
Low modulus adhesives for exterior tile finishing

*Adhésifs à faible module d'élasticité pour le collage extérieur des
carreaux 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.

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 189, *Ceramic tile*.

Low modulus adhesives for exterior tile finishing

1 Scope

This International Standard specifies a quality standard and test methods for a low modulus adhesive composed of chemical reaction resins and used for the installation of tiles to exterior walls.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 37:2011, *Rubber, vulcanized or thermoplastic — Determination of tensile stress-strain properties*

ISO 188:2011, *Rubber, vulcanized or thermoplastic — Accelerated ageing and heat resistance tests*

ISO 679:2009, *Cement — Test methods — Determination of strength*

ISO 2811-1, *Paints and varnishes — Determination of density — Part 1: Pycnometer method*

ISO 6344-2, *Coated abrasives — Grain size analysis — Part 2: Determination of grain size distribution of macrogrits P12 to P220*

ISO 8336, *Fibre-cement flat sheets — Product specification and test methods*

ISO 10364:2007, *Structural adhesives — Determination of the pot life (working life) of multi-component adhesives*

ISO 13006, *Ceramic tiles — Definitions, classification, characteristics and marking*

ISO 21948, *Coated abrasives — Plain sheets*

3 Terms and definitions

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

3.1

pot-life

time interval during which the adhesive can be used after mixing

3.2

open time

maximum time interval after application at which tiles can be embedded in the applied adhesive and meet the specified tensile adhesion strength requirement

3.3

shelf life

time of storage under stated conditions during which an adhesive may be expected to maintain its working properties

3.4

slip

downward movement of a tile applied to a combed adhesive layer on a vertical surface

3.5

reaction resin adhesive

single- or multi-component mixture of synthetic resin, mineral fillers and organic additives in which curing occurs by chemical reaction

3.6

notched trowel

toothed tool, which makes it possible to apply the adhesive as a series of ribs of a uniform thickness onto the fixing surface and/or the reverse face of the tile

3.7

cohesive failure ratio

percentage of total cohesive failure area of adhesive, substrate or tile, over total adhesion area

3.8

low modulus adhesive

adhesives curing to elastomeric rubbery film which has minimum 35 % of elongation at tensile testing break point

3.9

cement

finely ground inorganic material that, when mixed with water, forms a paste that sets by means of hydration reactions and processes, and that, after hardening, retains its strength and stability, even under water

Note 1 to entry: Cement for mortar substrate shall be Portland cement which is specified in ASTM C150 type 1.

[SOURCE: ISO 6707-1:2014, 6.4.16, modified]

4 Classification and designation

Adhesives shall be sorted into four groups as shown in [Table 1](#), based on the principal components and the reaction modes.

Table 1 — Grouping of tile adhesive

	Sort	Remarks
Polyurethane resin	1 component reaction-cure	Urethane resin based 1 component adhesive
	2 component reaction-cure	Urethane resin based 2 component adhesive
Silyl terminated polymers (exclude silicone)	1 component reaction-cure	Silyl terminated polymers based 1 component adhesive
	2 component reaction-cure	Silyl terminated polymers based 2 component adhesive

5 Requirement

The adhesives shall meet the requirements of [Table 2](#).

Table 2 — Product requirements

Property				Requirement	Test method
Shelf life				Homogeneous with no gelling, Less than 5 % weight change,	7.1
Mixing homogeneity inspection (2 component adhesives)				Homogeneous after mixing	7.2
Adhesive strength	Standard curing			0,60 N/mm ² or higher and 75 % or more cohesive failure ratio	7.3
	Low temperature curing			0,40 N/mm ² or higher and 50 % or more cohesive failure ratio	
	Alkaline warm water immersion			0,40 N/mm ² or higher and 50 % or more cohesive failure ratio	
	Freeze-thaw cycles			0,40 N/mm ² or higher and 50 % or more cohesive failure ratio	
	Heat aging			0,40 N/mm ² or higher and 50 % or more cohesive failure ratio	
Cured film property	Tensile property	Tensile strength		0,60 N/mm ² or higher	7.4
		Elongation at break		35 % or more	
	Cold and hot resistance	Tensile strength	Test temp: 80 °C	0,60 N/mm ² or higher	
			Test temp: -20 °C	0,60 N/mm ² or higher	
		Elongation at break	Test temp: 80 °C	35 % or more	
			Test temp: -20 °C	35 % or more	
	Tensile property after treatment	Tensile strength	Immersion in alkaline water	0,40 N/mm ² or higher	
			Heat aging	0,40 N/mm ² or higher	
		Elongation at break	Immersion in alkaline water	25 % or more	
			Heat aging	25 % or more	
Heat stability				4 weeks of stable tile maintenance at 80 °C , under 1 kg load	7.5
Slip				No slip	7.6
Pot-life (2 component adhesives)				Time indicated on the label	7.7
Open time (1 component adhesives)				Time indicated on the label	7.8
Density				Density indicated on the label	7.9

6 General test conditions and procedures

6.1 Testing conditions

Standard conditions shall be $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \%$ relative humidity (RH). Other test conditions may be specified in [Clause 7](#).

6.2 Test materials

6.2.1 General

Condition all test materials including water for at least 24 h under standard conditions. The adhesive to be tested shall be within its shelf life, where this is specified.

6.2.2 Cement mortar substrate

Mold a block in a 70 mm × 70 mm × 20 mm metal frame by pouring mortar specified in ISO 679:2009, Clause 6 and cure it at $(20 \pm 3) ^\circ\text{C}$ and at least 80 % RH for 24 h before taking it out. Then, cure the block in water at $(20 \pm 3) ^\circ\text{C}$ for 7 d. Then, condition for two weeks at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \%$ RH. Polish the surface well using sandpaper as specified in ISO 21948 with a P150 grain size specified in ISO 6344-2, to remove any efflorescence or release agents from the surface.

6.2.3 Ceramic tiles

The tiles used for this test shall be Group Bla tiles complying with ISO 13006 with water absorption less than 0,5 % by mass. The tiles shall be checked prior to conditioning to ensure that they are unused, clean and dry.

6.2.4 Fibre cement flat sheets

The fibre cement flat sheets shall be category C as defined in ISO 8336 with a thickness of 8 mm.

6.3 Notched trowel

The adhesive spreading tool for the test shall be a common comb trowel of which the blade is made of steel or similar and of dimensions as shown in [Figure 1](#). A different comb trowel may be used if specified in the instruction of the adhesive manufacturer.

Dimensions in millimetres

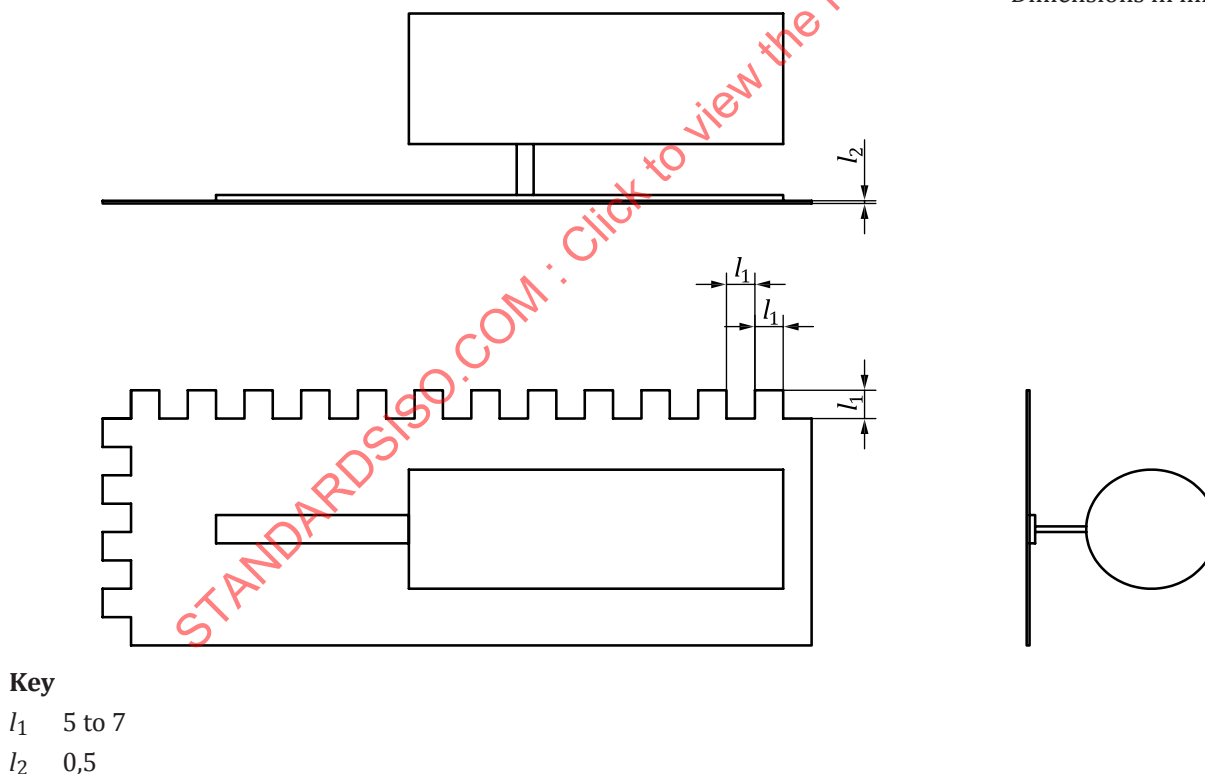
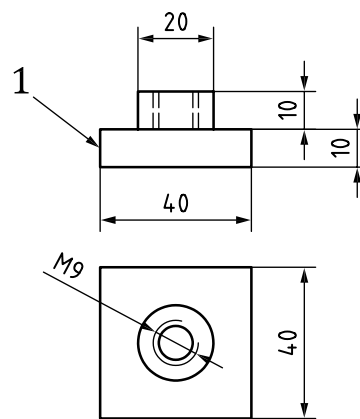


Figure 1 — Common comb trowel

6.4 Pull head plate

Square metallic plates, with dimensions of $(40 \pm 1) \text{ mm} \times (40 \pm 1) \text{ mm}$ with a suitable fitting for connection to the test machine. The dimensions of the block are shown in [Figure 2](#).

Dimension in millimetres

**Key**

1 metallic plates

Figure 2 — Pull head plate**7 Test methods****7.1 Shelf life**

Store the adhesive for four weeks in the original unopened package at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 10) \% \text{RH}$ for the first two weeks and at $(50 \pm 2) ^\circ\text{C}$ and $(85 \pm 5) \% \text{RH}$ for the next two weeks. After the storage period, place approximately 100 g adhesive on the glass plate with dimensions 100 mm $\times$ 100 mm $\times$ 5 mm and immediately spread the adhesive to about 1 mm layer using a suitable paddle. Inspect the layer for any gel and foreign matters. This test is applicable only to the 1 component adhesives.

7.2 Mixing homogeneity inspection

Take base resin and hardener in an approximate volume to gain 200 g to 300 g blend and in the ratio that the manufacturer specifies. Place it on the glass plate with dimensions 300 mm $\times$ 300 mm $\times$ 5 mm and immediately mix well for about 3 min. After mixing, confirm homogeneity by a visual check. This test is applicable only to the 2 component adhesives.

7.3 Adhesive strength**7.3.1 Materials for the testing****7.3.1.1 Substrate**

The substrate is the cement mortar substrate defined in [6.2.2](#) with dimensions of approximately 70 mm $\times$ 70 mm $\times$ 20 mm. The surface should be free of dust, dirt, etc.

7.3.1.2 Ceramic tiles

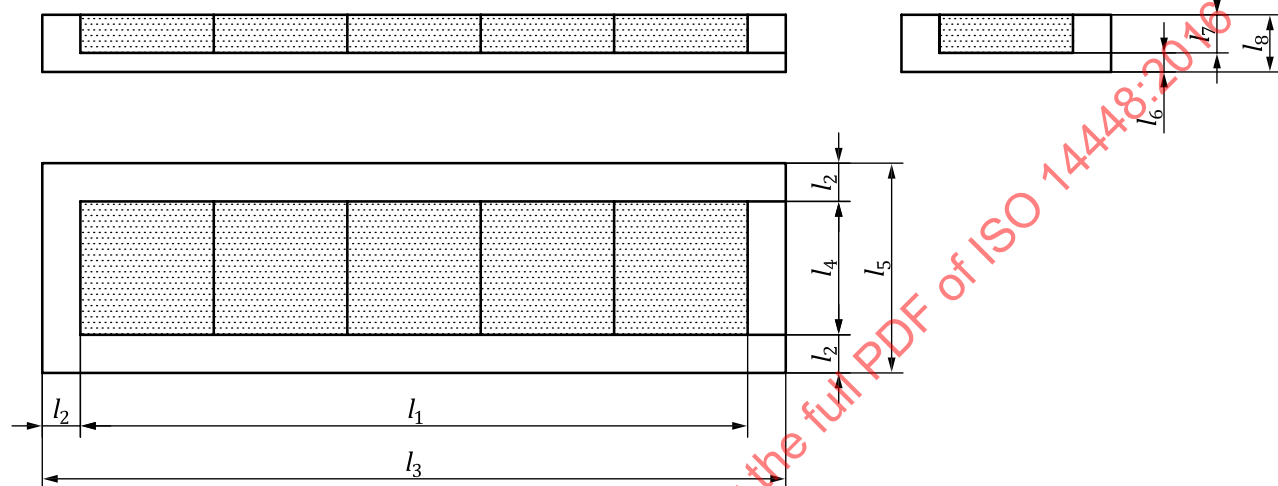
The ceramic tiles are the ones defined in [6.2.3](#) with dimensions of approximately 45 mm $\times$ 45 mm $\times$ 7 mm.

7.3.2 Preparation of test pieces

7.3.2.1 Spreading of adhesive

Insert five substrate with their polished surfaces up, into the steel frame of [Figure 3](#) and fix them without leaving gaps. Adhere a flexible masking tape on the steel frame as shown in [Figure 4](#), so that it goes 7 mm over the substrate edges. Apply a sufficient volume of adhesive to the substrate and spread it to a layer of approximately 5 mm. Comb the adhesive layer with a common comb trowel, holding the comb at an angle of approximately 60°, so that the adhesive is evenly spread. Remove the masking tape slowly.

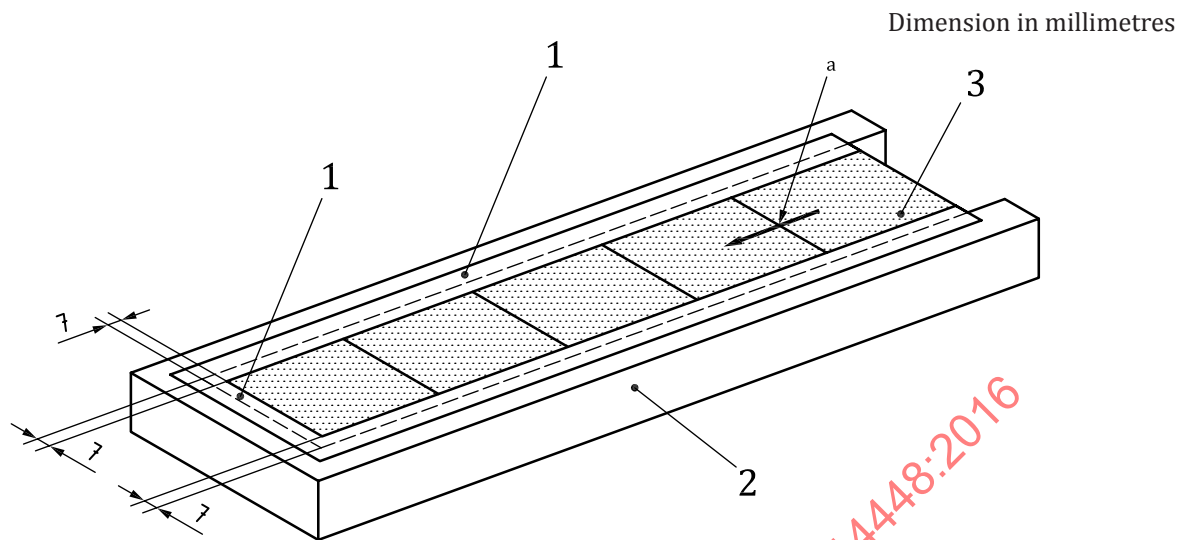
Dimension in millimetres



Key

l_1	350 ± 1
l_2	20 ± 1
l_3	390 ± 1
l_4	$70 \pm 0,5$
l_5	110 ± 5
l_6	10 ± 4
l_7	20 ± 1
l_8	30 ± 4

Figure 3 — Steel frame for adhesive spreading

**Key**

- 1 masking tape
- 2 steel frame for spreading
- 3 substrate to be spread of adhesive
- a Direction of comb trowel stroke.

Figure 4 — Adhesive spreading**7.3.2.2 Placing of tile**

When the adhesive is spread, place a ceramic tile as defined in [7.3.1.2](#) on each substrate. Excess adhesive pushed out of the tile should be removed immediately.

7.3.3 Curing of test assembly**7.3.3.1 Standard cure**

Cure the assembly for 672 h in standard conditions.

7.3.3.2 Low temperature curing

Cure the assembly for 672 h under $(5 \pm 2) ^\circ\text{C}$ conditions.

7.3.4 Treating of test assembly**7.3.4.1 Immersion in warm alkaline water**

Cure the assembly according to [7.3.3.1](#) and then immerse in saturated lime water at $60 ^\circ\text{C}$. After 168 h, remove the test pieces from the lime water, rinse with clean water, wipe lightly with a dry cloth and test immediately.

7.3.4.2 Freeze-thaw cycles

Cure the assembly according to [7.3.3.1](#) and then immerse in water (conditioned between $15 ^\circ\text{C}$ and $25 ^\circ\text{C}$) for 24 h in order to saturate the mortar substrate with water, before carrying out 200 freeze-thaw cycles.

For each freeze-thaw cycle:

- a) remove the test pieces from the water and maintain the test pieces at $(-20 \pm 3) ^\circ\text{C}$ for 2 h.
- b) immerse in water at $(20 \pm 3) ^\circ\text{C}$ for 1 h.

Repeat the cycle 200 times. Condition the test pieces for a further 24 h under standard conditions.

7.3.4.3 Heat aging

Cure the assembly according to 7.3.3.1 and then place them in an air-circulating oven at $(80 \pm 3) ^\circ\text{C}$ for a further 336 h. Remove from the oven and condition the test pieces for a further 24 h under standard conditions.

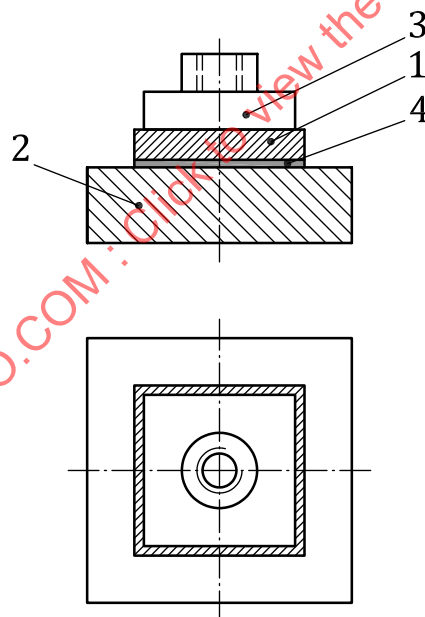
7.3.5 Adhesive strength

7.3.5.1 Test machine

The test machine should be capable of giving breaking tensile force to the test assembly, which should fall between 15 % and 85 % of its force capacity and can stretch the test piece at a rate of 3 mm/min.

7.3.5.2 Bond the pull head plate

Prior to the tensile test, the pull head plate, as shown in Figure 5, is adhered to the test assembly tiles by an epoxy adhesive.



Key

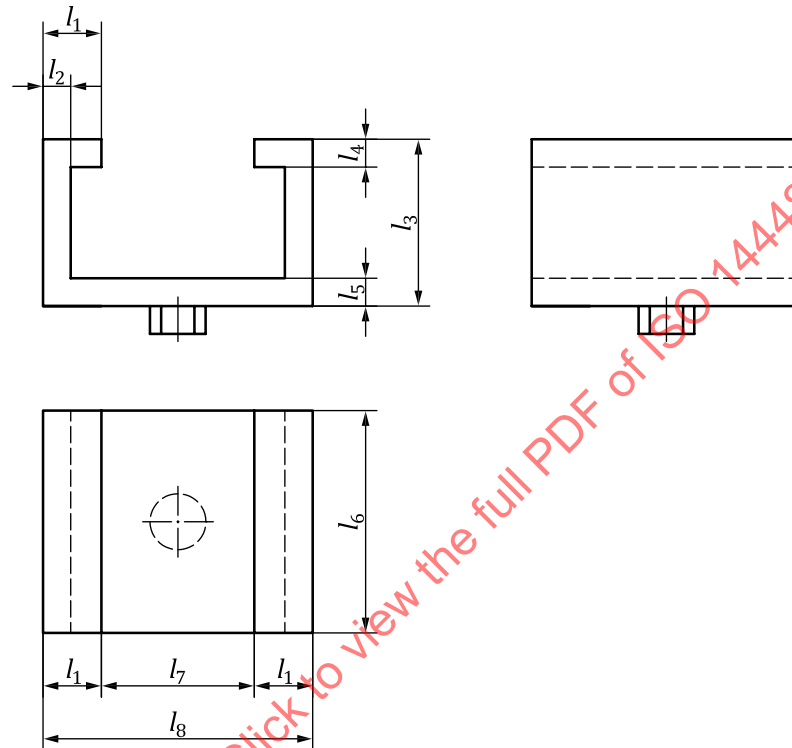
- 1 tile
- 2 substrate
- 3 steel pulling block
- 4 adhesive

Figure 5 — Bond the pull head plate

7.3.5.3 Adhesive strength

Give the test assembly, made according to 7.3.2, the treatment of 7.3.3 and 7.3.4, and bond the pull head plate to it, as shown in Figure 5. Install this assembly in the tensile tester as shown in Figure 8, using a substrate holder (see Figure 6) and a spacer frame (see Figure 7). Operate the tensile tester at a stretch rate of 3 mm/min until the test assembly breaks and record the maximum tensile load. The mode of failure is recorded by observation. All the tests are conducted in the standard conditions.

Dimension in millimetres

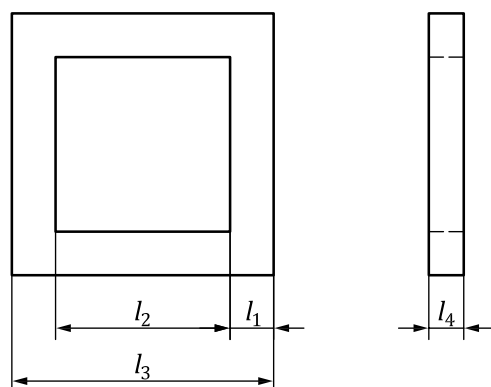


Key

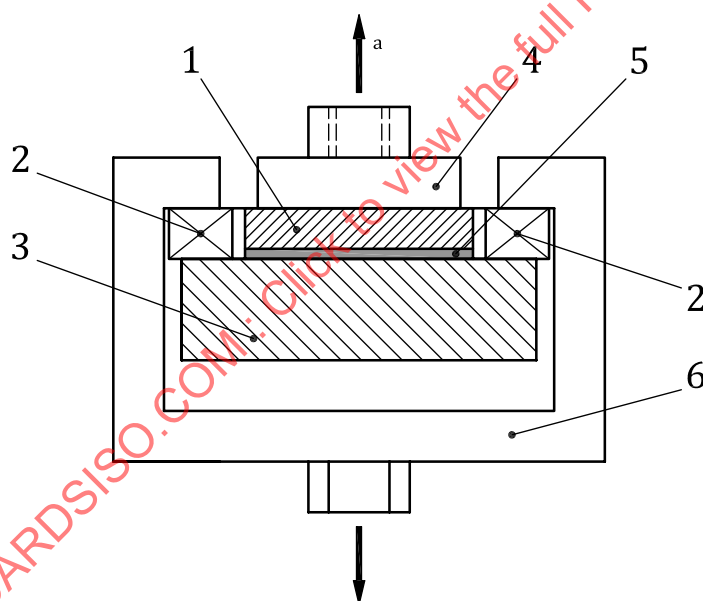
l_1	21
l_2	10
l_3	60
l_4	10
l_5	10
l_6	80
l_7	55
l_8	97

Figure 6 — Substrate holder

Dimension in millimetres

**Key**

l_1	12,5
l_2	50
l_3	75
l_4	10

Figure 7 — Spacer frame**Key**

1	tile
2	spacer frame
3	substrate
4	pull head plate
5	adhesive
6	substrate holder
a	Tensile direction.

Figure 8 — Installation of test assembly

7.3.5.4 Calculation of adhesive strength

The adhesive strength is calculated by [Formula \(1\)](#):

$$F = \frac{P}{S} \quad (1)$$

where

F is adhesive strength in (N/mm²);

P is maximum load (N);

S is the bonding area (area of tile: 45 mm × 45 mm) (mm²).

The adhesive strength is represented by the average value of five test pieces.

7.3.5.5 Record of failure mode

The failure mode needs to be recorded as a cohesive failure ratio as follows: inspect the failure surface and verify the (A + G + B) area as well as the (GA + AB) area, referring to [Figure 9](#). The failure mode ratio shall be determined by carrying out a visual check and obtaining the cohesive failure area (A + G + B) using [Formula \(2\)](#):

$$C = \frac{M}{S} \times 100 \quad (2)$$

where

C is cohesive failure ratio (of adhesive and adherend) (%);

M is area of (A + G + B) (mm²);

S is the bonding area (area of tile: 45 mm × 45 mm) (mm²).

Key

A adhesive

B tile

G substrate

AB interface of tile and adhesive

GA interface of adhesive and substrate

1 tile

2 adhesive

3 substrate

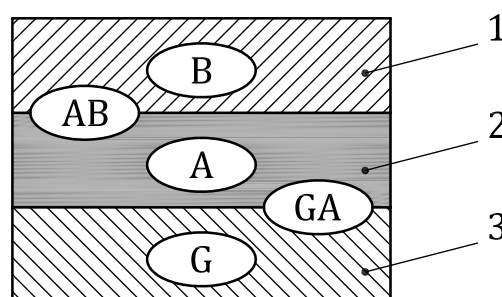


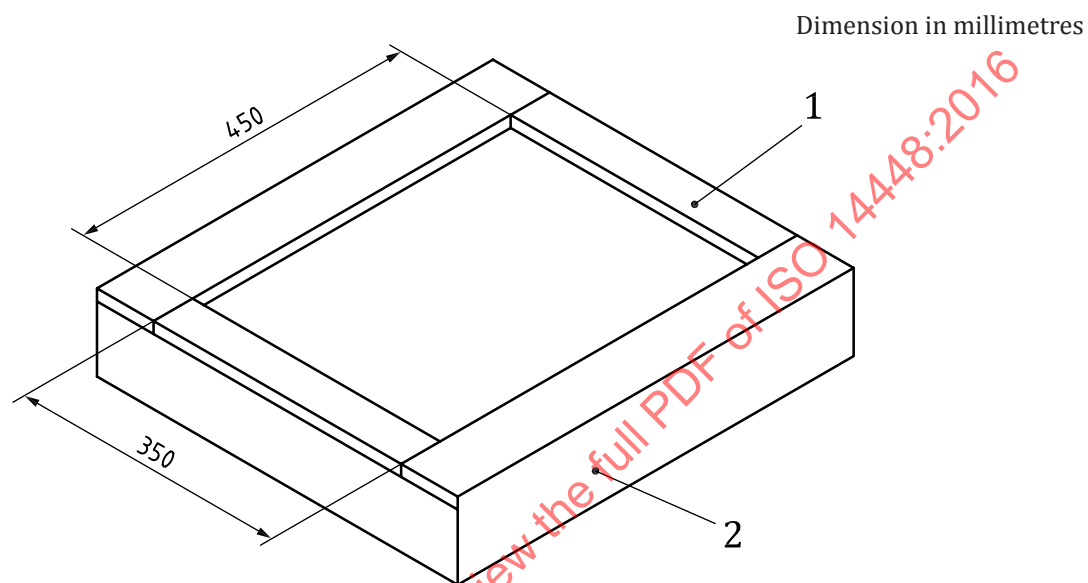
Figure 9 — Location of failure

7.4 Cured film test

7.4.1 Preparation of sample

7.4.1.1 Preparation of film

Carefully fill the cavity with adhesive to a depth of 2 mm as shown in [Figure 10](#), avoiding air bubble inclusion and cure it for four weeks at $(23 \pm 2) ^\circ\text{C}$, $(50 \pm 10) \% \text{RH}$. The finish gauge of cured film should be 2 mm.



Key

- 1 dam frame
- 2 base

Figure 10 — Cavity mold for adhesive film

7.4.1.2 Preparation of test pieces

Prepare type 1 dumbbells as shown in [Figure 11](#) which are specified in ISO 37, out of the cured film of [7.4.1.1](#). The required number of test pieces are shown in [Table 3](#).

Table 3 — Required numbers of test pieces

Test		Number of test pieces
Tensile properties		6
Temperature dependency ($-20 ^\circ\text{C}$, $80 ^\circ\text{C}$)		6 for each temp.
Tensile properties after treating	Immersion in alkaline water	6
	Heat aging	6

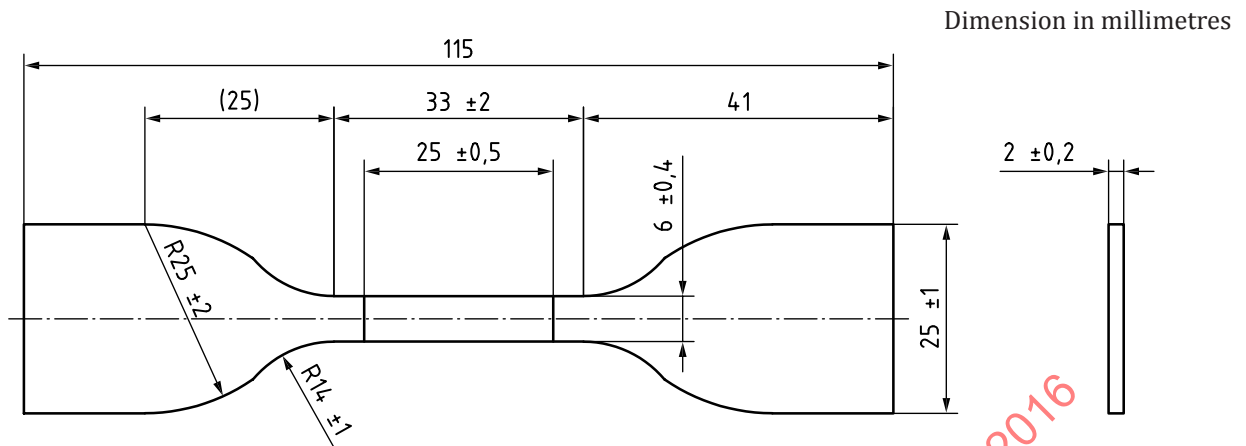


Figure 11 — Test piece of cured film

7.4.1.3 Determination of thickness and distance between bench marks of test pieces

The thickness and the distance between bench marks of test piece is measured according to ISO 37:2011, Clause 6 and Clause 12.

7.4.2 Tensile test

7.4.2.1 Tensile tester

The tensile tester should be capable of giving breaking tensile force to the test piece, which should fall between 15 % and 85 % of its force capacity and can stretch the test piece as much as eight times the distance of the bench mark distance. The tester should be able to record the load and the displacement automatically.

7.4.2.2 Test procedure

Condition the test pieces in standard conditions for more than 1 h prior to testing. Conduct the tensile test on five dumbbells by installing the test piece in the grips and extending them at a rate of (100 ± 10) mm/min until the test piece breaks. If a test piece breaks outside the bench mark, reject the result and repeat the test on an extra test piece.

7.4.2.3 Tensile strength

Get the maximum load from the recorded chart and calculate the strength using [Formula \(3\)](#). The average of five tests is rounded to three significant digits.

$$T_b = \frac{P_s}{A} \quad (3)$$

where

T_b is the tensile strength (N/mm²);

P_s is the maximum load (N);

A is the initial cross section area of test piece (mm²).

7.4.2.4 Elongation at break

Measure the distance between bench marks at break and calculate the elongation at break using [Formula \(4\)](#). The average of five tests is rounded to two significant digits.

$$E_B = \frac{L_1 - L_0}{L_0} \times 100 \quad (4)$$

where

E_B is the elongation at break (%);

L_1 is the distance between bench marks at break (mm);

L_0 is the initial distance between bench marks (mm).

7.4.2.5 Temperature dependency of tensile properties

7.4.2.5.1 Tensile tester

The tensile tester should be the same as [7.4.2.1](#).

7.4.2.5.2 Test procedure

Condition five test pieces each at -20 °C and 80 °C for more than 1 h prior to the test. Set a test piece in the grips of the thermal chamber of the tensile tester, adjusted to (-20 ± 2) °C, and extend it at a rate of (100 ± 10) mm/min until the test piece breaks. If a test piece breaks outside the bench mark, reject the result and repeat the test on an extra test piece. Repeat the test on a total of five dumbbells and also conduct the test at (80 ± 2) °C chamber temperature.

7.4.2.5.3 Tensile strength

Calculate the tensile strength according to [7.4.2.3](#). The average of five tests is rounded to three significant digits figure.

7.4.2.5.4 Elongation at break

Calculate the elongation at break according to [7.4.2.4](#). The average of five tests is rounded to two significant digits.

7.4.2.6 Alkaline water immersion test

7.4.2.6.1 Test procedure

Immerse five test pieces for 168 h in approximately 400 ml, saturated lime water at 60 °C. Rinse the test pieces well, wipe them with a dry cloth and dry them in a 50 °C to 60 °C oven for more than 6 h. Condition them for more than 4 h in standard conditions. Conduct the tensile test on five dumbbells by installing the test piece in the grips of the test chamber adjusted to the standard conditions and extending them at a rate of (100 ± 10) mm/min until the test piece breaks. If a test piece breaks outside the bench mark, reject the result and repeat the test on an extra test piece.

7.4.2.6.2 Tensile strength

Calculate the tensile strength according to [7.4.2.3](#). The average of five tests is rounded to a significant digits.

7.4.2.6.3 Elongation at break

Calculate the elongation at break according to [7.4.2.4](#). The average of five tests is rounded to two significant digits.

7.4.2.7 Heat aging test

7.4.2.7.1 Heating oven

Heating oven is “Type 2 oven with turbulent air flow” specified in ISO 188:2011, 4.1.4 or an equivalent.

7.4.2.7.2 Test procedure

The heat aging of test pieces is performed according to ISO 188:2011, Clause 9. If the test pieces tend to deform, lay them on a release paper during aging. Aging is performed for 336 h at $(80 \pm 2) ^\circ\text{C}$. The aged test pieces are conditioned for more than 4 h in standard conditions to the tensile test. Conduct the tensile test on five dumbbells by installing the test piece in the grips of the test chamber adjusted to the normal conditions and extending them at a rate of (100 ± 10) mm/min until the test piece breaks. If a test piece breaks outside the bench mark, reject the result and repeat the test on an extra test piece.

7.4.2.7.3 Tensile strength

Calculate the tensile strength according to [7.4.2.3](#). The average of five tests is rounded to three significant digits.

7.4.2.7.4 Elongation at break

Calculate the elongation at break according to [7.4.2.4](#). The average of five tests is rounded to two significant digits.

7.5 Heat stability

7.5.1 Materials for the testing

7.5.1.1 Substrate

The substrate is the cement mortar substrate defined in [6.2.2](#) with dimensions of approximately 70 mm × 70 mm × 20 mm. The surface should be free of dust, dirt, etc.

7.5.1.2 Ceramic tiles

The ceramic tiles are the ones defined in [6.2.3](#) with dimensions of approximately 45 mm × 45 mm × 7 mm. Adhere 1 mm spacers (e.g. steel balls) on the four corners of the tile bottom to assure the thickness of adhesive.

7.5.2 Preparation of test pieces

7.5.2.1 Spreading of adhesive

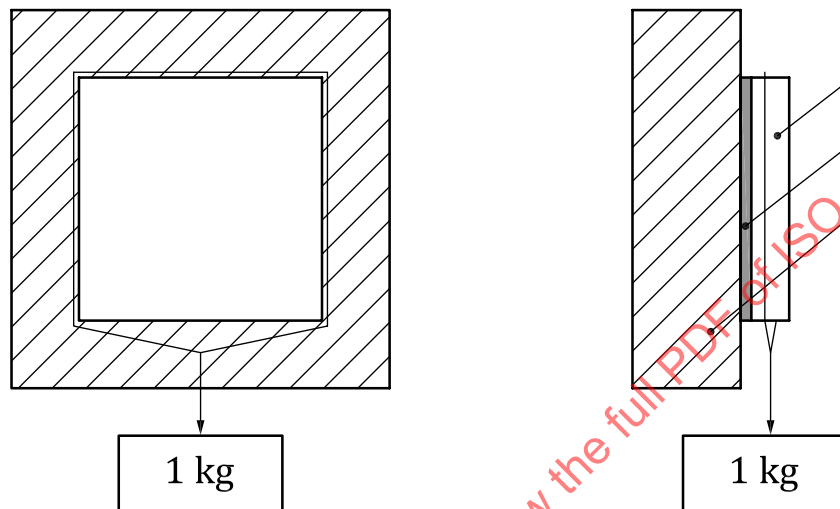
Insert five substrates with their polished surfaces up, into a steel frame of [Figure 3](#) and fix them without leaving gaps. Adhere a flexible masking tape on the steel frame as shown in [Figure 4](#), so that it goes 7 mm over the substrate edges. Apply a sufficient volume of adhesive to the substrates and spread it to a layer of approximately 5 mm. Comb the adhesive layer with a common comb trowel, holding the comb at an angle of approximately 60° , substrate so that the adhesive is evenly spread. Remove the masking tape smoothly.

7.5.2.2 Placing of tile

When the adhesive is spread, place a ceramic tile in the centre of the substrate and press it by hand until the spacers touch the substrate. Excess adhesive pushed out of the tile should be removed immediately. Cure the assembly in standard conditions for two weeks for 2 component adhesive or for four weeks for 1 component adhesive.

7.5.2.3 Test procedure

After curing, hold the test assembly vertically in an oven adjusted to 80 °C and apply 1 kg weight to the tile as shown in [Figure 12](#). If the tile does not come off for four weeks, the adhesive is qualified.



Key

- 1 tile
- 2 adhesive
- 3 substrate

Figure 12 — Heat resistance test

7.6 Slip test

7.6.1 Materials for the testing

7.6.1.1 Substrate

The substrate is the fibre cement flat sheets defined in [6.2.4](#) with dimensions of approximately 200 mm × 500 mm × 8 mm. The surface should be free of dust, dirt, etc.

7.6.1.2 Ceramic tiles

The ceramic tiles are the ones defined in [6.2.3](#) with dimensions of approximately 45 mm × 95 mm × 7 mm. Adhere 1 mm spacers (e.g. steel balls) on the four corners of the tile bottom to assure the thickness of adhesive.