



Designation: C 1469 – 00

Standard Test Method for Shear Strength of Joints of Advanced Ceramics at Ambient Temperature¹

This standard is issued under the fixed designation C 1469; 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 determination of shear strength of joints in advanced ceramics at ambient temperature. Test specimen geometries, test specimen fabrication methods, testing modes (that is, force or displacement control), testing rates (that is, force or displacement rate), data collection, and reporting procedures are addressed.

1.2 This test method is used to measure shear strength of ceramic joints in test specimens extracted from larger joined pieces by machining. Test specimens fabricated in this way are not expected to warp due to the relaxation of residual stresses but are expected to be much straighter and more uniform dimensionally than butt-jointed test specimens prepared by joining two halves, which are not recommended. In addition, this test method is intended for joints, which have either low or intermediate strengths with respect to the substrate material to be joined. Joints with high strengths should not be tested by this test method because of the high probability of invalid tests resulting from fractures initiating at the reaction points rather than in the joint. Determination of the shear strength of joints using this test method is appropriate particularly for advanced ceramic matrix composite materials but also may be useful for monolithic advanced ceramic materials.

1.3 Values expressed in this test method are in accordance with the International System of Units (SI) and Practice E 380.

1.4 *This test method does not purport to address the safety problems associated with its use. It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are noted in 8.1 and 8.2.

2. Referenced Documents

2.1 ASTM Standards:

- C 1145 Terminology of Advanced Ceramics²
- C 1161 Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperatures²
- C 1211 Test Method for Flexural Strength of Advanced

Ceramics at Elevated Temperatures²

- C 1341 Test Method for Flexural Properties of Continuous Fiber-Reinforced Advanced Ceramic Composites²
- D 3878 Terminology of High-Modulus Reinforcing Fibers and Their Composites³
- D 5379/D 5379M Test Method for Shear Properties of Composite Materials by the V-Notched Beam Method³
- E 4 Practices for Force Verification of Testing Machines⁴
- E 6 Terminology Relating to Methods of Mechanical Testing⁴
- E 122 Practice for Choice of Sample Size to Estimate the Average Quality of a Lot Process⁵
- E 337 Test Method for Measuring Humidity with Psychrometer (the Measurement of Wet-Bulb and Dry-Bulb Temperatures)⁶
- E 380 Practice for Use of International System of Units (SI)⁷

3. Terminology

3.1 *Definitions*—The definitions of terms relating to shear strength testing appearing in Terminology E 6, to advanced ceramics appearing in Terminologies C 1145 and D 3878 apply to the terms used in this test method. Additional terms used in conjunction with this test method are defined as follows.

3.1.1 *advanced ceramic, n*—a highly-engineered, high-performance predominately nonmetallic, inorganic, ceramic material having specific functional attributes. (C 1145)

3.1.2 *breaking force [F], n*—the force at which fracture occurs.

3.1.3 *ceramic matrix composite, n*—a material consisting of two or more materials (insoluble in one another), in which the major, continuous component (matrix component) is a ceramic while the secondary component(s) may be ceramic, glass-ceramic, glass, metal, or organic in nature. These components are combined on macroscale to form a useful engineering material possessing certain properties or behaviour not possessed by the individual constituents. (C 1275)

¹ This test method is under the jurisdiction of ASTM Committee C-28 on Advanced Ceramics and is the direct responsibility of Subcommittee C-28.

Current edition approved May 10, 2000. Published September 2000.

² Annual Book of ASTM Standards, Vol 15.01.

³ Annual Book of ASTM Standards, Vol 15.03.

⁴ Annual Book of ASTM Standards, Vol 03.01.

⁵ Annual Book of ASTM Standards, Vol 14.02.

⁶ Annual Book of ASTM Standards, Vol 11.03.

⁷ Discontinued 1997; Replaced by IEEE/ASTM SI-10.

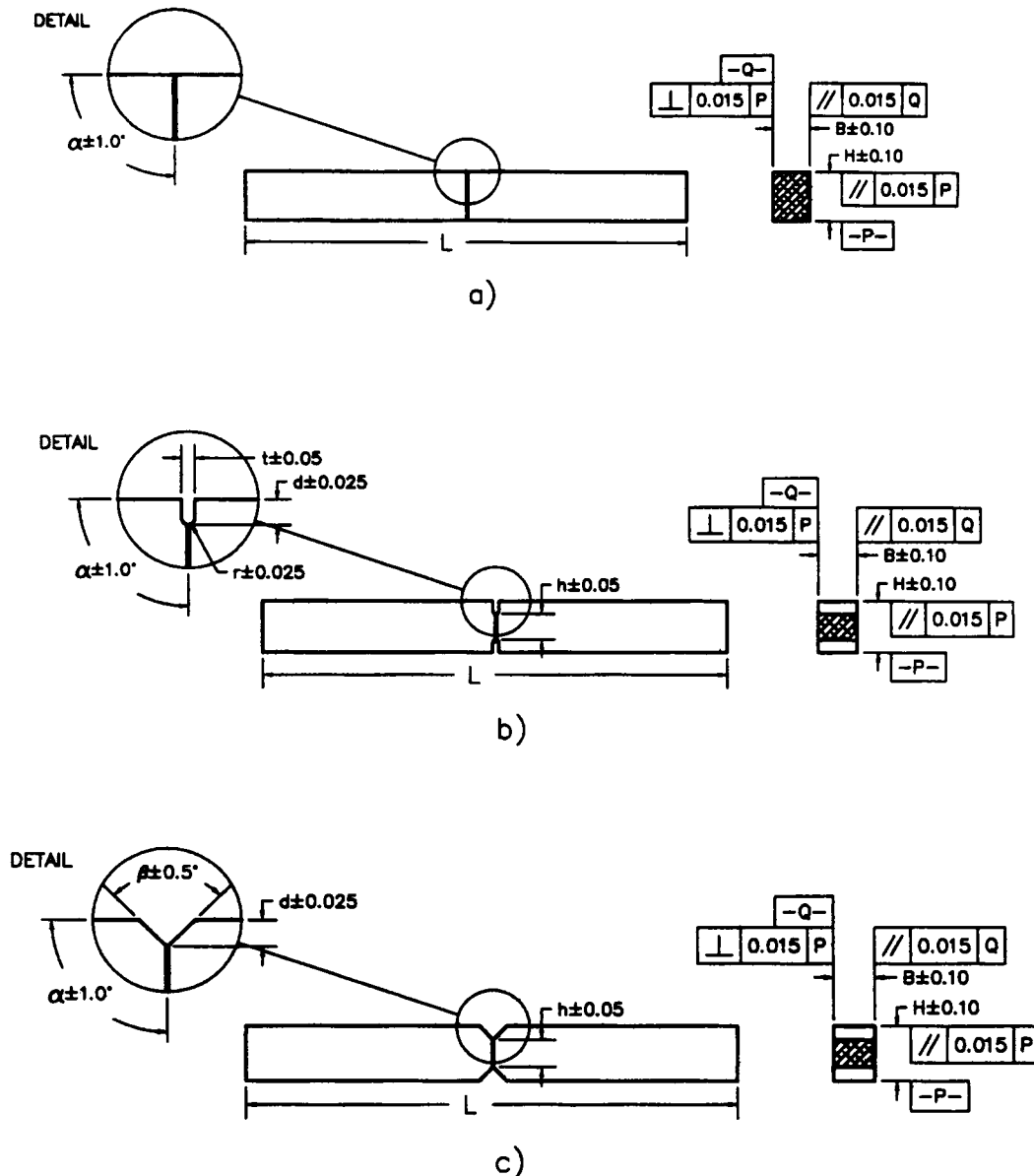
3.1.4 *joining, n*—controlled formation of chemical, or mechanical bond, or both, between similar or dissimilar materials.

3.1.5 *shear strength* [F/L^2], *n*—the maximum shear stress which a material is capable of sustaining. Shear strength is calculated from the shear fracture force and the shear stressed area.

4. Summary of Test Method

4.1 This test method describes an asymmetrical four-point flexure test method to determine shear strengths of advanced ceramic joints. Test specimens and test setup are shown schematically in Fig. 1 and Fig. 2, respectively. Selection of the test specimen geometry depends on the bond strength of the joint, which may be determined by preparing longer test

specimens of the same cross-section and using a standard four-point flexural strength test, for example, Test Method C 1161 for monolithic advanced ceramic base material and Test Method C 1341 for composite advanced ceramic base material. If the joint flexural strength is low (that is, <25 % of the flexural strength of the base material), the recommended test specimen geometry for shear strength testing of the joint is the uniform test specimen shown in Fig. 1a. If the joint flexural strength is moderate (that is, 25 to 50 % of the flexural strength of the base material), the recommended test specimen geometry for shear strength testing of the joint is the straight- or V-notched test specimen shown in Fig. 1b and Fig. 1c, respectively. If the joint flexural strength is high (>50 % of the flexural strength of the base material) this test method should



NOTE 1—The width of the joint, which varies between 0.05 and 0.20 mm, based on the joining method used, is smaller than that of the notch in b). All dimensions are given in mm.

FIG. 1 Schematics of Test Specimen Geometries: a) Uniform, b) Straight-Notched and c) V-Notched

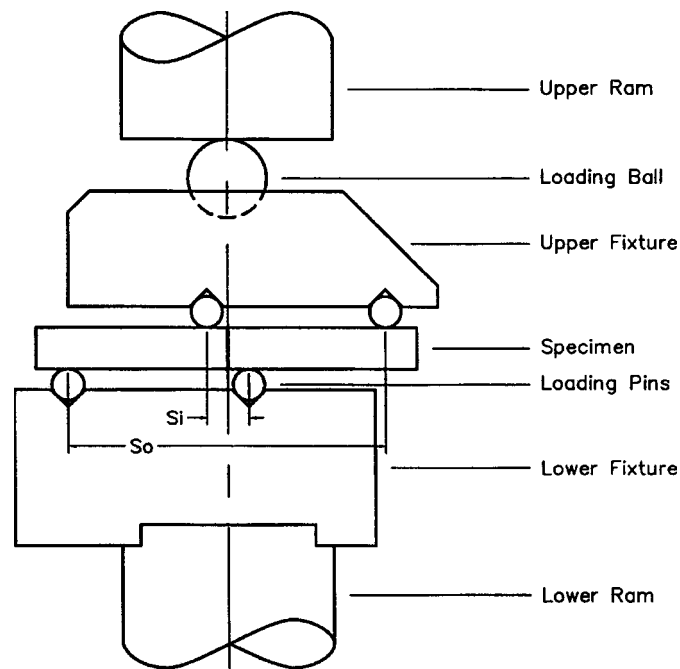


FIG. 2 Schematic of Test Fixture

not be used to measure shear strength of advanced ceramic joints because very high contact stresses at the reaction points will provide a high probability of invalid tests (that is, fractures not at the joint).

4.2 The testing arrangement of this test method is asymmetrical flexure, as illustrated by the force, shear and moment diagrams in Fig. 3a, Fig. 3b, and Fig. 3c, respectively. Note that the greatest shear exists over a region of $\pm S_i/2$ around the centerline of the joint (see Fig. 3b). In addition, while the moment is zero at the centerline of the joint, the maximum moments occur at the inner reaction points (see Fig. 3c). The points of maximum moments are where the greatest probability of fracture of the base material may occur if the joint flexural strength, and therefore, joint shear strength is too high.

5. Significance and Use

5.1 Advanced ceramics are candidate materials for structural applications requiring high degrees of wear and corrosion resistance, often at elevated temperatures.

5.2 Joints are produced to enhance the performance and applicability of materials. While the joints between similar materials are generally made for manufacturing complex parts and repairing components, those involving dissimilar materials usually are produced to exploit the unique properties of each constituent in the new component. Depending on the joining process, the joint region may be the weakest part of the component. Since under mixed-mode and shear loading, the load transfer across the joint requires reasonable shear strength, it is important that the quality and integrity of joint under in-plane shear forces be quantified. Shear strength data are also needed to monitor the development of new and improved joining techniques.

5.3 Shear tests provide information on the strength and deformation of materials under shear stresses.

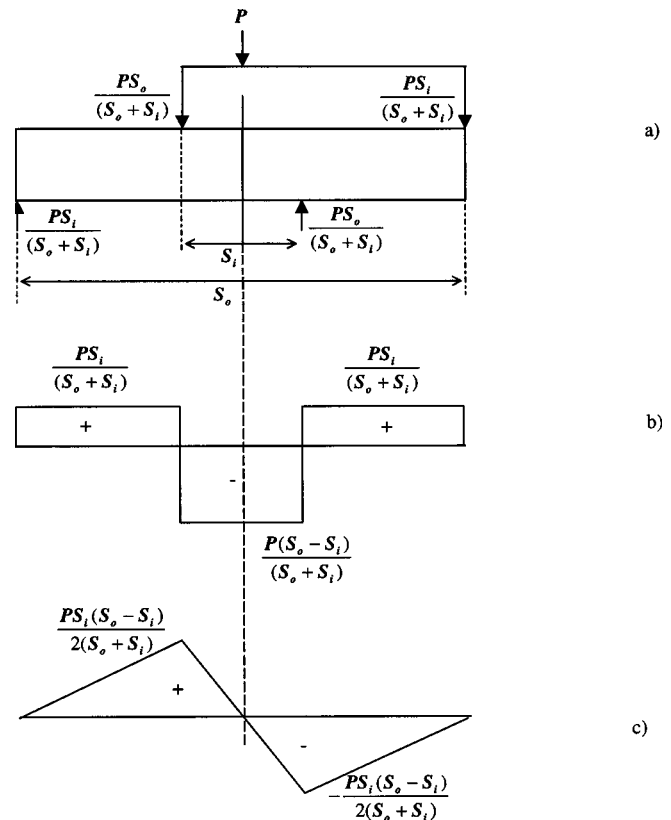


FIG. 3 Idealized a) Force, b) Shear, and c) Moment Diagrams for Asymmetric Four-point Flexure, Where S_o and S_i Are the Outer and Inner Reaction Span Distances, Respectively, and P is the Applied Force

5.4 This test method may be used for material development, material comparison, quality assurance, characterization, and design data generation.