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Preskušanje strjenega betona - 18. del: Določanje koeficienta migracije klorida

Testing hardened concrete - Part 18: Determination of the chloride migration coefficient

Prüfung von Festbeton - Teil 18: Bestimmung des Chloridmigrationskoeffizienten

Essai sur béton durci - Partie 18: Détermination du coefficient de migration des chlorures

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Testing hardened concrete - Part 18: Determination of the chloride migration coefficient

Essai sur béton durci - Partie 18: Détermination du coefficient de migration des chlorures

Prüfung von Festbeton - Teil 18: Bestimmung des Chloridmigrationskoeffizienten

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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 12390-18:2018) 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.

A list of all parts in the EN 12390 series, published under the general title "Testing hardened concrete", can be found on the CEN website.

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prEN 12390-18:2018 (E)**1 Scope**

This document describes the procedure for obtaining the non-steady-state chloride migration coefficient of specimens of hardened concrete at a specified age. The test procedure does not take into account any interaction of concrete with the saline solution over time. The test result is a durability indicator with respect to the resistance of the concrete investigated against chloride penetration.

The test procedure does not apply to concrete specimens with surface treatments such as silanes.

If the aggregate is electrically conductive or porous this will influence the magnitude of chloride migration. This fact is taken into account when establishing threshold values. It prevents comparison of chloride migration values between concretes if the aggregates show a difference of half an order of magnitude (higher or lower) of chloride migration.

Similar influence may be seen when metallic or electrically conducting fibres or particles are present.

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 1766, *Products and systems for the protection and repair of concrete structures - Test methods - Reference concretes for testing*

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

EN 12390-11, *Testing hardened concrete - Part 11: Determination of the chloride resistance of concrete, unidirectional diffusion*

EN 14488-1, *Testing sprayed concrete - Sampling fresh and hardened concrete*

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 migration cell

apparatus for holding a cylindrical test specimen with a lateral sealing of non-conductive material enabling the test specimen to be exposed on two parallel surfaces to test solutions

3.2 migration test set-up

test container with a migration cell support, migration cell test solutions, sleeve, sleeve clamps, electrodes and electronics

3.3 migration

movement of ions under the action of an external electrical field

3.4

chloride migration coefficient

transport property which reflects the resistance against chloride penetration under the action of an externally applied electrical field

4 Symbols

c_d	Chloride concentration at which a colour change occurs, $c_d = 0,07 \text{ mol}\cdot\text{l}^{-1}$
c_0	Chloride concentration of the potassium hydroxide solution (catholyte) [$\text{mol}\cdot\text{l}^{-1}$]
d, h	Diameter and height, respectively, of the cylindrical specimen [m]
M_{RCM}	Rapid chloride migration coefficient (non steady state) [$\times 10^{-12} \text{ m}^2\cdot\text{s}^{-1}$]
E	Voltage gradient [$\text{V}\cdot\text{m}^{-1}$]
erf^{-1}	Inverse Error Function
F	Faraday Constant, $F = 9,649 \cdot 10^4 \text{ J} \cdot (\text{V}\cdot\text{mol})^{-1}$
m_w	Mass of the water-saturated test specimen [kg]
R	Gas constant, $R = 8,314 \text{ J} \cdot (\text{K}\cdot\text{mol})^{-1}$
t	Duration of the migration test with an external voltage over the test specimen applied [s]
T	Absolute, mean temperature of both test solutions during the migration test [K]
U	Absolute value of the applied voltage [V]
x_d	Mean penetration depth of chloride ions of the two halves of the split test specimen
x_{max}	Maximum penetration depth
z	Ionic charge, for chloride ions $z = 1$

5 Principle

A specimen of concrete or mortar is placed between a chloride free and a chloride containing alkaline solution and an electric voltage is applied between two external electrodes to drive the chloride ions into the concrete specimen. After a given period of time, the specimen is split and the penetration depth of the free chloride ions is determined by using a suitable colour indicator solution. The chloride migration coefficient is calculated based on the measured depth of penetration, the magnitude of the applied voltage and other parameters.

NOTE This procedure may also be applied for testing products according to EN 1504-3 [1], EN 14487-1 [2].

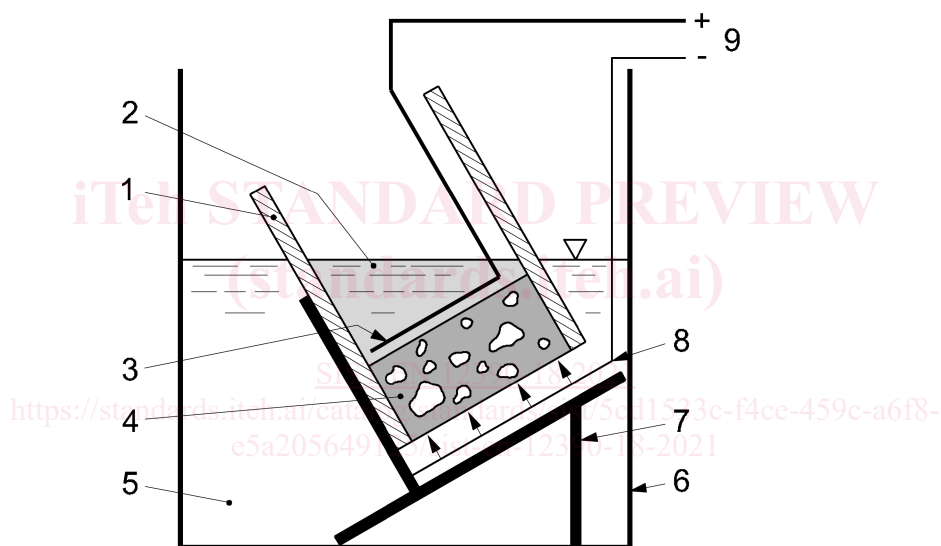
6 Apparatus and equipment

Laboratory room with an air temperature of $(20 \pm 2) \text{ }^\circ\text{C}$;

- scale with a measurement uncertainty not exceeding $\pm 0,05 \text{ g}$;
- vernier calliper gauge with a measurement uncertainty not exceeding $\pm 0,05 \text{ mm}$;
- ruler;
- water bath for storing the test specimens under water at $(20 \pm 2) \text{ }^\circ\text{C}$;
- thermometer;

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- f) drying oven with ventilation and adjustable temperature;
- g) migration set-up comprising (also see Figure 1 to Figure 3):
- 1) migration cell for test specimens with a diameter of 50 mm or 100 mm (fabric-reinforced, electrically non-conductive rubber sleeve [see Figure 2] and, depending on the construction of the cell, stainless steel sleeve clamps [see Figure 3]);
 - 2) migration cell support made from non-corrosive and electrically non-conductive material;
 - 3) rectifier with voltage regulator (up to 40 V);
 - 4) voltmeter, ammeter;
 - 5) stainless steel electrodes;
 - 6) catholyte reservoir: non-corroding and electrically non-conductive material.



Key

- | | |
|-----------------|--------------------------|
| 1 rubber sleeve | 6 catholyte reservoir |
| 2 anolyte | 7 migration cell support |
| 3 anode | 8 cathode |
| 4 test specimen | 9 rectifier |
| 5 catholyte | |

Figure 1 — Schematic illustration of a migration test set-up

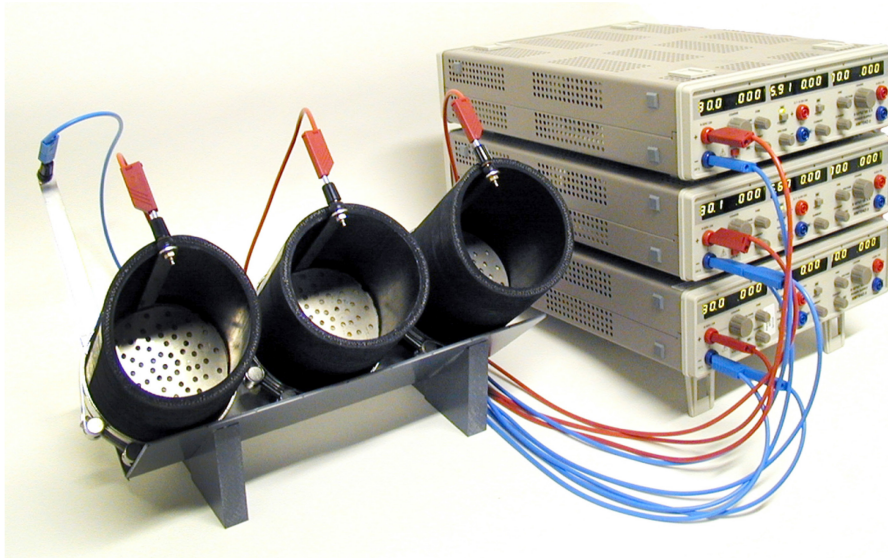


Figure 2 — Photograph of a migration test set-up



Figure 3 — Stainless steel sleeve clamp

h) Test solutions:

- 1) Anolyte: 0,2 N KOH (11,2 g KOH to be filled up to 1 000 ml with distilled or demineralized water) or 0,3 N NaOH (12,0 g NaOH to be filled up to 1 000 ml with distilled or demineralized water);
- 2) Catholyte: 5 % NaCl (50 g NaCl on 950 g 0,2 N KOH) (the reference solution) or (50 g NaCl on 950 g 0,3 N NaOH);

If specified or agreed, other NaCl concentrations between 3 % and 10 % may be utilized. This shall be explicitly noted in the test documentation and audit reports, and taken into account in the calculation of the migration coefficient.

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- 3) 0,1 N Silver nitrate solution;
- 4) 0,1 % Fluorescing compound in ethyl alcohol (0,1 g fluorescing in 100 g 70 % ethyl alcohol, stored in an opaque container) (optional);
- 5) 5 % Potassium dichromate solution (optional).

7 Preparation of specimens**7.1 Preparing sub-specimens**

A test series comprises at least five cylindrical specimens with a diameter of (50 ± 1) mm or at least three cylindrical specimens with a diameter of (100 ± 1) mm. Both diameters of the specimens shall have a height of (50 ± 2) mm. The diameter d and the height h of each specimen shall be determined with an accuracy of 0,1 mm. The diameter of the cores should not be less than three times the maximum aggregate size. If the diameter of the specimen is less than three times the maximum aggregate size, the number of specimens should be increased according to national provisions.

For cores with a diameter of 100 mm a minimum of three cubical specimens are prepared with at least 150 mm edge length, or a minimum of three cylindrical specimens with a diameter of 100 mm and a height of 200 mm. For cores with a diameter of 50 mm a minimum of two cubical specimens are necessary. The preparation and compaction of the specimens shall be executed in accordance with EN 12390-2. The trowelled surfaces shall be protected from drying with close fitting polythene sheeting or equivalent.

The cubical or cylindrical specimens shall be de-moulded according to EN 12390-2.

After de-moulding, the specimens shall be stored in tap water in accordance with EN 12390-2 until extracting the cylindrical specimens.

7.2 Preparing test specimens

For cubical specimens, the cores shall be extracted by drilling perpendicular to the troweled surface. For either cylindrical specimens or cores drilled from cubical specimens, the first 50 mm layer from the troweled surface shall be sawn and discarded.

The sawn surface of the remaining part of the specimen is ground flat to obtain the test surface. Grinding the sawn surface is essential in achieving the necessary surface quality. The resulting surface is considered to be the test surface area.

Visible spalls and holes on the test specimen face in contact with the NaCl solution (catholyte) ≤ 5 mm in diameter can be filled with sealing material. Depending on the size and number of defects, the sealed surface area should be less than 3 % of the test surface area. If there are spalls and holes > 5 mm in diameter on the test surface, a 5 mm till 10 mm layer containing the above defects shall be sawn and discarded, and the procedure described in EN 12390-11 shall be repeated. After no more than twice repeats, if there are still spalls and holes > 5 mm in diameter on the test surface the specimens have to be discarded.

Subsequently, the test specimens are to be cut parallel to the test surface to obtain a height of (50 ± 2) mm and this sawn surface is ground to be plano-parallel with a maximum deviation of 1 mm, determined at the quarter points.

After grinding both of the flat surfaces are cleaned by brushing and washing with tap water.

The specimens are stored in a laboratory room with (20 ± 2) °C and 40 % to 70 % RH until they are surface dry, then place them in the vacuum container for vacuum treatment. Both end surfaces must be exposed. The absolute pressure in the vacuum container has to be reduced to a pressure in the range of (10 – 50) mbar ([1 – 5] kPa) within a few minutes. Maintain the vacuum for three hours and then, with

the vacuum still applied, fill the container with a saturated $\text{Ca}(\text{OH})_2$ solution (by dissolving an excess of calcium hydroxide in distilled or de-ionized water) so as to immerse all the specimens. The vacuum has to be maintained for a further hour before allowing air to re-enter the container. The specimens are to be kept in the solution for (18 ± 2) h.

NOTE Other procedures to get fully saturated specimens might be allowed according to national provisions.

8 Procedure

8.1 Installation of the test specimens in the migration cell

The test specimens prepared in accordance with 7.2 shall be taken from the water storage immediately prior to testing and installed in the rubber sleeve as shown in Figure 1.

Two stainless steel sleeve clamps (see Figure 3) shall be fitted tight to the curved surface of the specimen to prevent lateral penetration of the test solution. Thereupon, the test specimens shall be flush mounted with the perforated stainless steel anode.

8.2 Installation of the migration cell in the migration apparatus

The migration cells are positioned in the migration chamber in such a way as shown in Figure 1 to let the test surface parallel to the stainless steel cathode with a distance of 10 mm till 15 mm so as to enable the resulting gas bubbles to escape.

Each migration cell should be filled with approximately 300 ml for a test specimen diameter of 100 mm and 75 ml for a test specimen diameter of 50 mm of the anolyte solution. The migration cell shall be installed tilted to approx. 30° from the horizontal to ensure unhindered escape of the emerging gas bubbles.

The migration chamber is filled with chloride solution (e.g. for the reference solution 5 % NaCl in 0,2 N KOH) to the meniscus of the anolyte solution in the migration cell (see Figure 1). The solutions shall not be mixed.

8.3 Test procedure

The duration of the migration test is dependent on the electrical resistance of the test specimen, which in turn is dependent upon the electrical resistivity and the dimensions, and it is based on the measured initial current in accordance with Table 1 or Tables 2 and 3 as appropriate. Intermediate values may be interpolated linearly. These test periods ensure the achievement of sufficient penetration depth. Anodes and cathodes are connected to a rectifier (up to 40 V, 0,5 A per cell migration). It is essential to ensure that the correct polarity has been achieved.

If the expected chloride migration coefficient, M_{RCM} , is known, a suitable test voltage and a respective test duration are selected directly (see NOTE and Table 1).

For concrete specimens with unknown M_{RCM} the following procedure shall be applied. The test is commenced by applying the test voltage of $(30 \pm 0,2)$ V. Depending upon the initial current, the voltage is either left at 30V or reduced in accordance with Table 2 or Table 3 as appropriate. If a test voltage is used which deviates from 30 V, a test period is to be selected which enables the achievement of penetration depths in the range of 10 mm till 30 mm.

Immediately after the start, at least once during and once before the end of the voltage application, the voltage and current of each individual migration cell as well as the temperatures of the two test solutions shall be measured and recorded.