INTERNATIONAL STANDARD

ISO 10545-5

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Ceramic tiles —

Part 5:
Determination of impact resistance by measurement of coefficient of restitution

Carreaux et dalles céramiques —

Partie 5: Détermination de la résistance au choc par mesurage du coefficient de restitution

Reference number
ISO 10545-5:1996(E)

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.

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.

International Standard ISO 10545-5 was prepared by Technical Committee ISO/TC 189, *Ceramic tile*.

ISO 10545 consists of the following parts, under the general title *Ceramic tiles*:

— *Part 1: Sampling and basis for acceptance*

— *Part 2: Determination of dimensions and surface quality*

— *Part 3: Determination of water absorption, apparent porosity, apparent relative density and bulk density*

— *Part 4: Determination of modulus of rupture and breaking strength*

— *Part 5: Determination of impact resistance by measurement of coefficient of restitution*

— *Part 6: Determination of resistance to deep abrasion for unglazed tiles*

— *Part 7: Determination of resistance to surface abrasion for glazed tiles*

— *Part 8: Determination of linear thermal expansion*

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— *Part 9: Determination of resistance to thermal shock*

— *Part 10: Determination of moisture expansion*

— *Part 11: Determination of crazing resistance for glazed tiles*

— *Part 12: Determination of frost resistance*

— *Part 13: Determination of chemical resistance*

— *Part 14: Determination of resistance to stains*

— *Part 15: Determination of lead and cadmium given off by glazed tiles*

— *Part 16: Determination of small colour differences*

— *Part 17: Determination of coefficient of friction*

Annex A of this part of ISO 10545 is for information only.

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Ceramic tiles —

Part 5:
Determination of impact resistance by measurement of coefficient of restitution

1 Scope

This part of ISO 10545 specifies a test method for determining the impact resistance of ceramic tiles by measuring the coefficient of restitution.

2 Definition

For the purpose of this part of ISO 10545, the following definition applies.

2.1 coefficient of restitution between two impacting bodies, e: Relative velocity of departure divided by the relative velocity of approach.

3 Principle

Determination of the coefficient of restitution by dropping a steel ball from a fixed height onto the test specimen and measuring the height of rebound.

4 Apparatus

4.1 Chrome steel ball, of diameter (19 ± 0,05) mm.

4.2 Ball-release apparatus, (see figure 1), consisting of a heavy steel base set on levelling screws with a vertical steel bar to which is attached an electromagnet, a guide tube and a test unit support.

The test unit is clamped firmly in a position so that when the steel ball drops it impinges on the centre of the horizontal tile surface. A clamping device is shown in figure 1, but any suitable system may be used.

4.3 Electronic timing device (optional), which, by means of a microphone, measures the time interval between the first and second impacts when the ball is dropped onto the test specimen.

5 Test specimens

5.1 Number of test specimens

A minimum of five pieces in dimensions 75 mm × 75 mm cut from five tiles. Tiles with facial dimensions less than 75 mm may be used.

5.2 Brief description of test units

The test units consist of test specimens fixed to mature concrete blocks by means of rigid epoxide resin adhesive.

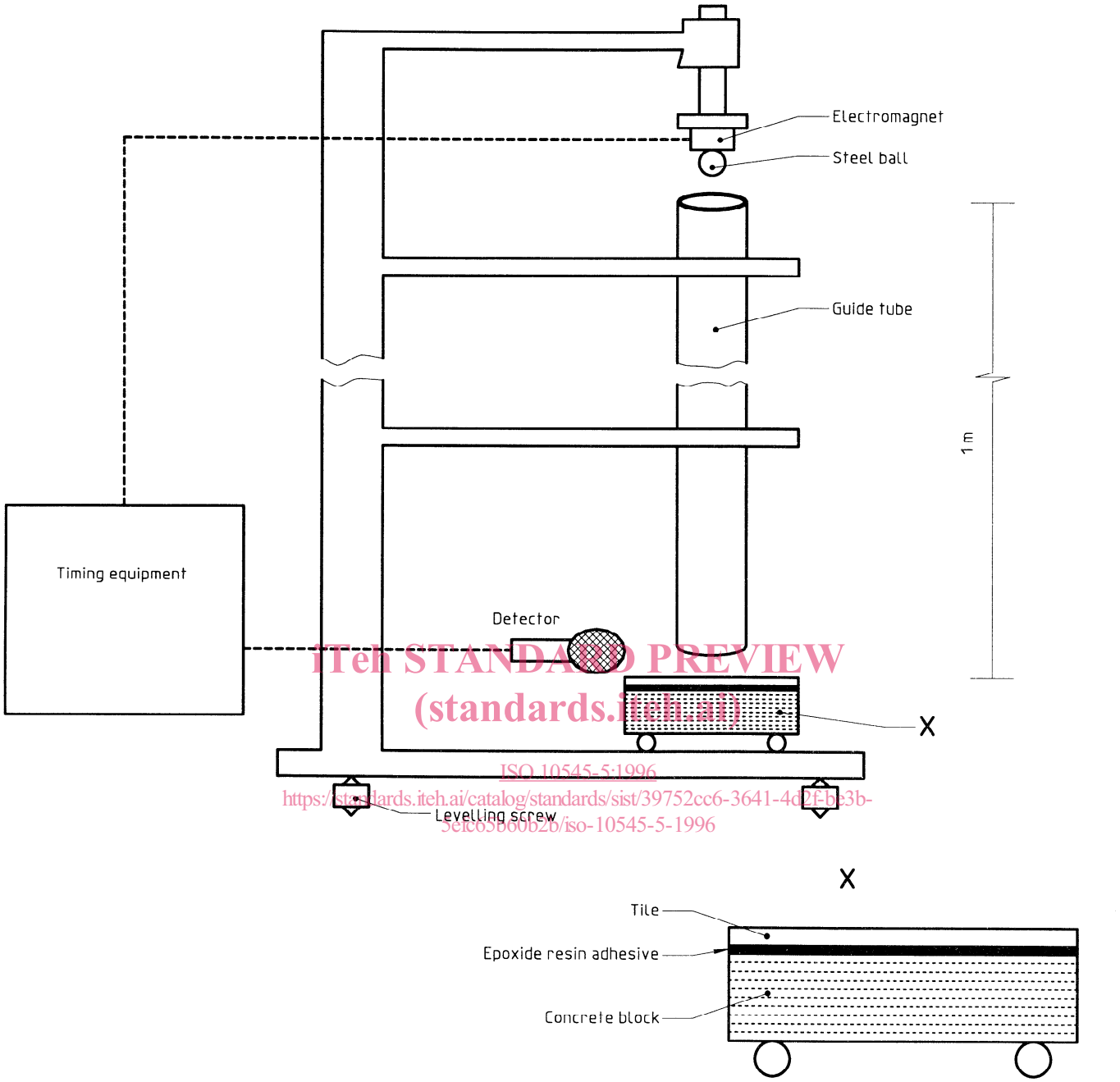

Figure 1 — Ball-release apparatus

5.3 Concrete blocks

The dense concrete blocks shall be of approximate dimensions 75 mm × 75 mm × 50 mm and prepared in moulds of this size, or alternatively cut from large concrete slabs.

The following method describes the preparation of dense concrete blocks made from gravel/sand, but other aggregates may be used and then the surface water absorption test may not be appropriate.

Concrete blocks or slabs may be made by adding one part by mass of Portland cement to 4.5 to 5.5 parts by mass of aggregate. The aggregate shall be gravel sand of 0 to 8 mm particle size with a continuous grading curve between the limits A and B in figure 2. The total fines of particle size below 0,125 mm in the mix of concrete, including Portland cement, should be about 500 kg per cubic metre.

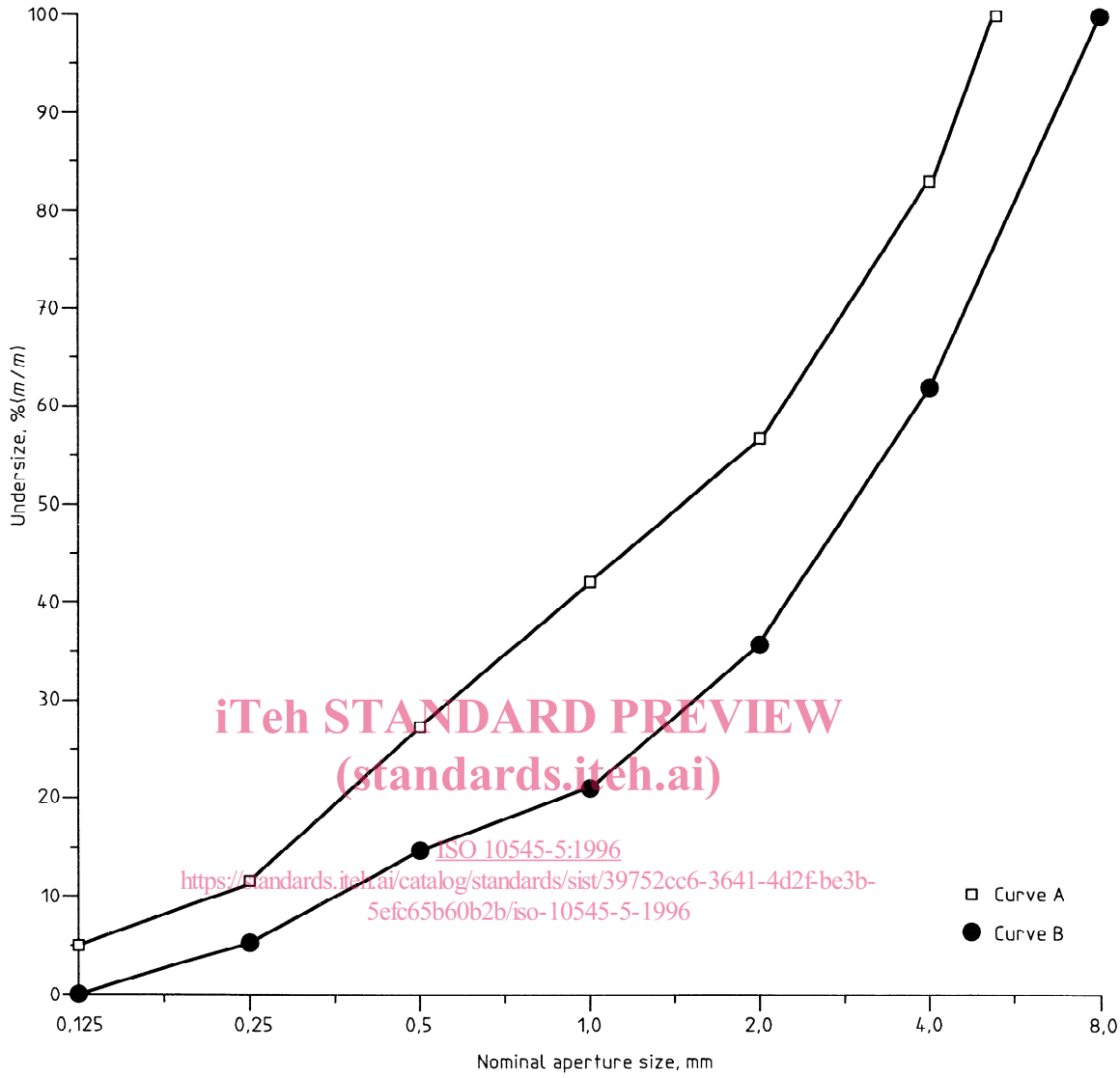

Figure 2 — Grading curves for gravel sand of maximum particle size 8 mm

The water/cement ratio shall be 0,5. Thoroughly mix the constituents in a mechanical mixer and trowel into moulds of the required size. Compact for 90 s at 50 Hz on a vibrating table.

Condition the concrete slabs for 48 h at (23 ± 2) °C and (50 ± 5) % relative humidity before removing them from the moulds. Thoroughly rinse off any mould release agent. Throughout the remaining conditioning, the slabs shall be held vertically, leaving gaps between them. Immerse in water at (20 ± 2) °C for 6 d, then in air at (23 ± 2) °C and (50 ± 5) % relative humidity for 21 d. The assembly face of the concrete shall have an absorption of surface water after 4 h in the range of 0,5 cm^3 to 1,5 cm^3 when three specimens are tested in accordance with the method shown in annex A and figure A.1.

Blocks subsequently cut from concrete slabs by wet methods require a minimum drying period of 24 h at (23 ± 2) °C and (50 ± 5) % relative humidity before assembly in test units.

5.4 Epoxide resin adhesive

The adhesive shall not contain ingredients which increase flexibility.

A suitable adhesive consists of 2 parts by mass of an epoxide resin, which is a reaction product of epichlorhydrin and diphenol isopropane and one part

by mass of a curing agent which is an activated amine. Pure silica filler of average particle size 5,5 µm, measured by the Coulter Counter or other similar methods, is thoroughly mixed with the other constituents in a proportion which is just sufficient to form a mixture that does not flow.

5.5 Assembly of test units

Spread epoxide resin adhesive in a layer about 2 mm thick over the upper surface of a mature concrete block in a uniform layer. Place three steel or plastics spacer pegs, of diameter 1,5 mm, in the centre of three of the sides so that each peg projects enough to allow it to be removed later. Press a test specimen, with the proper face upwards, into the adhesive and scrape off excess adhesive from the sides before gently removing the three spacer pegs. Allow to stand at a temperature of (23 ± 2) °C and at (50 ± 5) % relative humidity for 3 d prior to testing.

If tiles of less than 75 mm × 75 mm facial dimensions are to be tested, place one tile so that its centre coincides with the centre of the surface of the block. Use cut pieces of tile to complete the 75 mm × 75 mm area.

6 Procedure

Adjust the ball-release apparatus (4.2) by means of the levelling screws so that the steel bar is vertical. Place the test unit under the electromagnet so that a steel ball (4.1) released from the electromagnet will fall onto the centre of a test unit clamped in position.

Place a test unit in the support with the proper face of the test specimen upwards and horizontal. Release the steel ball from a height of 1 m above the proper face of the test unit and allow it to bounce. Measure the height of rebound to ± 1 mm by a suitable detector and calculate the coefficient of restitution (e).

Alternatively, allow the ball to bounce twice, note the time between bounces to the nearest millisecond and calculate the height of rebound and hence the coefficient of restitution.

Any suitable means of measuring the height of rebound, or the time interval between two impacts, may be used.

Examine the surface of the tile for signs of indentation or cracking. All minor Hertzian cracks which cannot be seen from a distance of 1 m with the naked eye, or with spectacles if usually worn, should be ignored. Edge chipping of surface relief should be noted but may be ignored when classifying tiles.

Repeat the whole procedure for the other test units.

7 Expression of results

For a ball impacting a horizontal static surface, the coefficient of restitution (e) is calculated using the equation

$$e = \frac{v}{u}$$

where

v is the velocity of departure (rebound);

u is the velocity of approach.

$$\frac{mv^2}{2} = mgh_2$$

Thus

$$v = \sqrt{2gh_2}$$

where

m is the mass, in grams, of the ball;

h_2 is the height of rebound, in centimetres;

g is the acceleration due to gravity (= 981 cm/s^2).

$$\frac{mu^2}{2} = mgh_1$$

Thus

$$u = \sqrt{2gh_1}$$

where h_1 is the height of drop, in centimetres.

Hence

$$e = \sqrt{\frac{h_2}{h_1}}$$

If the height of rebound is determined by allowing the ball to bounce twice and by measuring the time interval between bounces, the equation of motion is

$$h_2 = u_0 t + \frac{gt^2}{2}$$

where

u_0 is the velocity at peak rebound height (= zero);

t is $\frac{T}{2}$, where T is the time interval in seconds.

Hence

$$h_2 = 122{,}6T^2$$

8 Calibration

Assemble five test units (see 5.5) using (8 ± 0,5) mm thick, unglazed B1a tiles (water absorption < 0,5 %) with plane surfaces. Test in accordance with clause 6. The average height of rebound (h_2) shall be (72,5 ± 1,5) cm so that the coefficient of restitution is (0,85 ± 0,01).

9 Test report

The test report shall include the following information:

a) reference to this part of ISO 10545;

b) a description of the tiles;

c) the coefficient of restitution of each of the five test specimens;

d) the average coefficient of restitution;

e) any indentation or cracking of test specimens.