Fatigue And Fracture Mechanics

Annotation The tubular welded joints used in the construction of offshore structures can experience millions of variable amplitude load cycles during their service life. Such fatigue loading represents a main cause of degradation in these structures. As a result, fatigue is an important consideration in their design. Fatigue and Fracture Mechanisms of Offshore Structures present novel research and the results of wave-induced stress on the operational life of offshore structures. Containing results of an investigation undertaken to assess the fatigue and fracture performance of steels used in the offshore industry, Fatigue and Fracture Mechanics of Offshore Structures includes, Stress analysis of tubular joints Fatigue design Fatigue loading in Jackup structures Jack-up dynamic response Modelling of wave loading Test specimen considerations The stress intensity factor concept Variable amplitude crack growth models Consideration of sequence effects Sea state probability model The important research in this book will be of interest to those dealing with a wide range of engineering structures - from bridges and buildings to masts and pipelines, as well as fatigue and fracture specialists, and those concerned with materials technology.

This paper reviews some of the advances that have

been made in stress analyses of cracked aircraft components, in the understanding of the fatigue and fatigue-crack growth process, and in the prediction of residual strength of complex aircraft structures with widespread fatigue damage. Finite-element analyses of cracked metallic structures are now used to determine accurate stress-intensity factors for cracks at structural details. Observations of small-crack behavior at open and rivet-loaded holes and the development of small-crack theory has lead to the prediction of stress-life behavior for components with stress concentrations under aircraft spectrum loading. Fatigue-crack growth under simulated aircraft spectra can now be predicted with the crack-closure concept. Residual strength of cracked panels with severe out-of-plane deformations (buckling) in the presence of stiffeners and multiple-site damage can be predicted with advanced elastic-plastic finite-element analyses and the critical crack-tip-opening angle (CTOA) fracture criterion. These advances are helping to assure continued safety of aircraft structures.Newman, J. C., Jr.Langley Research CenterAIRCRAFT STRUCTURES; CRACKS; FINITE ELEMENT METHOD; FRACTURE MECHANICS; STRESS ANALYSIS; METALS; CRACK PROPAGATION; METAL FATIGUE; STRESS INTENSITY FACTORS; RESIDUAL STRENGTH; CRACK CLOSURE; DAMAGE; STRESS CONCENTRATION; RIVETED JOINTS;

PLASTIC PROPERTIES

"This book emphasizes the physical and practical aspects of fatigue and fracture. It covers mechanical properties of materials, differences between ductile and brittle fractures, fracture mechanics, the basics of fatigue, structural joints, high temperature failures, wear, environmentally-induced failures, and steps in the failure analysis process."--publishers website.

On Fracture Mechanics A major objective of engineering design is the determination of the geometry and dimensions of machine or structural elements and the selection of material in such a way that the elements perform their operating function in an efficient, safe and economic manner. For this reason the results of stress analysis are coupled with an appropriate failure criterion. Traditional failure criteria based on maximum stress, strain or energy density cannot adequately explain many structural failures that occurred at stress levels considerably lower than the ultimate strength of the material. On the other hand, experiments performed by Griffith in 1921 on glass fibers led to the conclusion that the strength of real materials is much smaller, typically by two orders of magnitude, than the theoretical strength. The discipline of fracture mechanics has been created in an effort to explain these phenomena. It is based on the realistic assumption that all materials contain crack-like defects from which failure initiates. Defects can exist in a material

due to its composition, as second-phase particles, debonds in composites, etc. , they can be introduced into a structure during fabrication, as welds, or can be created during the service life of a component like fatigue, environment-assisted or creep cracks. Fracture mechanics studies the loading-bearing capacity of structures in the presence of initial defects. A dominant crack is usually assumed to exist.

The purpose of this Handbook is to provide a review of the knowledge and experiences in the field of fatigue fracture mechanics. It is well-known that engineering structures can fail due to cyclic loading. For instance, a cyclically time-varying loading reduces the structure strength and can provoke a fatigue failure consisting of three stages: (a) crack initiation (b) crack propagation and (c) catastrophic failure. Since last century many scientists have tried to understand the reasons for the above-mentioned failures and how to prevent them. This Handbook contains valuable contributions from leading experts within the international scientific community and covers many of the important problems associated with the fatigue phenomena in civil, mechanical and nuclear engineering.

Fatigue of structures and materials covers a wide scope of different topics. The purpose of the present book is to explain these topics, to indicate how they can be analyzed, and how this can contribute to the designing of

fatigue resistant structures and to prevent structural fatigue problems in service. Chapter 1 gives a general survey of the topic with brief comments on the signi?cance of the aspects involved. This serves as a kind of a program for the following chapters. The central issues in this book are predictions of fatigue properties and designing against fatigue. These objectives cannot be realized without a physical and mechanical understanding of all relevant conditions. In Chapter 2 the book starts with basic concepts of what happens in the material of a structure under cyclic loads. It illustrates the large number of variables which can affect fatigue properties and it provides the essential background knowledge for subsequent chapters. Different subjects are presented in the following main parts: • Basic chapters on fatigue properties and predictions (Chapters 2–8) • Load spectra and fatigue under variable-amplitude loading (Chapters 9–11) • Fatigue tests and scatter (Chapters 12 and 13) • Special fatigue conditions (Chapters 14–17) • Fatigue of joints and structures (Chapters 18–20) • Fiber-metal laminates (Chapter 21) Each chapter presents a discussion of a speci?c subject. This book provides a comprehensive and thorough guide to those readers who are lost in the often-confusing context of weld fatigue. It presents straightforward information on the fracture mechanics and material background of weld fatigue, starting with fatigue crack initiation and short cracks, before moving on to long cracks, crack closure, crack growth and threshold, residual stress, stress concentration, the stress intensity factor, J-integral, multiple cracks, weld geometries and

defects, microstructural parameters including HAZ, and cyclic stress-strain behavior. The book treats all of these essential and mutually interacting parameters using a unique form of analysis.

This book contains 15 fully peer-reviewed Invited Papers which were presented at the 13th Biennial European Conference on Fracture and is a companion to the CD-ROM http://www.elsevier.com/locate/isbn/008043701xProceedings. The organisers of the ECF 13 opted from the very beginning for an application-orientated conference, and consequently, this book contributes to the understanding of fracture phenomena, and disseminates fracture concepts and their application to the solution of engineering problems to practitioners in a wide range of fields. The fields covered in this book can be broadly classified into: elastic-plastic fracture mechanics, fracture dynamics, fatigue and interactive processes, failure, structural integrity, coatings and materials, with applications to the following industrial sectors: transport, aerospace engineering, civil engineering, pipelines and automotive engineering.

These volumes, 7 and 8, of Fracture Mechanics of Ceramics constitute the proceedings of an international symposium on the fracture mechanics of ceramic materials held at Virginia Polytechnic Institute and State University, Blacksburg, Virginia on June 19, 20 and 21, 1985. These proceedings constitute the fourth pair of volumes of a continuing series of conferences. The theme of this conference, as the previous three, focused on the mechanical behavior of ceramic materials in terms of the characteristics of cracks, particularly the roles

which they assume in the fracture process. The 78 contributed papers by over 100 authors and co-authors represent the current state of the field. They address many of the theoretical and practical problems of interest to those concerned with brittle fracture. The program chairmen gratefully acknowledge the financial assistance for the Symposium provided by the EXXON Foundation, the Army Research Office, the National Science Foundation, and the Office of Naval Research. Without their support, this conference simply would not have been possible. The suggestions of Drs. J. C. Hurt, R. C. Pohanka, and L. Toth were particularly helpful in assuring the" success of this symposium. Special appreciation is extended to Professor J. I. Robertson, C. P. Miles Professor of History, whose presentation following the banquet on the American Civil War was very well received by the audience. Finally, we wish to also thank our joint secretaries, especially Karen Snider, for their patience and help in finally bringing these proceedings to press.

BASIC Fracture Mechanics: Including an Introduction to Fatigue discusses the fundamentals of fracture and fatigue. The book presents a series of Beginner's All-purpose Symbolic Instruction Code (BASIC) programs that implement fracture and fatigue methods. The first chapter reviews the BASIC, while the second chapter covers elastic fracture. Chapter 3 deals with the stress intensity factors. The book also tackles the crack tip plasticity and covers crack growth. The last chapter in the text discusses some applications in fracture mechanics. The book will be of great use to engineers

who want to get acquainted with fracture mechanics.
Selected, peer reviewed papers from the Conference on XXIV Symposium on Fatigue Failure and Fracture Mechanics, May 22-25, 2012, Bydgoszcz-Pieczyska, Poland
The application of methods of fracture mechanics to the prediction of fatigue life presupposes the existence of a single flaw of 'critical' size the slow propagation of which, under repeated cyclic loading, represents the relevant damage mechanism that governs 'fatigue' until the flaw has grown to unstable size. The conditions under which this approach to fatigue provides a reasonable model of real behavior are, however, exactly the conditions that should be avoided by adequate fatigue design. Thus the merit of fracture mechanics with respect to fatigue is not in the realistic modeling of the fatigue process in its various aspects, but in the delimitation of the conditions under which this process approaches the model too closely for purposes of design. The paper discusses the different aspects of the fatigue process in relation to the basic concepts of fracture mechanics. (Author).
The basic tenet of LEFM is that the stress intensity factor, K, is the key controlling parameter for fatigue crack growth and fast brittle fracture under monotonic loading. This research program examined whether or not this fundamental assumption formed an effective basis for an engineering technology.

And, as needed, suggested directions for an improved technology. Keywords: Fatigue, Fracture, Mechanics. (JES).

Mechanics of Fatigue addresses the range of topics concerning damage, fatigue, and fracture of engineering materials and structures. The core of this resource builds upon the synthesis of micro- and macro-mechanics of fracture. In micromechanics, both the modeling of mechanical phenomena on the level of material structure and the continuous approach are based on the use of certain internal field parameters characterizing the dispersed micro-damage. This is referred to as continuum damage mechanics. The author develops his own theory for macromechanics, called analytical fracture mechanics. This term means the system cracked body - loading or loading device - is considered as a mechanical system and the tools of analytical (rational) mechanics are applied thoroughly to describe crack propagation until the final failure. Chapter discuss: preliminary information on fatigue and engineering methods for design of machines and structures against failures caused by fatigue fatigue crack nucleation, including microstructural and continuous models theory of fatigue crack propagation fatigue crack growth in linear elastic materials subject to dispersed damage fatigue cracks in elasto-plastic material, including crack growth retardation due to overloading as well as

quasistationary approximation fatigue and related phenomena in hereditary solids application of the theory fatigue crack growth considering environmental factors unidirectional fiber composites with ductile matrix and brittle, initially continuous fibers laminate composites Mechanics of Fatigue serves students dealing with mechanical aspects of fatigue, conducting research in fracture mechanics, structural safety, mechanics of composites, as well as modern branches of mechanics of solids and structures.

This book introduces the field of fracture mechanics from an applications viewpoint. Then it focuses on fitness for service, or life extension, of existing structures. Finally, it provides case studies to allow the practicing professional engineer or student to see the applications of fracture mechanics directly to various types of structures.

Second edition of successful materials science text for final year undergraduate and graduate students.

In the preliminary stage of designing new structural hardware that must perform a given mission in a fluctuating load environment, there are several factors the designers should consider. Trade studies for different design configurations should be performed and, based on strength and weight considerations, among others, an optimum configuration selected. The selected design must be able to withstand the environment in question without failure. Therefore, a comprehen sive structural analysis that consists of static, dynamic, fatigue, and

fracture is necessary to ensure the integrity of the structure. During the past few decades, fracture mechanics has become a necessary discipline for the solution of many structural problems. These problems include the prevention of failures resulting from preexisting cracks in the parent material, welds or that develop under cyclic loading environment during the life of the structure. The importance of fatigue and fracture in nuclear, pressure vessel, aircraft, and aerospace structural hardware cannot be overemphasized where safety is of utmost concern. This book is written for the designer and strength analyst, as well as for the material and process engineer who is concerned with the integrity of the structural hardware under load-varying environments in which fatigue and frac ture must be given special attention. The book is a result of years of both acade mic and industrial experiences that the principal author and co-authors have accumulated through their work with aircraft and aerospace structures. Fracture Mechanics: Current Status, Future Prospects presents the remarkable increase in the number of tools available for engineers to deal with cracked structures in a quantitative manner. This book discusses the acceptance of the stress intensity factor as a distinguishing similitude parameter that properly accounts for the applied mechanics near crack tips in several cases of practical interest. Organized into nine chapters, this book begins with an overview of the competing micromechanics of fracture, including cleavage, rupture, ductile fracture, and intergranular creep fracture. This text then reviews the

characterization of crack tip stress fields by the stress intensity factor. Other chapters consider the analysis of fatigue cracking in a large generator rotor. This book discusses as well the use of Green's functions in the determination of stress intensity factors. The final chapter deals with the size effect with regard to extension of sharp cracks in technological materials. This book is a valuable resource for environmental and mechanical engineers.

The seventh Jerry L. Swedlow Memorial Lecture presents a review of some of the technical developments, that have occurred during the past 40 years, which have led to the merger of fatigue and fracture mechanics concepts. This review is made from the viewpoint of 'crack propagation.' As methods to observe the 'fatigue' process have improved, the formation of fatigue micro-cracks have been observed earlier in life and the measured crack sizes have become smaller. These observations suggest that fatigue damage can now be characterized by 'crack size.' In parallel, the crack-growth analysis methods, using stress-intensity factors, have also improved. But the effects of material inhomogeneities, crack-fracture mechanisms, and nonlinear behavior must now be included in these analyses. The discovery of crack-closure mechanisms, such as plasticity, roughness, and oxide/corrosion/fretting product debris, and the use of the effective stress-intensity factor range, has provided an engineering tool to predict small- and large-crack-growth rate behavior under service loading, conditions. These mechanisms have also provided a rationale for

developing, new, damage-tolerant materials. This review suggests that small-crack growth behavior should be viewed as typical behavior, whereas large-crack threshold behavior should be viewed as the anomaly. Small-crack theory has unified 'fatigue' and 'fracture mechanics' concepts; and has bridged the cap between safe-life and durability/damage-tolerance design concepts. Newman, James C., Jr. Langley Research Center...

Etube (mechanical engineering, University College London) presents novel research and the results of wave-induced stress on the operational life of offshore structures. Using the results of an investigation undertaken to assess the fatigue and fracture performance of steels used in the industry, the five chapters discuss details of the methodology to develop a typical jack-up offshore standard load history (JOSH); factors that influence fatigue resistance of structural steels used in the construction of jack-up structures; methods used to model the relevant factors for inclusion in JOSH, with emphasis on loading and structural response interaction; results and details of experimental variable amplitude corrosion fatigue tests conducted using JOSH; and a novel generalized methodology for fast assessment of offshore structural welded joints. Distributed by ASME. c. Book News Inc.

With its combination of practicality, readability, and rigor that is characteristic of any truly authoritative reference and text, Fracture Mechanics: Fundamentals and Applications quickly established itself as the most comprehensive guide to fracture

mechanics available. It has been adopted by more than 100 universities and embraced by thousands of professional engineers worldwide. Now in its third edition, the book continues to raise the bar in both scope and coverage. It encompasses theory and applications, linear and nonlinear fracture mechanics, solid mechanics, and materials science with a unified, balanced, and in-depth approach. Reflecting the many advances made in the decade since the previous edition came about, this indispensable Third Edition now includes: A new chapter on environmental cracking Expanded coverage of weight functions New material on toughness test methods New problems at the end of the book New material on the failure assessment diagram (FAD) method Expanded and updated coverage of crack closure and variable-amplitude fatigue Updated solutions manual In addition to these enhancements, Fracture Mechanics: Fundamentals and Applications, Third Edition also includes detailed mathematical derivations in appendices at the end of applicable chapters; recent developments in laboratory testing, application to structures, and computational methods; coverage of micromechanisms of fracture; and more than 400 illustrations. This reference continues to be a necessity on the desk of anyone involved with fracture mechanics.

Thematerialsusedinmanufacturingtheaerospace,aircr

aft,automobile,andnuclear parts have inherent aws that may grow under uctuating load environments during the operational phase of the structural hardware. The design philosophy, material selection, analysis approach, testing, quality control, inspection, and manufacturing are key elements that can contribute to failure prevention and assure a trouble-free structure. To have a robust structure, it must be designed to withstand the envir- mental load throughout its service life, even when the structure has pre-existing aws or when a part of the structure has already failed. If the design philosophy of the structure is based on the fail-safe requirements, or multiple load path design, partial failure of a structural component due to crack propagation is localized and safely contained or arrested. For that reason, proper inspection technique must be scheduled for reusable parts to detect the amount and rate of crack growth, and the possible need for repairing or replacement of the part. An example of a fail-sa- designed structure with crack-arrest feature, common to all aircraft structural parts, is the skin-stiffened design con guration. However, in other cases, the design p- losophy has safe-life or single load path feature, where analysts must demonstrate that parts have adequate life during their service operation and the possibility of catastrophic failure is remote. For example, all pressurized vessels that have single load path feature are classi ed as high-

risk parts. During their service operation, these tanks may develop cracks, which will grow gradually in a stable manner.

This book presents recent advances related to the following two topics: how mechanical fields close to material or geometrical singularities such as cracks can be determined; how failure criteria can be established according to the singularity degrees related to these discontinuities. Concerning the determination of mechanical fields close to a crack tip, the first part of the book presents most of the traditional methods in order to classify them into two major categories. The first is based on the stress field, such as the Airy function, and the second resolves the problem from functions related to displacement fields. Following this, a new method based on the Hamiltonian system is presented in great detail. Local and energetic approaches to fracture are used in order to determine the fracture parameters such as stress intensity factor and energy release rate. The second part of the book describes methodologies to establish the critical fracture loads and the crack growth criteria. Singular fields for homogeneous and non-homogeneous problems near crack tips, v-notches, interfaces, etc. associated with the crack initiation and propagation laws in elastic and elastic-plastic media, allow us to determine the basis of failure criteria. Each phenomenon studied is dealt with according to its

conceptual and theoretical modeling, to its use in the criteria of fracture resistance; and finally to its implementation in terms of feasibility and numerical application. Contents 1. Introduction. Part 1: Stress Field Analysis Close to the Crack Tip 2. Review of Continuum Mechanics and the Behavior Laws. 3. Overview of Fracture Mechanics. 4. Fracture Mechanics. 5. Introduction to the Finite Element Analysis of Cracked Structures. Part 2: Crack Growth Criteria 6. Crack Propagation. 7. Crack Growth Prediction in Elements of Steel Structures Submitted to Fatigue. 8. Potential Use of Crack Propagation Laws in Fatigue Life Design.

Proceedings of the first International Conference, on Computer-Aided Assessment and Control of Localized Damage, held in Portsmouth, UK, 26-28 June 1990

A Practical Approach to Fracture Mechanics provides a concise overview on the fundamental concepts of fracture mechanics, discussing linear elastic fracture mechanics, fracture toughness, ductile fracture, slow crack propagation, structural integrity, and more. The book outlines analytical and experimental methods for determining the fracture resistance of mechanical and structural components, also demonstrating the use of fracture mechanics in failure analysis, reinforcement of cracked structures, and remaining life estimation. The characteristics of crack propagation induced by fatigue, stress-

corrosion, creep, and absorbed hydrogen are also discussed. The book concludes with a chapter on the structural integrity analysis of cracked components alongside a real integrity assessment. This book will be especially useful for students in mechanical, civil, industrial, metallurgical, aeronautical and chemical engineering, and for professional engineers looking for a refresher on core principles. Concisely outlines the underlying fundamentals of fracture mechanics, making physical concepts clear and simple and providing easily-understood applied examples Includes solved problems of the most common calculations, along with step-by-step procedures to perform widely-used methods in fracture mechanics Demonstrates how to determine stress intensity factors and fracture toughness, estimate crack growth rate, calculate failure load, and other methods and techniques