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Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of ceramic composites at room temperature — Determination of flexural strength

Céramiques techniques — Propriétés mécaniques des composites céramiques à température ambiante — Détermination de la résistance en flexion

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Foreword

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This document was prepared by ISO/TC 206, *Fine ceramics,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 184, *Advanced technical ceramics,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 17138:2014) which has been technically revised.

The main changes are as follows:

— Clause 2 updated;

— Clause 4 on Significance and use added;

— Clause 10 updated;

— editorially revised.

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Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of ceramic composites at room temperature — Determination of flexural strength

1 Scope

This document specifies a test method for the determination of the flexural strength of ceramic matrix composite materials with continuous fibre reinforcement, under three-point or four-point bend at room temperature. This document is applicable to all ceramic matrix composites with a continuous fibre reinforcement, unidirectional (1D), bidirectional (2D), and tridirectional *x*D with ($2 < x \leq 3$) as defined in ISO 19634, loaded along one principal axis of reinforcement.

This document is not intended to be used to obtain absolute values of strength for design purposes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 7500-1, *Metallic materials — Calibration and verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Calibration and verification of the force-measuring system*

ISO 3611, *Geometrical product specifications (GPS) — Dimensional measuring equipment — Design and metrological characteristics of micrometers for external measurements*

ISO 19634, *Advanced technical ceramics — Ceramic composites — Notations and symbols*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 19634 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
maximum flexural force
F_m
highest recorded force during a flexural test on the test specimen when tested to failure

3.2
flexural stress
σ
nominal stress on the outer surface of the test specimen, calculated at mid-span

Note 1 to entry: This stress is conventionally calculated according to the beam theory, whose basic assumptions cannot be met by ceramic matrix composite materials.

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3.3
flexural strength
$\sigma_{f,m}$
maximum *flexural stress* (3.2) or force applied to a test specimen that fractures during a flexural test

4 Significance and use

Flexural tests are used for strength estimation for linear elastic brittle materials, for which tensile testing presents practical difficulties. They are never used for metallic materials that exhibit plasticity. On materials that exhibit damage induced non-linear deformations like CMCs, the use of bending tests for strength estimation is highly questionable, since the equations of elastic beam theory do not apply in the presence of non-linear deformations. Furthermore, in some cases uncommon facture modes are observed: fracture initiates from the part of specimens under compressive stresses, or the crack propagates parallel to the specimen axis. Despite the presence of damage that is not accounted for by the theory, many authors rely on bending tests and Formulae (1) and (2) of elastic beam theory to evaluate the ceramic matrix composites they are developing or using.

The elastic beam theory is based on the following main assumptions[1]:

a) The beam is symmetrical about neutral plane.

b) The beam is a straight bar of homogeneous material.

c) The transverse plane sections remain plane and normal to the longitudinal fibres after bending (Bernoulli's assumption).

d) The fixed relationship between stress and strain (Young's modulus) for the beam material is the same for tension and compression.

Requirements a), b) and d) are not met on fibre reinforced ceramic matrix composites that exhibit non-linear deformations associated to damage induced by the tensile stresses. As damage by matrix and interface cracking proceeds, the composite Young's modulus decreases in the tensile stressed volume which shifts the neutral axis.

The significance of damage is evidenced by the non-linearity of the force-displacement curve. When non-linearity is negligible, the formulae of stress can be used. Otherwise, the flexural force will be considered as the strength. It will be appropriate for comparison purposes of different materials on specimens having the same dimensions.

5 Principle

A beam is supported on two outer points and subjected to an external load applied perpendicularly to a longitudinal axis. The test is performed at constant crosshead displacement rate.

6 Apparatus

6.1 Test machine

The machine shall be equipped with a system for measuring the force applied to the test specimen. The system shall conform to grade 1 in accordance with ISO 7500-1.

6.2 Test fixture

The test fixture is composed of two parts, linked to the fixed and mobile parts of the machine. It has two outer support rollers and one (three-point bend) or two (four-point bend) inner rollers for application of load.

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