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# Concrete Repair according to EN 1504.
Basics and Guideline.

# Extending the service life of existing structures.

Concrete has become one the most important building materials in the last century. From infrastructure like roads, bridges and tunnels, to office and residential buildings, concrete structures can be found anywhere – being a safe, versatile and economical solution for long-lasting civil engineering structures.

And while concrete structures are known for their durability and their excellent ability to withstand mechanical, chemical, physical influences, they might also deteriorate due to design flaws, inadequate protective measures, overloading, or due to severe environmental conditions and natural wear and tear.

Whatever the reason might be, there is often a need to protect or repair concrete, which will extend the service life of the structure with consistent or even optimized properties. In this brochure, the basics of concrete repair according to harmonized European standard EN 1504 are explained.

We offer a broad variety of different products and solutions for concrete repair - from structural strengthening, through concrete repair mortars and many more. Details on our products can be found in the corresponding fischer catalogues and our website.


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# Rules and regulations in Europe.

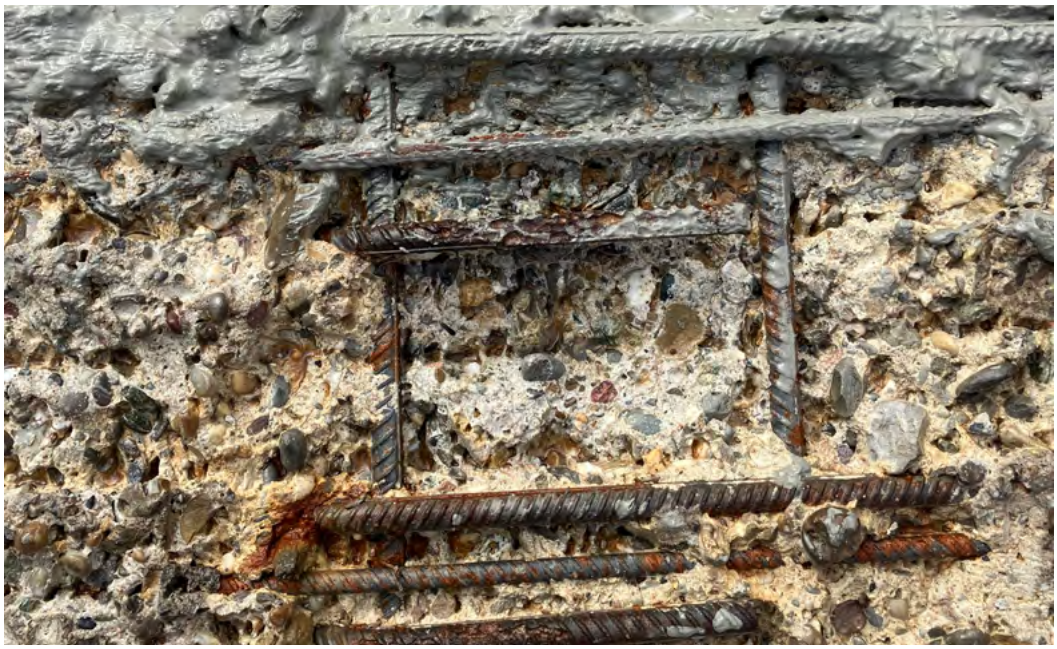
The most important harmonised standard in Europe is EN 1504 (“Products and systems for the protection and repair of concrete structures”). EN 1504 is subdivided into 10 parts and specifies requirements of the products to be used for concrete repair, as well as methods for the repair and protection of concrete structures.

This standard is recognised throughout the EU and is adopted by the individual countries in a respective national version (e.g., DIN EN 1504 in Germany). The product requirements and retrofitting principles are thus identical across the countries and ensure consistent quality. EN 1504 defines basic principles and methods for concrete repair and relates them to individual areas of application in various sections.

Products with technical definitions are specified, as well as the required quality controls.

Parts 2 to 7 of the standard define groups of products, while parts 1, 8, 9 and 10 give general assistance with the standard and concrete repair.

Part 9 of EN 1504 deals with the possible causes of damage and differentiates between damage to the concrete and the steel reinforcement. This part is of particular importance, because it defines the general principles of repair, which are then referred to in every other part of the standard. These principals are shown in detail on page 10.



## The 10 parts of EN 1504

1 **Definitions**
Explaining the basics of the standard and defining commonly used terminology.

2 **Surface protection systems for concrete**
Focus on protective coatings, impregnations and sealants as surface treatments for enhanced durability, water repellency as well as general resistance against ingress of e.g. chemical substances.

3 **Structural and non-structural repair**
Deals with repair mortars, grouts and concrete replacement materials, including different repair methods and application techniques.

4 **Structural Bonding**
Pertains to adhesive bonding of new to existing concrete, addressing load transfer, crack repair as well as different reinforcing application, specifying requirements for bonding agents as well as application procedures.

5 **Concrete Injection**
Covers injection materials and techniques for crack repair and waterproofing including methods like pressure injection, gravity-fed injection and resin-based systems, as well as the guidelines for assessing cracks and selecting the appropriate injection method.

6 **Anchoring of reinforcing steel bars**
Focuses on anchoring systems for reinforcement bars, specifying requirements for threaded rods, adhesive anchors and mechanical devices.

7 **Reinforcement corrosion protection**
Deals with corrosion inhibitors, coatings and cathodic protection systems with the aim to prevent or mitigate steel corrosion in the reinforcement of concrete structures.

8 **Quality control and evaluation of conformity**
Focus on quality assurance during production as well as application
of all products relating to the standard. This includes testing, certification and documentation to ensure compliance with specified performance criteria.

9 **General principles for the use of products and systems**
Containing the principles of repair and gives practical guidance on the selection of products and systems which are appropriate.

10 **Site application of products and systems, and quality control of the works**
Specifies requirements for on-site application to ensure proper execution of concrete repair and protection, addressing surface preparation, mixing, curing and quality control.

# Rules and regulations in Europe.

In addition to the harmonised standard EN 1504, further national regulations might be available in various countries. These may only add to the European standard and may not contradict it. Please note, that in general both the current and valid international as well as the national regulations need to be followed during the design and execution of concrete repair works.

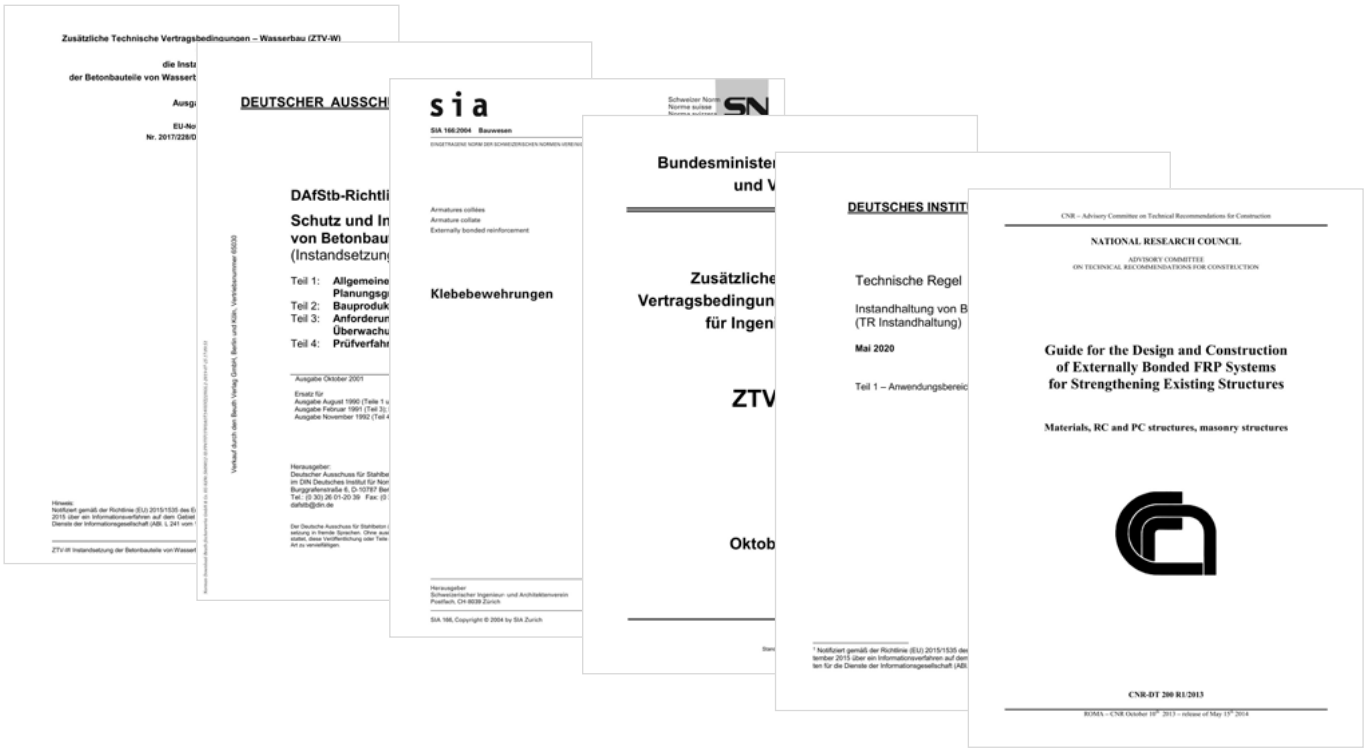
## Examples for national regulations for concrete repair

**Germany**
- DAfStb Richtlinie “Schutz und Instandsetzung von Betonbauteilen” (Technical guideline “Maintenance and repair of concrete structures”)
- Rili SIB 2001
- ZTV-ING Bundesanstalt für Straßenwesen
- ZTV-W Bundesanstalt für Wasserbau
- DIBt-TR Instandhaltung von Betonbauwerken

**Switzerland**
- SIA 269/2: Existing structures – concrete structures
- SIA 166: Bonded reinforcement

**Italy**
- CNR-DT 200 R1/2012 “Istruzioni per la Progettazione, l’Esecuzione ed il Controllo di Interventi di Consolidamento Statico mediante l’utilizzo di Compositi Fibrorinforzati” (“Guide for the Design and Construction of Externally Bonded FRP Systems for Strengthening Existing Structures”)

**Austria**
- ÖBV-Richtlinie “Erhaltung und Instandsetzung von Bauten aus Beton und Stahlbeton”



All products for concrete repair that meet the requirements of EN 1504 can be marked with the CE symbol.

The CE marking contains corresponding information for each product, in addition to general information such as the manufacturer, product description, number of the standard and declaration of performance, as well as the essential product characteristics, so that it is directly and clearly recognisable what constitutes a product. Note that the CE marking might not contain all relevant data that is needed for the design. Therefore, please always consult the individual technical datasheets of the products or our national sales teams for detailed information.

## Example for a CE marking with fischer products

| | | |
|---|---|---|
| CE<br>0921 | fischerwerke GmbH & Co. KG<br>Klaus-Fischer-Straße 1<br>72178 Waldachtal<br><br>24<br><br>CreNovate FCRM-RM R4 FS<br>(DoP-BS-013)<br>EN 1504-3: 2005 | Cement based mortar (CC) for structural and non-structural repair of concrete structures<br>EN-1504-3 Methods 3.1, 3.2, 4.4, 7.1, 7.2<br><br>Compressive strength — Class R4<br>Chloride ion content — ≤ 0.05 %<br>Adhesive bond — ≥ 2 MPa<br>Carbonation resistance — Passed<br>Elastic modulus — ≥ 20 GPa<br>Thermal compatibility<br>Part 1: Freeze-thaw — ≥ 2 MPa<br>Capillary absorption — ≤0.5 kg/m²h$^{0.5}$<br>Reaction to fire — Class A1<br>Dangerous substances — Comply with 5.4 (EN 1504-3) |

Repair Principle & Method acc. to EN 1504-9

Product description

Name of the European standard

Product name

Year of authorisation

Name and address of the manufacturer / approval holder / distributor

ID number of the notified body

Declared product characteristics, declaration of product performance

# Repair according to EN 1504-9.

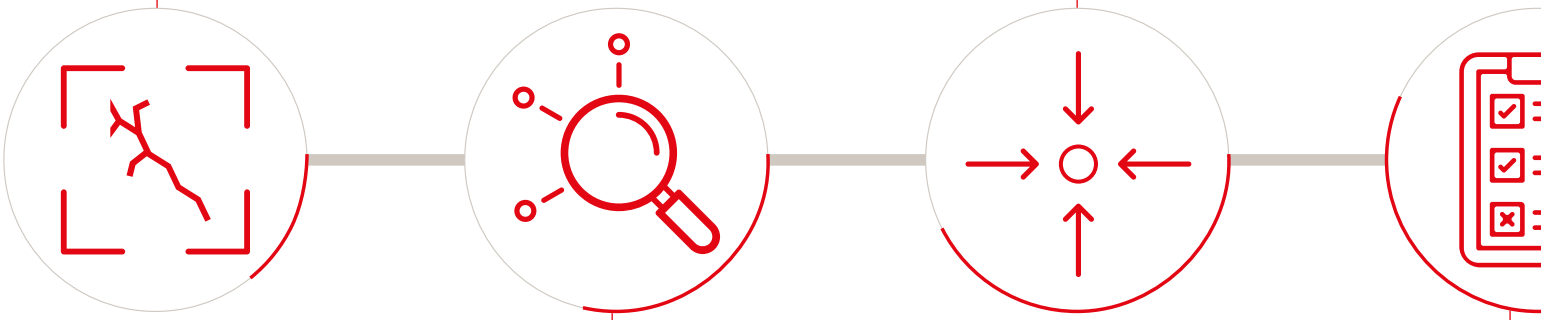
Repairing concrete structures might require complex planning. A lot of factors come into play when it comes to the decision of adequate structural retrofitting methods and principles, as well as the correct product choice.

When following these defined steps in accordance with EN 1504-9, it can be assured that all factors are considered, and the concrete repair is carried out in a technically correct and sustainable way.

## 1. Condition analysis and structural assessment

This involves a thorough examination of the existing structure to understand its current state and condition. It includes assessing the physical and mechanical properties of the concrete, the extent of any damage, and the structural integrity.

There are multiple destructive and non-destructive investigation methods that can be carried out, which help to assess the actual condition. It further helps to study existing documents of e.g. the structural design, reinforcement and execution plans, and information on the history of the structure.



## 2. Identification of the causes of deterioration

This step involves identifying the root causes of the observed damage. Usually, multiple factors come into play, and all of them have to be identified. Only when the causes of damage are known, it is possible to sustainably fix the damage and prevent the same problems from happening again in the future.

There are various factors that could cause damage, such as corrosion, structural damage, water infiltration, freeze and thaw cycles, seismic activity, reactive aggregates, etc.

## 3. Objectives of protection and repair

After understanding the causes for the damage, the goals of the repair and protection measures are defined in this step. These objectives should take into account economic, functional and environmental factors, as well as the future requirements intended by the owner of the building.

## 4. Choice of principles for protection and repair

Based on the determined objectives, suitable protection and repair principles are chosen. These different methods are defined in the EN 1504 standard and include options like structural strengthening, surface protection systems for concrete, structural and non-structural repair, structural bonding, concrete injection, etc.

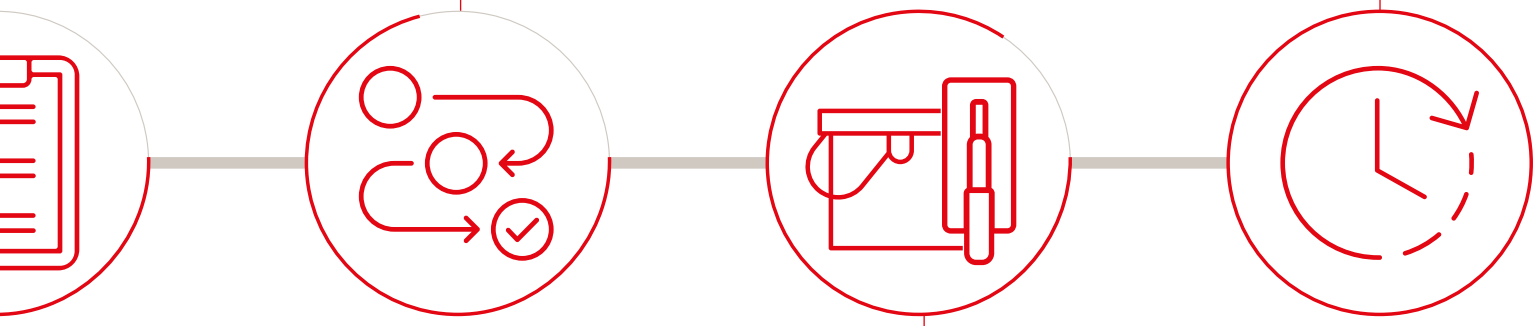
## 5. Definition of repair methods

The specific procedures for implementing the chosen repair and protection methods are selected in this step. These procedures should align with the specifications provided in the EN 1504 standard.

## 7. Future maintenance requirements

Finally, a plan for future maintenance of the structure is developed. This plan should ensure the longevity of the repair and protection measures implemented and help prevent further damage.

This step is crucial to ensure a sustainable repair process and to lengthen the lifecycle of the structure.



## 6. Definition of products and system properties

This involves defining the specifications of the products and systems to be used for the repair based on the requirements defined in parts 2 to 7 of EN 1504. Based on the information given in the corresponding product catalogues, the products can be matched to the principles and methods.

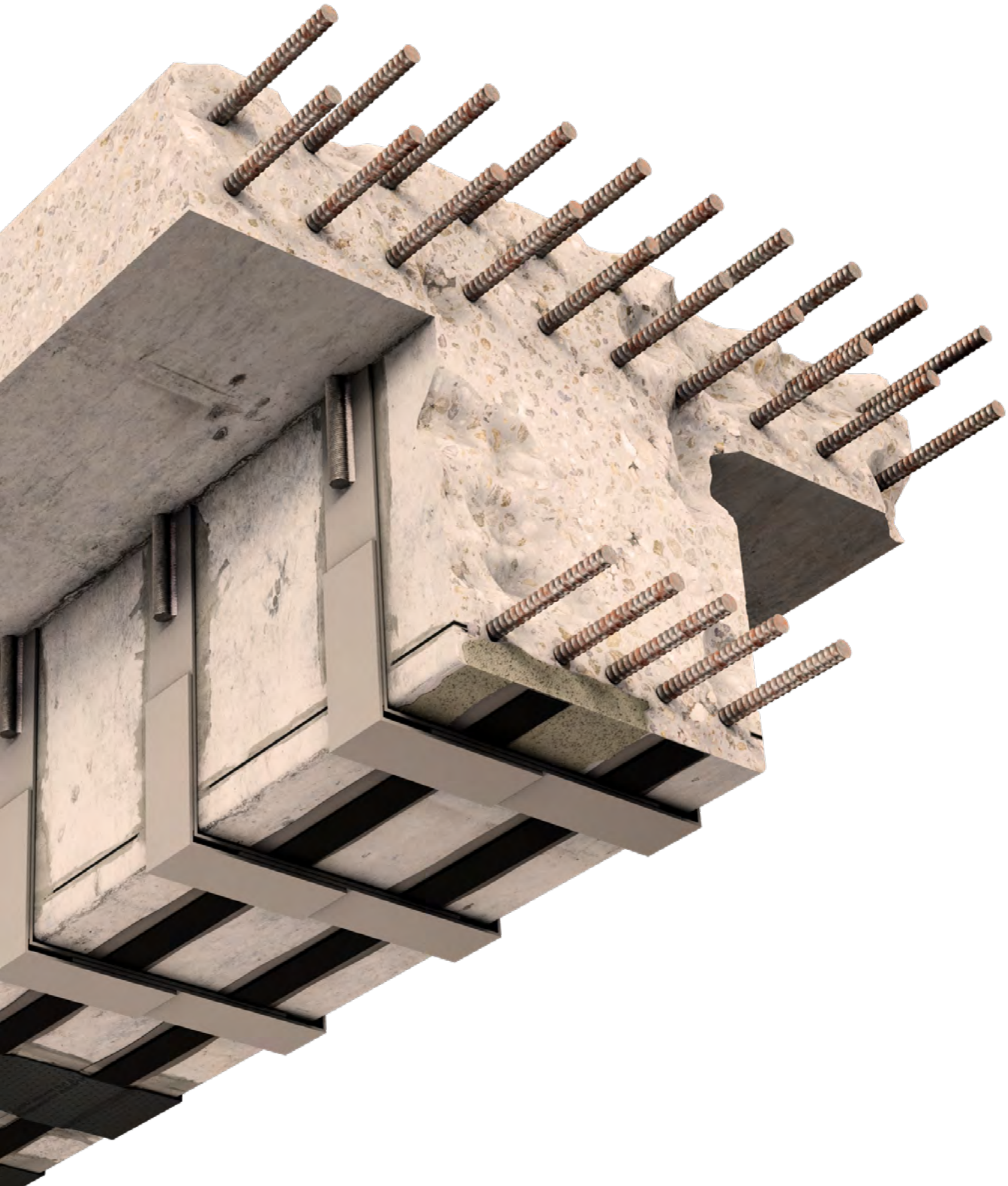
# Principles and methods of repair.

Part 9 of EN 1504 defines general principles and methods which are referred to in all other parts of the standard. These basic principles are shown in the table on the right.

For each principle, one or several methods are named in the standard. While some procedures are specific to one principle, other procedures are repeated for several principles, because they can fulfil different functionalities at the same time.

For example, a surface coating helps against the ingress of substances, while it functions as a bidirectional moisture barrier, and increases resistance against chemical as well as physical attacks.

Principles 1 to 6 are relating to damage and protection of the concrete, while principles of 7 to 11 are relating to corrosion protection of the steel reinforcement.



## Concrete

| No. | Principle | Regulated method based on principle |
|---|---|---|
| 1 | **Protection against ingress**<br>Preventing the ingress of substances that might favour corrosion or other damages. These substances might be water, other liquids, vapour, gas, chemicals or biological agents. | 1.1 Hydrophobic impregnation |
| | | 1.2 Impregnation |
| | | 1.3 Coating |
| | | 1.4 Surface bandaging of cracks |
| | | 1.5 Filling of cracks or cavities |
| | | 1.6 Transferring cracks into joints |
| | | 1.7 Erecting external panels |
| | | 1.8 Applying membranes |
| 2 | **Moisture control**<br>Setting and maintaining the moisture content within the concrete inside a predefined range. | 2.1 Hydrophobic impregnation |
| | | 2.2 Impregnation |
| | | 2.3 Coating |
| | | 2.4 Erecting external panels |
| | | 2.5 Electrochemical treatment |
| 3 | **Concrete restoration**<br>Repairing damaged or missing concrete. | 3.1 Hand-applied mortar |
| | | 3.2 Recasting with concrete or mortar |
| | | 3.3 Spraying concrete or mortar |
| | | 3.4 Replacing elements |
| 4 | **Structural strengthening**<br>Adding additional strength either due to damage or to improve the existing structure. | 4.1 Adding or replacing embedded or external reinforcing bars |
| | | 4.2 Adding reinforcement anchored in pre-formed or drilled holes |
| | | 4.3 Bonding plate reinforcement |
| | | 4.4 Adding mortar or concrete |
| | | 4.5 Injecting cracks, voids or interstices |
| | | 4.6 Filling cracks, voids or interstices |
| | | 4.7 Prestressing (post-tensioning) |
| 5 | **Physical resistance**<br>Improving the resistance against physical or mechanical attacks on the concrete. | 5.1 Coating |
| | | 5.2 Impregnation |
| | | 5.3 Adding mortar or concrete |
| 6 | **Chemical resistance**<br>Against substances such as water, chlorides. | 6.1 Coating |
| | | 6.2 Impregnation |
| | | 6.3 Adding mortar or concrete |

## Steel reinforcement

| | | |
|---|---|---|
| 7 | **Preservation or restoration of passivity**<br>Maintaining or re-applying the concrete's natural passivity to protect the embedded steel. | 7.1 Increasing cover with additional mortar or concrete |
| | | 7.2 Replacing contaminated or carbonated concrete |
| | | 7.3 Electrochemical realkalization of carbonated concrete |
| | | 7.4 Realkalization of carbonated concrete by diffusion |
| | | 7.5 Electrochemical chloride extraction |
| 8 | **Increasing resistivity**<br>Reducing the water-content of the concrete for less electrical conductivity and therefore minimizing the chance of corrosion of the steel. | 8.1 Hydrophobing |
| | | 8.2 Impregnation |
| | | 8.3 Coating |
| 9 | **Cathodic control**<br>Limiting the oxygen supply to the steel reinforcement. | 9.1 Limiting oxygen content (at the cathode) by saturation or surface coating |
| 10 | **Cathodic protection**<br>Electrochemical protection to prevent corrosion. | 10.1 Applying an electrical potential |
| 11 | **Control of anodic areas**<br>Protecting the anodic steel surface to reduce their corrosion potential. | 11.1 Active coating of the reinforcement |
| | | 11.2 Barrier coating of the reinforcement |
| | | 11.3 Applying corrosion inhibitors in or to the concrete |

# Types of damages.

## Damage to the concrete

Concrete structures, while durable and versatile, are vulnerable. Over time, they might be subjected to various deterioration processes that compromise their structural integrity as well as their appearance.

Understanding these potential damages is an essential step in effective concrete repair, ensuring the longevity and resilience of the concrete structures.

Damage to concrete can occur in many ways. For example, through simple mechanical effects, such as overloading, vibrations caused by traffic loads, and abrasion.

Concrete can also be damaged by chemical processes, such as the typical alkali-silica reaction, which occurs when components of the gravel contained in the concrete are exposed to moisture and consequently swell internally and cause the concrete to crack.

Another reason are physical influences, such as water penetration, which causes the concrete to crack due to the freeze-thaw cycle and the associated change in volume, or fire.

**Mechanical effects**
- Impact stress
- Overload
- Movement
- Explosion
- Vibration
- Earthquake

**Chemical processes**
- Alkali-silica reaction
- Aggressive chemical load, e. g., by sulfates, soft water, salts, chlorides
- Biological activities
- Efflorescence

**Physical influences**
- Freeze-thaw cycle
- Thermal effects
- Salt formations
- Shrinkage
- Erosion
- Wear and tear

## Corrosion of the steel reinforcement

In addition to concrete damage, the embedded reinforcing steel can also deteriorate caused by different influencing factors. Corrosion can be promoted by a variety of reasons, such as concrete carbonation, corrosive contaminants, or stray currents.

If the concrete cover is already damaged through progressing carbonation and the steel is exposed, this naturally leads to a considerable acceleration of steel corrosion. The embedded reinforcing steel is naturally protected by the alkaline environment of the surrounding concrete. During concrete carbonation, a chemical reaction takes place in the concrete in conjunction with carbon. In this process, the alkaline components of the concrete are converted into calcium carbonate through the supply of $CO_2$ via the environment. While this does not directly harm the concrete itself, it leads to corrosion of the embedded reinforcing steel resulting in the development of rust as by-product of the steel corrosion.

The developing rust and the consequential volume increase might cause spalling of the concrete cover. Furthermore, as a result of the steel corrosion, the effective steel cross section reduces (depassivation), causing the loss of the load-bearing capacity of the concrete structure.

Therefore, the thickness of the concrete cover and the concrete mixture need to be selected in a way that the carbonated layer does not reach the reinforcement within the foreseen service life.

During repair, the carbonated concrete parts must be removed and replaced by adequate means and concrete repair products.

Corroded steel can either be cleaned, if the rust is only on the surface layer, or must be replaced.

**Fire**

**Corrosion**

- Carbonation of the concrete
- Corrosion-promoting contamination, e.g. caused by chlorides in salt water or de-icing salts
- Stray electrical currents, e.g. high-voltage power lines of railways

The information presented in the brochure is intended for general guidance only. Additional information and advice on specific applications is available from our Technical Support Team. For this, however, we require a precise description of your particular application. All the data in this brochure must be adapted to suit local conditions and the type of material in use. Although we continuously update our technical documents based on the current regulations, please always check to the current and valid standards and norms referred to in this document.

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