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Products and systems for the protection and repair of concrete structures - Test methods - Determination of carbonation depth in hardened concrete by the phenolphthalein method

This draft European Standard is for submission to Formal Vote.

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

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European Committee for Standardization
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Europäisches Komitee für Normung

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 104 "Concrete and related products, the Secretariat of which is held by DIN).

This draft is presented to TC104 SC8 for approval for submission to Formal Vote.

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

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 depth of carbonation of concrete.

Introduction
Steel reinforcement in concrete may be at risk of corrosion because the cover is carbonated.

ENV 1504-9 defines the principles for protection and repair of concrete structures which have suffered or may suffer damage or deterioration and gives guidance on the selection of products and systems which are appropriate for this intended use.

To establish whether there is a sufficient depth of uncarbonated concrete to protect the reinforcement for the remainder of the design life of the structure, the total depth of cover and the depth of carbonation must be determined. The total depth of cover can be determined by physical measurement or by the use of a cover meter. The depth of carbonation determined as defined in this standard is the most widely used method of measuring carbonation depth. It is measured by using the indicator phenolphthalein. Above a pH value of approximately 9 the indicator gives the concrete a red-purple colour. Only concrete which is coloured is sufficiently alkaline to provide passivity for steel.

1. Scope

The phenolphthalein test method is intended to measure the depth of the carbonated layer near the surface of hardened concrete. It is not suitable for concrete made with high-alumina cement. It may be used on site or in the laboratory, on test specimens or on cores or fragments removed from hardened concrete structures.

2. Normative references

This Standard incorporates, by dated or undated reference, provisions from other publications or documents in preparation. 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 Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

ENV 1504-9: Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control, evaluation of conformity - Part 9: General principles for the use of products and systems.

3. Materials and apparatus

A solution of phenolphthalein indicator. normally 1g phenolphthalein is dissolved in 70ml ethyl alcohol and diluted to 100ml with distilled or deionised water.

A labelled container fitted with a nozzle to give a fine spray of indicator solution.

NOTE: Other suitable alcohols such as isopropyl alcohol may also be used to prepare the indicator solution.

A measuring device to measure the distance from the surface of the concrete to the carbonation front, such as a calliper or ruler, capable of measuring to the nearest mm.

4. Test procedure

4.1 Sampling

Samples shall be in accordance with a sampling plan prepared for the assessment or repair works according to ENV 1504-9.

In situ testing may be carried out by chiselling from the structure under investigation to reveal an adequate area of freshly broken concrete. The test is normally carried out in situ.

NOTE: This may be done by drilling a series of holes into the concrete to allow a fresh surface to be broken between them.

Alternatively, large fragments or core samples may be removed from the structure. Where cores are obtained by wet cutting or where the maximum nominal aggregate size exceeds 16mm, the minimum nominal diameter of cores shall be 50mm.

Any surface water shall be removed from cores and fragments as quickly as possible. They shall be marked to indicate their location and orientation with respect to the original concrete surface, and shall then be stored in a dry place until tested, which should be as soon as possible after sampling.

Cut or drilled surfaces shall not be used as they often give misleading results because they can expose and reactivate unhydrated cement particles in otherwise fully carbonated concrete.

4.2 Determination of Carbonation Depth

Cores shall be split along their longitudinal axis and as nearly as possible across the diameter of the core. Large fragments (normally those with a smallest dimension of approximately 50 mm) shall be split as nearly as possible perpendicularly to the original external concrete surface; smaller fragments should not be split further but tested immediately after they are removed from the structure.

The freshly broken surfaces shall be cleared of any dust and loose particles without the use of water or abrasion and shall be sprayed with just enough phenolphthalein indicator solution to wet the surface without running down the surface. The test shall be completed as soon as possible after splitting the concrete face.

NOTE 1: The instantaneous colour change to red-purple must be measured and recorded within 30 seconds of spraying. If the colour changes slowly and/or the boundary is diffuse the method will not give accurate enough results in all cases and may indicate partial carbonation zones. In this case an alternative method of test such as petrographic examination may be adopted to confirm site test results.

NOTE 2: In the case of very dry concrete a light mist of water may be applied to the broken surface immediately prior to the application of phenolphthalein solution.

NOTE 3: Care must be taken when this test method is used on concrete containing or treated with hydrophobic materials, eg. silanes, siloxanes, polymeric additives or water resisting admixtures. These may inhibit development of the characteristic purple colour even in uncarbonated concrete. Under

these conditions there may be a delay of several minutes before the colour develops, and the colour may appear to be patchy when compared with untreated or unmodified CEM I concretes. It is not necessary to analyse the concrete prior to testing, but abnormal results may indicate that the concrete contains or has been treated with these materials.

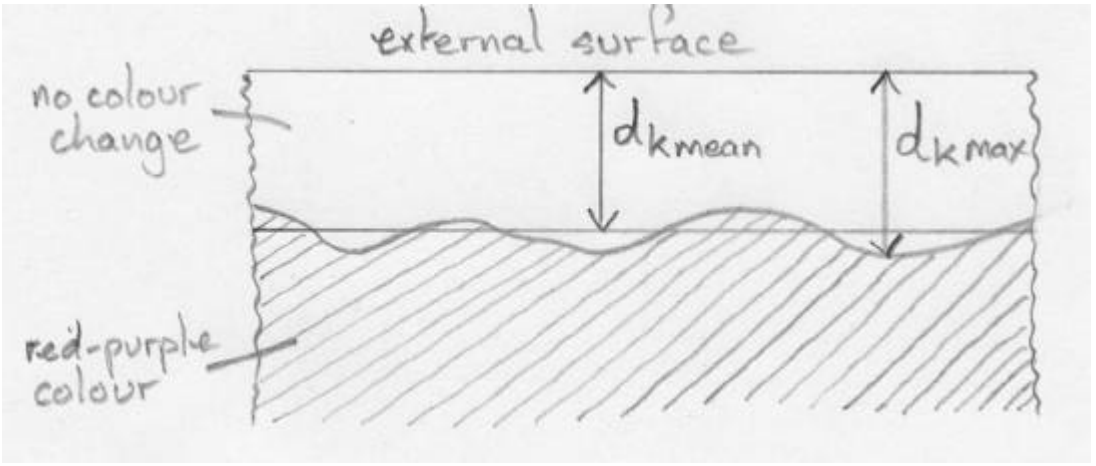
NOTE 5: The method cannot distinguish between loss of alkalinity caused by carbonation or by other causes such as exposure to acids or other acidic gases. Where other causes may be present, their effects may be determined by laboratory analysis.

4.3 Measurement of Carbonation Depth

The carbonation depth at any given point is the distance d_k (measured in mm) from the external surface of the concrete to the edge of the red-purple coloured region.

As in practice the carbonation front is irregular, both the average $d_{k\,mean}$ and maximum depth $d_{k\,max}$ shall be measured to the nearest mm (Figure 1).

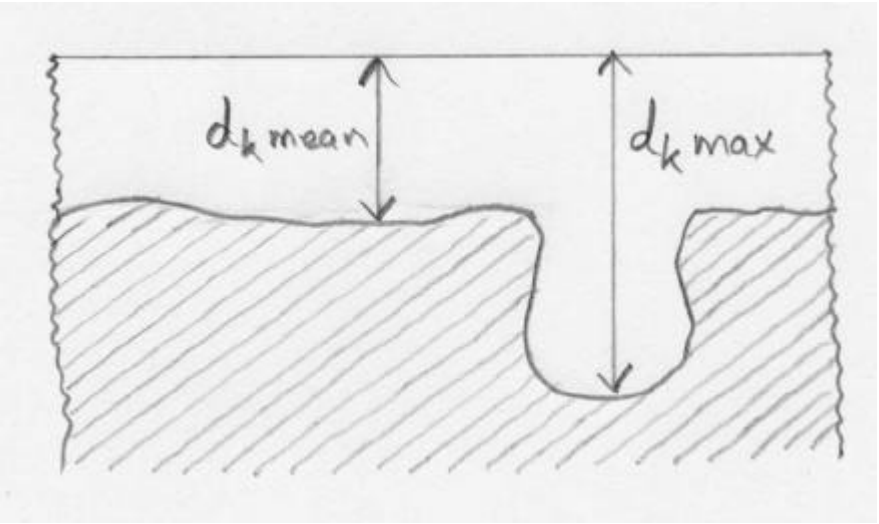
Figure 1: Carbonation front



Drafting note: need 2 arrows – dk mean and dk max.

If there are isolated pockets, for example at cracks, where the maximum depth $d_{k\,max}$ is significantly greater than the mean $d_{k\,mean}$ (figure 2) then the value $d_{k\,max}$ shall not be included in the calculation of $d_{k\,mean}$. The adjusted mean value $d_{k\,mean}$ and the maximum depth or depths $d_{k\,max\,(1...n)}$ shall be recorded to the nearest mm, preferably on a drawing or photograph.

Figure 2: Isolated pockets of deeper carbonation



Drafting note: need to change dk to dk mean and make the front wavy

5 Test Report

The test report shall include the following information:

a) date and time of test;
b) name of the person who carried out the test;
c) general weather conditions during in situ testing;
d) identification number and location of each sample and its exposure; eg. sheltered from or exposed to rain, internal or external;
e) size and type of specimen used (ie. in situ, core or fragment);
f) the composition of the indicator solution used;
g) carbonation depth values as defined above;
h) a record of the carbonation profile where one is required by this standard eg. as in Figure 2;
j) a reference to this European Standard

Other relevant observations made at the time of obtaining samples may be included in the test report.

The test report should record any slow development of coloration or creep back towards the surface that occurred after the original result was recorded within say 30s of spraying: eg carbonation was 15 mm crept back to 10 mm. Carbonation was 50 mm, boundary was diffuse.

Any available information on the mix design and age of the concrete shall be reported. The presence of any polymeric admixtures or additions or of hydrophobic treatments shall be reported where known.

The information shall be recorded in such a manner that it can be located and referred to at all times during the assessment or repair works. Sample locations shall be recorded on drawings of the construction works in a manner which allows the report of the relevant carbonation test to be identified.