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Advanced technical ceramics - Mechanical properties of ceramic composites at ambient temperature - Determination of in-plane shear properties

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Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei Raumtemperatur - Bestimmung der Schereigenschaften in der Ebene

Céramiques techniques avancées - Propriétés mécaniques des céramiques composites a température ambiante - Détermination des caractéristiques en cisaillements plan

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This document (EN 12289:2005) has been prepared by Technical Committee CEN/TC 184 “Advanced technical ceramics”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by December 2005, and conflicting national standards shall be withdrawn at the latest by December 2005.

This document supersedes ENV 12289:1996.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

1 Scope

This European Standard specifies the conditions for the determination of the in-plane shear properties at ambient temperature of ceramic matrix composite materials with continuous fibre reinforcement.

This European Standard applies to ceramic matrix composites with a continuous fibre reinforcement, bi-directional (2D) and tri-directional (xD, with $2 < x \leq 3$).

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force measuring system (ISO 7500-1:2004).*

ISO 3611, *Micrometer callipers for external measurement*.

3 Terms, definitions and symbols

For the purposes of this document, the following terms and definitions apply.

3.1
initial cross-section area, A_0
area of the test piece cross section in the 2,3 plane between the two notches (see Figure A.1)

3.2
measurement zone
part of the test piece, in the 1,2 plane, between the notches, in which a uniform shear field is assumed (see Figure A.1)

NOTE For practical purposes, it is generally assumed to be ± 2 mm on the longitudinal axis of the test piece, on each side of the cross section area.

3.3
in-plane shear strain, γ_{12}
change in angle of an originally orthogonal set of lines parallel to the directions 1 and 2 as a consequence of load application

3.4
in-plane shear, τ_{12}
ratio of applied force to the cross section area

3.5
in-plane shear strength, $\tau_{12,m}$
ratio of the maximum force applied, to the cross section area

3.6
proportionality ratio or pseudo-elastic shear modulus, Gp_{12} elastic shear modulus G_{12}
slope of the linear section of the shear stress-shear strain curve, if any

NOTE Examination of the shear stress-shear strain curves for ceramic matrix composites allows definition of the following cases:

a) Material with a linear section in the shear stress-shear strain curve;

for ceramic matrix composites that have a mechanical behaviour characterized by a linear section, the proportionality ratio is defined as:

$$Gp_{12}\left(\tau_{12,1},\tau_{12,2}\right)=\frac{\tau 12{,}2-\tau 12{,}1}{\gamma_{12,2}-\gamma_{12,1}} \quad (1)$$

where

$\left(\gamma_{12,1},\tau_{12,1}\right)$ and $\left(\gamma_{12,2},\tau_{12,2}\right)$ lie on the linear section of the shear stress-shear strain curve.

b) proportionality ratio or pseudo elastic shear modulus is termed the elastic shear modulus, G_{12}, in the single case where the linearity starts from the origin.

c) material with non linear shear stress-strain behaviour.

In this case, only stress strain couples can be fixed.

4 Principle

NOTE 1 Figures pertaining to test specimens and equipment are given in Annexes A and B.

A test specimen with two centrally located V notches (see Figure A.1) is submitted to a translation of its part B parallel to the plane 1,2 along the direction 2 while its part A is kept still.

The directions 1 and 2 correspond to the principal reinforcement directions of the material. The displacement of part B with respect to part A results in a pure shear zone in the section between the notches subjecting the material to an in-plane shear.

Force and shear strain along the principal directions in the plane 1,2 are measured and recorded simultaneously, from which shear modulus and shear strength can be determined.

NOTE 2 The test is performed at constant displacement rate, up to failure.

5 Apparatus

5.1 Test machine

The machine shall be equipped with a system for measuring the force applied to the test specimen which shall conform to grade 1 or better according to EN ISO 7500-1.

5.2 Test jig

The test jig shall be designed so that the force is applied in the 1,2 plane, normal to the longitudinal axis of the test piece. It shall allow the displacement of part B, relatively to part A.

The jig shall allow accurate mounting of the specimen, so that the notches are midway between the loading points.

NOTE 1 This is usually achieved with an alignment pin or similar tool.

The jig shall prevent out-of-plane loading of the specimen. This shall be verified using a dummy specimen made of an homogenous isotropic material equipped with strain gauges on the front and back faces located as specified in 5.3.

The dummy test piece shall be loaded to at least 50 % of the expected failure load of the material to be tested, and readings taken from all four strain gauges. The average strain gauge reading shall be calculated. Individual strain gauge readings at any load shall not differ by more than 5 % from the average of that load. The dummy test piece shall remain linear elastic during this verification.

NOTE 2 An example of a jig is shown in Figure B.1.

5.3 Strain gauges

At least one face of the specimen shall be equipped with two strain gauges in the measurement zone, orientated at ± 45° with respect to the longitudinal axis of the specimen (see example in Figure B.2).

The gauge length shall be at least equal to the length of the representative volume element of the material structure in the direction of the gauge and compatible with the size of the measurement zone.

5.4 Data recording system

NOTE A calibrated recorder may be used to record force-deformation curves. The use of a digital data recording system combined with an analogue recorder is recommended.

5.5 Micrometers

Micrometers used for the measurement of the cross-sectional dimensions of the test specimen shall conform to ISO 3611 and shall be accurate to ± 0,01 mm.

6 Test specimens

Test piece sides used to apply the forces shall be flat and parallel (see Figure A.2). Recommended dimensions are given in Table 1.

Table 1 — Recommended dimensions for test specimens

	2D and *x*D	Tolerance
l_t, total length	50 mm to 100 mm	± 0,5 mm
b, width	>12 mm	± 0,2 mm
h, thickness (indicative)	>3 mm	± 0,2 mm
Notch angle	90° to 120°	± 2°
W, depth of each notch	20 % of *b*	± 0,2 mm
r, notch radius	1,0 mm < *r* < 1,5 mm	± 0,2 mm
Parallelism between machined parts and notch root	0,05 mm	
Perpendicularity of machined parts and notch root	0,05 mm	

NOTE Bonded tabs on front face and rear face should help prevent buckling and/or damages from the application of load.

7 Test specimen preparation

7.1 Machining

During cutting out, care shall be taken to align the test specimen axis with the desired reinforcement direction.

Machining parameters that avoid damage, e.g. initial breaking or structure modification, to the material shall be established and documented. These parameters shall be adhered to during test piece preparation.

7.2 Bonding of the gauges

The gauges shall be positioned as close as possible to the centre of the measurement zone.

If the material is porous, care shall be taken that penetration of adhesive into the material does not modify its behaviour.

7.3 Number of test specimens

At least three valid test results, as specified in 8.3, are required for any condition.