REFURBISHMENT PROTECTIVE COATINGS FOR CONCRETE

BUILDING TRUST

SIKA – YOUR PARTNER

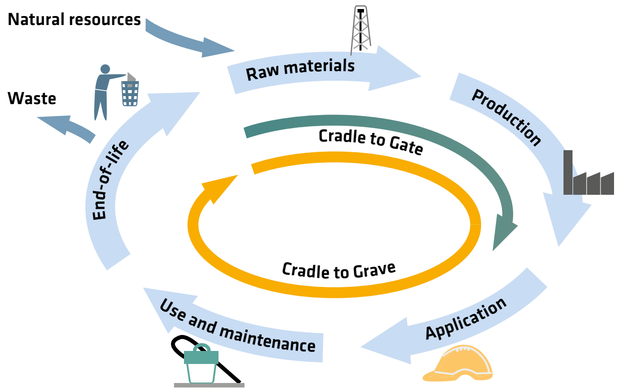
Concrete is a material especially used in civil engineering structures for its strength and durability. For buildings it also has to achieve the look and beauty envisaged by the owner and their architect. To enhance these aesthetics and bring more colors, or for example to increase the durability of the concrete by preventing water ingress and to seal and accommodate surface cracks, protective coating systems can provide the ideal solution.

We have developed and produced coating systems that are used all around the world to protect concrete surfaces and structures for many decades. This includes the protection of all types of buildings and structures, in various types of environment and climatic conditions, from the winter cold of North America and Eastern Europe, the heat and humidity of Central and Southern America or Asia, to the dry, arid heat of the Middle East and desert regions.

CONTENTS

SIKA'S LIFE CYCLE ASSESSMENT APPROACH

Life Cycle Assessment (LCA) is a standardized method to assess and compare the inputs, outputs and potential environmental impacts of products and services over their life cycle. LCAs are increasingly recognized as the best way to evaluate the sustainability of products and systems.



Sika carries out LCAs according to the ISO 14040 series and the Standard EN 15804. The impact assessment methodology used is CML 2001. The data for the Sika LCA is based on public databases, such as those from ecoinvent, the European Reference Life Cycle Database (ELCD) and PE-GaBi, plus the specific data from Sika production plants and products.

Sika evaluates all impact categories and resource indicators deemed as important according to the relevant standards.

Cumulative Energy Demand (CED), Global Warming Potential (GWP) and Photochemical Ozone Creation Potential (POCP) are considered to be most relevant for concrete repair and protection:

- Cumulative Energy Demand (CED) is the total amount of primary energy from renewable and non-renewable resources.
- Global Warming Potential (GWP) is the potential contribution to climate change due to greenhouse gases emissions.
- Photochemical Ozone Creation Potential (POCP) is the potential contribution to summer smog, related to ozone induced by sunlight on volatile organic compounds (VOC) and nitrous oxides (NOx).

SUSTAINABLE REFURBISHMENT OF COOLING TOWERS

Sika LCAs on refurbishment strategies for cooling towers are based on a 'Cradle to Grave' approach. Potential environmental impact of products for concrete repair and protection are investigated from raw material extraction, production, application and use to final disposal at end of life. Construction and end-of-life scenario of the reinforced concrete structure itself are excluded.

Natural Draft Cooling Tower Refurbishment Scenarios 20'000 m²

	Scenario 1 **Cost orientated**	**Scenario 2** **Retrofitting with durable system**	**Scenario 3** **Durability orientated**
Initial construction	No protection	No protection	Full protection with proven coating and adequate surface preparation
After 20 years	Full refurbishment Inadequate surface preparation highly solvented coatings	Full refurbishment proper surface preparation proven protective coatings	Refreshing coat only
Every 10 years	Full refurbishment as after 20 years	No requirement	No requirement
Every 20 years		Refreshing coat only	Refreshing coat only

SUSTAINABLE REFURBISHMENT OF COOLING TOWERS

Sika's well proven and durable protective system (scenarios 2 & 3) allows a reduction in the frequency of refurbishment while having a significant reduction on the three impact categories and a lower material input.
Advantages of scenario 3 over scenario 2 is the better flexibility for correct application of the protection system at the time when the tower is erected.

Scenario 1: Polymer modified cement protective coating system

20 years → 10 years → 10 years → 10 years → 10 years

No Protection | Full refurbishment every 10 years

Scenario 2: Retrofitting with durable system

20 years → 20 years → 20 years

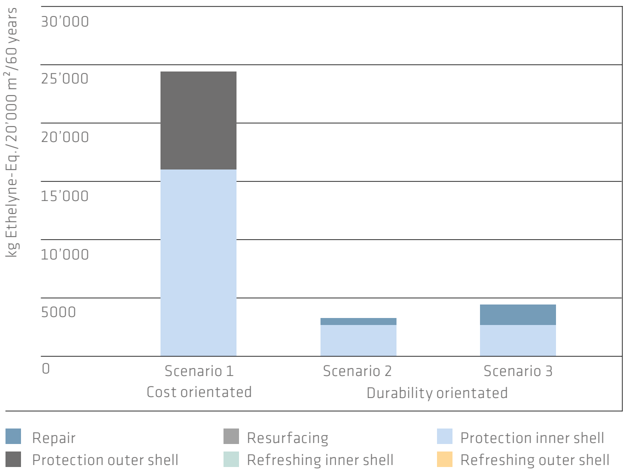
No Protection | Full Refurbishment | Refreshing coat

Scenario 3: Durability oriented system

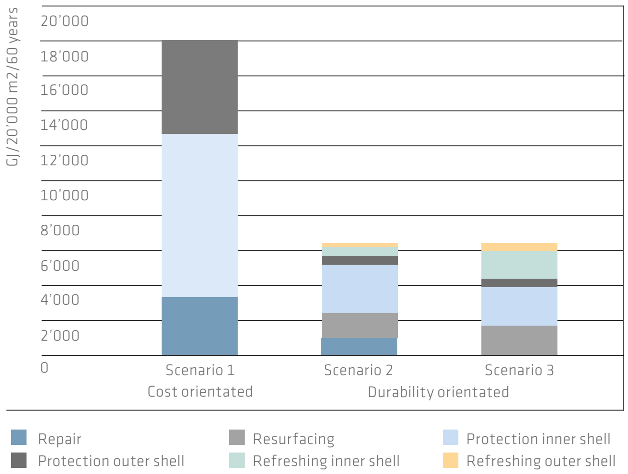
20 years → 20 years → 20 years

Full Protection | Refreshing coat every 20 years

Photochemical Ozone Creation Potential (POCP)



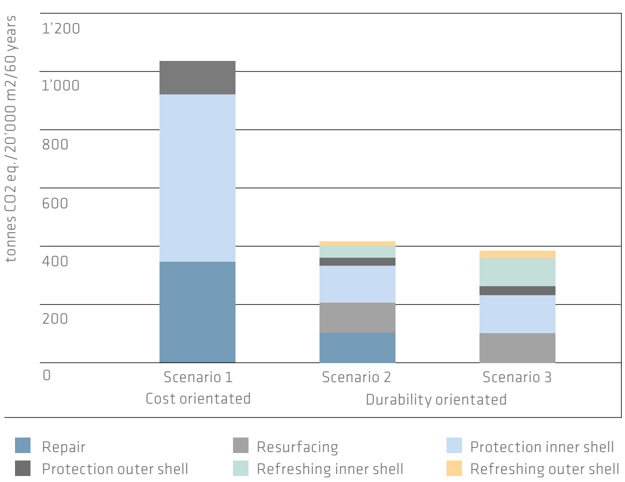
Cumulative Energy Demand (CED)



The higher impact of **scenario 1** is due to the use of heavily solvent containing coating system.
The difference between the scenario 1 and the other two is around 20'000 liters of Ethylene equivalent over the life cycle period of 60 years.
➔ This is equivalent to a saving of more than one drum of pure solvent a year.

Scenarios 2 and 3 have significant lower CED than scenario 1. This is due to a greater resource efficiency (lower material consumption over the whole life cycle).
➔ This is equivalent to a saving of 1'300 liter of oil per year.

Global Warming Potential (GWP)



The greater resource efficiency of **scenario 2 and 3** allows saving of 600 tons of CO_2 over the life cycle of 60 years.
➔ This is equivalent to a saving of 77'000 km a year (compared to the limit of the European Union of not more than 130 g of CO_2 per km targeted for 2015).

CONCLUSION

Overall savings for the plant owner with positive incidence on sustainability:

The appropriate strategy can have a beneficial impact:
- by reducing the frequency of refurbishment cycles
- by improving the resource efficiency and the environmental performance of the refurbishment process
- by providing a more sustainable solution

PROVEN LONG-TERM DURABILITY

SIKA PROTECTIVE COATINGS have been applied all over the world for several decades. Extensive references and Case Studies are available for all types of structures and exposures.

In the late 1990's Sika commissioned various external institutes to investigate the performance of Sika concrete repair and protection systems that had been applied some years before. This in-depth investigation was carried out in Europe (England, Germany, Denmark and Norway), and revealed the outstanding performance of the different Sika protective coatings that had been applied from 10 to 20 years ago on the different projects.
In 2008, a similar investigation was made into the performance of the protective coating systems applied 16 years ago at that time, on multiple Cooling Towers of a power plant in Poland. This revealed that despite the harsh conditions, both internally and externally the Sika protective coating systems still achieved, and even still outperformed, the protective performance requirements of the latest European Standard EN 1504-2.
It is therefore also no surprise that Sika won more than 100 awards from the prestigious ICRI institute, for projects successfully completed and having proven durability using Sika Concrete Repair and Protection Systems. Among them many ICRI awards of longevity were won when using Sika protective coatings.

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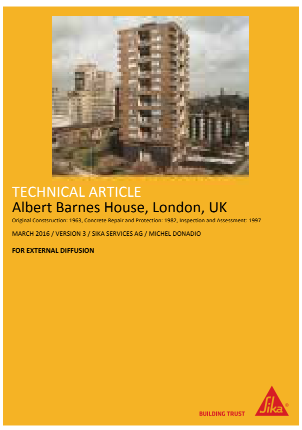
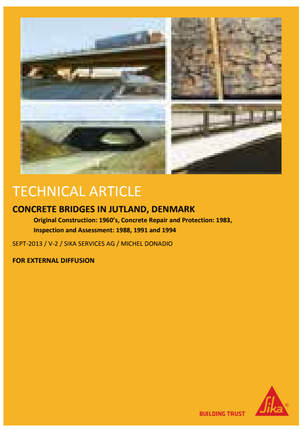
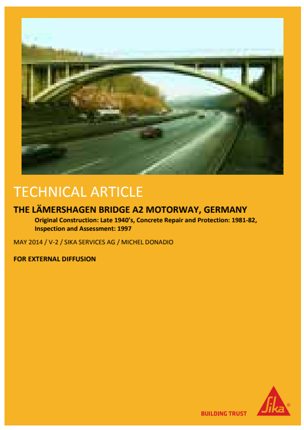




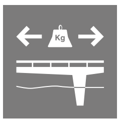


CONCRETE STRUCTURES AND THEIR EXPOSURE

DEPENDENT ON THEIR LOCATION AND USE, concrete structures are subjected to a wide range of exposure conditions – from normal atmospheric carbonation to the aggressive influences in polluted urban and/or industrial environments, plus marine atmospheres and other chemicals (liquid and gaseous) etc., together with other influences and actions that can damage or attack the concrete and / or its embedded steel reinforcement.

Water Ingress
Water can penetrate naturally through the capillary pore structures of reinforced concrete. In areas of carbonated concrete, or where there is a high chloride content on the surface of the steel reinforcing bars, reinforcement corrosion, cracks or spalling can occur on the surface.

Freeze / Thaw Action
The freeze thaw process creates stresses in the concrete matrix due to the expansion of free water in the capillary pores during freezing conditions; this can result in scaling of the surface of poor quality concrete. This action is also greatly accelerated by the presence of chlorides in the water.

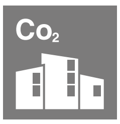


Dynamic and Static Load
Overloading due to increasing traffic loads, inadequate design, damage to the structure, stress/ fatigue failure, earthquake effects, or any other mechanical impact such as vehicle impact, can all exceed or reduce the load capacity of the structure.

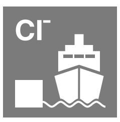
Chemical
Some structures such chemical plants or sewer system or waste water treatment plants are subjected to different level of chemical attacks. Some special coatings may be required – refer to the relevant Sika brochure.

Wide Temperature Variation
Buildings and bridges may be subjected to a wide variation of temperatures between day and night / winter and summer conditions, or between different sides or surfaces of the structure. These frequent cycles result in thermal stresses and movement in the concrete structure that can also result in cracks.

Fire
Reinforced concrete may be damaged from fire exposure. Special intumescent coatings may be used to protect against the structures against the effect of fire. What is expected from normal coating is they should not bring food to the fire in order not to increase its intensity. Some structures like tunnel have special consideration with this particular risk.



Carbon Dioxide
Carbon Dioxide (CO_2) reacts with the Calcium Hydroxide ($Ca(OH)_2$) in the pore liquid of the cement matrix of concrete structures and deposits as calcium carbonate ($CaCO_3$). This process known as carbonation reduces the protection of embedded steel reinforcement, when the process reaches the reinforcement bars.



Chlorides Ingress
Chlorides come from de-icing salts used in winter, or from salt water in marine environments. They can penetrate the concrete structure and once they reach the reinforcement bars, they can locally destroy the passivation film causing fast pitting corrosion.

KEY STAGES IN THE CONCRETE REFURBISHMENT PROCESS

THE SUCCESSFUL REPAIR, PROTECTION AND CORROSION MANAGEMENT of concrete structures always requires an initial professional assessment and an appropriate detailed condition survey.

KEY STAGES IN THE CORRECT REPAIR AND REFURBISHMENT PROCESS:

1. ASSESSMENT OF THE STRUCTURE
A condition survey by qualified and experienced people to include the condition of the structure and its surfaces, including visible, non-visible and potential defects.

2. IDENTIFICATION AND DEGREE OF THE CAUSE(S) OF DAMAGE
A review of the original construction details and any previous refurbishment works, plus analysis and diagnosis from the condition survey to identify:
- Damage due to concrete defects or attack (mechanical, chemical or physical types)
- Damage due to reinforcement corrosion (carbonation or chloride attack)

3. DETERMINATION OF REPAIR AND PROTECTION OBJECTIVES AND OPTIONS
Owners and engineers always have a number of options for deciding the appropriate refurbishment strategy to meet the future requirements of the structure.

4. SELECTION OF APPROPRIATE REPAIR PRINCIPLES AND METHODS
In accordance with EN 1504-9 the appropriate "repair principles" should be selected and then the best "method" of achieving each principle can be defined.

Following this selection, the performance requirements of suitable products are defined, using European Standards EN 1504 Parts 2 to 7 in conjunction with Part 10, which also provides guidelines for the work preparation and site application including quality control. On these substantial structures with their very specific exposure and damage potential, the materials selected must also be tested and proven in these very specific conditions.

5. FUTURE MAINTENANCE
As with all refurbishment projects, the need and likely time schedule for future inspection and maintenance should be defined. Complete and fully detailed records of the works undertaken must always be maintained.

SIKA PRINCIPLES IN ACCORDANCE WITH EUROPEAN STANDARD EN 1504

SIKA IS THE GLOBAL MARKET AND TECHNOLOGY LEADER in research, development and production of concrete repair systems for all types of buildings and civil engineering structures.

For every owner or consultant, their own project, building or structure is always the most important. Sika is the ideal partner for owners and their architects, engineers, contractors and access equipment suppliers focused on these works, whatever the type, sizes and age of the structure.

All of the products and systems required for the successful repair and protectionof the concrete structure, including all of the exposed surfaces are produced by Sika and fully in accordance with European Standards EN 1504. This includes grades of the materials developed for application in all of the different exposure and climatic conditions that can be encountered all over the world.

Sika also provides a complete package of documentation to assist all of our partners with the selection of the most appropriate concrete repair and protection principles and methods, the necessary detailed specifications and tender documents, plus complete integrated Method Statements for the correct use of all of the products and systems. Then Sika's Technical Services Department will train your engineers and contractors in the Quality Controlled use and application of the products both off and on site.

Extensive independent testing with all relevant approvals and certificates, supported by an equally extensive portfolio of successfully completed case studies and reference projects around the world, provides maximum confidence and security for everyone involved in the project.

Whatever damage has occurred, whatever the future exposure requirements are, and wherever the location – Sika is the ideal partner for your project.

ASSESSMENT OF TYPICAL CAUSES AND EFFECTS OF DAMAGE

DAMAGE DUE TO CONCRETE DEFECTS OR ATTACK

CHEMICAL
- Aggressive exhaust gases
- Condensation leaching
- Waste water
- Chemical spillage

Severe detoriation of concrete and corrosion of reinforcing steel despite a previously applied unadequate coating in the internal face of a cooling tower.

PHYSICAL
- Thermal movement cracking
- Adverse thermal gradient cracking
- Freeze/thaw action
- Shrinkage (from hydration)
- Erosion

Chimneys in direct sunlight indicating variations in thermal exposure which are further exacerbated by the effects of the downward flow of hot exhaust gases during periods of temperature inversions.

DAMAGE DUE TO STEEL REINFORCEMENT CORROSION

CARBONATION

Atmospheric carbon dioxide ingress (loss of alkaline protection).

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

Carbon dioxide from the atmosphere penetrates progressively into the concrete and reacts with the calcium hydroxide in the pore liquid. This eventually reduces the protective alkalinity around the steel, allowing corrosion to start in presence of water. This phenomenon is often associates with low concrete cover.

General corrosion induced by carbonation aggravated with low concrete cover issue.

CHLORIDES

Dependent on their location and use (e.g. bridges or buildings and structures near the sea), corrosion of the reinforcement can also occur due to attack from chlorides in marine atmospheres or from de-icing salts (e.g. bridge piers on roads in northern Europe).

Reinforcing steel corrosion in a pier.

CONCRETE REFURBISHMENT STRATEGY

IN THE 21ST CENTURY, REINFORCED CONCRETE STRUCTURES ARE BUILT TO LAST (e.g. most bridges are now designed to last more than 100 – 150 years). The two most universal causes of reinforcement corrosion and concrete damage are carbonation and chloride attack.

The faster carbon dioxide or chlorides penetrate the concrete, the sooner the passive layer around the reinforcement bars is destroyed and the corrosion process initiated.
To ensure long lasting durability, an appropriate maintenance strategy should also be followed by the owners and their construction management. Protective coatings can be an important part of this strategy, to ensure a long service-life for new structures and also to increase the durability of existing ones.

GENERAL CONCRETE REFURBISHMENT PROCEDURES

THE REPAIR AND PROTECTION OF CONCRETE STRUCTURES must always be executed according to all relevant local Standards and Regulations.

After a detailed condition survey and root cause analysis, the right procedures for successful refurbishment can be defined. Standards (such as European Standard EN 1504-9) define principles and methods to refurbish damaged concrete. Please refer to our Brochure "The Repair and Protection of Reinforced Concrete with Sika" for more information relating to repair and protection according to EN 1504.

Types of Damage/ Defects (Examples)		Possible Principles/Methods EN 1504-9	
		For the Repair	**For the Protection**
Concrete spalling/ scaling of concrete surface		Principle 3: Concrete restoration (Method 3.1/3.2/3.3)	Principle 1: Protection against ingress (Methods 1.1/1.2/1.3) Principle 5: Physical resistance (Method 5.1/5.2/5.3)
Steel reinforcement corrosion		Principle 7: Restoring passivity (Method 7.1/7.2)	Principle 8: Increasing resistivity (Method 8.1/8.2/8.3) Principle 9: Cathodic control (Method 9.1) Principle 10: Cathodic protection (Method 10.1) Control of anodic areas (Methods 11.1/11.2/11.3)
Structural cracks		Concrete restoration (Methods 3.1/3.3) Crack Injection (Methods 4.5/4.6) Structural strengthening (Methods 4.1/4.3/4.4/4.7)	Not applicable
Non-structural cracks		Principle 1: Filling of cracks (Method 1.5)	Principle 1: Protection against ingress (Method 1.1/1.2/1.3) Principle 2: Moisture control (Method 2.1/2.2/2.3) Principle 5: Physical resistance (Methods 5.1/5.2/5.3)
Chemical attacks		Principle 6: Adding mortar or concrete (Method 6.3)	Principle 6: Resistance to chemicals with coating (Method 6.1) Not treated in this document – refer to Sika Waste Water Treatment Plant brochure

REFURBISHMENT PROCESS

THE FIRST STAGE OF THE REPAIR WORK ITSELF ON SITE is usually to remove the damaged concrete and then to clean any exposed steel reinforcement.

Any exposed steel reinforcement should be cleaned to remove rust and corrosion products. EN 1504 Part 10 recommends the steel be prepared to Sa 2½ (if a barrier coating is to be applied) or to Sa 2 (if an active protective coating is to be applied) according to the classification in ISO 8501-1.
This cleaning and preparatory work should all be carried out in accordance with the site works and application guidelines of EN 1504 Part 10 Section 7.

EXPOSED STEEL PROTECTION

Sika has several products for this purpose; all using active corrosion inhibitors. The selection of the most appropriate product is dependent on the environmental exposure level:

- For normal environments (e.g. typical urban atmosphere): Sika MonoTop®-910 one-component, cement based, active corrosion protection is used,.
- For aggressive environments (e.g. marine, chemical, sewage, etc.): SikaTop® Armatec®-110 EpoCem® epoxy modified, cement based, active corrosion protection is used.

These products with EN 1504 Part 9 Principle 11 Control of anodic areas: Method 11.1 Painting reinforcement with active coatings also comply with EN1504 Part 7 reinforcement corrosion protection.

EMBEDDED STEEL

Additional protection can also be provided to steel that is not actually exposed, but is at risk of corroding, i.e. in carbonated concrete. This is done by the application of Sika® FerroGard® corrosion inhibitors.
Sika® FerroGard® corrosion inhibitors are based on amino-alcohol or nitrite technology.
Amino-alcohol materials form a mono-molecular passivating film or barrier layer over the surface of the steel, whilst nitrite based materials help to oxidize the steel and form ferric oxide, which resists chloride attack. These Sika® FerroGard® corrosion inhibitors can be applied at the surface or mixed within the concrete:

- Surface applied inhibitor: Sika® FerroGard®-903 Plus (Amino-alcohol based).
- Mixed in the concrete: Sika® FerroGard®-901 S (amino-alcohol based) or Sika® FerroGard-910 CNI (nitrite based).

This technique conforms with EN 1504-9 Principle 11 Control of Anodic Areas, Method 11.3 Applying corrosion inhibitors in, or to the concrete, but currently there is no harmonized performance standard available.

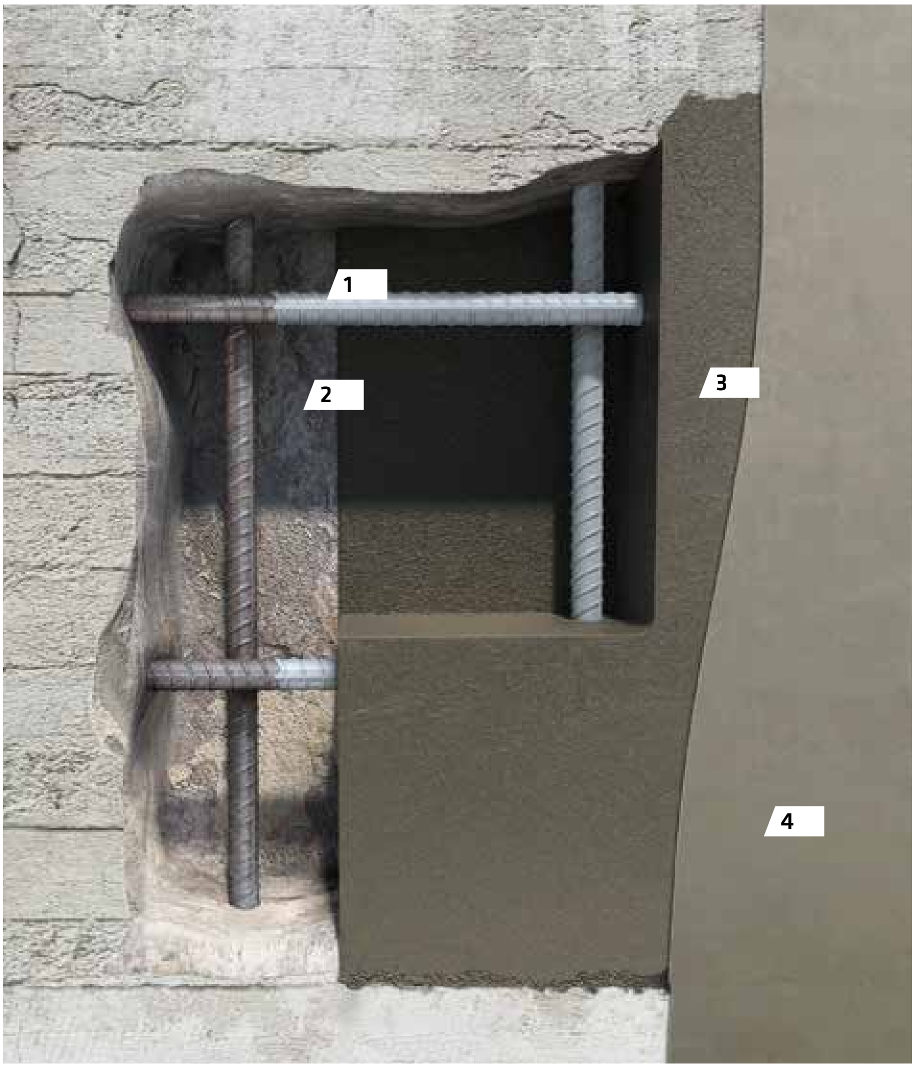
The use of deep penetrating hydrophobic impregnations is also a proven and efficient technology to mitigate corrosion in carbonated concrete or in chloride environment.
This technique conforms with EN 1504-9 Principle 8 Increasing Resistivity, Method 8.1 hydrophobic impregnation.
These products shall comply with highest requirements of EN 1504-2.

Sika MonoTop® CONCRETE REPAIR MORTAR SYSTEM

SIKA PRODUCES A COMPLETE RANGE OF REPAIR MORTARS AND MICRO CONCRETES, which are specifically designed for restoring or replacing the original profile and function of the damaged concrete, with grades suitable for all types of structures (buildings, cooling towers, bridges, WWT plants etc.).

These include cement-bound, polymer modified, cement-based and epoxy resin based products, for selection according to the specific project application and performance requirements.
All of these repair materials are in accordance with EN 1504-9 Principle 3 (CR) Concrete Restoration and comply with EN 1504-3. The class of mortar to be used is generally determined in relation to the nature and function of the concrete in the structure.
Repair materials can be applied using different application techniques. For each different application technique, there are correspondingly different products available.

Sika MonoTop® CONCRETE REPAIR MORTAR SYSTEM



1

Reinforcement Corrosion Protection
- To prevent further corrosion of steel reinforcement

2

Bonding Primer
- To promote adhesion of the repair mortar on demanding substrates

3

Repair Mortar
- To repair concrete defects
- To restore structural integrity
- To improve durability
- To improve appearance
- To extend the structure's design life

4

Pore Sealer / Levelling Mortar
- To restore durability
- To restore aesthetic appearance
- To restore geometric appearance
- To provide a surface for overcoating

Sika MonoTop® RANGE FOR COST-EFFECTIVE SOLUTIONS

Requirement	Main features	Products
Multi-functional products	Products for normal and demanding applications: → 2 in 1 Bonding Primer & Reinforcement Corrosion Protection	■ Sika MonoTop®-910 N or ■ SikaTop® Armatec®-110 EpoCem®
Durable and long-lasting repair mortars	Increased performances above standard requirements: → Successfully tested with 400 freeze and thaw cycles → Increase sulfate resistance → Low chloride diffusion	■ Sika MonoTop®-412 NFG / -SFG
Reduce the number of application steps	3 in 1 product solution → Improved fresh adhesion – bonding primer not required → Corrosion inhibitor – no reinforcement corrosion protection → Smooth finishing – no levelling mortar necessary	■ Sika MonoTop®-412 NFG / -SFG or ■ Sika® MonoTop®-352 NFG / -SFG
Minimizing transport disruption and closures	A new application system: → Successfully tested under live dynamic loading	■ Sika MonoTop®-412 N / -S with ■ SikaTop® Armatec®-110 EpoCem®
Value for money	A better yield from each bag: → Low density lightweight mortars	■ Sika MonoTop®-352 NFG / -SFG or ■ Sika® MonoTop®-352 N / -S
Fast over-coating within one day	Complete system compatibility: → Proven & tested with thin film coatings	■ Sika MonoTop®-211 RFG / -FG and ■ Sikagard®-675 W

Sika MonoTop®-723 N: resurfacing mortar for hand and spray application.

KEY PARAMETERS FOR SELECTION OF THE CONCRETE PROTECTION SYSTEM

"ACCORDING TO THE EXPOSURE CONDITIONS (e.g. marine or urban environment, resistance to freeze-thaw etc.), and the requirements of the owner in terms of aesthetics and durability etc., the responsible design consultant can determine and specify consider the characteristics of the protective coating system to be used."

For protective coatings, the only global standard that covers this range of product is the EN 1504-2. An example of the key criteria for the protective coating product/system selection and based on this European Standard is given in the table below (as table 1 of EN 1504-2:2004)

	Principles	Protection against ingress	Moisture control	Increasing Physical Resistance	Resistance to chemicals	Increasing resistivity
Test methods	**Performance Characteristics**	**1.3 (C)**	**2.3 (C)**	**5.1 (C)**	**6.1 (C)**	**8.3 (C)**
EN 12617-1	Linear shrinkage	▪	▪	▪	▪	▪
EN 12190	Compressive strength			▪	▪	
EN 1770	Coefficient of thermal expansion	▪	▪	▪	▪	▪
EN ISO 5470-1	Abrasion resistance			■		
EN ISO 2409	Adhesion by cross-cut test	▪	▪	▪	▪	▪
EN 1062-6	Permeability to CO_2	■				
EN ISO 7783-1 EN ISO 7783-2	Permeability to water vapour	■	■			■
EN 1062-3	Capillary absorption and permeability to water	■	■	■	▪	■
	Adhesion after thermal compatibility					
EN 13687-1	Freeze-thaw cycling with de-icing salt immersion	▪	▪	▪	▪	▪
EN 13687-2	Thunder-shower cycling (thermal shock)	▪	▪	▪	▪	▪
EN 13687-3	Thermal cycling without de-icing salt impact	▪	▪	▪	▪	▪
EN 1062-11:2002	4.1: Ageing: 7 days at 70 °C	▪	▪	▪	▪	▪
EN 13687-5	Resistance to thermal shock	▪	▪	▪	▪	
EN 1062-11:2002	4.2: Behaviour after artificial weathering	▪	▪	▪	▪	▪
EN ISO 2812-1	Chemical resistance	▪			▪	
EN 13529	Resistance to severe chemical attack				■	
EN 1062-7	Crack bridging ability	▪	▪	▪	▪	▪
EN ISO 6272-1	Impact resistance			■		
EN 1542	Adhesion strength by pull-off test	■	■	■	■	■
EN 13501-1	Fire classification of construction products and building elements Part 1: Classification using test data from reaction to fire test	▪	▪	▪	▪	▪
EN 13036-4	Slip/skid resistance	▪	▪	▪	▪	▪
EN 13578	Adhesion on wet concrete	▪	▪	▪	▪	

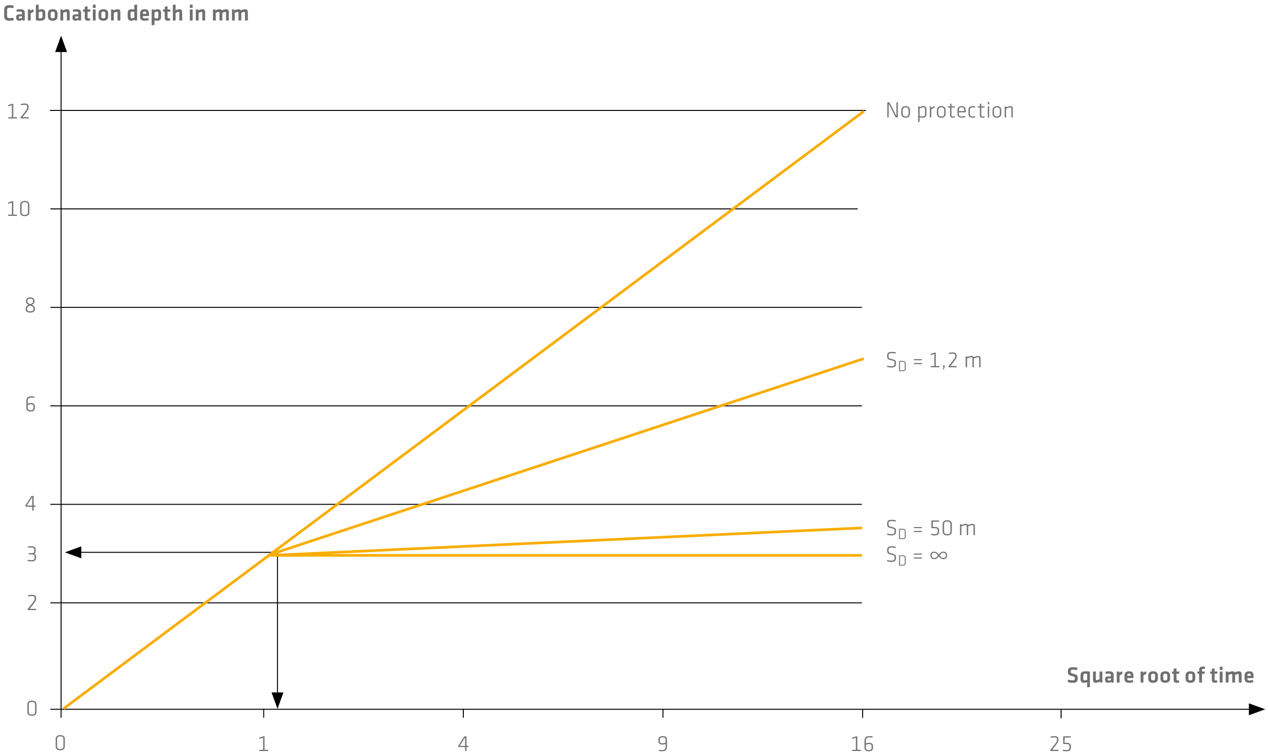
Key: ■ Characteristic for all intended uses ▪ Characteristic for certain intended uses within the scope of EN 1504-9:2008

BARRIER TO CARBON DIOXIDE

ONE OF THE MOST IMPORTANT PROPERTIES OF A PROTECTIVE COATING ON CONCRETE structures is its ability to prevent or significantly reduce the diffusion of carbon dioxide (CO_2) into the concrete.

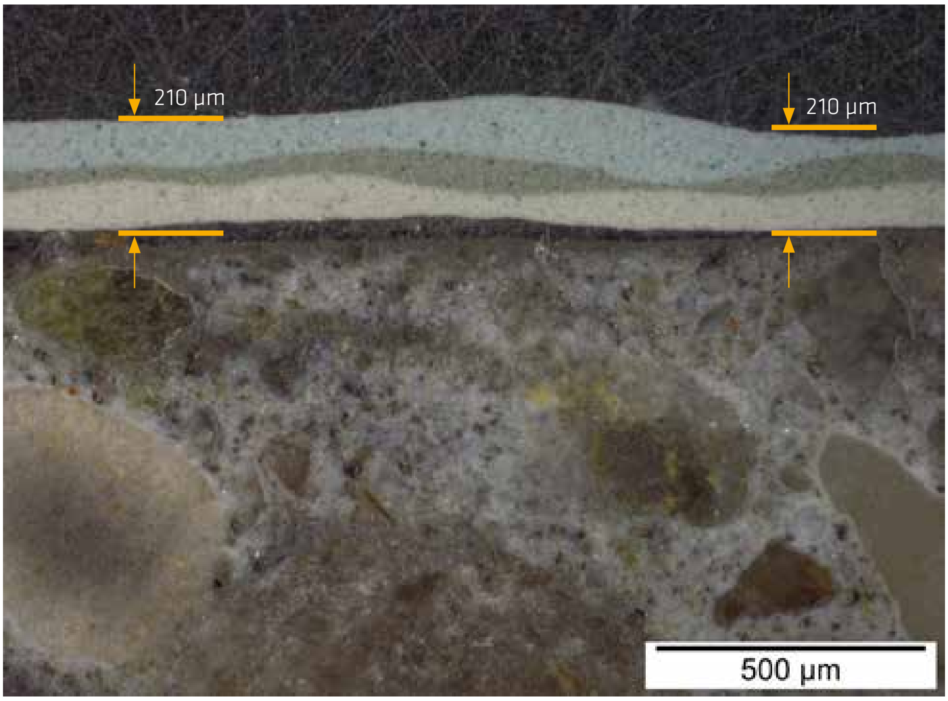
If CO_2 penetrates the concrete, it will react with free lime present as calcium hydroxide in the pore liquid, which produces insoluble calcium carbonate and reduces the protective alkalinity (pH level) of the concrete. This natural process is known as carbonation and it progresses inwards from the surface over time.
When the carbonation front reaches the level of the reinforcement, the steel bars are no longer in a passive environment due to the loss of protective alkalinity, and if oxygen and moisture are present, then the steel bars will start to corrode.

Therefore an effective protective coating for concrete must prevent or very significantly reduce diffusion of CO_2 into the concrete. The European Standard EN 1504-2 places a minimum threshold for this as being equivalent to a 50 m barrier of air. One of the founders of this test method, Dr.-Ing. Robert Engelfried, in a paper published in New Orleans in 1996 (ICRI International Concrete Repair Institute Annual Meeting) clearly demonstrates that this 50 meter threshold provides a sufficiently effective long term barrier protection to be regarded as completely stopping the progression of carbonation.

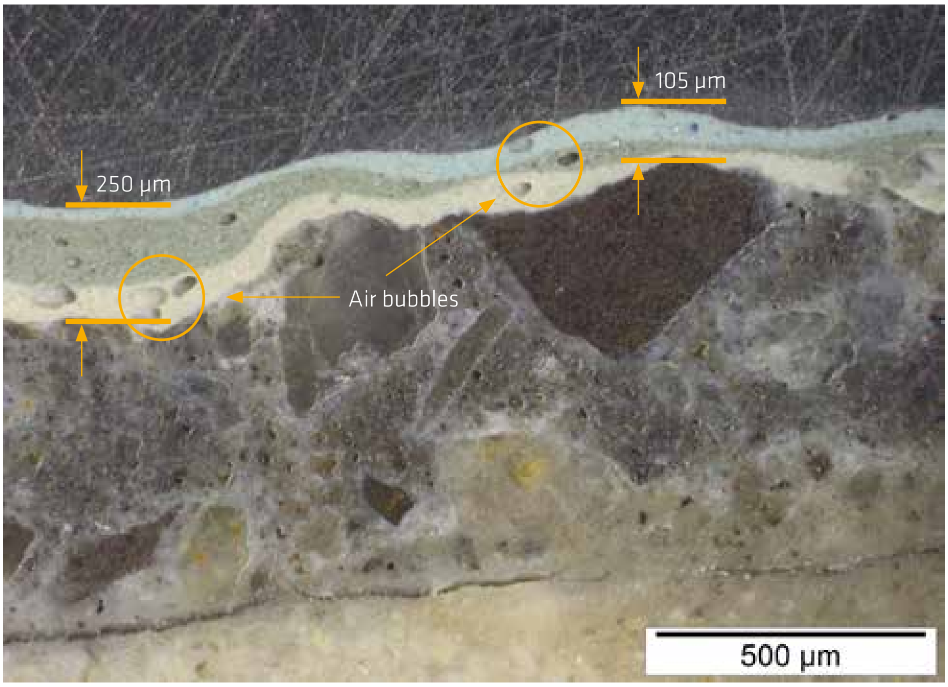


Evolution of carbonation depth over time when different coatings are being used:

- No protection
- A basic decorative paint with no protection performance (SD = 1.2 m)
- A protective coating complying with the threshold of EN 1504-2 (SD = 50 m) and
- A complete stop of the carbonation progression (equivalent to an SD which has an infinite value).



An even concrete surface with appropriate surface preparation leads to homogeneous film thickness and a surface free of defects. This will ensure the applied protective coating can perform as expected.



An uneven surface or inadequate surface preparation will lead to defects – entrapped air, variable thickness, etc. – in the coating that will reduce its performance (e.g. lower crack bridging capability, lower protection against CO_2 or even direct water ingress).

SIKA ORGANIC COATING

WHEN SELECTING A PROTECTIVE COATING, designers/engineers shall consider the following parameters:

- Level of water tightness to liquid water – e.g. Is the project near the sea? The ability to reduce or prevent chloride migration
- Permeability to water vapor – e.g. Highly breathable or restricting vapor exchange?
- Barrier against CO_2 diffusion – e.g. At which thickness?
- Crack bridging – e.g. Static or dynamic? Which minimum temperature?

In the same time, any selected protective coating shall have good resistant to weathering and ageing, shall exhibit good hiding power and low dirt pick up.
Sika range of protective coatings cover all the different requirements for almost all project types and can performed in completely opposite environmental conditions e.g. from the cold climate of Sweden, to the hot and dry weather of Saudi Arabia and the humid and hot conditions of Colombia.

ELASTIC COATINGS

Elastic protective coating shall retain their elastic properties at very low temperature (As elastomeric material tends to become more brittle when temperature is decreasing) – this parameter is important for countries with heavy winter:

Sikagard®-550 W Elastic

- Water dispersed elastomeric coating with low dirt pick up

Sikagard®-545 W Elastofill

- Intermediate coat for heavy crack bridging behaviour

PROTECTIVE COATINGS

The use of highly elastic coatings may not be desirable in some structures or part of them in order to be able to be in the position to detect potential development of severe structural cracks. These coatings nevertheless may be able to bridge surface crazing in order to be able to provide the relevant protection.

Sikagard®-675 W ElastoColor

- Water dispersed protective coating

Sikagard®-674 W Lazur

- Water dispersed transparent protective coating

Sikagard®-680 S BetonColor

- Solvent based high performance coating

SIKA CEMENT BASED COATING

SOME DESIGNERS WOULD PREFER USING CEMENT BASED PROTECTIVE COATING as they prefer to maintain a “mineral look” at their structure whilst protecting it against aggressive environment.

Concrete has been the most common building material of the 20th century and still being largely used nowadays. Many famous internationally known architects such as Auguste Perret or Le Corbusier used concrete as decorative elements. These magnificent structures required sometimes to be protected. However the use of organic coating may denature the original aesthetic of the bare concrete. Therefore some designers will prefer to use cement based protective coatings to protect their structures against aggressive environments. Additionally to comply to EN 1504-2, some of these cement based coatings are also used as surface repair materials and as such shall also comply to EN 1504-3.

CEMENT BASED PROTECTIVE COATINGS

Sikagard®-720 EpoCem®
- Epoxy-cement resurfacing mortar
- Surface repair as per EN 1504-3
- Concrete protection as per EN 1504-2
- Temporary moisture barrier

SikaTop® Seal 107
- Polymer modified cement based protective coating and waterproofing mortar
- Can be tinted with water based pigment
- Concrete protection EN 1504-2

Sikalastic-152
- Elastic polymer modified cement based protective coating and waterproofing mortar
- Crack bridging
- Concrete protection as per EN 1504-2

SIKA REACTIVE COATINGS

REACTIVE COATINGS are sometimes used for the protection of concrete against normal aggressive atmospheric influences (preventing CO_2 chlorides and water ingress), as well as when additional chemical protection is needed.

Therefore for particularly aggressive or special exposure situations such as in tunnels, on marine structures or bridges, they can potentially be used for both requirements.
However, if epoxy resin based coatings are considered, consideration must be given to their relatively poor resistance to UV light exposure - For example an additional top coat of a lightfast UV resistant polyurethane coating may be required in these situations.

TUNNELS
Protective coatings in tunnels need to withstand the harsh environment (deicing salts, SO_X and NO_X pollution, plus abrasive cleaning procedures, etc.). Additionally they can be used in colours to improve the lighting and visual aspects and to prevent dust pick-up on the walls.

- Water borne epoxy Sikagard® WallCoat T

or

- Water borne polyurethane Sikagard®-260 WPU

MARINE STRUCTURES
Concrete structures in marine environments are subjected to severe aggression – abrasion from the force of the waves and sand, plus potentially severe corrosion issues due to chloride penetration. The concrete can be protected using a reactive coating such as:

- Solvent-free, 100% solids, epoxy based SikaCor® SW-500

BRIDGE STRUCTURES
Reactive coatings can be used to protect concrete surfaces on bridge structures for the long-term e.g. using:

- 100% solid epoxy Sikagard®-62

Followed by:

- A two part, elastic polyurethane top coating

SIKA PRODUCT SELECTION GUIDE

The table below is intended to provide an overview of the Sika protective concrete coatings range, using key parameters such as the required level of performance, method of application or aesthetics, together with their typical use.

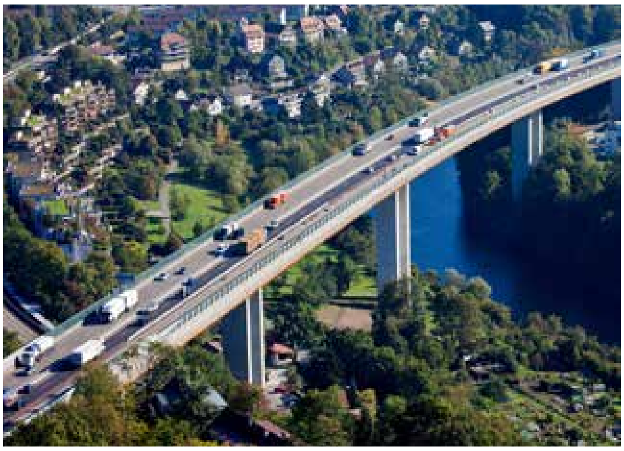
	Aesthetic Parameters			Performance Parameters	
	Color retention*	UV resistance*	Dirt pick up resistance	Crack bridging	Long term performance
Sikagard®-550 W Elastic	xxx	xxx	xx	xxx	xxx
Sikagard®-545 W ElastoFill + Sikagard®-550 W Elastic	xxx	xxx	xx	xxxx	xxx
Sikagard®-675 W ElastoColor	xxx	xxx	xxx	x	xxx
Sikagard®-680 S BetonColor	xxx	xxxx	xxx	–	xxxx
Sikagard®-720 EpoCem®	–	xxx	x	–	xx
SikaTop® Seal-107	xx	xx	x	x	xx
Sikagard® WallCoat T	x	–	xxx	–	xxx
Sikagard®-260 W PU	xxx	xxxx	xxx	–	xxx
Sikagard®-62 + Sikagard®-363	xxx	xxxx	xxx	–	xxx
SikaCor SW-500	x	–	xx	–	xxx
Sikalastic®-152	xx	xx	x	xxx	xx

Legend: xxxx: Best performance xxx: Very suitable xx: Suitable x: can be considered for short to medium term – : Not suitable
Note*: Color retention and UV resistance are dependent on the color, as darker, more intense shades will always have lower UV resistance and color retention.

	Application Parameters			Usage			
Mechanical cleaning resistance	VOC	Hand application	Machine application	Civil engineered structures	Buildings	Tunnels	Marine structures
–	xxxx	xxxx	xxxx	xxxx	xxxxx	–	xx
–	xxxx	xxxx	xxxx	xxx	xxxxx	–	xx
x	xxxx	xxxx	xxxx	xxx	xxx	x	xx
x	–	xxxx	xxxx	xxxx	xx	x	xx
–	xxx	xxx	xxx	xxx	–	xxx	xx
–	xxxx	xxx	xxx	xxx	xxx	–	xx
xxxx	xx	xxxx	xxx	–	–	xxxx	–
xxxx	xx	xxxx	xxx	–	–	xxxx	–
xx	x	xxx	xxx	xxx	–	–	–
xxx	x	xxx	xxx	–	–	–	xxxx
–	xxxx	xxx	xxx	xx	xxx	–	xx

CASE STUDIES

VIADUCT BRIDGE BERN, SWITZERLAND



PROJECT DESCRIPTION
A full refurbishment of the tangential A1 highway North of the City of Berne took place in the early 2010's including the Felsenau Viaduct (1.1 km long and up to 60 m high).

PROJECT REQUIREMENTS
Full refurbishment of the concrete structures and protection of the exposed concrete surfaces against carbonation and freeze-thaw attack accelerated by the use of de-icing salts. This work is designed to maintain the serviceability of the structure for the next 30 years.

SIKA SOLUTION
The horizontal concrete deck refurbishment was done using SikaTop®-122 SP, then Sikadur®-186 was used to waterproof the deck. The reinforced concrete parapet walls and other surfaces were given long term protection with Sikagard®-706 Thixo, Sikagard®-551 S Primer, Sikagard®-545 W Elastic and Sikagard®- 550 W, the crack-bridging protective coating.

PROJECT PARTICIPANTS
Client: Federal Roads Office FEDRO (ASTRA)
Consulting Engineers: IUB , Bern; Emch+Berger, Bern
Contractor: ARGE Felsenau: Marti AG; Bern;
Frutiger AG, Thun; Implenia Bau AG, Bern

ARENC SILOS MARSEILLE, FRANCE

PROJECT DESCRIPTION
The Arenc silos were originally erected in the late 1920's and they have become a well-known landmark in Marseille. However the grain silos were out of use for many years and concrete was showing severe decays.

PROJECT REQUIREMENTS
A complete redevelopment of the whole port and docks area was undertaken by the city of Marseille. This concrete silos was planned to be converted into a cultural complex. Thorough survey was carried out by the LERM to set out the project requirements.

SIKA SOLUTION
Refurbishment of concrete was carried out using repair mortar Sika MonoTop® system, corrosion inhibitor Sika® FerroGard®-903, strengthening using carbon fabric SikaWrap® and finally concrete protection using a cement based coating SikaTop®-107 which provided carbonation protection and maintain the original appearance of the structure.

PROJECT PARTICIPANTS
Client: City of Marseille
Project Manager: Éric CASTALDI Architect
QA / QC Laboratory: LERM
Contractor: MIDI FACADES

HESLACH TUNNEL, GERMANY

PROJECT DESCRIPTION
Stuttgart's Heslach Tunnel is the longest urban bi-directional tunnel in Germany. Around 50,000 vehicles use the centrally sited tunnel on a daily basis. The tunnel was built in the 1980's.

PROJECT REQUIREMENTS
After full refurbishing of the fire system, the renewal of the tunnel wall coating was carried out. The product had to comply with OS 4 coating system and provide a bright look to improve the safety of users

SIKA SOLUTION
Wall coating was carried out using Sikagard®-260 WPU, a waterborne 2-component polyurethane coating that complied with the OS4 system and the prescribed fire protection.
The product is dirt-repellent, scrub resistant, highly inflammable, UV resistant and non yellowing.

PROJECT PARTICIPANTS
Client: Federal Highway Research Institute (BASt)
Main Contractor: Osmo Anlagenbau GmbH & Co. KG
Coating Applicator: BIK Uhr GmbH

SALDAHAN JETTY, SOUTH AFRICA

PROJECT DESCRIPTION
Refurbishment of a 40-years old industrial jetty in Saldahan, South Africa. The jetty is used by the National Port to receive iron ore ships and by Petro SA for crude oil tankers.
Despite remedial works carried out 15 years ago using system comprising of 8 to 9 coats of elastomeric coating, the jetty was already in need of repair.

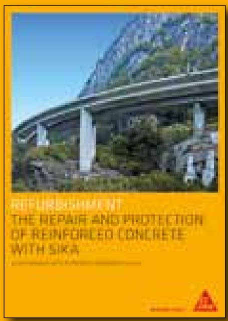
PROJECT REQUIREMENTS
The Specifiers requested system offering multi stages of protection and prevention – they did not want to rely only on a single protective system.

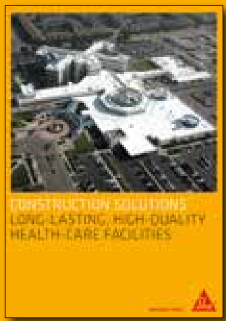
SIKA SOLUTION
After adequate concrete repair using Sika MonoTop® repair material and proper removal of the existing multiple layers of protective coating, Sika offers a multiple level of protection system:

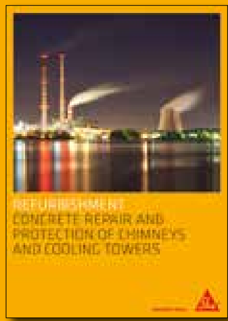
- Surface applied corrosion inhibitor Sika® FerroGard®-903 to protect the embedded rebars.
- Silane cream Sikagard®-706 Thixo acting as moisture control and primer underneath the final top protective coating.
- Concrete protection against ingress with elastomeric Sikagard®-550 W

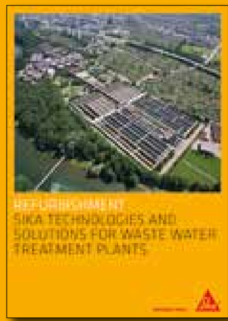
PROJECT PARTICIPANTS
Owners: National Port and Petro SA
Contractors: PEAK Projects SA

ALSO AVAILABLE FROM SIKA









FOR MORE INFORMATION ON SIKA REFURBISHMENT SYSTEMS AND SOLUTIONS:

WE ARE SIKA
Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika's product lines feature concrete admixtures, mortars, sealants and adhesives, structural strengthening systems, flooring as well as roofing and waterproofing systems.

Our most current General Sales Conditions shall apply. Please consult the most current local Product Data Sheet prior to any use.

since 1986 since 1997

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