Overview

Elastic-plastic fracture mechanics (EPFM) had its birth in the late 1960s and early 1970s. After nearly two decades of steadily growing effort, the field has seen a maturing as well as a change in emphasis. EPFM developed in response to a real technology need. The parent technology, linear elastic fracture mechanics (LEFM), did not apply to many of the engineering materials used in modern structures. New and better materials were developed to attain more ductility and higher fracture toughness, and where LEFM could no longer be used for analyzing failures in these materials, EPFM provided the solution.

To organize and document the results of the growing research effort in the field, ASTM Committee E-24 on Fracture Testing sponsored the First International Elastic-Plastic Fracture Symposium in Atlanta, Georgia, in 1977. The bulk of this symposium, as peer-reviewed papers, is published in *ASTM STP 668, Elastic-Plastic Fracture*. Subsequently, a second international symposium on this subject was held in 1981, resulting in the two-volume *ASTM STP 803, Elastic-Plastic Fracture: Second Symposium.*

The 1980s saw a rise in more general interest in nonlinear fracture mechanics topics, particularly time-dependent fracture mechanics. It became apparent that the title for the next symposium would have to be modified to include this emerging field. As a result, that symposium was called the Third International Symposium on Nonlinear Fracture Mechanics and it was held in Knoxville, Tennessee, in 1986. This symposium, sponsored by ASTM Committee E-24 and its Subcommittee E24.08 on Elastic-Plastic Fracture and Fully Plastic Fracture Mechanics Terminology, featured both time-dependent and elastic-plastic topics in fracture mechanics. The time-dependent fracture mechanics papers (as peer-reviewed papers) are published in Volume I of this Special Technical Publication (*ASTM STP 995)*; this book, Volume II of *ASTM STP 995*, features elastic-plastic contributions to the symposium.

In the early years of the field, EPFM activities centered on the power generation industry, particularly the nuclear power industry, where the needs for safety and reliability were at an all-time high and a new level of technology was required to satisfy those needs. The earliest work concentrated on the development of characterizing parameters and the development of test methods. Debate was often centered on two or more candidate parameters or test methods, among them the *J*-integral, the crack-tip opening displacement (CTOD), and various energy approaches. After more than a decade of this debate, it was recognized that the leading candidate parameters were all related and the various test methods produced complementary results. Therefore, what was needed was not more work on basic approaches but rather work on standardizing methods of testing and seeking new and better methods of applying the technology.

Test standardization for EPFM began with the development of the ASTM Test for J_{Ic}, a Measure of Fracture Toughness (E 813-81) in 1981, the year of the second international symposium. The ASTM Test for Determining J-R Curves (E 1152-87) was developed in 1987, and a standard on CTOD testing is presently in ballot. The goal of applying the technology was slower in developing. However, with the ever-expanding capabilities of modern computers, numerical solutions to nonlinear fracture problems become easier to attain. Most recently, interest in EPFM has expanded to the study of models and mechanisms of fracture at the microstructural level.

The elastic-plastic portion of the symposium included all of these topics of current interest. This volume is divided into four major sections, covering the topics of analysis, fracture toughness, applications, and models and mechanisms.

Analysis

The section on analysis contains a variety of new topics that make use of the capabilities of modern computers. One of the new areas included is that of the local criterion for fracture, a topic that has gained in importance in recent years. A feature of many recent studies is the comparison between experimental and analytical techniques and results. The improvement in analytical capabilities has helped EPFM to grow and has been particularly helpful in the development of application techniques.

Fracture Toughness

The section on fracture toughness features results from experimental studies. Some areas of study include size and geometry effects, the effect of material quality, the effect of prestrain, and the study of weldments. Experimental results on the various fracture behaviors continues to provide one of the cornerstones of the methodology, that of determining the material behavior.

Applications

The section on applications represents the largest section of papers, which suggests that, at present, this is the most important aspect of EPFM development. The list of topics for application is still dominated by the interests of the power generation industry. Components include pressure vessels, pipes, and tubes, with an interest in welded components prevailing. Approaches to application remain varied, ranging from well-documented ones—such as the failure assessment diagram, tearing instability, and leak-before-break applications—to newly developed methods being presented for the first time in this volume. Many of the application approaches are accompanied by experimental results to illustrate their success with the particular problem addressed.

Models and Mechanisms

The final section, on models and mechanisms, represents the newest area of interest in EPFM. It features the study of both metallurgical and microstructural features, as well as models, based on macroscopic continuum aspects. Although this section is the smallest one in this volume, it is nevertheless an important one. Use of a technology and its characteristic parameters to formulate models and study mechanisms of behavior indicates a level of confidence in that technology. After nearly two decades of EPFM, this level of confidence is evident from this volume and is one of its important results.

On reviewing the Third International Symposium on Nonlinear Fracture Mechanics and this volume (Volume II of *ASTM STP 995*), on elastic-plastic fracture, certain important aspects of EPFM have emerged. EPFM has survived its first decade of controversy over parameters and testing methods and has moved ahead to the study of problems with testing techniques and applications of the technology. Confidence in EPFM is at a high level, as evidenced by the study of models and mechanisms. Although the technology is still dominated by the interests of the power generation industry, new areas of interest are emerging, especially in critical structures for the defense industry. Elastic-plastic fracture is still progressing, and a fourth symposium will probably be needed in the not-too-distant future.

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