, T.T. Wu of National Taiwan University, C.K. Chao of National Taiwan University of Science and Technology, and T. Chen of National Cheng Kung University for their helpful discussions during my research on anisotropic elasticity. I acknowledge the National Science Council of Taiwan for the support of my research in the area of anisotropic elasticity.

Finally, I would like to dedicate this book to my wife, Wenling, and my daughters, Frannie and Vevey, with thanks for their constant support and encouragement in everything.

Tainan, Taiwan Chyanbin Hwu
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