BUILDING TRUST

THE REPAIR AND PROTECTION OF REINFORCED CONCRETE WITH SIKA®
In Accordance with European Standards EN 1504

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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 Existing National Standards which have not been harmonized with the new EN 1504 were therefore withdrawn at the end of 2008 and CE Marking has become mandatory.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

01234

- CE – Symbol
- Identification number of the notified body

Sika Services AG
Tüffenwies 16, CH-8048 Zürich
Factory Nº 1111
09
01234-CPD-00234

- Name or identifying mark of the producer
- Year in which the marking was affixed
- Certificate number as on the attestation certificate

EN 1504-3
Concrete Repair product for structural repair
CC mortar (based on hydraulic cement)

- Number of the relevant part of the European Standard
- Description of the product

Compressive strength:	class R4
Chloride ion content:	≤ 0,05%
Adhesive Bond:	≥ 2,0 MPa
Carbonation resistance:	Passes
Elastic modulus:	≥ 20 GPa
Thermal compatibility part 1:	≥ 2,0 MPa
Capillary absorption:	≤ 0,5 kg · m^{-2} · $h^{-0,5}$
Dangerous substances:	comply with 5.4
Reaction to fire:	Euroclass A1

- Additional Information on the regulated characteristics

THE PROJECT PHASES OF THE CONCRETE REPAIR AND PROTE
IN ACCORDANCE WITH EUROPEAN STANDARD EN 1504-9

1
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

2
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

3
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.

4 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 affect of the selected materials on the rest of the structure i.e. no adverse affect.

5 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.

6 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, discolouration or delamination?
- What is the inspection period?
- What remedial work might be required in case of deterioration?

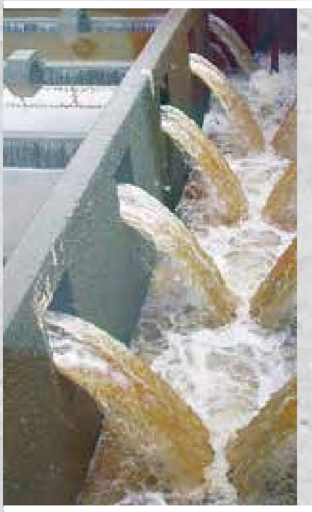
THE ROOT CAUSE(S) OF CONCRETE DAMAGE AND DETERIORA

ASSESSMENT FROM THE CONDITION SURVEY AND THE RESULTS OF LA

Concrete Defects and Damage

Mechanical attack

Cause	Relevant principles for repair and protection
Impact	Principles 3,5
Overloading	Principles 3,4
Movement	Principles 3,4
Vibration Earthquake Explosion	Principles 3,4



Chemical attack

Cause	Relevant principles for repair and protection
AAR Alkali aggregate reactions	Principles 1,2,3
Aggressive chemical Exposure	Principles 1,2,6
Bacterial or other biological action	Principles 1,2,6
Efflorescence / leaching	Principles 1,2

Physical attack

Cause	Relevant principles for repair and protection
Freeze/thaw action	Principles 1,2,3,5
Thermal movement	Principles 1,3
Salt crystal expansion	Principles 1,2,3
Shrinkage	Principles 1,4
Erosion	Principles 3,5
Abrasion and wear	Principles 3,5

Concrete Damage due to Steel Reinforcement Corrosion

Chemical attack

Cause

Carbon dioxide (CO_2) in the atmosphere reacting with calcium hydroxide in the concrete pore liquid.

$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

Soluble and strongly alkaline pH 12 –13 → almost insoluble and much less alkaline pH 9

Steel protected (passivation) → steel unprotected

Relevant principles for repair and protection

Principles 1,2,3,7,8,11

Corrosive contaminants e.g. Chlorides

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

Stray electrical current

Cause

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

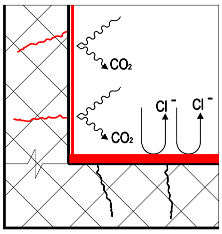
Corrosion can also be due to stray electrical currents from power supply and transmission networks

Relevant principles for repair and protection

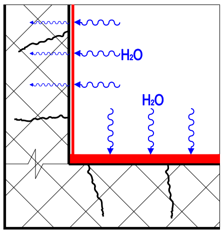
No specific Repair Principles defined at this time.
For repair of the concrete use Principles 2,3,10

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.

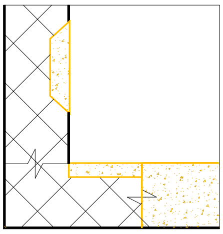
The Principles Relating to Concrete Defects



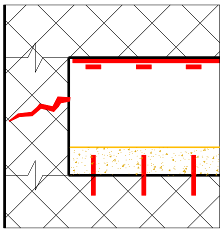
Principle 1 (PI)
Protection against ingress



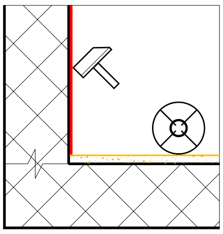
Principle 2 (MC)
Moisture control



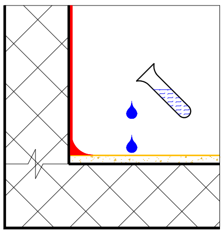
Principle 3 (CR)
Concrete restoration



Principle 4 (SS)
Structural strengthening



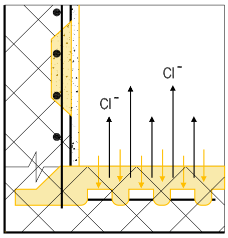
Principle 5 (PR)
Increasing physical resistance



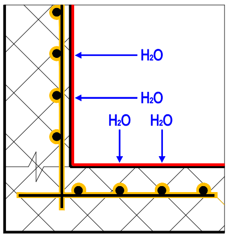
Principle 6 (RC)
Resistance to chemicals

The Principles Relating to Steel Reinforcement Corrosion

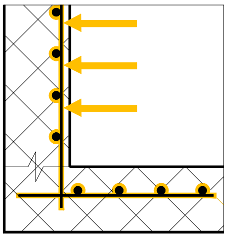
Principle 7 (RP)
Preserving or restoring passivity



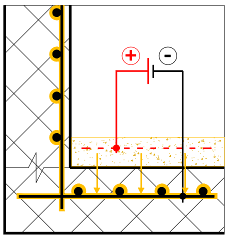
Principle 8 (IR)
Increasing resistivity



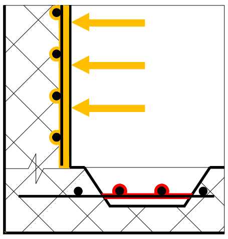
Principle 9 (CC)
Cathodic control



Principle 10 (CP)
Cathodic protection



Principle 11 (CA)
Control of anodic areas



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 specifica-tion 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 EN 1504 repair Principles and Methods can be selected.

Table 1: Principles and Methods Related to Concrete Defects

Principle	Description	Method	Sika Solution
Principle 1 (PI)	**Protection against ingress.** Reducing or preventing the ingress of adverse agents, e.g. water, other liquids, vapour, gas, chemicals and biological agents.	1.1 Hydrophobic Impregnations	**Sikagard**® range of hydrophobic impregnations
		1.2 Impregnations	**Sikafloor**® range of impregnations
		1.3 Coatings	**Sikagard**® range of elastic and rigid coatings **Sikafloor**® range for flooring applications
		1.4 Surface bandaging of cracks	**Sikadur**® **Combiflex**® **System**, and **Sika**® **SealTape**®
		1.5 Filling of cracks	**Sika**® **Injection** systems, **Sikadur**® range
		1.6 Transferring cracks into joints	**Sikaflex**® range, **Sikadur**®**-Combiflex**® **System**
		1.7 Erecting external panels	**SikaTack**®**-Panel System**
		1.8 Applying membranes	**Sikaplan**® sheet membranes, **Sikalastic**® liquid membranes
Principle 2 (MC)	**Moisture control.** Adjusting and main-taining the moisture content in the concrete within a specified range of values.	2.1 Hydrophobic impregnations	**Sikagard**® range of hydrophobic impregnations
		2.2 Impregnations	**Sikafloor**® range of impregnations
		2.3 Coatings	**Sikagard**® range of elastic and rigid coatings **Sikafloor**® range for flooring applications
		2.4 Erecting external panels	**SikaTack**®**-Panel System**
		2.5 Electrochemical treatment	A process
Principle 3 (CR)	**Concrete restoration.** Restoring the original concrete to the originally specified profile and function.	3.1 Hand applied mortar	**Sika MonoTop**®, **SikaTop**®, **SikaQuick**® **Sikadur**® and **SikaRep**® range
		3.2 Recasting with concrete or mortar	**Sika MonoTop**® range, **SikaGrout**® range
		3.3 Spraying concrete or mortar	**SikaCem**®, **Sikacrete**®**-Gunite**® ranges, **SikaRep**® and **Sika MonoTop**® systems
	Restoring the concrete structure by replacing part of it.	3.4 Replacing elements	**Sika**® bonding primers and **Sika**® concrete technology

Principle 4 (SS)	**Structural strengthening.** Increasing or restoring the structural load bearing capacity of an element of the concrete structure.	4.1 Adding or replacing embedded or external reinforcing bars	**Sikadur®** range
		4.2 Adding reinforcement anchored in pre-formed or drilled holes	**Sika® AnchorFix®** range **Sikadur®** range of adhesives
		4.3 Bonding plate reinforcement	**Sikadur®** adhesive systems combine with **Sika® CarboDur®** and **SikaWrap®**
		4.4 Adding mortar or concrete	**Sika®** bonding primers, repair mortars and concrete technology
		4.5 Injecting cracks, voids or interstices	**Sika® Injection** systems
		4.6 Filling cracks, voids or interstices	**Sika® Injection** systems
		4.7 Prestressing (post-tensioning)	**Sika® CarboStress®** system, **Sika®** cable grout
Principle 5 (PR)	**Physical resistance.** Increasing resistance to physical or mechanical attack.	5.1 Coatings	**Sikagard®** reactive coatings range, **Sikafloor®** systems
		5.2 Impregnations	–
		5.3 Adding mortar or concrete	As for Methods 3.1, 3.2 and 3.3
Principle 6 (RC)	**Resistance to chemicals.** Increasing resistance of the concrete surface to deteriorations from chemical attack.	6.1 Coatings	**Sikagard®** and **Sikafloor®** reactive coatings range
		6.2 Impregnations	–
		6.3 Adding mortar or concrete	As for Methods 3.1, 3.2 and 3.3

Table 2: Principles and Methods Related to Steel Reinforcement Corrosion

Principle	Description	Method	Sika Solution
Principle 7 (RP)	**Preserving or restoring passivity.** Creating chemical conditions in which the surface of the reinforcement is maintained in or is returned to a passive condition.	7.1 Increasing cover with additional mortar or concrete	**Sika MonoTop®, SikaTop®, SikaCem®, Sikacrete®, SikaRep® and Sika® EpoCem®** range
		7.2 Replacing contaminated or carbonated concrete	As for Methods 3.2, 3.3, 3.4
		7.3 Electrochemical realkalisation of carbonated concrete	**Sikagard®** range for post-treatment
		7.4 Realkalisation of carbonated concrete by diffusion	**Sikagard®** range for post-treatment
		7.5 Electrochemical chloride extraction	**Sikagard®** range for post-treatment
Principle 8 (IR)	**Increasing resistivity.** Increasing the electrical resistivity of the concrete.	8.1 Hydrophobic impregnations	**Sikagard®** range of hydrophobic impregnations
		8.2 Impregnations	**Sikafloor®** range of impregnations
		8.3 Coatings	As for Method 1.3
Principle 9 (CC)	**Cathodic control.** Creating conditions in which potentially cathodic areas of reinforcement are unable to drive an anodic reaction.	9.1 Limiting oxygen content (at the cathode) by saturation or surface coating	**Sika® FerroGard®** admixtures and surface applied corrosion inhibitors **Sikagard®** and **Sikafloor®** reactive coatings range **Sikadur®-32** reactive coatings
Principle 10 (CP)	**Cathodic protection.**	10.1 Applying an electrical potential	**Sika®** overlay mortars
Principle 11 (CA)	**Control of anodic areas.** Creating conditions in which potentially anodic areas of reinforcement are unable to take part in the corrosion reaction.	11.1 Active coating of the reinforcement	**SikaTop® Armatec®-110 EpoCem®, Sika MonoTop®-910**
		11.2 Barrier coating of the reinforcement	**Sikadur®-32**
		11.3 Applying corrosion inhibitors in or to the concrete	**Sika® FerroGard®** admixtures and surface applied corrosion inhibitors

EN 1504-9 PRINCIPLE 1: PROTECTION AGAINST INGRESS (PI)

PROTECTING THE CONCRETE SURFACE AGAINST LIQUID AND GASEOUS I

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.

Methods	Pictures
Method 1.1 Hydrophobic Impregnation Corresponding part of the Standards: EN 1504-2	
Method 1.2 Impregnation Corresponding part of the Standards: EN 1504-2	
Method 1.3 Coating Corresponding part of the Standards: EN 1504-2	
Method 1.4 Surface banding of cracks Corresponding part of the Standards: None	

*** This table is continued on pages 16 and 17**

NGRESS

Description	Main Criteria	Sika® Products (examples)
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.	Penetration: Class I: <10 mm Class II: ≥10 mm Capillary absorption: $w < 0.1$ kg/$(m^2 \times \sqrt{h})$ Drying rate coefficient	**Sikagard®-700 range** ■ Based on silane or siloxane hydrophobic impregnations ■ penetrate deeply and provide a liquid water repellent surface **Sikagard®-706 Thixo** (Class II) **Sikagard®-705 L** (Class II) **Sikagard®-704 S** (Class I) **Sikagard®-740 W** (Class I) **Sikagard®-700 S** (Class I)
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: $w < 0.1$ kg/$(m^2 \times \sqrt{h})$	**Sikafloor®-CureHard-24** ■ Sodium silicate base ■ Excellent abrasion and surface hardening ■ Greater densification capacity **Sikafloor®-CureHard-LI** ■ Lithium silicate base ■ Increased penetration and aesthetics ■ Reduced application costs Refer to local availability
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.	Carbonation resistance: $S_d > 50$ m Capillary absorption: $w < 0.1$ kg/$(m^2 \times \sqrt{h})$ Water vapour permeability: Class I: $S_d < 5$ m Adhesion strength: Elastic: ≥0.8 N/mm^2 or ≥1.5 N/mm^2 (trafficking) Rigid: ≥1.0 N/mm^2 or ≥2.0 N/mm^2 (trafficking)	Rigid systems: **Sikagard®-680 S** ■ Acrylic resin, solvent based ■ Waterproof Elastic systems: **Sikagard®-550 Elastoflex W** ■ Acrylic resin, water based ■ Waterproofing and crack-bridging **Sikagard®-545 Flexfill W** ■ One component acrylic resin ■ Elastic **Sikagard®-675 Color W** ■ Acrylic resin, water based ■ Waterproof **Sikagard®-674 Lazur W** ■ Acrylic resin ■ Clear glaze
Locally applying a suitable material to prevent the ingress of aggressive media into the concrete.	No specific criteria	**Sikadur®-Combiflex® System** ■ Extremely flexible ■ Weather and water resistant ■ Excellent adhesion **Sika® SealTape-S** ■ High elasticity ■ Waterproof

EN 1504-9 PRINCIPLE 1: PROTECTION AGAINST INGRESS (PI)

PROTECTING THE CONCRETE SURFACE AGAINST LIQUID AND GASEOUS I

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	Pictures
Method 1.5 Filling of Cracks Corresponding part of the Standards: EN 1504-5	
Method 1.6 Transferring cracks into joints Corresponding part of the Standards: None	
Method 1.7 Erecting of external panels Corresponding part of the Standards: None	
Method 1.8 Applying membranes Corresponding part of the Standards: None	

INGRESS (CONTINUED)

Description	Main Criteria	Sika® Products (examples)
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.	Classification of injection materials: D: ductile S: swelling	Waterproof Sealing of Joints/Cracks/Voids: Class D: **Sika® Injection-201/-203** Class S: **Sika® Injection-29/-304/-305**
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.	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
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.	No specific criteria	**SikaTack®-Panel System** ■ for the discrete or 'secret fixing' of curtain wall façade systems ■ One-component polyurethane
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.	No specific criteria	**Sikaplan®** sheet membranes ■ Full surface waterproofing **Sikalastic®** liquid membranes ■ Waterproofing ■ Particularly useful for complex details

EN 1504-9 PRINCIPLE 2: MOISTURE CONTROL (MC)

ADJUSTING AND MAINTAINING THE MOISTURE CONTENT IN THE CONCRE

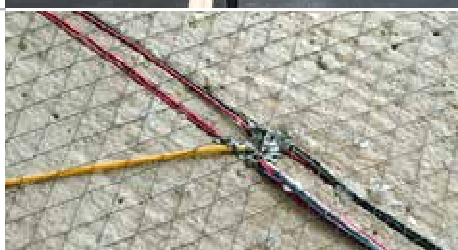
In some situations, such as where there is a risk of further alkali aggregate reaction, the concrete structure has to be protected against water penetration.

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 Sika systems for the Method "Moisture Control" are fully in accordance with the requirements of EN 1504.

Methods	Pictures
Method 2.1 Hydrophobic Impregnation Corresponding part of the Standards: EN 1504-2	
Method 2.2 Impregnation Corresponding part of the Standards: EN 1504-2	
Method 2.3 Coating Corresponding part of the Standards: EN 1504-2	
Method 2.4 Erecting external panels Corresponding part of the Standards: None	
Method 2.5 Electrochemical treatment Corresponding part of the Standards: None	

Description	Main Criteria	Sika® Products (examples)
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: $w < 0.1\ kg/(m^2 \times \sqrt{h})$ Drying rate coefficient	**Sikagard®-700 range** ■ Based on silane or siloxane hydrophobic impregnations ■ Penetrate deeply and provide a liquid water repellent surface **Sikagard®-706 Thixo** (Class II) **Sikagard®-705 L** (Class II) **Sikagard®-704 S** (Class I) **Sikagard®-740 W** (Class I) **Sikagard®-700 S** (Class I)
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: $w < 0.1\ kg/(m^2 \times \sqrt{h})$	**Sikafloor®-CureHard-24** ■ Sodium silicate base ■ Excellent abrasion and surface hardening ■ Greater densification capacity **Sikafloor®-CureHard-LI** ■ Lithium silicate base ■ Increased penetration and aesthetics ■ Reduced application costs Refer to local availability
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: $w < 0.1\ kg/(m^2 \times \sqrt{h})$ Water vapour permeability: Class I: $S_d < 5$ 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)	Rigid systems: **Sikagard®-680 S** ■ Acrylic resin, solvent based ■ Waterproof Elastic systems: **Sikagard®-550 Elastoflex W** ■ Acrylic resin, water based ■ Waterproofing and crack-bridging **Sikagard®-545 Flexfill W** ■ One component acrylic resin ■ Elastic **Sikagard®-675 Color W** ■ Acrylic resin, water based ■ Waterproof **Sikagard®-674 Lazur W** ■ Acrylic resin ■ Clear glaze
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
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	Pictures
Method 3.1 Hand-applied mortar Corresponding part of the Standards: EN 1504-3	
Method 3.2 Recasting with concrete or mortar Corresponding part of the Standards: EN 1504-3	

*** This table is continued on pages 22 and 23.**

Description	Main Criteria	Sika® Products (examples)
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.	Structural repair: Class R4 Class R3 Non structural repair: Class R2 Class R1	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) Class R2: **Sikadur®-43 HE** range ■ Epoxy based filling mortar ■ Non shrink
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.	Structural repair: Class R4 Class R3	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

EN 1504-9 PRINCIPLE 3: CONCRETE RESTORATION (CR)
REPLACING AND RESTORING DAMAGED CONCRETE (CONTINUED)

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	Pictures
Method 3.3 Spraying concrete or mortar Corresponding part of the Standards: EN 1504-3	
Method 3.4 Replacing concrete elements Corresponding part of the Standards: None	

Description	Main Criteria	Sika® Products (examples)
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.	Structural repair: Class R4 Class R3	Class R4: **SikaCem® Gunit-133** ■ High performance repair mortar ■ Very dense, high carbonation resistance ■ "Dry" spray mortar **Sika MonoTop®-412** range ■ High performance repair mortar ■ Extremely low shrinkage behaviour ■ Applied by hand or "wet" spray applied Class R3: **Sikacrete®-103 Gunit** ■ One-component ■ Contains silica fume ■ "Dry" spray mortar **Sika MonoTop®-352** range ■ Extremely low shrinkage behaviour ■ Lightweight repair mortar ■ Applied by hand or "wet" spray applied
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.	No specific criteria	System consisting of Sika® bonding primer and Sika® concrete technology Sika® bonding primers: **SikaTop® Armatec®-110 EC** ■ Epoxy modified high performance ■ Long open time **Sikadur®-32** ■ Two part epoxy based ■ High strength characteristics Sika® concrete technology: **Sika® ViscoCrete®** range **Sikament®** range

EN 1504-9 PRINCIPLE 4: STRUCTURAL STRENGTHENING (SS)

INCREASING OR RESTORING THE STRUCTURAL LOAD CAPACITY

Whenever there is a need for structural strengthening due to a change of the structures designation, or to an increase in the structural load bearing capacity for example, the appropriate analysis must be performed by a qualified structural engineer. Various methods are available to achieve the necessary strengthening and these include: adding external support or embedded reinforcement, by bonding external plates, or by increasing the dimensions of the structure.

The selection of the appropriate method is dependant 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 unidirectional fabrics (SikaWrap®) based on several different fibre types (carbon, glass, etc.).

Methods	Pictures
Method 4.1 Adding or replacing embedded or external reinforcing bars Corresponding part of the Standards: None	
Method 4.2 Adding reinforcement anchored in pre-formed or drilled holes Corresponding part of the Standards: EN 1504-6	
Method 4.3 Bonding plate reinforcement Corresponding part of the Standards: EN 1504-4	
Method 4.4 Adding mortar or concrete Corresponding part of the Standards: EN 1504-3 and EN 1504-4	

*** This table is continued on pages 26 and 27.**

Description	Main Criteria	Sika® Products (examples)
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
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 **Sikadur®-42** ■ Epoxy grout system ■ Non-shrink
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.
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** **Sikadur®-41 CF** ■ Epoxy based patching mortar Bonding primers: **Sikadur®-32** **SikaTop® Armatec®-110 EpoCem®**

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.

Methods	Pictures
Method 4.5 Injecting cracks, voids or interstices Corresponding part of the Standards: EN 1504-5	
Method 4.6 Filling cracks, voids or interstices Corresponding part of the Standards: EN 1504-5	
Method 4.7 Prestressing – (post tensioning) Corresponding part of the Standards: None	

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Description	Main Criteria	Sika® Products (examples)
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.	Classification of injection material: F: transmitting force / load transfer	**Sikadur®-52** Injection ■ Two-component epoxy resin ■ Low viscosity **Sikadur®-53** ■ Two-component epoxy resin ■ Insensitive to humidity **Sika® Injection-451** ■ High strength structural epoxy resin ■ Very low viscosity **Sika® InjectoCem®-190** ■ Two part micro-cement injection ■ Corrosion protection of embedded reinforcement
When inert cracks, voids or interstices are wide enough, they can filled by gravity (pouring) or by using an epoxy patching mortar.	Classification of injection material: F: transmitting force / load transfer	**Sikadur®-52** Injection ■ Two-component epoxy resin ■ Low viscosity **Sikadur®-53** ■ Two-component epoxy resin ■ Insensitive to humidity **Sika® Injection-451** ■ High strength structural epoxy resin ■ Very low viscosity **Sika® InjectoCem®-190** ■ Two part micro-cement injection ■ Corrosion protection of embedded reinforcement **Sikadur®-31** ■ Two part epoxy adhesive ■ High strengths ■ Thixotropic: non sag-flow in vertical or overhead applications
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	Carbon fibre prestressing systems: **Sika® CarboStress®** system Traditional bonded prestressing systems: **SikaGrout®-300 PT**

EN 1504-9 PRINCIPLE 5: PHYSICAL RESISTANCE (PR)

INCREASING THE CONCRETE’S RESISTANCE TO PHYSICAL AND /OR MEC

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 environ-mental conditions.

Methods	Pictures
Method 5.1 Coating Corresponding part of the Standards: EN 1504-2	
Method 5.2 Impregnation Corresponding part of the Standards: EN 1504-2	
Method 5.3 Adding mortar or concrete Corresponding part of the Standards: EN 1504-3	

HANICAL ATTACK

Description	Main Criteria	Sika® Products (examples)
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-lost <3000 mg Capillary absorption: w <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: **Sikafloor®-261/-263 SL** ■ Good chemical and mechanical resistance ■ Excellent abrasion resistance ■ Solvent free Class I: **Sikafloor®-2530 W** ■ Two part, water dispersed epoxy resin ■ Good mechanical and chemical resistance **Sikafloor®-390** ■ High chemical resistance ■ Moderate crack-bridging capability
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: w <0.1 kg/(m² × √h) Impact resistance: Class I to Class III	**Sikafloor®-CureHard-24** ■ Sodium silicate base ■ Excellent abrasion and surface hardening ■ Greater densification capacity **Sikafloor®-CureHard-LI** ■ Lithium silicate base ■ Increased penetration and aesthetics ■ Reduced application costs Refer to local availability
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 **Sikafloor®-82 /-83 EpoCem** ■ Epoxy modified cement mortar ■ High frost and deicing salt resistance **Sika® Abraroc®** ■ High mechanical strength ■ Excellent abrasion resistance **SikaGrout®** range ■ High performance levelling mortar ■ Excellent flow characteristics

EN 1504-9 PRINCIPLE 6: CHEMICAL RESISTANCE (RC)
INCREASING THE CONCRETE'S RESISTANCE TO CHEMICAL ATTACK

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	Pictures
Method 6.1 Coating Corresponding part of the Standards: EN 1504-2	
Method 6.2 Impregnation Corresponding part of the Standards: EN 1504-2	
Method 6.3 Adding mortar or concrete Corresponding part of the Standards: EN 1504-3	

Description	Main Criteria	Sika® Products (examples)
Only high performance reactive coatings are able to provide sufficient protection to concrete and improve its resistance to chemical attack.	Resistance to strong chemical attack: 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: **Sikagard®-63 N** ■ Two part epoxy resin with good chemical and mechanical resistance ■ Tightly cross-linked surface **Sikafloor®-390** ■ High chemical resistance ■ Moderate crack-bridging behaviour Class I: **Sikafloor®-261/-263 SL** ■ Good chemical and mechanical resistance ■ Excellent abrasion resistance ■ Solvent free
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.	Resistance to chemical attack after 30 days exposure	refer to local availability
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.	No specific criteria	**Sikagard®-720 EpoCem®, Sikafloor®-81/-82/-83 EpoCem®** ■ Epoxy modified cement mortars ■ Good chemical resistance ■ Very dense and watertight

EN 1504-9 PRINCIPLE 7: PRESERVING OR RESTORING PASSIVI
TREATING OR REPLACING CONCRETE SURROUNDING THE REINFORCEM

Corrosion of the reinforcing steel in a concrete structure only happens when various conditions are met: loss of passivity, the presence of oxygen and the presence of sufficient moisture in the surrounding concrete.

If one of these conditions is not met, then corrosion cannot occur. In normal conditions, the reinforcement steel is protected from the alkalinity surrounding the concrete cover. This alkalinity creates a passive film of oxide on the steel surface which protects the steel from corrosion.

However, this passive film can be damaged due to the reduction of the alkalinity by carbonation when the carbonation front has reached the reinforcement steel. A break-down also occurs due to chloride attack. In both these instances, the protecting passivation is then lost. Different methods to reinstate (or to preserve) the passivity of the reinforcement are available.

The selection of the appropriate method will depend on various parameters such as: the reasons for the loss of passivation (e.g. due to carbonation or chloride attack), the extent of the damage, the specific site conditions, the repair and protection strategy, maintenance possibilities, costs, etc.

Methods	Pictures
Method 7.1 Increasing cover with additional mortar or concrete. Corresponding part of the Standards: EN 1504-3	
Method 7.2 Replacing contaminated or carbonated concrete. Corresponding part of the Standards: EN 1504-3	
Method 7.3 Electrochemical realkalisation of carbonated concrete Corresponding part of the Standards: None	
Method 7.4 Realkalisation of carbonated concrete by diffusion Corresponding part of the Standards: None	
Method 7.5 Electrochemical chloride extraction Corresponding part of the Standards: None	

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Description	Main Criteria	Sika® Products (examples)
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.	Carbonation resistance: Class R4 or R3 Compressive strength: Class R4 or R3 Adhesive bond: Class R4 or R3	Class R4: **Sika MonoTop®-412** range **Sikacrete®-103 Gunit** **SikaTop®-121/-122** **Sikafloor®-82 EpoCem®** Class R3: **Sika MonoTop®-352** range
Through removing damaged concrete and rebuilding the concrete cover over the reinforcement, the steel is again protected by the alkalinity of its surroundings.	Carbonation resistance: Class R4 or R3 Compressive strength: Class R4 or R3 Adhesive bond: Class R4 or R3	Class R4: **Sika MonoTop®-412** range **Sikacrete®-103 Gunit** Class R3: **Sika MonoTop®-352** range Sika concrete technology for quality concrete replacement: **Sika® ViscoCrete®** **Sikament®**
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.	No specific criteria	For post-treatment: **Sikagard®-720 EpoCem®** For post-treatment: **Sikagard®-680 S**
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.	No specific criteria	For post-treatment: **Sikagard®-720 EpoCem®** For post-treatment: **Sikagard®-680 S**
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).	No specific criteria	For post-treatment: penetrating hydrophobic impregnation with **Sikagard®-705 L** or **Sikagard®-706 Thixo** plus protective coating **Sikagard®-680 S**

EN 1504-9 PRINCIPLE 8: INCREASING RESISTIVITY (IR)

INCREASING THE ELECTRICAL RESISTIVITY OF THE CONCRETE TO REDU

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	Pictures
Method 8.1 Hydrophobic Impregnation Corresponding part of the Standards: EN 1504-2	
Method 8.2 Impregnation Corresponding part of the Standards: EN 1504-2	
Method 8.3 Coating Corresponding part of the Standards: EN 1504-2	

Description	Main Criteria	Sika® Products (examples)
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.	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%	**Sikagard®-700** range ■ Based on silane hydrophobic ■ Penetrate deeply and provide a liquid-- water repellent surface **Sikagard®-706 Thixo** (Class II) **Sikagard®-705 L** (Class II) **Sikagard®-704 S** (Class I) **Sikagard®-740 W** (Class I)
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: $w < 0.1\ kg/(m^2 \times \sqrt{h})$	**Sikafloor®-CureHard-24** ■ Sodium silicate base ■ Excellent abrasion and surface hardening ■ Greater densification capacity **Sikafloor®-CureHard-LI** ■ Lithium silicate base ■ Increased penetration and aesthetics ■ Reduced application costs Refer to local availability
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.	Capillary absorption: $w < 0.1\ kg/(m^2 \times \sqrt{h})$ Water vapour permeability: Class I: $S_d < 5$ m Class II: 5 m $\leq S_d \leq 50$ m Class III: $S_d > 50$ 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 Elastoflex W** ■ 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	Pictures
Method 9.1 Limiting oxygen content (at the cathode) by surface saturation and surface coating. Corresponding part of the Standards: None	

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	Pictures
Method 10.1 Applying an electrical potential. Corresponding part of the Standards: None	

Description	Main Criteria	Sika® Products (examples)
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 continious film on the surface of the steel reinforcement which acts as a barrier to oxygen.	Sika recommendation of: >100 ppm (parts per million) concentration of corrosion inhibitor at the rebar level in the presence of chlorides.	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

Description	Main Criteria	Sika® Products (examples)
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.	Resistiviy of the mortar: according to local requirements.	Mortars for embedded cathodic protection mesh: Spray applied mortar: **Sika MonoTop®-412 N** ■ Low shrinkage ■ Sufficient resistivity Levelling mortar: **Sikafloor® 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 contami-nated structures, spalling due to rein-forcement corrosion happens first in areas of low concrete cover. Additionally it is also important to protect repaired areas from the future ingress of aggres-sive 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	Pictures
Method 11.1 Active coating of the reinforcement Corresponding part of the Standards: EN 1504-7	
Method 11.2 Barrier coating of the reinforcement Corresponding part of the Standards: EN 1504-7	
Method 11.3 Applying corrosion inhibitors in or to the concrete. Corresponding part of the Standards: None	

Description	Main Criteria	Sika® Products (examples)
These coatings contain active pigments that can function as an inhibitor or/and 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 N** ■ 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
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
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.	Sika recommendation of: >100 ppm (parts per million) concentration of corrosion inhibitor at the rebar level in the presence of chlorides.	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

SUMMARY FLOW CHART AND PHASES OF THE CORRECT CON
IN ACCORDANCE WITH EUROPEAN STANDARDS EN 1504

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

Information about the Structure	Process of Assessment	Management Strategy
History of structure Review documentation Condition survey	Defect diagnosis Analysis results Root cause identification Structural assessment	Repair options Select Principles Select Methods Health and safety issues
EN 1504-9, Clause 4, Annex A	**EN 1504-9, Clause 4, Annex A**	**EN 1504-9, Clauses 5 and 6, Annex A**

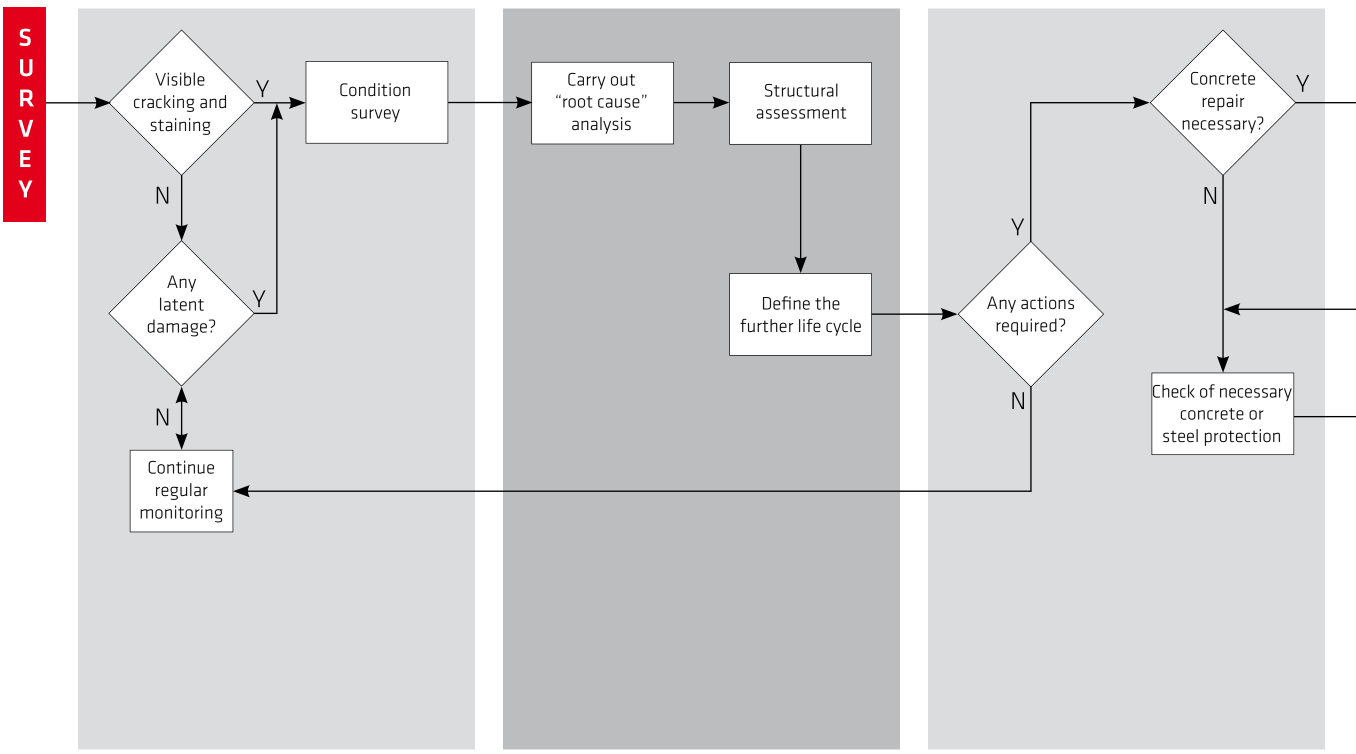
Related Pages in this Brochure

See more details on page 4

See more details on page 6/7

See more details on page 42 – 45

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



CRETE REPAIR AND PROTECTION PROCEDURE

Design of Repair Work

- Definition of performance
- Substrate preparation
- Products
- Application
- Specifications
- Drawings

EN 1504 Parts 2–7 and EN 1504-9, Clauses 6, 7 and 9

Repair Work

- Final product selection
- Equipment selection
- Health and safety assessment
- QA/QC definition

EN 1504-9, Clause 9 and 10 and EN 1504-10

Acceptance of Repair Work

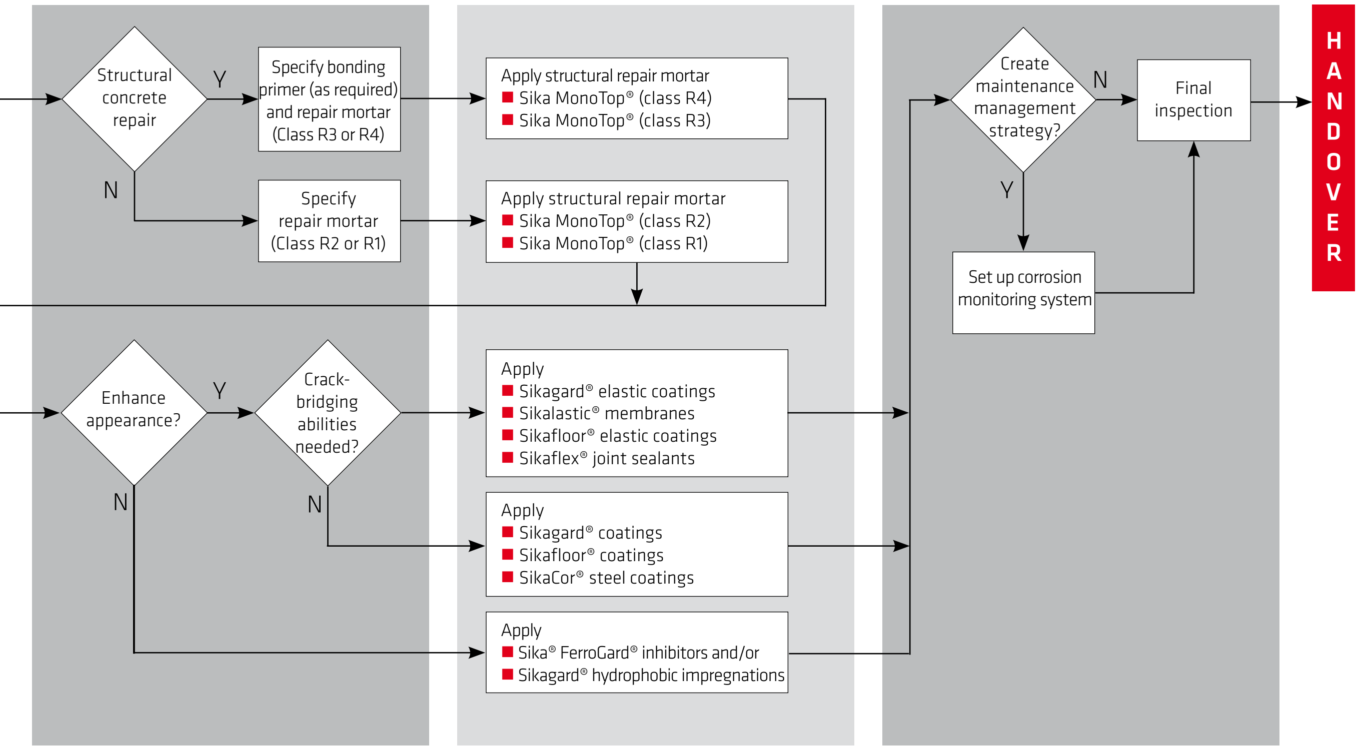
- Acceptance of testing
- Acceptance of finishing
- Final documentation
- Maintenance strategy

EN 1504-9, Clause 8 and EN 1504-10

See more details on page 12 – 39

See more details on page 46 – 47

See more details on page 5



SELECTION OF THE METHODS TO BE USED FOR CONCRETE RE

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

Concrete Defects / Damage	Minor Damage	Medium Damage	Heavy Damage
Concrete cracks	1.5 Filling of cracks	1.5 Filling of cracks 1.6 Transferring cracks into joints	4.5 Injecting cracks, voids or interstices 4.6 Filling cracks, voids or interstices
Concrete spalling due to mechanical impact	3.1 Hand applied mortar	3.1 Hand applied mortar 3.2 Recasting with concrete or mortar 3.3 Spraying concrete or mortar	3.2 Recasting with concrete or mortar 3.3 Spraying concrete or mortar
Structural damage from overloading or earthquake	3.1 Hand applied mortar **and** 4.4 Adding mortar or concrete	3.1 Hand applied mortar **and** 4.1 Adding or replacing embedded or external reinforcing bars 3.1 Hand applied mortar **and** 4.2 Adding reinforcement anchored in pre-formed or drilled holes	3.3 Spraying concrete or mortar **and** 4.3 Bonding plate reinforcement 3.2 Recasting with concrete or mortar **and** 4.7 Prestressing (post-tensioning) 3.4 Replacing elements
Scaling from Freeze/Thaw action	3.1 Hand applied mortar 5.1 Coating (cement based)	5.1 Coating (cement based) 5.3 Adding mortar or concrete	5.3 Adding mortar or concrete
Damage from chemical attack	6.1 Coating (cement based)	6.1 Coating (cement based) 6.3 Adding mortar or concrete	6.3 Adding mortar or concrete 3.2 Recasting with concrete or mortar 3.3 Spraying concrete or mortar

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

Damage due to Reinforcement Corrosion

Concrete Defects / Damage	Minor Damage	Medium Damage	Heavy Damage
Concrete spalling due to carbonation	3.1 Hand applied mortar	3.1 Hand applied mortar 3.2 Recasting with concrete or mortar 3.3 Spraying concrete or mortar	3.2 Recasting with concrete or mortar **and** 4.1 Adding or replacing embedded or external reinforcing bars 3.3 Spraying concrete or mortar **and** 4.2 Adding reinforcement anchored in pre-formed or drilled holes 7.2 Replacing contaminated or carbonated concrete
Reinforcement corrosion due to chlorides	3.1 Hand applied mortar	3.1 Hand applied mortar 3.2 Recasting with concrete or mortar 3.3 Spraying concrete or mortar	3.4 Replacing elements 7.2 Replacing contaminated or carbonated concrete **and** 4.1 Adding or replacing embedded or external reinforcing bars 7.2 Replacing contaminated or carbonated concrete **and** 4.3 Bonding plate reinforcement
Stray electrical currents	3.1 Hand applied mortar 3.2 Recasting with concrete or mortar	3.2 Recasting with concrete or mortar 3.3 Spraying concrete or mortar	3.2 Recasting with concrete or mortar **and** 4.2 Adding reinforcement anchored in pre-formed or drilled holes 3.3 Spraying concrete or mortar **and** 4.1 Adding or replacing embedded or external reinforcing bars

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

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

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

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

THE INDEPENDENT ASSESSMENT AND APPROVALS OF SIKA®
PLUS TESTING AND PROOF STATEMENTS IN ACCORDANCE WI

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.

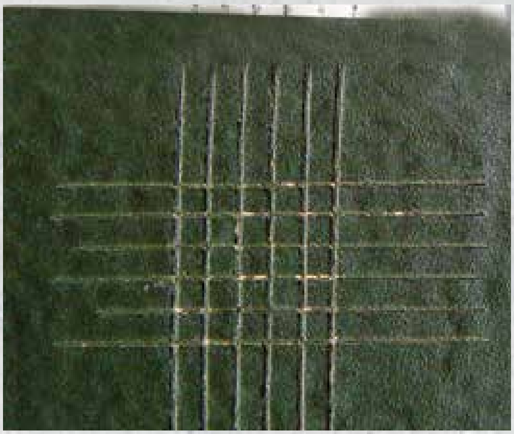
Replacing damaged concrete
- Bond strength
- Compressive and flexural strengths
- Permeability to water
- Elastic modulus (stiffness)
- Restrained shrinkage
- Thermal compatibility
- etc.

For concrete protection

Moisture control with hydrophobic impregnations
- Penetration depth
- Water absorption
- Alkalic resistance
- Water vapour permeability
- Freeze / thaw resistance
- etc.

Rigid 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.



PRODUCTS AND SYSTEMS,
ITH THE REQUIREMENTS OF EN 1504

The Performance Criteria

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.

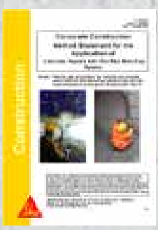
Equally **Sikagard**® coatings must have adequate viscosity and the right thixotropic properties at different temperatures, in order to obtain the desired wet and dry film thicknesses. This should be achieved in the minimum number of coats, plus they must also achieve adequate opacity and become weather resistant quickly.

Quality Assurance

Quality Control in Production

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

There are many reported causes of premature failures in repair mortar, but one of the most common is cracks forming in the material. For a long time Sika has recognised this issue and developed a practical test procedure to push performance limits and improve product quality.

The unfilled "Baenziger Block".

Filled "Baenziger Block" with crack sensitive Mortar.

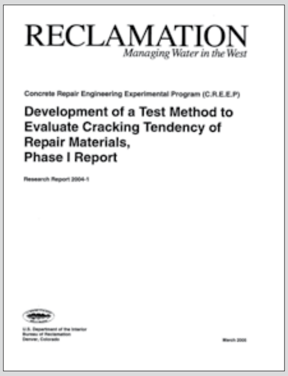
Mortar with good crack behavior.

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



RECLAMATION
Managing Water in the West

Concrete Repair Engineering Experimental Program (C.R.E.E.P)

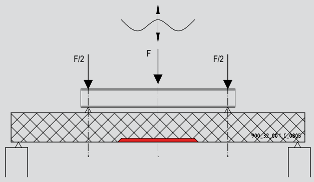
Development of a Test Method to Evaluate Cracking Tendency of Repair Materials, Phase I Report

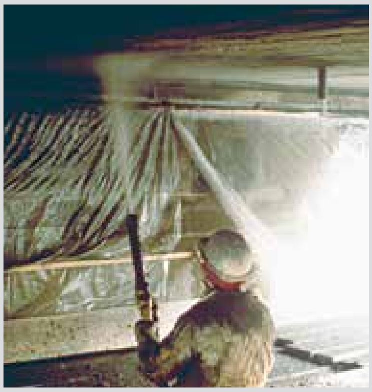
Research Report 2004-1

The "Baenziger Block" has now been assessed as the optimal specification and configuration for evaluating the sensitivity of repair materials by the USA Department of the Interior CREE Programme

Testing Product Application under Dynamic Load

Application for installation and perfor-mance testing of repair mortars under live dynamic loading.





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, Switzer-land 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 specializing in this field.

The excellent condition of the structures and the materials performance reports that were the conclusions of these en-gineers, 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 protec-tion.

These reports are available in a printed Sika reference document "Quality and Durability in Concrete Repair and Pro-tection".

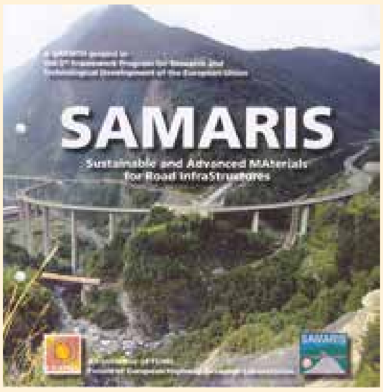
Concrete Protection

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)

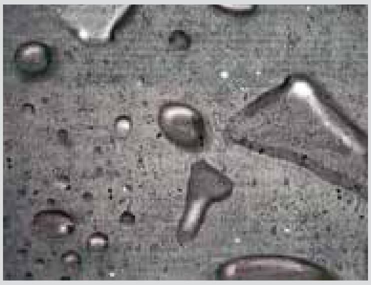


Additionally there is the European SAMARIS project begun in 2002 which forms part of the major European Community research project: **S**ustainable and **A**dvanced **Ma**terials for **R**oad **I**nfra-**S**tructure). This was set up to investigate innovative techniques for the maintenance of RC structures.

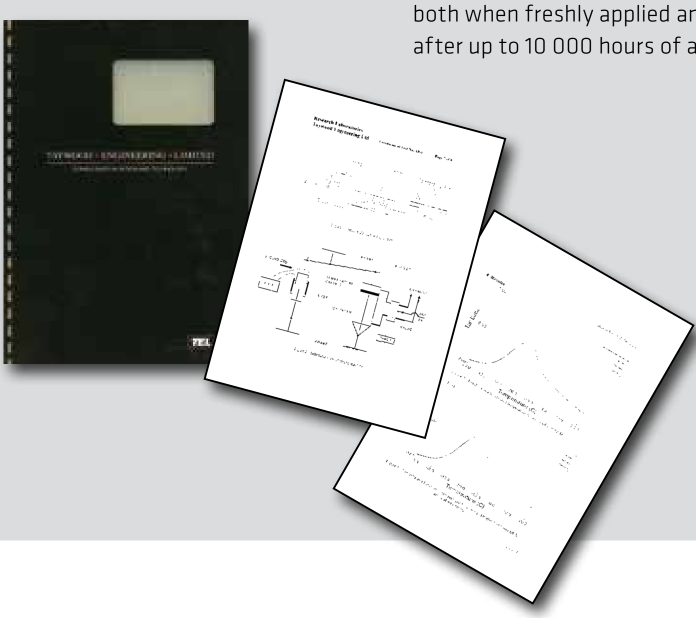
These reports all concluded that when the appropriate conditions are met, **Sika**® **FerroGard**®**-903**+ is a cost-effective method of corrosion mitigation.

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

Commercial Buildings

Issues:	Sika Solutions:*
■ Concrete Spalling	■ Applying concrete or repair mortar by Hand or Spray **Sika MonoTop®-352 N** Admixtures for concrete with **Sikament®**
■ Exposed Steel	■ Protect the rebars from corrosion **Sika MonoTop®-910 N**
■ 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 Elastoflex W**
■ Concrete Protection	■ Coatings to protect the concrete **Sikagard®-675 Color W Sikagard®-740 W**
■ 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** Admixtures for concrete with **Sika® ViscoCrete®**
■ 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 Elastoflex W** ■ Cracks more than 0.3 mm wide **Sikadur®-52 Injection**
■ Concrete Protection	■ Coatings to protect the concrete **Sikagard®-680 S** **Sikagard®-706 Thixo** ■ Waterproofing layer: **Sikalastic-822**
■ Joints	**Sikadur® Combiflex® System**

* Additional Sika solutions are also possible, please refer to specific documentation or contact our Technical Service Departments for advice.

AND PROTECTION WITH SIKA® SYSTEMS

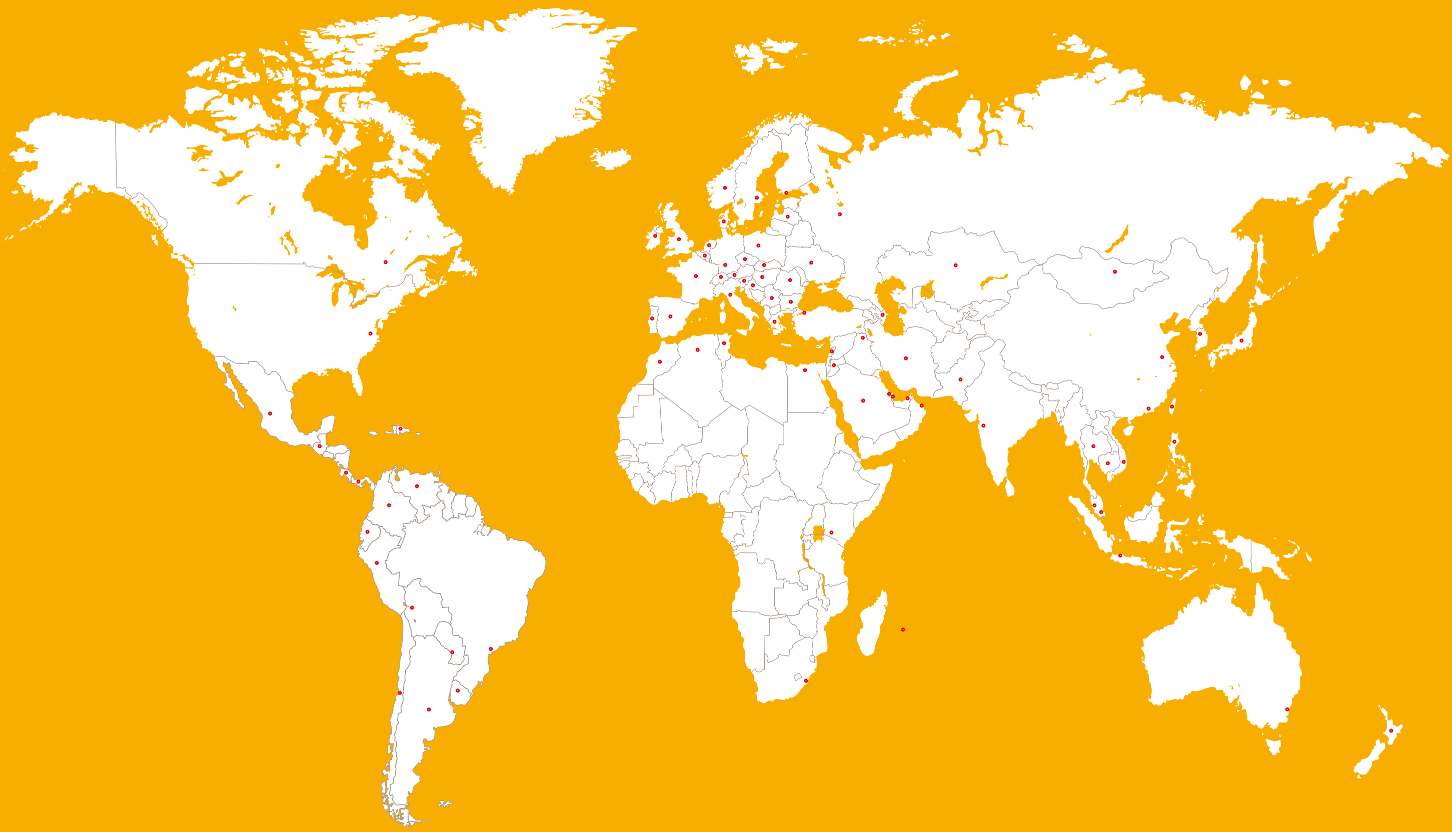
Chimneys and Cooling Towers

Issues:	Sika Solutions:*
Concrete Spalling	Applying concrete or repair mortar by Hand or Spray **Sika MonoTop®-412 NFG** or **SikaCem®-Gunit 133** Admixtures for concrete with **Sika® ViscoCrete®**
Exposed Steel	Protect the rebars from corrosion **SikaTop® Armatec®-110 EpoCem®** for highly corrosive environments
Embedded Steel	Protection of the reinforcement by applying corrosion inhibitors **Sika® FerroGard®-903+**
Cracks	For non-moving cracks **Sikagard®-720 EpoCem** For fine surface cracks **Sikagard®-550 Elastoflex W** Cracks more than 0.3 mm wide **Sika® Injection-451**
Concrete Protection	Coatings to protect the concrete **Sikagard®-720 EpoCem®** **Sikagard®-680 S** **SikaCor® 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** Admixtures for concrete with **Sika® ViscoCrete®**
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 **Sika® Injection-201**
Concrete Protection	Coatings to protect the concrete **Sikagard®-720 EpoCem®** **SikaCor® Poxitar F**
Abrasion	**Sika® Abraroc®**
Joints	**Sikadur® Combiflex® System**

GLOBAL BUT LOCAL PARTNERSHIP



COMMITTED TO EXCELLENCE
INSPIRED BY INNOVATION
BUILDING TRUST

CELEBRATING 25 YEARS IN THAILAND 1989-2014

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