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Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for interfacial bond strength of ceramic materials

Céramiques techniques — Méthode d'essai pour la résistance de l'interface des matériaux céramiques

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13124 was prepared by Technical Committee ISO/TC 206, *Fine ceramics*.

Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for interfacial bond strength of ceramic materials

1 Scope

This International Standard specifies a test method for determining the interfacial tensile and shear bond strength of ceramic-ceramic, ceramic-metal, and ceramic-glass joining at ambient temperature by compression tests on cross-bonded test pieces. Methods for test-piece preparation, test modes and rates (load rate or displacement rate), data collection and reporting procedures are addressed.

This International Standard applies primarily to ceramic materials, including monolithic fine ceramics and whisker-, fibre- or particulate-reinforced ceramic composites. This test method can be used for materials research, quality control, and characterization and design data generation purposes.

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.

ISO 3611:2010, *Geometrical product specifications (GPS) — Dimensional measuring equipment: Micrometers for external measurements — Design and metrological characteristics*

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

ISO 14704:2008, *Fine ceramics (advanced ceramics, advanced technical ceramics) — Test method for flexural strength of monolithic ceramics at room temperature*

3 Terms and definitions

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

3.1
fine ceramic (advanced ceramic, advanced technical ceramic)
highly engineered, high-performance predominately non-metallic, inorganic, ceramic material having specific functional attributes

3.2
cross-bonded sample
test sample in the form of a symmetrical cross, which is prepared by joining two rectangular bars with the same shape and size

NOTE 1 See Figure 1.

NOTE 2 The two bars joined to form the cross-bonded sample may be the same or different materials.

NOTE 3 The approach used for joining can be any chemical or physical bonding.

NOTE 4 The two bars should be joined perpendicularly and symmetrically within ±1° ($\alpha = 90° \pm 1°$).

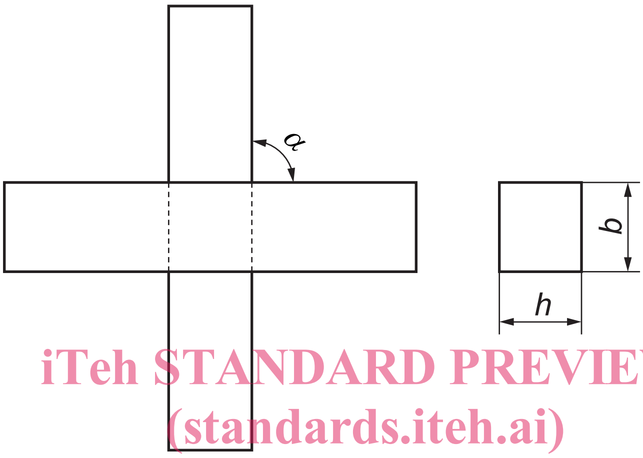


Figure 1 — Schematic diagram of the cross-bonded samples

3.3
tensile failure load
maximum tensile load applied to the interface during a tensile bond strength test

3.4
tensile bond strength
maximum mean tensile stress applied to the interface during a bond strength test

NOTE The tensile bond strength is calculated using the tensile failure load and the bonded area.

3.5
shear failure load
maximum shear load applied to the interface during a shear test of the cross-bonded sample

3.6
shear bond strength
maximum mean shear stress applied to the interface during a shear bond strength test

NOTE The shear bond strength is calculated using the shear failure load and the shear loaded area.

4 Symbols and abbreviated terms

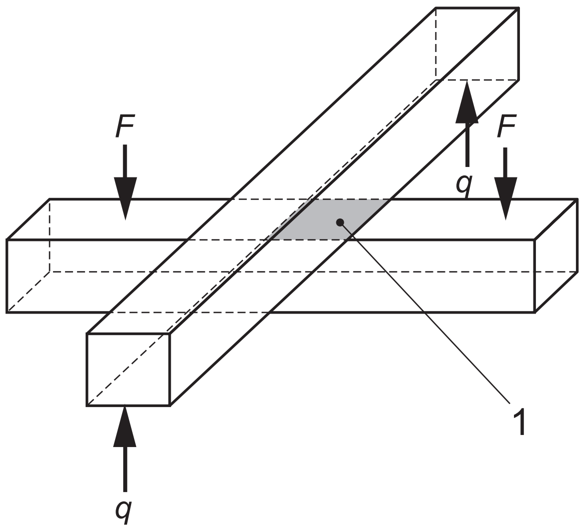
For the purposes of this document, the symbols and designations given in Table 1 apply.

Table 1 — Symbols and designations

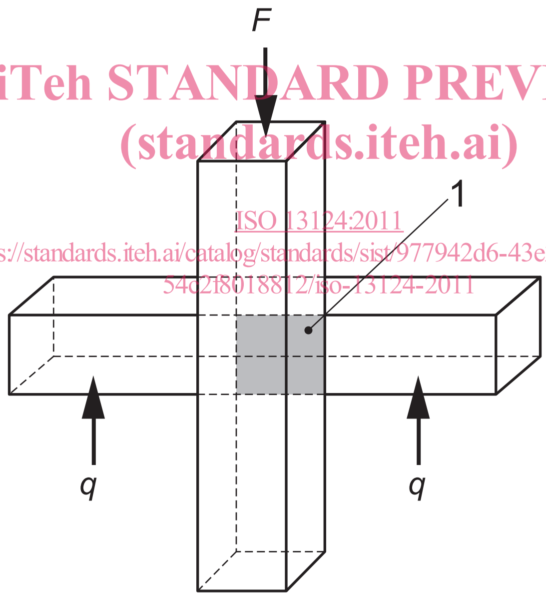
Symbol	Designation	Unit	References
l	Test-piece length	mm	Table 2
h	Test-piece thickness	mm	Figure 1, Table 2
b	Test-piece width	mm	Figure 1, Table 2
α	Right angle of cross-bonded sample	°	Figure 1
D	Diameter of the ball in pressure head	mm	Figure 3
σ_t	Tensile bond strength	MPa	Equation 1
τ	Shear bond strength	MPa	Equation 4
P_c	Critical load to debond	N	Equations 1, 4
A_1	Tensile loaded area	mm^2	Equation 1
A_2	Shear loaded area	mm^2	Equation 4
n	Number of valid tests	1	Equations 2, 3, 5, 6
$\bar{\sigma}_t$	Mean tensile bond strength	MPa	Equation 2
$\bar{\tau}$	Mean shear bond strength	MPa	Equation 5
s	Standard deviation	MPa	Equations 3, 6

5 Principle

A cross-bonded sample is loaded in compression which yields tensile or shear stress in the interface until the occurrence of debonding in the interface. Two different forms of mounting the cross-bonded sample in a fixture are designed to measure the interfacial tensile and shear bond strength, respectively. In the case of the former, a uniaxial tensile stress is generated when the testing sample is subjected to a compressive load, as shown in Figure 2 a). For the latter, a cross-bonded sample is loaded in compression to induce failure by shear at the interface, as shown in Figure 2 b). The test is usually performed at a constant cross-head displacement rate. The load at fracture and the bonded area are used to compute the tensile and shear bond strength.



a) Schematic diagram of loading, supporting and bonded area for cross-bonded sample in the test of the tensile bond strength



b) Schematic diagram of loading, supporting and bonded area for cross-bonded sample in the test of the shear bond strength

Key

1 loading, supporting and bonded area

F applied load

q uniform resultant stress on the supporting surfaces

Figure 2 — Schematic diagram of measuring the tensile and shear bond strength using the cross-bonded test piece subjected to compressive load

6 Apparatus

6.1 Testing machine

A suitable testing machine capable of applying a uniform cross-head speed shall be used. The testing machine shall be in accordance with ISO 7500-1:2004, Class 1, with an accuracy of 1 % of the indicated load during compression or tension tests.

6.2 Data acquisition

Obtain the maximum load and at least an autographic record of the applied load versus cross-head displacement or versus testing time.

Use either analog chart recorders or digital data acquisition systems. Recording devices shall be accurate to within 1 % of the selected range of the testing equipment including the readout unit, and have a minimum data acquisition rate of 10 Hz with a response of 50 Hz deemed more than sufficient.

6.3 Dimension-measuring device

Micrometers and other devices used for measuring linear dimensions must be accurate to at least 0,01 mm and shall be in accordance with ISO 3611. Alternative dimension-measuring instruments may be used provided that they have a resolution of 0,01 mm or finer.

6.4 Testing fixture

The sketch of the testing fixtures is shown in Figure 3. To avoid unsymmetrical stress in the sample, the top of the pressure head is in the centre point of the pressure head, and it is arc shaped at two perpendicular directions, as shown in Figure 3 a). Alternatively, a bearing ball inlayed in the centre of a rectangular pressure head can be used, as shown in Figure 3 b). Thus, a point-contact at the top of the pressure head can be realized in the compressive process. The supporting fixture shall be suitable and moveable, and the width of the groove such that the cross-bonded sample can be inserted into the fixture freely and with a smooth contact, as shown in Figure 3 c). The fixture shall remain elastic over the load ranges used. The fixture should be made of a hard metal with elastic modulus over 200 GPa and hardness (HV) over 3 GPa.

The pressure head is designed for applying the tensile load in the interface during the tensile bonding strength test, not for the shear bond strength test. The weight of the pressure head should be added into the final load for calculating the strength.

To avoid the unsymmetrical tensile stress, it is recommended that the width of the pressure head should be equal to that of the test piece, e.g. $b = b_3$.

The parallelism tolerance on opposite longitudinal faces of the supporting fixture shall not exceed 0,01 mm, and both the upper and lower surfaces should be smooth planes.

NOTE While the cross-bonded sample is put into the testing fixture, as shown in Figures 5 and 6, the inside bar would be in smooth contact with two inner surfaces of the fixture, without friction when it moves.

The thickness of the pressure head should be a little smaller than the width of the groove, and the depth of the groove in the pressure head is larger than the thickness of the bar, e.g. $b_3 < b_1$, $h_3 > h$.