

# Introduction

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Ravi Deo and I originally intended this symposium to focus on how industry has solved some of the problems associated with implementation of composite materials in products and hardware. As papers were submitted and reviewed for presentation, it became apparent that we were receiving papers with a greater emphasis on general solutions to the testing and design problems encountered by industry than on specific examples of solutions developed by industrial firms. While this may seem at cross purposes to our original plan, the results may ultimately be more useful to the technical community than a collection of specific examples would have been.

Because this volume contains more general examples of test and analysis methods applied to composite materials and structures, we believe it will serve two purposes; one to present new test and analysis techniques and the other to present the trends of the technology development in composite materials in this decade. The focus of the work presented herein is toward applications in more aggressive environments and reducing the cost of composite applications and testing to ensure economic viability.

This volume, containing 21 papers, should be valuable to both researchers and to those involved in the design and analysis of structures using advanced composite material systems. The papers cover four primary topics ranging from evaluation of the effects of environmental aging and physical damage to evaluation of new product forms and the analysis and design of structures implementing these new product forms.

## Environmental Effects Testing

Papers in this category reflect the emphasis in the research environment toward long term applications of composites in higher temperature structures. The effects of environmental aging include physical as well as chemical changes in the material which affect the mechanical response of the materials. Short term test techniques that can identify these behaviors and quantify their effects are valuable tools for determining what matrices are most useful for these long term applications. The fiber-matrix interface, or interphase material, if it exists, can often determine the life of the composite system even when the matrix material is capable of long term exposure without degradation. Either by wicking moisture of corrosion products into the system, or by directly attacking the integrity of the fiber, the interphase (or interface) degradation can cause sudden catastrophic failures not predicted by tests of fiber or matrix alone. Much more work needs to be done in this area. NDE methods must be developed to determine when composites have been damaged by heat to the point that their mechanical properties have been degraded. Environmental stress cracking and hygrothermal cracking are additional degradation mechanisms that must be understood so that short term tests can identify those systems which will survive and perform in aggressive environments.

### **Design Allowables and Damage Tolerance Testing**

Test techniques for damage tolerance testing continue to be a source of new ideas for tests that can be interpreted rationally for structural applications. Two new experimental techniques are evaluated herein: one on the use of static indentation to mimic impact damage in composites and the other on the use of a torsion specimen to eliminate specimen end effects on delamination fracture testing. While both methods show promise, static indentation test methods still require a rigorous test of their limitations, and application of the Mode III delamination results to realistic structures remains unproven. Of particular interest to structural designers and analysts will be the papers included in this section dealing with skin stiffener debonding in composite panels, mechanical characterization of syntactic foam core panels, and comparison of static indentation versus impact damage in composite tubes. These papers address a common problem in design of these structures in interpreting simple test results in the analysis of complex, realistic structural geometries.

### **Textile and Other Advanced Composites**

Papers in this section address two widely disparate systems: textile composites and metal matrix composites. Textile composites have long been a source of improved damage tolerance for both impact and manufacturing damage. However, as industry has accepted their use into cocured structures, evaluation through the thickness strength has become a concern. In a related vein, analysis to predict the properties of the wide variety of possible textile product forms has become a requirement, since no one can afford to test all the possibilities for a given application. Much more needs to be done here to assess all of the properties required for design purposes, but the analyses presented provide a start toward this development.

Metal matrix composite (MMC) materials have been relegated to the high temperature end of the composite family as resin matrix composite capabilities for intermediate temperatures expand. However, the analysis and design of structures under the high temperature loading conditions of these extreme environments becomes a complex study. But, even though the materials differ, the effects of creep at high temperatures, coupled with variable amplitude loadings, is a study as relevant to thermoplastic matrix systems at intermediate temperatures as it is to MMCs. This is likewise true of the study presented on inelastic behavior of MMC under compressive loadings.

### **Design, Analysis, and Test Techniques**

These papers examine the interpretation of test data from a variety of mechanical test techniques, ranging from micromechanical tests of creep in high temperature composites through the testing extension-twist-coupled composite laminates to the development of design allowables using regression models. These papers focus on the need in composite materials to link the analysis of the test result to the specimen and its loading to develop useful data for evaluation of real structures. From micromechanical models to overall structural models, analysis of the failure modes, loadings, and processes is vital to the proper application of the data to design and analysis of composite hardware.

The papers contained herein represent a broad spectrum of the applications being examined for composite materials today and a look toward the potential application of the future. While few specific hardware applications are presented, knowledgeable reviewers will see reflections of the direction of composite applications of the future in the data presented herein. And the test techniques presented herein point in the directions of simplified tests, greater depth of analytical interpretation, and ease in application to real structures. These are the directions of composite technology for the foreseeable future.

We want to acknowledge the efforts of the authors, presenters, reviewers, and the ASTM staff for making this volume possible.

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