Overview

Fracture mechanics forms the basis of a maturing technology and is used in quantifying and predicting the strength, durability, and reliability of structural components that contain cracks or crack-like defects. First utilized in the late 1940s to analyze catastrophic fractures in ships, the fracture mechanics approach found applications and increased acceptance in the aerospace industries through the late 1950s and early 1960s. Much of the early work was spearheaded by Dr. George R. Irwin and his co-workers at the U.S. Naval Research Laboratory and was nurtured through a special technical committee of ASTM, chaired by Dr. John R. Low. Over the past 20 years, fracture mechanics has undergone major development and has become an important subdiscipline in solid mechanics and an enabling technology for materials development, component and system design, safety and life assessments, and scientific inquiries. The contributions are now utilized in the design and analysis of chemical and petrochemical equipment, fossil and nuclear power generation systems, marine structures, bridges and transportation systems, and aerospace vehicles. The fracture mechanics approach is being used to address all of the major mechanisms of material failure; namely, ductile and cleavage fracture, stress corrosion cracking, fatigue and corrosion fatigue, and creep cracking. From its origin in glass and high strength metallic materials, the approach is currently applied to most classes of materials; including metallic materials, ceramics, polymers, composites, soils, and rocks.

The first National Symposium on Fracture Mechanics was organized by Professor Paul C. Paris, and was held on the campus of Lehigh University in June 1967. The National Symposium has gained prominence and international recognition and serves as an important international forum for fracture mechanics research and applications under the sponsorship of ASTM Committee E-24 on Fracture Testing. It has been held annually since 1967, with the exception of 1977. The growth of the National Symposium has paralleled the development and utilization of fracture mechanics. Landmark papers and Special Technical Publications have resulted from this Symposium series. It is appropriate that this, the 20th anniversary meeting of the National Symposium, be held again at Lehigh University and that the proceedings be archived in an ASTM book.

At this anniversary, following from two decades of intense and successful developments, it is appropriate and timely to conduct an introspective examination of the field of fracture mechanics and to define directions for future work. The Organizing Committee, therefore, set the following goals for the 20th National Symposium on Fracture Mechanics, *Fracture Mechanics: Perspectives and Directions*:

1. To provide perspective overviews of major developments in important areas of fracture mechanics and of associated applications over the past two decades.

2. To highlight directions for future developments and applications of fracture mechanics, particularly those needed to encompass the nontraditional areas.

To achieve the stated goals, the technical program was organized into the following six sessions:

(a) Analytical Fracture Mechanics
(b) Nonlinear and Time Dependent Fracture Mechanics
(c) Microstructure and Micromechanical Modeling
(d) Fatigue Crack Propagation
(e) Environmentally Assisted Cracking
(f) Fracture Mechanics of Nonmetals and New Frontiers

This Special Technical Publication accurately adheres to the objectives and approach of the Symposium. The twelve invited review papers, organized topically in the order of their presentation in one section, provide authoritative and comprehensive descriptions of the state of the art and important challenges in each of the six topical areas. The worker new to the field will be able to survey current understanding through the use of these seminal contributions. The thirty-one contributed papers, organized topically in a separate section, provide reports of current research. These papers are of particular importance to fracture mechanics researchers.

Although each manuscript was subjected to rigorous peer reviews in accordance with ASTM procedures, the authors of invited review papers were encouraged to respond thoughtfully to the reviewers comments and suggestions, but were granted considerable latitude to exercise their judgment on the final manuscript. This action was taken by the Editors to preserve the personal (*vis-à-vis*, a consensus) perspective of the individual experts, and to accurately reflect agreements and differences in opinion on the direction of future research. The invited papers, therefore, need to be read in this context. The opinions expressed and positions taken by the individual authors are not necessarily endorsed by the author's peers, the Editors, or the ASTM.

The review papers document the significant progress achieved over the past two decades of active research in fracture mechanics. Collectively, the authors provide compelling arguments for the need of continued development and exploitation of this technology, and insights on the challenges that must be faced. Some of the specific challenges are as follows:

1. On the analytical front, we must expand upon the effort to integrate continuum fracture mechanics analyses with the microscopic processes which govern local fracture at the crack tip.
2. In the area of advanced heterogeneous materials, fracture mechanics methods must be further developed and applied to describe novel failure modes. Claims of high performance for these materials must be supported by quantitative and scalable characterizations of fracture resistance that is relevant to specific applications.
3. In the area of subcritical crack growth (for both fatigue and sustained-load crack growth in deleterious environments and at elevated temperatures), the gains in understanding from multidisciplinary (mechancis, chemistry, and materials science) research must be reduced to practical life prediction methodologies. The critical issues of formulating mechanistically based procedures that enable the extrapolation of short-term laboratory data in predicting long-term service performance (that is, from weeks to decades) must be addressed.

4. In the area of education, we must better inform engineering students and practitioners on the interdisciplinary nature and intricacies of the material failure problem, whether by subcritical crack growth or by catastrophic defect-nucleated fracture. We must also continue to develop and to communicate governing ASTM standards to the engineering community.

This volume demonstrates that the existing fracture mechanics foundation is well positioned to meet these challenges over the next decade.

Professors Paul C. Paris and George R. Irwin provided important insights during the closing of the symposium and at the Conference Banquet. The banquet provided an opportunity for the awarding of the first ASTM E-24 Fracture Mechanics Medals to Professors Irwin and Paris.

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