Overview

The ASTM Eleventh Symposium on Composite Materials: Testing and Design was held on 4–5 May 1992 in Pittsburgh, Pennsylvania. As with the ten previous symposia of the same title, papers for the eleventh were solicited in the general area of testing and design of composite materials. Twenty-two of the twenty-nine papers presented at the symposium are included in this publication and fall into the three major categories of Materials Testing and Response, Design and Analysis, and Interlaminar Fracture and Strength.

Material Testing and Response

Twelve of the twenty-two papers in this volume fall in this category and are briefly described below.

Transverse Tension and Shear Properties

Four papers deal with the matrix dominated properties of transverse tension and shear. Lyon et al. present shear, transverse tension, and transverse compression data from unidirectional hoop-wound tubular specimens and cylindrical rods fabricated from wet-filament winding and prepreg systems. O'Brien and Salpekar discuss the influence of volume on the transverse tensile strength of carbon-reinforced composites and use transverse tensile strength data and Weibull statistics to predict the strength of 90° laminates loaded in three-point bending. Chatterjee et al. investigated the shear response of composite laminates using solid circular and rectangular bars, with Ho et al. investigating the same using V-notched beam specimens.

Compression Test Methods

In area of compression testing, two papers compare different compression test methods. Goeke discusses two test methods that can be used for evaluation of composite materials greater than 12 mm (0.5 in.) in thickness, and Daniels and Sandhu discuss six test methods and specimens for the evaluation of materials for more common specimen thicknesses (~2.5 mm [0.1 in.]).

Multiaxial Stress State Response

Crews and Naik evaluate the multiaxial ply strength of carbon-reinforced composites using an off-axis flexure test of unidirectional laminates. Wang and Socie present results from the multiaxial testing of fiberglass fabric-reinforced tubular specimens. In their work, loading is provided by varying combinations of tension, compression, internal pressure, and external pressure.

Other Properties

The four remaining papers in the category of Material Testing and Response address the following: deriving the elastic constants of nearly isotropic composites from modal vibration of a completely free plate (Ayorinde et al.), determining the high strain rate response (0/s to 3000/s) of composites using a high-strain rate drop tower and a split Hopkinson bar (Groves et al.), development of an elastic/viscoplastic constitutive model for in-plane, isothermal, axial tensile loading

(Gates), and the tension-tension thermomechanical fatigue response of titanium alumnide (Bartolotta and Verrilli).

Design and Analysis

This category contains six papers that range in level of focus from micromechanical analysis to the analysis of thick, laminated shells. At the micromechanical level, Naik and Crews used the classical Airy's stress function approach to compute fiber-matrix stresses for unidirectional carbon-reinforced composites under combined thermal and mechanical loading. At the level of laminate analysis, four papers are presented. The first two address the effect of holes in carbon-reinforced laminates with DiNicola and Fantle investigating the effect of clearance fit fasteners and Sorem et al. investigating the effect of hole interaction on stress concentrations. The other two papers on laminate level analysis address the design of laminates that exhibit optimum laminate extension-twisting coupling while considering laminate warping caused by residual thermal stresses (Armanios et al.), and the prediction of thermo-elastic properties of woven fabric composites in a deformed state such as those used for doubly curved surfaces (Laroche and Vu-Khanh). The final paper in this category is at the structural analysis level and deals with the behavior of thick-section composite shells subjected to hydrostatic pressure (Yuan).

Interlaminar Fracture and Strength

Four papers are included in this category. Three deal with delamination, and two of them focus on mixed-mode delamination and the mixed-mode bending (MMB) test method. This test method theoretically allows the evaluation of fracture toughness G_c under combinations of mixed-mode loading, from pure Mode I to pure Mode II. In the paper by Sriram et al., the MMB test is used to evaluate the fatigue response of two IM7 reinforced material systems. Reeder presents MMB data and introduces a bilinear failure criteria to characterize the data and account for different failure mechanisms observed on the delamination surfaces. The other paper on delamination considers the effect of various ply-drop configurations on delamination (Fish and Vizzini). The fourth paper in this category investigates curved beam specimens for the determination of interlaminar tension strength (Jackson and Martin).

Summary

In summary, the papers in this eleventh volume on Composite Materials: Testing and Design represent a significant contribution to the literature on testing, analysis, and design of composite materials. As with the previous ten volumes, the largest portion of the papers deals with testing and analysis of composites at the coupon level or below, with only a few papers dealing with design issues or analyses used specifically for a design. While this ratio is generally appropriate for the research-type symposia this STP covers, it is the editor's observation that earlier volumes of the same title (the First, Third, and Fifth) had a much higher percentage of papers describing testing and analysis with a specific design focus. It is also the editor's opinion that work on fundamental testing and analysis issues versus those with a design focus is a general trend in published literature at this time. While work to increase the level of understanding of fundamental mechanics issues is essential, the need to transition testing and analysis fundamentals into published design procedures is immediate.

In a time of defense conversion and the potential it provides for the composites industry, a large number of design engineers remain puzzled over the paradox between the thorough, fundamental understanding of testing and analysis procedures, and the lack of information on using these procedures in engineering design. It could be argued that it is difficult to establish simply used design procedures for complex, inhomogenous, anisotropic materials. While true, the testing,

design, and analysis community can move further towards this end through the effective transition of design experience from the corporate knowledge base of the defense industry.

While design handbooks and manuals will be the eventual sources of such information for the design engineer, their publication is limited and far from complete. For the near term, engineers should consider the critical role they could play in the transition of research based knowledge to engineering design. A forum such as the ASTM series on Composite Materials: Testing and Design could specifically assist in this transition with future focus on (1) relating test data to working stress design allowables, (2) relating analysis results to design allowables through effective failure criteria, and (3) relating data, design allowables, and failure criteria to design factors of safety for safe yet efficient and cost-effective design.

A Final Note

Finally, the successful publication of this STP would not have been possible without the gracious assistance of many individuals, and I would like to thank the authors and reviewers for their contributions in this effort. For their help as my Symposia Session Chairmen, thanks go to Roger Crane, Scott Groves, Steve Lubowinski, and Kevin O'Brien. The talented staff at ASTM headquarters deserves a special thanks for flawlessly handling the mountains of paper and endless phone calls necessary for such a publication effort. The assistance and pleasant spirit of Therese Pravitz and Lynn Hanson was particularly appreciated.

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