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Preskušanje strjenega betona - 12. del: Določanje odpornosti proti karbonizaciji betona - Metoda pospešene karbonizacije

Testing hardened concrete - Part 12: Determination of the carbonation resistance of concrete - Accelerated carbonation method

Prüfung von Festbeton - Teil 12: Bestimmung des Karbonatisierungswiderstandes von Beton - Beschleunigtes Karbonatisierungsverfahren

Essais pour béton durci - Partie 12 : Détermination de la résistance à la carbonatation du béton - Méthode de la carbonatation accélérée

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Testing hardened concrete - Part 12: Determination of the carbonation resistance of concrete - Accelerated carbonation method

Essais pour béton durci - Partie 12 : Détermination de la résistance à la carbonatation du béton - Méthode de la carbonatation accélérée

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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European foreword

This document (prEN 12390-12:2018) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

The series EN 12390, *Testing hardened concrete*, includes the following parts:

- *Part 1: Shape, dimensions and other requirements for specimens and moulds*
- *Part 2: Making and curing specimens for strength tests*
- *Part 3: Compressive strength of test specimens*
- *Part 4: Compressive strength – Specification for testing machines*
- *Part 5: Flexural strength of test specimens*
- *Part 6: Tensile splitting strength of test specimens*
- *Part 7: Density of hardened concrete*
- *Part 8: Depth of penetration of water under pressure*
- *Part 9: Freeze-thaw resistance with de-icing salts - Scaling (Technical Specification)*
- *Part 10: Determination of the carbonation resistance of concrete at atmospheric levels of carbon dioxide*
- *Part 11: Determination of the chloride resistance of concrete, unidirectional diffusion*
- *Part 13: Determination of the secant modulus of elasticity in compression*
- *Part 14: Semi-adiabatic method for the determination of heat released by concrete during its hardening process*
- *Part 15: Adiabatic method for the determination of heat released by concrete during its hardening process*
- *Part xx: Determination of the chloride migration coefficient¹⁾*
- *Part uu: Determination of resistivity¹⁾*
- *Part zz: Determination of the carbonation rate of concrete under test conditions that accelerate carbonation¹⁾*

¹⁾ under development

prEN 12390-12:2018 (E)**Introduction**

It is essential that ferrous steel reinforced concrete structures are durable to ensure that the intended working life is achieved. The resistance to corrosion of reinforcement induced by carbonation plays a significant role in a structure's serviceability and consequently carbonation resistance of concrete is an important property to measure. This European Standard sets out an accelerated test method that may be applied to cast test specimens to assess the carbonation resistance of a concrete mix.

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<https://standards.iteh.ai/catalog/standards/sist/da305181-51c1-4f10-88e2-20424af56a72/sist-en-12390-12-2020>

1 Scope

This procedure is a method for evaluating the carbonation resistance of concrete using test conditions that accelerate the rate of carbonation. After a period of preconditioning, the test is carried out under controlled exposure conditions using an increased level of carbon dioxide.

NOTE The test under reference conditions takes a minimum of 112 days comprising a minimum age of the specimen prior to conditioning of 28 days, a minimum conditioning period of 14 days and an exposure to increased carbon dioxide levels of 70 days.

This procedure is not a method for the determination of carbonation depths in existing concrete structures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12350-2, *Testing fresh concrete — Part 2: Slump-test*

EN 12350-3, *Testing fresh concrete — Part 3: Vebe test*

EN 12350-4, *Testing fresh concrete — Part 4: Degree of compactability*

EN 12350-5, *Testing fresh concrete — Part 5: Flow table test*

EN 12390-2, *Testing hardened concrete — Part 2: Making and curing specimens for strength tests*

3 Terms and definitions

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

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

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

carbonation rate

average rate at which the carbonation front penetrates concrete expressed as $\text{mm}/\sqrt{(\text{exposure time})}$

Note 1 to entry: The carbonation rate will vary depending upon the test conditions or exposure conditions and therefore any carbonation rate has to be qualified by the conditions under which it was obtained. The abbreviation ' K_{AC} ' is the carbonation rate under the test conditions specified in this standard.

3.2

depth of carbonation

depth as measured using a phenolphthalein solution or equivalent sprayed on the freshly-split concrete surface

3.3

effective time

time in days spent in the storage chamber

prEN 12390-12:2018 (E)**3.4****mean carbonation depth**

mean depth of carbonation of two specimens, d_k

3.5**single point carbonation depth**

depth of carbonation recorded for a single point on a specimen, $d_{k, \text{point}}$

Note 1 to entry: This is the measured depth of carbonation except where the measurement point coincides with a dense particle, porous particle or void, see 8.3 and 8.4.

3.6**specimen carbonation depth**

mean depth of carbonation of a single specimen, $d_{k, \text{spec}}$

3.7**specimen face carbonation depth**

mean depth of carbonation of a single exposed face of a single specimen, $d_{k, \text{face}}$

4 Principle

Two prisms or eight concrete cubes are cast and cured for 28 days in accordance with EN 12390-2. The test specimens are then conditioned in a laboratory air environment for 14 days and then placed in a storage chamber with a carbon dioxide concentration within the storage chamber in percent by volume of $3.00 \pm 0,10$ % when the storage chamber is at sea level²⁾, temperature (20 ± 2) °C and relative humidity (57 ± 3) % for periods of up to 70 days. After 0, 7, 28 and 70 days of storage in the chamber (this gives approximately equidistant values of $\sqrt{\text{days}}$), two of the cubes are split in half or a 50 mm slice is split from each of the prisms and the depths of carbonation measured.

On each slice of prism or on one half of each cube, twelve single point carbonation depths ($d_{k, \text{point}}$) are measured after each exposure period and the depth of carbonation d_k at that exposure time is expressed as the mean of the two test specimens. Using measurements taken at the fixed times, the carbonation rate expressed as $\text{mm}/\sqrt{\text{days}}$ is determined.

5 Reagents and apparatus

A solution of 1 g of phenolphthalein powder³⁾ dissolved in a solution of 70ml ethanol and 30 ml of deionised water or an alternative indicator giving a colour change in the range pH 8 to 11 that gives a sufficiently clear colour change in concrete to differentiate the neutralised zone, e.g. thymolphthalein⁴⁾.

Where used, a fixing solution to permanently fix the colour change in the concrete specimen, see 7.1.

NOTE 1 Suppliers of some indicator solutions also provide a fixing solution that permanently fixes the colour change.

2) CO₂ concentration can vary with altitude above the sea level

3) WARNING — Phenolphthalein is listed in REACH appendix 2 and its lists of substances of very high concern. Phenolphthalein powder should be handled with the greatest care using safety gloves in a fume cupboard fitted with an extractor.

4) Thymolphthalein is not currently classified under REACH as a health or environmental hazard.

A magnifier and a gauge to measure the depth of carbonation perpendicular to the exposed concrete surface with a precision of 0,5 mm.

A storage chamber with a carbon dioxide concentration within the storage chamber in percent by volume as indicated in Clause 4, temperature at (20 ± 2) °C and a relative humidity at (57 ± 3) % , see Annex A (informative) for details of a suitable chamber. The relative carbon dioxide concentration shall be within $\pm 0,1$ % by volume of the target value with no variation for longer than 4 h outside the target value $\pm 0,50$ %.

NOTE 2 Experience [1] has shown that if saturated surface-dry specimens are placed in the storage chamber shortly after removal from water curing, the relative humidity may exceed that permitted. Also, without active control of the carbon dioxide, the levels may drop below the permitted tolerance as the carbonation process continues. Therefore it is essential for this test method that the storage chamber has active control on carbon dioxide, relative humidity and temperature.

NOTE 3 Relative humidity levels may be maintained using methods at the discretion of the laboratory for example active humidification/dehumidification or saturated salt solutions.

NOTE 4 When the door of the storage chamber is opened, the carbon dioxide concentration within the chamber may fall rapidly and therefore for practical reasons a short period of low carbon dioxide concentration is permitted.

Apparatus for recording the relative humidity with a precision of at least $\pm 1,0$ % and the temperature with a precision of at least $\pm 0,5$ °C.

Apparatus for recording CO₂ concentration with a precision of at least $\pm 0,1$ % by volume.

NOTE 5 It is advised that recording apparatus be fitted with an audio/visual alarm to alert breaches of CO₂ concentration within the storage chamber due to possible apparatus malfunction.

Fans to facilitate steady circulation of air within the storage chamber.

6 Production of specimens

6.1 General

Representative samples of the constituents, e.g. cement, aggregates, shall be used for making the test specimens. Either a sample of concrete is taken from the concrete production plant or the concrete mixes shall be produced using the laboratory's standard procedures. The specimens for one test shall be cast from a single batch of concrete.

NOTE A minimum batch volume of 50 litres is recommended.

Where the specimens are prepared by the client or their representative, the test laboratory shall be informed of the day of casting and a confirmation that the specimens were stored as required by this European Standard.

Each test shall comprise at least two prismatic beams each being at least 280 mm long and the other dimensions at least three times the maximum aggregate size or two cubes per test age with a side length of at least three times the maximum aggregate size. Beams are the reference specimens.

Avoid or minimise the use of mould release agents on the moulds as they may influence the carbonation depth.

6.2 Making prisms/cubes and making and testing prisms and cubes

Measure the consistence class or target value using EN 12350-2, EN 12350-3, EN 12350-4 or EN 12350-5 as appropriate and record the value. If a self-compacting concrete is specified, measure and record the

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specified properties of the fresh concrete using the appropriate test methods. For each mix, cast two prisms or eight cubes from a single batch of concrete. Cast the prisms horizontally in accordance with EN 12390-2. After finishing the prisms/cubes, cover the exposed surface with polythene or similar impermeable sheeting to prevent drying. After (20 ± 4) h, the moulds shall be stripped and the prisms/cubes transferred without delay into a water filled bath with temperature control (20 ± 2) °C in accordance with EN 12390-2.

NOTE It is advised that in addition to the test specimens for measuring carbonation resistance at least two compressive strength specimens are made and tested in accordance with EN 12390-10 [2] at 28-days. Where a number of mixes are made, it is advised to undertake additional testing, e.g. the 28 day strength, to confirm consistent manufacture, or identify anomalous batches where mixes may need to be repeated.

After removal from the curing tank the specimens shall be immediately wrapped and sealed in polythene or similar material that will prevent drying during transportation. Alternatively they should be transported whilst remaining fully immersed in water e.g. in a mobile curing tank. On arrival at the test laboratory, the test specimens shall be unwrapped, checked for damage and then stored in a water filled curing tank with temperature control (20 ± 2) °C in accordance with EN 12390-2 until they are 28 days old.

At an age of 28 days, the prisms/cubes shall be removed from the water bath and transferred to a laboratory air drying environment (18 °C to 25 °C, 50 – 65 % relative humidity) for 14 days.

After 14 days of exposure to laboratory air⁵⁾, the test specimens shall be placed in the carbonation storage chamber (see Annex A for an example of a suitable chamber). The prisms/cubes shall be positioned in a way that permits air to circulate freely around the faces where carbonation measurements are to be taken.

7 Carbonation depth measurements

7.1 Exposure period and generation of colour change

The carbonation depth of slices from the prisms or two of the cubes shall be measured after the following reference exposure periods: 7, 28 and 70 days⁶⁾.

NOTE 1 With normal concrete, the carbonation depth at 70 days is expected to be ≥ 4 mm. A value lower than this indicates a concrete with high carbonation resistance, but the precision estimates given in Clause 10 are not applicable carbonation rates based on very low carbonation depths.

A slice approximately 50 mm thick shall be broken off the prism after each exposure period and the rest of the prism returned to the storage chamber. The cubes shall be split in half parallel to the trowelled face. The depths of carbonation on the freshly broken surface of the split slice of the prism or one half of the cube shall be measured.

NOTE 2 Slicing by saw is not suitable.

⁵⁾ It is recognised that concretes will dry at different rates depending on their mix-design, however experimental results and precision data (see e.g. [3]) indicate that the 14-day conditioning period is sufficient in the general case.

⁶⁾ Optional measurement at $t = 0$ (just before placing the specimens in the storage chamber) can be made, in particular in case of slow or very slow hardening concretes (see 7.2 of EN 206:2013+A1:2016).