Composites Contents

Listing of current literature of interest to the composite community as a service to our readers.

Introduction

In this section, the relevant portions of the tables of contents of current journals which publish composites articles will be reproduced. The entire tables of contents will be reproduced for dedicated composites journals, but in order to conserve space and reduce printing costs, only the composites-related contents of non-dedicated journals will be reproduced. At this time, permission to reproduce the tables of contents has been granted by the following journals:

- AIAA Journal
- Composite Science and Technology
- Composite Structures
- Composites
- Computers and Structures
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- Experimental Techniques
- International Journal of Analytical and Experimental Model Analysis
- International Journal of Cement Composites
- International Journal of Fracture
- International Journal of Solids and Structures
- Journal of Adhesion
- Journal of Applied Mechanics
- Journal of Composite Materials
- Journal of Engineering Materials and Technology
- Journal of Materials Science
- Journal of Reinforced Plastics and Composites
- Journal of Sound and Vibration
- Journal of Testing and Evaluation
- Mechanics of Composite Materials
- Polymer Composites
- SAMPE Journal
- SAMPE Quarterly
- Shock and Vibration Digest

The editor welcomes suggestions for improvements to "Composite Contents," although library acquisition and accessibility may prevent some additions to the list of journals surveyed.

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AIAA Journal

Vol. 27, No. 7, July 1989

Recent Advances in Analysis of Laminated Beams and Plates Part I: Shear Effects and Buckling—R. K. Kapania and S. Raciti, pp. 923–946

Recent Advances in Analysis of Laminated Beams and Plates Part II: Vibrations and Wave Propagation—R. K. Kapania and S. Raciti, pp. 935–946

Nonlinear Forced Vibration of Orthotropic Rectangular Plates Using the Method of Multiple Scales—H. Eslami and O. A. Kandil, pp. 955–960

Two-Mode Nonlinear Vibration of Orthotropic Plates Using the Method of Multiple Scales—H. Eslami and O. A. Kandil, pp. 961–967

Response of Moderately Thick Laminated Cross-Ply Composite Shells Subjected to Random Excitation—I. Elishakoff, G. Cederbaum, and L. Librescu

Vol. 27, No. 8, Aug. 1989

Flutter Analysis of Cantilever Composite Plates in Subsonic Flow—K.-J. Lin, P.-J. Lu, and J.-Q. Tarn, pp. 1102–1109

Vibrational Characteristics of Composite Panels with Cutouts—A. S. Bicos and G. S. Springer, pp. 1116–1141

Vol. 27, No. 9, Sept. 1989

Failure of Compression-Loaded Multidirectional Composite Laminates—M. J. Shuart, pp. 1274–1279

Vol. 27, No. 10, Oct. 1989

Buckling and Postbuckling of Laminated Composite Plates with Ply Dropoffs—M. T. DiNardo and P. A. Lagace, pp. 1392–1398

Degradation of Mechanical Properties of Advanced Composites Exposed to Aircraft Environment—W. J. Horn, F. M. Shaikh, and A. Soeganto

Dynamic Analysis for Free Vibrations of Rotating Sandwich Tapered Beams—C. L. Ko, pp. 1425–1433

Transverse Shear Deformation in Orthotropic Cylindrical Pressure Vessels Using a Higher-Order Shear Theory—S. T. Dennis and A. N. Palazotto, pp. 1441–1464

Vol. 27, No. 11, Nov. 1989

Transient Response of Graphite/Epoxy and Kevlar/Epoxy Laminates Subjected to Impact—D. S. Cairns and P. A. Lagace, pp. 1590–1596

Closed-Form Solutions for Arbitrary Laminated Anistropic Cylindrical Shells (tubes) Including Shear—R. A. Chaudhuri and K. R. Abu-Arja, pp. 1597–1605

Vibration Analysis of Composite Turbopropellers Using a Nonlinear Beam-Type Finite-Element Approach—J. B. Kosmatka and P. P. Friedman, pp. 1606–1614

Comments on "Stresses and Rate of Twist in Single-Cell Thin-Walled Beams with Anisotropic Walls"—W. T. Tsai, p. 1658

Composite Structures

Vol. 12, No. 1, 1989

Problems of Dynamic Buckling of Antisymmetric Rectangular Laminates—V. Birman, pp. 1–16

Vibrations of Orthotropic Triangular Plates—S. K. Malhotra, N. Ganesan, and M. A. Veluswami, pp. 17–26

Analysis of Hybrid Effect in Unidirectional Composites under Longitudinal Compression—L. N. Yao and T.-W. Chou, pp. 27–38

Geometrical Effects in the Low Velocity Impact Response of CFRP—W. J. Cantwell and J. Morton, pp. 39–60

Experimental Collapse Determination of Cylindrical Composite Panels with Large Cutouts under Axial Load—A. N. Palazotto and T. W. Tisler, pp. 61–78

Vol. 12, No. 2, 1989

A Shear-Deformable, Doubly-Curved Finite Element for the Analysis of Laminated Composite Structures—J. P. Fuehne and J. J. Engblom, pp. 81–96

Random Vibrations of Laminated Plates Modeled Within the First Order Shear Deformation Theory—G. Cederbaum, I. Elishakoff and L. Librescu, pp. 97–112

Vibration Studies for Simply Supported Symmetrically Laminated Retangular Olates—A. W. Leissa and Y. Narita, pp. 113–132

Buckling Analysis of Composite Laminates—Y. J. Lee, H. J. Lin and C. C. Lin, pp. 133–148

Vol. 12, No. 3, 1989

Effect of Shear Deformation on Bending of Bimodular Composite-Material Plates—F. Gordaninejad, pp. 161–170

Transverse Shear Effects in Stability Problems of Laminated Shallow Shells—A. Muc, pp. 171–180

Nonlinear Problems of Parametric Vibrations of Imperfect Laminated Plates—V. Birman and H. Zahed, pp. 181–192

Layup Optimization and Sensitivity Analysis of the Fundamental Eigenfrequency of Composite Plates—J. L. Grenestedt, pp. 193–210

High-Order Analysis of Generally Symmetrical Laminated Plates under Transverse Loading—J. T. Mottram, pp. 211–238

Vol. 12, No. 4, 1989

Analysis of Viscoelastic Laminated Composite Plates—J. Aboudi and G. Cederbaum, pp. 243–256

Thermal Postbuckling Analysis of Laminated Composite Plates by the Finite Element Method—L.-Wen. Chen and L.-Yi. Chen, pp. 257–270

A Study on the Effect of Bending-Twisting Coupling on Buckling Strength—J. L. Grenestedt, pp. 271–290

Thermoelastic Assessment of Damage Growth in Composites—R. Jones, M. Heller, D. Lombardo, S. Dunn, J. Paul, and D. Saunders, pp. 291–314

Vol. 13, No. 1, 1989

Impact Response of Tough Carbon Fibre Composites—J. Morton and E. W. Godwin, pp. 1–20

Buckling of Edge-Damaged Filament-Wound Composite Cylindrical Shells under Combined Toirsional/Axial Loads—Y. Stavsky, J. B. Greenberg and M. Sabag, pp. 21–34

Buckling of Thick Layered Composite Plates under In-Plane Moment Loading—G. Singh, Y. V. K. Sadasiva Rao and N. G. R. Iyengar, pp. 35–48

Non-Destructive Testing of Sandwich Constructions Using Thermography—M. Vikstrom, J. Backlund and K.-A. Olsson, pp. 49–66

Computer Aided Design for Composite Structures—S. V. Hoa, B. H. Journeaux and L. DiLalla, pp. 67–80

Vol. 13, No. 2, 1989

Recent Studies on the Behaviour of Interference Fit Pins in Composite Plates—T. S. Ramamurthy, pp. 81–100

The Influence of Varying Projectile Mass on the Impact Response of CFRP—W. J. Cantwell and J. Morton, pp. 101–114

Correlation Between Stress and Strain Based Polynominal Failure Criteria—W. Zhang and K. E. Evans, pp. 115–122

Study on Flexural Vibration of Triangular Composite Plates Influenced by Fibre Orientation—K. M. Liew, K. Y. Lam, and S. T. Chow, pp. 123–132

Observations on Bolted Connections in Composite Structures—I. H. Marshall, W. S. Arnold, J. Wood, and R. F. Mousley, pp. 133–152

Composites

Vol. 20, No. 4, July 1989

Effect of the Properties of the Constitutents on the Fatigue Performance of Composites: A Review—O. Konur and F. L. Matthews, pp. 317–328

Influence of Fatigue Damage on Tensile Creep Properties of Short Carbon Fibre Reinforced Nylon-6-Plastic—E. Jinen, pp. 329–340

The Effects of Thermal and Hygrothermal Ageing on the Failure Mechanisms of Graphite-Fabric Epoxy Composites Subjected to Flexural Loading—S. Birger, A. Moshonov and S. Kenig, pp. 341–348

New Material Models for Nonlinear Stress-Strain Behaviour of Composite Materials—G. Abu-Farsakh, pp. 349–360

Vol. 20, No. 5, Sept. 1989

Vol. 20, No. 6, Nov. 1989

Composites Science and Technology

Vol. 35, No. 1, 1989

Vol. 35, No. 2, 1989

Vol. 35, No. 3, 1989

Influence of Temperature and Moisture on Total Strain Energy Release Rates Associated with Edge Delamination of Composite Test Coupons—U. Schanz and G. Kress, pp. 219–235

Effect of Forming Temperature on the Properties of Polymeric Diaphragm Formed Thermoplastic Composites—C. M. O'Bradaigh and P. J. Mallon, pp. 235–256

Nonlinear Creep Deformation Analysis of a Radiation-Cured Wood-Polymer Composite—F. Y. C. Boey, pp. 257–272

A Note on Analytical Representation of Anisotropic Viscoelastic Constitutive Equations for Fiber-Reinforced Composites—R. J. Stango, S. S. Wang and C. R. Nelson, pp. 273–282

Effects of Fibre Bridging on G_{IC} of a Unidirectional Glass/Epoxy Composite—X. N. Huang and D. Hull, pp. 283–300

Measurement of Initation Values of G_{IC} in IM6/PEEK Composites—P. Davies, W. Cantwell and H. H. Kausch, pp. 301–314

Vol. 35, No. 4, 1989

Resin Impregnation During Composites Manufacturing: Theory and Experimentation—J. P. Coulter and S. I. Guceri, pp. 317–330

Probabilistic Strength Analyses of Interlaminated Hybrid Composites—H. Fukunaga, T.-W. Chou and H. Fukuda, pp. 331–346

A Material Model for the Finite Element Analysis of Metal Matrix Composites—J. F. Wu, M. S. Shephard, G. J. Dvorak and Y. A. Bahei-El-Din, pp. 347–366

End Corrections for Orthotropic DCB Specimens—J. G. Williams, pp. 367–376

Ply Cracking and Property Degradations of Symmetric Balanced Laminates Under General In-Plane Loading—Y. M. Han and H. T. Hahn, pp. 377–398

Vol. 36, No. 1, 1989

Electronic Properties of Carbon Fiber Reinforced Gypsum Plaster—D. D. L. Chung and Q. J. Zheng, pp. 1–6

A Model for Unidirectional Composites in Longitudinal Tension and Compression—F. J. Guild, P. J. Davy and P. J. Hogg, pp. 7–26

Amplitude and Counts per Event Analysis of the Acoustic Emission Generated by the Transverse Cracking of Cross-ply CFRP—J.-P. Favre and J.-C. Laizet, pp. 27–44

Failure of a Laminated Composite Under Tension-Compression Fatigue Loading—A. Roten and H. G. Nelson, pp. 45–62

Load and Failure Analyses of CFRP Laminates by Means of Electrical Resistivity Measurements—K. Schulte and C. Baron, pp. 63–76

The Effects of Matrix Complex Moduli on the Dynamic Properties of CFRP Laminate—T. A. Willway and R. G. White, pp. 77–94

An Electrical and Microstructural Study of Composite Films of a Carbon Black in Polyimide—K. H. Norian and U. Reick, pp. 95–98

Vol. 36, No. 2, 1989

Failure Modes and Damage Accumulation in Laminated Composites with Free Edges—C. T. Herakovich, pp. 105–120

Residual Stress Development During Processing of Graphite Epoxy Composites—K. S. Kim and H. T. Hahn, pp. 121–132

Spectroscopic Characterization of Interfaces in Polymer Composites—E. Occhiello, F. Garbassi, M. Morra and L. Nicolais, pp. 133–152

A Study of the Delamination Resistance of IM6/PEEK Composites—P. Davies, W. Cantwell, C. Moulin and H. H. Kausch, pp. 153–166

The Effect of Aging Conditions on the Mechanical Properties of Wood Fiber-Polystyrene Composites: I. Chemithermomechanical Pulp ad Reinforcing Filler—D. Maldas and B. V. Kokta, pp. 167–182

Vol. 36, No. 3, 1989

Creep-Fatigue Interactions in Glass Fibre/Polyester Composites—M. F. Crowther, R. C. Wyatt and M. G. Phillips, pp. 191–210

Complex Moduli of Aligned-Short-Fibre Reinforced Composites—R. Mao, pp. 211–226

An Extensible Modulus-Developing Polymer Composite—M. M. Pradas and R. D. Calleja, pp. 227–242

A Pratical Approach to Optimal Design of Laminated Cylindrical Shells for Buckling—G. Sun, pp. 243–254

A Physical Model of Nacre—A. P. Jackson, J. F. V. Vincent and R. M. Turner, pp. 255–266

The Computer Simulation of Rubber Components and Composites—G. Q. Liu and D. R. J. Owen, pp. 267–282

Computers and Structures

Vol. 31, No. 6, 1989

A Finite-Element Model for the Analysis of Thick, Anisotropic, Bimodular, Fibrous-Composite Plates—F. Gordaninejad, pp. 907–912

Sensitivity of Buckling Loads of Anisotropic Shells of Revolution to Geometric Imperfections and Design Changes—G. A. Cohen and R. T. Haftka, pp. 985–996

Post-Buckling Behaviour of Cylindrically Orthotropic Annular Plates with Uniform Internal Radial Load—G. V. Rao, N. K. Raju and N. V. R. Balabhaskar, pp. 1057–1060

Vol. 32, No. 1, 1989

An Alternative Analysis Model for Composite Wall-Beam Systems—M. Papia, pp. 149–156

A Finite Element for Modelling the Nonlinear Behavior of Shear Connectors in Composite Structures—A. G. Razaqpur and M. Nofal, pp. 169–174

Optimal Design of Laminated Composites Using a Modified Mixed Integer and Discrete Programming Algorithm—P. Hajela and C.-J. Shih, pp. 213–222

Engineering Fracture Mechanics

Vol. 34, No. 1, 1989

Delamination of Tapered Composite Structures—J. C. Fish and S. W. Lee, pp. 43–54
Fracture of Fibrous Metal Matrix Composites-. Experimental Results—G. J. Dvorak, Y. A. Bahei-El-Din and L. C. Bank, pp. 87–104
Fracture of Fibrous Metal Matrix Composites—II. Modeling and Numerical Analysis—Y. A. Bahei-El-Din, G. J. Dvorak and J.-F. Wu, pp. 105–124
Stiffness Reduction Analysis of Cracked Cross-Ply Laminates by Using Integral Equation Approach—B. Jia-Min, pp. 245–252
The General Solution to an Orthotropic Infinite Plate with a Bent Crack Under an Arbitrary Anti-Plane Shear Stress—X. S. Zhang and Y. Zhang, p. 263

Vol. 34, No. 2, 1989

A Fracture Control Plan for Composite Structures—W. C. Kim and C. K. H. Dharan, pp. 305–324
Mixed-Mode Crack Growth in Anisotropic Media—E. E. Gdoutos, D. A. Zacharopoulos and E. I. Meletis, pp. 337–346
An Improved Boundary Force Method for Analyzing Cracked Anisotropic Materials—P. W. Tan and C. A. Bigelow, pp. 347–358
Edge Crack in an Orthotropic Strip—A. Kumar and H. Parhi, pp. 368–378

Vol. 34, No. 3, 1989

A Simple Solution for the Stress Intensity Factor of a Flat Elliptical Crack in a Transversely Isotropic Solid—Z.-G. Zhang and Y.-W. Mai, pp. 645–648
On Evolution Laws of Anisotropic Damage—C. L. Chow and T. J. Lu, pp. 679–702
A New Criterion for Composite Material Mixed Mode Fracture Analysis—S. Q. Zhang, B. Z. Jang, B. T. Valaire and J. C. Suhling, pp. 749–770

Vol. 34, No. 4, 1989

Calculation of Stress Intensity Factors for Griffith Cracks in an Orthotropic Elastic Plate Using the Principle of Superposition— Z.-G. Zhang and Y.-W. Mai, pp. 803–814
Creep Damage Analysis and its Application to Non-Linear Creep of Reinforced Concrete Beam—L. Zhaoxia and Q. Jicheng, pp. 851–860
Computer Dimulation of Crack Propagation in Composite Materials — B. P. Landa and F. H. Olivares, pp. 909–916

Experimental Mechanics

Vol. 29, No. 2, June 1989

On the Relationship Between Impact Energy and Delamination Area — S. Hong and D. Liu, pp. 115–120
Thermographic Analysis of Stress Concentrations in a Composite—D. Zhang and B. I. Sandor, pp. 121–125
The Use of Stero X-Ray and Deply Techniques for Evaluation Instability of Composite Cylindrical Panels with Delaminations— A. Palazotto, G. E. Maddux and B. Horban, pp. 144–151
Strain-Field Analysis Acquired Through Correlation of X-Ray Radiographs of a Fiber-Reinforced Composite Laminate—S. S. Russell and M. A. Sutton, pp. 237–240

Vol. 29, No. 3, Sept. 1989

Stress-Optic Law in a Single Crystal and its Applications in Photo-Anisotropic Elasticity—T. Iwaki and T. Koizumi, pp. 295–299
Interfacial Transient Thermal Fracture of Adhesively Bonded Dissimilar Materials—K. Kokini and C. C. Smith, pp. 312–317
A New Bending Test Method of Advanced Composites—H. Fukuda, pp. 330–335
Wide-Band Measurement of Frequency-Dependent Viscoelastic Properties Using an Inverse Nyquist Plane Parameter Extraction Methodology—F. P. Suna and L. D. Mitchell, p. 350

Experimental Techniques

Vol. 13, No. 7, July 1989

Steel-Fiber Cementitious-Matrix Bond Studies at High Stress Rates—N. Banthia, M. Pigeon and J.-F. Trottier, pp. 19–22

Vol. 13, No. 9, Sept. 1989

Reusable Vacuum Bagging Technique for Autoclave Curing of Composites—F. Y. C. Boey, pp. 21–23

Vol. 13, No. 10, Oct. 1989

Manufacture of Composite Test Specimens for Delamination Studies—M. Sumich, pp. 20–22
Experimental Modal Analysis of Reinforced Concrete Structures—C. R. Farrar, pp. 27–31

International Journal of Fracture

Vol. 40, No. 1, May 1989

Weight Functions in Two-Dimensional Bodies with Arbitrary Anisotropy—T.-L. Sham and Y. Zhou, pp. 13–42
The Elastic-Perfectly Plastic Solution for Anitplane Problem of Crack in the Anistropic Plane in Elliptic Yield Surface, Hao-Tian-Hu, pp. 62–72

Vol. 40, No. 2, June 1989

Edge Cracks in a Laminated Cross-Ply Strip—R. L. Ryan and S. Mall, pp. 127–142
The Fracture Toughness of Particulate-Reinforced Ceramics—E. Smith, pp. R27–R30
Effect of Microstructure and Notch Root Radius on Fracture Toughness of an Aluminum Metal Matrix Composite—M. Manoharan and J. J. Lewandowski, pp. R31–R34

International Journal of Solids and Structures

The Journal of Adhesion

Photoacoustic FT-IR Analysis of Surface Modified Kevlar 49®Fibers—S. L. Tidrick and J. L. Koenig, pp. 43–52
Durability of Adhesion Between Metals and Polymers—W. Brockmann, pp. 53–62
Effects of Microwave Processing on Fiber-Matrix Adhesion in Composites—R. K. Agrawal and L. T. Drzal, pp. 63–80
Surface Preparation of Ti-6AI-4V for High Temperature Adhesive Bonding—H. M. Clearfield, D. K. Shaffer, S. L. Vandoren and J. S. Ahearn, pp. 81–102
Regeneration of Adhesive Bonding in Fiber/Resin Systems—B. Miller and U. Gaur, pp. 103–110
A Water Soluble Hydrated Metal Oxide Primer for Adhesively Bonded Joints—R. A. Pike and G. S. Golden, pp. 111–120
A Review of Certain Recent Work on the Durability of Aluminum Alloy Bonded with Epoxide and Phoenolic Adhesives—J. Comyn, pp. 121–130
Internal Stresses Adjacent to a Hole Through a Multilayer Wiring Board—K. H. G. Ashbee and D. A. Tossell, pp. 131–140
Osmosis and the Kinetics of Percolation of Petroleum Products Through an Epoxy Adhesive—K. H. G. Ashbee and J. P. Sargent, p. 141
Asymptotic Fields in Adhesive Fracture—R. S. Barsoum, pp. 149–166
On the Uniformity of Stresses in Some Adhesive Deformation Specimens—K. M. Liechti and T. Hayashi, pp. 167–192
The Adhesive Fracture Energy of Bonded Thermoplastic Fibre Composites—G. K. A. Kodokian and A. J. Kinloch, pp. 193–218
Application of the Island Blister Test for Thin Film Adhesion Measurement—M. G. Allen and S. D. Senturia, pp. 219–232
The Effects of Cure Conditions on the Relaxation Behavior of Thermosetting Adhesives—H. Jozavi and E. Sancaktar, pp. 233–244
A Preliminary Study of the Use of Kynar® Piezoelectric Film to Measure Peel Stresses in Adhesive Joints—D. A. Dillard, G. L. Anderson and D. D. Davis, Jr., pp. 245–256
Ultrasonic Evaluation of Adhesive Bonding—Y. Bar-Cohen, A. K. Mal and C.-C. Yin, p. 257

Journal of Applied Mechanics

Vol. 56, No. 2, June 1989

Cavity Formation at the Center of a Composite Incompressible Nonlinearly Elastic Sphere—C. L. Horgan and T. J. Pence, pp. 302–308
Dynamic Stability of Nonlinear Antisymmetrically-Laminated Cross-Ply Rectangular Plates—A. Tylikowksi, pp. 375–381
Transient Thermal Stresses in Cylindrically Orthotropic Composite Tubes—G. A. Kardomateas, pp. 411–417
Thermal Expansion of Three-Phase Composite Materials—G. J. Dvorak and T. Chen, pp. 418–422

Vol. 56, No. 3, Sept. 1989

A Anisotropic Hardening Rule for Elastoplastic Solids Based on Experimental Observations—F. Ellyin, pp. 499–507
Dynamic Modulus of Poroelastic Materials—A. Okuno and H. B. Kingsbury, pp. 535–540
Squeeze Film Behavior for Anisotropic Porous Rectangular Plates—A. B. Wheeler and R. Balasubramanyam, pp. 541–545
Environmental-Induced Expansion of Heterogeneous Media—K. Schulgasser, pp. 546–549
Line Inclusions in Anisotropic Elastic Solids—Q. Li and T. C. T. Ting, pp. 556–563
Three-Dimensional Transient Interlaminar Thermal Stresses in Angle-Ply Composites—Y. R. Wang and T.-W. Chou, pp. 601–608
Moderately Thick Angle-Ply Cylindrical Shells Under Internal Pressure—K. R. Abu-Arja and R. A. Chaudhuri

Journal of Composite Materials

Vol. 23, July 1989

Increasing Strength of Graphite/Epoxy Bolted Joints by Introducing an Adhesively Bonded Metallic Insert—S. Nilsson, pp. 642–650
Generic Buckling and Bending Behavior of Initially Stressed Antisymmetric Cross-Ply thick Laminates—I.-H. Yang, pp. 651–672
Influence of Transverse Shear Deformation on the Scaling of Cross-Ply Cylindrical Shells—K. R. Abu-Arija and R. A. Chaudhuri, pp. 673–694
Prediction of Transverse Cracking and Stiffness Reduction in Cross-Ply Laminated Composites—S. G. Lim and C. S. Hong, pp. 695–713
Strain-Energy Release Rate Analysis of Plates with Postbuckled Delaminations—J. D. Whitcomb and K. N. Shivakumar, pp. 714–734
Application of the Paris Equation to the Fatigue Growth of Transverse Ply Cracks—L. Boniface and S. L. Ogin, p. 735

Vol. 23, Aug. 1989

Analysis and Experimental Characterization of the Center Notch Flexural Test Specimen for Mode II Interlaminar Fracture—H. Maikuma, J. W. Gillespie, Jr. and J. M. Whitney, pp. 756–786
Moisture Absorption of Graphite/Polymer Composites Under 2000 Feet of Seawater—W. C. Tucker and R. Brown, pp. 787–797
Effect of Fiber Reinforcement Geometry on Single-Shear and Fracture Behavior of Three-Dimensionally Braided Glass/Epoxy Composite Pins—S. R. Malkan and F. K. Ko, pp. 798–818
The Characterization of Elastic Moduli and Damping Capacities of Graphite/Epoxy Composite Laminated Beams in Hygrothermal Environments—C. Y. Lee, M. Pfeifer, B. S. Thompson and M. V. Gandhi, pp. 819–845
Fracture Properties of Particle Filled Polymer Composites—C. Vipulanandan and N. Dharmarajan, p. 846

Vol. 23, Sept. 1989

Three-Dimensional Analysis of a Post Embedded Delamination—J. D. Whitcomb, pp. 862–889
Modeling of 3-D Angle-Interlock Textile Structural Composites— T. J. Whitney and T.-W. Chou, pp. 890–911

Vol. 23, Oct. 1989

Vol. 23, Nov. 1989

Vol. 23, Dec. 1989

Journal of Materials Science

Vol. 24, No. 5, May 1989

Stress Transfer in Single-Fibre Composites: Effect of Adhesion, Elastic Modulus of Fibre and Matrix, and Polymer Chain Mobility—E. M. Asloun, M. Nardin and J. Schultz, pp. 1835–1844

Vol. 24, No. 6, June 1989

Effect of Oxides on Binder Burnout During Ceramics Processing—S. Masia, P. D. Calvert, W. E. Rhine and H. K. Bowen, pp. 1907–1912

Effect of Absorbed Water, Temperature and Strain Rate on the Yield Strength of Two Methylmethacrylate-Based Plastics—P. J. Burchill, pp. 1936–1940

Crack Propagation in X-Al_2O_3/Mg Metal Matrix Composites—A. Magata and I. W. Hall, pp. 1959–1966

Internal Friction, Crack Length of Fracture Origin and Fracture Surface Energy in Alumina-Zirconia Composites—T. Ono, N. Nagata, M. Hashiba, E. Miura, Y. Nurishi and T. Shimada, pp. 1974–1978

Strength Coefficients of the Cubic Criterior for Graphite Composites—C. L. D. Huang, pp. 1979–1983

Residual Stresses and the Optimum Cure Cycle for an Epoxy Resin — J. Hodges, B. Yates, M. I. Darby, G. H. Wostenholm, J. F. Clemmet, T. F. Keates, pp. 1984–1990

Some Tensile Properties of Metal-Metallic Glass Laminates—Y. Leng and T. H. Courtney, pp. 1006–2010

Graphite-Epoxy Laminates with Almost Null Coefficient of Thermal Expansion Under a Wide Range of Temperature—T. Ishikawa, H. Fukunaga, and K.-I. Ono, pp. 2011–2017

Damage Analysis of a Crack Layer—J. Botsis, pp. 2018–2024

Interfaces with Controlled Toughness as mechanical Fuses to Isolate Fibres from Damage—V. Gupta, A. S. Argon and J. A. Cornie, pp. 2031–2040

Spherulitic Morphology of the Matrix of Thermoplastic PEEK/Carbon Fibre Aromatic Polymer Composites—D. J. Blundell, R. A. Crick, B. Fife, J. Peacock, A. Keller and A. Waddon, pp. 2057–2064

Oxidation of Silicon Nitride in Wet Atmosphere—M. Maeda, K. Nakamura and T. Ohkubo, pp. 2120–2126

Crystallization Studies of ZrO_2=SiO_2 Composite Gels—V. S. Nagarajan and K. J. Rao, pp. 2140–2146

Lifetime Statistics for Single Graphite Fibres in Creep Rupture—D. S. Farquhar, F. M. Mutrelle, S. L. Phoenix and R. L. Smith, pp. 2151–2164

The Mechanical Behavior of Polyimide-Copper Laminates Part 1, Locus of Failure Studies—A. J. Kinloch and M. L. Yuen, pp. 2183–2190

Mechanical Properties of Polyoxymethylene Whiskers/ Polyoxymethylene Resin Composite Films—M. Shimomura, Y. Maeda and Y. Tanabe, pp. 2245–2249

Rubber Toughening of Plastics, Part 12 Deformation Mechanisms in Toughened Nylon 6.6—C. B. Bucknall, P. S. Heather and A. Lazzeri, pp. 2255–2261

Vol. 24, No. 7, July 1989

The Origin of the "Crack Tip" Mode of Failure in Boron Filaments — F. E. Wawner and J. W. McCoy, pp. 2305–2308

Diffusion of Moisture into Two-Phase Polymers. Part 2. Styrenated Polyester Resins—P. M. Jacobs and F. R. Jones, pp. 2343–2347

Stability to Moisture from Chemically Vapour-Deposited Boron Nitride—T. Matsuda, pp. 2353–2357

Mechanisms of Stable Crack Growth in Ductile Polycarbonate—P. S. Theocaris and V. Kytopoulos, pp. 2358–2368

Short-Rod Elastic-Plastic Fracture Toughness Test Using Minature Specimens—C. T. Wang and P. M. Pilliar, pp. 2391–2400

A Predictive Model for Particulate Filled Composite Materials. Part 2 Soft Particles—F. J. Guild and R. J. Young, pp. 2454–2460

The Effect of the Environment on the Tensile Strength of Fluorozirconate Glass Fibres—J. S. Sanghera, D. Reinker and J. D. MacKenzie, pp. 2473–2477

Effect of Stress State and Microstructural Parameters on Impact Damage of Alumina-Based Ceramics—L. H. L. Louro and M. A. Meyers, pp. 2516–2532

Interfacial Role and Properties in Model Composites: Fracture Surfaces by Scanning Electron Microscopy—J. D. Miller, H. Ishida and F. H. J. Maurer, pp. 2555–2570

Toughening mechanisms in Elastomer-Modified Epoxies. Part 3 The Effect of Cross-Link Density—R. A. Pearson and A. F. Yee, pp. 2571–2580

Vol. 24, No. 8, Aug. 1989

Some Theoretical Considerations of the Surface Tension of Liquid Metals for Metal Matrix Composites—J. E. Schoutens, pp. 2681–2686

Carbon Fibres Coated with Titanium Carbide Using the Liquid Metal Transfer Agency Technique—D. D. Himbeault, R. A. Varin and K. Piekarski, pp. 2746–2750

Morphology Change in Carbons Prepared from Pitch-Polyvinylchloride Mixtures Under Pressure—M. Inagaki, M. Urata and M. Sakai, pp. 2781–2786

Craze Yielding and Fracture Mechanism in PE/PS/PE Laminated Films Part 2 Post-yielding, Craze Advance and Fracture—C. X. Zhu, S. Umemoto, N. Okui and T. Saki, pp. 2787–2793

In Situ Production of Polyethylene Fibres from Polymer Blends—F. Ehtaiatkar, M. J. Foles, and S. C. Steadman, pp. 2808–2814

The Tensile Failure of Brittle Matrix Composites Reinforced with Unidirectional Continuous Fibres—R. W. Davidge and A. Briggs, pp. 2815–2819

Comparison Between Acoustic and Mechanical Tapping Methods for Assessing the Interfacial States of Bone Implants—T. Kaneko, pp. 2820–2825

The Role of Non-Cozonal Twinning in the Growth of Fibrous Silicon in Strantium-Modified Al-Si Eutectic—M. Shamsuzzoha and L. M. Hogan, pp. 2849–2859

The Distribution of Graphitic Microcrystals and the Sensitivity of their Raman Bands to Strain in SiC Fibres—R. J. Day, V. Piddock, R. Taylor, R. J. Young and M. Zakikhani, pp. 2898–2902

Curing Studies of Epoxy System with Fillers—H. E. Pingsheng and L. Chune, pp. 2951–2956

Vol. 24, No. 9, Sept. 1989

Carbon Film from Polyphenylene Prepared by Electrochemical Polymerization—Y. Yamada, T. Furuta, M. Shiraishi, M. S. Sato and K. Kaeriyama, pp. 3113–3117

Vol. 24, No. 10, Oct. 1989

Vol. 24, No. 11, Nov. 1989

Journal of Reinforced Plastics and Composites

Vol. 8, No. 4, July 1989

Test Methods and Performance of Structural Core Materials-1. Static Properties—K. A. Feichtinger, pp. 334–357
Non-Isothermal, Multi-Layer Coextrusion Flow in Circular and Annular Dies—Y. H. Shu, S. J. Chen and J. S. Cheng, pp. 358–369
Design Procedures for Fiber Composite Box Beams—C. C. Chamis and P. L. N. Murthy, pp. 370–397
Elastodynamic Tailoring of Motion Conversion Mechanisms by Using Fiber Reinforced Composites—J. C. Prucz, J. D'Acquisto and J. Smith, pp. 398–409
Mechanical Response of Aramid/Epoxy under Tensile, Compressive and Shear Loading—M.-J. Pindera, Z. Gurdal, C. T. Herakovich, J. S. Hidde and J. M. Starbuck, p. 410

Vol. 8, No. 5, Sept. 1989

Dynamic Dielectric Analysis for Nondestructive Cure Monitoring and Process Control—D. Kranbuehl, P. Haverty, M. Hoff, R. D. Hoffman and J. J. Godfrey, pp. 422–431
Impact Resistance of Composite Sandwich Plates—M. L. Bernard and P. A. Lagace, pp. 432–445
Transverse Stress Calculations for Laminated Composite Shell Structures Using Plate/Shell Finite Element Formulations—J. J. Engblom, J. P. Fuehne and J. M. Hamdallah, pp. 446–457
Interlaminar Shear Stresses in Composite Laminates Due to Static Indentation—B. V. Sankar, pp. 458–471
An Analytical Model for Estimating the Coefficient of Thermal Expansion of Random Fiber Reinforced Composites—S. Yalvac and E. M. Tatistcheff, pp. 472–483

Journal of Sound and Vibration

Vol. 132, No. 1, 8 July 1989

Effect of Damping and Stiffness on the Random Vibration of Non Linear Periodic Plates—P. G. Reinhall and R. N. Miles, pp. 33–42

Vol. 132, No. 8, 8 Aug. 1989

Transverse Vibrations and Stability of Polar Orthotropic Circular Plates: High-Level Relationships—D. J. Gunaratnam and A. P. Bhattacharya, pp. 383–392
Theoretical Analysis of a Multi-Layered Tin Shell Coupled with Piezoelectric Shell Acturators for Distributed Vibration Controls—H. S. Tzou and M. Gadre, pp. 433–450

Vol. 133, No. 1, 22 Aug. 1989

On the Impulsive Loading of Muscle Fibres—G. Eason, pp. 163–172

Vol. 133, No. 2, 8 Sept. 1989

Dynamic Response of Viscoelastic Laminated Plates—G. Cederbaum and J. Aboudi, pp. 225–238

Vol. 134, No. 1, 8 October 1989

Vibrations of Unsymmetrically Laminated Plates Analyzed by Using a Higher Order Theory with a C° Finite Element Formulation—T. Kant and Mallikarjuna, pp. 1–16
Free Vibration of an Orthogonally Stiffened Cylindrical Shell, Part 1: Discrete Line Simple Supports—N. S. Bardell and D. J. Mead, pp. 29–54
Free Vibration of an Orthogonally Stiffened Cylindrical Shell, Part II: Discrete General Stiffeners—N. S. Bardell and D. J. Mead, pp. 55–72

Journal of Testing and Evaluation

Vol. 17, No. 4, July 1989

A Comparision of Test Methods for Shear Properties of the Cores of Sandwich Constructions—D. J. O'Connor, pp. 241–246

Vol. 17, No. 5, Sept. 1989

Morphological Structures in Analysis and Inspection of Hole Quantity in Fiber Composites—N. C. Griswold, W. A. Massarweh and C. L. Hough, pp. 281–286
The Concept of Filament Strength and the Weibull Modulus—S. van der Zwaag, pp. 292–298

Vol. 17, No. 6, Nov. 1989

A Technique to Evaluate the Bonding Reactivity of Thermosetting Adhesives—P. E. Humphrey and D. Zavala, pp. 323–328

Mechanics of Composite Materials

Vol. 24, No. 5, Sept.-Oct. 1988

Correlation Between the Physicomechanical Properties and Structural Parameters of Rolivsan-Type Binders Cured by Thermal and Catalytic Methods—S. V. Lukasov, B. A. Zaitsev, I. V. Kenunen, T. E. Sukhanova, D. M. Nasledov, S. L. Garkavi and A. V. Sidorovich, pp. 573–578
Conditions of the Ductile-Brittle Transition in Failure of Polymer Materials—Y. P. Zezin, pp. 579–584
Fatigue of Laminated Composites with Various Reinforcement Systems 1. Experimental Results—V. A. Limonov, V. G. Perevozchikov and V. P. Tamuzh, pp. 585–594
Effect of the Orientation of the Reinforcement in Dissipative Heating and Deformability of Viscoelastic Composites on Cyclic Loading—Y. I. Dimitrienko and V. A. Limonov, pp. 595–601
Effect of the Geometry of the Structure on the Strength Distribution of Multilaminate Tridirectional Reinforced Plastics—M. R. Gurvich and A. M. Skudra, pp. 602–609
Effect of the Porosity and Filling of Pores with Polystyrene and Polmethyl Methacrylate on the Compression Behavior and Impact Viscosity of Carbonized Materials Based on Polyvinyl Alcohol— V. K. Zabukas, R. Y. Andryulaitene and A. N. Machyulism, pp. 610–613
Calculation of Parameters of the Network Structure Stimulated by Infrared Laser Radiation in a Composite Component Based on Polyphenylene Oxide—V. V. Korshak, E. E. Saud-Galiev, L. N. Nikitin, A. A. Askadskii, A. P. Krasnov, I. A. Gribova and G. L. Slonimskii, pp. 614–621

Polymer Composites

Vol. 10, No. 3, June 1989

Vol. 10, No. 4, Aug. 1989

Vol. 10, No. 5, Oct. 1989

SAMPE Journal

Vol. 25, No. 4, July-August 1989

Vol. 25, No. 5, Sept.-Oct. 1989

Vol. 25, No. 6, Nov.-Dec. 1989

Vol. 20, No. 4, July 1989

Vol. 21, No. 1, Oct. 1989

World of Composites

News articles and announcements of interest to the composites technical community

Editor's Note

It goes without saying that the World of Composites has expanded tremendously during the ten years that the *Journal of Composites Technology & Research* has been published. It is my hope to reflect these changes in an expanded World of Composites section in the Journal. In addition to reporting composites activities within ASTM Committees D-30, E-24, and E-9, we hope to regularly summarize activities of the other societies concerned with composite materials. We will begin in this issue with notes on the American Society for Composites and the Suppliers of Advanced Composite Materials Association. Similarly, recognizing that universities are centers of composite material technology, we hope to routinely review their programs. The Center for Composite Materials at the University of Delaware has submitted a program summary for this issue. In closing, I would like to take this opportunity to solicit news articles and announcements for the future issues of the Journal.

John E. Masters, Co-Editor

ASTM Committee D-30 Best Paper Presentation Award

This is the first Committee D-30 Best Paper Presentation Award. This recognition of the "best" presentation is intended to encourage all the speakers to prepare their presentations to be the best possible, thus resulting in a better symposium. The recipient of the award is selected based upon evaluations of all the symposium speakers by at least three members of the audience.

Dr. P. Sriram is the recipient of this first award for his presentation of the paper entitled "Fracture Analysis of Transverse Crack-Tip and Free Edge Delamination in Laminated Composites," which was co-authored by Prof. E. A. Armanios and Mr. A. Badir. The paper was presented at the Third Symposium on Composite Materials: Fatigue and Fracture held 6–7 Nov. 1990 at Lake Buena Vista, FL, and chaired by Dr. T. K. O'Brien. Below is a short abstract of the winning paper and a brief article about the authors. Congratulations for a job well done!

Fracture Analysis of Transverse Crack-tip and Free Edge Delmaination in Laminated Composites

E. A. Armanios,[1] *P. Sriram*[1] *and A. Badir*[1]

Summary: Delamination is a predominant failure mode in continuous fiber reinforced laminated composite structures. Based on the location and direction of growth, there are two distinct types of delamination, namely, free edge delamination and local or transverse crack-tip delamination. In many cases, both types occur concurrently with varying levels of interaction. In this paper, a shear deformation model including hygrothermal effects is developed for the analysis of local delaminations originating from transverse cracks in 90° plies located in and around the laminate mid plane. A sublaminate approach is used and the model is combined with previously developed edge delamination shear deformation models. Hygrothermal effects are included in all the models to make realistic predictions of experimental behavior. The unified code is applied to $(\pm 25/90_n)_s$ T300/934 Graphite/Epoxy laminates for n values between 0.5 and 8. Critical loads and delamination modes are identified and found to be in agreement with published experimental results as shown in Fig. 1.

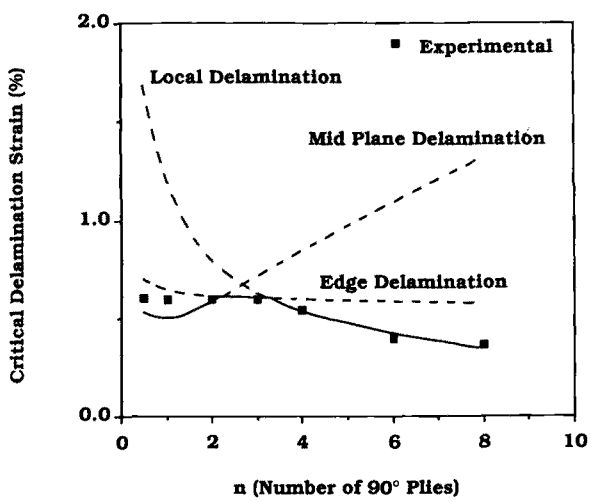

FIG. 1—*Critical delamination strains for* $(\pm 25/90_n)_s$ *T300/934 graphite epoxy specimen.*

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About the Authors

E. A. Armanios is an Assistant Professor of Aerospace Engineering at the Georgia Institute of Technology, Atlanta, Georgia (Fig. 2). His research interests are in the areas of modeling, stress analysis and failure processes of advanced composite structures. P. Sriram is a Post Doctoral Fellow in the School of Aerospace Engineering at the Georgia Institute of Technology and works in the areas of analysis and testing of composite structures and the development of sensing techniques for structural response measurements. A. Badir is a Ph.D. candidate in Aerospace Engineering at the Georgia Institute of Technology. His research interests are in the field of stability of structures, damage characterization and failure modes in laminated composites.

FIG. 2—*E. A. Armanios (left), P. Sriram (center), and A. Badir (right), winners of the ASTM Committee D-30 Best Presentation Award.*

ASTM Composites Activities

Committee D-30 on High Modulus Fibers and Their Composites

This committee has been chartered by ASTM to develop standards, sponsor symposia, stimulate research, and exchange technical information pertaining to fibers having a Young's modulus greater than 20 GPa (3 × 106 psi) and composites fabricated from these fibers. It recently completed a very successful meeting on 24–27 April in San Francisco, CA. Significant progress was made on each of the committee's mandates. Details of the committee's activities will be reviewed below.

Tenth Symposium on Composite Materials: Testing and Design

Dr. Glenn C. Grimes of Lockheed Aeronautical Systems organized and chaired this two day symposium, which served as the focal point for the committee meeting. A total of 33 papers were presented in the eight sessions that comprised the symposium. A variety of topics were addressed. They included: Damage, Flaws, and Repair; Interlaminar Fracture; Quality Assurance and Process Control; Structure Certification; Compression Testing; and Failure Criteria.

Dr. James M. Whitney of the Materials Laboratory at the Air Force's Wright Aeronautical Laboratory delivered the keynote address titled "Reflections on Development of Test Methods for Advanced Composites."

A Special Technical Publication featuring all the papers presented in the symposium will be issued by ASTM.

Subcommittee D30.02

This subcommittee houses several task groups and study groups that address current and long-range composite material testing problems. In addition to the symposia, a large amount of technical information is transferred during these working group meetings. Brief summaries of the individual group's progress are as follows.

Interlaminar Fracture Toughness (Chairman: Kevin O'Brien)

This task group was originally organized in 1981 to evaluate candidate interlaminar fracture toughness measurement test methods by conducting interlaboratory "round-robin" test programs. Several test methods have been evaluated. These include the Double Cantilever Beam (DCB) test for Mode I, the End-notched Flexure (ENF) test for Mode II, and the Edge Delamination Tension (EDT) test and the Cracked Lap Shear (CLS) tests for mixed Mode I and Mode II delamination. Tests were conducted on graphite reinforced composites with matrices that ranged from brittle epoxy (AS4/3501-6), to toughened epoxy (AS4/BP 907), to tough thermoplastics (AS4/PEEK). Several issues were resolved after two rounds of testing for the pure mode (DCB and ENF) tests. However, it was clear that several critical issues remained.

A third round of testing was initiated in Nov. 1989. Because of the growing interest in these test methods around the world, this next round will be conducted as an international round robin with the European Group on Fracture (EGF), and the Japanese Industrial Standards (JIS) group. ASTM, EGF, and JIS representatives set up a timetable for conducting DCB tests on AS4/PEEK in 1990. The DCB test protocol and test specimens have been sent to the participants. A similar timetable will be established for conducting ENF tests. Furthermore, a Mixed Mode Bending (MMB) test for characterizing mixed Mode I and II delamination has been proposed. Analysis indicates that it is more promising than either of the two mixed mode tests evaluated in previous round-robin tests. The MMB test will also be included in the international round robin.

The task group's charter was recently expanded to include delamination fatigue characterization. A fatigue round robin is currently underway using the Mode I (DCB) specimen. The recommended procedures for obtaining *G-N* curves for delamination onset characterization have been mailed to participants. Test specimens are to follow shortly. The ultimate goal of all these round-robin programs is to develop ASTM, and hopefully international, test standards for measuring interlaminar fracture toughness.

Compression Testing (Chairman: Paul Lagace)

The task group is currently developing five draft standards for the compression testing of composite materials. Round-robin testing has been initiated on two of the methods; the remaining three

will be underway soon. The progress of each of the efforts was reviewed at the last meeting. Bill Davis of 3M presented data from the Modified D 695 Test Specimen evaluation. Considerable variation existed on the data, and further statistical analysis will be required. Preliminary results of the open hole compression test specimen evaluation were reviewed by Steve Lubowinski of BASF. Further analysis will also be required on these data. Specimens required for the compression after impact tests are still being fabricated but should be distributed to participating labs before the next meeting. Crystal Newton reported that transverse compression of filament wound cylinders test specimens would, likewise, be distributed to investigators shortly. The laminate compression study group decided to adopt the draft standard from the open hole compression study as a working document for its work. They will initiate round-robin testing in the near future. This group will also discuss the use of 0/90 laminates to generate lamina properties at the next meeting. Results of a MIL-HDBK-17 Committee study will be reported at that time. As a final note, the thick (that is, >0.5 in. [12.7 mm]) laminate compression method written by Gene Camponeschi of NSRDC/Annapolis will be sent to Subcommittee D30.04 for development as a standard practice.

Specimen Preparation (Chairman: Richard Hall)

Under Mr. Hall's direction, this group has completed work on a document titled "Specimen Preparation through Data Reduction of Aramid, Carbon, and Glass Composite Test Laminates." The document addresses the necessary steps required to assure proper preparation of composite laminates. It specifically addresses techniques required when curing prepregs via autoclave or press techniques. The preparation and testing of laminates are modeled in a 15 step process that extends from laminate lay-up and cure to test operation and data reporting. The document will be sent to Subcommittee D30.04 for balloting to the membership. Once the document has been reviewed and accepted, it will be offered as a guideline. James Ferrell of Hercules will assume Mr. Hall's duties and usher the document through the review process.

Metal Matrix Composites (Chairman: Steven Johnson)

Details of the task group's round-robin test program were finalized during the past meeting. The tests are scheduled to begin in the late fall or early winter. Silicon carbide (SCS-6) fiber reinforced titanium (B21s) matrix specimens, donated by the National Aerospace Plane (NASP) program and Textron Specialty Materials, will be studied. At least six laboratories will be involved. Each laboratory will conduct tension and fatigue tests on unnotched specimens consisting of three lay-ups ([0], [0/90], and $[0/+45/-45/90]_s$). Tests will be conducted at room temperature and 900°F (482°C). Dave Harmon on McDonnell Aircraft is the round-robin coordinator. Paul Bartolott of NASA-Lewis Research Center is in charge of the tension tests; Steve Russ of the Air Force is heading the fatigue effort.

Fractography and Failure Analysis (Chairman: John Masters)

Ms. Pat Stumpff of the Materials Laboratory at Wright Aeronautical Laboratory presented a seminar summarizing the Air Force/FAA sponsored work in this area. She discussed a series of logic networks called Failure Analysis Networks that have been developed to aid the investigator in conducting an investigation of a failed composite component. Several case studies that demonstrated the application of the networks were also presented. Details of this work are contained in Air Force Reports AFWAL-TR-86-4137, AFWAL-TR-86-4033, and AFWAL-TR-87-4011.

Bolt Bearing Tests (Chairman: Thomas Bitzer)

This newly formed task group held its first meeting to define the scope of its efforts. It decided to consider both restrained and unsupported test procedures. Three test methods currently proposed by SACMA, the MIL-HDBK-17 committee, and by the Air Force will be investigated and discussed at the next meeting.

NDE/NDI Techniques (Chairman: Don Petit)

A planning session was held to define the scope of the task group. The group's objectives as defined at that meeting are to evaluate NDE techniques to determine physical properties, quality, and damage in composite materials. The group will also draft standards, procedures, and practices and will contribute its input to D-30 activities as related to NDE. Having considered the draft of a test method to measure composite resin content via ultrasonic NDE, the task group established the framework for round-robin testing. Test results may be available by the next meeting.

International Standards Coordination (Co-chairmen: David Adkins, Rod Martin)

This new study group has been set up to harmonize ASTM and international standards and test methods. Current ASTM and international standards will be reviewed and any noncompatibilities will be flagged. Noncompatabilities may be minor, such as terminology, specimen dimensions, etc., or major such as type of test used, data reported, etc. The study group will modify the current ASTM standard to encompass the minor discrepancies between methods. A dialogue with the key personnel responsible for the international standard will be set up to resolve major differences.

Volunteers who would be willing to review ASTM and international standards are urged to contact either of the study group's co-chairmen. Participation will involve reviewing two or three standards from Europe, Japan, ISO, and ASTM, detailing the differences, and, if required, participating in panel discussions to resolve the differences. Contact either Dr. David Adkins, E. I. DuPont, Composites Division, P.O. Box 6100, Newark, DE 19714-6100, Tel. (302) 733-8275, or Dr. Rod Martin, Mail Stop 188E, NASA Langley Research Center, Hampton, VA 23665-5225, Tel. (804) 864-3482.

Subcommittee D30.04

As indicated in the Spring issue of the Journal, this subcommittee is given the responsibility of developing and administering the committee's test methods, specifications, and standard guidelines. Committee actions at the last meeting included the review of comments received from the balloting of five standard test methods: D 3529, Standard Test Method for Resin Solids Content of Carbon Fiber-Epoxy Prepreg; D 3530, Standard Test

Method for Volatiles Content of Carbon Fiber-Epoxy Prepreg; D 3039, Standard Test Method for Tensile Properties of Fiber-Resin Composites; D 3410, Standard Test Method for Compressive Properties of Unidirectional or Crossply Fiber-resin Composites; and D 3518, Standard Practice for Inplane Shear Stress-Strain Response of Unidirectional Reinforced Plastics. Two of the methods, 3529 and 3530, passed this concurrent subcommittee and committee balloting and will be sent for society balloting. Negative votes on the remaining three standards, however, were found to be persuasive. These methods will be returned to the subcommittee for rewriting. Negative votes were also found persuasive on the proposed V-Notch Shear Test method, which had been submitted to ballot previously. It too will be sent back to the subcommittee for rewriting.

In addition to the work described above, several other standard test methods are being revised and rewritten. Major revisions are being prepared on D 4018, Standard Test Methods for Tensile Properties of Continuous Filament Carbon and Graphite Yarns, Strands, Rovings, and Tows, on D 3800, Standard Test Method for Density of High-Modulus Fibers, and on D 4255, Standard Guide for Testing Inplane Shear Properties of Composite Laminates. Actions are also underway to rewrite and potentially consolidate D 3171, Standard Test Method for Fiber Content of Resin-Matrix Composites by Matrix Digestion, and D 3553, Standard Test Method for Fiber Content by Digestion of Reinforced Metal Matrix Composites. The Standard Terminology of High-Modulus Reinforcing fibers and Their Composites, D 3878, is also under revision.

The subcommittee also accepted transfer of three test method/guideline activities, Mode I Delamination, Open Hole Tension, and Specimen Preparation, from D30.02. D30.04 will begin preparing the draft procedures developed by the D30.02 task groups for balloting.

Future Symposium: Damage in Composites: Nov. 1990

ASTM Subcommittee D-30 and the American Society for Composites will jointly sponsor a symposium titled Damage Detection and Quality Assurance in Composite Materials on 13–14 Nov. in San Antonio, TX. Eighteen papers are planned for the one and a half day symposium that will focus on the application of NDE techniques to identify defects and the use of this information to assess material response. Information on a variety of NDE techniques, composite materials and defects will be presented. The effects of porosity, impact, and fatigue were monitored in graphite and glass reinforced composites. X-Ray tomography was applied to metal matrix and organic matrix composites. Ceramic matrix composites were examined via acousto-ultrasonics and scanning acoustic microscopy. More information on this symposium is available from Symposium Chairman John Masters, Mail Stop 188E, NASA Langley Research Center, Hampton VA 23665-5225, Tel. (804) 864-3478 or from Steve Mawn, ASTM, 1916 Race Street, Philadelphia, PA 19103-1187, Tel. (215) 299-5521.

Committee E-9 on Fatigue

As indicated in the Spring 1990 issue, composites activities in this committee are based in subcommittee E9.03. This subcommittee, which is titled Fatigue of Advanced Materials, is headed by M. R. Mitchell of Rockwell International. Subcommittee E9.03 is concerned primarily with the thermal mechanical and multiaxial fatigue and lifetime predictions of heat resistant materials such as metal matrix and ceramic matrix composites. A number of standards writing and research activities are planned.

Round-Robin Testing

The subcommittee is planning round-robin testing of aluminum matrix silicon carbide whisker reinforced metal matrix composites, Al-SiCw(orientated), in conjunction with E24.07. E9.03 will conduct a series of low cycle fatigue tests on this material to determine if ASTM E 606 is applicable to whisker reinforced aluminum. In addition, the committee will conduct a damage analysis investigation. The loading and unloading moduli, peak stresses, etc., will be monitored throughout the fatigue cycling to assess damage. The ultimate objective is to ascertain if E 606 is applicable to metal matrix composites and to compare contemporary damage and the continuum damage model for these materials.

Future Symposium: Fatigue and Fracture of Advanced Materials, Nov. 1990

Plans have been finalized for the Symposium on Cyclic Deformation, Fracture, and Nondestructive Evaluation of Advanced Materials which will be jointly sponsored by E9, E24, and D30. The symposium will be held on 12–13 Nov. 1990 in San Antonio, TX. A total of 21 papers will be presented during the 1½ day long symposium. Topics to be covered include fatigue of alumina, directionally solidified superalloys, ceramic matrix composites, and metal matrix composites. Papers discussing the deformation and fracture of oriented polypropylene, aluminum-lithium, ceramics, and ceramic matrix composites will also be presented. The final session of the symposium will concentrate of NDE techniques. These papers will discuss the application of ultrasonics, acoustic emission, and acousto-ultrasonic techniques to metal matrix, and ceramic matrix composites. More information on this symposium is available from Symposium Chairman M. R. Mitchell, Rockwell International Science Center, 1049 Camino Dos Rios, Thousand Oaks, CA 91360, 805/373-4173; Otto Buck, Iowa State University, Ames Laboratory, 126 Materials Division, Ames, IA 50011, 515/294-4446; or from Patrick Barr, ASTM, 1916 Race Street, Philadelphia, PA 19103-11187, 215/299-5449.

Fall Meeting Agenda

In addition to the symposium, E9.03 will be conducting a subcommittee meeting in November. The status of the round-robin testing will be reviewed at that time. Further information may be obtained from M. R. Mitchell or Patrick Barr. Future directives will be established and various subcommittees will be established within this relatively new subcommittee at that time.

Committee E-24 on Fracture Testing

Subcommittee E24.07 on the Fracture of Advanced Materials, chaired by Noel Ashbaugh of the University of Dayton Research Institute, houses the composites materials activities within this committee. The committee has undertaken two initiatives to in-

vestigate the application of fracture mechanics to composites. Translaminar fracture and fatigue crack growth in composites are being studied.

Task Group E24.07.02 on the Translaminar Fracture of Advanced Materials is specifically charged with promoting research and developing standard test methods to measure the translaminar fracture properties of advanced composites. John Underwood of the Army Armament Research, Development, and Evaluation Center heads this task group. This group is preparing to begin middle-notch tension, edge-notch tension, and edge-notch bend testing of carbon/epoxy, carbon/bismaleimide, and SiC/aluminum composites. Proposed analysis of these tests is to include characterization of load-displacement plots, development of K and displacement expressions, investigation of configuration and orientation effects, and assessment of damage and failure.

The task group conducted a panel discussion on 24 April 1990 in San Francisco to finalize test and analysis plans. Panel comments will be incorporated as fully as possible into the initial program, which will be ready for sign-up of participants at the next meeting in Nov. 1990 in San Antonio, TX.

Subcommittee E.24.07 also finalized the approach for a round-robin test program on silicon whisker reinforced aluminum alloy in the recently concluded meeting in San Francisco. One of the purposes of this program will be to evaluate the validity of the procedures in the current standards on fracture toughness (E399) and fatigue crack growth (E647) tests. Sixteen laboratories volunteered to participate in the program. Test information and instructions are being prepared and will be sent to the participants. The test material and specimens should be available by the next E-24 Committee meeting.

American Society for Composites

Introduction

The American Society for Composites (ASC) was founded in 1985 to provide a forum for organizing conferences, symposiums, and workshops to disseminate information about composite materials within the scientific and engineering communities. Particular emphasis is placed on the interdisciplinary nature of composite materials technology. According to 1990 ASC President Dick J. Wilkins (Director of the Center for Composite Materials at the University of Delaware and Professor of Mechanical Engineering), "The Society has a number of goals, all of them underpinned by a common theme—communication. ASC, as the only organization in the United States devoted strictly to composites, can play a strong role in linking other related societies in this country and in reaching out to similar organizations in Europe, Japan, and Canada."

In the five years since its inception, the Society has grown to almost 500 members. ASC is governed by an executive committee consisting of the officers (president, vice president, recording secretary, membership secretary, treasurer, and editor), the immediate past president, division/chapter chairmen, and two elected members at large.

Following are brief biographies of this year's president and vice president and a summary of the Society's 1990 Annual Meeting. The Executive Committee is finalizing ASC's strategic plan for the coming decade; an overview of the plan will appear in the next issue.

ASC Executive Profiles

1990 President Dick J. Wilkins

Dick J. Wilkins has been Director of the Center for Composite Materials (CCM) and Professor of Mechanical Engineering at the University of Delaware since 1986. He spent the earlier part of his career at the Fort Worth Division of the General Dynamics Corporation, developing methods for designing, analyzing, and testing composite structures. He was responsible for fatigue and fracture analysis and testing for the F-16 airplane's vertical and horizontal tails, which were the U.S. Air Force's first primary, safety-of-flight components to employ carbon-epoxy.

Trained as an aerospace engineer, Wilkins has recently focused his research interests on design integration, creativity, composites manufacturing science, durability and damage tolerance, and structural mechanics. He is the author of more than 35 papers and technical reports on these and other composites-related subjects. Wilkins has served on a number of advisory boards and review panels, including committees for the National Materials Advisory Board and the Congressional Office of Technology Assessment. He oversees CCM's design research group and has recently become very interested in the workings of the human brain, particularly with regard to education, creativity, and design.

1990 Vice-President James H. Starnes, Jr.

Jim Starnes holds B.S. and M.S. degrees in Engineering Mechanics from the Georgia Institute of Technology and a Ph.D. in Aeronautics from the California Institute of Technology. He has been an instructor in aeronautics at the U.S. Naval Postgraduate School and is now Assistant Chief of the Structural Mechanics Division at NASA Langley Research Center in Hampton, VA.

Jim's research interests include mechanics of composite structures, failure mechanisms and analysis, damage tolerance and containment, experimental mechanics, structural analysis, and structural optimization, design, and tailoring.

Society Holds Annual Meeting in Michigan

As this issue was going to press, ASC was finalizing plans for its annual meeting (12–14 June 1990) at Michigan State University in East Lansing, MI. The goal of the Society's Fifth Technical Conference, "Composite Materials in Transition," was to address the problems that must be solved for composite materials to make a successful transition from aerospace use to a wider variety of applications. Conference session topics follow:

- Vibration and Damping
- Joining, Fastening and Fabrication
- Interfaces
- Biotechnology and Composite Materials
- Processing I: Novel Methods
- Mechanics I: Experimental
- Toughness and Damage Tolerance

- Processing II: Control and Modelling
- Structural Mechanics
- Metal Matrix Composites
- Processing III
- Impact
- Contemporary Issues in Design
- Cementitious Composites
- Thermal Aspects of Composites
- Compression
- Ceramic Composites
- Non-Destructive Methods
- Mechanics II

The broad-based program was selected for its potential appeal to a diverse audience: engineers, scientists, academics, and technical personnel involved in research, processing, and manufacturing of composite materials in the aerospace, automotive, and related industries. According to Lawrence T. Drzal, General Chairman, "We hope that this comprehensive program will facilitate the transition of composites to a new and changing world environment."

For more information, please call 1-800-447-3549 or write to

American Society for Composites
Engineering Lifelong Education
A394 Engineering
Michigan State University
East Lansing, MI 48824-1226

Suppliers of Advanced Composite Materials Application

The **Suppliers of Advanced Composite Materials Association,** commonly known as SACMA, is a non-profit international trade association of manufacturers that produce materials used in the construction of fiber-reinforced products as well as composite parts manufacturers and other interested organizations that provide ancillary support and service to the advanced composite materials industry.

Headquartered in Arlington, VA, the Association's 1989 membership roster included 78 companies who in terms of supplier participation equates to 90 to 95% of all the heretofore. "Free World" capacity of advanced fibers and prepregs.

Although international in scope, SACMA's principal mission is **"To support growth of the U.S. advanced composites industry based on common, not competitive, interests."** The operative words are "common, not competitive, interests." SACMA is neither in the business of promoting specific products nor subverting corporate initiatives in emerging markets. SACMA is in the business of providing a forum to discuss common obstacles and opportunities plus effect desired changes in the industry via proactive committee outreach programs.

Recognizing that a few, functionally oriented committees provide a greater degree of freedom in responding to industry problems and in launching new Association initiatives, SACMA narrowed its committee focus to concentrate member company expertise in three general areas: Technical Affairs, Public Affairs, plus Environmental, Health & Safety.

Technical Affairs

This column will focus on the organization (Fig. 3), objectives, and current activities of SACMA's Technical Affairs Steering Committee.

SACMA's Technical Affairs Committee objectives are to promote industry standardization, to address technical issues that facilitate expansion and diversification of advanced composite materials usage, and to expand the advanced composites industry technical skill base.

Within the past two years, Committee activities have led to the following:

- Development of nine recommended mechanical test methods for testing composite materials. Currently, four of the nine recommended methods are undergoing round-robin testing under the auspices of ASTM D-30.
- Publication of a recommended practice for printing and applying bar code labels to harmonize identification of advanced composite prepregs and fibers, as well as other products sold by advanced composite materials suppliers.
- Preparation of a recommended method for lot acceptance of carbon fibers along with recommended test methods for density, mass per unit length, sizing content, twist and tow tensile. Earlier this year, SACMA transmitted draft copies of the recommended test methods to ASTM D-30 and encouraged their use in revising ASTM D-4018.
- Sponsorship, in cooperation with the Navy and National Institute of Standards and Technology (NIST), of a Workshop on "Fire Issues in U.S. Navy Applications of Composite Materials."
- Collection of information on continuing education courses in advanced composites for assimilation into a catalogue for use by the practicing professional.

Committee plans for 1990 call for finalizing a recommended test method for bearing strength; drafting recommended test methods related to physical and chemical properties of advanced composites, for example, flow, drape and tack, etc.; advocating a national plan for industrywide standardization of composite material characterization practices; responding to governmental rulemakings, for example, FAA, relative to the certification of

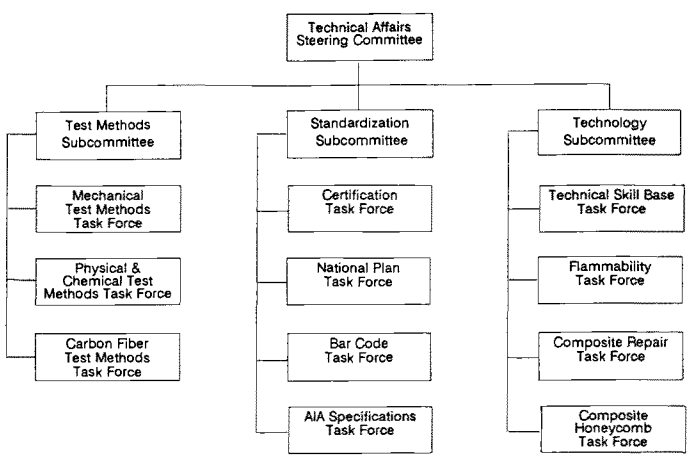

FIG. 3—*Organizational objectives for SACMA.*

advanced composites; coordinating development of composite repair guidelines with allied organizations, for example, SAE, IATA, etc.; and expanding familiarization with composite honeycomb design concepts.

In summary, that's what SACMA has done or plans to do in the technical affairs arena. For additional information on these activities, please contact Gigi Healy, SACMA Director of Public Affairs, at 1600 Wilson Boulevard, Suite 1008, Arlington, VA 22209; Telephone: (703) 841-1556.

Center for Composite Materials University of Delaware Research Highlights

Background

The University of Delaware's Center for Composite Materials (CCM) was founded in 1974 to address basic research issues in processing science, materials science, engineering mechanics, durability, and engineering design of composite materials. The goal of the program was to remove the fundamental science and engineering knowledge barriers blocking high-volume industrial use of composite materials. Basic research in the traditional thrust areas has since been augmented by work in several manufacturing science thrust areas. The two are highly interactive—designed to converge and provide the Center with a unique capability for conducting the basic research that combines engineering design and manufacturing science.

The following briefly summarizes work in CCM's five traditional and six manufacturing science research thrust areas. Because the work is highly cross-disciplinary, these categories have been designated largely for discussion purposes; most of the projects do not fit neatly into one category but instead bridge two or more of them. The Center for Composite Materials publishes an Annual Report and Poster Book that provide further information on its research programs.

Traditional Activities at CCM

The CCM has conducted research in the traditional areas of processing science, materials science, mechanics, durability, and design. This research provides a fundamental understanding of the behavior of composite materials and is frequently incorporated into the Center's work in manufacturing science.

Processing Science

The goal of the processing science research is to lay the engineering science foundation of the physical and chemical phenomena common to a wide variety of processing techniques. Research in reaction and crystallization kinetics, heat transfer, solidification, cure monitoring and modeling, and rheology has led to the development of process simulations and the design of better cure cycles. Accomplishments during the past several years include the development of flow models that predict fiber orientation states for polymer-matrix composites, a new understanding of processing-induced chemical gradients, and techniques for processing ceramic-matrix composites.

Materials Science

Research in materials science focuses on clarifying the relationships among processing, microstructure, and physical behavior. Work in predicting the stress-strain behavior of anisotropic short-fiber composites has been augmented by research dedicated to establishing structure-property relationships for strength and toughness and to modeling the electrical and thermal transport properties of these systems. Recent work has focused on characterizing the complex interphase region of thermoplastic composites, paving the way toward an understanding of how the interphase affects composite mechanical properties.

Engineering Mechanics

The goal of the work in engineering mechanics is to predict how structures will behave under actual service conditions. Capabilities in this area stem from an interdisciplinary research program that couples fundamental mechanical principles to process simulations and structure-property relationships. The Center's strategy enables the influence of processing on performance to be modeled and cure cycles to be optimized. Work has been done on a variety of materials, including thermosets and thermoplastics, thick and thin sections, and continuous, discontinuous, and textile reinforcements.

Durability

Work in durability is geared toward end-user concerns, including fatigue, fracture, failure, and long-term performance under service conditions. Delamination has been investigated as well as crack propagation, fracture toughness, and wear, and erosion behaviors. Recent efforts have focused on newer materials, including ceramics and three-dimensional fabric composites.

Engineering Design

The goal of the design work is to make the use of composites more cost-effective through simultaneous consideration of materials, configuration, and processing early in the design effort. Historically, this work has been aimed at integrating results from the other thrust areas in a manner that allows a designer to conduct benefit trade-off studies. Recent work has focused on paradigms for making critical decisions during the early design phase in light of uncertain and incomplete information.

Manufacturing Science Thrusts

CCM has defined manufacturing science as the fundamental understanding of manufacturing processes in terms of basic science and engineering disciplines. Thus, the work in the Center's six manufacturing thrust areas draws on the findings of the more fundamental research being conducted in the traditional areas.

Online Consolidation

Work in online consolidation is aimed at developing and understanding new techniques for the impregnation, placement, and consolidation of unidirectional reinforced tapes. The research has resulted in a technique that simultaneously impreg-

nates and consolidates thermoplastics, processes for in-situ consolidation of thermoplastics using laser and hot gas heating sources, and an interactive CAD package for filament winding.

Sheet Forming

Sheet forming is the most widely used method for producing curvilinear surfaces of complex geometries. Research is underway to make the technique usable with a variety of thermoplastic-based materials, including long discontinuous fiber sheets and commingled fabrics, as well as more traditional laminates laid-up from unidirectional prepregs. In addition to development of the diaphragm-forming process and identification of the acceptable range of processing parameters, a theoretical model has been developed to predict final part thickness, fiber volume fraction, and void content given the processing conditions.

Textile Preform Processing

Techniques developed for manufacturing textiles are being adapted for application to composite materials. Researchers are braiding and weaving advanced fibers, including ceramics, to make preforms of various geometric shapes. The work has resulted in the fabrication of 3-D structures that reduce delamination failures and enable production of near-net shape designs. The Center has also developed and applied for patents on new textile equipment.

Liquid Molding

Liquid molding—an inclusive term for RTM, RIM, SRIM, and other similar processes—involves forcing a low-viscosity resin into a mold containing a pre-placed reinforcement. The goal is to develop a rapid, reproducible, and verifiable manufacturing technology in this area. Recent developments include three-dimensional process models, as well as theoretical and experimental quantification of resin flow through the reinforcement.

Injection Molding

Injection molding has traditionally been used for low-cost, high-volume, net-shape manufacturing of parts made from short-fiber materials. CCM's work in this area has focused primarily on four issues: mold filling, resin cure or solidification, the final microstructure, and the properties of the molded component. Recently, a special interest has been developed to "long-fiber" compounds.

Joining

CCM's newest manufacturing thrust area, joining, has assumed increased importance as composites are used more extensively in automotive, military, and aerospace structural applications. Research includes investigation of various fusion bonding methods for thermoplastic composites and examination of the role of molecular mobility in the consolidation and bonding of composites. The work has already led to the development of several process models.

Call For Papers

4th Symposium on Composite Materials: Fatigue and Fracture

A call for papers is issued for the Fourth Symposium on Composite Materials: Fatigue and Fracture, sponsored by ASTM Committee D-30 on High Modulus Fibers and Their Composites. The symposium will be held 6–7 May 1991 in Indianapolis.

Previously unpublished papers are requested covering the Fatigue and Fracture of fiber reinforced composite materials, components, and structures. Topics of particular interest include:

- Failure Modes
- Failure/Instability Criteria
- Failure Analysis
- Evolution of Damage
- Micro/Macro Mechanics of Failure
- Nondestructive Inspection and Evaluation
- Damage/Performance Relationships
- Fatigue/Creep Interactions
- Life Prediction
- Damage Tolerance and Durability
- Test Methods
- Multiaxial Loading
- Environmental Effects
- High Temperature Composites
- Repair Criteria

Prospective authors are requested to submit a title, a 500 to 1000 word abstract with key figures, and an ASTM Paper Submittal Form by 6 Aug. 1990 to Dorothy Savini, ASTM, 1916 Race Street, Philadelphia, PA 19103. For additional paper submittal forms, call Ms. Savini at 215/299-5413. More information is available from Symposium Chairman Dr. Wayne Stinchcomb, Engineering Science and Mechanics Department, 227 Norris Hall, Virginia Tech, Blacksburg, VA 24061, 703/231-5316, FAX 703/231-9452.

A Special Technical Publication (STP) based on the symposium proceedings is anticipated by ASTM. Main authors will receive a complimentary copy of the volume(s) containing their papers. The main author is the author corresponding with the ASTM publication staff. All published authors may purchase reprints of the papers at cost.

Final manuscripts for the STP based on this symposium are due by 6 March 1991. This deadline will be rigidly enforced. All papers not submitted to ASTM by this deadline will not be accepted for the STP. If a paper is submitted after the deadline, it may be forwarded to the appropriate ASTM journal to be considered for publication. Please contact Dorothy Savini or the Symposium Chairman if you cannot meet the deadline. ASTM may print and distribute accepted abstracts with the approval of the chairman.

Creep and Fatigue of Metal Matrix Composites

A call for papers is issued for the Symposium on Creep and Fatigue of Metal Matrix Composites to be held 17–21 Feb. 1991 at New Orleans, LA, sponsored by the TMS Composite Materials Committee. Abstracts are due 31 July 1990.

This symposium will focus on recent developments that improve the theoretical and experimental understanding of creep and fatigue behavior in metal matrix composites (MMCs). Papers are solicited in the following areas: fatigue crack initiation and propagation, cyclic deformation, thermo-mechanical fatigue, creep deformation and fracture, and creep-fatigue interactions. The role of matrix microstructure and reinforcement volume fraction, size, type and morphology will also be explored. Papers detailing mechanistic studies, micromechemical and continuum mechanical modeling of creep elevated temperature deformation, and fatigue of MMCs are especially encouraged.

Submit abstracts on TMS Abstract Form D (3 copies) to:

Dr. John E. Allison
Room S2065, Sci. Res. Lab.
Ford Motor Co.
Dearborn, MI 48121
Telephone: 313 845-7224
FAX: 313 390-1710

or

Prof. J. Wayne Jones
Dept. of Materials Science and Engineering
University of Michigan
Ann Arbor, MI 48109
Telephone: 313 764-7503
FAX: 313 763-4788

Delaware Composites Design Encyclopedia, Volume One Published

The first volume is now available in a new six-volume design encyclopedia for advanced composite materials and components. The *Delaware Composites Design Encyclopedia* will provide users with basic knowledge about the design and analysis of composite materials and structures. It is intended for use by engineers, materials scientists, designers, and other technical personnel involved in the applications of composite materials to industrial products.

The material contained in the encyclopedia was written by international experts in the field and compiled at the University of Delaware's Center for Composite Materials (CCM). The CCM is supported by a university/industry consortium and several U.S. federal research agencies. The encyclopedia was originally offered as a special benefit to consortium members. It is now being offered for the first time to the composites community at large, in an updated and expanded format.

Volume 1/Mechanical Behavior and Properties of Composite Materials begins with a basic introduction to the roles and properties of the constituents and their relationship to the mechanics of composites. These sections provide the background information for more detailed subject matter on static strength and fatigue and elastic properties of continuous, discontinuous, and woven fabric composites. Authors of the first volume are Dr. H. Thomas Hahn, The Pennsylvania State University; Dr. Carl Zweben, General Electric Company; and Dr. Tsu-Wei Chou, University of Delaware.

According to Dr. Tsuyoshi Hayasi, Councillor (First President) of the Japan Society for Composite Materials, "The University of Delaware has compiled its Composites Encyclopedia with the same high standards as the research for which its Center for Composites has long been known."

The remaining volumes of the encyclopedia will be published during 1990. They are *Volume 2/Micromechanical Materials Modeling* (ISBN: 0-87762-699-5); *Volume 3/Processing and Fabrication Technology* (ISBN: 0-87762-701-0); *Volume 4/Failure Analysis of Composite Materials* (ISBN: 0-87762-702-9); *Volume 5/Design Studies* (ISBN: 0-87762-703-7); and *Volume 6/Test Methods* (ISBN: 0-87762-704-5). An *Index to Volumes 1-6* (ISBN: 0-87762-705-3) will also be published. The set is intended as an ongoing series, to which new volumes will be added as needs arise and new knowledge is gained. Each volume is Smythe sewn for years of library and desktop use.

Calendar on Composites

The following meetings may be of interest to researchers in the field of composite materials

26–28 June 1990
22nd National Symposium on Fracture Mechanics
Atlanta, GA
Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

27–30 June 1990
Advanced Structural Inorganic Composites
Montecatini Terme, Italy
Contact: 7th CIMTEC Satellite Symposium 2, PO Box 174, 48018 Faenza, Italy; Telephone: 546-664143

23–28 July 1990
4th International Congress on Computational and Applied Mathematics
K. U. Leuven, Belgium
Contact: R. Piessens, K.U. Leuven, Department of Computer Science, Celestijnenlaan 200A, B-3030 Heverlee, Belgium; E-MAIL: PIESSENS&CS.KULEUVEN.AC.BE
FAX: + + 32 16-20 53 08

29 July – 3 August 1990
International Conference on Advances in Structural Testing, Analysis and Design
Bangalore, India
Contact: Professor B. Dattaguru, Department of Aero Engineering, Indian Institute of Science, Bangalore 560 012, India; Telephone: 344411 EXT 2438, FAX: 0812-341683

1–3 August 1990
SEM: Experimental Mechanics for Composites
Blacksburg, VA
Contact: Society for Experimental Mechanics, Inc., 7 School Street, Bethel, CT 06801; Telephone: 203-790-6373, FAX: 203-790-1658

20–24 August 1990
9th International Conference on Experimental Mechanics
Copenhagen, Denmark
Contact: Vagn Askegaard, Afdelingen for Baerende Konstruktioner, Structural Engineering, Tech University of Denmark, Bldg. 118, DK 2800 Lyngby, Denmark

20–24 August 1990
3rd International Symposium on Advanced Composites in Emerging Technologies
Patras, Greece
Contact: Professor S.A. Paipetis, COMP'90 Symposium, P. O. Box 1134, 261 10 Patras, Greece

27–30 August 1990
2nd World Congress on Computational Mechanics
Stuttgart, Federal Republic of Germany
Contact: Conference Secretary, Institute for Computer Applications, Pfaffenwaldring 27, D-7000 Stuttgart 80, Federal Republic of Germany; FAX: 0711-685-3500

27–31 August 1990
Durability of Polymer Based Composite Systems for Structural Applications
Brussels, Belgium
Contact: Durability 90, Mrs. Bourlau, VUB-T.W. (KB), Pleinlaan, 2, B-1050 Brussels, Belgium; Telephone: 32/2/641.29.22 FAX: 32/2/641.2928

25–28 September 1990
ECCM-4 4th European Conference on Composite Materials: Eurocomposites and New Materials
Stuttgart, Federal Republic of Germany
Contact: DLR, Institut Fur Bauweisen und Konstruktionsforschung, Pfaffenwaldring 38-40, D-7000 Stuttgart 80/Federal Republic of Germany

1–5 October 1990
Eighth European Conference on Fracture
Torino, Italy
Contact: Conference Secretariat, IGF C/O Centro Congressi Internazionale C.SO Tassoni, 32 - 10143 Torino, Italy; Telephone: 39-(0)11-740625-761870, FAX: 39-(0)11-761640

10–12 October 1990
14th Polish Symposium on Experimental Mechanics of Solids
Jadwisin, Warsaw, Poland
Contact: Professor Jacek Stupnicki, DSC, Warsaw University of Technology, Nowowiejska 24, 00-665 Warszawa, Poland; Telex: 81 33 07, Telephone: 21 54 63, FAX: 21 68 92

16–18 October 1990
The 61st Shock and Vibration Symposium
Pasadena, CA
Contact: Dr. Ben K. Wada, Jet Propulsion Laboratory, Bldg. 157, Room 507, 4800 Oak Grove Drive, Pasadena, CA 91109; Telephone: 818-354-3600

12 November 1990
Symposium on Cyclic Deformation, Fracture, and Nondestructive Evaluation of Advanced Materials
San Antonio, TX
Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

12–13 November 1990
Fretting Fatigue Test Methods and Apparatus
San Antonio, TX
Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

13–14 November 1990
Symposium on Damage Detection and Quality Assurance
San Antonio, TX
Contact: Dorthy Savini, ASTM, 1916 Race St., Philadelphia, PA 19103; Telephone: 215-299-5431

13–15 November 1990
Symposium on Composites: Processing, Microstructure and Properties
Orlando, FL
Contact: Michael D. Sacks, Program Chair, Department of Materials Science and Engineering, 157 A Rhines Hall, University of Florida, Gainesville, FL

3–6 December 1990
EUROMECH 269; Experimental Identification of the Mechanical Characteristics of Composite Materials and Structures
St. Etienne, France
Contact: Professor A. Vautrin, Department of Mechanical and Materials Engineering, Ecole Des Mines De Saint-Etienne, 42023 St. Etienne Cedex 2, France

2–5 January 1991
The Second Pan American Congress of Applied Mechanics (PACAM II)
Valparaiso, Chile
Contact: Professor D. Mook, Department of Engineering Science and Mechanics, Virginia Tech, Blacksburg, VA 24061-0219, USA; Telephone: 703-231-6841

7–12 January 1991
Third International Conference on Constitutive Laws for Engineering Materials: Theory and Applications and Workshop on Innovative Use of Materials in Industrial and Infrastructure Design and Manufacturing
Tuscon, AZ
Contact: Professor Chandra S. Desai, Department of Civil Engineering Mechanics, University of Arizona, Tuscon, AZ 85721; Telephone: 602-621-2266, FAX: 602-621-2550

17–19 January 1991
Interfacial Phenomena in Composite Materials
Leuven, Belgium
Contact: Janet Miles, Conference Organiser, Butterworth Scientific Ltd., P. O. Box 63, Westbury House, Bury Street, Guildford, Surrey GU2 5BH, United Kingdom; Telephone: 0483 300966, TELEX: 859556 SCITEC G, FAX: 0483 301563

12–13 March 1991
Bonding and Repair of Composites II
Zurich, Switzerland
Contact: Kay Royle, Conference Coordinator, Rapra Technology Limited, Shawbury, Shrewsbury, Shropshire SY4 4NR, ENGLAND; Telephone: 0939-250383, FAX: 0939-251118

8–10 April 1991
AIAA/ASME/ASCE/AHS/ASC 32nd Structures, Structural Dynamics and Materials (SDM) Conference
Baltimore, MD
Contact: Ron Kollmansberger, 16761 Via Del Campo Court, San Diego, CA; Telephone: 619-592-2423

21–25 April 1991
(ICES '91) International Conference on Computational Engineering Science
Patras, Greece
Contact: ICES' 91 Secretariat, c/o Professor S. N. Atluri, Computational Mechanics Center, Georgia Institute of Technology, Atlanta, Georgia 30332-0356;

23–24 April 1991
Symposium on Constraint Effects in Fracture
Indianapolis, IN
Contact: Symposium Chairman E. M. Hackett, David Taylor Research Center, Code 2814, Annapolis, MD 21402; Telephone: 301-267-3755

Summer 1991
American Society of Composites 6th Technical Conference
Telephone: 513-255-9080

15–19 July 1991
The Eighth International Conference on Composite Materials (ICCM/VIII)
Honolulu, Hawaii
Contact: Profs. Stephen W. Tsai and George S. Springer, Department of Aeronautics and Astronautics, Stanford, University, Stanford, CA 94305; Telephone: 415-725-3305, FAX: 415-725-3377

7–9 October 1991
22nd Midwestern Mechanics Conference
Rolla, MO
Contact: Professor Romesh C. Batra, Department of Mechanical and Aerospace Engineering and Engineering Mechanics, University of Missouri-Rolla, Rolla, MO 65401-0249; Telephone: 314-341-4589

27 October – 1 November 1991
IUTAM Symposium on Local Mechanics Concepts for Composite Materials Systems
Blacksburg, VA
Contact: J. N. Reddy, Department of Engineering Science and Mechanics, Virginia Tech, Blacksburg, VA 24061-0219, USA; Telephone: 703-231-6744 FAX: 703-231-4574

1–6 December 1991
ASME Winter Annual Meeting
Atlanta, GA
Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

Summer 1992
6th US-Japan Conference on Composite Materials
San Diego, CA
Contact: Kenneth L. Reifsnider or M. W. Hyer, Department of Engineering Science and Mechanics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061-0219; Telephone: 703-231-5077 or 703-231-5372, FAX: 703-231-4574

Summer 1992
American Society of Composites 7th Technical Conference
Telephone: 513-255-9080

8–13 November 1992
ASME Winter Annual Meeting
Anaheim, MI
Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

28 November–3 December 1993
ASME Winter Annual Meeting
New Orleans, LA
Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

13–18 November 1994
ASME Winter Annual Meeting
Chicago, IL
Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

12–17 November 1995
ASME Winter Annual Meeting
San Francisco, CA
Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

17–22 November 1996
ASME Winter Annual Meeting
Atlanta, GA
Contact: ASME, 345 East 47th St., New York, NY 10017; Telephone: 212-705-7722

Send items for this calendar to:

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Virginia Polytechnic Institute and State University
Blacksburg, VA 24061-0219
Telephone: (703) 231-5372
FAX: (703)231-4574

Guest Commentary

Composites in Primary Aircraft Structures

Progress in the introduction of composite materials (for example, carbon fiber reinforced plastics) into engineering applications has been paced primarily by two key factors. They are our understanding of fundamental material characteristics and our ability to transfer this understanding into cost-effective structures. In high performance applications, such as commercial transport aircraft, composite materials are applied today in only secondary structures. These lightly loaded structures include control surfaces and vertical stabilizers. While these applications are significant, the big payoff for composites is in the primary wing and fuselage structures. Structural weight savings could be greater than 30%. Major advances in both our fundamental understanding of composites and in cost-effective structural concepts are required to achieve this benefit in future aircraft.

NASA initiated the Advanced Composites Technology Program in 1989 to address the key technical issues related to the application of composites in primary aircraft structures for subsonic transports. This is a joint government, industry, and university program with planned funding of about $150M over the next 5 years. The program has all of the essential ingredients of composite materials and structures research such as matrix resin technology and structural mechanics. However, innovative structural concepts are emphasized. They include structural concepts that take advantage of composite properties and that have the potential for cost-effective fabrication techniques. For example, woven textile structural forms offer one approach to cost effective structures. Such a process might use carbon fibers already coated with the matrix resin and woven into a structural part of near-net shape with the fibers in the proper orientation for structural load conditions. This could be a three-dimensional fiber structure to take care of out-of-plane loads—a serious shortcoming of planar composites. Composite cure could be done within structural forming tooling designed to provide the finished part shape. Several approaches of this type have the potential of achieving cost-effective aircraft structures. They will be included in the concept evaluation part of this program.

Supersonic transport aircraft offer another opportunity for the use of composites in primary aircraft structures. NASA is in the early phase of exploring the potential of an advanced supersonic transport aircraft with the aircraft industry. These exploratory studies emphasize overall economic feasibility including aircraft configurations, market potential, and environmental concerns. Systems studies have shown aircraft structural weight fraction to be a very strong economic driver and the potential benefits of composite structures look very attractive. Like the subsonic transport aircraft, cost-effective structural concepts will be a primary driver for composite applications in supersonic aircraft. Plans are being prepared to scope the technology program that would be required to develop an advanced supersonic transport operating in the March 2–3 range. They include both composite materials and structures technologies. Airframe operating temperatures of a supersonic transport (200 to 450°F [93 to 232°C]) will place a new demand on resin-matrix composites. Temperature and time dependent properties will be dominant for the 60 000 h life requirement. Most likely, a new resin-matrix composite will be required. Building the fundamental understanding and the required database in a new resin-matrix composite will be a very demanding task. Research directed toward meeting these materials requirements should be initiated in the near future.

Changes in composite structural configurations and in composite material requirements as outlined present new challenges for the technical community. These new composite structures with their multiple load paths may require new analysis methods. Failure modes may not be dominated by delamination. In some applications, thermal considerations may dominate structural designs. Time and temperature dependent properties will be of greater concern and significant advances in matrix-resins are required. Developing an integrated technology base is essential in order to realize the potential benefits of composites in engineering applications like subsonic and supersonic aircraft. Also, the development of this technology base is important to our continued technical leadership.

By Charles P. Blankenship

Mr. Blankenship graduated from Virginia Polytechnic Institute and State University with B.S. and M.S. degrees in Metallurgical Engineering. After a 3-year tour in the U.S. Air Force, he began his career with NASA at the Lewis Research Center in Cleveland, OH. From 1964 to 1980, he conducted and managed research in high-temperature materials for propulsion and power systems. In 1980, he was appointed Chief of the Materials Division at the NASA Langley Research Center in Hampton, VA. In this position, he managed the Center's research in the development of aircraft and spacecraft structural materials. He has been in his present position as Director for Structures at Langley since 1983. In this capacity, he manages the Center's research program in materials, structures, and acoustics.

NOTES