Book review

NONLINEAR VIBRATIONS AND STABILITY OF SHELLS AND PLATES

M. Amabili, Cambridge University Press, 2008
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This is a hardback volume that is attractively presented both internally and externally. It is a monograph rather than a textbook, which is aimed primarily at researchers and graduate students in structural mechanics who deal with elastic stability or vibration problems in plated and shell-type structures, with a view to extend their knowledge of relevant nonlinear phenomena. It would also be of interest to professional engineers who wish to understand the relevant theoretical background for the structures that they may be designing. It opens with a preface outlining the types of structures considered and where the particular phenomena described may appear in practice. Chapter 1 contains an extensive set of derivations of a sequence of increasingly complex geometrically nonlinear models for various types of elastic plates and shells: flat rectangular and circular plates, cylindrical shells and spherical caps are all covered. The chapter demonstrates the author's authoritative but accessible style in that quite advanced concepts are presented in a clear and concise manner. Moreover, the author avoids leaving out too many steps in the logical development of the models, making it relatively straightforward for the reader to follow.

Chapter 2 opens in a similar fashion to the first chapter but focuses instead on shells with double curvature. It then goes on to introduce and discuss the mechanics of composite and functionally-graded materials of which many doubly-curved shells are constructed, particularly for aeronautical applications. The first two chapters basically derive the models that are discussed in detail in later chapters.

Chapter 3 contains an introduction to the relevant concepts and techniques within the field of nonlinear dynamics. This is a key chapter for the reader to understand and interpret the mechanical response of structures when they suffer from large deflections, particularly from instability, whether this arises from static or dynamic loading. Fundamentally important bifurcations and powerful analytical and numerical techniques for describing the behaviour of nonlinear systems are introduced and discussed. The techniques within the excellent software for numerical continuation and bifurcation problems in ordinary differential equations—and one of my personal favourites—Auto, are discussed in detail as it is used

extensively in the numerical results presented throughout the rest of the book, usually towards the end of most chapters.

Chapters 4 and 5 discuss the nonlinear vibration characteristics of rectangular plates and cylindrical shells, respectively. The equations of motion are reduced from partial to ordinary differential equations primarily using semi-analytical methods, such as the Rayleigh–Ritz or Galerkin methods, followed by the resulting nonlinear equations being solved numerically. Direct integration methods are also employed in some cases. Chapter 6 continues this theme of problem order reduction by discussing the advantages and limitations of the important techniques of orthogonal decomposition and nonlinear normal modes.

Chapters 7–10 focus mainly on the behaviour of circular cylindrical shells. First, the various well-known shell theories developed in chapter 1 (Donnell, Sanders–Koiter, Flügge–Lur'e–Byrne, Novozhilov) are compared against each other and their features and differences are highlighted as far as their stability and vibration behaviour. Second, the effect of boundary conditions on vibration characteristics is discussed. Third, the discussions on vibrations and stability focus on cylindrical and doubly curved panels, the latter behaviour being compared when they are made from isotropic or laminated materials.

Chapter 11 takes an aside to look at meshless discretisation of shells using R-functions to aid numerical solution of plate or shell problems with complicated geometries. This is a technique that originated in the former Soviet Union and it is good to see a topic discussed in a concise and readable manner, which may be obscure in western Europe and North America.

The final four chapters (12–15) return to more conventional issues within structural mechanics. They discuss vibrations of circular and rotating discs, stability of cylindrical shells under static and dynamic loads, including the case when fluid is being conveyed, and finally the problem of supersonic flutter in imperfect shells.

This is a comprehensive and comprehensible monograph that is very well written and presented. The author should be congratulated on assembling this lucid piece of work. I can wholeheartedly recommend it to anyone wishing to further their knowledge of the nonlinear behaviour of thin plates and shells.

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