SLOVENSKI STANDARD
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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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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (prEN 14038-2:2018) has been prepared by Technical Committee CEN/TC 219 “Cathodic protection”, the secretariat of which is held by BSI.

This document is currently submitted to the CEN Enquiry.

This document will supersede CEN/TS 14038-2:2011.

Introduction

The purpose of chloride extraction is to rehabilitate a reinforced concrete part from corrosion activity and to provide long term corrosion protection of steel reinforcement in concrete which has been affected by chloride and to re-establish its self-protection ability. 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. The decision to terminate the application should be made according to the specific requirements detailed in this standard.

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 standard that the execution of its provisions 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 epoxy-coated or galvanized reinforcement.

In case of post-tensioned, pre-stressing concrete, the endangered tendon strands may 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 14038-1, *Electrochemical realkalization and chloride extraction treatments for reinforced concrete — Part 1: Realkalization*

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 — Basic terms and definitions (ISO 8044)*

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

EN ISO 15257, *Cathodic protection — Competence levels of cathodic protection persons — Basis for certification scheme (ISO 15257)*

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:

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

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

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 containing hydroxyl ions. 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 alkalises the concrete in the vicinity of the rebar as described in EN 14038-1 and is in correlation with the flowing current.

Usually the chloride content cannot 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 – usually ranging between 30 V and 40 V.

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 need to be reduced prior to the possible reduction of oxygen and water. During this period which may consume theoretically up to 700 Ah/m², few if any hydroxyl ions can be developed. In such a case, hydrogen evolution is likely just as in the later stages of the chloride extraction treatment, and high initial currents can be tolerated. Some electrolyte materials may change the surface appearance of the concrete.

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].

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.

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 personnel 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.

Personnel 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 Personnel which may be utilized for ECE as well as cathodic protection. Competence of Personnel to the appropriate level 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.

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 for 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.

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.

NOTE 2 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.

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. 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 has to 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. It is recommended to specify a dust sampling plan to monitor the chloride extraction progress. Chloride profiles shall be measured in all concrete areas with increased corrosion activity.

The concrete samples taken for chloride analysis may 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 may be designed to meet the requirements of EN 14038-1 as well.

6.7 Concrete cover thickness and reinforcement location measurements

Concrete cover thickness and reinforcement location measurements shall be carried out in order to enable a determination to be made of comparative current flow through areas of thick and thin cover, and to identify regions of varying reinforcement density. Any features that could impair the effectiveness of chloride extraction, such as shielding of the reinforcement caused by embedded metal mesh, metal fibres, metal plates, plastic sheets or non-conductive repair materials shall be identified. Points at which short circuits between the reinforcing steel and the anodes could occur shall be noted.