
**Maintenance and repair of concrete
structures —**

**Part 4:
Execution of repairs and prevention**

Entretien et réparation des structures en béton —

Partie 4: Exécution 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).

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).

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*, the secretariat of which is held by KATS. ISO 16311 consists of four parts:

- *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

This part of ISO 16311 defines and specifies site application of products and systems and quality control of the work. To be operable, this part of ISO 16311 needs a National Annex or a reference to where national complementary provisions are given. This part of ISO 16311 can also be applied on specific projects where a project specification will supplement the standards in lieu of a National Annex applicable in the place of use.

The execution of maintenance and repair of concrete structures is an important and integral part of the complex process of protection and repair, and this part of ISO 16311 specifies how it shall be carried out. The specifications in this part of ISO 16311 are part of the definition of the intended use for the relevant products and systems. The execution shall be in accordance with this series of International Standards: ISO 22966, ISO 22965-1, ISO 22965-2, ISO 2394, and any other relevant ISO and National Standards valid in the place of use.

This part of ISO 16311 incorporates rules for the use of maintenance and repair materials and systems that are covered by International Standards. Until International Standards are developed, the standards cited in the National Annex (often regional or national standards) for materials and systems shall be followed.

Maintenance and repair methods applying traditional concrete construction work are listed in this part of ISO 16311, but reference is made to relevant standards.

Maintenance and repair methods applying electrochemical methods, e.g. cathodic protection, realkalisation of carbonated concrete, and chloride extraction, are listed in this part of ISO 16311, but reference is made to standards or guidelines valid in the place of use.

Maintenance and repair shall be executed according to a project specification including the necessary requirements on remedies, methods, and materials per ISO 16311-3.

This part of ISO 16311 contains an [Annex A](#) which provides guidance and background information to the normative text. The contents of [Annex A](#) are numbered in the same way as the normative text to facilitate reference, but prefixed with "A".

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Maintenance and repair of concrete structures —

Part 4: Execution of repairs and prevention

1 Scope

This part of ISO 16311 gives requirements for substrate condition before and during application, including structural stability, storage of materials, the preparation, and application of products and systems for the protection and repair of concrete structures, including quality control and qualifications of personnel, maintenance, health and safety, and the environment.

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 1920-2, *Testing of concrete — Part 2: Properties of fresh concrete*
- ISO 1920-3, *Testing of concrete — Part 3: Making and curing test specimens*
- ISO 1920-4, *Testing of concrete — Part 4: Strength of hardened concrete*
- ISO 1920-5:2004, *Testing of concrete — Part 5: Properties of hardened concrete other than strength*
- ISO 1920-6, *Testing of concrete — Part 6: Sampling, preparing and testing of concrete cores*
- ISO 1920-7:2004, *Testing of concrete — Part 7: Non-destructive tests on hardened concrete*
- ISO 2394, *General principles on reliability for structures*
- ISO 2409, *Paints and varnishes — Cross-cut test*
- ISO 2808, *Paints and varnishes — Determination of film thickness*
- ISO 3274, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Nominal characteristics of contact (stylus) instruments*
- ISO 4288, *Geometrical Product Specifications (GPS) — Surface texture: Profile method — Rules and procedures for the assessment of surface texture*
- ISO 4624, *Paints and varnishes — Pull-off test for adhesion*
- ISO 4628-1, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 1: General introduction and designation system*
- ISO 4628-2, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 2: Assessment of degree of blistering*
- ISO 4628-3, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 3: Assessment of degree of rusting*
- ISO 4628-4, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 4: Assessment of degree of cracking*

ISO 4628-5, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 5: Assessment of degree of flaking*

ISO 4628-6, *Paints and varnishes — Evaluation of degradation of coatings — Designation of quantity and size of defects, and of intensity of uniform changes in appearance — Part 6: Assessment of degree of chalking by tape method*

ISO 4677-1, *Atmospheres for conditioning and testing — Determination of relative humidity — Part 1: Aspirated psychrometer method*

ISO 4677-2, *Atmospheres for conditioning and testing — Determination of relative humidity — Part 2: Whirling psychrometer method*

ISO 6935-2, *Steel for the reinforcement of concrete — Part 2: Ribbed bars*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 8502-2, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 2: Laboratory determination of chloride on cleaned surfaces*

ISO 8502-3, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 3: Assessment of dust on steel surfaces prepared for painting (pressure-sensitive tape method)*

ISO 8502-4, *Preparation of steel substrates before application of paints and related products — Tests for the assessment of surface cleanliness — Part 4: Guidance on the estimation of the probability of condensation prior to paint application*

ISO 13822, *Bases for design of structures — Assessment of existing structures*

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 16311-3, *Maintenance and repair of concrete structures — Part 3: Design of repairs and prevention*

ISO 19338, *Performance and assessment requirements for design standards on structural concrete*

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

ISO 22965-2, *Concrete — Part 2: Specification of constituent materials, production of concrete and compliance of concrete*

ISO 22966, *Execution of concrete structures*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in ISO 16311-1, ISO 2394, ISO 13822, and ISO 19338 and the following apply.

3.1**bond**

the adhesion of the applied product or system to the substrate

Note 1 to entry: The bond requirements for a given repair can range from negligible (i.e. a bond breaker is required) to firmly adherent.

3.2**cement grout**

mixture of cement, water, and, in some cases, admixtures

3.3**cementitious repair products and systems**

hydraulic or polymer hydraulic mortars, concretes, and grouts

3.4**dew point**

temperature at which water vapour condenses

3.5**hydraulic mortars and hydraulic concrete**

mortars or concrete based on a hydraulic binder which is blended together with graded aggregates and can include admixtures and additions which, when mixed with mortar, set by hydrated reaction

3.6**mortars or concrete**

hydraulic, polymer hydraulic, and polymer mortar and concrete

3.7**polymer hydraulic cement mortars and concrete**

hydraulic mortars or concrete modified by the addition of a polymer

3.8**polymer mortars and polymer concretes**

blended mixture of polymer binder and graded aggregate which set by polymerisation reaction

3.9**preformed hole**

hole or slot formed or cut in concrete into which reinforcement or other fixing is to be anchored

3.10**quality plan**

programme to ensure that the activities of a process are undertaken to comply with the intended design

3.11**overspray**

airborne debris resulting from the application of sprayed concrete or mortar which can form an unwanted coating on the substrate

3.12**sprayed mortar or concrete**

mortar or concrete applied under pressure through a nozzle delivered through pipes

3.13**wet on wet**

application of a cementitious mortar or concrete onto the surface of a similar material which has set but not hardened

4 Structural stability during execution of repairs

Safety and stability before, during, and after repair shall be maintained in accordance with ISO 16311-3.

Any period required for gain of strength of the repair products and systems shall be a part of the duration of the repair.

5 General requirements

Consideration shall be given to the chemical, electrochemical, and physical condition of the substrate and any contaminants, the ability of the structure to accept loading, movement and vibration during protection and repair, ambient conditions, and the characteristics of the materials contained in the structure and those of the protection and repair products and systems.

The following requirements shall be met.

- The achievement of the required condition of the substrate regarding cleanliness, roughness, cracking, tensile and compressive strength, chloride or other contaminant and their penetration, depth of carbonation, moisture content, temperature, and degree of corrosion of reinforcement.
- The achievement of the compatibility of the original concrete and reinforcement with the protection or repair products and systems and compatibility between any different products and systems, including avoiding the risk of creating conditions which can cause corrosion.
- The achievement of the specified properties of products and systems when applied and in their hardened condition regarding the fulfilment of their purpose for protection and repair of the structure.
- The achievement of the required storage and application conditions regarding ambient temperature, humidity and dew point, wind force and precipitation, and any temporary protection which is needed.

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6 Methods of prevention and repair ISO 16311-4:2014

The remedies and methods of prevention and repair given in Table 1 of ISO 16311-3, are described below, excluding those methods specified in other International Standards or standards valid in the place of use.

The preparation of substrate, application of products and systems, quality control, and maintenance for each method shall comply with [Clauses 7, 8, 9, and 10](#).

The relevant sub-clauses are given in [Table 1](#) for each method together with any deviations, additions, necessary precautions, and limitations.

7 Preparation of substrate

7.1 General

The preparation of the substrate of concrete and reinforcement shall be suitable for the required condition of the substrate and the structural status of the structure, so that the products and systems can be properly applied, and shall be carried out in such a way as to produce protection or repair which is in accordance with this and other parts of this part of ISO 16311. The requirements for preparation are given in the following sub-clauses and are related to the methods of repair and protection in [Table 2](#).

7.2 Preparation of concrete

7.2.1 General

Weak, damaged, and deteriorated concrete and, where necessary, sound concrete shall be removed in accordance with the repair remedy and method chosen from ISO 16311-3.

Table 1 — Table for each method together with any deviations, additions, necessary precautions and limitations

Repair remedies and methods		Preparation See clauses	Application See clauses	Quality control See clauses
Method	Methods to satisfy remedy 1 – Protection against ingress The following methods satisfy the remedy of reducing or preventing the ingress of adverse agents e.g. water, other liquids, vapour gas such as carbon dioxide, chemicals such as chlorides, and biological agents.			
1.1	Hydrophobic impregnation This method applies a product to prevent or reduce the passage of water by lining the surface pores with material with hydrophobic properties.	7.1, 7.2.1, 7.2.2	8.1, 8.2.7	9.1, 9.2
1.2	Impregnation This method is to apply liquid products which penetrate the concrete and block the pore system.	7.1, 7.2.1, 7.2.2	8.1, 8.2.7	9.1, 9.2
1.3	Coating This method applies a product to the surface of the concrete to prevent the passage of agents.	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.7	9.1, 9.2
1.4	Surface bandaging of cracks The method seals cracks in the concrete to prevent the passage of deleterious agents. Refer to A.5 .	7.1, 7.2.1, 7.2.2	a, 8.1, 8.2.1, 8.2.2, 8.2.5, 8.2.6	9.1, 9.2
1.5	Filling of cracks This method fills cracks to protect against ingress.	7.1, 7.2.1, 7.2.2	a, 8.1, 8.2.1, 8.2.2, 8.2.5, 8.2.6	9.1, 9.2
1.6	Transforming cracks into joints This method makes use of existing cracks as an integral part of the structure. Refer to A.3 .	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.6	9.1, 9.2
1.7	Erecting external panels This method installs barrier panels to protect or encapsulate the deteriorating substrate.	System dependent	System dependent	System dependent
1.8	Applying membranes This method installs proprietary systems to protect or encapsulate the concrete substrate.	System dependent	System dependent	System dependent

Table 1 — (continued)

Remedies and methods		Preparation See clauses	Application See clauses	Quality control See clauses
Method	Methods to satisfy remedy 2 – Moisture control The following methods satisfy the remedy of adjusting and maintaining the moisture content in the concrete between a specified range of values.			
2.1	Hydrophobic impregnation This method applies a product to reduce the penetration of water and other agents into the treated concrete by lining the surface pores with materials with hydrophobic properties.	7.1, 7.2.1, 7.2.2	8.1, 8.2.7	9.1, 9.2
2.2	Impregnation This method applies liquid products which penetrate the concrete and block the pore system.	7.1, 7.2.1, 7.2.2	8.1, 8.2.7	9.1, 9.2
2.3	Coating This method applies a product to the surface of the concrete to prevent the passage of water or water vapour.	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.7	9.1, 9.2
2.4	Erecting external panels (Refer to method 1.7)	System dependent	System dependent	System dependent
2.5	Electrochemical treatment This method applies an electro-osmotic pulse to reduce water content of the concrete. Refer to A.5 .	System dependent	System dependent	System dependent
Method	Methods to satisfy remedy 3 – Concrete restoration The following methods satisfy the remedy of restoring the original concrete of a member of the structure to the originally specified shape and function. Restoring the concrete structure by replacing part of it.			
3.1	Hand-applied localized patches	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	8.1, 8.2.1, 8.2.2, 8.2.5	9.1, 9.2
3.2	Recasting components with concrete or mortar	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4 , and ISO 22966	8.1, 8.2.1, 8.2.4, 8.2.5 , ISO 22965-1, ISO 22965-2, and ISO 22966	9.1, 9.2
3.3	Spraying concrete or mortar	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4 , and ISO 22966	8.1, 8.2.1, 8.2.3, 8.2.5 , and ISO 22966	9.1, 9.2
3.4	Replacing structural members	ISO 2394	ISO 22966	9.1, 9.2

Table 1 — (continued)

Remedies and methods		Preparation See clauses	Application See clauses	Quality control See clauses
Method	Methods to satisfy remedy 4 – Structural strengthening The following methods satisfy the remedy of increasing or restoring the structural load bearing capacity of a member of the concrete structure.			
4.1	Adding or replacing embedded or external reinforcing bars	7.1, 7.3.1, 7.3.2, 8.2.1, 8.3.2	8.1, 8.2.8, 8.3.1, 8.3.3, and ISO 22966	9.1, 9.2
4.2	Adding reinforcement anchored in pre-formed or drilled holes	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.8, 8.3.1, 8.3.3	9.1, 9.2
4.3	Bonding plate reinforcement This method bonds the strengthening plates externally to a member of the concrete structure.	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	8.1, 8.2.1, 8.2.6, 8.2.9	9.1, 9.2
4.4	Adding mortar or concrete This method bonds additional mortar or concrete to the concrete structure.	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	8.1, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5	9.1, 9.2
4.5	Injecting cracks, voids or interstices This method injects the concrete with appropriate fluid.	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.2, 8.2.5, 8.2.6	9.1, 9.2
4.6	Filling cracks, voids, or interstices	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.2, 8.2.5, 8.2.6 b	9.1, 9.2
4.7	Prestressing (post-tensioning) or FRP strengthening	ISO 2394	ISO 22966	9.1, 9.2

Table 1 — (continued)

Remedies and methods		Preparation See clauses	Application See clauses	Quality control See clauses
Method	Methods to satisfy remedy 5 – Increasing physical resistance The following methods satisfy the remedy of increasing resistance to physical or mechanical attack.			
5.1	Coating This method increases the physical resistance with a coating.	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.7	9.1, 9.2
5.2	Impregnation This method applies liquid products which penetrate the concrete.	7.1, 7.2.1, 7.2.2	8.1, 8.2.7	9.1, 9.2
5.3	Adding mortar or concrete This method bonds additional mortar or concrete to the concrete structure.	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	8.1, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5	9.1, 9.2
5.4	Applying membranes This method installs proprietary systems to protect or encapsulate the concrete substrate.	System dependent	System dependent	System dependent
Method	Methods to satisfy remedy 6 – Increasing resistance to chemicals The following methods increase the resistance of the concrete surface to deterioration by reducing the penetration of chemical agents.			
6.1	Coating This method increases the physical resistance with a coating.	7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.7	9.1, 9.2
6.2	Impregnation This method applies liquid products that penetrate the concrete.	7.1, 7.2.1, 7.2.2	8.1, 8.2.7	9.1, 9.2
6.3	Adding mortar or concrete This method bonds additional mortar or concrete to the concrete structure.	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	8.1, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5	9.1, 9.2

Table 1 — (continued)

Remedies and methods		Preparation See clauses	Application See clauses	Quality control See clauses
Method	Methods to satisfy remedy 7 – Preserving or restoring passivity The following methods satisfy the remedy of creating chemical conditions in which the surface of the reinforcement is maintained at or is returned to a passive condition.			
7.1	Increasing cover to reinforcement with additional cementitious mortar or concrete, or applying coatings These methods increase cover or provide surface coatings to prevent penetration of the de-passivating agents: — Concrete or mortar overlays — Coatings	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4 7.1, 7.2.1, 7.2.2	8.1, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5 8.1, 8.2.1, 8.2.7	9.1, 9.2 9.1, 9.2
7.2	Replacing contaminated or carbonated concrete This method replaces carbonate concrete with uncontaminated mortar or concrete	7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	8.1, 8.2.1, 8.2.2, 8.2.5	9.1, 9.2
7.3	Electrochemical re-alkalisation of carbonated concrete	System dependent.	System dependent.	9.1, 9.2
7.4	Re-alkalisation of carbonated concrete by diffusion	c, d, 7.1, 7.2.1, 7.2.2, 7.2.3, 7.2.4	e, 8.1, 8.2.1, 8.2.2, 8.2.3, 8.2.4, 8.2.5	9.1, 9.2
7.5	Electrochemical chloride extraction	System dependent	System dependent	System dependent, and 9.1, 9.2
7.6	Applying membranes (Preserving passivity only) This method installs proprietary systems to protect or encapsulate the concrete substrate, thereby maintaining passivity.	System dependent	System dependent	System dependent.