Preface

This second edition of the book retains all the features of the previous edition while new ones are added. The main work in this edition includes refining text in each chapter, expansion of some sections in several chapters, and addition of examples, problems, and new sections, such as conformal mapping and mechanical behavior of wood.

The purpose of this book is to present, in a closed form, analytical methods in deriving stress and strain functions related to fracture mechanics. This book contains a compilation of work available in the literature in a scatter form and, to a certain extent, selected experimental data of many researchers to justify the theoretical fracture mechanics models in solving crack problems. It is a self-contained and detailed book for the reader (senior and graduate students and engineers) involved in the analysis of failure using a mathematical approach for designing against fracture. However, it is important that the reader understands the concept of modeling, problem solving, and interpreting the meaning of mathematical solution for a particular engineering problem or situation. Once this is accomplished, the reader should be able to think mathematically, foresee metallurgically the significance of microstructural parameters on properties, analyze the mechanical behavior of materials, and recognize realistically how dangerous a crack is in a stressed structure, which may fail catastrophically.

In spite of the advances in fracture mechanics, many principles remain the same. Dynamic fracture mechanics is included through the field of fatigue and Charpy impact testing. The material included in this book is based upon the development of analytical and numerical procedures pertinent to particular fields of linear elastic fracture mechanics (LEFM) and plastic fracture mechanics (PFM), including mixed-mode-loading interaction. The mathematical approach undertaken herein is coupled with a brief review of several fracture theories available in cited references.

Fracture mechanics of engineering materials deals with fracture of solids undergoing large deformation (ductile materials) and/or fracture (brittle materials) when subjected to extreme loading. The analysis of a solid responding to loads is concerned partly with microscopic mechanisms of fracture, establishing fracture criteria, and predicting the fracture stress from a macroscopic approach.

Chapter 1 includes definitions of variables such as force, load, stress, strain, and displacement. These are vital for the understanding of state properties of solid materials and for characterizing the mechanical behavior of crack-free or cracked solids.

Chapter 2 deals with the introduction to fracture mechanics. It also includes the close form of Griffith crack theory and the strain-energy release rate associated with fracture.

Chapter 3 is devoted to solid bodies under quasi-static stress modes containing cracks. The theory of linear elastic fracture mechanics (LEFM) is integrated in this chapter using an analytical approach for deriving field equations ahead of a crack tip.

Chapter 4 includes the derivation of elastic field equations for mode I (tension), mode II (sliding), and mode III (tearing) loadings.

Chapter 5 is devoted to crack tip plasticity and relevant configuration. The yielding phenomenon is analyzed for a better understanding of the plastic deformation ahead of a crack tip.

Chapter 6 deals with the energy principles for assessing the elastic behavior of solids containing cracks. The energy terms included in this chapter are the energy release rate and the J-integral which are used to define fracture criteria.

Chapter 7 includes the theoretical concepts of plastic fracture mechanics for deriving the HRR field equations using the J-integral approach. An engineering approach is also included for determining the plastic J-integral.

Chapter 8 deals with a realistic engineering problem related to mixed-mode fracture mechanics. This is the case for a crack in a component being subjected to a mixed-mode loading, such as tension and torsion (mode I and II stress loading). A closed-form analytical approach is used in this chapter for deriving the field elastic equations.

Chapter 9 is devoted to fatigue crack growth since fatigue in solid materials being subjected to repeated cyclic loading is a cumulative damage phenomenon. Fatigue crack initiation is modeled using a crystallographic approach, and the fatigue crack growth rate is determined as a function of the change of the stress intensity factor. Thus, a fatigue life formula is derived for predicting fracture.

Chapter 10 is devoted to fracture toughness correlations, including indentation-induced cracking, Charpy impact energy, and dynamic effects.

A solution manual is available for educators or teachers upon the consent of the book publisher. Also, all images, pictures, or data taken from reliable sources are included in this book for educational purposes and academic support only. Additional material to this book can be downloaded from http://extras.springer.com.

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