Microstructural Design of Fiber Composites

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References

Chapter 1

Ashby, M. F. (1987) 'Technology on the 1990s: advanced material and predictive design', *Phil. Trans. R. Soc. London,* **A322,** 393–407.

Bunsell, A. R. and Harris, B. (1974) 'Hybrid carbon and glass fiber composites', *Composites,* **5,** 157–64.

Chou, T. W. (1989) 'Flexible composites', *J. Mat. Sci.,* **24,** 761–83.

Chou, T. W. and Kelly, A. (1976) 'What we do not know about fiber composites', *Mat. Sci. Engr.,* **25,** 35.

Chou, T. W., Kelly, A. and Okura, A. (1985) 'Fiber reinforced metal matrix composites', *Composites,* **16,** 177.

Chou, T. W., McCullough, R. L. and Pipes, R. B. (1986) 'Composites', *Sci. Am.,* **255,** 192–203.

Clark, J. P. and Flemings, M. C. (1986) 'Advanced materials and the economy', *Sci. Am.,* **255,** 50–7.

Compton, W. D. and Gjostein, N. A. (1986) 'Materials for ground transportation', *Sci. Am.,* **255,** 92–100.

Congress of the United States, Office of Technology Assessment (1988) *New Structural Materials Technologies,* OTA-E-352, Washington, D.C.

Gordon, J. E. (1988) *The Science of Structures and Materials,* Scientific American Library, New York.

Humphrey, J. D. and Yin, F. C. P. (1987) 'A new constitutive formulation for characterizing the mechanical behavior of soft tissues', *Biophys. J.,* **52,** 563–70.

Kelly, A. (1985) 'Composites in context', *Comp. Sci. Tech.,* **23,** 171–200.

Kelly, A. (1987a) 'An outline of trends in materials science and processing', *Mat. Sci. Engr.,* **85,** 1–13.

Kelly, A. (1987b) 'Composites for the 1990's', *Phil. Trans. R. Soc. London,* **A322,** 409–423.

McCullough, R. L. (1985) 'Generalized combining rules for predicting transport properties of composite materials', *Comp. Sci. Tech.,* **22,** 3–21.

Mignery, L. A., Tan, T. M. and Sun, C. T. (1985) *The use of stitching to suppress delamination in laminated composites,* ASTM STP876, American Society for Testing and Materials, Philadelphia, PA, pp. 371–85.

Mody, P. B. and Majidi, A. P. (1987) 'Metal and ceramic matrix composites: the heat is on', *Composites in Manufacturing,* **3,** 1–5.

Nardone, V. C. and Prewo, K. M. (1988) 'Tensile performance of carbon-reinforced glass', *J. Mat. Sci.,* **23,** 168–80.

Port, O., King, R. W. and Hawkins, C. (1988) 'Materials that think for themselves', *Business Week,* December 5, pp. 166–7.

Rogers, C. A., ed. (1988) *Smart Materials, Structures, and Mathematical Issues,* Technomic Pub. Co., Lancaster.

Sousa, L. J. (1988) *Problems and Opportunities in Metals and Materials: An Integrated Perspective,* US Department of the Interior, Washington, D.C.

Steinberg, M. A. (1986) 'Materials for aerospace', *Sci. Am.*, **255,** 66–72.
Sun, C. T. (1989) 'Intelligent tailoring of composite laminates', *Carbon,* **27,** 679–87.
Takagi, T. (1989) 'A concept of intelligent materials in Japan', in *Proceedings of International Workshop on Intelligent Materials,* The Society of Non-Traditional Technology, Tokyo, Japan, pp. 1–10.
Vinson, J. R. and Chou, T. W. (1975) *Composite Materials and Their Use in Structures,* Elsevier-Applied Science, London.

Chapter 2

Aköz, A. Y. and Tauchert, T. R. (1972) 'Thermal stresses in an orthotropic elastic semispace', *J. Appl. Mech.*, **39,** 87–90.
Aköz, A. Y. and Tauchert, T. R. (1978) 'Thermoelastic analysis of a finite orthotropic slab'. *J. Mech. Eng. Sci.*, **20,** 65–71.
Ashton, J. E., Halpin, J. C. and Petit, P. H. (1969) *Primer on Composite Materials: Analysis,* Technomic, Westport, Connecticut.
Carlsson, L. A. and Pipes, R. B. (1987) *Experimental Characterization of Advanced Composite Materials,* Prentice-Hall, Englewood Cliffs, New Jersey.
Carslaw, H. S. and Jaeger, J. C. (1959) *Conduction of Heat in Solids,* Clarendon Press, Oxford.
Chamis, C. C. (1983) *NASA Tech. Memo 83320* (presented at the 38th Annual Conference of the Society of Plastics Industry (SPI), Houston, TX, Feb. 1983).
Chang, Y. P. (1977) 'Analytical solution for heat conduction of anisotropic media in infinite, semi-infinite and two-plane bounded regions', *Int. J. Heat and Mass Transfer,* **20,** 1019.
Chawla, K. K. (1987) *Composite Materials Science and Engineering,* Springer-Verlag, New York.
Cheng, C. M. (1951) 'Resistance to thermal shock', *J. Am. Rocket Soc.*, **21,** 147–53.
Chou, T. W. (1989a) 'Flexible composites', *J. Mat. Sci.*, **24,** 761–83.
Chou, T. W. (1989b) 'Elastic properties of laminates', *Concise Encyclopedia of Composite Materials,* Pergamon Press, Oxford, p. 159.
Christensen, R. M. (1979) *Mechanics of Composite Materials,* Wiley-Interscience, New York.
Chu, H. S., Weng, C. I. and Chen, C. K. (1983) 'Transient response of a composite straight fin', *ASME J. Heat Transfer,* **105,** 307–11.
Fukunaga, H. and Chou, T. W. (1988a) 'On laminate configurations for simultaneous failure', *J. Comp. Mat.*, **22,** 271.
Fukunaga, H. and Chou, T. W. (1988b) 'Simplified design techniques for laminated cylindrical pressure vessels under stiffness and strength constraints', *J. Comp. Mat.*, **22,** 1156–69.
Halpin, J. C. (1984) *Primer on Composite Materials Analysis,* Technomic Pub. Co., Lancaster, Pennsylvania.
Halpin, J. C. and Tsai, S. W. (1967) *Environmental Factors in Composite Materials Design,* Air Force Materials Laboratory Technical Report 67-423.
Hsu, P. W. and Herakovich, C. T. (1977) 'A perturbation solution for interlaminar stresses in bidirectional laminates', *Composite Materials Testing and Design (4th Conference),* ASTM STP 617, American Society for Testing and Materials, Philadelphia, pp. 296–316.
Hsu, P. W. and Herakovich, C. T. (1977) 'Edge effects in angle-ply composite laminates', *J. Comp. Mat.*, **11,** 422–8.
Huang, S. C. and Chang, Y. P. (1980) 'Heat conduction in unsteady, periodic, and steady states in laminated composites', *ASME J. Heat Transfer,* **102,** 742–8.

Jones, R. M. (1975) *Mechanics of Composite Materials,* McGraw-Hill, New York.
Jost, W. (1960) *Diffusion,* Academic Press, New York.
Katayama, K., Saito, A. and Kobayashi, N. (1974) 'Transient heat conduction in anisotropic solids', *Proceedings of the International Conference on Heat and Mass Transfer,* Tokyo, p. 137.
Kingery, W. D. (1955) 'Factors affecting thermal stress resistance of ceramic materials', *J. Am. Ceramic. Soc.,* **38,** 3–5.
Lo, K. H., Christensen, R. M. and Wu, E. M. (1977a) 'A higher-order theory of plate deformation. Part 1: Homogeneous plates', *J. Appl. Mech.,* **44,** 663–8.
Lo, K. H., Christensen, R. M. and Wu, E. M. (1977b) 'A higher-order theory of plate deformation. Part 2: Laminated plates', *J. Appl. Mech.,* **44,** 669–76.
Luo, J. and Sun, C. T. (1989) 'Global–local methods for thermoelastic stress analysis of thick fiber-wound cylinders', *Proceedings of the Fourth Technical Conference on Composite Materials, American Society for Composites,* Technomic Pub. Co., Lancaster, Pennsylvania, pp. 535–44.
Mossakowska, Z. and Nowacki, W. (1958) 'Thermal stresses in transversely isotropic bodies', *Archiv. Mech. Stosow,* **10,** (4), 569–603.
Noda, N. (1983) 'Transient thermal stress problem in a transversely isotropic finite circular cylinder under three-dimensional temperature field', *J. Thermal Stresses,* **6,** 57–71.
Nomura, S. and Chou, T. W. (1986) 'Heat conduction in composite materials due to oscillating temperature field', *Int. J. Engr. Sci.,* **24,** 643.
Ozisik, M. N. (1980) *Heat Conduction,* John Wiley and Sons, Inc., New York.
Pipes, R. B., Vinson, J. R. and Chou, T. W. (1976) On the hygrothermal response of laminated composite systems. *J. Comp. Mat.,* **10,** 129–48.
Poon, K. C. and Chang, Y. P. (1978) 'Transformation of heat conduction problems from anisotropic to isotropic', *Heat and Mass Transfer,* **5,** 215.
Reddy, J. N. (1984) 'A simple higher-order theory for laminated composite plates', *J. Appl. Mech.,* **51,** 745–52.
Reissner, E. (1945) 'Transverse shear deformation on the bending of elastic plates', *J. Appl. Mech.,* **2,** (2), 69–77.
Rosen, B. W. (1973). 'Stiffness of fibre composite materials', *Composites,* **4,** 16–25.
Sharma, B. (1958). 'Thermal stresses in transversely isotropic semi-infinite elastic solid', *J. Appl. Mech.,* **25,** 86–8.
Singh, A. (1960) 'Axisymmetric thermal stresses in transversely isotropic bodies', *Archiv. Mech. Stosow.,* **39,** (3), 287–304.
Stein, M. and Jegley, D. C. (1987) 'Effects of transverse shearing on the cylindrical bending, vibration, and buckling of laminated plates', *AIAA J.,* **25,** (1), 123–9.
Sugano, Y. (1979) 'Transient thermal stress in a transversely isotropic finite circular cylinder due to an arbitrary internal heat-generation', *Int. J. Engr. Sci.,* **17,** 729–39.
Sun, C. T. and Li, S. (1988) 'Three-dimensional effective elastic constants for thick laminates', *J. Comp. Mat.,* **22,** 629–39.
Takahashi, K. and Chou, T. W. (1988) 'Transverse elastic moduli of unidirectional fiber composites with interfacial debonding', *Met. Trans. AIME,* **19A,** 129.
Takeuti, Y. and Noda, N. (1978). 'A general treatise on the three-dimensional thermoelasticity of curvilinear aeolotropic solids', *J. Thermal Stresses,* **1,** 25–39.
Tauchert, T. R. and Aköz, A. Y. (1974) 'Thermal stresses in an orthotropic elastic slab due to prescribed surface temperatures', *J. Appl. Mech.,* **41,** 222–8.
Tsai, S.-W. and Hahn, H. T. (1980) *Introduction to Composite Materials,* Technomic, Westport, Connecticut.

Van Dyke, M. (1975) *Perturbation Methods in Fluid Mechanics*, The Parabolic Press, Stanford, California.

Vinson, J. R. and Chou, T. W. (1975) *Composite Materials and Their Use in Structures*, Elsevier-Applied Science, London.

Wang, H. S. and Chou, T. W. (1985) 'Transient thermal stress analysis of a rectangular orthotropic slab', *J. Comp. Mat.*, **19,** 424–42.

Wang, H. S. and Chou, T. W. (1986) 'Transient thermal behavior of a thermally and elastically orthotropic medium', *AIAA J.*, **24,** 664–72.

Wang, H. S., Pipes, R. B. and Chou, T. W. (1986) 'Thermal transient stresses due to rapid cooling in thermally and elastically orthotropic medium', *Met. Trans. A*, **17A,** 1051–5.

Wang, Y. R. and Chou, T. W. (1988) 'Three-dimensional analysis of transient interlaminar thermal stress of laminated composites', *Symposium on Mechanics of Composite Materials ASME AMD*, **92,** 185–92.

Wang, Y. R. and Chou, T. W. (1989) 'Three-dimensional analysis of transient interlaminar thermal stress of laminated composites', *J. Appl. Mech.*, **56,** 601.

Wang, Y. R. and Chou, T. W. (1991). 'Thermal shock resistance of laminated ceramic matrix composites', *J. Mat. Sci.* in press.

Whitney, J. M. (1972) 'Stress analysis of thick laminated composite and sandwich plates', *J. Comp. Mat.*, **6,** 426–40.

Whitney, J. M. and Pagano, N. J. (1970) 'Shear deformation in heterogeneous anisotropic plates', *J. Appl. Mech.*, **37,** (4), 1031–6.

Whitney, J. M. and Sun, C. T. (1973) 'A higher order theory for extensional motion of laminated composites', *J. Sound and Vibration*, **30,** 85–97.

Chapter 3

Aveston, J. and Kelly, A. (1973) 'Theory of multiple fracture of fibrous composites', *J. Mat. Sci.*, **8,** 352–62.

Aveston, J. and Kelly, A. (1980) 'Tensile first cracking strain and strength of hybrid composites and laminates', *Phil. Trans. Royal Soc. London Series A*, **294,** 519–34.

Aveston, J., Cooper, G. and Kelly, A. (1971) 'Single and multiple fracture', in *The Properties of Fibre Composites*, Conference Proceedings, National Physical Laboratory, IPC Science and Technology Press Ltd., pp. 15–26.

Bader, M. G., Bailey, J. E., Curtis, P. T. and Parvizi, A. (1979) 'The mechanism of initiation and development of damage in multi-axial fibre-reinforced plastics on laminates', in *Mechanical Behavior of Materials*, K. J. Miller and R. F. Smith, eds., Pergamon Press, Oxford, pp. 227–39.

Bailey, J. E., Curtis, P. T. and Parvizi, A. (1979) 'On the transverse cracking and longitudinal splitting behavior of glass and carbon fibre reinforced epoxy cross-ply laminates and the effect of Poisson and thermally generated strain', *Proc. Royal Soc. London, Series A*, **366,** 599–623.

Bailey, J. E. and Parvizi, A. J. (1981) *J. Mat. Sci.*, **16,** 649.

Bjeletich, J. G., Crossman, F. W. and Warren, W. J. (1979) 'The influence of stacking sequence on failure modes in quasi-isotropic graphite-epoxy laminates', in *Failure Modes in Composites – IV*, J. R. Cornie and F. W. Crossman, eds., American Institute of Mining, Metallurgical and Petroleum Engineers, New York, p. 118.

Bradley, W. L. and Cohen, R. N. (1985) 'Matrix deformation and fracture in graphite reinforced epoxies', in *Delamination and Debonding of Materials*, W. S. Johnson, ed., ASTM STP 876, pp. 389–410.

Budiansky, B., Hutchinson, J. W. and Evans, A. G. (1986) 'Matrix fracture in fiber-reinforced ceramics', *J. Mech. Phys. Sol.*, **34,** 167–89.
Burgel, B., Perry, A. J. and Scheider, W. R. (1970) 'On the theory of fiber strengthening', *J. Mech. Phys. Sol.*, **18,** 101–14.
Carrara, A. S. and McGarry, F. J. (1968) 'Matrix and interface stresses in a discontinuous fiber composite model', *J. Comp. Mat.*, **2,** 222–43.
Chen, C. H. (1973) 'Tension of a composite bar with fibre discontinuities and soft inter-fibre material', *Fibre Sci. Tech.*, **6,** 1.
Chen, P. E. (1971) 'Strength properties of discontinuous fiber composites', *Polymer Eng. Sci.*, **11,** 51–6.
Chi, Z. F. and Chou, T. W. (1983) 'An experimental study of the effect of prestressed loose carbon strands on composite strength', *J. Comp. Mat.*, **17,** 196–209.
Chi, Z. F., Chou, T. W. and Shen, G. (1984) 'Determination of single fibre strength distribution from fibre bundle testings', *J. Mat. Sci.*, **19,** 3319–24.
Coleman, B. D. (1958) 'On the strength of classical fibres and fibre bundles', *J. Mech. Phys. Sol.*, **7,** 60.
Crossman, F. W. and Wang, A. S. D. (1982) *ASTM Symposium on Damages in Composite Materials: Basic Mechanisms, Accumulation, Tolerance, and Characterization,* K. L Reifsnider, ed., ASTM STP 775, ASTM, Philadelphia.
Crossman, F. W., Warren, W. J., Wang, A. S. D. and Law, G. E. (1980) 'Initiation and growth of transverse cracks and edge delamination in composite laminates, II. Experimental correlation', *J. Comp. Mat.*, **14,** 88–108.
Daniels, H. E. (1945) 'The statistical theory of the strength of bundles of threads I', *Proc. Royal Soc. London Series, A,* **183,** 405.
Dhingra, A. K. (1980) 'Alumina fibre FP', *Phil. Trans. R. Soc. London, (A),* **294,** 411–17.
Epstein, B. (1948) 'Statistical aspects of fracture problems', *J. Appl. Phys.*, **19,** 140.
Fichter, B. W. (1969) 'Stress concentration around broken filaments in a filament-stiffened sheet', NASA TN D-5453.
Fichter, B. W. (1970) 'Stress concentrations in filament-stiffened sheets of finite length', NASA TN D-5947.
Fukuda, H. and Kawata, K. (1976a) 'On the stress concentration factor in fibrous composites', *Fibre Sci. Tech.*, **9,** 189.
Fukuda, H. and Kawata, K. (1976b) 'Strength estimation of unidirectional composites', *Trans. Japan Soc. Comp. Mat.*, **2,** 59.
Fukuda, H. and Kawata, K. (1977) 'On the strength distribution of unidirectional fibre composites', *Fibre Sci. Tech.*, **10,** 53.
Fukuda, H. and Kawata, K. (1980) 'Stress distribution of laminates including discontinuous layers', *Fibre Sci. Tech.*, **13,** 255–67.
Fukunaga, H., Peters, P. W. M., Schulte, K. and Chou, T. W. (1984) 'Probabilistic failure strength analyses of graphite/epoxy cross-ply laminates', *J. Comp. Mat.*, **18,** 339.
Garrett, K. W. and Bailey, J. E. (1977a) *J. Mat. Sci.*, **12,** 157.
Garrett, K. W. and Bailey, J. E. (1977b) *J. Mat. Sci.*, **12,** 2189.
Goree, J. G. and Gross, R. S. (1979) 'Analysis of a unidirectional composite containing broken fibers and matrix damage', *Eng. Fracture Mech.*, **13,** 563–78.
Goree, J. G. and Gross, R. S. (1980) 'Stresses in a three-dimensional unidirectional composite containing broken fibers', *Eng. Fracture Mech.*, **13,** 395–405.
Gucer, D. E. and Gurland, J. (1962) 'Comparison of the statistics of two fracture modes', *J. Mech. Phys. Sol.*, **10,** 365.

Harlow, D. G. (1979) 'Properties of the strength distribution for composite materials', *Composite Materials: Testing and Design (Fifth conference)*, ASTM STP 674, S. W. Tsai, ed., American Society for Testing and Materials, pp. 484–501.

Harlow, D. G. and Phoenix, S. L. (1978a) 'The chain-of-bundles probability model for the strength of fibrous materials I: analysis and conjectures', *J. Comp. Mat.*, **12,** 195.

Harlow, D. G. and Phoenix, S. L. (1978b) 'The chain-of-bundles probability model for the strength of fibrous materials II: a numerical study of convergence', *J. Comp. Mat.*, **12,** 314.

Harlow, D. G. and Phoenix, S. L. (1979) 'Bounds on the probability of failure of composite materials', *Int. J. Fracture,* **15,** 321–36.

Harlow, D. G. and Phoenix, S. L. (1981a) 'Probability distributions for the strength of composite materials I: two level bounds', *Int. J. Fracture,* **17,** 347–72.

Harlow, D. G. and Phoenix, S. L. (1981b) 'Probability distributions for the strength of composite materials II: a convergent sequence of tight bounds', *Int. J. Fracture,* **17,** 601–30.

Hedgepeth, J. M. (1961) 'Stress concentrations in filamentary structures', NASA TN D-882.

Hedgepeth, J. M. and Van Dyke, P. (1967) 'Local stress concentrations in imperfect filamentary composite materials', *J. Comp. Mat.*, **1,** 294.

Henstenburg, R. B. and Phoenix, S. L. (1989) 'Interfacial shear strength studies using the single-filament-composite Test II: a probability model and Monte-Carlo simulation', *Polymer Composites,* **10,** 389–408.

Hikami, F. and Chou, T. W. (1984a) 'A probabilistic theory for the strength of discontinuous fiber composites', *J. Mat. Sci.*, **19,** 1805.

Hikami, F. and Chou, T. W. (1984b) 'Statistical treatment of transverse crack propagation in aligned composites', *AIAA J.*, **22,** 1485.

Hikami, F. and Chou, T. W. (1990) 'Explicit crack problem solutions of unidirectional composites: elastic stress concentrations', *AIAA J.*, **28,** 499–505.

Ji, X. (1982) 'On the hybrid effect and fracture mode of interlaminated hybrid composites', *Proceedings of the Fourth International Conference on Composite Materials,* Tokyo, p. 1137.

Ji, X., Liu, X. R. and Chou, T. W. (1985) 'Dynamic stress concentration factors in unidirectional composites', *J. Comp. Mat.*, **19,** 269–75.

Kelly, A. (1973) *Strong Solids,* Clarendon Press, Oxford.

Kelly, A. (1976) 'Composites with brittle matrices', in *Frontiers in Materials Science,* L. E. Murr and C. Stein, eds., Marcel Dekker Inc., New York, pp. 335–64.

Kelly, A. and Nicholson, R. B. (eds.) (1971) *Strengthening Methods in Crystals,* Elsevier, London.

Kies, J. A. (1962) US Naval Research Laboratory, Report No. 5752.

Kirkpatrick, E. G. (1974) *Introductory Statistics and Probability for Engineering, Science and Technology,* Prentice-Hall, Englewood Cliffs, New Jersey.

Kulkarni, S. V., Rosen, B. W. and Zweben, C. (1973) 'Load concentration factors for circular holes in composite laminates', *J. Comp. Mat.*, **7,** 387.

Lei, S. C. (1986) 'A stochastic model for the damage growth during the transverse cracking process in composite laminates', Ph.D. Thesis, Drexel University.

Lipson, S. G. and Lipson, H. (1981) *Optical Physics,* 2nd edn., Cambridge University Press.

McCartney, L. N. (1987) 'Mechanics of matrix cracking in brittle-matrix fibre-reinforced composites', *Proc. Royal Soc. London, Series A,* **409,** 329–50.

Manders, P., Bader, M. and Chou, T. W. (1982) 'Monte Carlo simulation of the strength of composite fiber bundles', *Fiber Sci. Tech.*, **17,** 183.

Manders, P. W. and Chou, T. W. (1983a) 'Variability of carbon and glass fibers, and the strength of aligned composites', *J. Reinforced Plastics & Composites*, **2,** 43.

Manders, P. W. and Chou, T. W. (1983b) 'Enhancement of strength in composites reinforced with previously-stressed fibers', *J. Comp. Mat.*, **17,** 26.

Manders, P. W., Chou, T. W., Jones, F. R. and Rock, J. W. (1983) 'Statistical analysis of multiple fracture in 0°/90°/0° glass fibre/epoxy resin laminates', *J. Mat. Sci.*, **18,** 2876–89.

Metcalfe, A. G. and Schmitz, G. K. (1964) 'Effect of length on the strength of glass fibers', *Proc. ASTM*, **64,** 1075.

Mileiko, S. T. (1969) 'The tensile strength and ductility of continuous fibre composites', *J. Mat. Sci.*, **4,** 974.

Mills, G. J. and Dauksys, R. J. (1973) 'Effect of prestressing boron/epoxy prepreg on composite strength properties', *AIAA J.*, **11,** 1459.

Netravali, A. N., Henstenburg, R. B., Phoenix, S. L. and Schwartz, P. (1989) 'Interfacial shear strength studies using the single-filament-composite Test I: experiments on graphite fibers in epoxy', *Polymer Composites*, **10,** 226–41.

Oh, K. P. (1979) 'A Monte Carlo study of the strength of unidirectional fiber-reinforced composites', *J. Comp. Mat.*, **13,** 311.

Pagano, N. J. and Pipes, R. B. (1971) 'The influence of stacking sequence on laminate strength', *J. Comp. Mat.*, **5,** 50–7.

Parratt, N. J. (1960) 'Defects in glass fibers and their effects on the strength of plastic mouldings', *Rubber and Plastics Age*, March 1960.

Parvizi, A. (1979). 'Transverse cracking in glass fibre reinforced plastic composites', Ph.D. Thesis, University of Surrey.

Parvizi, A. and Bailey, J. E. (1978) 'On multiple transverse cracking in glass fiber epoxy cross-ply laminates', *J. Mat. Sci.*, **13,** 2131.

Parvizi, A., Garrett, K. W. and Bailey, J. E. (1978) 'Constrained cracking in glass fiber-reinforced epoxy cross-ply laminates', *J. Mat. Sci.*, **13,** 195.

Peters, P. W. M. and Chou, T. W. (1987) 'On cross-ply cracking in glass- and glass-epoxy laminates', *Composites*, **18,** 40.

Phoenix, S. L. (1974) 'Probabilistic strength analysis of fiber bundle structures', *Fibre Sci. Tech.*, **7,** 15.

Phoenix, S. L. (1979) 'Statistical aspects of failure of fibrous composites', *Composite Materials: Testing and Design (Fifth Conference)*, ASTM STP 674, S. W. Tsai, ed., American Society for Testing and Materials, pp. 455–83.

Phoenix, S. L., Schwartz, P. and Robinson IV, H. H. (1988) 'Statistics for the strength and lifetime in creep-rupture of model carbon/epoxy composites', *Comp. Sci. Tech.*, **32,** 81–120.

Phoenix, S. L. and Smith, R. L. (1983) 'A comparison of probabilistic techniques for the strength of fibrous materials under local load-sharing among fibers', *Int. J. Sol. Structures*, **19,** 479–96.

Phoenix, S. L. and Taylor, H. M. (1973) 'The asymptotic strength distribution of a general fiber bundle', *Adv. Appl. Prob.*, **5,** 200.

Pipes, R. B. and Pagano, N. J. (1970) 'Interlaminar stresses in composite laminates under uniaxial extension', *J. Comp. Mat.*, **4,** 538–48.

Reifsnider, K. L., Henneke, E. G., Stinchcomb, W. W. and Duke, J. C. (1983) 'Damage mechanics and NDE of composite laminates', in *Mechanics of Composite Materials – Recent Advances* (Z. Hashin and C. T. Herakovich, eds.), Pergamon, New York, pp. 399–420.

Rosen, B. W. (1964) 'Tensile failure of fibrous composites', *AIAA J.*, **2,** 1985.
Rosen, B. W. (1970) 'Thermomechanical properties of fibrous composites', *Proc. Royal Soc. London, Series A,* **319,** 79–94.
Russell, A. J. and Street, K. N. (1985) 'Moisture and temperature effects on the mixed-mode delamination fracture of unidirectional graphite-epoxy', in *Delamination and Debonding of Materials*, W. S. Johnson, ed., ASTM STP 876, pp. 349–70.
Scop, P. M. and Argon, A. S. (1967) 'Statistical theory of strength of laminated composites', *J. Comp. Mat.*, **1,** 92.
Scop, P. M. and Argon, A. S. (1969) 'Statistical theory of strength of laminated composites II', *J. Comp. Mat.*, **3,** 30.
Smith, R. L. (1980) 'A probability model for fibrous composites with local load-sharing', *Proc. Royal Soc. London, Series A,* **372,** 539–53.
Smith, R. L. (1982) 'A note on a probability model for fibrous composites', *Proc. Royal Soc. London, Series A,* **382,** 179–82.
Smith, R. L. and Phoenix, S. L. (1981) 'Asymptotic distributions for the failure of fibrous materials under series–parallel structure and equal load sharing', *J. Appl. Mech.*, **48,** 75–82.
Smith, R. L., Phoenix, S. L., Greenfield, M. R., Henstenburg, R. B. and Pitt, R. E. (1983) 'Lower-tail approximations for the probability of failure of three-dimensional fibrous composites with hexagonal geometry', *Proc. Royal Soc. London, Series A,* **388,** 353–91.
Spiegel, M. R. (1961) *Statistics,* Schaum's Outline Series, McGraw-Hill, New York.
Takao, Y., Taya, M. and Chou, T. W. (1981) 'Stress field due to a cylindrical inclusion with constant axial eigenstrain in an infinite elastic body', *ASME J. Appl. Mech.*, **48,** 853–8.
Talreja, R. (1985) 'A continuum mechanics characterization of damage in composite materials', *Proc. Royal Soc., London, Series A,* **399,** 195–216.
Talreja, R. (1986) 'Stiffness properties of composite laminates with matrix cracking and interior delamination', *Eng. Fract. Mech.*, **25,** 751–62.
Talreja, R. (1987) *Fatigue of Composite Materials,* Technomic Pub. Co., Lancaster, Pennsylvania.
Talreja, R. (1989) 'Fatigue of composites', in *Concise Encyclopedia of Composite Materials,* A. Kelly, ed., Pergamon Press, Oxford, pp. 77–81.
Van Dyke, P. and Hedgepeth, J. M. (1969) 'Stress concentrations from single-filament failures in composite materials', *Textile Res. J.*, July, p. 618.
Vinson, J. R. and Chou, T. W. (1975) *Composite Materials and Their Use in Structures,* Applied Science Publishers, London.
Wang, A. S. D. (1984) 'Fracture mechanics of sublaminate cracks in composite materials', *Comp. Techl. Rev.*, **6,** 45–62.
Wang, A. S. D. (1987) 'Strength, failure, and fatigue analysis of laminates', *Engineering Materials Handbook,* **1,** 236–51, ASM International, Metals Park, Ohio.
Wang, A. S. D., Chou, P. C. and Lei, S. C. (1984) 'A stochastic model for the growth of matrix cracks in composite laminates', *J. Comp. Mat.*, **18,** 239–54.
Wang, A. S. D. and Crossman, F. W. (1977) 'Some new results on edge effects in symmetric composite laminates', *J. Comp. Mat.*, **11,** 92–102.
Wang, A. S. D. and Crossman, F. W. (1980) 'Initiation and growth of transverse cracks and edge delamination, I. An energy method', *J. Comp. Mat.*, **14,** 71-87.
Wang, A. S. D., Kishore, N. N. and Li, C. A. (1985) 'On crack development in

graphite-epoxy $[0_2/90_n]_s$ laminates under uniaxial tension', *Comp. Sci. Tech.*, **23,** 1–31.
Wang, A. S. D., Slomiana, M. and Bucinell, R. B. (1985) 'Delamination crack growth in composite laminates', in *Delamination and Debonding of Materials*, W. S. Johnson, ed., ASTM STP 876, pp. 135–67.
Weibull, W. (1939a) 'A statistical theory of the strength of materials', *Ing. Vetenskaps Akad. Handl.*, no. 151.
Weibull, W. (1939b) 'The phenomenon of rupture in solids', *Ing. Vetenskaps Akad. Handl.*, no. 153.
Weibull, W. (1951) 'A statistical distribution function of wide applicability', *J. Appl. Mech.*, **18,** 293.
Zender, G. W. and Deaton, J. W. (1963) 'Strength of filamentary sheets with one or more fibers broken', NASA TN D-1609.
Zweben, C. (1968) 'Tensile failure of fiber composites', *AIAA J.*, **6,** 2325.
Zweben, C. (1974) 'An approximate method of analysis for notched unidirectional composites', *Eng. Frac. Mech.*, **6,** 1.
Zweben, C. and Rosen, B. W. (1970) 'A statistical theory of material strength with application to composite materials', *J. Mech. Phys. Sol.*, **18,** 189.

Chapter 4

Akasaka, T. (1974) 'A practical method of evaluating the isotropic elastic constants of glass mat reinforced plastics', *Comp. Mat. Struct. (Japan)*, **3,** 21–2.
Anderson, R. M. and Lavengood, R. E. (1968) 'Variables affecting strength and modulus of short fiber composites', *Soc. Plastic. Engrs. J.*, **24,** 20.
Arridge, R. G. C. (1963) 'Orientation effects in fibre reinforced composites where the modulus of the fibres is no more than an order of magnitude greater than that of the matrix', *Proc. 18th Ann. Tech. Conf. Reinf. Plastics Div., Soc. Plastics Industry,* Sec. 4-A, February 1963.
Bader, M. G., Chou, T. W. and Quigley, J. (1979) 'On the strength of discontinuous fiber composites with polymeric matrices', in *New Developments and Applications in Composites,* D. Wilsdorf, ed., TMS-AIME, New York.
Baker, R. M. and MacLaughlin, T. F. (1971) 'Stress concentrations near a discontinuity in fibrous composites', *J. Comp. Mat.* **5,** 492.
Bert, C. W. (1979) 'Composite-material mechanics: prediction of properties of planar-random fiber composites'. Presented at the 34th Annual Conference of the Reinforced Plastics/Composites Institute, New Orleans, Louisiana, January 29–February 2.
Beran, M. (1965) *Nuovo Cimento Ser. X,* **35,** 771.
Beran, M. and Molyneax, J. (1966) *Quart. Appl. Math.*, **24,** 107.
Blumentritt, B. F., Vu, B. T. and Cooper, S. L. (1974) 'The mechanical properties of oriented discontinuous fibre-reinforced thermoplastics I. Unidirectional fiber orientation', *Polymer Eng. Sci.*, **14,** 633–45.
Blumentritt, B. G., Vu, B. T. and Cooper, S. L. (1975) 'Mechanical properties of discontinuous fiber reinforced thermoplastics, II. Random-in-plane fiber orientation', *Polymer Eng. Sci.*, **15,** 428–36.
Bowyer, W. H. and Bader, M. G. (1972) 'On the reinforcement of thermoplastics by imperfectly aligned discontinuous fibers', *J. Mat. Sci.*, **7,** 1315.
Budiansky, B. (1965) 'On the elastic moduli of some heterogeneous materials', *J. Mech. Phys. Sol.*, **13,** 223–7.
Budiansky, B. (1970) *J. Comp. Mat.*, **4,** 286.

Burgel, B., Perry, A. J. and Schneider, W. R. (1970) 'On the theory of fibre strengthening', *J. Mech. Phys. Sol.*, **18,** 101–14.

Carrara, A. S. and McGarry, F. J. (1968) 'Matrix and interface stresses in a discontinuous fiber composite model', *J. Comp. Mat.*, **2,** 222–43.

Chamis, C. C. and Sendeckyj, G. P. (1968) 'Critique on theories predicting thermoelastic properties of fibrous composites', *J. Comp. Mat.*, **2,** 232.

Chang, C. I., Conway, H. D. and Weaver, T. C. (1972) 'The elastic constants and bond stresses for a three-dimensional composite reinforced by discontinuous fibers', *Fibre Sci. Tech.*, **5,** 143–62.

Chen, P. E. (1971) 'Strength properties of discontinuous fiber composites', *Polymer Eng. Sci.*, **11,** 51.

Chen, P. E. and Lavengood, R. E. (1969) 'Stress fields around multiple inclusions', Monsanto/Washington University, ONR/ARPA Association, HPC 68-60, AD 846907, January, 1969.

Chen, P. E. and Lewis, T. B. (1970) 'Stress analysis of ribbon reinforced composites', *Polymer Eng. Sci.*, **10,** 43.

Chou, T. W. and Kelly, A. (1976) 'Fiber composites', in 'Challenges and opportunities in materials science and engineering', *Mat. Sci. Eng.*, **25,** 35.

Chou, T. W. and Kelly, A. (1980) 'Mechanical properties of composites', *Ann. Rev. Mat. Sci.*, **10,** 229.

Chou, T. W. and Nomura, S. (1980) 'On the thermoelastic behavior of short fiber and hybrid composites', *Proceedings of the Third International Conference on Composite Materials,* Pergamon Press, New York, pp. 69–80.

Chou, T. W. and Nomura, S. (1981) 'Fiber orientation effects on the thermoelastic properties of short-fiber composites', *Fibre Sci. Tech.*, **14,** 279.

Chou, T. W., Nomura, S. and Taya, M. (1980) 'A self-consistent approach to the elastic stiffness of short-fiber composites', *J. Comp. Mat.*, **14,** 178.

Christensen, R. M. (1971) *Theory of Viscoelasticity,* Academic Press, New York.

Christensen, R. M. and Waals, F. M. (1972) 'Effective stiffness of randomly oriented fibre composites', *J. Comp. Mat.*, **6,** 518–32.

Christensen, R. M. (1979) *Mechanics of Composite Materials,* Wiley-Interscience, New York.

Conway, H. D. and Chang, C. I. (1971) 'The effective elastic constants and bond stresses for a fiber reinforced elastic sheet', *Fibre Sci. Tech.*, **5,** 249–60.

Cook, J. (1968) 'The elastic constants of an isotropic matrix reinforced with imperfectly oriented fibres', *Brit. J. Appl. Phys. (J. Phys. D), Series 2,* **1,** 799–812.

Cox, H. L. (1952). 'The elasticity and strength of paper and other fibrous materials', *Brit. J. Appl. Phys.*, **3,** 72–9.

Curtis, P. T., Bader, M. G. and Bailey, J. E. (1978) 'The stiffness and strength of a polyamide thermoplastic reinforced with glass and carbon fibres', *J. Mat. Sci.*, **13,** 377.

Dederichs, P. H. and Zeller, R. (1973). 'Variational treatment of the elastic constants of disordered materials', *Z. Physik,* **259,** 103.

Edwards, H. and Evans, N. P. (1980) 'A method for the production of high quality aligned short fibre mats and their composites', *Proceedings of the Third International Conference on Composite Materials,* Pergamon Press, New York, pp. 1620–35.

Eimer, C. Z. (1971) 'The viscoelasticity of multi-phase media'. *Arch. Mech.*, **23,** 3–15.

Eshelby, J. D. (1957) 'The determination of the elastic field of an ellipsoidal inclusion and related problems', *Proc. Royal Soc.*, **A241,** 376–96.

Eshelby, J. D. (1961) 'Elastic inclusions and inhomogeneity', in *Progress in Solid Mechanics,* I. N. Sneddon and R. Hill, eds., vol. 2, North-Holland, Amsterdam, p. 89.

Favre, J. P. and Perrin, J. (1972) 'Carbon fibre adhesion to organic matrices', *J. Mat. Sci.,* **7,** 1113.

Friedrich, K. (1985) 'Microstructural efficiency and fracture toughness of short fiber/thermoplastic matrix composites', *Comp. Sci. Tech.,* **22,** 43–74.

Friedrich, K. (1989) 'Fractographic analysis of polymer composites', in *Application of Fracture Mechanics to Composite Materials,* Composite Material Series, vol. 6, Klaus Friedrich, ed., Elsevier, Amsterdam, p. 425.

Friedrich, K. and Karger-Kocsis, J. (1989) 'Fractography and failure mechanisms of unfilled and short fiber reinforced semi-crystalline thermoplastics', in *Fractography and Failure Mechanisms of Polymers and Composites,* A. C. Roulin-Moloney, ed., Elsevier-Applied Science, London, pp. 437–94.

Friedrich, K., Schulte, K., Horstenkamp, G. and Chou, T. W. (1985) 'Fatigue behavior of aligned short carbon fiber reinforced polyimide and polyethersulfone composites', *J. Mat. Sci.,* **20,** 3353.

Fukuda, H. and Chou, T. W. (1981a) 'An advanced shear-lag model applicable to discontinuous fiber composites', *J. Comp. Mat.,* **15,** 79.

Fukuda, H. and Chou, T. W. (1981b) 'A probabilistic theory for the strength of short-fiber composites', *J. Mat. Sci.,* **16,** 1088.

Fukuda, H. and Chou, T. W. (1982) 'A probabilistic theory of the strength of short-fiber composites and variable fiber length and orientation', *J. Mat. Sci.,* **17,** 1003.

Fukuda, H. and Kawata, K. (1974) 'On Young's modulus of short fibre composites', *Fibre Sci. Tech.,* **7,** 207–22.

Fukuda, H. and Kawata, K. (1977) 'On the strength distribution of unidirectional fibre composites', *Fibre Sci. Tech.,* **10,** 53.

Haener, J. and Ashbaugh, N. (1967) 'Three-dimensional stress distribution in a unidirectional composite', *J. Comp. Mat.,* **1,** 54–63.

Hahn, H. T. (1978) 'Stiffness and strength of discontinuous fiber composites', in *Composite Materials in the Automotive Industry,* S. V. Kulkarni, C. H. Zweben and R. B. Pipes, eds., ASME, New York, pp. 85–109.

Hale, D. K. and Kelly, A. (1972) 'Strength of fibrous composite materials', in *Annual Review of Materials Science,* vol. 2, R. A. Huggins, ed., Annual Review, Inc., Palo Alto, California, p. 405.

Halpin, J. C. (1969) 'Stiffness and expansion estimates for oriented short fiber composites', *J. Comp. Mat.,* **3,** 732–4.

Halpin, J. C. (1984) *Primer on Composite Materials: Analysis,* Technomic Publishing Co., Inc., Lancaster, Pennsylvania.

Halpin, J. C., Jerine, K. and Whitney, J. M. (1971) 'The laminate analogy for 2 and 3 dimensional composite materials', *J. Comp. Mat.,* **5,** 36–49.

Halpin, J. C. and Pagano, N. J. (1969) 'The laminate approximations for randomly oriented fibrous composites', *J. Comp. Mat.,* **3,** 720–4.

Hancock, P. and Cuthbertson, J. (1970) 'The effect of fibre length and interfacial bond in glass fibre-epoxy resin composites, *J. Mat. Sci.,* **15,** 762–8.

Hashin, Z. (1965a) 'On elastic behavior of fibre reinforced materials of arbitrary transverse phase geometry', *J. Mech. Phys. Sol,* **13,** 179.

Hashin, Z. (1965b) 'Viscoelastic behavior of heterogeneous media', *J. Appl. Mech.,* **32,** 630–6.

Hashin, Z. (1968) 'Assessment of the self-consistent scheme approximation: conductivity of particulate composites', *J. Comp. Mat.*, **2,** 284–300.
Hashin, Z. (1969) 'The inelastic inclusion problem', *Int. J. Eng. Sci.*, **7,** 11–36.
Hashin, Z. (1972) *Theory of Fiber Reinforced Materials,* NASA CR-1974.
Hashin, Z. and Rosen, B. W. (1964) 'The elastic moduli of fiber-reinforced materials', *J. Appl. Mech.*, **31,** 223–32.
Hashin, Z. and Shtrikman, S. (1962) *J. Appl. Phys.*, **30,** 3125.
Hashin, Z. and Shtrikman, S. (1963) 'A variational approach to the theory of the elastic behavior of multiphase materials', *J. Mech. Phys. Sol,* **11,** 127–40.
Hermans, J. J. (1967) 'The elastic properties of fibre reinforced materials when the fibers are aligned', *Proc. Konigl. Nederl, Akad, van Weteschappen Amsterdam, Series B,* **70,** 1–9.
Hikami, F. and Chou, T. W. (1984a) 'A probabilistic theory for the strength of discontinuous fiber composites', *J. Mat. Sci.*, **19,** 1805.
Hikami, F. and Chou, T. W. (1984b) 'Statistical treatment of transverse crack propagation in aligned composites', *AIAA J.*, **22,** 1485–90.
Hikami, F. and Chou, T. W. (1990) 'Explicit crack problem solutions of unidirectional composites: elastic stress concentrations', *AIAA J.*, **28,** 499–505.
Hill, R. (1952) 'The elastic behavior of a crystalline aggregate', *Proc. Phys. Soc.*, **A65,** 349.
Hill, R. (1965a) 'Theory of mechanical properties of fiber-strengthened materials – III. Self-consistent model', *J. Mech. Phys. Sol,* **13,** 189–98.
Hill, R. (1965b) 'A self-consistent mechanics of composite materials', *J. Mech. Phys. Sol,* **13,** 213–25.
Hori, M. and Yonezawa, F. (1975) 'Statistical theory of effective electrical, thermal and magnetic properties of random heterogeneous materials IV', *J. Math. Phys.*, **16.** 352.
Hsu, P. L., Yau, S. S. and Chou, T. W. (1986) 'Stress-corrosion cracking and its propagation in aligned short-fiber composites', *J. Mat. Sci.*, **21,** 3703.
Ishikawa, H., Chou, T. W. and Taya, M. (1982) 'Prediction of failure modes in unidirectional short fiber composites', *J. Mat. Sci.*, **17,** 832.
Jackson, P. W. and Cratchley, D. (1966) *J. Mech. Phys. Sol,* **14,** 49.
Kacir, L. and Narkis, M. (1975) *Polymer Eng. Sci.*, **15,** 525.
Kardos, J. (1973) 'Structure property relations in short-fiber reinforced plastics', *CRC Crit. Rev. Solid State Sci.*, August, pp. 419–50.
Kelly, A. (1971) 'Reinforcement of structural materials by long strong fibres', *Met. Trans.*, **3,** 2313.
Kelly, A. (1973) *Strong Solids,* 2nd edn., Clarendon Press, Oxford.
Kelly, A. and Davies, G. J. (1965) 'The principles of the fibre reinforcement of metals', *Met. Rev.*, **10,** 1.
Kelly, A. and Tyson, W. R. (1965a) 'Fibre-strengthened materials', in *High Strength Materials, V,* F. Zackay, ed., J. Wiley and Sons, Inc., New York, p. 578.
Kelly, A. and Tyson, W. R. (1965b) 'Tensile properties of fiber-reinforced metals: copper/tungsten and copper/molybdenum', *J. Mech. Phys. Sol,* **13,** 329.
Kerner, E. H. (1956) 'The elastic and thermoelastic properties of composite media', *Proc. Phys. Soc.*, **B69,** 808–13.
Kilchinskii, A. A. (1965) 'On the model for determining thermoelastic characteristics of fiber reinforced materials', *Prikladnaia Mekhanika,* **1,** 1.
Kilchinskii, A. A. (1966) 'Approximate method for determining the relation between the stresses and strains for reinforced materials of the fiber glass type',

Thermal Stresses in Elements of Construction, Naukova Kumka, Kiev, **6,** 123.

Knibbs, R. H. and Morris, J. B. (1974) 'The effects of fibre orientation on the physical properties of composites', *Composites,* **5,** 209–18.

Kröner, E. (1958) 'Berechnung der Elastichen Konstanten des Vielkristalls aus den Konstanten des Eikristalls', *Z. Physik,* **151,** 504.

Kröner, E. (1967) 'Elastic moduli of perfectly disordered composite materials', *J. Mech. Phys. Sol.,* **15,** 319.

Kröner, E. (1972) *Statistical Continuum Mechanics,* CISM Courses and Lectures no. 92, Udine, Springer-Verlag, Wien.

Kröner, E. (1977) 'Bounds for effective elastic moduli of disordered materials', *J. Mech. Phys. Sol,* **25,** 137.

Lavengood, R. E. (1972) 'Strength of short-fiber reinforced composites', *Polymer Eng. Sci.,* **12,** 48.

Laws, N. (1973) 'On the thermostatics of composite materials', *J. Mech. Phys. Sol,* **21,** 9.

Laws, N. and McLaughlin, R. (1978) 'Self-consistent estimates for the viscoelastic creep compliances of composite materials', *Proc. Royal Soc.,* **A359,** 251–73.

Lee, L. H. (1969) 'Strength-composition relationships of random short glass fiber–thermoplastics composites', *Polymer Eng. Sci.,* **9,** 213–24.

Lees, J. K. (1968) 'A study of the tensile modulus of short fiber reinforced plastics', *Polymer Eng. Sci.,* **8,** 186–94

Levin, V. M. (1967) *Inzh. Zh. Mekk. Tverd. Tela,* No. 1, p. 88.

MacLaughlin, T. F. (1966) 'Effect of fiber geometry on stress in fiber reinforced composite materials', *Exp. Mech.,* **6,** 481–92.

MacLaughlin, T. F. (1968) 'A photoelastic analysis of fiber discontinuities in composite materials', *J. Comp. Mat.,* **2,** (1), 44.

McNally, D. (1977) 'Short fiber orientation and its effect on the properties of thermoplastic composite materials', *Polymer Plast. Tech. Eng.,* **8,** 101–54.

Mandell, J. F., Grande, D. H., Tsiang, T.-H. and McGarry, F. J. (1986) 'Modified microdebonding test for direct in situ fiber/matrix bond strength determination in fiber composites', in *Composite Materials: Testing and Design (Seventh Conference),* ASTM STP 893, J. M. Whitney, ed., American Society for Testing and Materials, Philadelphia, pp. 87–108.

Manders, P. W. and Chou, T. W. (1982) 'The strength of aligned short-fiber carbon, glass, and hybrid carbon/glass composites', *Proceedings of the Fourth International Conference on Composite Materials,* The Japan Society for Composite Materials, Tokyo, pp. 1075–82.

Manera, M. (1971) 'Elastic properties of randomly oriented short fiber-glass composites', *J. Comp. Mat.,* **11,** 235–47.

Miller, B., Muri, P. and Rebenfeld, L. (1987) *Comp. Sci. Tech.,* **28,** 17.

Muki, R. and Sternberg, E. (1969) 'On the diffusion of an axial load from an infinite cylindrical bar embedded in an elastic medium', *Int. J. Sol. Struct.,* **5,** 587.

Muki, R. and Sternberg, E. (1970) 'Elastostatic load-transfer to a half-space from a partially embedded axially loaded rod', *Int. J. Sol. Struct.,* **6,** 69.

Muki, R. and Sternberg, E. (1971) 'Load-absorption by a discontinuous filament in a fiber-reinforced composite', *Z. Angew. Math. Phys.,* **22,** 809.

Mura, T. (1982) *Micromechanics of Defects in Solids,* Martinus Nijhoff Publishers, The Hague.

Nicolais L. (1975) 'Mechanics of composites', *Polymer Eng. Sci.*, **15,** 137–49.
Nielsen, L. E. and Chen, P. E. (1968) 'Young's modulus of composites filled with randomly oriented fibers', *J. Mat.*, **3,** 352–8.
Nomura, S. and Chou, T. W. (1980) 'Bounds of effective thermal conductivity of short-fiber composites', *J. Comp. Mat.*, **14,** 120.
Nomura, S. and Chou, T. W. (1981) 'Effective thermoelastic constants of short-fiber composites', *Int. J. Eng. Sci.*, **19,** 1.
Nomura, S. and Chou, T. W. (1984) 'Bounds of elastic moduli of multiphase short-fiber composites', *J. Appl. Mech.*, **51,** 540.
Nomura, S. and Chou, T. W. (1985) 'The viscoelastic behavior of short-fiber composite materials', *Int. J. Eng. Sci.*, **23,** 193.
Outwater, J. O., Jr. (1956) 'The mechanics of plastics reinforcement in tension', *Mod. Plast.*, **33,** 156–62.
Pakdemirli, E. and Williams, J. G. (1969) 'Metal fibre reinforced thermoplastics and the role of adhesion efficiency', *J. Mech. Eng. Sci.*, **11,** 68–75.
Piggott, M. R. (1987) 'Debonding and friction at fibre-polymer interfaces I: Criteria for failure and sliding', *Comp. Sci. Tech.*, **30,** 295–306.
Piggott, M. R. and Dai, S. R. (1988) 'Debonding and friction at fibre-polymer interfaces II: microscopic model experiments, *Comp. Sci. Tech.*, **31,** 15–24.
Reuss, A. (1929) *Zeit Angew Math. U. Mech.*, **9,** 49.
Richter, H. (1980) 'Single fibre and hybrid composites with aligned discontinuous fibres in polymer matrix', *Proceedings of the Third International Conference on Composite Materials,* Pergamon Press, New York, pp. 387–98.
Riley, V. R. and Reddaway, J. L. (1968) *J. Mat. Sci.*, **3,** 41.
Rosen, B. W. (1964) 'Tensile failure of fibrous composites', *AIAA J.*, **2,** 1985.
Rosen, B. W. and Shu, L. S. (1971) 'On some symmetry conditions for three dimensional fibrous composites', *J. Comp. Mat.*, **5,** 279.
Rosen, W. and Hashin, Z. (1970) 'Effective thermal expansion coefficients and specific heats of composite materials', *Int. J. Eng. Sci.*, **8,** 157–73.
Schapery, R. A. (1967) 'Stress analysis of viscoelastic composite materials', *J. Comp. Mat.*, **1,** 228–67.
Schapery, R. A. (1968) 'Thermal expansion coefficients of composite materials based on energy principles', *J. Comp. Mat.*, **2,** 380–404.
Schapery, R. A. (1974) *Composite Materials,* G. P. Sendeckyj, ed., Vol. 2, Academic Press, New York.
Schierding, R. G. and Deex, O. D. (1969) 'Factors influencing the properties of whisker–metal composites', *J. Comp. Mat.*, **3,** 618–29.
Stowell, E. Z. and Liu, T. S. (1961) *J. Mech. Phys. Sol,* **9,** 242.
Takao, T., Chou, T. W. and Taya, M. (1982) 'Effective longitudinal Young's modulus of misoriented short fiber composites', *J. Appl. Mech.*, **49,** 536.
Takao, Y., Taya, M. and Chou, T. W. (1981) 'Stress field due to cylindrical inclusion with constant axial eigenstrain in an infinite body', *J. Appl. Mech.*, **48,** 853.
Takao, Y., Taya, M. and Chou, T. W. (1982) 'Effects of fiber-end cracks on the stiffness of aligned short-fiber composites', *Int. J. Sol. Struct.*, **8,** 723.
Taya, M. and Chou, T. W. (1981) 'On two kinds of ellipsoidal inhomogeneities in infinite elastic body: an application to a hybrid composite', *Int. J. Sol. Struct.*, **17,** 553.
Taya, M. and Chou, T. W. (1982) 'Prediction of the stress–strain curve of a short fiber reinforced thermoplastics', *J. Mat. Sci.*, **17,** 2801.

Tsai, S. W. and Pagano, N. J. (1968) 'Invariant properties of composite materials', in *Composite Materials Workshop,* S. W. Tsai, J. C. Halpin and N. J. Pagano, eds., Technomic Pub. Co., Stamford, CT, pp. 233–53.
van de Poel, C. (1958) 'On the rheology of concentrated dispersions', *Rheol. Acta,* **1,** 198–205.
Vinson, J. R. and Chou, T. W. (1975) *Composite Materials and Their Use in Structures,* Elsevier-Applied Science, London.
Voigt, W. (1889) *Ann. Phys.*, **33,** 573.
Wadsworth, N. J. and Spilling, I. (1968) *Brit. J. Appl. Phys.*, **1,** 1049.
Warren, F. and Norris, C. B. (1953) 'Mechanical properties of laminate design to be isotropic', Forest Products Laboratory, Madison, WI, Report No. 1841, May 1953.
Wilczynki, A. P. (1978) 'Random directional reinforcement theory', *Fibre Sci. Tech.,* **11,** 19–22.
Willis, J. R. (1977) 'Bounds and self-consistent estimates for the overall properties of anisotropic composites', *J. Mech. Phys. Sol.,* **25,** 185–202.
Wu, C.-T. D. and McCullough, R. L. (1977) 'Constitutive relationships for heterogeneous materials', in *Developments in Composite Materials—1,* G. S. Holister, ed., Applied Science Publishers, London, p. 119.
Yates, B., Overy, M. J., Sargent, J. P., McCalla, B. A., Kingston-Lee, D. M., Phillips, L. N. and Rogers, K. F. (1978) *J. Mat. Sci.*, **13,** 433.
Yau, S. S. and Chou, T. W. (1989) 'Low temperature performance of short fiber reinforced thermoplastics', in *Test Methods and Design Allowables for Fiber Composites,* vol. 2, C. C. Chamis, ed., ASTM STP 1003, p. 45.
Zeller, R. and Dederichs, P. H. (1973) 'Elastic constants of polycrystals', *Phys. Stat. Sol.,* **b55,** 831.

Chapter 5

Adam, T., Fernando, G., Dickson, R. F., Reiter, H. and Harris, B. (1989) 'Fatigue life prediction for hybrid composites', *Int. J. Fatigue,* **11,** 233–7.
Adams, D. F. (1975) 'A scanning electron microscopic study of hybrid composite impact response', *J. Mat. Sci.*, **10,** 1591–602.
Adams, D. F. and Miller, A. K. (1975) 'An analysis of the impact behavior of hybrid composite materials', *Mat. Sci. Eng.*, **19,** 245–60.
Adams, D. F. and Miller, A. K. (1976) 'The influence of transverse shear on the static flexure and Charpy impact response of hybrid composite materials', *J. Mat. Sci.*, **11,** 1697–710.
Adams, D. F. and Zimmerman, R. S. (1986) 'Static and impact performance of PE fiber/graphite fiber hybrid composites', *SAMPE J.*, Nov./Dec., pp. 10–16.
Arrington, M. and Harris, B. (1978) 'Some properties of mixed fibre CFRP', *Composites,* **9,** 149–52.
Aveston, J. and Kelly, A. (1980) 'Tensile first cracking strain and strength of hybrid composites and laminates', *Phil. Trans. Royal Soc. London,* **A294,** 519–34.
Aveston, J. and Sillwood, J. M. (1976) 'Synergistic fibre strengthening in hybrid composites', *J. Mat. Sci.*, **11,** 1877.
Bader, M. G. and Manders, P. W. (1978) 'Failure strain enhancement in carbon/glass fiber hybrid composites', *Proceedings of the Third International Conference on Composite Materials,* vol. 3, Toronto.

Bader, M. G. and Manders, P. W. (1981a) 'The strength of hybrid glass/carbon fiber composites, part I, failure strain enhancement and failure mode', *J. Mat. Sci.*, **16,** 2233–45.

Bader, M. G. and Manders, P. W. (1981b) 'The strength of hybrid glass/carbon fiber composites, part II, a statistical model', *J. Mat. Sci.*, **16,** 2246–56.

Beaumont, P. W. R., Riewald, P. G. and Zweben, C. (1974) 'Methods for improving the impact resistance of composite materials', in *Foreign Object Impact Damage to Composites,* ASTM STP 568, American Society of Testing and Materials, Philadelphia, pp. 134–58.

Bucci, R. J., Mueller, L. N., Schultz, R. W. and Prohaska, J. L. (1987) 'ARALL laminates – results from a cooperative test program', in *Advanced Materials Technology 87, Proceedings 32nd International SAMPE Symposium,* vol. 32, Society for the Advancement of Material and Process Engineering, Corina, CA, pp. 902–16.

Bunsell, A. R. (1976) Letter to the Editor, *Composites,* **7, 158**.

Bunsell, A. R. and Harris, B. (1974) 'Hybrid carbon and glass fibre composites', *Composites,* **5,** 157–64.

Chamis, C. C., Hanson, M. P. and Serafini, T. T. (1972) 'Impact resistance of unidirectional fiber composites', *Composite Materials: Testing and Design (Second Conference),* ASTM STP 497, American Society for Testing and Materials, Philadelphia, pp. 324–49.

Chamis, C. C. and Lark, R. F. (1978) 'Non-metallic hybrid composites: analysis, design, application and fabrication', in *Hybrids and Selected Metal-Matrix Composites: A State-of-the-Art Review,* W. J. Renton, ed., AIAA, New York, pp. 13-51.

Chamis, C. C. and Sinclair, J. H. (1979) 'Micromechanics of intraply hybrid composites: elastic and thermal properties', in *Modern Developments in Composite Materials and Structures,* J. R. Vinson, ed., The American Society of Mechanical Engineers, New York, pp. 253–67.

Chan, W. S., Rogers, C. and Aker, S. (1976) 'Improvement of edge delamination strength using adhesive layers', in *Composite Materials Testing and Design,* 7th Conference, J. M. Whitney, ed., ASTM STP893, American Society for Testing and Materials, Philadelphia, pp. 266–85.

Chen, J. L. and Sun, C. T. (1989) 'Modeling of orthotropic elastic–plastic properties of ARALL laminates', *Comp. Sci. Tech.*, **36,** 321–38.

Chou, T. W. and Kelly, A. (1980a) 'Mechanical properties of fiber composite materials', in *Annual Review of Materials Science,* vol. 10, Annual Review, Inc., Palo Alto, pp. 229–59.

Chou, T. W. and Kelly, A. (1980b) 'The effect of transverse shear on the compressive strength of fiber composites', *J. Mat. Sci.*, **15,** 327.

Chou, T. W., Nomura, S. and Taya, M. (1980) 'A self-consistent approach to the elastic stiffness of short-fiber composites', *J. Comp. Mat.*, **14,** 178.

Chou, T. W., Steward, B. and Bader, M. G. (1979) 'On the compression strength of glass–epoxy composites', in *New Developments and Applications in Composites*, D. Wilsdorf, ed., TMS-AIME, New York.

Dorey, G., Sidey, G. R. and Hutchings, J. (1978) 'Impact properties of carbon fibre/Kevlar 49 fibre hybrid composites', *Composites,* **9,** 25–32.

Eshelby, J. D. (1957) 'The determination of the elastic field of an ellipsoidal inclusion, and related problem', *Proc. Royal Soc. London,* **241,** 376–96.

Fernando, G., Dickson, R. F., Adam, T., Reiter, H. and Harris, B. (1988) 'Fatigue

behaviour of hybrid composites: I carbon/Kevlar hybrids', *J. Mat. Sci.*, **23,** 3732–43.
Fischer, S. and Marom, G. (1987) 'The flexural behavior of aramid fiber hybrid composite materials', *Comp. Sci. Tech.*, **28,** 1–24.
Fukuda, H. (1983a) 'Mechanics of hybrid composites, part I', *Trans. Japan Soc. Composite Mat.*, **9,** 76–80.
Fukuda, H. (1982b) 'Mechanics of hybrid composites, part II', *Trans. Japan Soc. Composite Mat.*, **9,** 118–23.
Fukuda, H. (1983c) 'Mechanics of hybrid composites, part III'. *Trans. Japan Soc. Composite Mat.*, **9,** 153–9.
Fukuda, H. and Chou, T. W. (1981) 'Stress concentrations around a discontinuous fiber in a hybrid composite sheet', *Trans. Japan Soc. Composite Mat.*, **7,** 37–42.
Fukuda, H. and Chou, T. W. (1982a) 'Monte Carlo simulation of the strength of hybrid composites', *J. Comp. Mat.*, **16,** 357.
Fukuda, H. and Chou, T. W. (1982b) 'A statistical approach to the strength of hybrid composites', *Proceedings of the Fourth International Conference on Composite Materials,* Japan Society for Composite Materials, Tokyo, pp. 1145–52.
Fukuda, H. and Chou, T. W. (1983) 'Stress concentration in a hybrid composite sheet', *J. Appl. Mech.*, **50,** 845–8.
Fukunaga, H., Chou, T. W. and Fukuda, H. (1984) 'Strength of intermingled hybrid composites', *J. Reinforced Plastics Composites,* **3,** 145–60.
Fukunaga, H., Chou, T. W. and Fukuda, H. (1989) 'Probabilistic strength analyses of interlaminated hybrid composites', *Comp. Sci. Tech.*, **35,** 331.
Fukunaga, H., Chou, T. W., Peters, P. M. W. and Schulte, K. (1984a) 'Probabilistic failure strength analyses of graphite/epoxy cross-ply laminates', *J. Comp. Mat.*, **18,** 339–56.
Fukunaga, H., Chou, T. W., Schulte, K. and Peters, P. M. W. (1984b) 'Probabilistic initial failure strength of hybrid and non-hybrid laminates', *J. Mat. Sci.*, **19,** 3546.
Gruber, M. B., Overbeeke, J. L. and Chou, T. W. (1982) 'A reusable sandwich beam concept for composite compression test', *J. Comp. Mat.*, **16,** 162–71.
Gruber, M. B. and Chou, T. W. (1983) 'Elastic properties of intermingled hybrid composites', *Polymer Composites,* **4,** 265–9.
Hancox, N. L. and Wells, H. (1973) 'Izod impact properties of carbon-fibre/glass-fibre sandwich structures', *Composites,* **4,** 26–30.
Harlow, D. G. (1983) 'Statistical properties of hybrid composites', *Proc. Royal Soc.*, **A389,** 67–100.
Harlow, D. G. and Phoenix, S. L. (1978a) 'The chain-of-bundles probability model for the strength of fibrous materials I: analysis and conjectures', *J. Comp. Mat.*, **12,** 195.
Harlow, D. G. and Phoenix, S. L. (1978b) 'The chain-of-bundles probability model for the strength of fibrous materials II: a numerical study of convergence', *J. Comp. Mat.*, **12,** 314.
Harris, S. J. and Bradley, P. D. (1976) *Proceedings of the First International Conference on Composite Materials,* pp. 327–35.
Harris, B. and Bunsell, A. R. (1975) 'Impact properties of glass-fibre/carbon fibre hybrid composites', *Composites,* **6,** 197–201.
Hayashi, T. (1972) 'On the improvement of mechanical properties of composites by hybrid composition', *Proceedings of the Eighth International Reinforced Plastics Conference,* paper 22.

Hedgepeth, J. M. (1961) 'Stress concentration in filamentary structures', NASA TN D-882.

Jang, B. Z., Chen, L. C., Wang, C. Z., Lin, H. T. and Zee, R. H. (1989) 'Impact resistance and energy absorption mechanisms in hybrid composites', *Comp. Sci. Tech.*, **34,** 305–35.

Ji, X. (1982) 'On the hybrid effect and fracture mode of interlaminated hybrid composites', in *Proceedings of the Fourth International Conference on Composite Materials,* T. Hayashi, K. Kawata and S. Umekawa, eds., Japan Society for Composite Materials, Tokyo, pp. 1137–44.

Ji, X., Hsiao, G. C. and Chou, T. W. (1981) 'A dynamic explanation of the hybrid effect', *J. Comp. Mat.*, **15,** 443–61.

Kalnin, I. L. (1972) 'Evaluation of unidirectional glass–graphite fiber/epoxy resin composites', *Composite Materials Testing and Design (Second Conference)*, ASTM STP 497, American Society for Testing and Materials, Philadelphia, pp. 551–63.

Kenaga, D., Doyle, J. F. and Sun, C. T. (1987) 'The characterization of boron/aluminum composite in nonlinear range as an orthotropic elastic–plastic material', *J. Comp. Mat.*, **21,** 516–31.

Kirk, J. N., Munro, M. and Beaumont, P. W. R. (1978) 'The fracture energy of hybrid carbon and glass composites', *J. Mat. Sci.*, **13,** 2197–204.

Kretsis, G. (1987) 'A review of the tensile, compressive, flexural and shear properties of hybrid fiber-reinforced plastics', *Composites,* **18,** 13–23.

McColl, I. R. and Morley, J. G. (1977) 'Crack growth in hybrid fibrous composites', *J. Mat. Sci.*, **12,** 1165–75.

McCullough, R. L. and Peterson, J. M. (1977) 'Property optimization analysis for multicomponent (hybrid) composites', in *Developments in Composite Materials – 1,* G. S. Holister, ed., Applied Science Publisher, London.

Marissen, R. (1984) 'Flight simulation behavior of aramid reinforced aluminum laminates (ARALL)', *Eng. Fracture Mech.*, **19,** 261–77.

Marissen, R., Trautmann, K. H., Foth, J. and Nowack, H. (1984) 'Microcrack growth in aramid reinforced aluminum laminates (ARALL)', in *Fatigue 84, Proceedings 2nd International Conference on Fatigue and Fatigue Thresholds,* C. J. Beevers, ed. vol. II. EMAS Ltd, Warley, UK, pp. 1081–91.

Marom, G. and Chen, E. J. H. (1987) 'Asymmetric hybrid composite: a design concept to improve flexural properties of Kevlar aramid composites', *J. Comp. Sci. Tech.*, **29,** 161–8.

Marom, G., Fischer, S., Tuler, F. R. and Wagner, H. (1978) 'Hybrid effects in composites', *J. Mat. Sci.*, **13,** 1419–26.

Mori, T. and Tanaka, K. (1973) 'An average stress in matrix and average elastic energy of materials with misfitting inclusions', *Acta Met.*, **21,** 571–4.

Mueller, L. N., Prohaska, J. L. and Davis, J. W. (1985) 'ARALL (aramid aluminum laminates): introduction of a new composite material', *Proceedings AIAA Aerospace Engineering Conference,* AIAA, New York, AIAA paper no. 85-0846.

Nomura, S. and Chou, T. W. (1984) 'Bounds of elastic moduli of multiphase short-fiber composites', *J. Appl. Mech.*, **51,** 540.

Phillips, L. N. (1976) 'The hybrid effect–does it exist?' *Composites,* **7,** 7–8.

Pitkethly, M. J. and Bader, M. G. (1987) 'Failure modes of hybrid composites consisting of carbon fiber bundles dispersed in a glass fiber epoxy resin matrix', *J. Phys. D: Appl. Phys.*, **20,** 315–22.

Renton, W. J. (ed.) (1978) *Hybrids and Selected Metal–Matrix Composites: A State-of-the-Art Review,* AIAA, New York.
Rosen, B. W. (1964) 'Tensile failure of fibrous composites', *AIAA J.,* **2,** 1985.
Rybicki, E. and Kanninen, M. (1978) 'Fracture mechanics of non-metallic hybrid composites', in *Hybrids and Selected Metal–Matrix Composites: A State-of-the-Art Review,* W. J. Renton, ed., AIAA, New York, pp. 53–65.
Summerscales, J. and Short, D. (1978) 'Carbon fibre and glass fibre hybrid reinforced plastics', *Composites,* **9,** 157–66.
Sun, C. T. and Luo, J. (1985) 'Failure loads for notched graphite/epoxy laminates with a softening strip', *Comp. Sci. Tech.,* **22,** 121–33.
Sun, C. T. and Norman, T. L. (1988) 'Design of laminated composite with controlled-damage concept', *Proceedings of American Society for Composites, 3rd Technical Conference,* Technomic Pub. Co., Lancaster, PA, pp. 485–9.
Sun, C. T. and Rechak, S. (1988) 'Effect of adhesive layers on impact damage in composite laminates', in *Composite Materials Testing and Design, 8th Conference,* ASTM STP 972, J. D. Whitcomb, ed., American Society for Testing and Materials, Philadelphia.
Takahashi, K. and Chou, T. W. (1987) 'Non-linear deformation and failure behavior of carbon/glass hybrid laminate', *J. Comp. Mat.,* **21,** 396–420.
Taya, M. and Chou, T. W. 'On two kinds of ellipsoidal inhomogeneities in an infinite elastic body: an application to a hybrid composite', *Int. J. Sol. Struct.,* **17,** 553–63.
Vogelesang, L. B. and Gunnink, J. W. (1986) 'ARALL, a materials challenge for the next generation of aircraft', *Mat. & Design,* **7,** 287–300.
Wagner, H. D. and Marom, G. (1982) 'On composition parameters for hybrid composite materials', *Composites,* **13,** 18.
Walton, P. L. and Majumdar, A. J. (1975) *Composites,* **6,** 209–16.
Wells, H. and Hancox, N. L. (1971) 'Stiffening and strengthening GRP beams with CFRP', *Composites,* **2,** 147–51.
Yau, L. N. and Chou, T. W. (1989) 'Analysis of hybrid effect in unidirectional composites under longitudinal compressions', *Composite Structures,* **12,** 27–37.
Zweben, C. (1977) 'Tensile strength of hybrid composites', *J. Mat. Sci.,* **12,** 1325–37.

Chapter 6

Bishop, S. M. (1989) 'Strength and failure of woven carbon-fibre reinforced plastics for high performance applications', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 173–207.
Byun, J. H. and Chou, T. W. (1989) 'Modeling and characterization of textile structural composites: a review', *J. Strain Analysis,* **24,** 253–62.
Chang, L. W., Yau, S. S. and Chou, T. W. (1987) 'Notched strength of woven fabric composites with moulded-in holes', *Composites,* **18,** 233–41.
Chou, T. W. (1985) 'Characterization and modeling of textile structural composites: an overview', *Proceedings of the European Conference on Composite Materials,* AEMC, Bordeaux, pp. 133–7.
Chou, T. W. (1986) 'Strength and failure behavior of textile structural composites', *Proceedings of the American Society for Composites First Technical Conference,* Technomic Pub. Co., Lancaster, PA, p. 104.
Chou, T. W. (1989a) 'Properties of woven fabric composites', in *Encyclopedia of Materials Science and Engineering* and *Concise Subject Encyclopedias,* Pergamon Press, Oxford, p. 292.

Chou, T. W. (1989b) 'Mechanics of two-dimensional woven fabric composites', in *Mechanical Behavior and Properties of Composite Materials,* Technomic Pub. Co., Lancaster, PA, pp. 131–50.

Chou, T. W. and Ishikawa, T. (1989) 'Analysis and modeling of two-dimensional fabric composites', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 209–64.

Chou, T. W. and Ko, F. K. (1989) *Textile Structural Composites,* Elsevier Science Publishers B.V., Amsterdam.

Curtis, P. T. and Bishop, S. M. (1984) 'An assessment of the potential of woven carbon fibre-reinforced plastics for high performance applications', *Composites,* **15,** 259–65.

Douglass, W. A. (1964) *Braiding and Braiding Machinery,* Centrex Pub. Co., Eindhoven.

Dow, N. F. (1969) Triaxial Fabric, U.S. Patent 3446251, May 1969.

Dow, N. F. (1982) 'Studies of woven fabric reinforced composites for automotive applications', *Tech. Final Rep., MSC TFR 1301/8101,* Materials Science Corp., Springhouse, Pennsylvania.

Dow, N. F. and Tranfield, G. (1970) 'Preliminary investigations of feasibility of weaving triaxial fabrics (Doweave)', *Text. Res. J.,* **40,** 986–98.

Ghasemi Nejhad, M. N. and Chou, T. W. (1990a) 'Compression behavior of woven carbon fibre-reinforced epoxy composites with moulded-in and drilled holes', *Composites,* **21,** 33–40.

Ghasemi Nejhad, M. N. and Chou, T. W. (1990b) 'A model for the prediction of compressive strength reduction of composite laminates with molded-in holes', *J. Comp. Mat.* **24,** 236–55.

Hahn, H. T. and Tsai, S. W. (1973) 'Nonlinear elastic behavior of unidirectional composite laminate', *J. Comp. Mat.,* **7,** 102–18.

Hearle, J. W. S. (1989) 'Mechanics of yarns and nonwoven fabrics', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 27–65.

Hearle, J. W. S., Grosberg, P. and Backer, S. (1969) *Structural Mechanics of Fibers, Yarns, and Fabrics,* vol. 1, Wiley-Interscience, New York.

Ishikawa, T. (1981) 'Anti-symmetric elastic properties of composite plates of satin weave cloth', *Fiber Sci. Tech.,* **15,** 127–45.

Ishikawa, T. and Chou, T. W. (1982a) 'Elastic behavior of woven hybrid composites', *J. Comp. Mat.,* **16,** 2–19.

Ishikawa, T. and Chou, T. W. (1982b) 'Stiffness and strength behavior of woven fabric composites', *J. Mat. Sci.,* **17,** 3211–20.

Ishikawa, T. and Chou, T. W. (1982c) 'Stiffness and strength properties of woven fabric composites', in *Proceedings of the Fourth International Conference on Composite Materials,* Japan Society for Composite Materials, Tokyo, pp. 489–96.

Ishikawa, T. and Chou, T. W. (1983a) 'In-plane thermal expansion and thermal bending coefficients of fabric composites', *J. Comp. Mat.,* **17,** 92–104.

Ishikawa, T. and Chou, T. W. (1983b) 'One-dimensional analysis of woven fabric composites', *AIAA J.,* **21,** 1714.

Ishikawa, T. and Chou, T. W. (1983c) 'Nonlinear behavior of woven fabric composites', *J. Comp. Mat.,* **17,** 399–413.

Ishikawa, T. and Chou, T. W. (1983d) 'Thermoelastic analysis of hybrid fabric composite', *J. Mat. Sci.,* **18,** 2260–8.

Ishikawa, T., Koyama, K. and Kobayashi, S. (1977) 'Elastic moduli of carbon-epoxy composites and carbon fibers', *J. Comp. Mat.,* **11,** 332–44.

Ishikawa, T., Matsushima, M., Hayashi, Y. and Chou, T. W. (1985) 'Experimental confirmation of the theory of elastic moduli of fabric composites', *J. Comp. Mat.*, **19,** 443–58.

Jones, R. M. (1975) *Mechanics of Composite Materials,* McGraw-Hill, New York.

Kimpara, I., Hamamoto, A. and Takehana, M. (1977) *Trans. Japan Soc. Comp. Mat.*, **3,** 21.

Lekhnitskii, S. G. (1963) *Theory of Elasticity of an Anisotropic Elastic Body,* Holden-Day, San Francisco.

Lord, P. R. and Mohamed, M. H. (1982) *Weaving: Conversion of Yarn to Fabric,* 2nd edn, Merrow Publishing Company, Durham, UK.

Mody, P. B., Chou, T. W. and Friedrich, K. (1988) 'Effect of testing conditions and microstructure on the sliding wear of graphite fiber/PEEK matrix composites', *J. Mat. Sci.*, **23,** 4319–30.

Mody, P. B., Chou, T. W. and Friedrich, K. (1989) 'Abrasive wear behavior of unidirectional and woven graphite fiber/PEEK composites', in *Test Methods and Design Allowables for Fiber Composites,* ASTM STP 1003, C. C. Chamis, ed., American Society for Testing and Materials, Philadelphia, Pennsylvania, p. 75.

Rogers, K. F., Kingston-Lee, D. M., Phillips, L. N., Yates, B., Chandra, M. and Parker, S. F. H. (1981) 'The thermal expansion of carbon fibre-reinforced plastics, part 6. The influence of fibre weave in fabric reinforcement', *J. Mat. Sci.*, **16,** 2803–18.

Rogers, K. F., Phillips, L. N., Kingston-Lee, D. M., Yates, B., Overy, M. J., Sargent, J. P. and McCalla, B. A. (1977) 'The thermal expansion of carbon fibre-reinforced plastics, part 1. The influence of fibre type and orientation', *J. Mat. Sci.*, **12,** 718–34.

Rosen, B. W., Chatterjee, S. N. and Kibler, J. J. (1977) 'An analysis model for spatially oriented fiber composites', ASTM STP 617, *Composite Materials: Testing and Design (Fourth Conference),* American Society for Testing and Materials, Philadelphia, pp. 243–54.

Scardino, F. L. (1989) 'An introduction to textile structures and their behavior', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 1–26.

Scardino, F. L. and Ko, F. (1981) 'Triaxial woven fabrics Part I: behavior under tensile, shear, and burst deformation', *Text. Res. J.*, **51,** 80–9.

Schulte, K., Reese, E. and Chou, T. W. (1987) 'Fatigue behavior and damage development in woven fabric and hybrid fabric composites', *Proceedings of the Sixth International Conference and Second European Conference on Composite Materials,* vol. 4, Elsevier Applied Science, London, pp. 89–99.

Schwartz, P. (1984) A mathematical analysis of a fabric having non-orthogonal interlacings using strain energy methods', *Fiber Sci. Tech.*, **20,** 273–82.

Schwartz, P., Fornes, R. E. and Mohamed, M. H. (1982) 'An analysis of the mechanical behavior of triaxial fabrics and the equivalency of conventional fabrics', *Text Res. J.*, **52,** 388–94.

Schwartz, P., Rhodes, T. and Mohamed, M. H. (1982) *Fabric Forming Systems,* Noyes Publications, Park Ridge, New Jersey.

Skelton, J. (1971) Triaxially woven fabrics – their structure and properties, *Text. Res. J.*, **41,** 637–47.

Thomas, D. G. B. (1971) *An Introduction to Warp Knitting,* Merrow, Watford, UK.

Wray, G. R. and Vitols, R. (1982) 'Advances in stitch-bonding, warp- and weft-knitting systems, and automated knitwear manufacture', in *Contemporary Textile Engineering,* F. Happey, ed., Academic Press, London, pp. 375–409.

Yang, J. M. and Chou, T. W. (1986) 'Performance optimization of woven fabric composites for printed circuit boards', in *Electronic Packaging Materials Science, II,* Symposia Proceedings vol. 72, Materials Research Society, Pittsburgh, pp. 163–73.

Yang, J. M. and Chou, T. W. (1987) 'Performance maps of textile structural composites', *Proceedings of the Sixth International Conference on Composite Materials,* vol. 5, Elsevier Applied Science, London, p. 579.

Yang, J. M. and Chou, T. W. (1989) 'Thermo-elastic analysis of triaxial woven fabric composites', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 265–77.

Yates, B., Overy, M. J., Sargent, J. P., McCalla, B. A., Kingston-Lee, D. M., Phillips, L. N. and Rogers, K. F. (1978) 'The thermal expansion of carbon fibre-reinforced plastics, part 2. The influence of fibre volume fraction', *J. Mat. Sci.,* **13,** 433–40.

Yau, S. S. and Chou, T. W. (1988) 'Strength of woven fabric composites with drilled and molded holes', in *Composite Materials Testing and Design (Eighth Conference),* ASTM STP 972, J. D. Whitcomb, ed., ASTM, Philadelphia, pp. 423–37.

Yokoyama, A., Fujita, A., Kobayashi, H., Hamada, H. and Maekawa, Z. (1989) 'A new braiding process – robotised braiding mechanism', in *Materials and Processing – Move into the 90's,* S. Benson, T. Cook, E. Trewin and R. M. Turner, eds., Elsevier, Amsterdam, pp. 87–99.

Zweben, C. and Norman, J. C. (1976) 'Kevlar 49/Thornel 300 hybrid fabric composites for aerospace application', *SAMPE Quarterly,* **1,** 1–10.

Chapter 7

Annual Book of ASTM Standards, Part 10, Practice E399, 'Plane-strain fracture toughness of metallic materials', American Society for Testing and Materials, Philadelphia, PA.

Ashby, M. F., Gandi, C. and Taplin, D. M. R. (1979) 'Fracture-mechanism maps and their construction for F.C.C. metals and alloys', *Acta Metall.,* **27,** 699–729.

ASTM Standards and Literature References for Composite Materials, D 4255-83, 'In-plane shear properties of composite laminates', American Society for Testing and Materials, Philadelphia, PA.

ASTM Standards and Literature References for Composite Materials, D 2344-84, 'Apparent interlaminar shear strength of parallel fiber composites by short-beam method', American Society for Testing and Materials, Philadelphia, PA.

Brunnschweiler, D. (1954) 'The structure and tensile properties of braids', *J. Text. Instrum.,* **45,** T55–T77.

Byun, J. H., Leach, B. S., Stroud, S. S. and Chou, T. W. (1990a) 'Structural characteristics of three-dimensional angle-interlock woven fabric preforms', in *Processing of Polymers and Polymeric Composites,* ASME, MD-vol. 19 American Society for Mechanical Engineers, New York, pp. 177.

Byun, J. H., Du, G. W. and Chou, T. W. (1991) 'Analysis and modeling of 3-D textile structural composites', ACS Symposium Series **457,** American Chemical Society, Washington D.C., pp. 22–33.

Byun, J. H., Gillespie, J. W. and Chou, T. W. (1989) 'Mode II delamination of three-dimensional textile structural composites', *Proceedings of the American Society for Composites, 4th Technical Conference,* Technomic Pub. Co., Lancaster, PA, pp. 287–96.

Byun, J. H., Gillespie, J. W. and Chou, T. W. (1990b) 'Mode I delamination of a three-dimensional fabric composite', *J. Comp. Mat.*, **24,** 497.

Byun, J. H., Whitney, T. J., Du, G. W. and Chou, T. W. (1991) 'Analytical characterization of two-step braided composites' *J. Comp. Mat.* in press.

Chou, T. W. (1989) 'Structure–performance maps', in *Encyclopedia of Materials Science and Engineering and Concise Subject Encyclopedias,* Pergamon Press, Oxford, p. 261.

Chou, T. W., McCullough, R. L. and Pipes, R. B. (1986) 'Composites', *Sci. Am.*, **254,** 193–203.

Chou, T. W. and Yang, J. M. (1986) 'Structure–performance maps of polymeric, metal and ceramic matrix composites', *Metall. Trans. A,* **17A,** 1547–9.

Cole, P. M. (1988) 'Three-dimensional structures of interlocked strands', U.S. Patent 4,737,399.

Cooper, G. A. and Kelly, A. J. (1967) 'Tensile properties of fiber-reinforced metals: fracture mechanics', *Mech. Phys. Solids,* **15,** 279–97.

Crane, R. M. and Camponeschi, E. T. (1986) 'Experimental and analytical characterization of multidimensionally braided graphite/epoxy composites', *Exp. Mech.*, **26,** 259.

Dexter, H. B. and Funk, J. G. (1986) 'Impact resistance and interlaminar fracture toughness of through-the-thickness reinforced graphite epoxy', AIAA Paper 86-1020-CP, pp. 700–9.

Dhingra, A. K., Champion, A. R. and Krueger, W. H. (1975) 'Fiber FP reinforced aluminum and magnesium composites', in *Proceedings of the First Metal Matrix Composite Workshop,* Paper Number C-501, Institute for Defense Analyses, Washington, D.C., September.

Dow, N. F. (1984) *Proceedings of the Fiber Society/SAMPE Conference on High Performance Textile Structures,* Philadelphia College of Textile and Science, Philadelphia, PA.

Du, G. W., Popper, P. and Chou, T. W. (1989) 'Analysis and automation of two-step braiding', *FIBER-TEX 88,* NASA Conference Publication no. 3038, pp. 217–33.

Du, G. W., Popper, P. and Chou, T. W. (1991) 'Analysis of 3D textile preform for multidirectional reinforcement of composites', *J. Mat. Sci.* in press.

Florentine, R. (1982) 'Apparatus for weaving a three-dimensional article', U.S. Patent 4,312,261.

Fowser, S. W. (1986) 'The behavior of orthogonal fabric composites', M.S. thesis, University of Delaware.

Fowser, S. W. and Chou, T. W. (1989) 'Simplified Green's functions for mode I and II cracks', *Int. J. Fracture,* **39,** 301–21.

Fowser, S. W. and Chou, T. W. (1990a) 'Integral equations solution for reinforced mode I cracks opened by internal pressure', *J. Appl. Mech.*, in press.

Fowser, S. W. and Chou, T. W. (1990b) 'Numerical integration of Green's functions for an edge-loaded infinite strip', *Computers and Structures,* in press.

Frost, H. J. and Ashby, M. F. (1982) *Deformation-Mechanism Maps,* Pergamon Press, Oxford.

Gandi, C. and Ashby, M. F. (1979) 'Fracture mechanism maps for materials which cleave: F.C.C. and H.C.P. metals and ceramics', *Acta Metall.*, **27,** 1565–1602.

Guénon, V. A., Chou, T. W. and Gillespie, J. W. (1987) 'Interlaminar fracture toughness of a three-dimensional fabric composite', *Proceedings of the Society of*

Manufacturing Engineers, EM87-551, 1–17, Society of Manufacturing Engineers, Dearborn, Michigan.

Guénon, V. A., Chou, T. W. and Gillespie, J. W. (1989) 'Toughness properties of a three-dimensional carbon–epoxy composite', *J. Mat. Sci.,* **24,** 4168–75.

Guess, T. R. and Reedy, Jr., E. D. (1985) 'Comparison of interlocked fabric and laminated fabric Kevlar 49/epoxy composites', *J. Comp. Tech. Res.,* **7,** 136–42.

Hearle, J. W. S., Grosberg, P. and Backer, S. (1969) *Structural Mechanics of Fibers, Yarns, and Fabrics,* vol. 1, Wiley-Interscience, New York, p. 80.

Hunston, D. H. (1984) *Comp. Tech. Rev.,* **6,** 176.

Iosipescu, N. (1967) 'New accurate procedures for single shear testing of metals', *J. Mat.,* **2,** 537–66.

Ishikawa, T. and Chou, T. W. (1982) 'Stiffness and strength behavior of woven fabric composites', *J. Mat. Sci.,* **17,** 3211–20.

Kelly, A. and Macmillan, N. H. (1986) *Strong Solids,* 3rd edn, Clarendon Press, Oxford.

Kies, J. A. (1962) 'Maximum strains in the resin of fiberglass composites', U.S. Naval Research Laboratory Report NRL 5752.

Ko, F. K. (1989a) Three-dimensional fabrics for composites', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 129–71.

Ko, F. K. (1989b) 'Preform fiber architecture for ceramic–matrix composites', *Ceramic Bull.,* **68,** 401–14.

Ko, F. K. (1986) 'Tensile strength and modulus of a 3-D braided composite' in *Composite Materials: Testing and Design,* ASTM STP 893, American Society for Testing and Materials, Philadelphia, PA, p. 392.

Ko, F. K. and Pastore, C. M. (1985) 'Structure and properties of an integrated 3-D fabric for structural composites', ASTM STP 864, American Society for Testing and Materials, Philadelphia, PA, p. 428.

Ko, F. K., Pastore, C. M., Yang, J. M. and Chou, T. W. (1986) 'Structure and properties of multilayer, multidirectional warp knit fabric reinforced composites', in *Composites '86: Recent Advances in Japan and the United States,* Japan Society for Composite Materials, Tokyo.

Ko, F. K., Soebroto, H. B. and Lei, C. (1988) '3-D net shaped composites by the 2-step braiding process', *Proceedings of 33rd International SAMPE Symposium,* vol. 33, SAMPE International Business Office, Covina, California, pp. 912–21.

Kregers, A. F. and Teters, G. A. (1982) 'Structural model of deformation of anisotropic three-dimensionally reinforced composites', *Mech. Comp. Mat.,* **1,** 14.

Lekhnitskii, S. G. (1963) *Theory of Elasticity of an Anisotropic Elastic Body,* Holden-Day, San Francisco.

Li, W. and El Shiekh, A. (1988) 'The effect of processes and processing parameters on 3-D braided preforms for composites', *SAMPE Quarterly,* **19,** 22–8.

Li, W., Kang, T. J., and El Shiekh, A. (1988) 'Structural mechanics of 3-D braided preforms for composites, part I: Geometry of fabric produced by 4-step process', in *Proceedings of Fiber-Tex'87 Conference,* NASA Conference Publication.

Liu, C. H. and Chou, T. W. (1989) 'Mode II interlaminar fracture toughness of three-dimensional textile structural composites', *Proceedings of the 4th Japan–U.S. Conference on Composite Materials,* Technomic Pub. Co., 981.

Ma, C. L., Yang, J. M. and Chou, T. W. (1986) 'Elastic stiffness of three-dimensional braided textile structural composites', in *Composite Materials, Testing*

and Design (Seventh Conference), ASTM STP 893, American Society for Testing and Materials, Philadelphia, PA, pp. 404–21.

Majidi, A. P. and Chou, T. W. (1986) 'Impact tolerance of braided alumina fiber reinforced aluminum composites', *Proceedings of the 31st International SAMPE Symposium,* SAMPE International Business Office, Covina, California.

Majidi, A. P. and Chou, T. W. (1987) 'Structure-reliability studies of three-dimensionally braided metal matrix composites', in *Proceedings of the Sixth International and Second European Conference on Composite Materials,* vol. 2, Elsevier Applied Science, London.

Majidi, A. P., Rémond, O. G. and Chou, T. W. (1987) 'The effect of fiber architecture on the mechanical performance of metal matrix composites', *Proceedings of the 2nd Annual Conference of the American Society for Composites,* Technomic Pub. Co., Lancaster, Pennsylvania, p. 371.

Majidi, A. P., Yang, J. M. and Chou, T. W. (1986) 'Toughness characteristics of three-dimensionally braided AI203/Al–Li composites', in *Interfaces in Metal–Matrix Composites,* A. K. Dhingra and S. G. Fishman, eds., The Metallurgical Society, Warrendale, PA, pp. 27–44.

Majidi, A. P., Yang, J. M. and Chou, T. W. (1988) 'Mechanical behavior of three-dimensional braided metal–matrix composites', *Testing Technology of Metal Matrix Composites,* ASTM STP 964, American Society for Testing and Materials, Philadelphia, PA, p. 31.

Majidi, A. P., Yang, J. M., Pipes, R. B. and Chou, T. W. (1985) 'Mechanical behavior of three-dimensional woven fiber composites', in *Proceedings of the Fifth International Conference on Composite Materials,* The Metallurgical Society of AIME, Warrendale, PA, pp. 1247–65.

Masters, J. E. (1987) 'Characterization of impact development in graphite epoxy laminates', ASTM, STP 948, American Society for Testing and Materials, Philadelphia, PA, pp. 238–58.

Mignery, L. A., Tan, T. M. and Sun, C. T. (1985) 'The use of stitching to suppress delamination in laminated composites', ASTM STP 876, American Society for Testing and Materials, Philadelphia, PA, pp. 371–85.

Ogo, Y. (1987) 'The effect of stitching on in-plane and interlaminar properties of carbon–epoxy fabric laminates', M.S. Thesis, University of Delaware,

Peirce, F. T. (1937) 'The geometry of cloth structure', *J. Text. Instrum.,* **28,** T45–T96.

Popper, P. and McConnell, R. F. (1988) 'Complex shaped braided structures', U.S. Patent 4,719,837.

Rémond, G. O. (1987) 'Characterization and modeling of 3-D braided metal matrix composites', M.S. Thesis, University of Delaware.

Rybicki, E. F. and Kanninen, M. F. (1977) 'A finite element calculation of stress intensity factors by a modified crack closure integral', *Eng. Fracture Mech.,* **9,** 931–8.

Simonds, R. A., Stinchcomb, W. and Jones, R. M. (1988) 'Mechanical behavior of braided composite materials', ASTM STP 972, American Society for Testing and Materials, Philadelphia, PA, p. 438.

Steeger, USA, Inc. (1989) Production Program, Spartanburg, South Carolina.

Takahashi, K. and Chou, T. W. (1986) 'Modeling of the interfacial behavior of flexible composites', in *Interfaces in Metal–Matrix Composites,* A. K. Dhingra and S. G. Fishman, eds., The Metallurgical Society, Warrendale, PA, pp. 45–59.

Tattersall, H. G. and Tappin, G. J. (1966) *J. Mat. Sci.* **1,** 296.
Walrath, D. E. and Adams, D. F. (1983a) 'The Iosipescu shear test as applied to composite materials', *Exp. Mech.*, **23,** 105–10.
Walrath, D. E. and Adams, D. F. (1983b) 'Analysis of the stress state in an Iosipescu shear test specimen', Technical Report UWME-DR-301-102-1, University of Wyoming, Laramie, Wyoming.
Weller, R. D. (1985) 'AYPEX: a new method of composite reinforcement braiding, *3-D Composite Materials,* NASA Conference Publication 2420.
Whitcomb, J. D. (1989) 'Three dimensional stress analysis of plain weave composites', NASA Technical Memorandum 101672.
Whitney, J. M., Browning, C. E. and Hoogsteden, W. (1982) *J. Reinf. Plastics Comp.*, **1,** 297.
Whitney, T. J. (1988) 'Analytical characterization of 3-D textile structural composites using plane stress and 3-D lamination analogies', M.S. Thesis, University of Delaware.
Whitney, T. J. and Chou, T. W. (1988) 'Modeling of elastic properties of 3-D textile structural composites', *Proceedings of the American Society for Composites, Third Technical Conference,* Technomic Pub. Co., Lancaster, Pennsylvania, p. 427.
Whitney, T. J. and Chou, T. W. (1989) 'Modeling of 3-D angle-interlock textile structural composites', *J. Comp. Mat.*, **23,** 890–911.
Yang, J. M. and Chou, T. W. (1989) 'Thermo-elastic analysis of triaxial woven fabric composites', in *Textile Structural Composites,* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers B.V., Amsterdam, pp. 265–77.
Yang, J. M., Ma, C. L. and Chou, T. W. (1986) 'Fiber inclination model of three-dimensional textile structural composites', *J. Comp. Mat.*, **20,** 472–84.
Yau, S. S., Ko, F. and Chou, T. W. (1986) 'Flexural and axial compressive failures of three-dimensionally braided composite I-beams', *Composites*, **17,** 227.
Yoshida, H., Ogasa, T. and Hayashi, R. (1986) 'Statistical approach to the relationship between ILSS and void content of CFRP', *Comp. Sci. Tech.*, **25,** 3–18.

Chapter 8

Akasaka, T. (1959–64) Various Reports/Bulletins, Faculty of Science and Engineering, Chuo University, Tokyo.
Akasaka, T. (1989) 'Flexible composites', in *Textile Structural Composites* T. W. Chou and F. Ko, eds., Elsevier Science Publishers, Amsterdam, pp. 279–330.
Akasaka, T. and Hirano, M. (1972) *Comp. Mat. Struc.*, **1,** 70.
Akasaka, T. and Yoshida, N. (1972) *Proc. Intl. Conf. Mech. Behavior of Mater.*, Kyoto, Japan, vol. 5, pp. 187–97.
Alley, V. A. and Fairslon, R. W. (1972) 'Experiment investigation of strains in a fabric under biaxial and shear forces', *J. Aircraft,* **9,** 55.
Bert, C. W. and Kumar, M. (1981) 'Experiments on highly nonlinear elastic composites', *Proc. NCKU/AAS Int-Sym. in Eng. Sci. and Mech.*, National Chen Kung Univ., Taiwan, vol. 2, pp. 1269–83.
Bert, C. W. and Reddy, J. N. (1982) 'Mechanics of bimodular composite structures', in *Mechanics of Composite Materials: Recent Advances,* Proceedings of the IUTAM Symposium, Virginia Polytechnic Institute, pp. 323–37.

Biderman, V. I., Gusliter, R. L., Sakharov, S. P., Nenakhov, B. V., Seleznev, I. I. and Tsukerberg, S. M. (1963) 'Automobile tires, construction, design, testing and usage', NASA, TT F-12, 382, 1969. (Original publication in Russian, State Scientific and Technical Press for Chemical Literature, Moscow).

Bohm, F. (1966) 'Mechanik des Gürtelreifens', *Ing-Arch.*, **35,** 82–101.

Chamis, C. C. (1984) 'Simplified composite micromechanics equations for hygral, thermal and mechanical properties', *SAMPE Quarterly,* **15,** 14–23.

Chou, T. W. (1985) 'Characterization and modeling of textile structural composites: an overview', *Proceedings of First European Conference on Composite Materials,* A.E.M.C., Bordeaux, France, pp. 133–8.

Chou, T. W. (1989) 'Review: flexible composites', *J. Mat. Sci.*, **24,** 761–83.

Chou, T. W. (1990) 'Flexible composites', in *International Encyclopedia of Composites,* VCH Publishers, New York.

Chou, T. W. and Takahashi, K. (1987) 'Nonlinear elastic behavior of flexible fiber composites', *Composites,* **18,** 25.

Chou, T. W. and Yang, J. M. (1986) 'Structure-performance maps of textile structural composites in polymeric, metal and ceramic matrices', *Met. Trans. A,* **17A,** 1547.

Clark, S. K. (1963a) 'The plane elastic characteristics of cord–rubber laminates', *Textile Res. J.*, **33,** 295–313.

Clark, S. K. (1963b) 'Internal characteristics of orthotropic laminates', *Textile Res. J.*, **33,** 935–53.

Clark, S. K. (1964) 'A review of cord–rubber elastic characteristics', *Rubber Chem. Tech.*, **37,** 1365–90.

Clark, S. K. (1980) 'The role of textiles in pneumatic tires', in *Mechanics of Flexible Fibre Assembles,* J. W. S. Hearle, J. J. Thwaites and J. Amirbayat, eds., Sijthoff and Noordhoff, The Netherlands.

Clark, S. K. and Dodge, R. N. (1969) 'A load transducer for tire cord', SAE Paper 690521, Society of Automotive Engineers, Warrendale, PA.

Gough, V. E. (1968) 'Stiffness of cord and rubber constructions', *Rubber Chem. Tech.*, **41,** 988–1021.

Hearle, J. W. S., Grosberg, P. and Backer, S. (1969) *Structural Mechanics of Fibers, Yarns and Fabrics,* vol. 1, Wiley-Interscience, New York.

Ishikawa, T. and Chou, T. W. (1983) 'Nonlinear behavior of woven fabric composites', *J. Comp. Mat.*, **17,** 399.

James, H. M. and Guth, E. (1943) 'Theory of the elastic properties of rubber', *J. Chem. Phys.*, **11,** 455–81.

Jones, R. E. (1975) *Mechanics of Composite Materials,* McGraw-Hill, New York.

Kuo, C. M., Takahashi, K. and Chou, T. W. (1988) 'Effects of fiber waviness on the nonlinear elastic behavior of flexible composites', *J. Comp. Mat.*, **12,** 1004.

Lou, A. Y. C. and Walter, J. D. (1978) 'Interlaminar shear strain measurements in cord–rubber composites', paper presented at SESA meeting, Wichita, Kansas, May.

Luo, S. Y. and Chou, T. W. (1988) 'Finite deformation and nonlinear elastic behavior of flexible composites', *J. Appl. Mech.*, **55,** 149–55.

Modern Plastics Encyclopedia, Engineering Data Bank, McGraw-Hill, Inc., New York.

Patterson, R. G. (1969) 'The measurement of cord tensions in tires', *Rubber Chem. Echnology,* **42,** 812.

Petit, P. H. and Waddoups, M. E. (1969) 'A method of predicting the nonlinear behavior of laminated composites', *J. Comp. Mat.*, **3,** 2–19.

Reinhardt, H. W. (1976) 'On the biaxial testing and strength of coated fabrics', *Exp. Mech.*, **11,** 71.
Skelton, J. (1971) 'The biaxial stress–strain behavior of fabrics for air-supported tents', *J. Mat., J.M.L.S.A.*, **6,** 656.
Stubbs, N. (1988) 'Elastic and inelastic response of coated fabrics to arbitrary loading paths', in *Textile Structural Composites* T. W. Chou and F. K. Ko, eds., Elsevier Science Publishers, Amsterdam, pp. 331–54.
Stubbs, N. and Thomas, S. (1984) 'A nonlinear elastic constitutive model for coated fabrics', in *Mechanics of Material,* S. Nernat-Nasser, eds., vol. 3, Elsevier Science Publishers, BV, Amsterdam, pp. 157–68.
Takahashi, K. and Chou, T. W. (1986) 'Modeling of the interfacial behavior of flexible composites', in *Interfaces in Metal–Matrix Composites,* A. K. Dhingra and S. G. Fishman, eds., The Metallurgical Society, Warrendale, PA, pp. 45–59.
Takahashi, K., Kuo, C. M. and Chou, T. W. (1986) 'Nonlinear elastic constitutive equations of flexible fiber composites', in *Composites '86: Recent Advances in Japan and the United States,* Japan Society for Composite Materials, Tokyo, p. 389.
Takahashi, K., Yano, T., Kuo, C. M. and Chou, T. W. (1987) 'Effect of fiber waviness on elastic moduli of fiber composites', *Trans. Japan Fiber Soc.*, **43,** 376.
Treloar, L. R. G. (1973) 'The elasticity and related properties of rubbers', *Rep. Prog. Phys.*, **36,** 755–826.
Walter, J. D. (1978) 'Cord–rubber tire composites: theory and application', *Rubber chem. Tech.*, **51,** 524.
Walter, J. D. and Hall, G. L. (1969) 'Cord load characteristics in bias and belted-bias tires', SAE Paper 690522, Society of Automotive Engineers, Warrendale, PA.
Walter, J. D. and Patel, H. P. (1979) "Approximate expressions for the elastic constants of cord–rubber laminates', *Rubber Chem. Tech.*, **52,** 710–24.

Chapter 9

Adkins, J. E. and Rivlin, R. S. (1955) 'Large elastic deformation of isotropic materials X. Reinforcements by inextensible cords', *Phil. Trans. Royal Soc. London,* (*A*), **248,** 201–23.
Aspden, R. M. (1986) 'Relation between structure and mechanical behavior of fibre-reinforced composite materials at large strains', *Proc. Royal Soc. London,* (*A*), **406,** 287–98.
ASTM Standard D3518-76 (1982) 'Practice for in-plane shear stress–strain response of unidirectional reinforced plastics' American Society for Testing and Materials, Philadelphia.
Chou, T. W. (1989) 'Flexible composites', *J. Mat. Sci.*, **24,** 761–83.
Ericksen, J. L. and Rivlin, R. S. (1954) 'Large elastic deformations of homogeneous anisotropic materials', *J. Rational Mech. Analysis,* **3** (3) 281–301.
Fung, Y. C. (1965) *Foundations of Solid Mechanics,* Prentice-Hall Inc., Englewood Cliffs, NJ.
Fung, Y. C. (1977) *A First Course in Continuum Mechanics,* Prentice-Hall, Inc., Englewood Cliffs, N.J.
Fung, Y. C. (1981) *Biomechanics: Mechanical Properties of Living Tissues,* Springer Verlag, New York.
Hahn, H. T. (1973) 'Nonlinear behavior of laminated composites', *J. Comp. Mat.*, **7,** 257–71.

000

Hahn, H. T. and Tsai, S. W. (1973) 'Nonlinear elastic behavior of unidirectional composite laminae', *J. Comp. Mat.*, **7,** 102–18.

Humphrey, J. D. and Yin, F. C. P. (1987) 'A new constitutive formulation for characterizing the mechanical behavior of soft tissues', *Biophys. J.*, **52,** 563–70.

Ishikawa, T. and Chou, T. W. (1983) 'Nonlinear behavior of woven fabric composites', *J. Comp. Mat.*, **17,** 399–413.

Jones, R. S. and Morgan, H. S. (1977) 'Analysis of nonlinear stress–strain behavior of fiber-reinforced composite materials', *AIAA J.*, **15,** 1669–76.

Kuo, C. M., Takahashi, K. and Chou, T. W. (1988) 'Effect of fiber waviness on the nonlinear elastic behavior of flexible composites', *J. Comp. Mat.*, **12,** 1004.

Lai, W. M., Rubin, D. and Krempl, E. (1978) *Introduction to Continuum Mechanics,* Pergamon Press, Oxford.

Luo, S. Y. (1988) 'Theoretical modeling and experimental characterization of flexible composites', Ph.D. Dissertation, University of Delaware, Newark, Delaware.

Luo, S. Y. and Chou, T. W. (1988a) 'Finite deformation and nonlinear elastic behavior of flexible composites', *J. Appl. Mech.*, **55,** 149–55.

Luo, S. Y. and Chou, T. W. (1988b) 'Constitutive relations of flexible composites under finite elastic deformation', in *Mechanics of Composite Materials – 1988,* G. J. Dvorak and N. Laws, eds., ASME, AMD, New York, vol. **92,** pp. 209–16.

Luo, S. Y. and Chou, T. W. (1989) 'Elastic behavior of laminated flexible composites under finite deformation', in *Micromechanics and Inhomogeneity – The Toshio Mura Anniversary Volume,* G. J. Weng, M. Taya and H. Abe, eds., Springer-Verlag, New York, pp. 243–56.

Luo, S. Y. and Chou, T. W. (1990a) 'Modeling of the nonlinear elastic behavior of elastomeric flexible composites', in *Composites: Chemical and Physicochemical Aspects,* T. L. Vigo and B. J. Kinzig eds., VCH Publishers, New York, in press.

Luo, S. Y. and Chou, T. W. (1990b) 'Finite deformation of flexible composites', *Proc. Royal Soc. London,* (*A*), **429,** 569–86.

Luo, S. Y., Kuo, C. M. and Chou, T. W. (1988) 'Theoretical modeling and experimental characterization of flexible composites', *Proceedings of the Fourth Japan–United States Conference on Composite Materials,* Technomic Pub. Co., Lancaster, Pennsylvania, pp. 885–74.

Malvern, L. E. (1969) *Introduction to the Mechanics of a Continuous Medium,* Prentice-Hall, Inc., Englewood Cliffs.

Pagano, N. J. and Halpin, J. C. (1968) 'Influence of end constraint in the testing of anisotropic bodies', *J. Comp. Mat.*, **2,** 18–31.

Petit, P. H. and Waddoups, M. E. (1969) 'A method of predicting the nonlinear behavior of laminated composites', *J. Comp. Mat.*, **3,** 2–19.

Pipkin, A. C. and Rogers, T. G. (1971) 'Plane deformation of incompressible fiber-reinforced materials', *J. Appl. Mech.*, **38,** 634–40.

Posfalvi, O. (1977) 'The Poisson ratio for rubber–cord composites', *Rubber Chem. Tech.*, **50,** 224–32.

Rivlin, R. S. (1948a) 'Large elastic deformation of isotropic materials I. Fundamental Concepts', *Phil. Trans. Royal Soc. London,* (*A*), **240,** 459–90.

Rivlin, R. S. (1948b) 'Large elastic deformation of isotropic materials IV. Further developments of the general theory', *Phil. Trans. Royal Soc. London,* (*A*), **241,** 379–97.

Rivlin, R. S. (1959) 'Mathematics and rheology, the 1958 Bingham Medal Address', *Phys. Today,* **12,** (5), 32–6.

Rivlin, R. S. (1964) 'Networks of inextensible cords', in *Nonlinear Problems of Engineering,* W. F. Ames, ed., Academic Press, New York.

Rivlin, R. S. (1970) 'Nonlinear continuum theories in mechanics and physics and their applications', in *Centro Internazionale Matematico Estivo,* Ciclo, II and R. S. Rivlin, eds., Edizioni Cremonese, Roma.

Rivlin, R. S. and Saunders, D. W. (1951) 'Large elastic deformation of isotropic materials XII. Experiments on the deformation of rubber', *Phil. Trans. Royal Soc. London,* (*A*), **243,** 251–98.

Spencer, A. J. M. (1972) *Deformation of Fibre Reinforced Materials,* Clarendon Press, Oxford.

Truesdell, C. (1966) *Elements of Continuum Mechanics,* Springer-Verlag, New York.

Whitney, J. M., Daniel, I. M. and Pipes, R. B. (1982) *Experimental Mechanics of Fiber Reinforced Composite Materials,* The Society for Experimental Stress Analysis, Brookfield Center, Connecticut.