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Fourth edition
2019-02

Ceramic tiles —

Part 4: Determination of modulus of rupture and breaking strength

Carreaux et dalles céramiques —

Partie 4: Détermination de la résistance à la flexion et de la force de rupture

Reference number
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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

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Foreword

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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 of the voluntary nature of standards, 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 189, *Ceramic tile.*

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

This fourth edition cancels and replaces the third edition (ISO 10545-4:2014), which has been technically revised. The main changes compared to the previous edition are as follows:

— test specimens are tested in different format size according to their work size thickness that can be minor or greater/equal than 7,5 mm;

— the minimum number of specimen to be tested has been changed.

A list of all parts in the ISO 10545 series can be found on the ISO website.

Ceramic tiles —

Part 4: Determination of modulus of rupture and breaking strength

1 Scope

This document specifies a test method for determining the modulus of rupture and breaking strength of all ceramic tiles.

NOTE ISO 13006 provides property requirements for tiles and other useful information on these products.

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 48-2, *Rubber, vulcanized or thermoplastic — Determination of hardness — Part 2: Hardness between 10 IRHD and 100 IRHD*

3 Terms and definitions

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

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

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

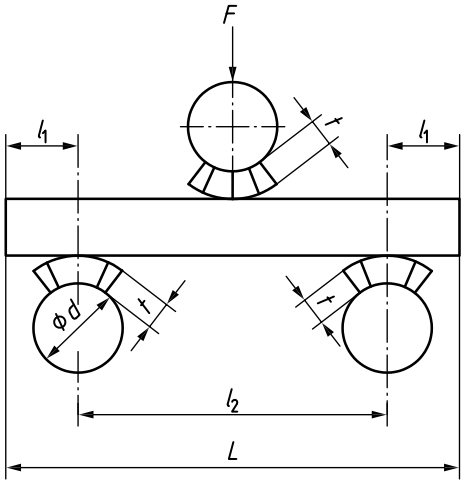
— IEC Electropedia: available at http://www.electropedia.org/

3.1
breaking load
F
force necessary to cause the test specimen to break, as read from the pressure gauge (see Figure 1)

3.2
breaking strength
S
force obtained by multiplying the *breaking load* (3.1) by the ratio (span between support rods)/(width of the test specimen)

3.3
modulus of rupture
R
quantity obtained by dividing the calculated *breaking strength* (3.2) by the square of the minimum thickness along the broken edge

3.4
work size thickness
thickness of the tile specified by the manufacturer



Key

d diameter of rod
L long side of tile
l_1 overlap of tile beyond the edge supports
l_2 span between the support rods
t thickness of rubber

Figure 1 — Application of load to test specimens

4 Principle

Determination of the breaking load, breaking strength, and modulus of rupture of a tile by applying a force at a specified rate to the centre of the tile, the point of application being in contact with the proper surface of the tile.

5 Apparatus

5.1 Drying oven, capable of being operated at (105 ± 5) °C.

Microwave, infrared or other drying systems can be used provided that it has been determined that equal results are obtained.

5.2 Recording pressure gauge, accurate to 2,0 %.

5.3 Two cylindrical support rods, made of metal, the parts in contact with the test specimens being covered with rubber having a hardness of (50 ± 5) IRHD, measured in accordance with ISO 48-2.

One rod shall be slightly pivotable (see Figure 2) and the other shall be slightly rotatable about its own axis. See Table 1 for relevant dimensions.

Table 1 — Diameter of rods, d, thickness of rubber, t, and overlap of tile beyond the edge supports, l_1

Dimensions in millimetres

Long side of tile L	Diameter of rod d	Thickness of rubber t	Overlap of tile beyond the edge supports l_1
$18 \leq L < 48$	5 ± 1	1 ± 0,2	2 ± 1
$48 \leq L < 95$	10 ± 1	2,5 ± 0,5	5 ± 3
$L \geq 95$	20 ± 1	5 ± 1	10 ± 5

5.4 Central cylindrical rod, of the same diameter as the support rods (5.3) and covered with the same rubber, for transmission of the load.

This rod shall also be slightly pivotable (see Figure 2). See Table 1 for relevant dimensions.

5.5 Stiff brush, with coarse bristles for removing loose particles.

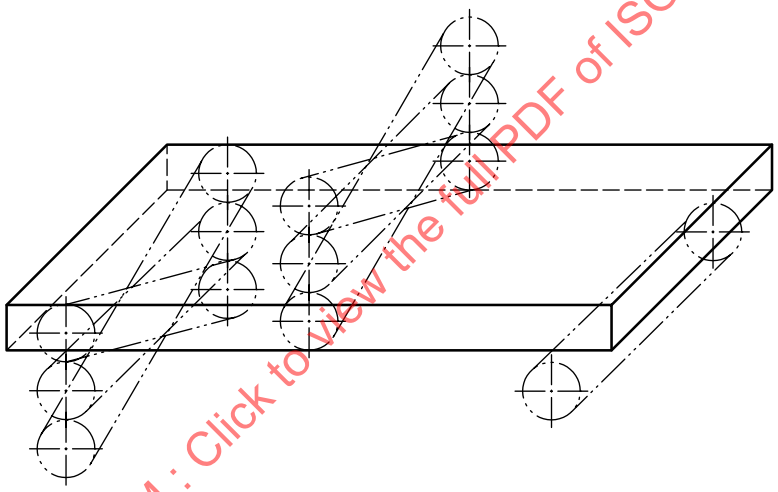


Figure 2 — Allowable movement of rods

6 Test specimens

6.1 If the tile has a work size thickness greater than or equal to 7,5 mm, select the tiles at random from the lot to be tested. Whenever possible, whole tiles shall be tested. However, it can be necessary to cut exceptionally large tiles (that is, those greater than 600 mm in length) in order to fit them in the apparatus. Test specimens of the largest possible size, though not larger than the rod length, shall then be cut, having their centres coinciding with the centres of the tiles. In case of doubt, results obtained using whole tiles shall always be preferred to results obtained with cut tiles. If cut tiles are used, it shall be noted in the test report and tolerance for cuts must be within 10 mm.

When aspect ratio is $L/B \leq 3$, where L is the long side of the tile and B is the short side of the tile,

— if $L \leq 600$ mm, then maintain the original dimension;

— if $L > 600$ mm, then maintain the original aspect ratio until $L = 600$ mm.

EXAMPLES

(900 × 900) mm is cut to (600 × 600) mm,

(1 200 × 600) mm is cut to (600 × 300) mm,

(900 × 300) mm is cut to (600 × 200) mm,

(1 800 × 900) mm is cut to (600 × 300) mm

When aspect ratio is $L/B > 3$, where L is the long side of the tile and B is the short side of the tile:

— if $L \leq 600$ mm, then maintain the original dimension;

— if $L > 600$ mm, reduce L to 600 mm, maintaining as much as possible the aspect ratio and cutting B not less than 250 mm (this means that if $B < 250$ mm, it shall maintain the original dimension).

EXAMPLES

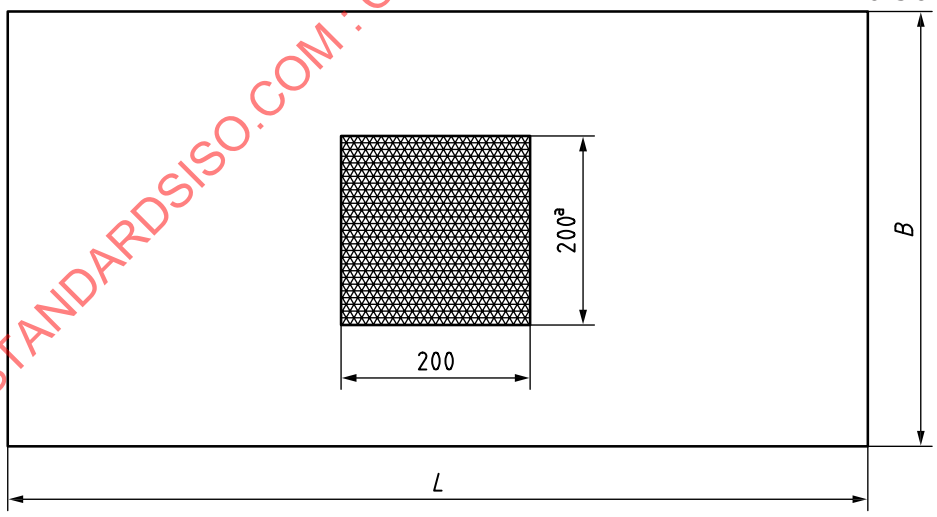
(1 800 × 500) mm is cut to (600 × 250) mm

(1 200 × 300) mm is cut to (600 × 250) mm

(1 200 × 200) mm is cut to (600 × 200) mm

6.2 If the tile has a work size thickness less than 7,5 mm, select the tiles at random from the lot to be tested. Whole tiles shall be tested when their maximum area is in the range 324 mm^2 to 40 000 mm^2. When tile maximum area is in the range 40 000 mm^2 to 360 000 mm^2, quadrangular test specimens of 200 mm × 200 mm size shall be cut, having their centres coinciding with the centres of the tiles (see Figure 3). For tiles with the short side, B, less than 200 mm and maximum area in the range 40 000 mm^2 to 360 000 mm^2, the test specimens shall be the dimension of the short side, B, by 200 mm, having their centres coinciding with the centres of the tiles (for example, a tile with dimensions of 1 000 × 150 mm would be cut to 200 × 150 mm for testing). When tile maximum area is greater than 360 000 mm^2 quadrangular test specimens of 200 mm × 200 mm size shall be cut as illustrated in Figure 4.

Dimensions in millimetres



Key

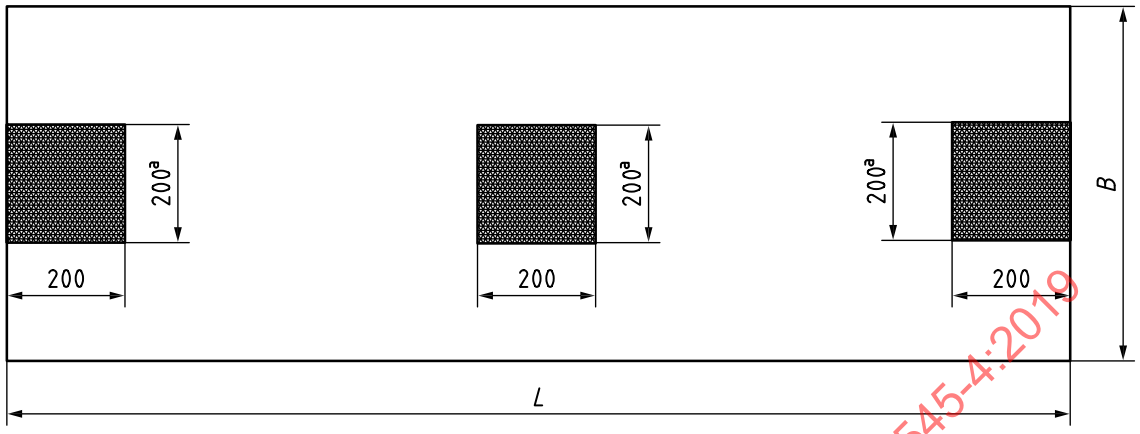
B short side of the tile

L long side of the tile

[a] Or B if $B \leq 200$ mm.

Figure 3 — Specimen for tile with a maximum area in the range 40 000 mm^2 to 360 000 mm^2 and work size thickness <7,5 mm

Dimensions in millimetres



Key

B short side of the tile

L long side of the tile

[a] Or *B* if $B \leq 200$ mm.

Figure 4 — Specimen for tile having a maximum area >360 000 mm² and work size thickness <7,5 mm

6.3 Tiles and relevant specimens shall not contain any visible damage or cracks prior to testing and shall not have been tested previously.

6.4 The minimum number of test specimens for each sample when the tile has a work size thickness ≥7,5 mm or <7,5 mm is reported in Table 2 and Table 3, respectively.

Table 2 — Minimum number of test specimens for tiles with a work size thickness ≥7,5 mm

Maximum area *A* mm²	Number of specimens to be tested	Total number of tiles	Total number of specimens	Minimum number of acceptable results
$2\,500 < A \leq 40\,000$	1	7	7	5
$40\,000 < A \leq 360\,000$	1	7	7	5
$A > 360\,000$	1	3	3	3

Table 3 — Minimum number of test specimens for tiles with a work size thickness <7,5 mm

Maximum area *A* mm²	Number of specimens to be tested	Total number of tiles	Total number of specimens	Minimum number of acceptable results
$2\,500 < A \leq 40\,000$	1	7	7	5
$40\,000 < A \leq 360\,000$	1	7	7	5
$A > 360\,000$	3	3	9	8

7 Procedure

7.1 Remove any loosely adhering particles from the back of all test specimens with a stiff brush. Dry each test specimens in the drying oven (5.1) maintained over (105 ± 5) °C during at least 24 h, and let them cool until they reach room temperature. Test specimens shall be tested not later than 3 h after they have reached room temperature.

7.2 Place the test specimen on the support rods (5.3), with the glazed or proper surface uppermost so that the test specimen projects by a length, l_1 (see Table 1 and Figure 1) beyond each support rod.

7.3 In the case of reversible tiles, such as unglazed ceramic mosaic tiles, it does not matter which side of the tile is uppermost. For extruded tiles, place the test specimen so that the projecting ribs are at right angles to the support rods. For all other rectangular tiles, place the test specimens so that the long side, *L*, is at right angles to the support rods.

7.4 For tiles with a relief surface, place a second layer of rubber, of the appropriate thickness given in Table 1, on the central rod (5.4) in contact with the relief surface.

7.5 Position the central rod equidistant between the support rods. Apply the load evenly in such a way as to obtain a rate of increase in stress of (1 ± 0,2) N/mm^2 per second; the actual rate per second can be calculated using Formula (2). Record the breaking load, *F*.

8 Calculation

Use only the results for test specimens that break within a central portion of length equivalent to one third of the distance between the supporting rods to calculate the mean breaking strength and the mean modulus of rupture. Minimum number of acceptable results, necessary to calculate the mean value is indicated in Table 2 and Table 3.

If the minimum number of acceptable results is not reached, a second sample shall be tested consisting of twice the number of tiles. A minimum number of acceptable results twice the first number of minimum results is then required to calculate the average value.

The breaking strength, *S*, expressed in newtons, is calculated using Formula (1):

$$S = \frac{Fl_2}{B} \tag{1}$$

where

F is the breaking load, expressed in N;

l_2 is the span between the support rods (see Figure 1), in mm;

B is the short side of the test specimen under testing, in mm.

The modulus of rupture, *R*, expressed in newtons per square millimetre, is calculated using Formula (2):

$$R = \frac{3Fl_2}{2Bh^2} = \frac{3S}{2h^2} \tag{2}$$

where

F is the breaking load, expressed in N;

l_2 is the span between the support rods (see Figure 1), in mm;

B is the short side of the test specimen under testing, in mm;

h is the minimum thickness of the test specimen measured after the test along the broken edge, in mm.

The calculation of the modulus of rupture is based on a rectangular cross-section. In the case of tiles with variable thickness along the broken edge, only approximate results are produced. The shallower the relief, the more exact are the approximations.

Record all individual results.

Calculate the mean breaking strength and the mean modulus of rupture of the sample as the mean of the acceptable results.

9 Test report

The test report shall include the following information:

a) a reference to this document, i.e. ISO 10545-4;

b) a description of the tiles, including relief surface, if any;

c) the number of test specimens in the sample;

d) the values of d, t, l_1, and l_2 (see Figure 1);

e) the breaking load, F, of each test specimen;

f) the mean breaking load;

g) the breaking strength, S, of each test specimen;

h) the mean value of the breaking strength;

i) the modulus of rupture, R, of each test specimen;

j) the mean value of the modulus of rupture;

k) the note “test performed on cut tiles specifying the dimensions of the specimen”, when applicable.