SLOVENSKI STANDARD
SIST EN 14038-2:2020

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Elektrokemična realkalizacija in postopki kloridne ekstrakcije za armirani beton - 2. del: Kloridna ekstrakcija

Electrochemical realkalization and chloride extraction treatments for reinforced concrete - Part 2: Chloride extraction

Elektrochemische Realkalisierung und Chloridextraktionsbehandlungen für Stahlbeton - Teil 2: Chloridextraktion

Réalcalinisation électrochimique et traitements d'extraction des chlorures applicables au béton armé - Partie 2 : Extraction des chlorures

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Electrochemical realkalization and chloride extraction treatments for reinforced concrete - Part 2: Chloride extraction

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This European Standard was approved by CEN on 14 September 2020.

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European foreword

This document (EN 14038-2:2020) has been prepared by Technical Committee CEN/TC 219 “Cathodic protection”, the secretariat of which is held by BSI.

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of an identical text or by endorsement, at the latest by April 2021, and conflicting national standards shall be withdrawn at the latest by April 2021.

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.

This document supersedes CEN/TS 14038-2:2011.

EN 14038, *Electrochemical realkalization and chloride extraction treatments for reinforced concrete* is currently composed of the following parts:

— Part 1: Realkalization;

— Part 2: Chloride extraction.

In comparison with CEN/TS 14038-2:2011, the following changes have been made:

a) Clause 2 “*Normative references*” has been revised;

b) Clause 4 “*Principle*”, Clause 6 “*Assessment and repair of the structure*” has been revised;

c) 7.2.2 “*Anode*” has been complemented by requirements for the used anodes;

d) Requirements for anode zones have been added to 7.2.3 “*Anode zone*”;

e) A note has been added to 7.4 “*Power supply*”;

f) Clause 8 “*Installation procedures*” has been revised;

g) Clause 9 “*Commissioning, operation and termination of treatment*” has been revised, especially 9.6 “*Termination of treatment*”;

h) Clause 10 “*Final report*” and Clause 11 “*Post-treatment coating and monitoring*” have been revised;

i) Bibliography has been supplemented with several publications;

j) Document has been revised editorially.

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.

Introduction

The purpose of chloride extraction is to rehabilitate a reinforced concrete part from corrosion activity non-destructively and to provide long term corrosion protection of steel reinforcement in concrete which has been affected by chloride. The duration of the treatment is from several weeks up to as much as several months, depending on the amount and ingress depth of accumulated chloride, the permeability of the concrete, the layout of the reinforcement and other factors.

NOTE Based on experience, in case of a cover thickness of 30 mm to 40 mm and a concentration of chloride in the cover zone, an ECE can be done successfully in a one-stage treatment of 4 to 6 weeks.

There are other electrochemical procedures that can be used to provide corrosion protection to steel in concrete structures. These include cathodic protection and re-alkalization. There are European standards for cathodic protection of steel in concrete (EN ISO 12696) and for the re-alkalization of carbonated concrete (EN 14038-1).

It has been assumed in the drafting of this document that design and execution of a chloride extraction application will be entrusted to appropriately qualified, competent and experienced people, for whose use it has been prepared.

1 Scope

This document specifies a procedure for carrying out impressed current electrochemical chloride extraction from chloride bearing concrete in existing structures. It is applicable to atmospherically exposed parts of structures with ordinary reinforcement and/ or post-tensioned tendon ducts embedded in concrete. In the latter case, it is essential to verify that there is no risk of hydrogen embrittlement, if necessary by conducting trials and installing monitoring during the treatment.

This document does not apply to concrete containing pre-stressing steel, which can suffer hydrogen embrittlement during chloride extraction, or to concrete containing coated or galvanized reinforcement.

In case of post-tensioned, pre-stressing concrete, the endangered tendon strands can be shielded by the tendon ducts from unwanted and/or exceeded polarization into the cathodic range and respective water reduction.

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 1504-2, *Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 2: Surface protection systems for concrete*

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

EN 14629, *Products and systems for the protection and repair of concrete structures - Test methods - Determination of chloride content in hardened concrete*

EN 14630, *Products and systems for the protection and repair of concrete structures - Test methods - Determination of carbonation depth in hardened concrete by the phenolphthalein method*

EN ISO 8044, *Corrosion of metals and alloys - Vocabulary (ISO 8044)*

EN ISO 12696:2016, *Cathodic protection of steel in concrete (ISO 12696:2016)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 8044 and EN 1504-2 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
chloride extraction
electrochemical treatment for providing a low chloride content and developing a high pH value to concrete which surrounds reinforcing bars, corresponding to sound, carbonated or non-carbonated concrete

4 Principle

Electrochemical Chloride extraction (ECE) of reinforced concrete is performed by applying an electric field between the steel reinforcement embedded in the concrete and an anode surrounded by an alkaline electrolyte solution. The anodes are placed temporarily on the concrete surface. Dissolved, negatively charged ions – such as chloride – will be moved from the reinforcement to the external electrode. This is a physical process, controlled by the applied voltage.

Coincidentally, the electrochemical reactions occurring at the steel surface provide the evolution of hydroxyl ions by the reduction of oxygen and water. This process alkalizes the concrete in the vicinity of the rebar as described in EN 14038-1 and is in correlation with the flowing current.

The chloride content will not be reduced to zero; the usual target content is an average profile of 0,4 %, related to the cement mass. To achieve this, the driving voltage between reinforcement and the external anode should be set as high as possible, but not exceeding safety limits.

NOTE 1 The chloride extraction effect is not limited to the zone between concrete surface and next reinforcement layer, but can be triggered in greater depths of concrete, as long as reinforcement is present and is connected with the upper reinforcement layer. In such a case, a multi-stage treatment is required. Treatments from the opposite side of a concrete slab are possible, but will need an extended time of application.

If the reinforcement surface is covered by corrosion products, these oxides will have to be reduced prior to the possible reduction of oxygen and water. During this period which can consume theoretically up to 700 Ah/m^2, few if any hydroxyl ions can be developed. In such a case, hydrogen evolution is unlikely, and high initial currents can be tolerated.

NOTE 2 Details of the principles underlying this process are given in the European Federation of Corrosion report [1] and in a more recent publication [2]. Fundamental research reports on ECE have been published in [5] to [8].

NOTE 3 Some electrolyte materials can change the surface appearance of the concrete.

5 General

5.1 Quality management systems

The design, the installation, the energizing, the commissioning, the long-term operation of all of the elements of electrochemical chloride extraction systems for steel in concrete shall be fully documented.

NOTE EN ISO 9000 constitutes a suitable Quality Management Systems Standard, which can be utilized.

Each element of the work shall be undertaken in accordance with a fully documented quality plan. Each stage of the design shall be checked and the checking shall be documented. Each stage of the installation, energizing, commissioning and operation shall be the subject of appropriate visual, mechanical and/or electrical testing and all testing shall be documented.

All test instrumentation shall have valid calibration certificates traceable to national or European Standards of calibration.

The documentation shall constitute part of the permanent records for the works.

5.2 Personnel

Each aspect of the ECE system design, installation, testing of the installation, energizing, commissioning and long-term operational control shall be under the supervision of persons with appropriate qualification, training, expertise and experience in the particular element of the work for which they are responsible.

ECE of steel in concrete is a specialist multidiscipline activity. Expertise is required in the fields of electrochemistry, concrete technology, civil and/or structural engineering and cathodic protection engineering.

Persons who undertake the design, supervision of installation, commissioning, supervision of operation, measurements, monitoring and supervision of maintenance of ECE applications shall have the appropriate level of competence for the tasks undertaken.

EN ISO 15257 constitutes a suitable method of assessing Competence of Cathodic Protection Persons which can be utilized for ECE as well as cathodic protection. Competence of Persons to the appropriate level in the application sector of reinforced concrete for tasks undertaken should be demonstrated by certification in accordance with EN ISO 15257 and suitable experience with ECE or by another equivalent prequalification procedure.

6 Assessment and repair of the structure

6.1 General

Prior to undertaking chloride extraction, an assessment of the structure, including its physical condition, its structural integrity and the nature and extent of any repairs which might be needed, shall be performed in accordance with EN 1504-9. In most cases such condition surveys are made on the occasion of damage observations and have resulted in the choice of ECE as a possible repair option. So many of the following mentioned data might be available already, and just the missing and/ or out-of-date information needs to be added as appropriate.

The investigations specified in 6.2 to 6.9 shall be carried out in order to:

a) determine the suitability of the structure for chloride extraction;

b) provide information for design and time of treatment;

c) identify any conditions which can preclude the use of chloride extraction.

6.2 Review of records

All available drawings, specifications, records and notes shall be reviewed for information on the location, quantity, nature (e.g. mild or high strength steel, smooth or deformed bar, galvanized, epoxy-coated) and continuity of the reinforcement, as well as the constituents and quality of the concrete.

The possible sensitivity to reduction of bond strength should be evaluated in the case of smooth reinforcement.

6.3 Inspection

An inspection shall be carried out to ascertain the type, causes and extent of defects and any features of the structure or of its surrounding environment, which could influence the application and effectiveness of the chloride extraction. All areas of the structure, which require chloride extraction, shall be checked for delamination of the concrete cover. Defects such as delamination, cracks, honeycombing or poor construction joints which could permit significant water penetration, or prevent current flow and thereby impair the effectiveness of the chloride extraction treatment, shall be recorded.

In areas, which have been previously repaired, the repair methods and materials used should be identified as far as possible. If the concrete behind the repair is to be treated with chloride extraction, the electrical resistivity and porosity of the repair media should be considered in comparison to the original concrete.

The cause of any deterioration which is not attributable to corroding reinforcement shall be determined.

If any signs of structural distress are evident, an assessment of both the load-bearing capacity of the structure and the need for temporary or permanent strengthening or support should be made.

6.4 Assessment of corrosion activity

Corrosion measurements provide essential information about the effect of chloride on the corrosion behaviour of the reinforcement and help to identify the concrete areas which are in need of appropriate repair. Suitable measurement methods are potential survey, galvanostatic pulse measurements, AC impedance measurements, linear polarization measurements (LPR) and Tafel polarization measurements. Details and work principles of these methods as well as approaches for the interpretation of the received data are discussed comprehensively in [3].

NOTE 1 A usual approach is to do a full-scale potential survey along with the inspection for concrete defects first, to correlate these data with reinforcement cover depths and to assess corrosion suspect areas for a local detailed inspection.

NOTE 2 Great care needs to be taken on the interpretation of the potential readings, as they are not only influenced by macro-cell induced corrosion, but also by variations in concrete moisture, the total water content and varying cover depths or concrete composition.

Better accuracy in the interpretation of the corrosion status can be obtained by including enhanced methods (galvanostatic pulse, etc.) in the scope of survey. These methods can also prove the result and success of the chloride extraction application; if this is intended initial data need to be taken on specified test coordinates before the chloride extraction, preferably along with chloride profiles. If available, these enhanced corrosion measurements should be applied.

6.5 Determination of chloride content

The chloride content of the concrete shall be determined as a proportion of the mass of cement or concrete according to EN 14629 as well as the source of the chloride contamination. Concrete samples shall be taken from areas expected to have the highest possible chloride content in order to ascertain whether chloride contamination is present and the profile from the surface through the cover to behind the reinforcement.

It shall be made certain by an appropriate condition survey that sufficient and correct information are known about the chloride distribution across the concrete surface and the related depth of ingress. A dust sampling plan shall be specified to monitor the chloride extraction progress in relation to the initial condition. Chloride profiles shall be measured in all concrete areas with increased corrosion activity.

The concrete samples taken for chloride analysis should also be analysed for their water content. This provides additional information for an improved understanding of potential data (e.g. the reason for negative potential readings) or for designing the chloride extraction application.

6.6 Visual inspection of the rebar surface and carbonation depth measurement

A visual inspection of the rebar surface shall be made in locations with high corrosion activity and/ or high chloride content in rebar vicinity. The results shall be documented accordingly. Carbonation depth shall be measured at several of those locations to ascertain its distribution according to EN 14630 and to verify, if there is a possible combined limitation of the corrosion protection (especially at low concrete cover). In such case, the chloride extraction treatment can be designed to meet the requirements of EN 14038-1 as well.