

Book Reviews

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Plate Structures

Victor Birman, Springer-Verlag, Dordrecht, The Netherlands, 2011, 298 pp, \$179.

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THERE are a number of books on the theory and analysis of plate and shell structures available to scientists and engineers. Therefore, a new book specifically concerned with plates deserves close scrutiny. Although the subject has been extensively researched, this recent addition presents a new and original approach. One of the strengths of this book is its broad scope, addressing isotropic and composite plates and static, dynamic, and thermomechanical problems, and it even includes a chapter on functionally graded plates and plates with piezoelectric sensors and actuators. The other impressive feature is the numerous recommendations that can be helpful to designers or investigators modeling and comprehending the response of plate structures. The book outlines theoretical foundations of the relevant models and practical aspects of the analysis of plates and their peculiar structural characteristics in a relatively short but self-contained volume that can easily be adopted for a graduate course or used by practicing engineers and scientists.

The book begins with a chapter outlining the fundamentals of the theory of plates and the concepts of mechanics employed in the multitude of specialized plate formulations, including linear and nonlinear problems, thermal effects, and anisotropic plates. The chapter is useful for the comprehension of the subsequent material, and the subject is presented in a clear and logical style. Although the material is unavoidably diverse, referring to such fundamental areas as the strength theories and energy methods, the discussion is presented in a form that ties together various topics in an easily understandable and comprehensible format.

Static problems of isotropic plates, including both bending and buckling, are considered in the second chapter of the book. The focus on problems that are particularly important in applications, such as the proper formulation and comprehension of boundary conditions, the effect of initial imperfections, and peculiarities of the postbuckling response of plates as compared with that of columns and shells, will be appreciated by engineers seeking a concise yet comprehensive outline of the subject. The formulation and solution of the problem of bending of plates reinforced with stringers demonstrates a methodology that remains valuable, providing an insight that is not always evident using numerical methods. Numerous examples illustrating the application and

limitations of the theoretical solutions are useful for the comprehension of the material discussed in the chapter.

The third chapter of the book is concerned with isotropic circular plates and plates of other shapes. With respect to circular and annular plates, the emphasis is on axisymmetric bending and buckling. The solution for asymmetric bending of a circular plate is demonstrated, without much elaboration. This progression is reflective of the author's approach throughout the book, avoiding laborious transformations in the problems that are almost invariably solved using standard software packages. Plates of noncircular shapes considered in the chapter include equilateral- and isosceles-triangular plates, skew, elliptical, and sector plates.

Although the second and third chapters refer to a multitude of static solutions, the fourth chapter presents a short review of dynamic structural problems in isotropic rectangular plates. In the beginning of the chapter, the author presents an introduction to dynamic structural problems and their qualification. The problems considered in the chapter deal with free vibrations and the dynamic response of rectangular plates driven by a periodic harmonic pressure that can be uniform or distributed over a segment of the plate surface or by the periodic harmonic motion of supports. Blast loading of a rectangular plate is presented as an example of the problem where the plate exhibits a nonperiodic response. The chapter also includes a discussion on geometrically nonlinear vibrations and dynamic instability. The insight into such phenomena as the resonance in reinforced plates will be useful to engineers.

Static and dynamic problems of composite plates are discussed in the fifth chapter of the book. The author was able to present a comprehensive and easy-to-read review of the subject in the contents of a single chapter. The chapter is insightful, with numerous practical recommendations that will be useful to engineers working with composite structures. The broad range of problems considered in the chapter includes bending, buckling, and vibrations; the effect of geometric nonlinearity and initial imperfections; as well as the analysis of stringer-reinforced plates. In addition to a review of the mechanics of thin plates, shear deformable and sandwich plates are considered. Although higher-order theories of shear deformable plates are avoided and the discussion is limited to the first-order shear deformation theory, the

author clearly explains the limitations of this theory, pointing out the class of problems where it is not adequate.

The effect of temperature on the response of plates is discussed in Chapter 6. The approach adopted in this chapter is logical, beginning with the analysis of the heat transfer problem that is further elaborated on via the example of a functionally graded plate. This is followed by thermal bending and buckling solutions for isotropic and composite plates. The author emphasizes the interaction between heat transfer and thermomechanical response problems, as well as the dual effect of elevated temperatures reflected in both explicit thermal stresses and the deterioration of material constants. As an example of a practical problem, the effect of fire on a composite plate is discussed. This includes the time-dependent material deterioration exemplified by the conversion of epoxy matrix into char, gradual time-dependent change in temperature distribution through the thickness, and changes in deflections. The discussion on conditions resulting in thermally-induced bending versus thermal buckling is valuable for the comprehension of the response of plates subject to thermal loading.

The closing chapter of the book is concerned with two representative advanced applications of plate structures: plates with piezoelectric sensors and actuators and functionally graded plates. Although the two subjects are only superficially related to each other, they definitely expand the horizons of the theory of plates and their applications. The formulation of the problem for composite plates with piezoelectric layers is presented using the first-order shear deformable and classical thin-plate theories. Additionally, the response of plates with piezoelectric actuators arranged in the pattern of "active" stringers, i.e., long and narrow strips, is demonstrated, thus expanding the previously discussed theory of stringer-reinforced plates. The effect of temperature on the accuracy of measurements from piezoelectric sensors bonded to a composite plate is also considered, the problem being essential in applications where plate structures are exposed to environmental effects or other possible sources of high temperature.

The second part of Chapter 7 is concerned with functionally graded plates that have received significant

attention in recent years. The emphasis is on thermal effects in functionally graded plates because these structures were developed and are still often used to enhance thermomechanical response. As with Chapter 6, the author emphasizes the entire spectrum of the corresponding problems, beginning with the analysis of the heat transfer in a plate that is necessary to define the distribution of temperature and thermally degraded properties throughout the domain occupied by the material. Examples of solutions include thermoelastic analyses of rectangular plates by the theory of elasticity and by the first-order theory. The conclusions from the chapter emphasize the multidisciplinary and multiscale nature of advanced plate problems.

The book is well written, and the author does his best presenting complicated concepts and formulations in an easily understandable and reader-friendly manner. Very appropriately, every chapter is finished with a concluding section regarding design philosophy and recommendations or with a summary of the previous discussions. These final comments will be particularly useful to engineers designing plate structures and to graduate students who have had limited exposure to the relevant research literature. Because of the broad content of the book, discussion of certain subjects is abbreviated and could have been extended. However, the presented material is always relevant, and the style of the author intentionally avoids detailed analytical solutions of problems that are currently solved via available numerical packages: in light of the increasing use of software in research and practice, this approach is understandable. Even if details of the analytical solutions are sometimes avoided, the theoretical foundations and the scope of the applicability of the relevant problems are always presented in detail. Overall, this book represents a welcome addition to the literature on the mechanics of plates and fully deserves its place in the library of a scientist or engineer engaged in the field of aerospace, mechanical engineering, or civil engineering structures.

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