SLOVENSKI STANDARD
oSIST prEN ISO 18610:2020

01-oktober-2020

Fina keramika (sodobna keramika, sodobna tehnična keramika) - Mehanske lastnosti keramičnih kompozitov pri temperaturi okolice in pri zračnem tlaku - Ugotavljanje elastičnih lastnosti z ultrazvokom (ISO 18610:2016)

Fine ceramics (advanced ceramics, advanced technical ceramics) - Mechanical properties of ceramic composites at ambient temperature in air atmospheric pressure - Determination of elastic properties by ultrasonic technique (ISO 18610:2016)

Hochleistungskeramik - Mechanische Eigenschaften von keramischen Verbundwerkstoffen bei Raumtemperatur - Bestimmung der elastischen Eigenschaften durch eine Ultraschallmethode (ISO 18610:2016)

Céramiques techniques (céramiques avancées, céramiques techniques avancées) - Propriétés mécaniques des céramiques composites à température ambiante sous air à pression atmosphérique - Détermination des propriétés élastiques par méthode ultrasonore (ISO 18610:2016)

Ta slovenski standard je istoveten z: **prEN ISO 18610**

ICS:

81.060.30	Sodobna keramika	Advanced ceramics

oSIST prEN ISO 18610:2020 **en,fr,de**

INTERNATIONAL
STANDARD

ISO
18610

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2016-09-15

Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of ceramic composites at ambient temperature in air atmospheric pressure — Determination of elastic properties by ultrasonic technique

Céramiques techniques (céramiques avancées, céramiques techniques avancées) — Propriétés mécaniques des céramiques composites à température ambiante sous air à pression atmosphérique — Détermination des propriétés élastiques par méthode ultrasonore

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 206, *Fine ceramics*.

INTERNATIONAL STANDARD **ISO 18610:2016(E)**

Fine ceramics (advanced ceramics, advanced technical ceramics) — Mechanical properties of ceramic composites at ambient temperature in air atmospheric pressure — Determination of elastic properties by ultrasonic technique

1 Scope

This document specifies an ultrasonic method to determine the components of the elasticity tensor of ceramic matrix composite materials at room temperature. Young's moduli shear moduli and Poisson coefficients, can be determined from the components of the elasticity tensor.

This document applies to ceramic matrix composites with a continuous fibre reinforcement: unidirectional (1D), bidirectional (2D), and tridirectional (×D, with 2 < × ≤ 3) which have at least orthotropic symmetry, and whose material symmetry axes are known.

This method is applicable only when the ultrasonic wavelength used is larger than the thickness of the representative elementary volume, thus imposing an upper limit to the frequency range of the transducers used.

NOTE Properties obtained by this method might not be comparable with moduli obtained by ISO 15733, ISO 20504 and EN 12289.

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

ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

EN 1389, *Advanced technical ceramics — Ceramic composites — Physical properties — Determination of density and apparent porosity*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in CEN/TR 13233 and the following apply.

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

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
stress-strain relations for orthotropic material

elastic anisotropic behaviour of a solid homogeneous body described by the elasticity tensor of fourth order C_{ijkl}, represented in the contracted notation by a symmetrical square matrix (6 × 6)

Note 1 to entry: If the material has at least orthotropic symmetry, its elastic behaviour is fully characterized by nine independent stiffness components C_{ij}, of the stiffness matrix (C_{ij}), which relates stresses to strains, or equivalently by nine independent compliance components S_{ij} of the compliance matrix (S_{ij}), which relates strains to stresses. The stiffness and compliance matrices are the inverse of each other.

If the reference coordinate system is chosen along the axes of symmetry, the stiffness matrix C_{ij} and the compliance matrix S_{ij} can be written as follows:

$$\begin{bmatrix}\sigma_1\\ \sigma_2\\ \sigma_3\\ \sigma_4\\ \sigma_5\\ \sigma_6\end{bmatrix}=\begin{bmatrix}C_{11} & C_{12} & C_{13} & 0 & 0 & 0\\ C_{12} & C_{22} & C_{23} & 0 & 0 & 0\\ C_{13} & C_{23} & C_{33} & 0 & 0 & 0\\ 0 & 0 & 0 & C_{44} & 0 & 0\\ 0 & 0 & 0 & 0 & C_{55} & 0\\ 0 & 0 & 0 & 0 & 0 & C_{66}\end{bmatrix}\begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \varepsilon_4\\ \varepsilon_5\\ \varepsilon_6\end{bmatrix}$$

$$\begin{bmatrix}\varepsilon_1\\ \varepsilon_2\\ \varepsilon_3\\ \varepsilon_4\\ \varepsilon_5\\ \varepsilon_6\end{bmatrix}=\begin{bmatrix}S_{11} & S_{12} & S_{13} & 0 & 0 & 0\\ S_{12} & S_{22} & S_{23} & 0 & 0 & 0\\ S_{13} & S_{23} & S_{33} & 0 & 0 & 0\\ 0 & 0 & 0 & S_{44} & 0 & 0\\ 0 & 0 & 0 & 0 & S_{55} & 0\\ 0 & 0 & 0 & 0 & 0 & S_{66}\end{bmatrix}\begin{bmatrix}\sigma_1\\ \sigma_2\\ \sigma_3\\ \sigma_4\\ \sigma_5\\ \sigma_6\end{bmatrix}$$

Note 2 to entry: For symmetries of higher level than the orthotropic symmetry, the C_{ij} and S_{ij} matrices have the same form as here above. Only the number of independent components reduces.

3.2
engineering constants

compliance matrix components of an orthotropic material which are in terms of engineering constants:

$$\left[S_{\mathrm{ij}}\right]=\begin{bmatrix}{}^{1}\!/_{E_{11}} & {}^{-\nu_{21}}\!/_{E_{22}} & {}^{-\nu_{31}}\!/_{E_{33}} & 0 & 0 & 0\\ {}^{-\nu_{12}}\!/_{E_{11}} & {}^{1}\!/_{E_{22}} & {}^{-\nu_{32}}\!/_{E_{33}} & 0 & 0 & 0\\ {}^{-\nu_{13}}\!/_{E_{11}} & {}^{-\nu_{23}}\!/_{E_{22}} & {}^{1}\!/_{E_{33}} & 0 & 0 & 0\\ 0 & 0 & 0 & {}^{1}\!/_{G_{23}} & 0 & 0\\ 0 & 0 & 0 & 0 & {}^{1}\!/_{G_{13}} & 0\\ 0 & 0 & 0 & 0 & 0 & {}^{1}\!/_{G_{12}}\end{bmatrix}$$

where

E_{11}, E_{22} and E_{33} are the elastic moduli in directions 1, 2 and 3, respectively;

G_{12}, G_{13} and G_{23} are the shear moduli in the corresponding planes;

ν_{12}, ν_{13}, ν_{23} are the respective Poisson coefficients.

3.3

angle of incidence

θ_i

angle between the direction 3 normal to the test specimen front face and the direction n_i of the incident wave

Note 1 to entry: See Figures 1 and 2.

3.4

refracted angle

θ_r

angle between the direction 3 normal to the test specimen front face and the direction n of propagation of the wave inside the test specimen

Note 1 to entry: See Figures 1 and 2.

3.5

azimuthal angle

ψ

angle between the plane of incidence (3, n_i) and plane (2, 3) where n_i corresponds to the vector oriented along the incident plane wave and direction 2 corresponds to one of the axes of symmetry of the material

Note 1 to entry: See Figure 1.

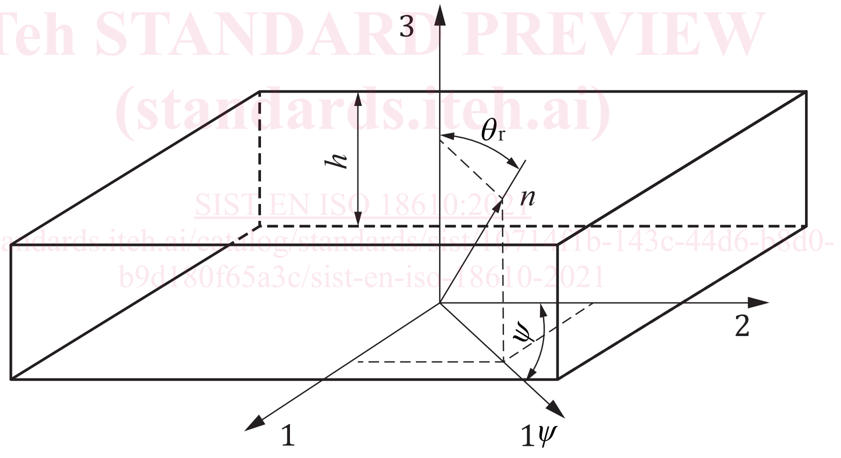


Figure 1 — Definition of angles

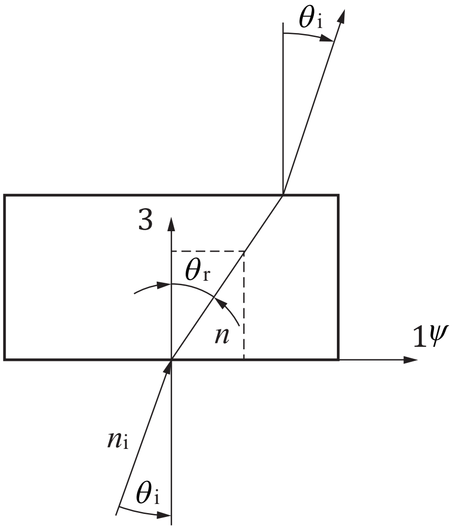


Figure 2 — Propagation in the plane of incidence

3.6
first critical angle

θ_c

angle of incidence θ_i that provides an angle of refraction of 90 degrees of the quasi longitudinal wave angle

3.7
unit vector

n

vector of length 1 oriented along the propagation direction of the incident plane wave inside the specimen, with its components n_k (k = 1, 2, 3):

$$n_1 = \sin\theta_r \sin\psi$$

$$n_2 = \sin\theta_r \cos\psi$$

$$n_3 = \cos\theta_r$$

Note 1 to entry: See Figures 1 and 2.

3.8
propagation velocity

$V(n)$

phase velocity of a plane wave inside the specimen in dependence on unit vector n (i.e. in dependence on ψ and θ_r)

Note 1 to entry: V_0 is the propagation velocity in the coupling fluid.

3.9
delay

$\delta t(n)$

difference between the time-of-flight of the wave when the test specimen is in place and the time-of-flight of the wave in the coupling fluid with the test specimen removed under the same configuration of the probes in dependence on unit vector n

3.10
bulk density

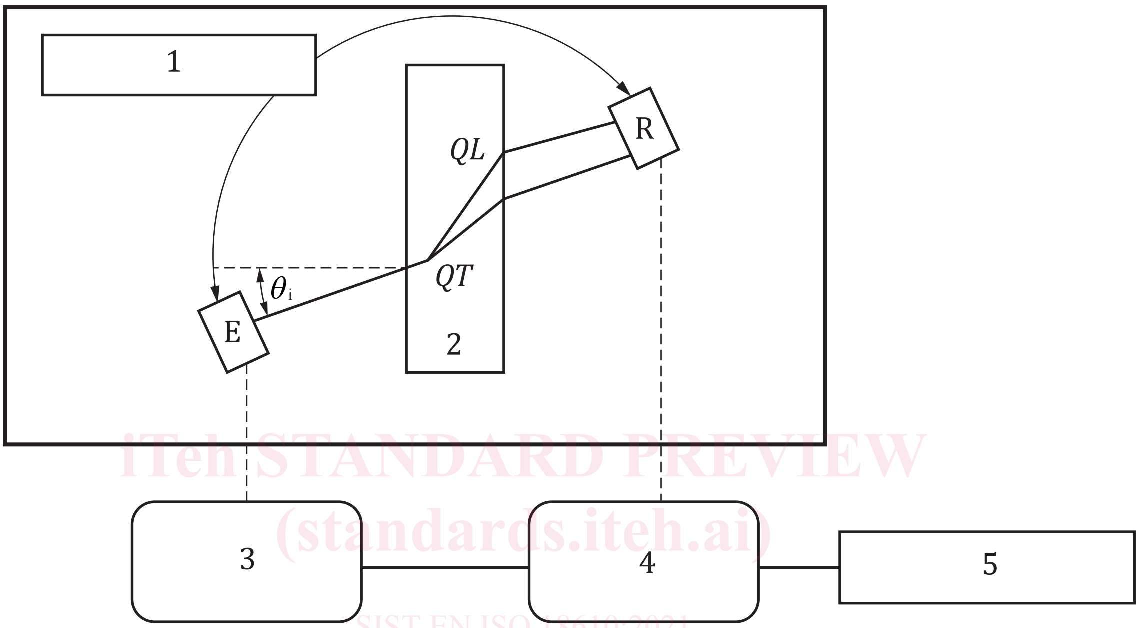
ρ

ratio of the mass of the material without porosity to its total volume including porosity

4 Principle

The determination of the elastic properties consists of calculating the coefficients of the propagation equation of an elastic plane wave, from a set of properly chosen velocity measurements along known directions.

A thin specimen with plane parallel faces is immersed in an acoustically coupling fluid (e.g. water), see Figure 3. The specimen is placed between a transmitter (T) and a receiver (R), which are rigidly connected to each other and have two rotational degrees of freedom. Using appropriate signal processing, the propagation velocities of each wave in the specimen are calculated.



Key

1	rotation drive
2	test object
3	pulse generator
4	digital oscilloscope
5	micro-computer

Figure 3 — Ultrasonic test assembly

Depending on the angle of incidence, the wave created by the pulse sent by the transmitter T is refracted within the material in one (a quasi longitudinal wave *QL*, or a quasi transverse wave *QT)*, two (*QL*+ *QT or* two quasi transverse waves QT_1, QT_2) or three bulk waves (QL+ QT_1+QT_2) that propagate in the solid at different velocities and in different directions.

The receiver R collects one, two or three pulses, corresponding to each of these waves.

The difference between the time-of-flight of each of the waves and the time-of-flight of the transmitted pulse in the coupling fluid without the test object is measured. The evaluation procedure is based on the measurement of the time-of-flight of the quasi-longitudinal and one or both quasi-transverse waves, and is only valid when the *QL* and the *QT* waves are appropriately separated (see Figure 4).