BS EN 1062-7:2004

Paints and varnishes — Coating materials and coating systems for exterior masonry and concrete —

Part 7: Determination of crack bridging properties

The European Standard EN 1062-7:2004 has the status of a British Standard

ICS 87.040

British Standards

National foreword

This British Standard is the official English language version of EN 1062-7:2004.

The UK participation in its preparation was entrusted to Technical Committee STI/28, Paint systems for non-metallic substrates, which has the responsibility to:

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Paints and varnishes - Coating materials and coating systems for exterior masonry and concrete - Part 7: Determination of crack bridging properties

Peintures et vernis - Produits de peinture et systèmes de revêtement pour maçonnerie et béton extérieurs - Partie 7 : Détermination de la résistance à la fissuration

Beschichtungsstoffe - Beschichtungsstoffe und Beschichtungssysteme für mineralische Substrate und Beton im Außenbereich - Teil 7: Bestimmung der rissüberbrückenden Eigenschaften

This European Standard was approved by CEN on 24 March 2004.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This document (EN 1062-7:2004) has been prepared by Technical Committees CEN/TC 104 “Concrete and related products” and CEN/TC 139 “Paints and varnishes”, the secretariats of which are held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2004, and conflicting national standards shall be withdrawn at the latest by November 2004.

EN 1062, *Paints and varnishes – Coating materials and coating systems for exterior masonry and concrete*, consists of the following parts:

– Part 1: Classification

– Part 3: Determination and classification of liquid-water transmission rate (permeability)

– Part 6: Determination of carbon dioxide permeability

– Part 7: Determination of crack bridging properties

– Part 11: Methods of conditioning before testing

Annexes A and B are normative. Annex C is informative.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

Introduction

This is one of a number of parts of EN 1062 dealing with test methods for coating materials and coating systems for masonry and concrete.

1 Scope

This European Standard specifies two methods for determining the crack-bridging properties of coating materials, coating systems and related products, intended for exterior masonry and concrete. It should be read in conjunction with EN 1062-1 and prEN 1504-2.

It also gives a classification of coatings on the basis of their crack-bridging properties.

NOTE The method to be used for a particular product or system should be agreed between the interested parties.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 196-1, *Methods of testing cement — Part 1: Determination of strength.*

EN 971-1:1996*, Paints and varnishes - Terms and definitions for coating materials - Part 1: General terms.*

EN 1062-11, *Paints and varnishes — Coating materials and coating systems for exterior masonry and concrete - Part 11: Methods of conditioning before testing.*

EN 1766:2000, *Products and systems for the protection and repair of concrete structures —Test methods — Reference concretes for testing.*

EN ISO 1513, *Paints and varnishes —Examination and preparation of samples for testing (ISO 1513:1992).*

EN ISO 15528, *Paints, varnishes and raw materials for paints and varnishes —Sampling (ISO 15528:2000).*

3 Terms and definitions

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

3.1
coating system
sum total of the coats of coating materials which are to be applied or which have been applied to a substrate [EN 971-1:1996]

3.2
crack
first visible or measurable failure through the coating, coating system or substrate

3.3
crack bridging
ability of the coating or coating system to take up the elongation resulting from the movement of the crack sides (3.4)

3.4
crack sides
surfaces of the break in the substrate that are generated when the substrate is marking the crack

3.5
crack width
mean distance of the crack sides (3.4) measured on the surface of the substrate

3.6
nominal crack point
place in the substrate where the crack will occur

3.7
substrate
surface to which a coating material is applied or is to be applied [EN 971-1:1996]

4 Principle

After coating the substrate, a defined crack is made in the substrate at a nominal crack point. The applied coating is stretched over this crack. The mechanical stress is applied to the coating using one of the following methods:

Method A: The crack width is continuously enlarged at a defined speed. The measurement is taken when either failure occurs in the coating or coating system or when the required crack width is reached.

Method B: The crack width varies periodically within defined limits. The measurement is taken when either failure occurs in the coating or the coating system or the dynamic cycle is completed.

The crack-bridging properties can be determined at different temperatures.

Annexes A and B, respectively, specify test conditions for methods A and B and lay down classes for the crack-bridging properties on the basis of the respective test conditions. Annex C describes examples of suitable test procedures which meet the further requirements specified for methods A and B.

5 Apparatus

The test apparatus for changing and controlling the crack width at specified temperatures shall ensure that the movement of the cracks lies between given limits, and that shearing (horizontal and vertical movement) of the crack sides is avoided during the determination.

It shall be provided with a device for maintaining the temperature at which the determination of the crack bridging properties is to be carried out. The tolerance of the test temperature shall be ± 2 K.

Devices for measuring the crack width, e.g. extension measuring strip or inductive path finder, accurate to ± 5 µm, shall be provided. These measuring devices shall be suitable to monitor the change of the crack width during the test (8.3.2 and 8.3.3).

6 Sampling

Take a representative sample of the product to be tested (or of each product in the case of a multi-coat system), as described in EN ISO 15528.

Examine and prepare each sample for testing, as described in EN ISO 1513.

7 Test pieces

7.1 Substrate

The substrate shall consist of either:

concrete complying with the requirements of EN 1766, using a test mortar MC (0,45) with an aggregate size 0 mm to 8 mm,

or:

mortar complying with the requirements of EN 196-1, using a test mortar with 0 mm to 2 mm standard sand and CEM I 42,5 R.

Both types of substrate shall prepared as described in 6.4 and 6.5 of EN 1766:2000.

Store these substrates in accordance with EN 1062-11 for at least 7 days at (21 ± 2) °C and (60 ± 10) % relative humidity.

If specified, carry out a surface preparation, either using a metallic brush or by abrasive-blasting in accordance with EN 1766, using grit abrasive.

Other substrates and their preparation can be agreed between the interested parties.

7.2 Number and dimensions

Usually, three test pieces are used. The preparation and dimensions of the test pieces are given in annex C.

NOTE Test pieces of larger dimensions facilitate the application of the coating under practical conditions and a more uniform film thickness will be achieved.

7.3 Coating and conditioning of the substrates

Before coating measure the roughness index in accordance with EN 1766.

For preparation of the test pieces, coat the substrate and cure the test piece in accordance with the manufacturer's instructions.

Condition the test pieces in accordance with EN 1062-11 prior to testing. The conditioning method shall be agreed between the interested parties and stated in the test report.

7.4 Cracking of the test pieces

Make an immediate crack into the coated substrate of the test piece at 23 °C (see annex C). The crack width shall be ≤ 100 µm. The nominal crack point shall be in the middle of the length of the test pieces.

8 Procedure

8.1 Preparation of the test apparatus

Mount the devices for measuring the crack width on to the test piece on both sides of the crack. Align the test piece in the test apparatus in such a manner that the relative movement of the test piece and the apparatus is negligible in relation to the crack movement.

NOTE 1 If necessary, the device for measuring the crack width may be mounted to the movable parts of the test apparatus.

NOTE 2 The test piece can be mounted directly in the test apparatus or be fixed in the apparatus, e.g. with steel clips fixed on the surface or with reinforcement bars in the substrate.

8.2 Test temperature

Condition the test pieces at the test temperature specified in annex A or B (see 8.3) prior to testing and start the measurement when the test pieces and the test apparatus have stabilized at the test temperature.

8.3 Measurement of the crack-bridging properties of the coating

8.3.1 Preparation

Apply force to the test piece in the test apparatus, following the procedures described in 8.3.2 or 8.3.3 respectively.

8.3.2 Method A: Continuous opening of the crack

Open the crack continuously at the test temperature until the coating shows failure, using a speed of 0,05 mm/min or 0,5 mm/min (see annex A).

8.3.3 Method B: Cyclic opening of the crack

Change periodically the crack width at the test temperature as defined in annex B. The curve is defined by frequency f, amplitude $w/2$ and mean width of the crack.

The measurement will be finished when a crack in the coating or coating systems occurs or the dynamic cycle is finished.

9 Expression of results

9.1 Method A: Continuous opening of the crack

Note the crack width in the substrate at which first failure in the coating or coating system in the area of the crack occurs.

9.2 Method B: Periodical change of the crack width

Note whether the coating shows failure or not. Failures are cracks on the surface or cracks from underneath the coating. Describe the type of cracking in the test report.

NOTE Cracks from underneath the coating become visible when the test piece is cut into slices rectangular to the crack.

10 Precision

Precision data are currently not available.

11 Test report

The test report shall contain at least the following information:

a) details necessary to identify the product tested;

b) reference to this European Standard (EN 1062-7);

c) nature and the dimensions of the substrate;

d) preparation of the substrate and its roughness index in accordance with EN 1766:2000, clause 7;

e) number of coats and the method of application of the coating or coating system including waiting times and spreading rates;

f) method and extent of conditioning before testing;

g) procedure for inducing the crack;

h) test method used (method A or method B);

i) for method A: the test conditions in accordance with annex A;

j) for method B: the test conditions in accordance with annex B;

k) test temperature;

l) film thickness of the coating in the area of the crack in the substrate;

m) disbonded area in the vicinity of the crack;

n) type and extent of cracking, as indicated in 9.2;

o) any deviation from the test methods specified;

p) date of the test;

q) classification of the crack-bridging ability of the coating or coating system.

Annex A
(normative)

Crack-bridging properties — Classification and test conditions for method A

Table A.1 — Classification and test conditions (method A)

Class	Width of the crack bridged µm	Speed mm/min
A 1	> 100	— [a]
A 2	> 250	0,05
A 3	> 500	0,05
A 4	> 1250	0,5
A 5	> 2500	0,5
[a] Static tensile test (see Annex C)		

The test temperature for class A 1 is 23 °C. As test temperature for classes A 2 to A 5 -10 °C is recommended. Other test temperatures can be agreed between the interested parties, e.g. 10 °C, 0 °C, -20 °C, - 30 °C and -40 °C. In this case the test temperature shall be indicated in brackets after the class, e.g. A 4 (-20 °C).

Annex B
(normative)

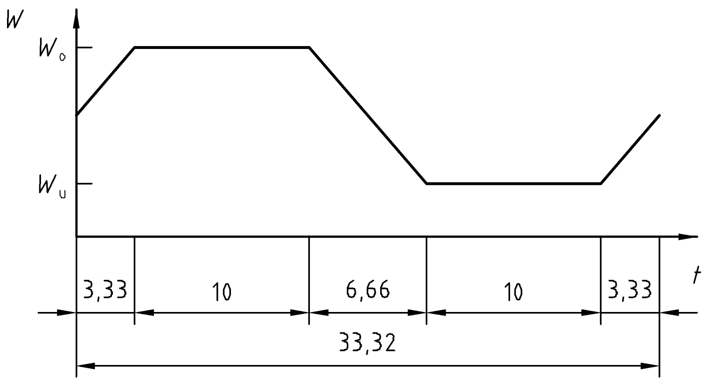
Crack-bridging properties —Classification and test conditions for method B

Table B.1 — Classification and test conditions (method B)

Class	**Test conditions** (see figures B.1 and B.2)
B 1	w_o = 0,15 mm ü ý trapezoid w_u = 0,10 mm þ n = 100 f = 0,03 Hz w = 0,05 mm
B 2	w_o = 0,15 mm ü ý trapezoid w_u = 0,10 mm þ n = 1000 f = 0,03 Hz w = 0,05 mm
B 3.1	w_o = 0,30 mm ü ý trapezoid w_u = 0,10 mm þ n = 1000 f = 0,03 Hz w = 0,2 mm
B 3.2	as 3.1 and w_L = ± 0,05 sinus n = 20 000 f = 1 Hz
B 4.1	w_o = 0,50 mm ü ý trapezoid w_u = 0,20 mm þ n = 1000 f = 0,03 Hz w = 0,30 mm
B 4.2	as 4.1 and w_L = ± 0,05 sinus n = 20 000 f = 1 Hz

Explanation of symbols:	
f	frequency
n	number of crack cycles
w	change in crack width
w_L	load-dependent crack movement
w_o	maximum crack width
w_u	minimum crack width

As test temperature -10 °C is recommended. Other test temperatures can be agreed between the interested parties, e.g. 10 °C, 0 °C, -20 °C, -30 °C and -40 °C. The test temperature is to be indicated in brackets after the class, e.g. B 1 (-20 °C).

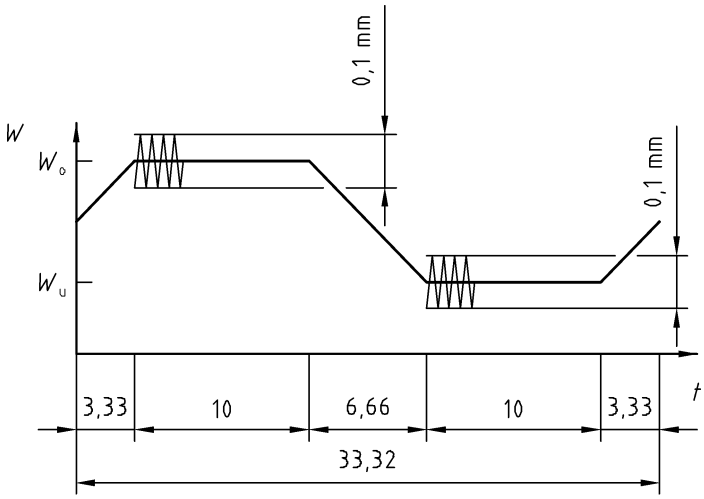


Key

t Time in seconds
w Crack width in millimetres

100 or 1000 crack cycles as a trapezoidal function using 0,03 Hz.

Figure B.1 —Change of crack width as a function of time for classes B 1, B 2, B 3.1 and B 4.1



Key

t Time in seconds
w Crack width in millimetres

1000 crack cycles as a trapezoidal function using 0,03 Hz, superimposed crack cycles as a sinus function using 1 Hz.

Figure B.2 — Change of crack width as a function of time for classes B.3.2 and B.4.2

Annex C
(informative)

Examples of suitable test procedures

C.1 Static tensile test

C.1.1 Principle

This test procedure is an example of a static crack-bridging test in a tensile experiment in accordance with clause 4, method A.

C.1.2 Test pieces

Prepare rectangular slabs of at least 75 mm × 50 mm × 20 mm or disc-shaped of diameter 50 mm × 20 mm, sawn or cored from slabs of, for example, 300 mm × 300 mm × 20 mm in accordance with EN 196-1 or EN 1766 (see 7.1).

Coat and condition the substrates in accordance with 7.3.

Weaken the test pieces with a notch of depth 15 mm, width 2 mm to 3 mm on the uncoated side as shown in figure C.1.

Dimensions in millimetres

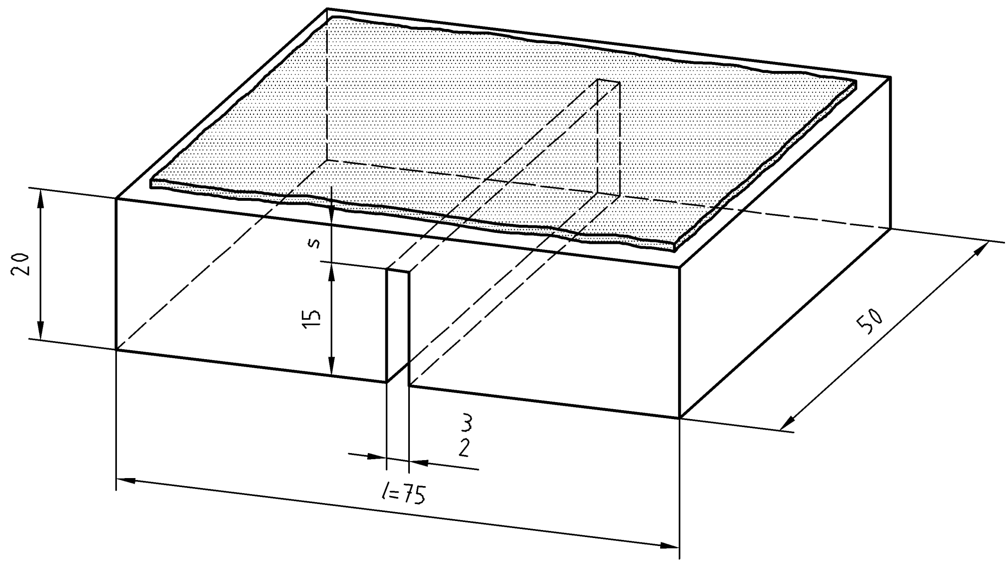


Figure C.1 — Example of a test piece for the static tensile test

C.1.3 Procedure

C.1.3.1 Jig for generating cracks

For the measurement of the crack-bridging class A 1 a jig is to be used (see figure C.2). The geometry of the jig is chosen as a function of the length *l* of the test piece and its thickness *s* over the notch and is calculated using equation C.1.

$$w = \frac{4\ h}{l}\ s \qquad \text{(C.1)}$$

where

w is the nominal crack width, in micrometres (see figure C.4);

h is the height of the support, in micrometres (see figure C.2);

l is the length of the test piece, in millimetres (see figure C.1);

s is the thickness of the test piece, in millimetres, over the notch (see figure C.1).

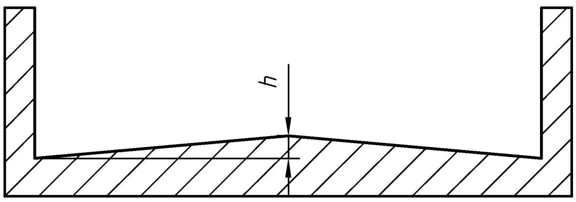
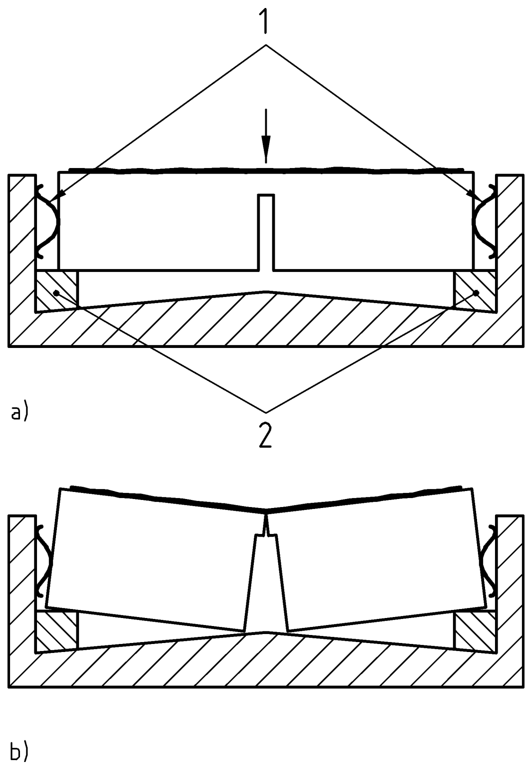


Figure C.2 — Jig for generating cracks with a given crack width

C.1.3.2 Generation of the initial crack in the substrate

Place the test piece into the jig on the two supports. Apply pressure to the test piece so that it is immediately broken without any extension of the coating while it rests on the two supports of height greater than *h* [(see figure C.3 a) and b)].



Key

1 Springs
2 Movable supports

Figure C.3 — Jig with support and test piece before (a) and after (b) the substrate is broken

C.1.3.3 Determination of the crack-bridging properties for class A 1

Remove the two supports and apply pressure to both ends of the test piece until the two parts rest on the bottom of the jig [(see figure C.4 a) and b)].

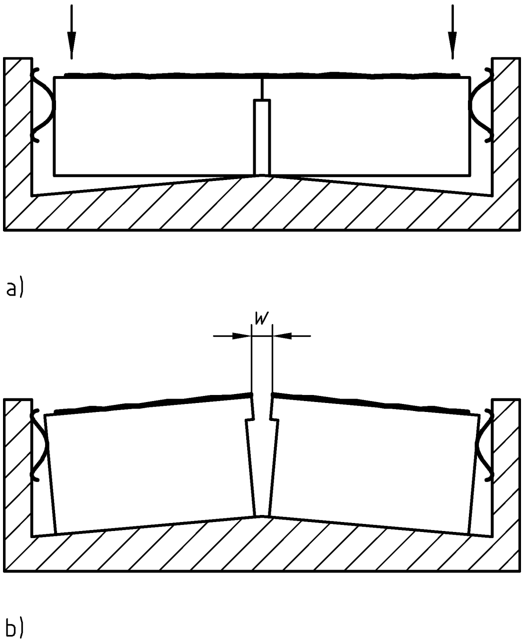


Figure C.4 — Jig with test piece before (a) and after (b) the crack is opened

Because of the geometry of the jig the crack-bridging properties for class A 1 can be determined without a special testing device.

C.1.3.4 Determination of the crack bridging-properties for classes A 2 to A 5

Remove carefully the broken test piece from the jig and place is in the measuring device defined in 8.1 and proceed in accordance with 8.3.2.

C.2 Static bending test

C.2.1 Principle

This test procedure is an further example of a static crack-bridging test in a bending experiment in accordance with clause 4, method A.

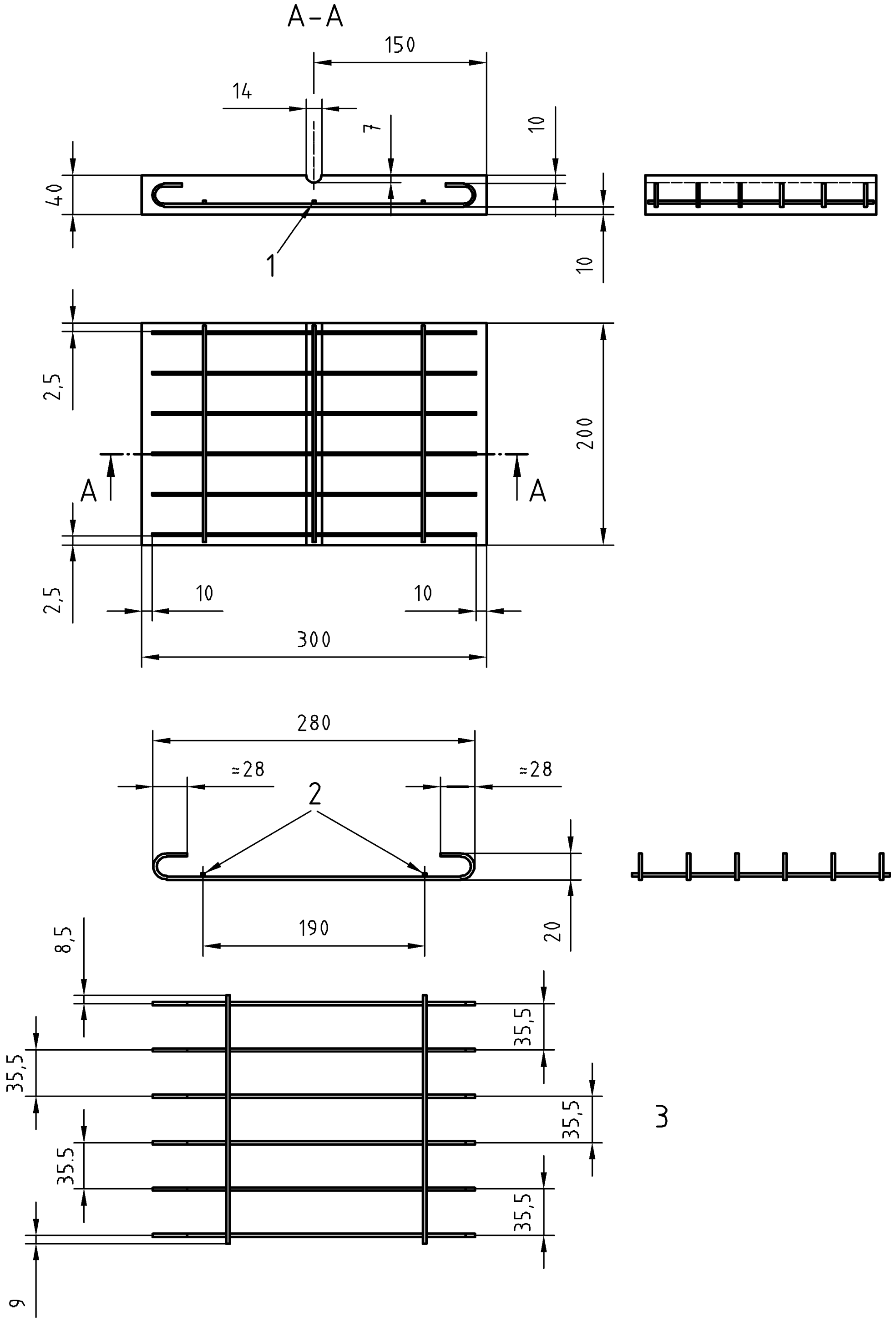
C.2.2 Test pieces

Prepare concrete slabs of 300 mm × 200 mm × 40 mm in accordance with EN 1766 (see 7.1). Reinforce the concrete slabs by six hooked main reinforcement bars (diameter 4 mm) along the longitudinal axis and two transversal reinforcement bars (see figure C.5). The reinforcement cage is fixed. A steel with an extension at break of 25 % is used. The coverage is 1 cm. Weaken the side opposite to the coating by a notch so that a predetermined crack can subsequently be induced at this point. The notch extends over the whole width of the slab and has a triangular shape. The depth of the notch should be up to a fifth of the thickness of the slab.

Coat the substrates to a width of 150 mm over the whole length of the slab, leaving 25 mm at the edges at each side uncoated for detecting cracks during the crack-bridging test and condition in accordance with 7.3.

Note A thin coating of gypsum can be applied on the upper side of the slab to the uncoated areas and smoothed with a putty knife. In this way, the displacement sensors can be fixed more easily and the incipient crack can be observed more simply. The sensors are fitted on both sides of the coated area in such a way that any influence on the measurement is excluded.

Dimensions in millimetres



Key

1 Coating
2 Spot-welding
3 Reinforcement steel with a diameter of 4 mm

Figure C.5 — Reinforced concrete slabs

C.2.3 Procedure

The crack-bridging test is a displacement- or deformation-controlled bending test in accordance with the experimental set-up shown in figure C.6.

In the following, the displacement-controlled test procedure is described as an example.

Dimensions in millimetres

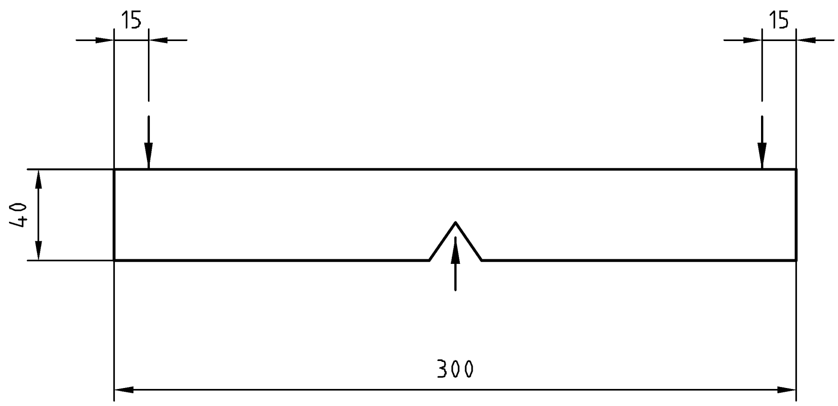


Figure C.6 — Experimental set-up for the static bending test

Fix the sensors alongside the coated area on the opposite side to the notch. Bring the test piece to the test temperature. During the test, continuously measure the crack opening in the uncoated edges of the surface of the slab and observe the coating to detect any changes. The induced crack should have opened on each side of the coated area to the required crack width.

At the end of the test, remove the test piece and inspect for damage in accordance with clause 9.

C.3 Dynamic tensile test 1

C.3.1 Principle

This test procedure is an example of a dynamic crack-bridging test in a tensile experiment in accordance with clause 4, method B.

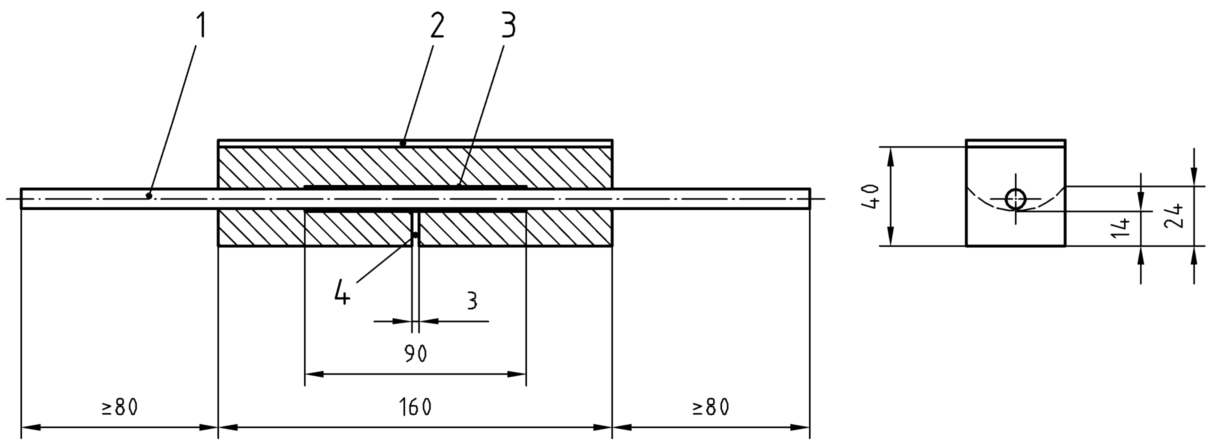
C.3.2 Test pieces

Prepare the following substrates in accordance with EN 196-1 (see 7.1). The substrate has a minimum surface to be coated of 40 mm × 160 mm.

Fabrication of substrates 40 mm × 40 mm × 160 mm with reinforcing steel (see figure C.7): A permitted reinforcing steel (e.g. 1420/1570 Ø 8 ribbed) sheathed in a 90 mm long plastic tube and projecting at least 80 mm on each side is placed along the longitudinal axis of the substrate. The side opposite to the coating is weakened by a notch with a width of 3 mm and a depth of 14 mm to 24 mm, so that a predetermined crack can subsequently be induced at this point.

Fabrication of substrates 40 mm × 40 mm × 160 mm without reinforcing steel (see figures C.8 and C.9): Substrates are sawn from a slab measuring (n × 40 mm) × 40 mm × 160 mm. (The length of the slab can be chosen as required). Every 45 mm plastic tubes (polyvinyl chloride, diameter 8 mm) are placed in the middle of the slab. For better positioning of the tubes, steel bars projecting some 20 mm on each side are put in the tubes. After curing of the coating, the steel bars are replaced by shorter steel bars having a length of 140 mm. The holes are filled with a joint sealant. Then, the slab is subjected to conditioning. Afterwards, the slab is sawn in test pieces of 40 mm × 40 mm × 160 mm. Immediately before the crack-bridging test is carried out, the steel bar is removed and a notch with a depth of some 25 mm is sawn. For the crack bridging test, the steel bar is placed again in the test piece.

Dimensions in millimetres

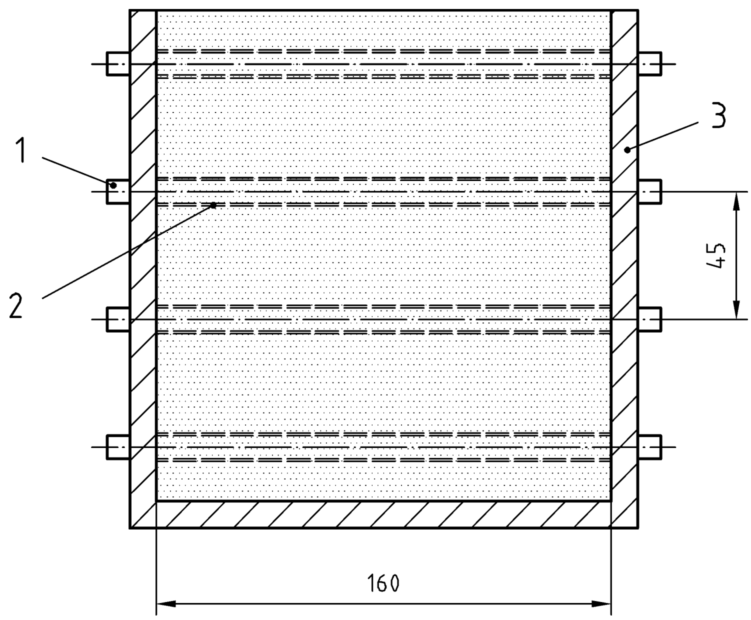


Key

1 Steel with a diameter of 8 mm
2 Coating
3 Plastic tube with an internal diameter of 8 mm, wall thickness *d* = 2 mm
4 Predetermined breaking point

Figure C.7 — Dimensions of coated prisms

Dimensions in millimetres



Key

1 Steel with a diameter of 8 mm
2 Plastic tube with an internal diameter of 8 mm, wall thickness *d* = 2 mm
3 Form board

Figure C.8 — Sketch of the basic test pieces

Weaken the side opposite to the coating by a notch of 2 mm to 3 mm width.

Coat and condition the substrates in accordance with 7.3.

NOTE Prior to testing, a cut of 15 mm to 20 mm in length reaching down to the substrate can be made above the crack zone, parallel to and at a distance of 2 mm from the edges of the cube, so that, the crack in the substrate can be observed more easily.

Break the test pieces in accordance with 7.4.

C.3.3 Procedure

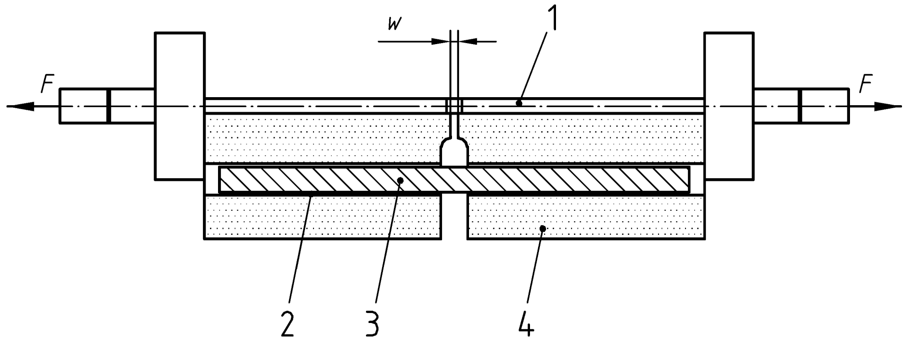
The type of stress is governed by the minimum crack-bridging class in accordance with annex B, table B.1. The dynamic test is performed in a testing machine which allows test pieces to be tempered and permits dynamic pulsating tensile loads at a frequency of up to 1 Hz.

Clamp the test piece in the fixture.

NOTE Examples for fixtures are as follows:

For test pieces of 40 mm × 40 mm × 160 mm with reinforcing steel (see figure C.7): The ends of the reinforcing steel are fixed in the clamps of the testing apparatus.

For test pieces of 40 mm × 40 mm × 160 mm without reinforcing steel (see figure C.9): On each front side, two stiff steel plates are glued, so that the axis of the steel plates is in the middle of the coating thickness.



Key

1 Polymer (EP-PUR)
2 Plastic tube
3 Steel
4 Mortar

Figure C.9 — Sketch of the test piece of 40 mm × 40 mm × 160 mm without reinforcing steel before testing

Place at least one displacement sensor on the side on which the largest crack occurs and close to the interface over the crack. The sensor should be fitted in such a way that any influence on the measurement through slight, sometimes unavoidable bending of the test piece is excluded or compensated.

Apply, at room temperature, a tensile stress to open the crack to the maximum envisaged crack width (w_o) at a rate of 0,02 mm/s. Alternate the crack width 5 times between the maximum and minimum envisaged crack widths (w_o; w_u) to ensure that the test piece holder is firmly seated and that the crack opening widths on the two sides are as identical as possible. Then reduce the crack to the lowest possible value, taking care to ensure that a slight force is still exerted. Condition the test piece at the test temperature for at least 2 h. During conditioning, w_o should not be exceeded.

Carry out the dynamic test under displacement control, using a crack width function assigned to the crack-bridging class required in each case. The largest crack width occurring at the prisms is decisive.

During the test, visually inspect in intervals of about 1 h the surface of the test piece for cracks. If cracks occur, stop the test and consider the test piece as having failed the test. Note the associated number of crack alternations.

At the end of the test, remove the test piece and inspect for damages in accordance with clause 9.

C.4 Dynamic tensile test 2

C.4.1 Principle

This test procedure is a further example of a dynamic crack-bridging test in a tensile experiment in accordance with clause 4, method B.

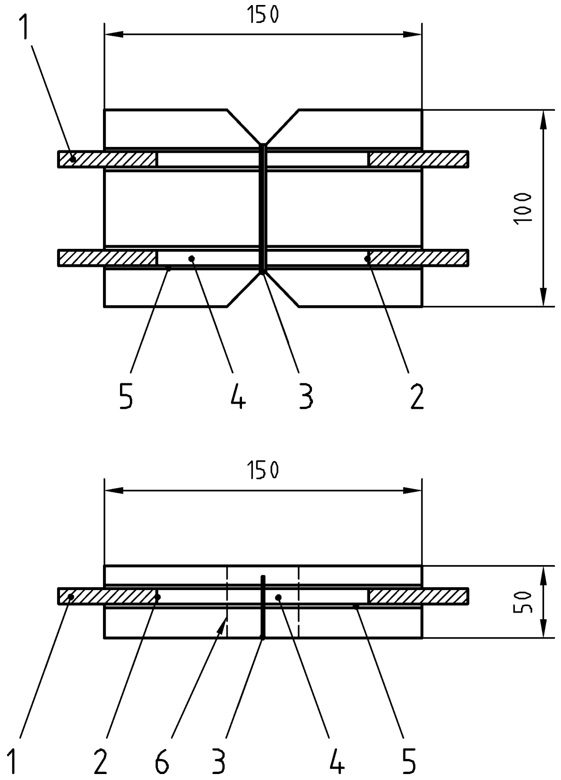
C.4.2 Test pieces

Prepare substrates with the dimensions of 150 mm × 100 mm × 50 mm in accordance with EN 1766 (see 7.1). The design of the substrates is shown in figure C.10.

NOTE The notches in the middle of the substrate (see figure C.10) act as stress raisers to ensure that the crack propagates between the notches across the substrates. The plastic insert used in the substrates also aids in propagating a straight crack between the two notches of the substrates. This reduces the load required to crack the substrates during testing. Mild-steel runners minimize the flexural movement of the substrate during testing. Steel studs are glued into the stainless steel tube and are used to fix the substrate in the testing machine.

Coat and condition the substrates in accordance with 7.3.

Dimensions in millimetres



Key

1 Studding
2 Plastic washer
3 Plastic spacer
4 Steel rod
5 Stainless steel tube
6 Outer limit of notch

Figure C.10 — Substrate for dynamic tensile test 2

C.4.3 Procedure

Fix the test piece in the testing machine by locating the two studs at either end of the test pieces into the holes in two metal brackets attached to the testing machine by locating pins. The locating pins can later be prestressed by locking nuts to eliminate backlash. Adjust the load cell output to zero force with half a test piece hanging from the cross-head which incorporates the load cell. Position the cross-head of the testing machine so that the test piece is located in the testing machine without the nuts tightened. Then apply a small compressive preload so that accurate alignment of the test piece is achieved. Locate a retaining nut finger tightly on each of the four studs. Carefully tighten the four nuts in rotation while the cross head is under computer control to maintain zero force on the test piece. Position the test piece so that the coated surface can be seen, especially if it is enclosed within a thermal cabinet, and also tighten the prestressed locating pins while zero force is maintained.

Select the appropriate control programme in accordance with annex B, table B.1. After appropriate conditioning at the test temperature, start the test.

Use a video camera, together with an image archiving system, to store an image of the test piece every 10 cycles.

At the end of the test (see annex B), remove the test piece and inspect for damage in accordance with clause 9.

NOTE Trials with movement transducers attached across the gap of a coated specimen have shown that there is no appreciable lost motion between the cross-head of the testing machine and the gap in the test piece. Measurements of displacement or amplitude were within 3 % of the desired value, and the frequency was within 5 %. No other trials to establish reproducibility for different machines and test houses have taken place.

C.5 Dynamic tensile test 3

C.5.1 Principle

This test procedure is a further example of a dynamic crack-bridging test in a tensile experiment in accordance with clause 4, method B.

C.5.2 Test pieces

Prepare substrates with the dimensions of 500 mm × 250 mm × 50 mm in accordance with EN 1766 (see 7.1).

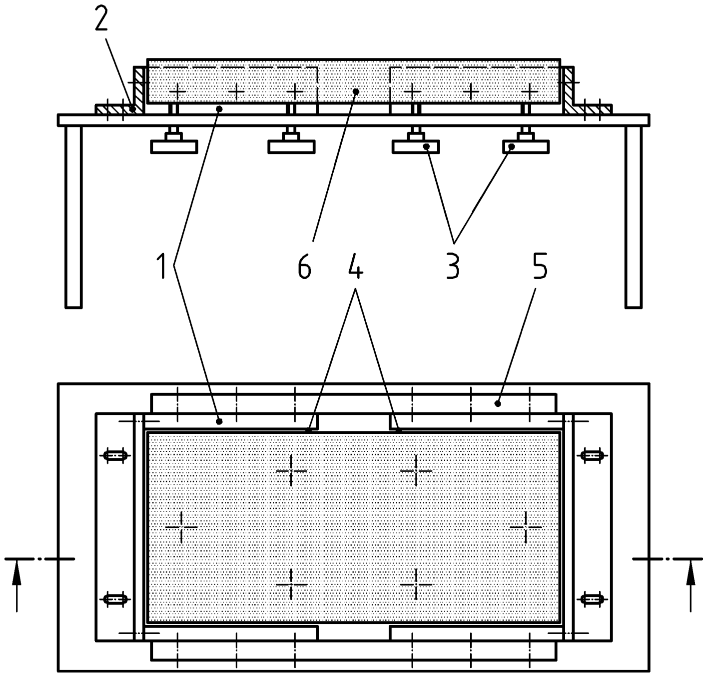
Coat and condition the substrates in accordance with 7.3.

C.5.3 Procedure

Using the special gluing jig described below, fix two steel flanges of 60 mm × 18 mm × 225 mm (see 1 in figure C.11) to each of the longitudinal faces of the concrete slab which have previously been blast-cleaned using grit abrasive and from which all dust has been removed to obtain a perfect gluing result. The gluing jig consists of a horizontal table with two adjustable guide rails on the two smaller sides (see 2 in figure C.11). During the gluing process, the test piece and the steel flanges are fixed by means of the guide rails. The lower side of the test piece is placed on the table, lifted somewhat above the table surface by means of adjusting screws, and its height is aligned. Before the steel flanges on both sides are glued to the concrete slab, they are connected with each other by means of 500 mm long connecting strips having the same cross section (see 5 in figure C.11). The lateral faces of the flanges rest on the table surface, and the flanges are about 70 mm apart to take up the transducers for crack-bridge testing. The gluing jig allows the test piece to be adjusted accurately in the test device (see figure C.12). After the adhesive has hardened, the test piece is removed from the gluing jig, and notches (width 2 to 3 mm) are made on the surface opposite to the coating in the centre of the test piece transversely to the vertical direction in order to initiate a defined crack in the notch.

The connecting flanges are removed to enable a cut to be made in the concrete slab, using a wet-cutting stone saw. The depth of the cut in the concrete is about 40 mm. Then, the connecting flanges are replaced.

Dimensions in millimetres

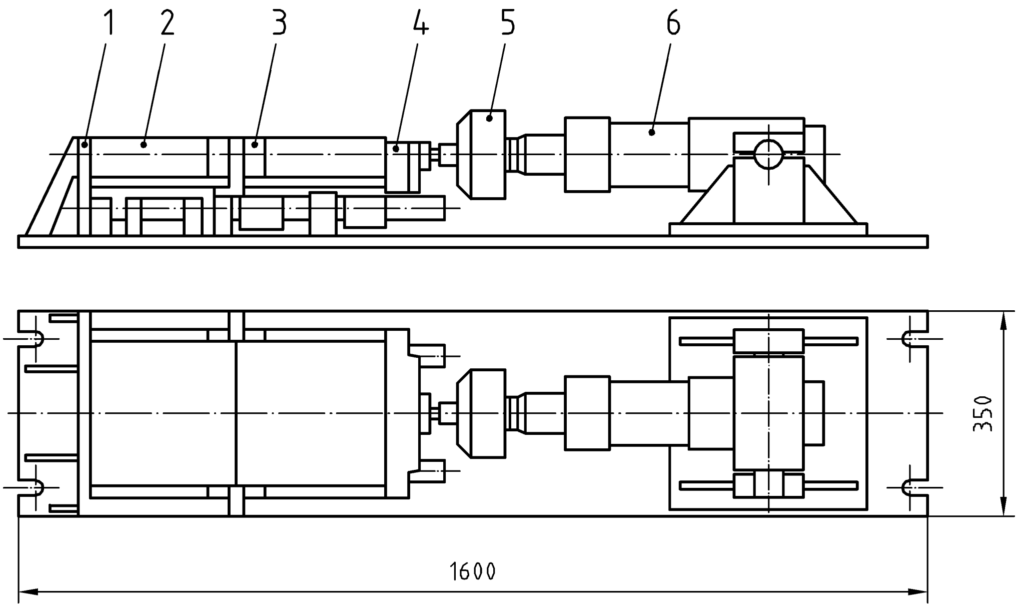


Key

1 Steel flanges
2 Guide rail
3 Adjusting screws
4 Adhesive joint
5 Connection strip
6 Concrete slap

Figure C.11 — Gluing jig

Dimensions in millimetres



Key

1 Retaining plate
2 Test piece
3 Distance recorder
4 Test frame
5 Load sensor device
6 Cylinder

Figure C.12 — Testing device

For the test, a special servo-hydraulic testing device (see figure C.12) is used. It is mounted on a plate which is fixed on the T-slotted table of the testing apparatus and consists of a horizontal test piece holder comprising two adjustable halves. The left half of the holding device (see figure C.12) is fixed to the base plate, the right half may be adjusted by means of friction bearings free from play on two shafts by a 50 kN test cylinder. A 50 kN load-sensing device is placed between the cylinder and the test piece holder.

Place the test piece with the flanges on the holding device and screw the flanges with the stop plate to the fixed part of the holding device, and the cross-head to the adjustable part. Take care that no tensile stresses be produced in the test pieces. Then remove the connecting flanges and attach transducers to both sides of the concrete slab above the cut directly below the coating.

Before applying the dynamic tensile load, generate a first crack at room temperature until the concrete breaks (either a crack may be observed with the naked eye or a sudden stress release is observed). After the stress is relieved (force = 0), alternate the crack width 5 times between the maximum and minimum envisaged crack widths. When the force is reduced to the lowest possible value (force = 0), store the test piece at the testing temperature for at least 16 hours. During this storage period, the force is re-adjusted (force = 0).

The test is displacement-controlled by means of the transducer which indicates the bigger crack width when the crack is opened. Record the stress curves and above all the stress peaks of the cycles. A drop in stress might indicate a strength reduction of the coating due to cracks.

At the end of the test (see annex B), remove the test piece and inspect for damage in accordance with clause 9.

C.6 Dynamic bending test

C.6.1 Principle

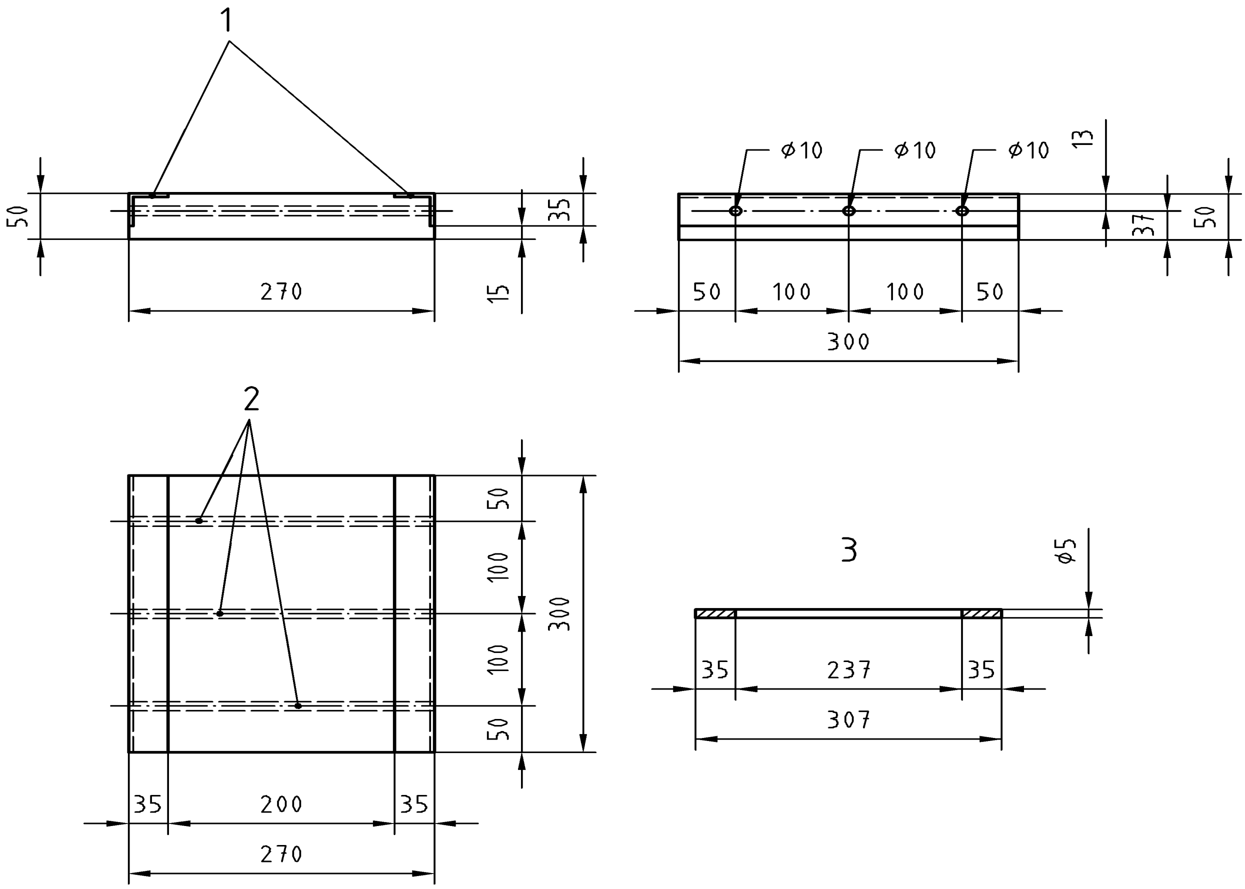
This test procedure is a further example of a dynamic crack-bridging test in a bending experiment in accordance with clause 4, method B.

C.6.2 Test pieces

Prepare concrete slabs of dimensions of 270 mm × 300 mm × 50 mm (see figure C.13) in accordance with EN 1766 (see 7.1). Reinforce the concrete slabs at the points of support for the bending stress by two L-profiles. Position the L-profiles along the longitudinal edges on the upper side of the slab. The L-profiles take up three reinforcing steels which are pre-stressed. In the middle of both ends of the slabs, parallel to the L-profiles, drill holes with a diameter of 2 mm to 3 mm and a depth of about 50 mm to generate a notch.

Coat the concrete slabs leaving 40 mm at the edges at each side uncoated and condition in accordance with 7.3.

Dimensions in millimetres



Key

1 L-profile, 35 mm 35 mm 4 mm 300 mm
2 Plastic tube with an internal diameter of 10 mm, wall thickness *d* = 1 mm, *l* = 270 mm
3 Reinforcement steel $ß_S$ = 900 N/mm²

Figure C.13 — Structure and dimensions of slabs

C.6.3 Procedure

Perform the dynamic test in a bend testing apparatus which allows test pieces to be conditioned and dynamic pulsating bending loads at a frequency of up to 1 Hz. The dynamic test is carried out under displacement control. Generate cracks by using three points of support (see figure C.14).

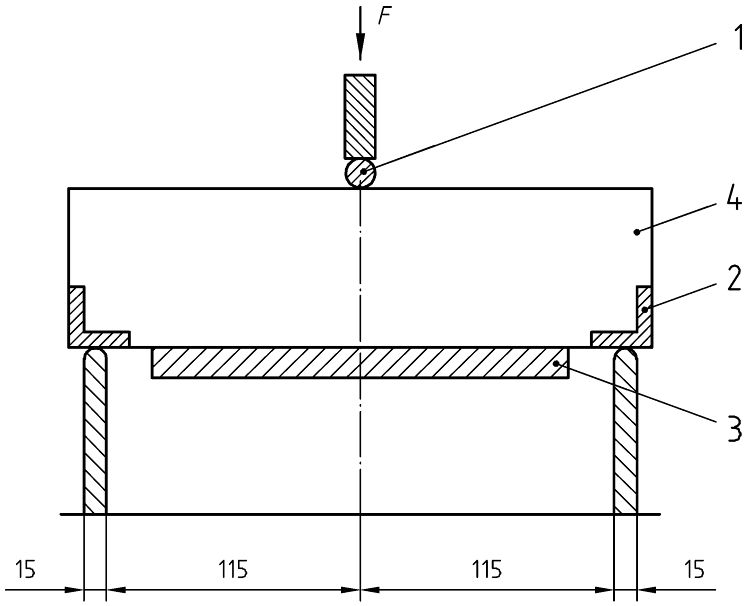
Install the test piece in the testing apparatus. with the coated side on the two points of support and the L-profiles parallel to the points of support. The distance between the points of support is 245 mm. Fix a displacement sensor to the test piece at the level of the coating, using an adhesive. Connect the displacement sensor with the control unit of the bend testing apparatus and govern the crack cycles by measuring the crack widths. Prior to testing, apply a slight bending stress until a crack in the substrate is generated (at room temperature). Then remove the load and store the test piece is for 3 h at the test temperature before starting the crack-bridging test.

During the test, visually inspect in intervals of about 1 h the surface of the test piece for cracks. If cracks occur, stop the test and consider the test piece as having failed the test. Note the associated number of crack alternations.

At the end of the test (see annex B), remove the test piece and inspect for damage in accordance with clause 9.

NOTE It is also possible to indicate the failure of the coating automatically by applying a vacuum enclosure on the test piece; a sudden rise in air pressure can be recorded. This is very interesting for tests that last more than a few hours.

Dimensions in millimetres



Key

1 Point of support with a diameter of 15 mm
2 L-profile
3 Coating
4 Test piece

Figure C.14 — Dynamic bending test

Bibliography

EN 1062-1:1996, *Paints and varnishes — Coating materials and coating systems for exterior masonry and concrete — Part 1: Classification.*

prEN 1504-2, *Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity — Part 2: Surface protection systems.*

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