

Conference Reports

SESA Spring Meeting

The 1981 spring meeting of the Society for Experimental Stress Analysis was held May 31–June 4, 1981 in Dearborn, Michigan. Of the 30 technical sessions, four were devoted to composites: Dynamic Response of Composite Materials, Nondestructive Testing of Composite Materials, Composite Materials (in general), and Composite Materials in the Automotive Industry. Several papers dealing with composites were presented in other sessions.

The session on dynamic response consisted of three educational reviews by Ross, Sierakowski, and C. T. Sun dealing respectively with stress wave propagation, dynamic property measurement, and vibrations of composite plates.

The session on nondestructive evaluation consisted of a general review of methods by Daniel, a discussion of vibrothermography by Henneke, a discussion by Stinchcomb of nondestructive investigation of fatigue damage and its relationship to material response, and a description of dither techniques for increasing the speed and resolution of ultrasonic C-scans by Blake.

In the general composites session, Chai described experimental results on damage in compressively loaded composite plates subjected to low-speed projectile impact; shadow moiré and high-speed photography were used. Hyer studied the shapes of unsymmetric laminates and noted that thin unsymmetric laminates cure into cylindrical shapes, whereas classical lamination theory predicts saddle shapes with two nonzero curvatures of opposite sign. The agreement between experiment and theory is better when large deflection theory is used. Dillard, Brinson, and Morris reported on creep rupture of general laminates. A modified rate equation was used to represent creep rupture data at various temperatures. Daniel presented an experimental study of the behavior of $[O_2/\pm 45]_s$ graphite/epoxy laminates under biaxial tension. The ratio of notched to unnotched strength is lower than for uniaxial loading, although biaxial loading reduces the stress concentration. This is attributed to the fact that two sources of failure initiation exist in the biaxial case with different but interacting failure modes. The commonly used average stress criterion proved inadequate to describe the hole size effect.

The session on automotive applications consisted of two overviews by Riegner of General Motors and Harwood of Ford. Harwood pointed out that composites will find it very hard to compete with high-strength steel on a direct material substitution basis. A weight savings of 0.45 kg (1 lb) saves only 3.8 L (1 gal) of gasoline over the lifetime of the car. Only when weight savings are accompanied by other improvements, such as manufacturability, can composites find more extensive applications in the automotive industry. Despite the difficulties, Harwood predicted that composites will find ever-increasing applications in the automotive industry.

Several papers in other sessions dealt with applications of experimental methods to composites. Prabhakaran discussed an oblique incidence technique for photo-orthotropic elasticity with transparent composites. An experimental-analytical comparison of composite panel buckling was presented by Becker, Palazotto, and Khot. Post and his students from Virginia Polytechnic Institute and State University described very interesting moiré interferometric techniques for measuring thermal deformations in composites. Rutkowski described a modal vibration test method using flat panels to determine the anisotropic elastic constants.

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Summary of Sixth ASTM Conference on Testing and Design of Composite Materials

The Sixth Conference on Testing and Design of Composite Materials (12–13 May 1981, Phoenix, AZ) is the general conference sponsored by ASTM Committee D-30 on High Modulus Fibers and Their Composites dealing with all aspects of testing and design. The conference brings together the active workers in composites technology and provides a forum for presenting and discussing developments in composites testing and design, including applications to the aircraft, automotive, and other industries.

Forty-one papers were presented during the two-day conference in eight sessions with two concurrent sessions at all times. The technical program was organized in eight sessions arranged in a logical order: Test Methods, Material Characterization, Fracture and Failure Analysis, Fatigue, Fatigue and Nondestructive Evaluation, Time-Dependent and Dynamic Response, Environmental Aspects, Durability, and Reliability, and Structural Testing and Design. Although there seemed to be some emphasis on fracture and fatigue, the program showed a great deal of diversity in the subjects covered. This may be an indication that composites technology has reached a state of maturity and that researchers are not preoccupied with a single aspect or problem.

In the session on test methods, Mao and Owen discussed the diametrically compressed disk as a specimen for obtaining the through-the-thickness tensile strength of glass-reinforced plastics. Two papers were presented on the "Iosipescu" shear test and its variations. Freeman described a unique destructive technique, the "deply" technique, for separating a cured graphite/epoxy composite into its individual laminae while maintaining the integrity of each lamina. Delaminations, matrix cracking, fiber breaks, and voids can be clearly identified.

The session on characterization included papers on properties of all composites during curing, shear testing, graphite/polyimide, and sheet molding compound properties. Of special interest was the paper by Yeow on ribbon-reinforced composites.

In the session on fracture and failure analysis, Wells and Beaumont presented toughness maps for micromechanical fracture analysis. Gallo, Sendekyj, and Sandhu presented a finite-element study of damage accumulation in notched composites using a non-linear elastic program and a failure criterion that is a function of both stress and strain states. Bhatia discussed fracture characteristics of intraply hybrids. Mandell and Lee indicated that the resistance of composites to matrix cracking is governed by the fracture toughness of the matrix resin.

Seven papers were presented in the session on fatigue. Campomeschi and Stinchcomb discussed stiffness reduction as an indica-

tor of fatigue damage in T300/5208 graphite/epoxy. Hahn and Hwang discussed the failure behavior of a graphite/epoxy laminate and found that proof-testing has little effect on residual strength and life, that strength and life are interrelated, and that a higher modulus indicates higher strength and longer life. Ryder discussed the effects of load history on behavior of graphite/epoxy and showed that the damage state is path-dependent and varies with the type of loading. Badalian, Dill, and Potter discussed the effects of spectrum variations on fatigue life. The spectrum variations that increased the number or magnitude of the high loads in the spectrum caused the greatest reduction in fatigue life. Owen and Rice studied the biaxial behavior of glass-fabric-reinforced polyester by testing tubular specimens. Results were compared with predictions of many failure theories. Wang discussed the behavior of G-10 glass/epoxy under biaxial fatigue at cryogenic temperatures. Tubular specimens under combined axial tension and torsion were used.

The fifth session dealt with fatigue and nondestructive evaluation. Talreja discussed stiffness changes during fatigue. He measured changes in Young's modulus, shear modulus, and Poisson's ratios in unidirectional glass/polyester. He noted that when the stiffness change reaches a steady state, the underlying damage mechanisms are not expected to lead to failure. Gibbins and Stinchcomb tested laminates with an embedded notch and determined flaw growth nondestructively. Lauraitis and Pettit investigated flaw growth and its effect on mechanical response. Davis, Raymond, and Romano and Ultman and Henneke presented papers on nondestructive evaluation of metal-matrix composites. Ultrasonic C-scanning and X-ray radiography were the primary methods used. Bar-Cohen described how backscattering measurements can be used to determine fiber orientation or misalignment and matrix cracking in surface and subsurface plies.

In the session on time-dependent and dynamic response, Dillard, Brinson, and Morris reported on viscoelastic response and delayed failure of laminates. Lamination theory was used to predict long-term creep and creep rupture in laminates from short-term tests of the unidirectional material. Min and Crossman reported on mechanical and thermal testing of unidirectional graphite/aluminum composite. It was shown that the residual stress, which depends on the thermomechanical loading path, controls the yield strength of the composite. Daniel discussed a new method for testing composites at high strain rates. He presented results for longitudinal, transverse, and in-plane shear moduli, Poisson's ratios, strengths, and ultimate strains for strain rates ranging from

quasi-static to over 500 s^{-1} . Putter, Buchanan, and Rehfield described vibration tests of graphite/epoxy beams at temperatures ranging between 25 and 93°C and moisture conditioning from dry to fully saturated over a frequency range of 10 to 1000 Hz. Yang and Sun presented an indentation law between spheres and composite plates which they extended from the static to the impact loading case. Williams and Rhodes discussed various resin materials from the point of view of impact damage.

In the seventh session of the program (Environmental Effects, Durability, and Reliability), Whitney proposed the lognormal distribution as more practical and advantageous than the Weibull distribution for application to the analysis of specific data on composite materials. Chamis and Sinclair presented an empirical model for predicting the hygrothermomechanical response of composites in the form of a polynomial relationship relating strength with various independent variables such as temperature, moisture, fatigue cycles, and so forth. Grimes and Dusablon presented results from compression fatigue tests of laminates with ply drop-off discontinuities over a temperature range from -48 to 103°C (-65 to $+218^\circ\text{F}$) and a moisture range from dry to fully saturated. Clements discussed failure morphology in variously conditioned graphite/epoxy specimens.

The final session dealt with structural applications of composites. Papers were presented on fabrication and testing of composite flywheels (Nimmer, Torossian, and Hickey) and on testing of large glass-fiber-reinforced pipes buried in soil (Galili and Shmulevitch). Results showed that internal pressure in the pipe helps a great deal in resisting soil overpressure and that, in general, experimentally determined deflections and bending moments were lower than predicted analytically. Kedward and Spier described initial buckling and postbuckling of composite plates and structural shapes. An informative film was shown illustrating the buckling of the web of a channel section under cyclic loading and the change in buckling mode after some degradation in the web.

The conference as a whole was intense and compact and generated a great deal of discussion during the presentation. Participants were asked to submit their questions and comments in writing to ASTM so that they and the authors' responses can be included in the special technical publication (STP) to be published.

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Call for Papers

Third Risø International Symposium on Metallurgy and Materials Science: Fatigue and Creep of Composite Materials

This symposium will be held at the Risø National Laboratory, Roskilde, Denmark, on 6-10 Sept. 1982. The aim of this meeting is to provide a forum for presenting the latest developments in the understanding of the physical aspects of fatigue and creep of fiber composite materials. Emphasis will be placed on studies that provide explanations of the mechanisms of deformation and fracture of composite materials under uniaxial and multiaxial loadings. Studies of environmental effects that are related to fatigue and creep properties will also be considered, as will studies of engineering applications when they are based on use of the fundamental understanding of fatigue and creep. The materials that will be considered are composites with short or long fibers in polymeric, metallic, or ceramic matrices.

Abstracts are required by 1 Jan. 1982, and final papers by 1 May 1982. For further details, contact H. Lilholt or R. Talreja, Metallurgy Department, Risø National Laboratory, 4000 Roskilde, Denmark.

International Symposium on Adhesive Joints: Their Formation, Characteristics, and Testing

This international symposium, to be held in Kansas City, MO, on 12-17 Sept. 1982, will provide a forum for discussing the latest developments and identifying areas needing intensified research and development activity. The technical program will contain both invited and contributed papers; invited speakers have been selected to represent widely differing disciplines and interests. Among the topics to be covered are:

- Surface cleaning, preparation, and modification for adhesive bonding.
- Contact angle, wettability, and adhesive joint strength.
- Understanding the interfacial interactions and their relevance to joint strength.
- Ways to improve joint strength (for example, using adhesion promoters).
- Bond durability and the effect of moisture.
- Characterization of adhesive joints.
- Destructive and nondestructive testing of adhesive joints.
- Fracture behavior of adhesive joints.

Papers dealing with any of the above or allied topics are solicited. All inquiries should be addressed to Dr. K. L. Mittal, Symposium Chairman, IBM Corporation, Bldg. 300-40E, Hopewell Junction, NY 12533 (914-897-6630)

14th National SAMPE Technical Conference

The 14th National SAMPE Technical Conference will be held 12-14 Oct. 1982, in Atlanta, GA. The theme for this conference is

"Material and Process Advances '82." Papers on the following topics are solicited:

- Metallic and nonmetallic material and process advancements and applications.
- Actual experience, including both good and bad experiences.
- Requirements and needs for future applications.

Two copies of a 250-word abstract, including author(s) name, affiliation, business address, and telephone number, should be submitted no later than 1 Feb. 1982, with completed papers due by 1 July 1982. Papers should be submitted to, and information obtained from Paul Carpenter, Program Chairman, Lockheed-Georgia Co., Dept. 59-13, Zone 262, 86 South Cobb Dr., Marietta, GA 30063 (404-424-4913).

Fourth International Conference on Composite Materials

The fourth International Conference on Composite Materials (ICCM-IV) will be held on 25-28 Oct. 1982, in Tokyo, Japan. This conference is cosponsored by the Japan Society for Composite Materials and the Metallurgical Society of AIME. The conference will cover all aspects of the science, technology, and application of composite materials and structures. Emphasis will be placed on recent developments in laboratories and industries all over the world. The following themes will be included:

- Reinforcements, matrices, fillers, and adhesives.
- Interfacial problems.
- Properties of composite (hybrid) materials, structural components, and structures.
- Analysis of composite materials and structures.
- Fabrication technologies for composites.
- Design of composites, hybrids, structures, including jointed and bonded structures.
- Testing and nondestructive evaluation.
- Materials evaluations.
- Applications in various fields.

Those who wish to present papers should submit three copies of their abstract (500-word maximum) to the general chairman of this conference. The abstract must include the title of the paper, full name and mailing address of the author, and the paper's table of contents; illustrations may be included in the abstract. Papers will be selected on the basis of the abstracts and authors will be notified of the paper screening committee's decision. Instructions for final manuscripts will be mailed later; final manuscripts will be due 31 May 1982. All correspondence should be addressed to Professor T. Hayashi, General Chairman of ICCM-IV, c/o Japan Society for Composite Materials, Business Center for Academic Societies Japan, 2-4-16, Yayoi, Bunkyo-ku, Tokyo 113, Japan.

Calendar on Composites

9-10 March 1982

ASTM D-30 Symposium on the Long-Term Behavior of Composites
Williamsburg, VA
Contact: Alice C. Cavallaro
ASTM, 1916 Race Street, Philadelphia, PA 19103 (215-299-5546)

4-6 May 1982

27th National SAMPE Symposium and Exhibition
San Diego, CA
Contact: Marge Smith
SAMPE, P.O. Box 613, Azusa, CA 91702 (213-334-1810)

9-12 May 1982

Mechanics of Nondestructive Evaluation
VPI&SU, Blacksburg, VA
Contact: K. L. Reifsnider
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061 (703-961-5316)

10-12 May 1982

23rd Structures, Structural Dynamics, and Materials Conference
New Orleans, LA
Contact: Dr. Russell J. Reck
McDonnell Douglas Astronautics Co.
5301 Bolsa Ave., Huntington Beach, CA 92647 (714-896-3761)

13-14 July 1982

Joining in Fiber Reinforced Plastics
Imperial College/RAE, London, England
Contact: F. L. Matthews
Aeronautics Department, Imperial College, London, SW7-2BY, England

6-10 Sept. 1982

Third Risø International Symposium on Metallurgy and Materials Science: Fatigue and Creep of Composite Materials
Roskilde, Denmark
Contact: H. Lilholt or R. Talreja
Metallurgy Department, Risø National Laboratory, 4000 Roskilde, Denmark

12-17 Sept. 1982

International Symposium on Adhesive Joints: Their Formation, Characteristics, and Testing
Kansas City, MO
Contact: Dr. K. L. Mittal, Symposium Chairman
IBM Corporation, Bldg. 300-40E, Hopewell Junction, NY 12533 (914-897-6630)

12-14 Oct. 1982

14th National SAMPE Technical Conference
Atlanta, GA
Contact: Marge Smith
SAMPE, P.O. Box 613, Azusa, CA 91702 (213-334-1810)

25-28 Oct. 1982

Fourth International Conference on Composite Materials
Tokyo, Japan
Contact: Prof. T. Hayashi
c/o Japan Society for Composite Materials
Business Center for Academic Societies Japan
2-4-16, Yayoi, Bunkyo-ku, Tokyo 113, Japan

15-17 Dec. 1982

ASTM-ASME-ASM-SAE Symposium on Multiaxial Fatigue
San Francisco, CA
Contact: Kathy Green
ASTM, 1916 Race Street, Philadelphia, PA 19103 (215-299-5414)

ASTM Symposium on the Long-Term Behavior of Composites Williamsburg, VA, 9-10 March 1982

9 March 1982

Session I—Time-Dependent Behavior

Session Chairman: F. W. Crossman
Lockheed Palo Alto Research Lab
Palo Alto, CA 94304

- 8:45 a.m. Introductory Remarks—Symposium Chairman
T. K. O'Brien, USARTL (AVRADCOM), NASA
Langley Research Center, Hampton, VA
- 9:00 a.m. "Bolt Clampup Relaxation in a Graphite/Epoxy
Laminate" by K. N. Shivakumar and J. H. Crews,
Jr., NASA Langley Research Center, Hampton,
VA
- 9:30 a.m. "A Numerical Procedure for Predicting Creep and
Delayed Failures in Laminated Composites" by
D. A. Dillard, University of Missouri, Rolla, MO
and H. F. Brinson, VPI&SU, Blacksburg, VA
- 10:00 a.m. Break
- 10:30 a.m. "Damage and Failure in Carbon Fibre Reinforced
Epoxy Resin" by A. R. Bunsell, D. Laroche, and
D. Valentin, Ecole Nationale Supérieure des
Mines de Paris, France
- 11:00 a.m. "Effects of Stress Ratio, Frequency, and Loading
Time on the Tensile Fatigue of Glass Reinforced
Plastics" by J. F. Mandell and U. Meier, MIT,
Cambridge, MA
- 11:30 a.m. "Effect of Load Frequency and Layup on Fatigue
Life of Composites" by C. R. Saff, McDonnell-
Douglas Corp., St. Louis, MO
- 12:00 noon Lunch

Session II—Fatigue Behavior

Session Chairman: T. K. O'Brien
U.S. Army R&T Laboratory (AVRADCOM)
NASA Langley Research Center
Hampton, VA 23665

- 1:30 p.m. "Compression Fatigue Damage in Thick, Notched
Graphite Epoxy Laminates" by N. F. Black and
W. W. Stinchcomb, VPI&SU, Blacksburg, VA
- 2:00 p.m. "Fatigue Damage Mechanisms in Thick Graphite/
Epoxy Laminates" by D. A. Ulman and J. E.
Masters, General Dynamics, Fort Worth, TX
- 2:30 p.m. "Effect of Low Velocity Impact Damage on the Fa-
tigue Behavior of Graphite/Epoxy Laminates"
by R. L. Ramkumar, Northrop Corp., Hawthorne,
CA
- 3:00 p.m. Break
- 3:30 p.m. "Long-Term Fatigue Behavior of Composite Lam-
inates" by K. L. Reifsnider, J. E. Masters, J. C.
Duke, and K. Schulte, VPI&SU, Blacksburg, VA
- 4:00 p.m. "Modeling Metal Matrix Composite Degradation
Due to Fatigue" by W. S. Johnson, NASA Langley
Research Center, Hampton, VA

10 March 1982

Session III—Long-Term Environmental Effects

Session Chairman: P. Shyprykevich
Grumman Aerospace Corp.
Bethpage, Long Island, NY 11714

- 9:00 a.m. "Corrosion and Corrosion-Fatigue of Several Silicon
Carbide/Aluminum Composites in a Marine En-
vironment" by D. A. Davis and M. G. Vassilaros,
David W. Taylor Naval Ship R&D Center, Annap-
olis, MD
- 9:30 a.m. "Environmental Influences on Transverse Failure
Mechanisms of Graphite/Epoxy Composites" by
L. L. Clements, San Jose State University, San
Jose, CA and M. J. Adamson, NASA Ames Re-
search Center, Moffett Field, CA
- 10:00 a.m. Break
- 10:30 a.m. "A Concept of the Thermal Spike Damage Mechan-
ism in Graphite/Epoxy Composites" by M. J.
Adamson, NASA Ames Research Center, Moffett
Field, CA
- 11:00 a.m. "The Distribution of Absorbed Moisture in Graph-
ite-Epoxy After Real-Time Environmental Cycl-
ing" by J. Whiteside, R. DeIasi, and R. Schulte,
Grumman Aerospace Corp., Bethpage, Long Is-
land, NY
- 11:30 a.m. "Thermal Aging of Graphite/Polyimide Composites"
by J. B. Nelson, NASA Langley Research Center,
Hampton, VA
- 12:00 noon Lunch

Session IV—Reliability and Life Prediction

Session Chairman: H. T. Hahn
Washington University
St. Louis, MO 63130

- 1:30 p.m. "A Residual Strength Degradation Model for Compet-
ing Failure Modes" by J. M. Whitney, Materials
Laboratory, AFWAL, Wright-Patterson AFB, OH
- 2:00 p.m. "Load Sequence Effects on Graphite/Epoxy [$\pm 35^\circ$]_{2s}
Laminates" by J. N. Yang and D. L. Jones, George
Washington University, Washington, DC
- 2:30 p.m. "The Role of Fatigue Data Scatter in the Certifica-
tion of Composite Airframe Structures" by R. S.
Whitehead and M. G. Schwarz, Northrop Corp.,
Hawthorne, CA
- 3:00 p.m. Break
- 3:30 p.m. "Prediction of Long-Term Failure in Kevlar Com-
posites" by F. P. Gerstle, Jr., Sandia National Lab-
oratories, Albuquerque, NM
- 4:00 p.m. "Effect of Matrix Composition on Stiffness and Fa-
tigue Properties of Fiber Reinforced Epoxy Pre-
pregs" by M. Farioli, P. Rossi, G. Samanni, V.
Wagner, and C. Zanotti, Giovanni Agusta, Gal-
larate, Italy
- 4:30 p.m. Adjourn

Composites Technology Review

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