The Repair and Protection of Reinforced Concrete with Sika®
In Accordance with European Standards EN 1504
Concrete Repair and Protection with Corrosion Management in Reinforced Concrete Structures

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The European Standards EN 1504 Series

The European Standards EN 1504 consist of 10 parts. With these documents products for the protection and repair of concrete structures are defined. Quality control of the repair materials production and the execution of the works on site are also all part of these standards.

- **EN 1504 – 1** Describes terms and definitions within the standard
- **EN 1504 – 2** Provides specifications for surface protection products / systems for concrete
- **EN 1504 – 3** Provides specifications for the structural and non-structural repair
- **EN 1504 – 4** Provides specifications for structural bonding
- **EN 1504 – 5** Provides specifications for concrete injection
- **EN 1504 – 6** Provides specifications for anchoring of reinforcing steel bars
- **EN 1504 – 7** Provides specifications for reinforcement corrosion protection
- **EN 1504 – 8** Describes the quality control and evaluation of conformity for the manufacturing companies
- **EN 1504 – 9** Defines the general principles for the use of products and systems, for the repair and protection of concrete
- **EN 1504 – 10** Provides information on site applications of products and quality control of the works

These standards will help owners, engineers and contractors successfully complete concrete repair and protection works to all types of concrete structures.

**CE Marking**

The European Standards EN 1504 have been fully implemented since January 1st, 2009. Existing National Standards which have not been harmonized with the new EN 1504 were therefore withdrawn at the end of 2008 and CE Marking has become mandatory. All products used for concrete repair and protection now have to be CE marked in accordance with the appropriate part of EN 1504. This CE conformity marking contains the following information – using the example of a concrete repair mortar suitable for structural use:

- **CE – Symbol**
- **Identification number of the notified body**
- **Name or identifying mark of the producer**
- **Year in which the marking was affixed**
- **Certificate number as on the attestation certificate**
- **Number of the relevant part of the European Standard**
- **Description of the product**
- **Additional information on the regulated characteristics**
### Management Strategy

Based on the assessment of the survey, the owner has a number of options to be selected while deciding the relevant actions to meet the future requirements of the structure.

For example, the repair options can be defined from the following:
- Do nothing or downgrade the capacity
- Prevent or reduce further damage without repair
- Repair all or part of the structure
- Reconstruction of all or part of the structure
- Demolition

Important factors when considering these options:
- Intended design life following repair and protection
- Required durability or performance
- Safety issues during repair works
- Possibility of further repair works in the future including access and maintenance
- Consequences and likelihood of structural failure
- Consequences and likelihood of partial failure

And environmentally:
- Protection from sun, rain, frost, wind, salt and/or other pollutants during the works
- Environmental impact of, or restrictions on the works in progress
- Noise and dust pollution
- Time needed to carry out the work etc.

Future maintenance:

Any future inspection and maintenance work that will need to be undertaken during the defined service life of the structure, shall also be defined as part of the management strategy.

### Process of Assessment

In-depth condition survey shall be made of the visible and not readily visible defects of a structure to address the root causes of the damage. This will be used to assess the ability of the structure to perform its function.

The survey and its assessment shall only be carried out by a suitably qualified and experienced person.

In the event of not carrying out any repairs to the concrete structure, a qualified engineer may give an estimation of the remaining service life.

The aim of a concrete survey is to identify defects:
- Types of defects to the concrete
  - Mechanical
  - Chemical
  - Physical
- Defects in concrete due to reinforcement corrosion

### Project Phases of the Concrete Repair and Protection Process

In Accordance with European Standard EN 1504-9

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
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<tbody>
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<td>1</td>
<td>Information about the Structure</td>
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<tr>
<td>2</td>
<td>Process of Assessment</td>
</tr>
<tr>
<td>3</td>
<td>Management Strategy</td>
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<tr>
<td>4</td>
<td>Design of Repair Work</td>
</tr>
<tr>
<td>5</td>
<td>Repair Work</td>
</tr>
<tr>
<td>6</td>
<td>Acceptance of Repair Work</td>
</tr>
</tbody>
</table>

### Information about the Structure

A study is carried out at the beginning of a project to collect information about the structure. This may include:
- General condition and history
- Documentation e.g. calculations, drawings and specifications etc.
- Repair and maintenance schedule

This information will provide valuable data to understand the existing condition of the structure.

### Process of Assessment

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  - Physical
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- Safety issues during repair works
- Possibility of further repair works in the future including access and maintenance
- Consequences and likelihood of structural failure
- Consequences and likelihood of partial failure

And environmentally:
- Protection from sun, rain, frost, wind, salt and/or other pollutants during the works
- Environmental impact of, or restrictions on the works in progress
- Noise and dust pollution
- Time needed to carry out the work etc.

Future maintenance:

Any future inspection and maintenance work that will need to be undertaken during the defined service life of the structure, shall also be defined as part of the management strategy.

### Design of Repair Work

The relevant protection and repair principles will be defined from EN 1504-9 and the repair options contained in the management strategy.

The design philosophy for repair shall take into consideration the following:
- Type, causes and extend of defects
- Future service conditions
- Future maintenance program

Following the selection of the relevant principles from EN 1504-9, the design engineer shall also consider the intended use of the structure.

In the case of concrete refurbishment, the specifications can be drawn up based on the requirements of the relevant parts 2 to 7 of EN 1504 (e.g. freeze and thaw cycles in external situations where appropriate).

It is important this work considers not only the long term performance of the structure, but also the effect of the selected materials on the rest of the structure i.e. no adverse affect.

### Repair Work

Based on the relevant principles selected from EN 1504, the appropriate method of work is then based on:
- Site access
- Site conditions (e.g. selection of appropriate repair method – patch repair, pouring or spray application)
- Health and safety issues
- etc.

The surface preparation, application and Quality Control procedure for the repair works shall be carried out in accordance with the recommendations contained in Part 10 of EN 1504.

### Acceptance of Repair Work

Complete records of all the materials used in the works shall be provided for future reference at the end of each project. These shall include the answer to these following issues:
- What is the anticipated new life expectancy?
- What is the mode and result of the selected materials’ eventual deterioration, i.e. chalking, embrittlement, discoloration or delamination?
- What is the inspection period?
- What remedial work might be required in case of deterioration?
Concrete Defects and Damage

### Chemical attack

**Cause**
- AAR: Alkali aggregate reactions
- Aggressive chemical exposure
- Bacterial or other biological action
- Efflorescence/leaching

**Mechanical attack**

**Physical attack**

**Cause**
- Freeze/thaw action
- Thermal movement
- Salt crystal expansion
- Shrinkage
- Erosion
- Abraision and wear

### Mechanical attack

**Cause**
- Impact
- Overloading
- Movement
- Vibration
- Earthquake
- Explosion

**Relevant principles for repair and protection**
- Principles 3, 5
- Principles 3, 4
- Principles 3, 4
- Principles 3, 4
- Principles 3, 5

### Chemical attack

**Cause**
- Carbon dioxide (CO₂) in the atmosphere reacting with calcium hydroxide in the concrete pore liquid.
- \[ \text{CO}_2 + \text{Ca(OH)}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]
- Soluble and strongly alkaline pH 12 – 13
- Almost insoluble and much less alkaline pH 9

**Steel**
- Protected (passivation)
- Unprotected

### Physical attack

**Cause**
- Freeze/thaw action
- Thermal movement
- Salt crystal expansion
- Shrinkage
- Erosion
- Abraision and wear

**Relevant principles for repair and protection**
- Principles 1, 2, 3, 7, 8, 11

### Corrosion Due to Steel Reinforcement

**Chemical attack**

**Cause**
- Chlorides accelerate the corrosion process and can also cause dangerous “pitting” corrosion
- At above 0.2 – 0.4% concentration in the concrete, chlorides can break down the passive oxide protective layer on the steel surface
- Chlorides are typically from marine/salt water exposure and/or the use of de-icing salts

**Relevant principles for repair and protection**
- Principles 1, 2, 3, 7, 8, 9, 11

**Corrosive contaminants e.g. Chlorides**

**Cause**
- Chlorides

**Physical attack**

**Chemical attack**

**Cause**
- Metals of different electropotential are connected to each other in the concrete and corrosion occurs

**Relevant principles for repair and protection**
- Principles 2, 3, 10

**Stray electrical current**

**Cause**
- No specific repair principles defined at this time

**Relevant principles for repair and protection**
- Principles 1, 2, 3, 10
The repair and protection of concrete structures require relatively complex assessment and design. By introducing and defining the key principles of repair and protection, EN 1504-9 helps owners and construction professionals to fully understand the problems and solutions throughout the different stages of the repair and protection process.

### The Principles Relating to Concrete Defects

- **Principle 1 (PI)**
  Protection against ingress

- **Principle 2 (MC)**
  Moisture control

- **Principle 3 (CR)**
  Concrete restoration

- **Principle 4 (SS)**
  Structural strengthening

- **Principle 5 (PR)**
  Increasing physical resistance

- **Principle 6 (RC)**
  Resistance to chemicals

### The Principles Relating to Steel Reinforcement Corrosion

- **Principle 7 (RP)**
  Preserving or restoring passivity

- **Principle 8 (IR)**
  Increasing resistivity

- **Principle 9 (CC)**
  Cathodic control

- **Principle 10 (CP)**
  Cathodic protection

- **Principle 11 (CA)**
  Control of anodic areas
The Principles of Concrete Repair and Protection

Why Principles?

For many years the different types of damage and the root causes of this damage have been well known and equally the correct repair and protection methods have also been established. All of this knowledge and expertise is now summarized and clearly set out as 11 Principles in EN 1504, Part 9. These allow the engineer to correctly repair and protect all of the potential damage that can occur in reinforced concrete structures. Principles 1 to 6 relate to defects in the concrete itself, Principles 7 to 11 relate to damage due to reinforcement corrosion.

The European Union fully introduced all of the European Standards 1504 on 1st January 2009. These Standards define the assessment and diagnostic work required, the necessary products and systems including their performance, the alternative procedures and application methods, together with the quality control of the materials and the works on site.

The Use of the EN 1504 Principles

To assist owners, engineers and contractors with the correct selection of repair Principles, Methods and then the appropriate products, together with their specification and use, Sika has developed a useful schematic system of approach. This is designed to meet the individual requirements of a structure, its exposure and use and is illustrated on pages 42 to 45 of this brochure.

Expertise and Experience from Sika

The Sika Solutions in Accordance with EN 1504

Sika is a global market and technology leader in the development and production of specialist products and systems for construction. The Repair and Protection of concrete structures is one of Sika’s core competencies, with the Sika range including concrete admixtures, resin flooring and coating systems, all types of waterproofing solutions, sealing, bonding and strengthening solutions, as well as the complete range of products developed specifically for the repair and protection of concrete structures. These Sika products have all relevant international approvals and are available worldwide through the local Sika companies and our specialist contracting and distribution partners.

During the past 100 years, Sika has gained extensive experience and expertise in all aspects of concrete repair and protection, with documented project references dating back to the 1920’s. Sika provides ALL of the necessary products for the technically correct repair and protection of concrete, ALL of which are fully in accordance with the Principles and Methods now defined in European Standards EN 1504. These include systems to repair damage and defects in the concrete and also to repair damage caused by steel reinforcement corrosion. Special Sika products and systems are also available for use on many different specific types of structures and for carrying out concrete repair works in all different application, climatic and exposure conditions.
An Overview of the Principles and Methods of Repair and Protection from EN 1504-9

Tables 1 and 2 include all of the repair Principles and Methods in accordance with Part 9 of EN 1504. Following assessment from the condition survey and diagnosis of the root causes of damage, together with the owners repair objectives and requirements, the appropriate EN1504 repair Principles and Methods can be selected.

### Table 1: Principles and Methods Related to Concrete Defects

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Method</th>
<th>Sika Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 1</strong> (PI)</td>
<td>Protection against ingress. Reducing or preventing the ingress of adverse agents, e.g. water, other liquids, vapour, gas, chemicals and biological agents.</td>
<td>1.1 Hydrophobic impregnations</td>
<td>Sikagard® range of hydrophobic impregnations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 Impregnations</td>
<td>Sikafloor® range of impregnations</td>
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<tr>
<td></td>
<td></td>
<td>1.3 Coating</td>
<td>Sikafloor® range of impregnations</td>
</tr>
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<td>1.4 Surface bandaging of cracks</td>
<td>Sikaflex® range, Sikadur®-Combiflex® System</td>
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<tr>
<td></td>
<td></td>
<td>1.5 Filling of cracks</td>
<td>Sikadur®-Combiflex® System</td>
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<td></td>
<td></td>
<td>1.6 Transferring cracks into joints</td>
<td>Sikatouch®-Panel System</td>
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<td></td>
<td></td>
<td>1.7 Erecting external panels</td>
<td>Sikaplan® sheet membranes, Sikalastic® liquid membranes</td>
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<tr>
<td></td>
<td></td>
<td>1.8 Applying membranes</td>
<td>Sikaplan® sheet membranes, Sikalastic® liquid membranes</td>
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</tbody>
</table>

### Table 2: Principles and Methods Related to Concrete Defects

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Method</th>
<th>Sika Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 2</strong> (MC)</td>
<td>Moisture control. Adjusting and maintaining the moisture content in the concrete within a specified range of values.</td>
<td>2.1 Hydrophobic impregnation</td>
<td>Sikagard® range of hydrophobic impregnations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.2 Impregnation</td>
<td>Sikafloor® range of impregnations</td>
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<tr>
<td></td>
<td></td>
<td>2.3 Coating</td>
<td>Sikafloor® range of impregnations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4 Erecting external panels</td>
<td>Sikaflex® range, Sikadur®-Combiflex® System</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5 Electrochemical treatment</td>
<td>A process</td>
</tr>
</tbody>
</table>

### Table 2: Principles and Methods Related to Steel Reinforcement Corrosion

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Method</th>
<th>Sika Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 3</strong> (CR)</td>
<td>Concrete restoration. Restoring the original concrete to the originally specified profile and function. Restoring the concrete structure by replacing part of it.</td>
<td>3.1 Hand applied mortar</td>
<td>Sikadur®-32, Sikatop®-910, Sikatop®-110 EpoCem®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.2 Recasting with concrete or mortar</td>
<td>Sikadur®-32, Sikatop®-910, Sikatop®-110 EpoCem®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.3 Spraying concrete or mortar</td>
<td>Sikadur®-32, Sikatop®-910, Sikatop®-110 EpoCem®</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.4 Replacing elements</td>
<td>Sikadur®-32, Sikatop®-910, Sikatop®-110 EpoCem®</td>
</tr>
</tbody>
</table>

### Table 2: Principles and Methods Related to Steel Reinforcement Corrosion

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Method</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 4</strong> (SS)</td>
<td>Structural strengthening. Increasing or restoring the structural load bearing capacity of an element of the concrete structure.</td>
<td>4.1 Adding or replacing embedded or external reinforcing bars</td>
<td>Sikadur® range</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2 Adding reinforcement anchored in pre-formed or drilled holes</td>
<td>Sikadur®-910 adhesive systems combine with Sika® CarboDur® and SikaWrap®</td>
</tr>
<tr>
<td></td>
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<td>4.3 Bonding plate reinforcement</td>
<td>Sika® bonding primers, repair mortars and concrete technology</td>
</tr>
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<td></td>
<td>4.4 Adding mortar or concrete</td>
<td>Sika®-110 EpoCem® admixtures and surface applied corrosion inhibitors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.5 Injecting cracks, voids or interstices</td>
<td>Sika®-110 EpoCem® admixtures and surface applied corrosion inhibitors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.6 Filling cracks, voids or interstices</td>
<td>Sika®-110 EpoCem® admixtures and surface applied corrosion inhibitors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.7 Prestressing (post-tensioning)</td>
<td>Sika®-110 EpoCem® admixtures and surface applied corrosion inhibitors</td>
</tr>
</tbody>
</table>

### Table 2: Principles and Methods Related to Steel Reinforcement Corrosion

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Method</th>
<th>Sika Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 5</strong> (PR)</td>
<td>Physical resistance. Increasing resistance to physical or mechanical attack.</td>
<td>5.1 Coating</td>
<td>Sikadur® reactive coatings range, Sikafloor® systems</td>
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<td></td>
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<td>5.2 Impregnation</td>
<td>–</td>
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<tr>
<td></td>
<td></td>
<td>5.3 Adding mortar or concrete</td>
<td>As for Methods 3.1, 3.2 and 3.3</td>
</tr>
</tbody>
</table>

### Table 2: Principles and Methods Related to Steel Reinforcement Corrosion

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
<th>Method</th>
<th>Sika Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle 6</strong> (RC)</td>
<td>Resistance to chemicals. Increasing resistance of the concrete surface to deteriorations from chemical attack.</td>
<td>6.1 Coating</td>
<td>Sikadur® and Sikafloor® reactive coatings range</td>
</tr>
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<td></td>
<td></td>
<td>6.2 Impregnation</td>
<td>–</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.3 Adding mortar or concrete</td>
<td>As for Methods 3.1, 3.2 and 3.3</td>
</tr>
</tbody>
</table>

## References
- Sika® Adhesives: [www.sika.com](http://www.sika.com)
EN 1504-9 Principle 1: Protection against Ingress (PI)
Protecting the Concrete Surface against Liquid and Gaseous Ingress

A large amount of concrete damage is the result of the penetration of deleterious materials into the concrete, including both liquid and gaseous materials. The Principle 1 (PI) deals with preventing this ingress and includes Methods to reduce the concrete permeability and porosity of the concrete surfaces to these different materials.

The selection of the most appropriate method is dependent on different parameters, including the type of deleterious material, the quality of the existing concrete and its surface, the objectives of the repair or protection works and the maintenance strategy.

Sika produces a full range of impregnations, hydrophobic impregnations and specialized coatings for use in protecting concrete according to the Principles and Methods of EN 1504.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Pictures</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1.1 Hydrophobic Impregnation</td>
<td></td>
<td>A hydrophobic impregnation is defined as the treatment of concrete to produce a water-repellent surface. The pores and capillary network are not filled, but only lined with the hydrophobic material. This functions by reducing the surface tension of liquid water, preventing its passage through the pores, but still allowing each way water vapour diffusion, which is in accordance with standard good practice in building physics.</td>
<td>Penetration: Class I: &lt;10 mm; Class II: ≥10 mm</td>
<td>Sikagard®-700 range</td>
</tr>
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<td></td>
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<td></td>
<td>Capillary absorption: ( w &lt; 0.1 \text{ kg/(m}^2 \times \sqrt{\text{h)}) )</td>
<td>Based on silane or siloxane hydrophobic impregnations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Drying rate coefficient</td>
<td>penetrates deeply and provides a liquid water repellent surface</td>
</tr>
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<td></td>
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<td></td>
<td>Corresponding part of the Standards: EN 1504-2</td>
<td>Sikagard®-705 Thixo (Class II)</td>
</tr>
<tr>
<td>Method 1.2 Impregnation</td>
<td></td>
<td>An impregnation is defined as the treatment of concrete to reduce the surface porosity and to strengthen the surface. The pores and capillaries are then partly or totally filled. This type of treatment usually also results in a discontinuous thin film of 10 to 100 microns thickness on the surface. This serves to block the pore system to aggressive agents.</td>
<td>Penetration depth: ( \geq 5 \text{ mm} )</td>
<td>Sikagard®-704 S (Class I)</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Capillary absorption: ( w &lt; 0.1 \text{ kg/(m}^2 \times \sqrt{\text{h)}) )</td>
<td>Sikagard®-700 S (Class I)</td>
</tr>
<tr>
<td>Method 1.3 Coating</td>
<td></td>
<td>Surface coatings are defined as materials designed to provide an improved concrete surface, for increased resistance or performance against specific external influences. Fine surface cracks with a total movement of up to 0.3 mm can be safely repaired, then sealed and their movement accommodated by the use of elastic, crack bridging coatings, which are also waterproof and carbonation resistant. This will accommodate thermal and dynamic movement in structures subject to wide temperature fluctuation, vibration, or that have been constructed with inadequate or insufficient jointing details.</td>
<td>Carbonation resistance: ( S_d \geq 50 \text{ m} )</td>
<td>Rigid systems: Sikagard®-680 S</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Capillary absorption: ( w &lt; 0.1 \text{ kg/(m}^2 \times \sqrt{\text{h)}) )</td>
<td>Based on acrylic resin, solvent based</td>
</tr>
<tr>
<td></td>
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<td>Water vapour permeability: Class I: ( S_d \geq 5 \text{ m} )</td>
<td>Waterproof</td>
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<td>Adhesion strength: Elastic: ( \geq 0.8 \text{ N/mm}^2 ) or ( \geq 1.5 \text{ N/mm}^2 ) (trafficking)</td>
<td>Sikagard®-550 W Elastic</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Rigid: ( \geq 1.0 \text{ N/mm}^2 ) or ( \geq 2.0 \text{ N/mm}^2 ) (trafficking)</td>
<td>Acrylic resin, water based</td>
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<td></td>
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<td>Corresponding part of the Standards: EN 1504-2</td>
<td>Waterproofing and crack-bridging</td>
</tr>
<tr>
<td>Method 1.4 Surface banding of cracks</td>
<td></td>
<td>Locally applying a suitable material to prevent the ingress of aggressive media into the concrete.</td>
<td>No specific criteria</td>
<td>Sikagard®-Combiflex® System</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Extremely flexible</td>
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<td></td>
<td>Weather and water resistant</td>
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<td></td>
<td>Excellent adhesion</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>Sikadur®-SealTape-S</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>High elasticity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Waterproof</td>
</tr>
</tbody>
</table>

* This table is continued on pages 16 and 17.
EN 1504-9 Principle 1: Protection against Ingress (PI)  
Protecting the Concrete Surface against Liquid and Gaseous Ingress (continued)

All concrete protection works must take account of the position and size of any cracks and joints in the concrete. This means investigating their nature and cause, understanding the extent of any movement in the substrate and its effect on the stability, durability and function of the structure, as well as evaluating the risk of creating new cracks as a result of any remedial joint or crack treatment and repair.

If the crack has implications for the integrity and safety of a structure, refer to Principle 4 Structural strengthening, Methods 4.5 and 4.6 on Page 24/25. This decision must always be taken by the structural engineer and then the selected surface treatments can then be applied successfully.

### Methods

**Method 1.5 Filling of Cracks**
- **Description:** Cracks to be treated to prevent the passage of aggressive agents should be filled and sealed.
  - Non-moving cracks – These are cracks that have been formed by initial shrinkage for example, they need only to be fully exposed and repaired / filled with a suitable repair material.

**Method 1.6 Transferring cracks into joints**
- **Description:** Cracks to be treated to accommodate movement should be repaired so that a joint is formed to extend through the full depth of the repair and positioned to accommodate that movement. The cracks (joints) must then be filled, sealed or covered with a suitably elastic or flexible material. The decision to transfer a crack to the function of a movement joint must be made by a structural engineer.

**Method 1.7 Erecting of external panels**
- **Description:** Protecting the concrete surface with external Panels. A curtain wall or similar external façade cladding system, protects the concrete surface from external weathering and aggressive materials attack or ingress.

**Method 1.8 Applying membranes**
- **Description:** Applying a preformed sheet or liquid applied membrane over the concrete surface will fully protect the surface against the attack or ingress of deleterious materials.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Pictures</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1.5</td>
<td><img src="image1" alt="Filling of Cracks" /></td>
<td>Cracks to be treated to prevent the passage of aggressive agents should be filled and sealed. Non-moving cracks – These are cracks that have been formed by initial shrinkage for example, they need only to be fully exposed and repaired / filled with a suitable repair material.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method 1.6</td>
<td><img src="image2" alt="Transferring cracks into joints" /></td>
<td>Cracks to be treated to accommodate movement should be repaired so that a joint is formed to extend through the full depth of the repair and positioned to accommodate that movement. The cracks (joints) must then be filled, sealed or covered with a suitably elastic or flexible material. The decision to transfer a crack to the function of a movement joint must be made by a structural engineer.</td>
<td>No specific criteria</td>
<td></td>
</tr>
<tr>
<td>Method 1.7</td>
<td><img src="image3" alt="Erecting of external panels" /></td>
<td>Protecting the concrete surface with external Panels. A curtain wall or similar external façade cladding system, protects the concrete surface from external weathering and aggressive materials attack or ingress.</td>
<td>No specific criteria</td>
<td></td>
</tr>
<tr>
<td>Method 1.8</td>
<td><img src="image4" alt="Applying membranes" /></td>
<td>Applying a preformed sheet or liquid applied membrane over the concrete surface will fully protect the surface against the attack or ingress of deleterious materials.</td>
<td>No specific criteria</td>
<td></td>
</tr>
</tbody>
</table>

**Classification of injection materials:**
- D: ductile
- S: swelling

**No specific criteria**
- **Sikaflex® PU and AT- ranges**
  - One-component polyurethanes
  - High movement capability
  - Excellent durability

**Sikadur®-Combiflex® System**
- Extremely flexible
- Weather and water resistant
- Excellent adhesion

**SikaTack®-Panel System**
- for the discrete or ‘secret fixing’ of curtain wall façade systems
- One-component polyurethane

**Sikaplan® sheet membranes**
- Full surface waterproofing

**Sikalastic® liquid membranes**
- Waterproofing
- Particularly useful for complex details

Waterproof Sealing of Joints/Cracks/Voids:
- **Class D:** Sika® Injection-201/-203
- **Class S:** Sika® Injection-29/-304/-305
EN 1504-9 Principle 2: Moisture Control (MC)
Adjusting and Maintaining the Moisture Content in the Concrete

In some situations, such as where there is a risk of further alkali aggregate reaction, the concrete structure has to be protected against water penetration.

This can be achieved by the use of different types of products including hydrophobic impregnations, surface coatings and electrochemical treatments.

For many years, Sika has been one of the pioneers in concrete protection through the use of deeply penetrating silane and siloxane hydrophobic impregnations, plus durable acrylic and other resin based protective coatings.

Several of these are also tested and approved for use in conjunction with the latest electrochemical treatment techniques.

All of these Sikab products for the Method “Moisture Control” are fully in accordance with the requirements of EN 1504.

### Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Pictures</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
</table>
| **Method 2.1** Hydrophobic Impregnation | ![Picture](#) | A hydrophobic impregnation is defined as the treatment of concrete to produce a water-repellent surface. The pores and capillary network are not filled, but only lined with the hydrophobic material. This function by reducing the surface tension of liquid water, thus preventing its passage through the pores, but still allowing each way water vapour diffusion, which is in accordance with standard good practice in building physics. | Penetration:  
Class I: <10 mm  
Class II: ≥10 mm  
Capillary absorption:  
aw <0.1 kg/(m² × √h)  
Drying rate coefficient | Sikagard®-700 range  
Based on silane or siloxane hydrophobic impregnations  
Penetrate deeply and provide a liquid water repellent surface |
| **Method 2.2** Impregnation | ![Picture](#) | An impregnation is defined as the treatment of concrete to reduce the surface porosity and to strengthen the surface. The pores and capillaries are then partly or totally filled. This type of treatment usually also results in a discontinuous thin film of 10 to 100 microns thickness on the surface. This serves to block the pore system to aggressive agents. | Penetration depth:  
≥5 mm  
Capillary absorption:  
aw <0.1 kg/(m² × √h) | Sikafloor®-2420  
Based on epoxy resin  
Good bond to smooth surfaces  
Good penetration behaviour |
| **Method 2.3** Coating | ![Picture](#) | Surface coatings are defined as materials designed to provide an improved concrete surface, for increased resistance or performance against specific external influences. Fine surface cracks with a total movement of up to 0.3 mm can be safely repaired, then sealed and their movement accommodated by crack bridging coatings which are also for waterproof and carbonation resistant. This is to accommodate thermal and dynamic movement in structures subject to wide temperature fluctuation, vibration, or that have been constructed with inadequate or insufficient jointing details. | Capillary absorption:  
aw <0.1 kg/(m² × √h)  
Water vapour permeability:  
Class I: Sd <5 m  
Adhesion strength:  
Elastic: ≥0.8 N/mm² or ≥1.5 N/mm² (trafficking)  
Rigid: ≥1.0 N/mm² or ≥2.0 N/mm² (trafficking) | Sikagard®-680 S  
Acrylic resin, solvent based  
Waterproof  
Elastos®-650 W Elastic  
Acrylic resin, water based  
Waterproofing and crack-bridging  
Sikagard®-645 W ElastoFill  
One component acrylic resin  
Elastic  
Sikagard®-675 W ElastoColor  
Acrylic resin, water based  
Waterproof |
| **Method 2.4** Erecting external panels | ![Picture](#) | As long as the concrete surface is not exposed, no water can penetrate and the reinforcement can not corrode. | No specific criteria | SikaTack®-Panel System  
For the discrete or “secret fixing” of curtain wall façade systems  
One-component polyurethane |
| **Method 2.5** Electrochemical treatment | ![Picture](#) | By applying an electric potential in the structure, moisture can be moved towards the negatively charged cathode area. | No specific criteria | This is a process |
EN 1504-9 Principle 3: Concrete Restoration (CR)
Replacing and Restoring Damaged Concrete

The selection of the appropriate method of replacing and restoring concrete depends on a number of parameters including:

- The extent of damage (e.g. Method 3.1 Hand applied mortar, is more economic for limited damage)
- Congestion of rebar (e.g. Method 3.2 Recasting with concrete or mortar is usually to be preferred in the presence of heavily congested bars).

### Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
</table>
| Method 3.1 | Hand-applied mortar                                                          | Traditionally the localised repair of concrete defects and damage has been undertaken using hand-placed repair mortars. Sika provides an extensive range of pre-batched, hand-applied repair mortars for general repair purposes and also for very specific repair requirements. These include lightweight mortars for overhead application and chemically resistant materials to protect against aggressive gases and chemicals. | Class R4: 
Sika® MonoTop®-412 range |
- High performance repair mortar
- Extremely low shrinkage behavior |
Class R3: 
Sika® MonoTop®-352 range |
- Extremely low shrinkage behavior
- Lightweight repair mortar |
Class R2: 
Sika® MonoTop®-211 range |
- Fast setting repair mortar
- Corrosion inhibitor inside (FerroGard-Technology) |
SikaGrout®-318 |
- High final strengths
- Expands during the plastic phase of curing
- Excellent flow characteristics |
Sikafloor®-82/-83 EpoCem |
- Epoxy modified cement mortar
- High performance characteristics
- Temporary moisture barrier |
| Method 3.2 | Recasting with concrete or mortar                                            | Typical recasting repairs, which are also frequently described as pourable or grouting repairs, are employed when whole sections or larger areas of concrete replacement are required. These include the replacement of all, or substantial sections of, concrete bridge parapets and balcony walls etc. This method is also very useful for complex structural supporting sections, such as cross head beams, piers and column sections, which often present problems with restricted access and congested reinforcement. The most important criteria for the successful application of this type of product is its flowability and the ability to move around obstructions and heavy reinforcement. Additionally they often have to be poured in relatively thick sections without problems of thermal shrinkage cracking. This is to ensure that they can fill the desired volume and areas completely, despite the restricted access or application points. Finally they must also harden to provide a suitably finished surface, which is tightly closed and free of cracks. | Class R4: 
Sika® MonoTop®-438 R |
- One component
- Pourable
- Rapid hardening |
SikaGrout®-318 |
- High final strengths
- Expands during the plastic phase of curing
- Excellent flow characteristics |
Sikafloor®-82/-83 EpoCem |
- Epoxy modified cement mortar
- High performance characteristics
- Temporary moisture barrier |

* This table is continued on pages 22 and 23.
### Selection of the concrete replacement / restoring method (continued)

- **Site access** (e.g. Method 3.3 Spraying concrete or mortar by the “dry” spray process will be more suitable for long distances between the repair area and the point of preparation).
- **Quality control issues** (e.g. Method 3.3 Sprayed concrete or mortar results in higher quality due to better compaction).
- **Economic aspects** (e.g. Method 3.4 replacement of the whole or part of the structure by precast concrete elements).

#### Methods

<table>
<thead>
<tr>
<th>Method 3.3</th>
<th>Spraying concrete or mortar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corresponding part of the Standards: EN 1504-3</td>
<td></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>Spray applied materials have also been used traditionally for concrete repair works. They are particularly useful for large volume concrete replacement, for providing additional concrete cover, or in areas with difficult access for concrete pouring or the hand placement of repairs. Today in addition to traditional dry spray machines, there are also “wet spray” machines. These have a lower volume output, but also much lower rebound, plus they produce less dust than the dry spray machines. Therefore they can also be used economically for smaller or more sensitive repair areas, where there is restricted access, or in confined environments. The most important application criteria for sprayed repair materials are minimal rebound, plus high-build properties to achieve the required non-sag layer thickness. Application under dynamic load and minimal or easy finishing and curing, are also important due to their areas of use and the difficulties in access.</td>
</tr>
<tr>
<td><strong>Main Criteria</strong></td>
<td>Structural repair: Class R4 Class R3</td>
</tr>
<tr>
<td><strong>Sika® Products</strong> (examples)</td>
<td>Class R4: SikaCem® Gunit -133 <strong>High performance repair mortar</strong> Very dense, high carbonation resistance “Dry” spray mortar Sika® MonoTop®-412 range <strong>High performance repair mortar</strong> Extremely low shrinkage behaviour Applied by hand or “wet” spray applied</td>
</tr>
<tr>
<td><strong>Class R3:</strong></td>
<td>Sikaacrete®-103 Gunit <strong>One-component</strong> Contains silica fume “Dry” spray mortar Sika® MonoTop®-352 range <strong>Extremely low shrinkage behaviour</strong> Lightweight repair mortar Applied by hand or “wet” spray applied</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Method 3.4</th>
<th>Replacing concrete elements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corresponding part of the Standards: None</td>
<td></td>
</tr>
<tr>
<td><strong>Description</strong></td>
<td>In some situations it can be more economical to replace either the whole structure or part of it, rather than to carry out extensive repair works. In this situation, care needs to be taken to provide appropriate structural support and load distribution during the works, for example by using suitable bonding systems or agents to ensure this is maintained.</td>
</tr>
<tr>
<td><strong>Main Criteria</strong></td>
<td>No specific criteria</td>
</tr>
<tr>
<td><strong>Sika® Products</strong> (examples)</td>
<td>System consisting of Sika® bonding primer and Sika® concrete technology Sika® bonding primers: SikaTop® Armatec®-110 EC <strong>Epoxy modified high performance</strong> Long open time Sikadur®-32 <strong>Two part epoxy based</strong> High strength characteristics Sika® concrete technology: Sika® ViscoCrete® range Sikament® range</td>
</tr>
</tbody>
</table>
Increasing or Restoring the Structural Load Capacity

EN 1504-9 Principle 4: Structural Strengthening (SS)

The selection of the appropriate method is dependent on the different project parameters such as the type of structure, cost, site environment and conditions, plus access and maintenance possibilities etc.

Sika has pioneered the development of many new materials and techniques in the field of structural strengthening. Since the early 1960’s this has included the development of steel plate bonding and epoxy structural adhesives. In the 1990’s Sika began working on the adaptation of these techniques using modern composite materials, particularly pultruded carbon fibre plates (Sika® CarboDur®).

Since then, Sika has further developed this technology by using multidirectional fabrics (SikaWrap®) based on several different polymer types (carbon, glass, aramid, etc.).

**Methods**

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
</table>
| Method 4.1 Adding or replacing embedded or external reinforcing bars | The selection of the appropriate size and configuration of such reinforcement, plus the locations where it is to be fixed, must always be determined by the structural engineer. | No specific criteria | For embedded bars:  
Sikadur~30  
- Structural adhesive  
- High mechanical strength  
- Excellent bond characteristics |
| Method 4.2 Adding reinforcement anchored in pre-formed or drilled holes | The points for anchorages into the concrete should be designed, produced and installed in accordance with EN 1504 Part 6 and the relevant European Technical Approval Guideline (ETAG-001). The surface cleanliness of the grooves or anchor holes cut in the concrete should be prepared to be in accordance with EN 1504 Part 10 Sections 7.2.2 and 7.2.3. | Pull-out: Displacement ≤0.6 mm at load of 75 kN  
Creep under tensile load: Displacement ≤0.6 mm after continuous loading of 50 kN after 3 month  
Chlorid ion content: ≤0.05% | Sika®AnchorFix~1  
- Fast setting methacrylate based anchoring adhesive  
- Can be used at low temperatures (-10 °C)  
Sika®AnchorFix~2  
- ETA approved for structural applications  
- Fast and secure bonding of additional steel reinforcement into concrete structures  
Sika®AnchorFix~3  
- High performance epoxy adhesive  
- Shrink-free hardening |
| Method 4.3 Bonding plate reinforcement | Structural strengthening by the bonding of external plates is carried out in accordance with the relevant national design codes and EN 1504-4. The exposed surfaces of the concrete that are to receive externally bonded reinforcement should be thoroughly cleaned and prepared. Any weak, damaged or deteriorated concrete must be removed and repaired, to comply with EN 1504 Part 10 Section 7.2.4 and Section 8. This must be completed prior to the overall surface preparation and plate-bonding application work being undertaken. | Shear strength: ≥12 N/mm²  
E-Modulus in compression: ≥2000 N/mm²  
Coefficient of thermal expansion: ≤100 ×10⁻⁶ per K | Sikadur~30  
- Epoxy based adhesive for use with the carbon fibre reinforced Sika® CarboDur® system and traditional steel plate reinforcement.  
Sikadur~330  
- Epoxy based adhesive used with SikaWrap® systems. |
| Method 4.4 Adding mortar or concrete | These methods and Sika systems are well documented in Principle 3 Concrete restoration. To ensure the necessary performance, these products also have to fulfill the requirements of EN 1504-3, class 3 or 4. | Mortar/Concrete: Class R4 or R3  
Adhesives: Shear strength ≥6 N/mm² | Repair mortars:  
Sika® MonoTop~412 /-352 range  
Sikafloor~82/-83 EpoCem  
Bonding primers:  
Sikadur~32  
SikaTop® Armatec®-110 EpoCem® |

* This table is continued on pages 26 and 27.
### EN 1504-9 Principle 4: Structural Strengthening (SS)
Increasing or Restoring the Structural Load Capacity (continued)

Injecting and sealing cracks generally does not structurally strengthen a structure. However, for remedial work or when temporary overloading has occurred, the injection of low viscous epoxy resin based materials can restore the structure to its original structural condition.

The introduction of prestressed composite reinforcement for strengthening has now brought this technology to another level. This uses high strength, lightweight carbon fibre reinforced plates, plus curing times are reduced and the application conditions can be extended through innovative electrical heating of the adhesive.

These innovations serve to further demonstrate that Sika is the clear global leader in this field.

### Table: Methods of Injection and Sealing Cracks

<table>
<thead>
<tr>
<th>Methods</th>
<th>Pictures</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
</table>
| **Method 4.5** Injecting cracks, voids or interstices  
Corresponding part of the Standards: EN 1504-5  
The cracks should be cleaned and prepared in accordance with the guidelines of EN 1504 Part 10 Section 7.2.2. Then the most suitable Sika system for resealing and bonding can be selected to fully reinstate the structural integrity.  
Sikadur®-52 Injection  
Two-component epoxy resin  
Low viscosity  
Sika® Injection-451  
High strength structural epoxy resin  
Very low viscosity  
Sika® InjectoCem®-190  
Two part micro-mortar injection  
Corrosion protection of embedded reinforcement | **Classification of injection material:**  
F: transmitting force / load transfer | **No specific criteria** | **Carbon fibre prestressing systems:**  
Sika® CarboStress® system  
Traditional bonded prestressing systems:  
SikaGrout®-300 PT |
| **Method 4.6** Filling cracks, voids or interstices  
Corresponding part of the Standards: EN 1504-5  
When inert cracks, voids or interstices are wide enough, they can filled by gravity (pouring) or by using an epoxy patching mortar.  
Sikadur®-52 Injection  
Two-component epoxy resin  
Low viscosity  
Sika® Injection-451  
High strength structural epoxy resin  
Very low viscosity  
Sika® InjectoCem®-190  
Two part micro-mortar injection  
Corrosion protection of embedded reinforcement | **Classification of injection material:**  
F: transmitting force / load transfer | **No specific criteria** | **Carbon fibre prestressing systems:**  
Sika® CarboStress® system  
Traditional bonded prestressing systems:  
SikaGrout®-300 PT |
| **Method 4.7** Prestressing – (post tensioning)  
Corresponding part of the Standards: None  
Pre-stressing; with this method the system involves applying forces to a structure to deform it in such a way that it will withstand its working loads more effectively, or with less total deflection. (Note: post-tensioning is a method of pre-stressing a poured in place concrete structure after the concrete has hardened). | **No specific criteria** | **No specific criteria** | **No specific criteria** |
**EN 1504-9 Principle 5: Physical Resistance (PR)**

*Increasing the Concrete’s Resistance to Physical and/or Mechanical Attack*

Concrete structures are damaged by different types of physical or mechanical attack:
- Increased mechanical load
- Wear and tear from abrasion, such as on a floor (e.g. in a warehouse)
- Hydraulic abrasion from water and water borne solids (e.g. on a dam or in drainage/sewage channels)
- Surface breakdown from the effects of freeze – thaw cycles (e.g. on a bridge)

Sika provides all of the right products to repair all of these different types of mechanical and physical damage on all different types of concrete structure and in all different climatic and environmental conditions.

<table>
<thead>
<tr>
<th>Methods</th>
<th>Pictures</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
</table>
| **Method 5.1 Coating**  
Corresponding part of the Standards: EN 1504-2 | | Only reactive coatings are able to provide sufficient additional protection for the concrete to improve its resistance against physical or mechanical attack. | Abrasion (Taber-Test): mass-loss <3000 mg  
Capillary absorption: v<0.1 kg/(m² × √h)  
Impact resistance: Class I to Class III  
Adhesion strength: Elastic: ≥0.8 N/mm² or ≥1.5 N/mm² (trafficking)  
Rigid: ≥1.0 N/mm² or ≥2.0 N/mm² (trafficking) | Class II:  
Sika®-261/-263 SL  
- Good chemical and mechanical resistance  
- Excellent abrasion resistance  
- Solvent free |
| **Method 5.2 Impregnation**  
Corresponding part of the Standards: EN 1504-2 | | An impregnation is defined as the treatment of concrete to reduce the surface porosity and to strengthen the surface. The pores and capillaries are partly or totally filled. This type of treatment also usually result in a discontinuous thin film of 10 to 100 microns thickness on the surface. Certain impregnations can react with some of the concrete constituents to result in higher resistance to abrasion and mechanical attack. | Abrasion (Taber-Test): 30% improvement in comparison to non impregnated sample  
Penetration depth: >5 mm  
Capillary absorption: v<0.1 kg/(m² × √h)  
Impact resistance: Class I to Class III | Class I:  
Sika®-2530 W  
- Two part, water dispersed epoxy resin  
- Good mechanical and chemical resistance  
Sika®-390  
- High chemical resistance  
- Moderate crack-bridging capability  
refer to local availability |
| **Method 5.3 Adding mortar or concrete**  
Corresponding part of the Standards: EN 1504-3 | | The Methods to be used and suitable systems for this are defined in Principle 3 Concrete restoration and the products have to fulfill the requirements of EN 1504-3, Class R4 or R3. In some specific instances products may also need to fulfill additional requirements such as resistance to hydraulic abrasion. The engineer must therefore determine these additional requirements on each specific structure. | Mortar/Concrete:  
Class R4  
Class R3 | Class R4:  
Sika® MonoTop®-412 range  
- Very low shrinkage  
- One component repair mortar  
Sika®-62/-63 EpoCem  
- Epoxy modified cement mortar  
- High frost and deicing salt resistance  
Sika® Abraro®  
- High mechanical strength  
- Excellent abrasion resistance  
SikaGrout® range  
- High performance levelling mortar  
- Excellent flow characteristics |
The chemical resistance requirements of a concrete structure and its surfaces are dependent on many parameters including the type and concentration of the chemicals, the temperatures and the likely duration of exposure, etc. Appropriate assessment of the risks is a prerequisite to allowing the correct protection strategy to be developed for any specific area.

Different types of protective coatings are available from Sika to provide full or short-term chemical resistance, according to the type and degree of exposure.

Sika therefore provides a full range of protective coatings to protect concrete in all different chemical environments. These are based on many different resins and materials including: acrylic, epoxy, polyurethane silicate, epoxy-cement combinations, polymer modified cement mortars, etc.

### Methods

<table>
<thead>
<tr>
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<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method 6.1 Coating</strong></td>
<td></td>
<td>Only high performance reactive coatings are able to provide sufficient protection to concrete and improve its resistance to chemical attack.</td>
<td>Resistance to strong chemical attack: Class I to Class III</td>
<td>Class II: Sikagard®-63 N&lt;br&gt;Two part epoxy resin with good chemical and mechanical resistance&lt;br&gt;Tightly cross-linked surface&lt;br&gt;Class I: Sikafloor®-390&lt;br&gt;High chemical resistance&lt;br&gt;Moderate crack-bridging behaviour</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Adhesion strength:&lt;br&gt;Elastic: ≥ 0.8 N/mm² or ≥ 1.5 N/mm² (traffic)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Rigid: ≥ 1.0 N/mm² or ≥ 2.0 N/mm² (traffic)</td>
<td></td>
</tr>
<tr>
<td><strong>Method 6.2 Impregnation</strong></td>
<td></td>
<td>An impregnation is defined as the treatment of concrete to reduce the porosity and to strengthen the surface. The pores and capillaries are then partly or totally filled. This type of treatment usually also results in a discontinuous thin film of 10 to 100 microns thickness on the surface. This therefore serves to block the pore system to aggressive agents.</td>
<td>Resistance to chemical attack after 30 days exposure</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Class I: Sikafloor®-261/-263 SL&lt;br&gt;Good chemical and mechanical resistance&lt;br&gt;Excellent abrasion resistance&lt;br&gt;Solvent free</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>refer to local availability</td>
<td></td>
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<tr>
<td><strong>Method 6.3 Adding mortar or concrete</strong></td>
<td></td>
<td>The Methods and systems required are defined in Principle 3, Concrete restoration. To be able to resist a certain level of chemical attack, cement-based products need to be formulated with special cements and/or combined with epoxy resins. The engineer has to define these specific requirements on each structure.</td>
<td>No specific criteria</td>
<td>Sikagard®-720 EpoCem®, Sikafloor®-81/82/83 EpoCem®&lt;br&gt;Epoxy modified cement mortars&lt;br&gt;Good chemical resistance&lt;br&gt;Very dense and watertight</td>
</tr>
</tbody>
</table>
**EN 1504-9 Principle 7: Preserving or Restoring Passivity (RP)**
Treating or Replacing Concrete Surrounding the Reinforcement

<table>
<thead>
<tr>
<th>Methods</th>
<th>Pictures</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 7.1 Increasing cover with additional mortar or concrete.</td>
<td><img src="image1.png" alt="Method 7.1" /></td>
<td>If the reinforcement does not have adequate concrete cover, then by adding cementitious mortar or concrete the chemical attack (e.g. from carbonation or chlorides) on the reinforcement will be reduced.</td>
<td>Carbonation resistance: Class R4 or R3</td>
<td>Class R4: Sikagard® MonoTop®-412 range Sikacrete®-103 Gunit Sikafloor®-82 EpoCem®</td>
</tr>
<tr>
<td>Method 7.2 Replacing contaminated or carbonated concrete.</td>
<td><img src="image2.png" alt="Method 7.2" /></td>
<td>Through removing damaged concrete and rebuilding the concrete cover over the reinforcement, the steel is again protected by the alkalinity of its surroundings.</td>
<td>Carbonation resistance: Class R4 or R3</td>
<td>Class R4: Sikagard® MonoTop®-412 range Sikacrete®-103 Gunit</td>
</tr>
<tr>
<td>Method 7.3 Electrochemical realkalisation of carbonated concrete.</td>
<td><img src="image3.png" alt="Method 7.3" /></td>
<td>Realkalisation of concrete structures by electrochemical treatment is a process performed by applying an electric current between the embedded reinforcement to an external anode mesh, which is embedded in an electrolytic reservoir, placed temporarily on the concrete surface. This treatment does not prevent the future ingress of carbon dioxide. So to be effective on the long term, it also needs to be combined with appropriate protective coatings that prevent future carbonation and chloride ingress.</td>
<td>No specific criteria</td>
<td>For post-treatment: Sikagard®-720 EpoCem®</td>
</tr>
<tr>
<td>Method 7.4 Realkalisation of carbonated concrete by diffusion</td>
<td><img src="image4.png" alt="Method 7.4" /></td>
<td>There is limited long term experience with this method. It requires the application of a very alkaline coating over the carbonated concrete surface and the realkalisation is achieved by the slow diffusion of the alkali through the carbonated zone. This process takes a very long time and it is very difficult to control the right distribution of the material. After treatment, it is also always recommended to prevent further carbonation by applying a suitable protective coating.</td>
<td>No specific criteria</td>
<td>For post-treatment: Sikagard®-720 EpoCem®</td>
</tr>
<tr>
<td>Method 7.5 Electrochemical chloride extraction</td>
<td><img src="image5.png" alt="Method 7.5" /></td>
<td>The electrochemical chloride extraction process is very similar in nature to cathodic protection. The process involves the application of an electrical current between the embedded reinforcement and an anode mesh placed at the outer surface of the concrete structure. As a result, the chlorides are driven out toward the surface. Once the treatment is completed, the concrete structure has to be protected with a suitable treatment to prevent the further ingress of chlorides (post treatment).</td>
<td>No specific criteria</td>
<td>For post-treatment: penetrating hydrophobic impregnation with Sikagard®-705 L or Sikagard®-706 Thixo plus protective coating Sikagard®-680 S</td>
</tr>
</tbody>
</table>
EN 1504-9 Principle 8: Increasing Resistivity (IR)
Increasing the Electrical Resistivity of the Concrete to reduce the Risk of Corrosion

Principle 8 deals with increasing the resistivity of the concrete, which is directly connected to the level of moisture available in the concrete pores. The higher the resistivity, the lower is the amount of free moisture available in the pores.

This means that reinforced concrete with high resistivity will have a low corrosion risk.

Principle 8 deals with the increase of the concrete’s electrical resistivity, therefore then covers almost the same methods of repair as Principle 2 (MC) Moisture Control.

Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Main Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrophobic Impregnation</td>
<td>A hydrophobic impregnation is defined as the treatment of concrete to produce a water-repellent surface. The pores and capillary network are not filled, but only lined with the hydrophobic material. These function by reducing the surface tension of liquid water, thus preventing its passage through the pores, but still allowing each way water vapour diffusion, which is in accordance with standard good practice in building physics.</td>
<td>Penetration:</td>
</tr>
<tr>
<td>Impregnation</td>
<td>An impregnation is defined as the treatment of concrete to reduce the surface porosity and to strengthen the surface. The pores and capillaries are then partly or totally filled. This type of treatment usually also results in a discontinuous thin film of 10 to 100 microns thickness on the surface. This serves to block the pore system to aggressive agents.</td>
<td>Penetration depth:</td>
</tr>
<tr>
<td>Coating</td>
<td>Surface coatings are defined as materials designed to provide an improved concrete surface, for increased resistance or performance against specific external influences. Fine surface cracks with a total movement of up to 0.3 mm can be safely repaired, then sealed and their movement accommodated by elastic, crack bridging coatings, which are also waterproof and carbonation resistant. This is to accommodate thermal and dynamic movement in structures subject to wide temperature fluctuation, vibration, or that have been constructed with inadequate or insufficient jointing details.</td>
<td>Capillary absorption:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sika® Products (examples)</th>
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</thead>
<tbody>
<tr>
<td>Sikagard®-700 range</td>
</tr>
<tr>
<td>Based on silane hydrophobic</td>
</tr>
<tr>
<td>Penetrate deeply and provide a liquid--water repellent surface</td>
</tr>
<tr>
<td>Sikagard®-706 Thixo</td>
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<tr>
<td>(Class II)</td>
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<tr>
<td>Sikagard®-705 L</td>
</tr>
<tr>
<td>(Class II)</td>
</tr>
<tr>
<td>Sikagard®-704 S</td>
</tr>
<tr>
<td>(Class II)</td>
</tr>
</tbody>
</table>

Penetration:
- Class I: <10 mm
- Class II: ≥10 mm

Drying rate coefficient:
- Class I: >30%
- Class II: >10%

Water absorption and resistance to alkali:
- Absorption rate: <7.5%
- Alkali solution: <10%

Penetration depth:
- ≥5 mm

Capillary absorption:
- w <0.1 kg/(m² × √h)

Water vapour permeability:
- Class I: S ≤5 m
- Class II: 5 m ≤S ≤50 m
- Class III: S >50 m

Adhesion strength:
- Elastic: ≥0.8 N/mm² or ≥1.5 N/mm² (trafficking)
- Rigid: ≥1.0 N/mm² or ≥2.0 N/mm² (trafficking)

Rigid systems:
- Sikagard®-680 S
- Acrylic resin
- Waterproof

Sikagard® Wallcoat T
- Two part epoxy resin
- Water barrier

Elastic systems:
- Sikagard®-550 W Elastic
- Acrylic resin
- Waterproofing and Elastic (crack-bridging)
# EN 1504-9 Principle 9: Cathodic Control (CC)
Preventing Corrosion of the Steel Reinforcement

Principle 9 relies upon restricting the access of oxygen to all potentially cathodic areas, to the point when corrosion is prevented.

An example of this is to limit the available oxygen content by the use of coatings on the steel surface.

Another is the application of an inhibitor in sufficient quantities, that can form a film on the steel surface which acts as a barrier to block access to oxygen.

### Methods

**Method 9.1** Limiting oxygen content (at the cathode) by surface saturation and surface coating.

**Description**

Creating conditions in which any potentially cathodic areas of the reinforcement are unable to drive an anodic reaction.

Although not mention on the standard as method 9.1, inhibitors added to the concrete as admixtures or surface applied on the hardened concrete as an impregnation form a continuous film on the surface of the steel reinforcement which acts as a barrier to oxygen.

**Main Criteria**

- Corrosion inhibitors:
  - Sika® FerroGard®-901 (admixture)
  - Sika® FerroGard®-903+ (surface applied)
- Amino alcohol based inhibitors
- Long term protection and durability
- Economic extension of the service life of reinforced concrete structures

**Sika® Products (examples)**

- **Surface coatings:**
  - Sika® MonoTop®-412 N
    - Low shrinkage
    - Sufficient resistivity
  - Sika® Level-30
    - Self levelling
    - Sufficient resistivity

---

# EN 1504-9 Principle 10: Cathodic Protection (CP)
Preventing Corrosion of the Steel Reinforcement

Principle 10 refers to cathodic protection systems. These are electrochemical systems which decrease the corrosion potential to a level where the rate of the reinforcing steel dissolution is significantly reduced. This can be achieved by creating a direct electric current flow from the surrounding concrete to the reinforcing steel, in order to eliminate the anodic parts of the corrosion reaction. This current is provided by an external source (Induced Current Cathodic Protection), or by creating a galvanic current through connecting the steel to a less noble / more reactive metal (galvanic anodes e.g. zinc).

### Methods

**Method 10.1** Applying an electrical potential.

**Description**

In Induced Current Cathodic Protection, the current is supplied by an external electrical source and is distributed in the electrolyte via auxiliary anodes (e.g. mesh placed on top of and connected to the reinforcing steel). These auxiliary anodes are generally embedded in a mortar in order to protect them from degradation. To work efficiently the system requires the surrounding mortar to have a resistivity low enough to allow sufficient current transfer.

**Main Criteria**

- Resistivity of the mortar: according to local requirements.

**Sika® Products (examples)**

- Mortars for embedded cathodic protection mesh:
  - Sika® MonoTop®-412 N
    - Low shrinkage
    - Sufficient resistivity
  - Sika® Level-30
    - Self levelling
    - Sufficient resistivity
EN 1504-9 Principle 11: Control of Anodic Areas (CA)

Preventing Corrosion of the Steel Reinforcement

In considering the control of anodic areas to prevent corrosion with Principle 11, it is important to understand that particularly in heavily chloride contaminated structures, spalling due to reinforcement corrosion happens first in areas of low concrete cover. Additionally it is also important to protect repaired areas from the future ingress of aggressive agents (carbonation, chlorides).

A protective cement slurry can be applied directly on the reinforcement after appropriate cleaning, to prevent further steel dissolution at the anodic areas.

Additionally, to protect against the formation of incipient anodes in the areas surrounding the patch repairs, a corrosion inhibitor can be applied to migrate through the concrete and reach the reinforcement, where it forms a barrier, also protecting the anodic zones.

Note: Dual function inhibitors such as Sika® FerroGard® also protect the cathodic areas simultaneously.

### Methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Main Criteria</th>
<th>Sika® Products (examples)</th>
</tr>
</thead>
</table>
| Method 11.1 Active coating of the reinforcement | These coatings contain active pigments that can function as an inhibitor or provide a passive environment due to their alkalinity. Although care must be taken to apply them properly, they are less sensitive to application defects than barrier coatings. | Compliance with EN 1504-7 | Cement based:  
Sika® MonoTop®-910  
1-component corrosion protection  
Good resistance to water and chloride penetration  

Epoxy modified cement based:  
SikaTop® Armatec®-110 EpoCem®  
High density, suitable for demanding environments  
Excellent adhesion to steel and concrete |
| Method 11.2 Barrier coating of the reinforcement | These barrier coatings work by completely isolating the reinforcement from oxygen or water. Therefore they require higher levels of surface preparation and application control. This is because they can only be effective if the steel is completely free from corrosion and fully coated without any defects – this can be very difficult to achieve in site conditions. Any effective reduction in the bonding of the repair material to the treated reinforcement should also be considered. | Compliance with EN 1504-7 | Epoxy based:  
Sikadur®-32  
Low sensitivity to moisture  
Very dense, no chloride penetration |
| Method 11.3 Applying corrosion inhibitors in or to the concrete. | Applying corrosion inhibitors to the concrete surface, they diffuse to the reinforcement and form a protective layer on the surface of the bars. These corrosion inhibitors can also be added as admixtures to the repair mortar or concrete that is used for the concrete reinstatement works. | Recommendation of Sika: >100 ppm (parts per million) concentration of corrosion inhibitors at rebar level. | Corrosion inhibitors:  
Sika® FerroGard®-901 (admixture)  
Sika® FerroGard®-003 (surface applied)  
Amino alcohol based inhibitors  
Lung term protection and durability  
Economic extension of the service life of reinforced concrete structures |

Compliance with EN 1504-7  
Recommandation of Sika: >100 ppm (parts per million) concentration of corrosion inhibitors at rebar level.

![Method 11.1 Active coating of the reinforcement](image1)

![Method 11.2 Barrier coating of the reinforcement](image2)

![Method 11.3 Applying corrosion inhibitors in or to the concrete.](image3)
Summary Flow Chart and Phases of the Correct Concrete Repair and Protection Procedure
In Accordance with European Standards EN 1504

The Phases of Concrete Repair and Protection Projects in Accordance with EN 1504 Part 9

<table>
<thead>
<tr>
<th>Information about the Structure</th>
<th>Process of Assessment</th>
<th>Management Strategy</th>
<th>Design of Repair Work</th>
<th>Repair Work</th>
<th>Acceptance of Repair Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>History of structure</td>
<td>Defect diagnosis</td>
<td>Repair options</td>
<td>Definition of performance</td>
<td>Final product selection</td>
<td>Acceptance of testing</td>
</tr>
<tr>
<td>Review documentation</td>
<td>Analysis results</td>
<td>Select Principles</td>
<td>Substrate preparation</td>
<td>Equipment selection</td>
<td>Acceptance of finishing</td>
</tr>
<tr>
<td>Condition survey</td>
<td>Root cause identification</td>
<td>Select Methods</td>
<td>Products</td>
<td>Health and safety assessment</td>
<td>Final documentation</td>
</tr>
<tr>
<td></td>
<td>Structural assessment</td>
<td>Health and safety issues</td>
<td>Application</td>
<td>QA/QC definition</td>
<td>Maintenance strategy</td>
</tr>
<tr>
<td>EN 1504-9, Clause 4, Annex A</td>
<td>EN 1504-9, Clause 4, Annex A</td>
<td>EN 1504-9, Clauses 5 and 6, Annex A</td>
<td>EN 1504 Parts 2–7 and EN 1504-9, Clauses 6, 7 and 9</td>
<td>EN 1504-9, Clause 9 and 10 and EN 1504-10</td>
<td>EN 1504-9, Clause 8 and EN 1504-10</td>
</tr>
</tbody>
</table>

Related Pages in this Brochure

See more details on page 4
See more details on page 6/7
See more details on page 42–45
See more details on page 12–39
See more details on page 46–47
See more details on page 5

Flow Chart of Concrete Repair and Protection Procedure with the Sika® Systems

- Visible cracking and staining
  - Condition survey
    - Any latent damage?
      - Carry out “root cause” analysis
      - Structural assessment
    - Any actions required?
      - Define the further life cycle
      - Check of necessary concrete or steel protection
      - Enhance appearance
        - Crack-bridging abilities needed?
          - N
          - S
          - U
          - V
          - E
          - H
          - A
          - N
          - D
          - O
          - V
          - E
          - R
          - N
          - S
          - I
          - N
          - A
          - C
          - H
          - Y
        - Y
          - Apply structural repair mortar
            - Sika® MonoTop® (class R2 or R4)
          - Apply structural repair mortar
            - Sika® MonoTop® (class R3 or R4)
          - Apply structural repair mortar
            - Sika® MonoTop® (class R1)
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            - Sika® MonoTop® (class R2)
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            - Sika® MonoTop® (class R103)
          - Apply structural repair mortar
            - Sika® MonoTop® (class R104)
          - Apply structural repair m...
**Selection of the Methods to be Used for Concrete Repair**

In the matrix tables below the most common defects and damage of concrete structures and their possible repair methods are listed. This list is intended to be indicative rather than exhaustive. The repair proposals must be customised according to the specific conditions on each project. Deviations from this matrix of outline recommendations are therefore possible and these must be determined individually for each situation. The numbers indicated in the tables are reference to the relevant Principles and Methods defined in EN 1504-9.

### Damage to Concrete

<table>
<thead>
<tr>
<th>Concrete Defects / Damage</th>
<th>Minor Damage</th>
<th>Medium Damage</th>
<th>Heavy Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete cracks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete spalling due to carbonation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete spalling due to mechanical impact</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural damage from overloading or earthquake</td>
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<tr>
<td>Scaling from Freeze/Thaw action</td>
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<tr>
<td>Damage from chemical attack</td>
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</tr>
</tbody>
</table>

**Concrete Defects / Damage**

- Concrete cracks
- Concrete spalling due to mechanical impact
- Structural damage from overloading or earthquake
- Scaling from Freeze/Thaw action
- Damage from chemical attack

**Minor damage:**
- Local damage, no influence on load capacity

**Medium damage:**
- Local to significant damage, slight influence on load capacity

**Heavy damage:**
- Extensive and large-scale damage, strong influence on load capacity

### Damages due to Reinforcement Corrosion

- Concrete spalling due to carbonation
- Reinforcement corrosion due to chlorides
- Stray electrical currents

**Concrete Defects / Damage**

- Concrete spalling due to carbonation
- Reinforcement corrosion due to chlorides
- Stray electrical currents

**Minor damage:**
- 3.1 Hand applied mortar

**Medium damage:**
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar

**Heavy damage:**
- 3.2 Recasting with concrete or mortar
- 4.1 Adding or replacing embedded or external reinforcing bars
- 4.2 Adding reinforcement anchored in pre-formed or drilled holes
- 7.2 Replacing contaminated or carbonated concrete

**Minor damage:**
- 3.1 Hand applied mortar

**Medium damage:**
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar

**Heavy damage:**
- 3.1 Hand applied mortar
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar
- 4.1 Adding or replacing embedded or external reinforcing bars
- 4.2 Adding reinforcement anchored in pre-formed or drilled holes

**Minor damage:**
- 3.1 Hand applied mortar

**Medium damage:**
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar

**Heavy damage:**
- 3.1 Hand applied mortar
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar
- 4.1 Adding or replacing embedded or external reinforcing bars
- 4.2 Adding reinforcement anchored in pre-formed or drilled holes
- 3.3 Spraying concrete or mortar
- 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

**Minor damage:**
- 3.1 Hand applied mortar

**Medium damage:**
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar

**Heavy damage:**
- 3.1 Hand applied mortar
- 3.2 Recasting with concrete or mortar
- 3.3 Spraying concrete or mortar
- 4.1 Adding or replacing embedded or external reinforcing bars
- 4.2 Adding reinforcement anchored in pre-formed or drilled holes
- 3.3 Spraying concrete or mortar
- 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
### Selection of the Methods to be Used for Concrete and Reinforcement Protection

The overall protection required for concrete structures as well as that required for their embedded steel reinforcement, is dependent on the type of structure, its environmental exposure and location, its use and the selected maintenance strategy. Therefore protection proposals should be adapted to individual structures, their specific conditions and their specific requirements. Deviations from these outline recommendations are therefore possible and should always be determined on each individual project.

The prefix numbers in the following tables are the references of the relevant Principles and Methods of EN 1504-9.

#### Protection to Concrete

<table>
<thead>
<tr>
<th>Protection Requirements</th>
<th>Minimal Level</th>
<th>Medium Level</th>
<th>Heavy Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cracks</td>
<td>1.1 Hydrophobic impregnation</td>
<td>1.1 Hydrophobic impregnation</td>
<td>1.1 Hydrophobic impregnation</td>
</tr>
<tr>
<td></td>
<td>1.3 Coating</td>
<td>1.3 Coating (elastic)</td>
<td>1.3 Coating (elastic)</td>
</tr>
<tr>
<td></td>
<td>1.8 Applying sheet or liquid membranes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mechanical impact</td>
<td>5.2 Impregnation</td>
<td>5.1 Coating</td>
<td>5.3 Adding mortar or concrete</td>
</tr>
<tr>
<td>Freeze/Thaw action</td>
<td>2.1 Hydrophobic impregnation</td>
<td>2.2 Impregnation</td>
<td>1.1 Hydrophobic impregnation</td>
</tr>
<tr>
<td></td>
<td>2.3 Coating</td>
<td></td>
<td>5.1 Coating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 Hydrophobic impregnation</td>
<td>5.3 Adding mortar or concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.3 Coating (elastic)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.8 Applying sheet or liquid membranes</td>
<td></td>
</tr>
<tr>
<td>Alkali aggregate reactions (AAR)</td>
<td>2.1 Hydrophobic impregnation</td>
<td>2.1 Hydrophobic impregnation</td>
<td>2.1 Hydrophobic impregnation</td>
</tr>
<tr>
<td></td>
<td>2.3 Coating</td>
<td>2.1 Hydrophobic impregnation</td>
<td>2.3 Coating (elastic)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.1 Hydrophobic impregnation</td>
<td>1.8 Applying sheet or liquid membranes</td>
</tr>
<tr>
<td>Chemical attack</td>
<td>6.2 Impregnation</td>
<td>6.3 Adding mortar or concrete</td>
<td>6.1 Coatings (reactive)</td>
</tr>
</tbody>
</table>

**Minimal level:** slight concrete defects and/or short-term protection  
**Medium level:** moderate concrete defects and/or middle-term protection  
**High level:** extensive concrete defects and/or long-term protection

#### Protection to Reinforcement

<table>
<thead>
<tr>
<th>Protection Requirements</th>
<th>Minimal Level</th>
<th>Medium Level</th>
<th>High Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonation</td>
<td>11.3 Applying corrosion inhibitors in or to the concrete</td>
<td>1.3 Coating</td>
<td>11.3 Applying corrosion inhibitors in or to the concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.3 Electrochemical realkalization of carbonated concrete</td>
<td>1.3 Coating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7.4 Realkalization of carbonated concrete by diffusion</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>7.3 Electrochemical realkalization of carbonated concrete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>and 1.3 Coating</td>
</tr>
<tr>
<td>Chlorides</td>
<td>1.1 Hydrophobic impregnation</td>
<td>11.3 Applying corrosion inhibitors in or to the concrete</td>
<td>7.5 Electrochemical chloride extraction</td>
</tr>
<tr>
<td></td>
<td>1.2 Impregnation</td>
<td>1.1 Hydrophobic impregnation</td>
<td>7.3 Coating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.3 Applying corrosion inhibitors in or to the concrete</td>
<td>7.5 Electrochemical chloride extraction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and 1.1 Hydrophobic impregnation</td>
<td>and 1.3 Coating</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.3 Applying corrosion inhibitors in or to the concrete</td>
<td>11.2 Barrier coating of the reinforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and 1.3 Coating</td>
<td>10.1 Applying an electrical potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stray electrical currents</td>
<td>If disconnection of the electrical current is not possible:</td>
<td>If disconnection of the electrical current is not possible:</td>
<td>If disconnection of the electrical current is not possible:</td>
</tr>
<tr>
<td></td>
<td>2.2 Impregnation</td>
<td>2.5 Electrochemical treatment</td>
<td>10.1 Applying an electrical potential</td>
</tr>
<tr>
<td></td>
<td></td>
<td>and 2.3 Coating</td>
<td></td>
</tr>
</tbody>
</table>

The protection methods are listed in the following order:

1. Hydrophobic impregnation
2. Impregnation
3. Coating (reactive)
4. Coating (elastic)
5. Applying sheet or liquid membranes
6. Electrochemical realkalization of carbonated concrete
7. Electrochemical chloride extraction
8. Applying an electrical potential
Sika uses specific in-house and independent testing and assessment criteria to evaluate all of its products and systems for concrete repair and protection, which are fully in accordance with the requirements of the appropriate parts and sections of European Standards EN 1504 (Parts 2 – 7). The Sika Product and System Testing and Assessment criteria for these concrete repair and protection materials are as follows:

**For concrete repairs**
- Protecting exposed reinforcement
  - Bond strength to steel and concrete
- Corrosion protection
- Permeability to water
- Permeability to water vapour
- Permeability to carbon dioxide
- etc.

**Levelling the profile and filling surface pores**
- Bond strength
- Permeability to carbon dioxide
- Permeability and absorption of water
- etc.

**Replacing damaged concrete**
- Bond strength
- Compressive and flexural strengths
- Permeability to water
- Elastic modulus (stiffness)
- Restrained shrinkage
- Thermal compatibility
- etc.

**For concrete protection**
- Protecting exposed reinforcement
  - Bond strength to steel and concrete
- Corrosion protection
- Permeability to water
- Permeability to water vapour
- Permeability to carbon dioxide
- Freeze / thaw resistance
- etc.

**Rigide protective coatings**
- Bond strength
- Cross-cut test
- Permeability to carbon dioxide
- Permeability to water vapour
- UV light resistance
- Alkaline substrate resistance
- Freeze/thaw resistance
- Fire behavior
- etc.

**Elastic protective coatings**
- Crack-bridging ability
  - Statically
  - Dynamically
    - At low temperatures (–20 °C / -4 °F)
- Bond strength
- Cross-cut test
- Permeability to carbon dioxide
- Permeability to water vapour
- UV light resistance
- Alkaline substrate resistance
- Freeze/thaw resistance
- Fire behavior
- etc.

**The Independent Assessment and Approvals of Sika® Products and Systems, Plus Testing and Proof Statements in Accordance with the Requirements of EN 1504**

**Product and System Performance**

There are functional and performance requirements which must be met by both the individual products as components of a system and the system functioning together as a whole.

**Practical Application Criteria of the Performance**

In addition to their performance in place on the structure, it is also essential to define and then test the application characteristics and properties of the products. At Sika we ensure that these are in accordance with the guidelines of EN 1504 Part 10, but additionally we also ensure that Sika products can all be applied practically on site and in all of the differing climatic conditions that will be encountered around the world.

For example:
- Sika repair mortars must be suitable for use in differing thicknesses, areas and volumes of repair, which need to be applied in as few layers as possible. They must then rapidly become weather resistant.
- Equally Sikagard® coatings must have adequate viscosity and the right thixotropic properties at different temperatures, in order to obtain the desired wet and dry film thicknesses. This should be achieved in the minimum number of coats, plus they must also achieve adequate opacity and become weather resistant quickly.

**Quality Assurance**

It is also necessary for any product or system to meet well defined Quality Assurance and Quality Control standards in production. Contained in European Standard EN 1504 Part 2 to 7 are the relevant requirements for quality control in the production plant. In addition to these requirements, compulsory in Europe, Sika is accredited to ISO 9001 in all production facilities throughout the world.

**Quality Control on Site**

More and more important repair work requires an established Quality Assurance plan. With knowledge in quality management, Sika can help the contractor to work out and prepare the relevant procedures to comply with all these requirements. EN 1504-10 gives guidance regarding the relevant Quality Control to be carried out on site. Sika also publishes product and system specification details together with method statements for applying the product on site. Quality Control Procedures and checklists are available to support the site supervisor and overall management of concrete repair and protection projects.
Concrete Repair

The “Baenziger Block” for Mortar Testing

Sika advanced repair mortar product performance testing

The “Baenziger Block” for concrete repair mortars testing allows direct comparisons and measurements of performance between products, production methods, production facilities and application conditions everywhere in the world.

This Sika innovation allows:
- Direct comparison worldwide
- Application horizontal, vertical and overhead
- Realistic site dimensions
- Additional lab testing by coring
- Shrinkage and performance crack testing

The Real Proof on Real Structures – Independent Evaluation of Completed Projects

A major international study of completed repair projects by inspection, testing and review was undertaken in 1997 by leading independent consultants and testing institutes. This involved more than twenty major buildings and civil engineering structures in Norway, Denmark, Germany, Switzerland and the United Kingdom which were repaired and protected with Sika systems between 1977 and 1986. These were re-inspected and their condition and the repair systems’ performance assessed after periods from 10 to 20 years by leading consultants specialising in this field.

The excellent condition of the structures and the materials performance reports that were the conclusions of these engineers, provide a clear and unequivocal testimony for Sika’s concrete repair and protection products. They also confirm Sika’s pioneering work in the early development of the modern, systematic approach to concrete repair and protection.

These reports are available in a printed Sika reference document “Quality and Durability in Concrete Repair and Protection”.

Concrete Protection

Testing the Performance of Corrosion Inhibitors

Sika has introduced Surface Applied Corrosion Inhibitors in 1997. Since then, millions of square metres of reinforced concrete have been protected from corrosion all over the world. Sika® FerroGard®-903 covers the Principle 9 (Cathodic control) and Principle 11 (Anodic control). Since this introduction, many studies have confirmed the efficiency of the corrosion protection afforded by this technology.

The latest international reports, amongst many available from leading institutions worldwide, are from the University of Cape Town South Africa, showing its efficiency in carbonated structures. From the building Research Establishment (BRE) showing the effectiveness of Sika® FerroGard®-903 applied as a preventative measure in a heavily chloride contaminated environment. This performance was monitored and evaluated over a 2.5 year programme (BRE 224-346A).

Additional Test Procedure for Hydrophobic Impregnations

In addition to the European Standard EN 1504-2, the penetration performance of hydrophobic impregnations in concrete is tested by measuring the water absorption in the depth profile of concrete (e.g. on concrete cores from the top surface till 10 mm depth). Therefore the maximum penetration depth and effectiveness could be determined. On that penetration limit, the exact quantity of the active ingredient in the concrete is measured in the laboratory by FT-IR analysis. This value reflects the minimum content of hydrophobic particles and can therefore also be used for quality control on site.

Accelerated Weathering testing

- Sikagard® products are tested for their performance as anti-carbonation and water vapour diffusible coatings, both when freshly applied and also after up to 10 000 hours of accelerated weathering (equivalent to in excess of 15 years atmospheric exposure). Only this type of practically applied laboratory testing can give a true and complete picture of a product and its long-term performance.
- Sikagard® crack-bridging coating products and systems are tested to confirm their dynamic performance at low temperatures down to -20 °C.
- Sikagard® coatings will therefore continue to perform long after many other so-called “protective” coatings have ceased to provide any effective protection.
Examples of Typical Concrete Damage and its Repair and Protection with Sika® Systems

Commercial Buildings

Issues: Sika Solutions:
- Concrete Spalling
  - Applying concrete or repair mortar by Hand or Spray
    - Sika® MonoTop®-352 N
- Exposed Steel
  - Protection of the reinforcement by applying corrosion inhibitors
    - Sika® FerroGard®-903
- Embedded Steel
  - Protection of the reinforcement by applying corrosion inhibitors
    - Sika® ViscoCrete®
- Cracks
  - For non-moving cracks
    - Sika® MonoTop®-723 N
  - For fine surface cracks
    - Sikagard®-550 W Elastic
- Concrete Protection
  - Coatings to protect the concrete
    - Sikagard® ElastColor 675 W
    - Sikagard®-700 S
- Joints
  - Sikaflex®-AT Connection

Bridges

Issues: Sika Solutions:
- Concrete Spalling
  - Applying concrete or repair mortar by Hand or Spray
    - Sika® MonoTop®-412 N or SikaCem®-Gunit 133
- Exposed Steel
  - Protect the rebars from corrosion
    - SikaTop® Armatec®-110 EpoCem®, Sikadur®-32
      for highly corrosive environments
- Embedded Steel
  - Protection of the reinforcement by applying corrosion inhibitors
    - Sika® FerroGard®-903
- Cracks
  - For non-moving cracks
    - Sika® MonoTop®-723 N
  - For fine surface cracks
    - Sikagard®-550 W Elastic
  - Cracks more than 0.3 mm wide
    - Sikadur® Injection-822
- Concrete Protection
  - Coatings to protect the concrete
    - Sikagard®-680 S
    - Sikagard®-700 Thixo
  - Waterproofing layer:
    - Sikalastic®-822
- Joints
  - Sikadur® CombiFlex® System

Chimneys and Cooling Towers

Issues: Sika Solutions:
- Concrete Spalling
  - Applying concrete or repair mortar by Hand or Spray
    - Sika® MonoTop®-412 NFG
    - SikaCem®-Gunit 133
      for highly corrosive environments
- Exposed Steel
  - Protect the rebars from corrosion
    - SikaTop® Armatec®-110 EpoCem®, Sikadur®-32
      for highly corrosive environments
- Embedded Steel
  - Protection of the reinforcement by applying corrosion inhibitors
    - Sika® FerroGard®-903
- Cracks
  - For non-moving cracks
    - Sika® MonoTop®-723 N
  - For fine surface cracks
    - Sikagard®-550 W Elastic
  - Cracks more than 0.3 mm wide
    - Sikadur® Injection-451
- Concrete Protection
  - Coatings to protect the concrete
    - Sikagard®-720 EpoCem
  - Coatings to protect the concrete
    - Sikagard®-720 EpoCem®
    - Sikagard®-680 S
    - Sikadur® EG 5
      (official aircraft warning colours)
- Joints
  - Sikadur® CombiFlex® System

Sewage treatment Plants

Issues: Sika Solutions:
- Concrete Spalling
  - Applying concrete or repair mortar by Hand or Spray
    - Sika® MonoTop®-412 N
- Exposed Steel
  - Protect the rebars from corrosion
    - SikaTop® Armatec®-110 EpoCem®, Sikadur®-32
    for highly corrosive environments
- Cracks
  - For non-moving cracks
    - Sikagard®-720 EpoCem
  - For fine surface cracks
    - Sikafloor®-390 Thixo
  - Cracks more than 0.3 mm wide
    - Sikadur® Injection-201
- Concrete Protection
  - Coatings to protect the concrete
    - Sikagard®-720 EpoCem®
    - Sikadur®-32
    - Sikacrete®-507 for abrasion
- Abrasion
  - Sikadur® Abraroc®
- Joints
  - Sikadur® CombiFlex® System

* Additional Sika solutions are also possible, please refer to specific documentation or contact our Technical Service Departments for advice.
Our most current General Sales Conditions shall apply. Please consult the Product Data Sheet prior to any use and processing.