

Advanced technical ceramics — Mechanical properties of ceramic composites at room temperature —

Part 5: Determination of interlaminar shear strength by short span bend test (three points)

The European Standard EN 658-5:2002 has the status of a
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National foreword

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Céramiques techniques avancées - Propriétés mécaniques des céramiques composites à température ambiante - Partie 5: Détermination de la résistance au cisaillement interlaminaire par essai de flexion sur appuis rapprochés (trois points)

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Foreword

This document (EN 658-5:2002) 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of an identical text or by endorsement, at the latest by June 2003, and conflicting national standards shall be withdrawn at the latest by June 2003.

This document supersedes ENV 658-5:1993.

EN 658 '*Advanced technical ceramics – Mechanical properties of ceramic composites at room temperature*' has six parts:

- Part 1: *Determination of tensile properties*
- Part 2: *Determination of compressive properties*
- Part 3: *Determination of flexural strength*
- Part 4: *Determination of interlaminar shear strength by compression loading of notched test specimens*
- Part 5: *Determination of interlaminar shear strength by short span bend test (three-points)*
- Part 6: *Determination of interlaminar shear strength by double-punch shearing*

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

1 Scope

This part of this European Standard specifies the conditions for determination of the interlaminar shear strength of ceramic matrix composite materials with continuous fibre reinforcement at room temperature, by subjecting a test specimen to a short-span bend test (three points). This method applies to all ceramic matrix composites with a continuous fibre reinforcement unidirectional (1D) and bidirectional (2D) and tridirectional (xD, with $2 < x < 3$) as defined in ENV 13233.

Two other methods for the determination of shear strength are given in further parts of EN 658.

NOTE 1 The interlaminar shear characteristics can vary significantly depending on test specimen preparation and dimensions, rate of application of the test force, surface condition, etc..

NOTE 2 However, results obtained by this part of EN 658 cannot be compared with results obtained by the two other methods.

NOTE 3 Care should be exercised in interpreting the results of the method to obtain absolute values of the interlaminar shear strength of ceramic matrix composites for design purposes.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

ENV 13233:1998, *Advanced technical ceramics – Ceramic composites – Notations and symbols*.

EN ISO 7500-1:1999, *Metallic materials - Verification of static uniaxial testing machines - Part 1: Tension/compression testing machines (ISO 7500-1:1999)*.

ISO 3611, *Micrometer callipers for external measurement*.

3 Principle

The test consists of measuring the force required to fracture a test specimen subjected to a short-span, three point bend test. The geometry of loading in the direction normal to the plies (direction 3) and the test specimen dimensions shall be such that failure occurs in the form of interlaminar shear in plane (1,2). The test is performed at constant crosshead displacement rate.

4 Terms, definitions and symbols

For the purposes of this European Standard, the following terms, definitions and symbols and those given in ENV 13233:1998 apply.

4.1

shear failure force, F

the maximum force required to produce interlaminar shear failure when test specimen is subjected to three-points short span bend test

4.2

interlaminar shear strength, $ILSS_b$

ratio calculated on the basis of the shear failure force and the shear loaded area

NOTE The notation $ILSS$ is supplemented by a small letter referring to the test method described ; in this case $ILSS_b$ for the interlaminar shear strength obtained from a short span bend test.

5 Apparatus

5.1 Test machine

The test machine shall be equipped with a system for recording the force applied to the test specimen. The machine shall conform to grade 1 in EN ISO 7500-1:1999.

5.2 Test jig

The test jig is composed of two parts, linked to the fixed and mobile parts of the machine. It has two outer support rollers and one inner support roller.

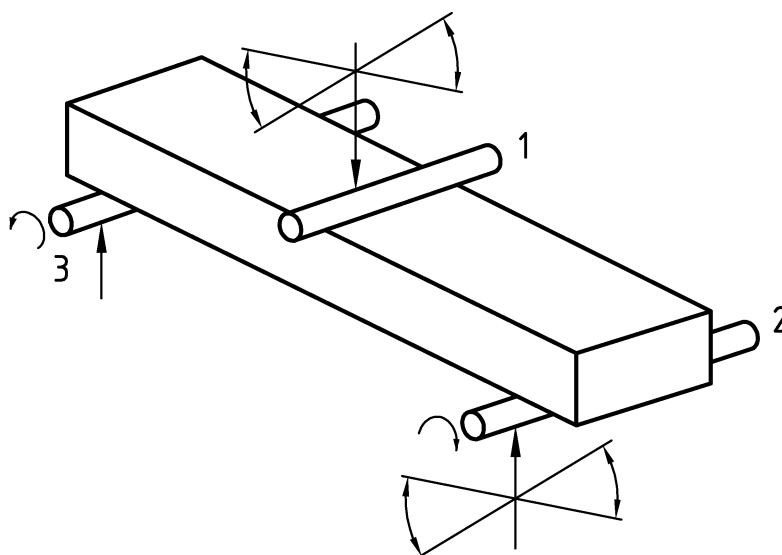
The cylindrical rollers shall have a diameter of 4 mm to 10 mm. Their length shall be at least equal to the width of the test specimen. They shall be made of a material with a hardness at least equal to that of the test specimen. The axes of the rollers shall be parallel to within 0,01 mm/mm.

The outer rollers shall be free to rotate (see Figure 1).

Two rollers shall be free to pivot around an axis parallel to the longitudinal direction of the test specimen, in order to adapt to the non-parallelism of the upper and lower faces of unmachined test specimens (see Figure 1).

The distance between rollers shall be in accordance with clause 6.

The inner roller shall be centred with respect to the outer rollers to within 0,2 mm.



Key

- 1 Pivoting loading roller
- 2 Rolling and pivoting support roller
- 3 Rolling but non – pivoting support roller

Figure 1 – Test jig

5.3 Dimension measuring devices

Devices used for measuring linear dimensions of the test specimen shall be accurate to ± 0,1 mm. Micrometres shall be in accordance with ISO 3611.

6 Test specimens

Recommended test specimen dimensions are given in Table 1.

Table 1 – Recommended test specimen dimensions

Dimensions in millimetres

	1D, 2D, xD	Tolerance
l_t , total length	20 to 25	± 1
h , thickness	3	± 1
b , width	10	± 0,1
S, support span	15	± 0,1
Plane parallelism of machined parts	0,05	

NOTE The support span of 15 mm is derived from the test specimen thickness of 3 mm given in Table 1. If a different thickness is used the span should be changed according to:

$$S = 5 h \pm 1$$

7 Test specimen preparation

7.1 Machining

During cutting out, care shall be taken to ensure that the test specimen axes coincide with the fibre directions. Machining parameters which avoid damage to the material shall be established and documented. These parameters shall be adhered to during test specimen preparation.

7.2 Number of test specimens

At least five valid test results (see 8.4) are required.

NOTE If statistical evaluation is required, the number of test specimens should be in accordance with ENV 843-5.

8 Procedure

8.1 Displacement rate

Use a constant cross head displacement rate which allows test specimen failure within 1 min. The displacement rate shall be reported.

NOTE Generally, a displacement rate between 0,5 mm/min and 1 mm/min is used.

8.2 Measurement of test specimens

Measure the width and thickness to the nearest 0,1 mm in the centre and at each end of the test specimen and report the arithmetic means of the measurements.

8.3 Testing technique

8.3.1 Test specimen mounting

The test specimen shall be installed in the test jig centred with respect to the rollers and with its longitudinal axis perpendicular to the axes of the rollers.

NOTE It is recommended to use a tool for this purpose.

Zero the load cell output. When required, a small preload can be applied in order to maintain correct positioning of the test specimen. This preload shall not increase beyond 5 % of the expected failure force at any time.

8.3.2 Measurements

- Set the displacement rate on the test machine;
- zero the load cell;
- record the force versus time;
- load the test specimen up to failure;
- read the load signal after test specimen failure;
- note the position of fracture location and identify the failure mode (see 8.4).

8.4 Test validity

The following circumstances will invalidate a test:

- a) failure to specify and record test conditions;
- b) failure to note the mode and location of fracture;
- c) test specimen failure not occurring in a shear plane within $\pm \frac{h}{4}$ from the mid-plane.

9 Calculation of results

The following expression shall be used to calculate the interlaminar shear strength:

$$ILSS_b = \frac{3F}{4bh}$$

where

$ILSS_b$ is the interlaminar shear strength, in plane (1,2), in megapascal (MPa);

F is the shear failure force, in newton (N);

b is the mean test specimen width, in millimetre (mm);

h is the mean test specimen thickness, in millimetre (mm).

10 Test report

The test report shall contain at least the following information:

- a) name and address of the testing establishment;
- b) date of the test, unique identification of report and of each page, customer name and address and signatory;
- c) a reference to this European standard, i.e. "determined in accordance with EN 658-5";
- d) test specimen drawing or reference;
- e) description of the test material (material type, manufacturing code, batch number);
- f) the area and orientation of test specimens taken from a sample of material;
- g) displacement rate;
- h) number of test carried out and the number of valid results obtained;
- i) force versus time record;
- j) individual results and arithmetic means;
- k) mode and failure location of all the test specimens used for obtaining the above results;
- l) any comments about the test or test results.

Bibliography

- [1] ENV 843-5, *Advanced technical ceramics – Monolithic ceramics – Mechanical tests at room temperature Part 5: Statistical analysis.*

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