Designation: D5379/D5379M – 19

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 are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.2.1 Within the text, the inch-pound units are shown in brackets.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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:*[3]

ANSI Y14.5M-1982 Geometric Dimensioning and Tolerancing

ANSI/ASME B 46.1-1985 Surface Texture (Surface Roughness, Waviness, and Lay)

2.3 *ASTM Adjuncts:*

V-Notched Beam Shear Fixture Machining Drawings[4]

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.
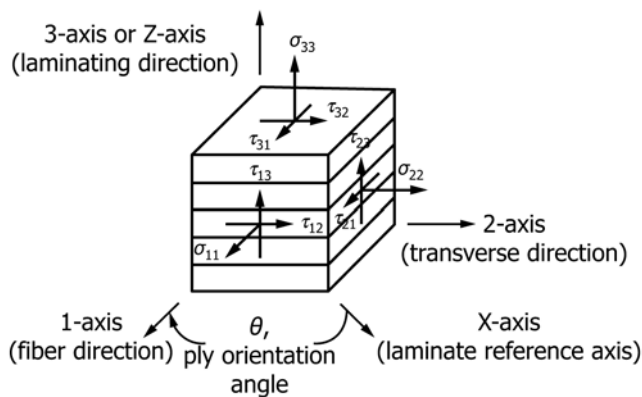
FIG. 1 Material Coordinate System

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 $F°$ *(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]

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

[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.
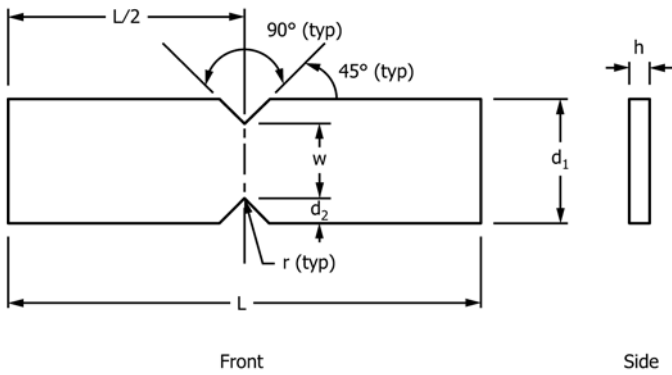
Nominal Specimen Dimensions

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.]
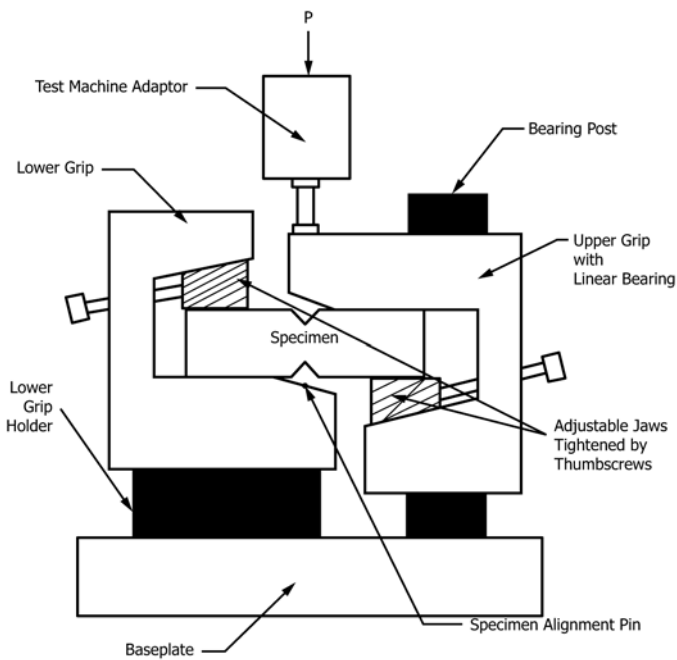
FIG. 2 V-Notched Beam Test Coupon Schematic

**FIG. 3 V-Notched Beam Test Fixture Schematic**

4.2 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 gage 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.

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.

5. Significance and Use

5.1 This test method is designed to produce shear property data for material specifications, research and development,

[6] While the idealization indicates constant shear loading and zero bending moments 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**).
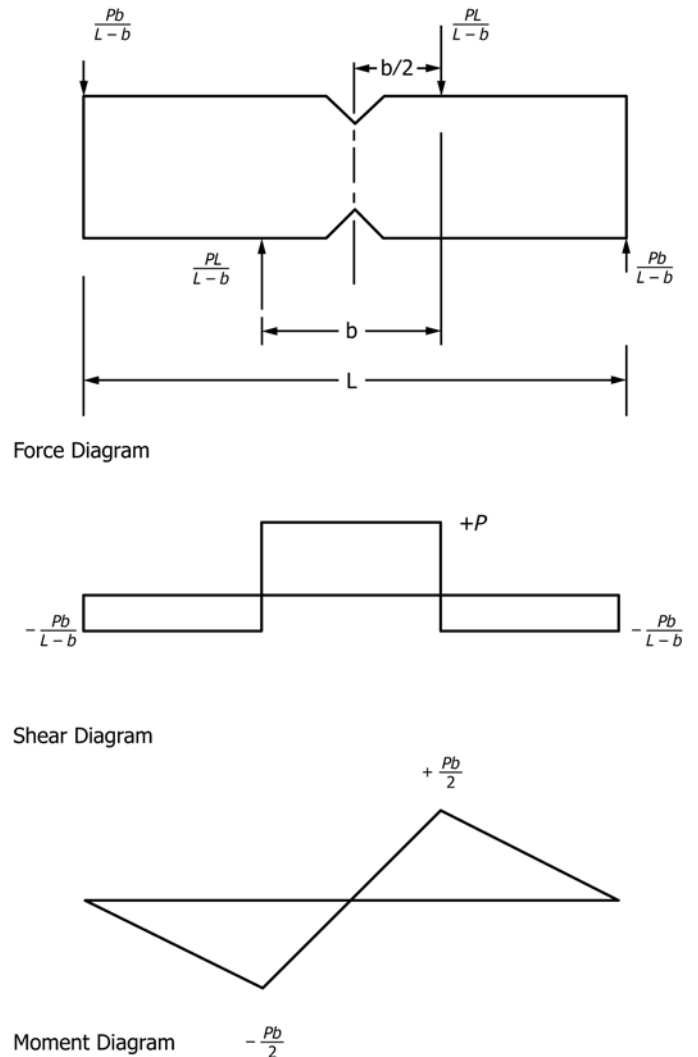
NOTE 1—The value of the dimension *b* is not critical to the concept.
FIG. 4 Idealized Force, Shear, and Moment Diagrams