Designation: D5379/D5379M – 12

Standard Test Method for
Shear Properties of Composite Materials by the V-Notched Beam Method[1]

This standard is issued under the fixed designation D5379/D5379M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the shear properties of composite materials reinforced by high-modulus fibers. The composite materials are limited to continuous-fiber or discontinuous-fiber-reinforced composites in the following material forms:

1.1.1 Laminates composed only of unidirectional fibrous laminae, with the fiber direction oriented either parallel or perpendicular to the loading axis.

1.1.2 Laminates composed only of woven fabric filamentary laminae with the warp direction oriented either parallel or perpendicular to the loading axis.

1.1.3 Laminates composed only of unidirectional fibrous laminae, containing equal numbers of plies oriented at 0 and 90° in a balanced and symmetric stacking sequence, with the 0° direction oriented either parallel or perpendicular to the loading axis.

1.1.4 Short-fiber-reinforced composites with a majority of the fibers being randomly distributed.

NOTE 1—This shear test concept was originally developed without reference to fiber direction for use on isotropic materials such as metals or ceramics.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D883 Terminology Relating to Plastics
D2584 Test Method for Ignition Loss of Cured Reinforced Resins
D2734 Test Methods for Void Content of Reinforced Plastics
D3171 Test Methods for Constituent Content of Composite Materials
D3878 Terminology for Composite Materials
D5229/D5229M Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials
E4 Practices for Force Verification of Testing Machines
E6 Terminology Relating to Methods of Mechanical Testing
E111 Test Method for Young's Modulus, Tangent Modulus, and Chord Modulus
E122 Practice for Calculating Sample Size to Estimate, With Specified Precision, the Average for a Characteristic of a Lot or Process
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages
E456 Terminology Relating to Quality and Statistics
E1237 Guide for Installing Bonded Resistance Strain Gages

2.2 *Other Documents:*

ANSI Y14.5M-1982 Geometric Dimensioning and Tolerancing[3]
ANSI/ASME B 46.1-1985 Surface Texture (Surface Roughness, Waviness, and Lay)[3]

2.3 *ASTM Adjuncts:*

V-Notched Beam Shear Fixture Machining Drawings[4]

[1] This test method is under the jurisdiction of ASTM Committee D30 on Composite Materialsand is the direct responsibility of Subcommittee D30.04 on Lamina and Laminate Test Methods.

Current edition approved July 15, 2012. Published February 2013. Originally approved in 1993. Last previous edition approved in 2005 as D5379/D5379M – 05. DOI: 10.1520/D5379_D5379M-12.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from ASTM International Headquarters. Order Adjunct No. ADJD5379.

3. Terminology

3.1 *Definitions*—Terminology D3878 defines terms relating to high-modulus fibers and their composites. Terminology D883 defines terms relating to plastics. Terminology E6 defines terms relating to mechanical testing. Terminology E456 and Practice E177 define terms relating to statistics. In the event of a conflict between terms, Terminology D3878 shall have precedence over the other standards.

3.2 *Definitions of Terms Specific to This Standard:*

NOTE 2—If the term represents a physical quantity, its analytical dimensions are stated immediately following the term (or letter symbol) in fundamental dimension form, using the following ASTM standard symbology for fundamental dimensions, shown within square brackets: [*M*] for mass, [*L*] for length, [*T*] for time, [Θ] for thermodynamic temperature, and [*nd*] for nondimensional quantities. Use of these symbols is restricted to analytical dimensions when used with square brackets, as the symbols may have other definitions when used without the brackets.

3.2.1 *in-plane shear, n*—any of the shear properties describing the response resulting from a shear force or deformation applied to the *1-2* material plane. (See also *material coordinate system*.)

3.2.2 *interlaminar shear, n*—any of the shear properties describing the response resulting from a shear force or deformation applied to the *1-3* or *2-3* material planes. (See also *material coordinate system*.)

3.2.3 *material coordinate system, n*—a Cartesian coordinate system describing the principal material coordinate system, using *1, 2*, and *3* for the axes, as shown in Fig. 1.

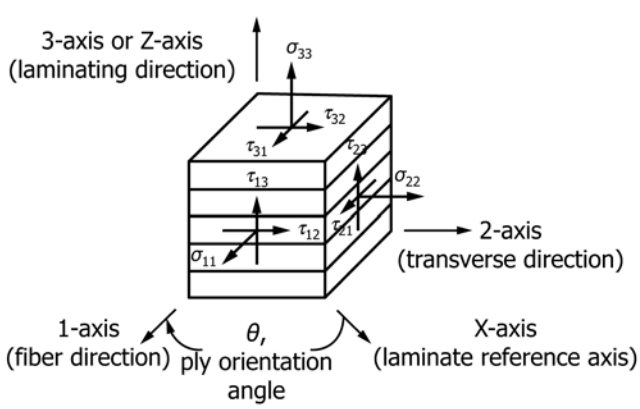


FIG. 1 Material Coordinate System

3.2.4 *nominal value, n*—a value, existing in name only, assigned to a measurable property for the purpose of convenient designation. Tolerances may be applied to a nominal value to define an acceptable range for the property.

3.2.5 *shear strength, n*—the shear stress carried by a material at failure under a pure shear condition.

3.2.5.1 *Discussion*—There are no standard test methods that are capable of producing a perfectly pure shear stress condition to failure for every material, although some test methods can come acceptably close for a specific material for a given engineering purpose.

3.3 *Symbols:*

3.3.1 *A*—minimum cross-sectional area of a coupon.

3.3.2 *CV*—coefficient of variation statistic of a sample population for a given property (in percent).

3.3.3 F^{su}—ultimate shear strength in the test direction.

3.3.4 F^{u}—ultimate strength in the test direction.

3.3.5 F^{o} *(offset)*—the value of the shear stress at the intersection of the shear chord modulus of elasticity and the stress strain curve when the modulus is offset along the engineering shear strain axis from the origin by the reported strain offset value.

3.3.6 *G*—shear modulus of elasticity in the test direction.

3.3.7 *h*—coupon thickness.

3.3.8 *n*—number of coupons per sample population.

3.3.9 *P*—force carried by test coupon.

3.3.10 P^{f}—force carried by test coupon at failure.

3.3.11 P^{max}—maximum force carried by test coupon before failure.

3.3.12 s_{n-1}—standard deviation statistic of a sample population for a given property.

3.3.13 *w*—coupon width.

3.3.14 x_i—test result for an individual coupon from the sample population for a given property.

3.3.15 $\bar{x}$—mean or average (estimate of mean) of a sample population for a given property.

3.3.16 γ—engineering shear strain.

3.3.17 ε—general symbol for strain, whether normal strain or shear strain.

3.3.18 ε—indicated normal strain from strain transducer or extensometer.

3.3.19 σ—normal stress.

3.3.20 τ—shear stress.

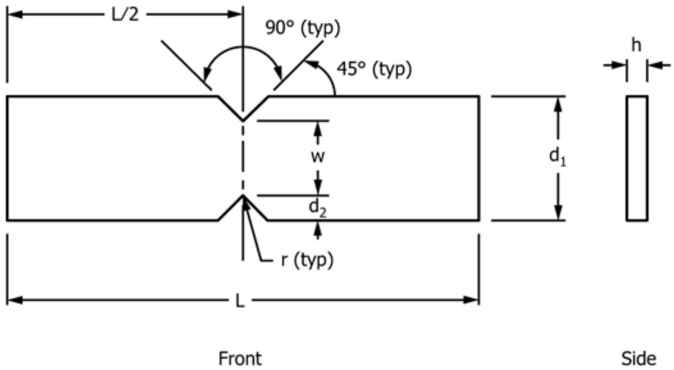
3.3.21 θ—ply orientation angle.

4. Summary of Test Method

4.1 A material coupon in the form of a rectangular flat strip with symmetrical centrally located *v*-notches, shown schematically in Fig. 2, is loaded in a mechanical testing machine by a special fixture (shown schematically in Fig. 3 and in more detail in the machining drawings of ASTM Adjunct ADJD5379.[5]

4.2 The specimen is inserted into the fixture with the notch located along the line of action of loading by means of an alignment tool that references the fixture. The two halves of the fixture are compressed by a testing machine while monitoring force. The relative displacement between the two fixture halves loads the notched specimen. By placing two strain gauge elements, oriented at ±45° to the loading axis, in the middle of the specimen (away from the notches) and along the loading axis, the shear response of the material can be measured.

[5] The specimen and fixture are based upon work at the University of Wyoming Composite Materials Research Group (**1, 2**), and were subsequently modified by the group (**3, 4**) into the configuration used by this test method. The Wyoming investigations referred to the earlier work of Arcan (**5-7**) and Iosipescu (**8-10**), and the later work of a number of other researchers, including Refs (**11-16**) (early historical perspectives are given in Refs (**1, 17**)). The boldface numbers in parentheses refer to the list of references at the end of this standard.



Nominal Specimen Dimensions

d_1	=	19 mm [0.75 in.]
d_2	=	3.8 mm [0.15 in.]
h	=	as required
L	=	76 mm [3.0 in.]
r	=	1.3 mm [0.05 in.]
w	=	11.4 mm [0.45 in.]

FIG. 2 V-Notched Beam Test Coupon Schematic

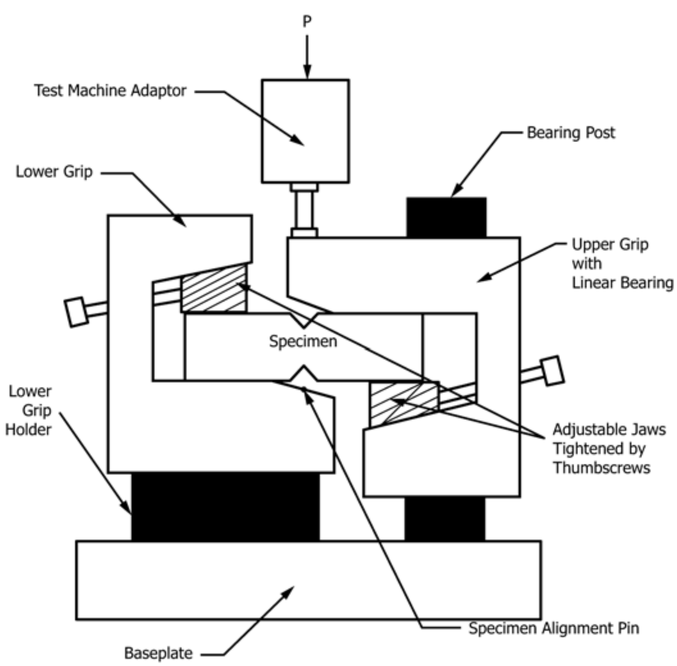
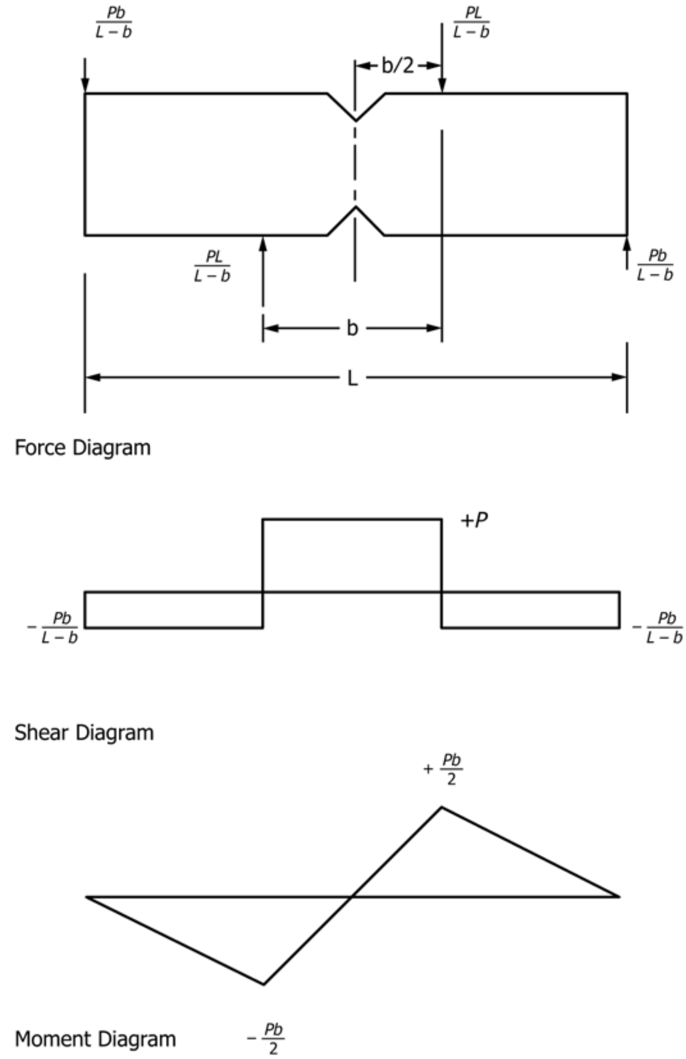


FIG. 3 V-Notched Beam Test Fixture Schematic

4.3 The loading can be idealized as asymmetric flexure, as shown by the shear and bending moment diagrams of Fig. 4.[6] The notches influence the shear strain along the loading direction, making the distribution more uniform than would be seen without the notches. While the degree of uniformity is a function of material orthotropy, the best overall results, when testing in the *1-2* plane, have been obtained on $[0/90]_{ns}$-type laminates.



NOTE 1—The value of the dimension *b* is not critical to the concept.

FIG. 4 Idealized Force, Shear, and Moment Diagrams

5. Significance and Use

5.1 This test method is designed to produce shear property data for material specifications, research and development, quality assurance, and structural design and analysis. Either in-plane or interlaminar shear properties may be evaluated, depending upon the orientation of the material coordinate system relative to the loading axis. Factors that influence the shear response and should therefore be reported include the following: material, methods of material preparation and lay-up, specimen stacking sequence, specimen preparation, specimen conditioning, environment of testing, specimen alignment and gripping, speed of testing, time at temperature, void content, and volume percent reinforcement.

5.2 In anisotropic materials, properties may be obtained in any of the six possible shear planes by orienting the testing plane of the specimen with the desired material plane (*1-2* or

[6] While the idealization indicates constant shear loading and zero bending moment in the specimen at the notches, the actual load application is distributed and imperfect, which contributes to asymmetry in the shear strain distribution and to a component of normal stress that is particularly deleterious to $[90]_n$ specimens (**16**).