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prEN 13295

Products and systems for the protection and repair of concrete structures - Test methods - Determination of resistance to carbonation

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The co-ordination of the requirements of this draft with those of any related standards is of particular importance and you are invited to point out any areas where this may be necessary.

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NATIONAL FOREWORD

This draft European Standard is one of a series being prepared by CEN/TC 104 - Concrete.

The United Kingdom has been fully involved with the CEN Technical Committee responsible for the preparation of this standard and comments on it will be considered when formulating the national response to the CEN Enquiry.

If the draft is approved at final vote and the standard published, it is obligatory for it to be implemented without deviation and national standards withdrawn and any codes of practice aligned.

The Standard would then be published as BS EN 13295

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DRAFT
prEN 13295

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

July 1998

ICS

Descriptors:

English version

Products and systems for the protection and repair of concrete structures - Test methods - Determination of resistance to carbonation

Produits et systèmes de protection et de réparation des structures en béton - Méthodes d'essai - Détermination de la résistance à la carbonatation

Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken - Prüfverfahren - Bestimmung des Karbonatisierungswiderstands

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 104.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CEN in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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0 Foreword

This European Standard is under the responsibility of the technical committee CEN/TC 104 "Concrete - Performance, production, placing and compliance" (Secretariat DIN).

It has been prepared by sub-committee 8 "Products and systems for the protection and repair of concrete structures" (Secretariat AFNOR).

This Document has been submitted to CEN enquiry and the comments obtained therefrom have been incorporated into this draft.

This European Standard is one of a series dealing with products and systems for the protection and repair of concrete structures. It describes a method for determining the resistance to carbonation of a test specimen made from a repair product or system, excluding application of a protective coating system.

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1 Scope

This European Standard specifies an accelerated laboratory method for measuring the resistance against carbon dioxide penetration through repair products and systems, as defined in EN 1504-3[1)]. The method is suitable for assessing the performance of repair grouts, mortars and concretes without a protective coating system applied.

The method does not measure the resistance to reduction in pH-value that may occur by absorption of other acidic gases (e.g. SO_2, HCl etc.).

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. Normative references are cited at the appropriate places in the text and the relevant 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 this European Standard refers to the latest edition of the publication.

EN 1504-1[1)] Products and systems for the protection and repair of concrete structures - Part 1 : General scope and definitions.

EN 1504-3[1)] Products and systems for the protection and repair of concrete structures - Part 3 : Structural and non-structural repair.

EN 1015-2[1)] Methods of test for mortar for masonry - Part 2 : Bulk sampling of mortars and preparation of test mortars

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

EN 1766[1)] Products and systems for the protection and repair of concrete structures - Test methods - Reference substrates for testing.

3 Definitions

The definitions contained in prEN 1504-1 apply, along with the following.

3.1 Carbonation

When carbon dioxide penetrates into the concrete surface, it reacts with alkaline components in the cement paste. After this reaction the pH of the concrete substrate reduces, termed carbonation.

3.2 Carbonation Depth

The carbonation depth (d_k) is the average distance, measured in mm, from the surface of the concrete or mortar where the carbon dioxide (CO_2) has reduced the alkalinity of the hydrated cement to an extent such that an indicator solution based on phenolphthalein is not coloured red.

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[1)] At present at the draft stage

4. Principle

The resistance of the repair product or system against Carbonation, is measured by an accelerated laboratory test, where samples are exposed to an atmosphere containing 1 % CO_2 at a temperature of (21 ± 2) °C and relative humidity (RH) of (60 ±10) %.

NOTE : The concentration of 1 % CO_2 in air develops the same reaction products with hydrated cement as a normal atmosphere at 0.03 % CO_2. The relative humidity of (60 ± 5) % results in the fastest rate of carbonation of HC and PCC materials.

The carbonation depth is measured by applying phenolphthalein colour indicator on a freshly broken piece of the specimen. The same specimen may be used several times to measure the increase in carbonation depth with time.

5. Equipment

5.1 Sealed cabinet for specimen exposure, with provision for gas inlets and outlets such that a uniform flow of CO_2 reaches all parts of the cabinet.

5.2 Gas supply of 1% CO_2 in air, which should be supplied in a premixed bottled form.

5.3 Humidity controller designed to maintain (60 ± 10) % RH inside the cabinet in the presence of concrete samples that react with CO_2 to liberate extra moisture.

5.4 Phenolphthalein solution comprising 1g of phenolphthalein indicator in a solution of 70 ml ethanol and 30 ml distilled / ion exchanged water (conductivity ≤ 0.5 µS/mm).

5.5 Concrete cutting tools including a hammer and chisel for breaking pieces off the specimens.

5.6 Moulds for producing specimens made from non absorbent, rigid material, not attacked by cement paste or polymers.

5.7 Mortar mixer, in accordance with EN 196-1, or **concrete mixer**, (forced action pan mixer).

5.8 Compaction tools and equipment

NOTE : The compaction method shall be in accordance with the manufacturer's instructions.

5.9 Curing and conditioning room in accordance with Annex A.

6. Preparation

The test shall be carried out on rectangular specimens of various shapes. For a grout or mortar, a prism-shaped specimen to EN 196 (40 x 40 x 160) mm shall be the minimum size used. For a concrete, the minimum size of specimen shall be (100 x 100 x 500) mm.

The test is carried out on two parallel samples of repair product or system, and compared alongside two samples of control concrete.

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6.1 Mixing and curing

Unless otherwise instructed by the manufacturer, use the following mixing technique for preparing the specimens.

For PCC and cementitious mortar, use the mortar mixer (**5.7**) set to a low speed, pouring the gauging liquid to the bowl and adding the dry ingredients, mixing for a total period of two minutes.

For concrete mixes that contain coarse aggregates (> 5 mm), preparation shall be in accordance with EN 196-1, using a concrete mixer (**5.7**), or as otherwise instructed by the manufacturer.

Where manufacturers' instructions preclude use of part bags of material, a concrete mixer (**5.7**) or other method recommended by the manufacturer shall be used.

NOTE: It has been found that certain types of repair mortar can foam excessively under the action of the mortar mixer specified in EN 196-1. An alternative is to use a concrete mixer (**5.7**).

Place the mixed material carefully into the moulds, compacting thoroughly. The specimens shall be finished flush with the sides of the mould using a steel float.

NOTE: The air content, strength and density of the HC and PCC mixes should normally be determined to characterise the mortar under test.

The specimens to be tested shall be compared against prisms of reference concrete type C (0.45), as defined in prEN 1766. No air entraining admixture shall be used in the mix. The moulds (100 x 100 x 500) mm shall be filled and compacted on a vibrating table.

All specimens shall be stripped from their moulds and then cured in accordance with the requirements of Annex A.

6.2 Dry Conditioning

The test specimens and concrete control specimens shall be brought to an even moisture content by storage in the standard laboratory climate defined in Annex A, until the weight change is less than 0,2 % in a 24-hour period.

NOTE : The necessary period of storage will be at least 14 days.

7. Procedure

After preparation and conditioning, the specimens shall be placed on knife edge supports inside the sealed cabinet and exposed to the test gas, adjusting the flow rate to provide positive pressure.

> NOTE :The gas flow rate into the chamber will depend on the size of chamber and number of specimens behaving as CO_2 absorbers. The flow rate should be checked and verified as satisfactory by periodic sampling of the gas in representative areas of the cabinets, including likely still-air positions.

The depth of carbonation (d_k) shall be measured at the end of the Dry Conditioning period and then after 56 days in the cabinet.

The depth of carbonation shall be measured on freshly broken faces from each prism. For each measurement a slice of 15 mm minimum thickness shall be broken off the prism using the chisel or bolster and the piece sprayed with the phenolphthalein indicator solution. Measurement of the depth of carbonation shall then be made (60 ± 5) min after spraying.

The carbonation depth for the specimen (d_k) is the average depth on all four faces, measured in accordance with the following procedure.

7.1 Standard measuring procedure

The result should produce a level, pink coloration in the uncarbonated concrete on each side of the specimen except for the edges, which are rounded and should be ignored for the measurement. The standard result is termed shape A as shown in Figure 1a. The normal length (l) of level surface shall be not less than 30 mm.

> NOTE :Greater depths of carbonation occur in the corner areas of specimens, where carbon dioxide can penetrate from two sides at once. This effect should be omitted from the calculation.

For each surface in turn, the length of level surface (l) shall be divided into five equal points. With the help of a ruler or sliding gauge the carbonation depth shall be measured at each point, determined perpendicular to the surface, to the nearest 0.1 mm. The average carbonation depth (e.g. d_{k1}) on that side of the specimen shall be calculated from the five individual values, rounded to the nearest 0.5 mm. The measurement shall then be repeated for the three remaining sides, with the average of these four calculated values giving the carbonation depth (d_k) for the specimen.

The measurements shall then be repeated for the duplicate specimen. The carbonation depth on duplicate specimens should not differ by more than 20%. If the difference is > 20%, both values should be reported. If the difference is < 20%, reporting the average value is sufficient.

If the edges of the uncarbonated square are rounded, such that the length of the level portion on one or more sides (l) is less than 30 mm, then a shorter length may be used, to a minimum of 20 mm. The reduced length shall be divided into three equal parts, calculating the average carbonation depth (e.g. d_{k1}) from the three measurements (Figure 1b) and then the average for all four sides (d_k).

If l_{min} < 20 mm, the test shall be halted and a larger prismatic specimen used for the measurement.

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If the carbonation front does not run as a straight line parallel to the surface, as shown in Figure 1, but is of uneven depth, the depth of carbonation shall be determined in the following manner.

7.1.1 Wave front, shown as shape B in Figure 2a: in this case the graphical average (d_{k1}) and maximum value between the rounded edges of each side shall be recorded.

7.1.2 Isolated deep carbonation, shown as shape C in Figure 2b: in this case the average depth (d_{k1}) shall be determined in accordance with the standard procedure, recording also the maximum depth of carbonation. If the difference between the results for any one side (e.g. d_{k1} and $d_{k1,max}$) is greater than 4 mm, as shown in Figure 2b, then the maximum depth shall be recorded and also the average for that side (d_{k1}). The average result shall not be calculated for the specimen.

7.2 Effect of dense aggregates

Dense aggregate that is lying within the carbonation front will not be coloured by the phenolphthalein solution and the carbonation front will be interrupted (Figure 3a). Where such aggregate coincides with a measuring point, the carbonation front shall be drawn through the aggregate, connecting the limits on each side of the grain.

7.3 Effect of voids / porous aggregates / extreme values of d_{max}

When there are voids in the concrete or pieces of porous aggregate in the carbonation front, high values of carbonation depth may occur (Figure 3b). When the values of d_{max} are less than 4 mm for concrete or 1.5 mm for mortar, they can be ignored. With higher values of d_{max}, an estimate of the maximum depth of carbonation shall be given.

8. Precision and reproducibility

The precision of the carbonation measurements, expressed as a standard deviation is sd = 0.5 mm.

The reproducibility (i.e. the variation between laboratories using the same materials), expressed as standard deviation, depends on the depth of carbonation depth and can be calculated from the following formula:

$$sd = 0.21 d_k + 0.64$$

where d_k is the average carbonation depth.

9. Test results and test reports

The average depth of carbonation shall be reported for each side of the specimen noting the position relative to the trowelled surface. The average depth of carbonation for the specimen is the mean value of all four sides.

The results shall be expressed in tabular form, including specimen dimensions, carbonation depth, exposure time. The results may also include a photograph of the phenolphthalein-sprayed fracture surface.

The test report shall include the following information:

a) a reference to this European Standard;

b) name and address of the testing laboratory;

c) identification number of the test report;

d) name and address of the organization or the person who ordered the test;

e) name and address of the manufacturer or supplier of the product;

f) name or other identification marks on the product;

g) date of supply of the product;

h) date of manufacture of the test specimens, the maximum aggregate size and the dimensions of the specimen;

I) date of test;

j) curing and conditioning data for the test specimens, (duration, temperature, RH);

k) environmental conditions during the test (temperature, RH, CO_2 concentration);

l) identification of the test equipment and instruments used;

m) average depth of carbonation on each side (d_k) to the nearest 0.5 mm with details of the position of the face relative to the trowelled face;

n) the shape of the carbonation front i.e. shape A (normal), B or C;

o) other irregularities in the shape of the carbonation front from the normal shape A, i.e. as shown in Figures 2 & 3;

p) mean value of all four sides for each specimen (where appropriate);

q) results for the control concrete;

r) inaccuracy or uncertainty of the test results;

s) date and signature.

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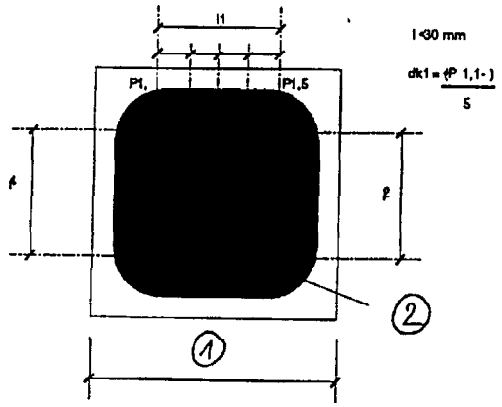
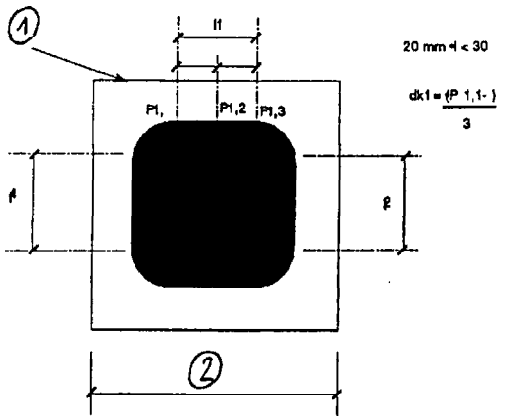


1 Prism side dimension
2 Area stained pink by phenolphtalein indicator solution

Figure 1a. Standard test with five measurements per side.



1 Trowelled face
2 Prism side dimension

Figure 1b. Large corner effect with only three measurements per side.

Figure 1 - Standard carbonation, Shape A

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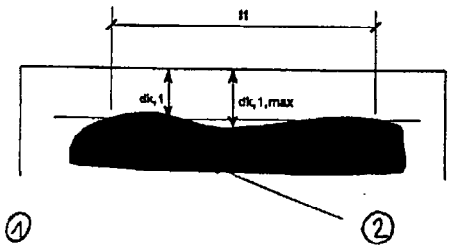

Bild 2a): Form B mit unregelmäßigem Karbonatisierungsprofil

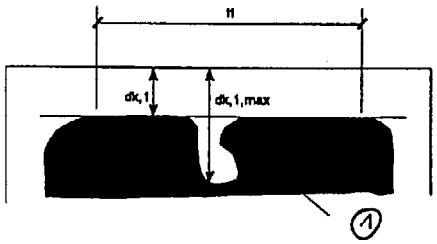

Bild 2b): Form C mit stellenweisen tiefen Karbonatisierungen

Figure 2 - Abnormal profiles for the carbonation front

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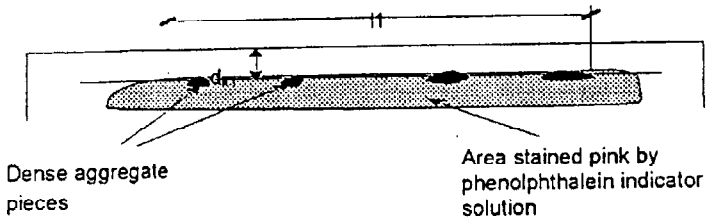

Figure 3a. Interference from large, dense aggregate pieces

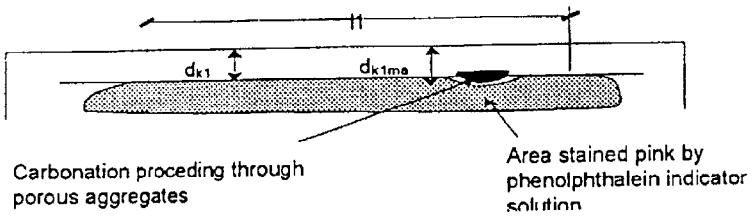

Figure 3b. Influence of porous aggregate pieces

Figure 3 - Influence of aggregate

Annex A

Summary of temperatures and humidities for the Curing, Conditioning and Testing of Repair Products and Systems.

A.1 Curing

A.1.1 HC (grouts, mortars and concretes)

- Prepare as EN 196, cover in film for 24 h.
- Demould after 24 h.
- Cure under water at (21 ± 2) °C for 27 days.

A.1.2 PCC (grouts, mortars and concretes)

- Prepare as EN 196, cover in film for 24 h.
- Demould after 24 h and wrap in film for 48 h.
- Unwrap and cure for 25 days in a standard laboratory climate of (21 ± 2) °C and (60 ± 10) % RH.

A.2 Standard laboratory climate

- (21 ± 2) °C and (60 ± 10) % RH.

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