

Chapter 2 delves into elements of solid mechanics. It considers the analysis of stress and strain and their complementary equations, theory of elasticity, energy principles, potential and complementary potential energy plus principle of virtual work. This follows with viscoelasticity of linear thermal bearings of simple material and elastoplasticity (yield criterion, deformation plasticity, and elastic-viscoplasticity). Chapter 3 deals with linear elastic fracture mechanics (LEFM) and considers linear elasticity tip fields plus stress intensity factor (closed form solution and more recent methods). The chapter continues with the “J” integral, energy release rate, additional invariant integrals (Knowles and Sternberg) plus others and the path independent I integral. The plastic zone, fracture toughness relations, and plane stress fracture plus the R curve relation conclude the chapter.

Chapter 4 highlights dynamic fracture mechanics. The authors stress the continuum based (material to be continuous). Pioneers in this endeavor are Mott (extended Griffith theory by including kinetic energy and assumed  $dv/da=0$ ), Roberts and Wells, Berry and Dulaney et al. who corrected Mott’s approach. Additional efforts were expended in crack branching. Later work covered the mathematical investigation of elastodynamic fracture mechanics, crack arrest, and nonlinear aspects of fracture mechanics. The authors continue with a full blown derivation of elastodynamic crack tip fields and energy release rate. Analysis of laboratory specimens and study of crack propagation used in fracture mechanics are considered. They are (a) DCB (double cantilever beam), (b) DT (double torsion specimen), (c) axial crack propagation in a pressurized pipeline, (d) steady state crack propagation, and (e) strip yield models. The chapter concludes with the study of crack propagation, experimentation, dynamic crack propagation analysis, crack growth interaction with dynamic loading.

Chapter 5 is an eye-opener on elastic-plastic fracture mechanics (EPFM). Due to limitations of LEFM, the need to include influence of significant plastic deformation leads to increased development in EPFM. The initial attempt in modeling plastic deformation was instituted by Dugdale. This follows anti-plane, elastic plastic solutions for Mode III. This continues with solution of plastic crack tip fields, based on a two-dimensional field. Present results have shown that J integral has become the preferred fracture characterization parameter due to the ease of computation and is quite simple in measuring the crack tip opening displacement. Further mathematical efforts tempered by experiments, consider the fully plastic solution plus the estimation technique, hardening failure assessment diagram. This leads to J integral testing based on a single measured load displacement record proposed by Rice. ASTM suggests a standard test method (E813) for determining  $J_{Ic}$  (plane strain value of J at initiation of crack growth). The chapter ends with a full blown discussion of J controlled crack growth and extended crack growth. They stress the importance of J integral and its variants.

Chapter 6 explains the fracture mechanics models for fiber reinforced composites. Since composites are anisotropic, the field of anisotropic fracture mechanics opens up. The micromechanical approach is the favored one at present but still the analysis is wrought with some problems. Related topics include fracture of adhesive joints.

Chapter 7 speaks about time dependent fracture. This stems from the application of a suddenly applied constant stress which produces an instantaneous elastic strain followed by a slow continuous straining or creep. Two competing mechanisms are involved in creep crack growth. Creep deformation is characterized by crack tip blunting in the material ahead of the crack tip. This tends to retard crack tip growth due to relaxation of crack tip stress field. The other mechanism involves an accumulation of creep damage in form

of microcracks and voids that enhance crack growth as they coalesce. Important aspects of crack tip fields are (a) elastic-secondary creep, (b) elastic-primary creep, (c) primary secondary creep (secondary creep zone developing near crack tip), (d) plastic-primary creep (sudden applied load; sufficient to induce instantaneous plastic strain in a cracked body), (e) plastic-exponential low creep (stationary crack under Mode III loading). The next set of topics consider creep crack growth. The important considerations are (f) elastic-secondary creep crack fields (Mode I loading of a crack extending in an elastic-power low creeping material), (g) steady-state crack growth (small scale yielding for Mode I), (h) transient crack growth (difficult to estimate), and (i) elastic-primary creep crack fields (based on an extensive set of experiments performed by a number of researchers). One believes that  $C^*$  (energy rate integral) correlates better with crack growth rate than the stress intensity factor for creep crack growth correlation. Models for crack growth in viscoelastic materials have mainly concentrated in linear material behavior. They are an extension of Dugdale’s yielded stress model. There is great need for a nonlinear growth theory for viscoelastic materials.

Chapter 8 covers some nonlinear aspects of fatigue crack propagation. Most of LEFM in fatigue is of an empirical nature. This considers the constant-amplitude fatigue crack growth relation (Paris’ law and its variants). The second is Miner’s law which ignores load interaction. The next concept in crack closure is due to Elber (crack closes and prevents further propagation and is tensile by nature). Budiansky and Hutchinson propose a theoretical model used in examining Elber’s concept. Kanninen and coworkers have improved the concept employing a steady state crack propagation model. Another important subject is fatigue crack growth emanating in and around welds. Work has been done using FE calculations. Due to large disparities, inelastic deformation must be incorporated in determining crack propagation in welding. The final chapter recounts the sources of information in fracture mechanics. It includes a list of technical journals, conference proceedings, standards, dissertations, handbooks, treatises (volume assembled by Prof. Leibowitz), and textbooks.

This book covers fracture mechanics in a very lucid and comprehensive manner and contains a number of topics not found in other texts. It is a masterpiece in fracture mechanics and should appeal to the tyro and expert on this subject. The reviewer would have preferred seeing the following incorporated in the book. They are (a) table explaining the symbols, (b) cross reference for the tremendous number of authors, and (c) incorporate more information on fracture mechanics from a probabilistic fatigue point of view. Nevertheless, the reviewer highly recommends this book. Bravo to the authors!

**Vibration of Engineering Structures**, C. A. Brebbia, H. Tottenham, G. B. Warburton, J. M. Wilson, R. R. Wilson, Springer-Verlag, Berlin and New York, 1985, 300 pages, \$21.00 (paperback).

#### Reviewed by H. Saunders

This book is based on course notes and given by a number of instructors. This volume does possess cohesiveness. There is good continuity from one chapter to another. The book does not falter in any place. The book is based on a week’s course given at Southampton, England. As cited by the editors, “The increasing size and complexity of new structural forces in engineering have made it necessary for designers to be aware

of their dynamic behavior. Dynamics is a subject which has traditionally been poorly taught in most engineering courses. The book was conceived as a way of providing an engineer with a deeper knowledge of dynamic analysis and it indicates to them how some of the new vibration problems can be solved." Starting with the elementary basis of vibration, it continues to the more advanced and includes the latest random vibration and its variants accompanied by detailed applications. Although small in the number of pages for the topics covered, it does encompass a tremendous amount of territory in a well-explained fashion. The book consists of 17 chapters.

The initial chapter introduces the subject of vibration and continues with single degree of freedom equations of motion, response and dynamic interaction of an elastic body on a rigid body which in turn is mounted on soil. Chapter 2 dwells on free vibration, resonances, and damping. It contains simple spring-mass and pendulum systems, beam with central load, springs in series and parallel and derivation of potential and kinetic energy. The latter part of this chapter considers damped and undamped free response, damped, and undamped transient response.

Chapter 3 delves into free vibration of two and multi-degree of freedom systems, orthogonality of mode shapes and modal decomposition. The chapter concludes with a discussion of damped free and forced vibrations of multi-degree of freedom systems. Chapter 4 introduces the eigenvalue-eigenvector problem and solutions. A three degree of freedom system with its associated matrices opens up the chapter. This leads to banded and symmetric matrices, reduction of eigenvalue equation to standard form and solution of standard eigenvalue and original equation employing Sturm's theorem or sequence. This continues with a short discourse on direct iteration and then compares the four different solutions of the eigenvalue problem. It concludes with a very sparse and too brief node condensation and substructuring analysis. The next chapter covers approximate methods for calculating natural frequencies and dynamic response of elastic systems. Beginning with the equivalent one degree of freedom (mass and stiffness), this leads to simple and continuous beams plus derivation of the dynamic "three moment equation" and simple multi-story frames. Chapter 6 focuses on the determination of steady state response with and without damping, truncation of series solution, and response spectrum methods.

Chapter 7 considers the finite element (FE) technique. Starting with the principle of virtual displacements, it goes forward into the determination of the triangular and rectangular element and their formulation in meshes and matrix derivation of a beam element containing an applied distributed load. The stiffness and continuous mass matrices are derived and applied to a two element beam. The chapter concludes with a system of equations and their solutions. An informative chapter but too condensed!

Chapter 8 delves into two dimensional and plate bending applications. The inplane plate elements and plate bending elements are derived in matrix form. They are then applied to the solution of a plane and transverse vibration of plates. The chapter ends with the formation of a system of equations for the combination of plate and beam elements.

Chapter 9 speaks about the transient response of structures with and without damping. The final section draws upon the finite difference method and Newmark's  $\beta$  methods and applies them in interesting examples. Mention is made of Wilson  $\theta$  method and Houbolt method as applied to transient response. Chapter 10 considers the make-up of machine foundations. Initially, the topic expounds upon the transmissibility of foundation on a rigid or flexible base. This brings into play the damped and undamped dynamic absorber. The chapter concludes with a short discussion of British and German codes

and the use of response analysis in designing steel foundations for turbo-alternators. Chapter 11 reports on the vibration of shells of revolutions. Employing Novozhilov's thin shell theory, the equilibrium equations are derived and stress-strain and stress-displacement relations are proposed. The book leads us into the development of stiffness and mass matrices for the shell of revolution element. A short discussion on reduction of mass and stiffness via Guyan's method and Henshall's extension to element matrices. Chapter 12 proposes some recent advances in structural vibration. They are direct integration (Park, Hilber, etc.) and Newmark  $\beta$ . The author concludes that the Newmark average acceleration method is the best since it doesn't introduce any artificial attenuations of modal contribution to response. A short discussion on nonlinear problems with partitioning into (a) explicit, (b) explicit/explicit, (c) explicit/implicit, (d) implicit, and (e) implicit/implicit.

Chapter 13 is an informative chapter and considers fluid/structure interaction. Beginning with fluid flow, the author describes vortex shedding, pressure distribution over a cylinder, linear wave theory, various inertia constants, axial drag and inertia forces for slender bodies. This continues with the computation of inertia coefficients using potential theory, wave diffraction analysis, and hydrodynamic forces. The author suggests the use of the Pierson-Moskowitz wave spectrum relationship. Chapter 14 is a short introduction into random vibration. This covers basic probability distributions, idea of a stationary ergodic random process, and spectral density functions. The autocorrelation function is introduced via Weiner-Khinchin relationships. An example of a simple spring system subjected to random load concludes the chapter.

The next chapter briefly discusses earthquake response and spectral density of response with examples in application to a cantilever beam and a cooling tower shell. Chapter 16 covers response of structures and response of shells to wind loading. The Davenport spectrum equation is stressed.

The final chapter dwells upon random response analysis to off-shore structures. Beginning with analysis of a one degree of freedom system, this progresses into multi-degree of freedom systems. The Pierson-Moskowitz relationship is discussed exclusively. The chapter concludes with a good derivation of the above equation and applied to random responses.

In summary, this is a good book. The reviewer found some of the contents and subjects to be very sketchy. Reference must be made to the original source. However, the book covers a tremendous amount of subjects. This could easily be expanded to double the size. The reviewer recommends this book to those interested in the many facets of structural dynamics. At times the reader must employ additional reading to acquire a full understanding of the particular subject.

**Stochastic Processes in Engineering Systems**, E. Wong and B. Hajek, Springer-Verlag, New York, Berlin, 1985, 361 pages.

**Reviewed by H. Saunders**

This is not just another book on stochastic systems. The text covers both the traditional topics of stationary processes in linear time invariant systems as well as the more modern theory of stochastic systems where dynamics play one of the leading roles. As stated by the authors, "Our aim is to provide a high level, yet readily accessible treatment of these topics in