SLOVENSKI STANDARD
SIST EN 12390-12:2020

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Preskušanje strjenega betona - 12. del: Določanje odpornosti proti karbonatizaciji betona - Metoda pospešene karbonatizacije

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
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European foreword

This document (EN 12390-12:2020) has been prepared by Technical Committee CEN/TC 104 “Concrete and related products”, the secretariat of which is held by SN.

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of an identical text or by endorsement, at the latest by July 2020, and conflicting national standards shall be withdrawn at the latest by July 2020.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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 16: Determination of the shrinkage of concrete*
- *Part 17: Determination of creep of concrete in compression*
- *Part 18: Determination of the chloride migration coefficient (in preparation)*

- *Part uu: Determination of resistivity*[1]
- *Part zz: Determination of the carbonation rate of concrete under test conditions that accelerate carbonation*[1].

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

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[1] Under development.

Introduction

Reinforced concrete structures need to be 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 behaviour of concrete is an important property to measure. This document specifies an accelerated test method that could be applied to cast test specimens to assess the carbonation behaviour of a concrete mix.

1 Scope

This document quantifies 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 performed under reference conditions takes a minimum of 112 days comprising a minimum age of the specimen prior to curing under water of 28 days, a minimum preconditioning period of 14 days and an exposure period 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 mm/√(days)

Note 1 to entry: The carbonation rate will vary depending upon the test curing, preconditioning 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 document.

3.2
depth of carbonation
depth as measured using a phenolphthalein solution or an alternative indicator that results in a colour change in the range of pH 8 to pH 11 on the freshly-split concrete surface

3.3
effective time
time in days spent in the storage chamber with the concrete specimens continually exposed to carbon dioxide

3.4
mean carbonation depth

d_k

mean depth of carbonation of two specimens

3.5
single point carbonation depth

$d_\mathrm{k,\ point}$

depth of carbonation recorded for a single point on a specimen

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

$d_\mathrm{k,\ spec}$

mean depth of carbonation of a single specimen

3.7
specimen face carbonation depth

$d_\mathrm{k,\ face}$

mean depth of carbonation of a single exposed face of a single specimen

4 Principle

2 concrete prisms, 8 concrete cubes or 5 concrete cylinders are cast and thereupon 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 (3,0 ± 0,5) % when the storage chamber is at normal conditions (1 013 mbar at 25°C) [2], temperature (20 ± 2) °C and relative humidity (57 ± 3) % for periods of up to 70 days. Immediately prior to placing specimens in the storage chamber and after prescribed ages corresponding to 7, 28 and 70 days of storage in the chamber (this gives approximately equidistant values of √days), 2 of the cubes are split in half; 1 cylinder is split in half along its vertical axis and a 50 mm slice is split from each of the prisms and the depths of carbonation measured.

On one half of each cylinder or each slice of prism or on one half of each cube, twelve single point carbonation depths ($d_\mathrm{k,point}$) 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 mm/√days is determined.

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[2] CO_2 concentration can vary with with altitude above the sea level.

5 Reagents and apparatus

A solution of 0,8 g of phenolphthalein powder dissolved in a solution of 70 ml ethanol and 30 ml of deionised water or a suitable 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 neutralized zone, e.g. thymolphthalein[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.

Where needed, a fixing solution to permanently fix the colour change in the concrete specimen, see Clause 7.

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

A magnifier and a gauge 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 carbon dioxide concentration shall be within ± 0,5 % by volume of the target value with no variation for longer than 4 h outside the target value ± 1,0 %.

NOTE 2 Experience [5] has shown that if saturated surface-dry specimens are placed in the storage chamber shortly after removal from water curing, the relative humidity can exceed that permitted. Also, without active control of the carbon dioxide concentration, the levels can drop below the permitted tolerance as the carbonation process continues. Therefore, it is important that the storage chamber has active control on carbon dioxide concentration, relative humidity and temperature.

NOTE 3 Relative humidity levels can be maintained using methods at the discretion of the laboratory, for example active humidification/dehumidification.

NOTE 4 When the door of the storage chamber is opened, the carbon dioxide concentration within the chamber can fall rapidly, and therefore, for practical reasons, a short period of low carbon dioxide concentration is acceptable. The cumulative periods of times of low carbon dioxide concentration cannot exceed 4 % of the storage time of 63 days. The relative carbon dioxide concentration is expected to be within ± 0,1 % by volume of the target value during 96 % of the storage time in the carbonation chamber

Apparatus for recording the relative humidity with a maximum permissible measurement error of ± 3,0 % and the temperature with a maximum permissible measurement error of ± 0,5 °C.

Apparatus for recording CO_2 concentration with a maximum permissible measurement error of ± 0,1 % by volume.

NOTE 5 The recording apparatus can be fitted with an audio/visual/email or other suitable alarm to alert breaches of CO_2 concentration within the storage chamber due to possible apparatus malfunction.

The accuracy of the sensors shall be higher than the requirements for the CO_2 and humidity content measurements. The CO_2 and humidity sensors shall be controlled and calibrated regularly

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

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[3] Thymolphthalein is not currently classified under REACH as a health or environmental hazard.

6 Production of concrete 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 1 test shall be cast from a single batch of concrete.

NOTE A minimum batch volume of 50 l is sufficient.

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 document.

Each test shall comprise at least 2 prismatic beams each being at least 280 mm long and the designated size *d*, according to EN 12390-1, shall be at least 3 times the maximum aggregate size or 2 cubes per test age with a side length of at least 3 times the maximum aggregate size. Prismatic beams with designated size *d* of 100 mm are the reference specimens.

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

6.2 Making and testing concrete specimens

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 specified properties of the fresh concrete using the appropriate test methods. For each mix, cast 2 prisms or 8 cubes or 5 concrete cylinders from a single batch of concrete. Cast the prisms horizontally in accordance with EN 12390-2. After finishing the prisms/cubes/cylinders, 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/cylinders stored in accordance with EN 12390-2.

It is recommended that in addition to the test specimens for quantifying carbonation resistance at least 2 compressive strength specimens are made and tested in accordance with EN 12390-3 at 28 days. Where a number of mixes are made, additional testing, e.g. the 28 day strength, should be undertaken 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 accordance with EN 12390-2 until they are 28 days old.

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

NOTE The use of different procedures can be noted as described in Clause 9.

The reference procedure is 14 days at 18 °C to 25 °C, 50 % to 65 % relative humidity.

An excessive duration of exposure to drying environment may affect test results.

After 14 days of exposure to laboratory air[4], the test specimens shall be placed in the carbonation storage chamber (see Annex A for an example of a suitable chamber). The prisms/cubes/cylinders shall be

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[4] 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.