

Overview

Fatigue and fracture are topics of primary importance to the development of damage-tolerant composite materials, to the design of high-performance composite components and structures, and to the certification of composite products. The ASTM Symposium on Composite Materials: Fatigue and Fracture, held in Indianapolis, Indiana in May 1991, was the fourth in a series of ASTM symposia to address current issues related to fatigue and fracture of composites. This special technical publication (STP) contains peer-reviewed and approved papers presented at the Indianapolis symposium. The STP is one of more than 25 ASTM STPs, dating back to 1973, which either focus on or address the subjects of fatigue and fracture of composites and related issues.

The Fourth Symposium on Composite Materials: Fatigue and Fracture was sponsored by ASTM Committees D-30 on High Modulus Fibers and Their Composites, E-9 on Fatigue, and E-24 on Fracture Testing. Wayne Stinchcomb of Virginia Polytechnic Institute and State University and Noel Ashbaugh of the University of Dayton Research Institute served as chairmen of the symposium. Doug Ward of General Electric Aircraft Engines, Ted Nicholas of Wright-Patterson Air Force Base, Steven Lubowinski of BASF Structural Materials, James Whitney of the University of Dayton Research Institute, Charles Bakis of the Pennsylvania State University, and W. Steven Johnson of NASA Langley Research Center served as session chairmen. The authors of the STP papers present their experimental and analytical work on fatigue and fracture of composites conducted in the United States, Canada, Japan, the United Kingdom, and Austria.

Papers in the first section on strength and failure modes present results on the failure process in composites, including the initiation and growth of matrix cracks and delaminations and fractures. The papers describe failures of materials, components (tubes and notched laminates), and structural elements (stiffened panels). Results are presented for axial, transverse, and biaxial loading conditions.

The second section contains papers on the measurement, analysis, and modeling of damage, three elements essential to the development of relationships between the state of the material and its performance. The results presented in these papers reflect current progress in the understanding and modeling of damage and its consequences. The polymer matrix and glass-ceramic matrix composites discussed in this section are indicators of current interests in high-performance and high-temperature composites.

Intralaminar and interlaminar fracture, the subjects of the third section, continue to be topics of particular interest as new materials and material configurations are developed and evaluated for damage tolerance and fracture toughness. The papers in this section address Mode I and Mode II fracture, environmental effects and test methods. The importance of using proper experimental and analytical procedures is emphasized, and several practical recommendations are offered.

Micromechanics and interfaces add new dimensions to the topics of fatigue and fracture of composites and are the themes of the fourth section. These subjects are the focus of much of the current work on long-term behavior and provide much-needed information on the understanding and analysis of failure processes. Several micromechanics models are presented to represent the local behavior of matrices, fibers, and interfaces. Two test methods are also presented to measure and evaluate the quality and strength of interfaces.

Fatigue of polymer matrix composites, presented in the fifth section, continues to be a subject of primary interest and importance as higher performance requirements for composite materials and structures must be satisfied. Data are presented showing the effects of important factors such as laminate thickness, notches, interleaves, and stress ratios on the fatigue response of polymer matrix composites. The papers also discuss the development of damage, including matrix cracks and edge and local delaminations, and its influence on fatigue response.

The final section of the STP contains papers on the fatigue response of metal matrix and glass-ceramic matrix composites and an aramid fiber-reinforced epoxy/aluminum laminate (ARALL). The papers address the need for development and characterization of advanced, high-performance materials which can survive in aggressive and hostile environments. The papers in the sixth section present results of experimental work to evaluate the thermomechanical and tension-compression fatigue response of metal matrix composites, tension-tension fatigue damage in glass-ceramic matrix tubes, and high-cycle fatigue behavior of ARALL laminates.

The technical results contained in this STP provide many practical insights on new developments in areas of continuing interest, such as damage and failure analysis and test methods. They also provide new directions for emerging technology areas, such as micromechanics and interfacial analysis, which are applicable to fatigue and fracture of composites. The materials addressed are thermosetting and thermoplastic polymer matrix composites, metal matrix composites, and ceramic matrix composites, as well as a specialty laminate. Furthermore, the results were obtained for several configurations of composites ranging from laboratory specimens to subcomponents to structural elements.

One measure of the value of a technical publication is the applicability of new information contained therein to the solution of current problems. Another measure of value is the significance of new directions, methodologies, and innovations to help achieve further understanding and solutions. By both measures, this STP has value to all who are concerned with fatigue and fracture of composites.

The full spectrum of activities necessary to organize and hold a technical symposium and to publish an STP requires coordination and cooperation by a team of many people. To the ASTM staff, the sponsoring technical committees, the session chairman, the authors, the reviewers, and the clerical staffs of our organizations, we express our sincere appreciation for your professional efforts and jobs well done.

Wayne Stinchcomb

Virginia Polytechnic Institute and State University and the U.S. Air Force Academy; symposium chairman and editor

Noel Ashbaugh

University of Dayton, Research Institute, Dayton, OH; symposium chairman and editor