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**Maintenance and repair of concrete  
structures —**

**Part 3:  
Design of repairs and prevention**

*Entretien et réparation des structures en béton —*

*Partie 3: Conception des réparations et prévention*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures*.

ISO 16311 consists of the following parts, under the general title *Maintenance and repair of concrete structures*:

- *Part 1: General principles*
- *Part 2: Assessment of existing concrete structures*
- *Part 3: Design of repairs and prevention*
- *Part 4: Execution of repairs and prevention*

## Introduction

The repair and prevention of defects and deterioration in concrete structures requires complex design work. This part of ISO 16311 defines the design principles, strategies, remedies, and methods for preventing accelerated deterioration and the repair of concrete structures that have suffered or may suffer damage or deterioration. It gives guidance on the choice of repair design principles, strategies, remedies, methods, and selection of products and systems which are appropriate for the intended use.

This part of ISO 16311 identifies key stages in the repair process:

- the need for assessment of the condition of the structure;
- the need for identification of the causes of deterioration;
- evaluating the options for repair and prevention, and decision-making;
- the selection of the appropriate remedies for repair and prevention;
- the selection of methods;
- the definition of properties of products and systems;
- the specification of maintenance requirements following repair and prevention.

This part of ISO 16311 does not deal with matters related to structural design and the verification of structural performance in both deteriorated and repaired condition. The information related to the deteriorated condition is presented in ISO 16311-2.

This part of ISO 16311 contains an [Annex A](#) which provides guidance and background information on the normative text.

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# Maintenance and repair of concrete structures —

## Part 3: Design of repairs and prevention

### 1 Scope

This part of ISO 16311 defines basic considerations and decision-making for the specification of repair and prevention remedies, and management strategies for reinforced and unreinforced concrete structures using products and systems specified in other International Standards or Technical Specifications. This part of ISO 16311 covers only atmospherically exposed structures, and buried or submerged structures, if they can be accessed.

This part of ISO 16311 specifies repair and prevention design principles, and strategies for defects and on-going deterioration including, but not limited to:

- a) mechanical actions, e.g. impact, overloading, movement caused by settlement, blast, vibration, and seismic actions;
- b) chemical and biological actions from environments, e.g. sulfate attack, alkali-aggregate reaction;
- c) physical actions, e.g. freeze-thaw, thermal cracking, moisture movement, salt crystallization, fire, and erosion;
- d) reinforcement corrosion;
- e) original construction defects that remained unaddressed from the time of construction.

The execution of maintenance and repairs is covered in ISO 16311-4.

Further background information on the scope of this part of ISO 16311 is given in [Annex A](#).

### 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14040, *Environmental management — Life cycle assessment — Principles and framework*

ISO 14044, *Environmental management — Life cycle assessment — Requirements and guidelines*

ISO 16311-1, *Maintenance and repair of concrete structures — Part 1: General principles*

ISO 16311-2, *Maintenance and repair of concrete structures — Part 2: Assessment of existing concrete structures*

ISO 16311-4, *Maintenance and repair of concrete structures — Part 4: Execution of repairs and prevention*

ISO 22965-1, *Concrete — Part 1: Methods of specifying and guidance for the specifier*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 16311-1 and the following apply.

## ISO 16311-3:2014(E)

### 3.1 defect

fault, or deviation from the intended level of performance of a structure or its parts

[SOURCE: ISO 15686-1:2000]

### 3.2 design service life

specified period of time for which a structure or its members is to be used for its intended purpose without major repair being necessary

[SOURCE: ISO 16311-1]

### 3.3 maintenance

set of activities undertaken to check, evaluate the performance of a structure and preserve/restore it so as to satisfy its performance requirements in service

[SOURCE: ISO 13823:2008]

### 3.4 passivity

state in which steel in concrete is protected by a thin film and the corrosion rate is minimized

Note 1 to entry: This film is destabilized or lost when concrete carbonates to the level of the reinforcing steel, when aggressive salts concentrate and attack the steel, or atypically, when all oxygen is depleted at the surface of the steel (i.e. submerged concrete members after many years)

### 3.5 prevention

remedial action to prevent or slow down further deterioration of a structure or structural member and reduce the possibility of damage to the user or any third party, inhibiting the progress of deterioration, and proactively preventing deterioration

### 3.6 protection

measure that is intended to prevent or reduce the development of defects in the structure

### 3.7 repair

restoration of a structure or its components to an acceptable condition by the renewal or replacement of worn, damaged, or deteriorated components

[SOURCE: ISO 13823:2008]

## 4 Minimum considerations before repair and prevention design

### 4.1 General

This clause outlines procedures that shall be undertaken to assess the current condition of a concrete structure prior to designing repair and prevention programs.

General guidance is given in [Annex A](#).

### 4.2 Initial risk assessment

The risks to health and safety from falling debris or localized structural failure due to removing deteriorated materials, and the effect of deterioration upon the mechanical stability of the concrete structure shall be assessed pre-repair work, as well as the anticipated loads and forces during repair work.



Where the concrete structure or a portion thereof is considered to be unsafe, appropriate actions and sequences shall be specified to make it safe before other prevention or repair work is undertaken and while underway, taking into account any additional risks that can arise from the repair work itself. Such action can include local prevention or repairs, the installation of support or other temporary stabilization measures, or partial or even complete demolition.

### 4.3 Assessment of defects and their causes

An assessment shall be made of the defects in the concrete structure, their causes, and of the ability of the concrete structure to perform its function per the detailed guidance provided in ISO 16311-2. This information is briefly summarized in the subsequent paragraphs.

The process of assessment of the structure shall include, but not be limited to, the following.

- a) Documentation of the materials and systems comprising the structure.
- b) The visible condition of the existing concrete structure.
- c) Testing to determine the condition of the concrete and reinforcing steel.
- d) The original design approach and potential design deficiencies.
- e) The environment, including exposure to deleterious species.
- f) The history of the concrete structure, including environmental exposure, and previous maintenance and repair programs.
- g) The conditions of use, (e.g. loading or other actions).
- h) Requirements for future use.

The nature and causes of defects and deficiencies, including combinations of causes, shall be identified and recorded (see [Figure 1](#)).

The approximate extent and likely rate of increase of defects shall then be assessed. An estimate shall be made of when the member or concrete structure would no longer perform as intended, with no prevention or repair measures (other than maintenance of existing systems) applied.

The results of the completed assessment shall be valid at the time that the prevention and repairs are designed and carried out. If, as a result of passage of time or for any other reason, there are doubts about the validity of the assessment, a new assessment shall be made.

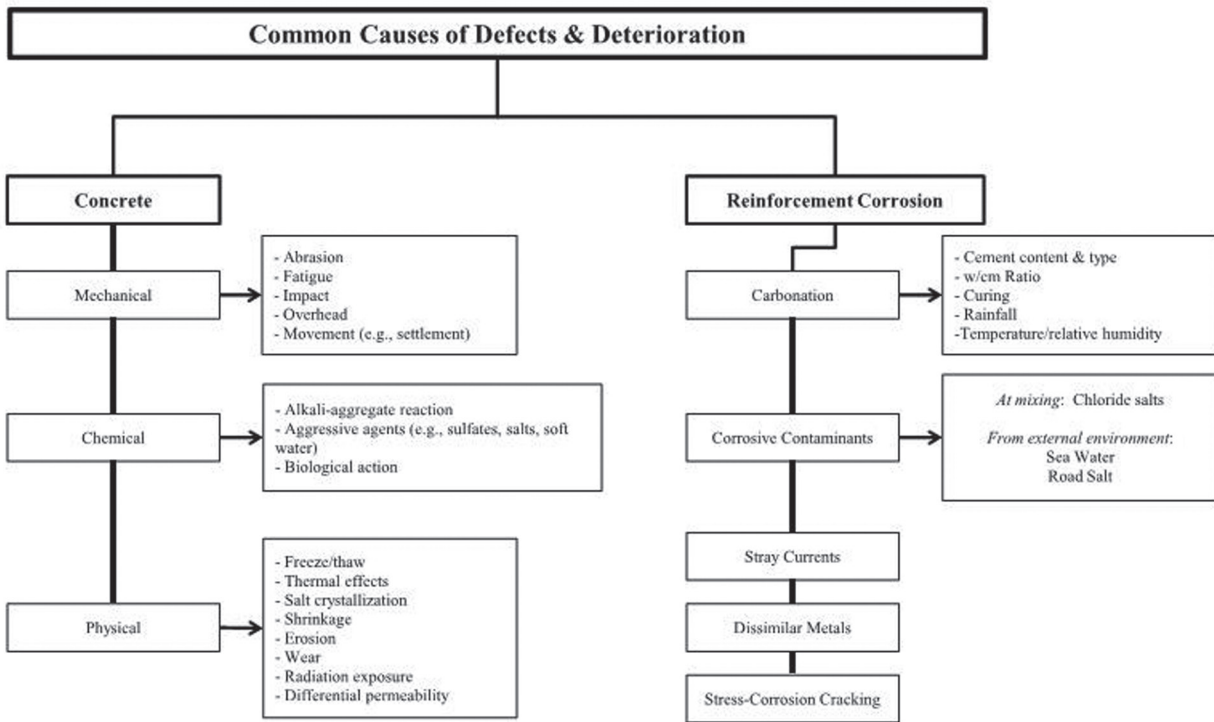


Figure 1 — Common causes of defects and deterioration (standards.iteh.ai)

## 5 Strategies for maintenance, repair, and prevention

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### 5.1 General

This clause identifies options and factors to be considered when choosing a strategy for the management of the structure.

### 5.2 Options

Per ISO 16311-1, the following options shall be taken into account in deciding the appropriate action to meet the future requirements for the life of the structure.

- Do nothing for a certain time while monitoring the structure.
- Re-analyse the structural capacity, possibly leading to a downgrade in function.
- Prevent or reduce further deterioration.
- Strengthen or repair and protect all or part of the concrete structure.
- Reconstruct all or part of the concrete structure.
- Demolish all or part of the concrete structure.

### 5.3 Factors

The factors that shall be considered when choosing a management strategy include, but are not limited to the following categories.

#### 5.3.1 General

- a) The intended use and remaining service life of the structure.
- b) The required performance of the structure.  
NOTE This can include, for example, fire resistance and watertightness.
- c) The likely service life of the repair and prevention work.
- d) The required availability of the structure, permissible interruption to its use and opportunities for additional prevention, repair, and monitoring work.
- e) The acceptable number and cost of repair cycles during the design life of the concrete structure.
- f) The comparative whole life cost of the alternative management strategies, including future inspection and maintenance or further repair cycles.
- g) Properties and possible methods of preparation of the existing substrate.
- h) The appearance of the protected and repaired structure.

### 5.3.2 Structural

The actions and how they will be resisted, including during and after implementation of the strategy.

### 5.3.3 Risk assessment

- a) The consequences of structural failure.
- b) Health and safety requirements.
- c) The effect on occupiers or users of the structure and on adjacent structures and the general public.

### 5.3.4 Environmental

- a) The exposure environment of the structure and whether it can be changed locally.

NOTE Exposure classes are given in ISO 22965-1, Annex A.2.

- b) The need or opportunity to protect part or all of the concrete structure, from weather, pollution, salt spray, etc., including protection of the substrate during the repair work.

## 5.4 Choice of appropriate strategy

The choice of strategy for the structure shall be based on the above assessment of the structure, client requirements, and relevant provisions (e.g. safety requirements) valid in the place of execution. All repair and prevention work undertaken as part of a structure management strategy shall comply with this part of ISO 16311.

A repair and prevention remedy or remedies shall be chosen according to [Clause 6](#), that is:

- a) appropriate to the type, cause or combination of causes and to the extent of the defects;
- b) appropriate to the future service conditions.

## 6 Basis for the choice of specific repair and prevention design principles, strategies, remedies, and methods

### 6.1 General

This clause specifies the basic repair and prevention strategies and remedies which shall be used, separately or in combination, to protect, maintain, or repair concrete structures. Determining the suitability of these remedies and methods for a particular condition can only be assessed after a thorough evaluation of the component or structure per ISO 16311-2 and reconciling repair and prevention design principles that include, but are not limited to:

- a) do no harm to the structure or member;
- b) adopt proven techniques and products with a documented record of success in similar projects;
- c) harmonize prevention, repair, and maintenance strategies with budgets and planning.

### 6.2 Repair remedies and methods of maintenance, repair, and prevention

#### 6.2.1 General

Maintenance, repair, and prevention remedies are based on chemical, electrochemical, or physical remedies that can be used to prevent or stabilize the deterioration of concrete, or corrosion of the steel or other embedded metals, or to strengthen the concrete structure.

[Table 1](#) contains examples of repair and prevention methods which apply the remedies. Only methods which comply with the remedies shall be selected, taking into account any possible undesirable consequences of applying a particular method or combination of methods under the specific conditions of the individual repair.

Execution of the repairs and prevention is addressed in ISO 16311-4.

#### 6.2.2 Remedies and methods addressing defects in concrete and reinforcement corrosion

Remedies 1 to 6 in [Table 1](#) address defects in the concrete or concrete structures that can be caused by the following actions, separately or in combination:

- a) mechanical: e.g. impact, overloading, movement caused by settlement, vibration, seismic actions, and blast;
- b) chemical and biological: e.g. sulfate attack, alkali-aggregate reaction;
- c) physical: e.g. freeze-thaw action, fire, thermal cracking, moisture movement, salt crystallization, and erosion.

Remedies 7 to 11 in [Table 1](#) address reinforcement corrosion caused by:

- a) physical loss of the protective concrete cover;
- b) chemical loss of alkaline pH in the protective concrete cover as a result of reaction with atmospheric carbon dioxide (carbonation);
- c) contamination of the protective concrete cover with corrosive agents (usually chloride ions) which were incorporated in the concrete when it was mixed or which have penetrated into the concrete from the environment;
- d) stray electrical currents conducted or induced in the reinforcement from neighbouring electrical installations;
- e) stress corrosion cracking of prestressed members;