OVERVIEW

Elastic-Plastic Fracture Mechanics (EPFM) had its birth in the late 1960s and early 1970s. In nearly two decades of growing effort, the field has seen a maturing trend 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. 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 Philadelphia in 1981, which resulted 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. Therefore, the title for the next symposium was modified to include this emerging field. As a result, the Third International Symposium on Nonlinear Fracture Mechanics was held in Knoxville, Tennessee, in 1986. This symposium, sponsored by ASTM Committee E-24 and its Subcommittee E24.08 on Elastic-Plastic and Fully Plastic Fracture Mechanics Technology, featured both time-dependent and elastic-plastic topics in fracture mechanics. The time-dependent fracture mechanics papers are published in Volume I (this volume) of this Special Technical Publication (*ASTM STP 995*). Volume II features the elastic-plastic contributions to the symposium.

In the mid-1970s, when consensus in the approaches to elastic-plastic fracture was emerging, the attention of some researchers shifted to elevated-temperature crack growth behavior. The motivation for this work came primarily from projects active at the time, and was directed toward building commercial advanced nuclear reactors, improving energy conversion efficiencies of conventional power plants and jet engines, exploring the feasibility of alternate energy sources such as coal gasification, and understanding failures in major equipment, such as Tennessee Valley Authority's Gallatin steam turbine rotor. New concepts which could adequately account for the presence of time-dependent creep strains in cracked body analysis were needed for integrity assessment and prevention of failures in these components. A creep analog to the J-integral called C^* was proposed in 1974, which over time has proven to be the first major breakthrough in the development of time-dependent fracture mechanics (TDFM). In its range of applicability, C^* is now a well-accepted crack-tip parameter.

At the time of the second elastic-plastic fracture symposium in 1981, it was becoming clear that the application of C^* is limited to cracked bodies undergoing dominantly secondary-stage creep. Researchers were engaged in understanding the limitations of C^* and also in extending the concept into the small-scale creep (SSC) regime, where a good portion of the practical problems lie. Only single session was devoted to papers on this subject at the second symposium. In the third symposium, TDFM was one of the prominent themes and several sessions were organized on the subject. The papers from these sessions are included in the first section of this volume.

Creep Crack Growth

The papers on creep crack growth deal with the issues of crack growth under small-scale creep conditions, the usefulness of the recently proposed C_t parameter, the applicability of damage mechanics concepts in understanding micromechanics and micromechanisms of creep crack growth, embrittlement due to aging in service and its influence on creep crack growth behavior, and experimental methods. While significant progress has occurred since the last symposium on this topic, a lot more remains to be done. Some issues not addressed in the papers at the symposium include the influence of cyclic loading and inclusion of creep deformation other than that represented by power-law creep. These are areas of current research. Also, further evaluation of the C_t parameter is likely to continue until a consensus can be reached, and stable and unstable crack growth and fracture at elevated temperature should be addressed. Therefore, a good number of problems still remain unresolved in this area. Although some of the original reasons for developing TDFM are no longer the primary driving force, the field has found considerable use in remaining life assessment of fossil power-plant components and will be useful in the development of advanced aircraft. Hence, this area is expected to be represented in future symposia on nonlinear fracture mechanics.

Dynamic Fracture

The second section of this volume is devoted to dynamic fracture. This is also one of the newer areas of research in fracture mechanics. The papers in this section deal with the issue of calculating the crack driving force, with proper emphasis on inertial effects and the measurement of fracture toughness under conditions of high rate loading. This area continues to be of significant interest to the nuclear power industry and the U.S. Navy.

Cyclic Loading

The papers in the section on cyclic loading are concerned with experimental evaluation of ΔJ for characterizing fatigue crack growth behavior under gross plasticity conditions and with cracking under mixed-mode loading. Crack-tip mechanics under cyclic loading was studied by measuring displacements, using optical interferometry. Damage accumulation in the form of dislocation motion at the crack-tip field was modeled in another paper.

Fracture of Nonmetals

The final section of the book is devoted to papers based on exploratory work in the area of fracture in nonmetallic materials, such as polymers and ceramics. This is an emerging field in which there is considerable need for new ideas.

On glancing over the Third International Symposium on Nonlinear Fracture Mechanics and Volume I of this Special Technical Publication, it is clear that very significant progress has occurred in the field of TDFM. The field is not very far along in its readiness for applications when we compare its recent progress to the status of its parent technologies, LEFM and EPFM. The concepts are based on sound principles which should ensure their widespread acceptance and usage in the future. The same is true for the status of dynamic fracture mechanics. In the area of cyclic loading, the ΔJ parameter has survived ten years of criticism, and it appears that the theory behind its success in correlating experimental data is becoming increasingly understood. Fracture mechanics of new materials such as polymers, ceramics, and composites are fields in which considerable interest is expected in the near future.

A. Saxena
Georgia Institute of Technology, Atlanta, GA 30332; symposium cochairman and editor.

J. D. Landes
University of Tennessee, Knoxville, TN 37996; symposium cochairman and editor.

J. L. Bassani
University of Pennsylvania, Philadelphia, PA 19104; symposium cochairman and editor.