Sika Total Corrosion Management Summary

Product	Best Use	Target	Initial Cost
Sika FerroGard 901	New Construction and admixture to any repair mortar	Protect anodes and cathodes throughout the structure or “ring anode” and added protection in repairs	$
Sika CNI	New Construction	Protect anodes throughout the structure	$
Sika FerroGard 903	Low to medium chlorides, carbonation, early maintenance, ring-anode treatment, reduce moderate existing corrosion	Protect anodes and cathodes throughout the structure, reduce active corrosion	$
Sikagard Coatings	Preventative on existing structures. Supplement to Sika FerroGard 903 and Sika Galvashield	Prevent ingress of chlorides, carbonation and water	$
Sika Galvashield XP	Ring-anode protection; high chlorides where inhibitor may be limited	Protection of steel adjacent to patch, “ring anode” prevention	$$
Sika Galvashield CC	Reduce moderate, existing corrosion in targeted areas; medium to high chlorides where inhibitor may be limited	Protection of steel at “hot spots” throughout a structure. Targeted corrosion mitigation	$$
Norcure	High chloride environments, long-term power not available, minimal maintenance	Simple steel geometries where access is not an issue but wiring is difficult for CP installation	$$$
Sika Ebonex	Existing and new construction, deep steel, targeted durable protection, high chlorides, wet environments, steel frame buildings	Complex or highly reinforced steel areas such as joints, beams, columns and behind masonry façades	$$$

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One Source.
Worldwide.

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Construction

Total Corrosion Management (TCM®)
for Reinforced Concrete

Bringing Together the Resources for Total Corrosion Management (TCM®)

The global leader in concrete repair and protection, corrosion inhibition and structural strengthening systems. All are supported by the most highly trained and experienced sales and technical support network in the industry.

Providing electrochemical solutions for corrosion mitigation including galvanic anodes, cathodic protection, chloride extraction, and re-alkalization.

Total Corrosion Management (TCM®)

Capabilities

- Assessment surveys
- System choice advice and design
- Full range of products
- Bid formulation support
- Trained field personnel
- Specialist support during contract
- Commissioning
- After-care management

Full Range of Products

- Impressed current cathodic protection
- Chloride extraction
- Re-alkalization
- Sacrificial anodes
- Surface-applied inhibitors
- High performance coatings
- Early detection monitoring
- Mixed systems (combination of the above)

Your Sika sales representative is now able to bring together these combined resources for you to support your complete project requirements for corrosion management.

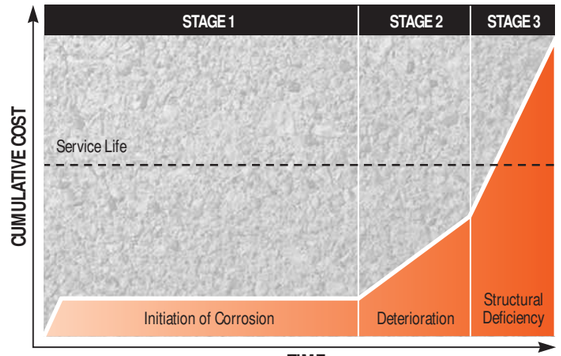
Ignoring Corrosion is NOT an Option

Cost of Corrosion Grows Over Time

- 3% of GDP each year attributed to corrosion
- 27.5% of US bridges are structurally deficient or functionally obsolete*
- Condition of infrastructure rated a D+ by ASCE*

* Ref. ASCE 2003 Progress Report

TIME / COST MODEL



This diagram depicts the maintenance cost of a structure versus time. As time goes by the cost of repairing a structure increases at a faster rate as the steel corrodes and the concrete deteriorates.

These bridge columns had to be demolished and rebuilt because the corrosion was too far advanced.

Start with the condition survey

A thorough condition survey is critical to ensure a successful repair & protection project. This testing should always be conducted by a qualified professional.

Surveys generally consist of performing any number of the following tests:

- Spall and delamination survey
- Chloride and carbonation testing
- Reinforcement mapping and cover measurements
- Half-cell potential contour mapping
- Corrosion rate assessment

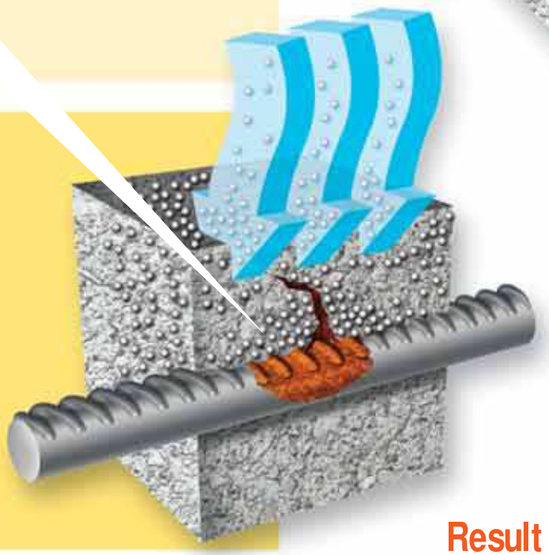
The results of these tests should be the basis for selecting a repair and protection strategy that will meet the project requirements.

Half-cell testing

The Root Causes of Corrosion

Chlorides

Chlorides accumulate near the concrete surface due to wetting and drying effects, then diffuse towards the reinforcement. When a certain threshold concentration is reached at the surface of the steel, (typically about 1.5 lb./cy of concrete) corrosion may start. This problem is commonly found on horizontal surfaces such as bridge decks and parking decks as well as in all elements of marine structures.

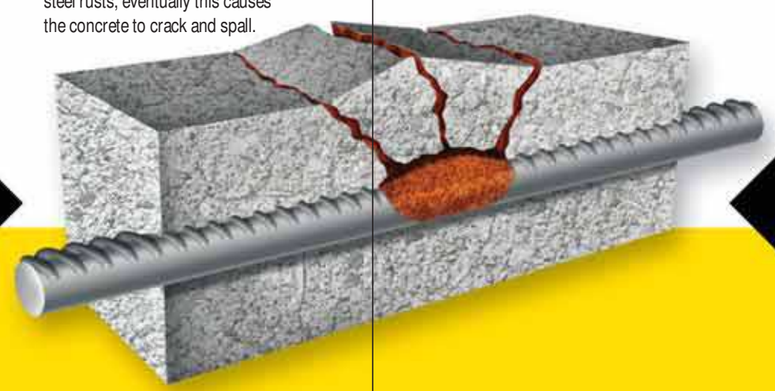


Repair & Protection Options

- Repair & protect with Sika repair mortars, Sika FerroGard 903 and a Sikagard sealer or coating, or Sikadur protective membrane
- Galvanic protection with Sika Galvashield XP and CC anodes
- Electrochemical chloride extraction treatment
- Cathodic protection with Sika Ebonex

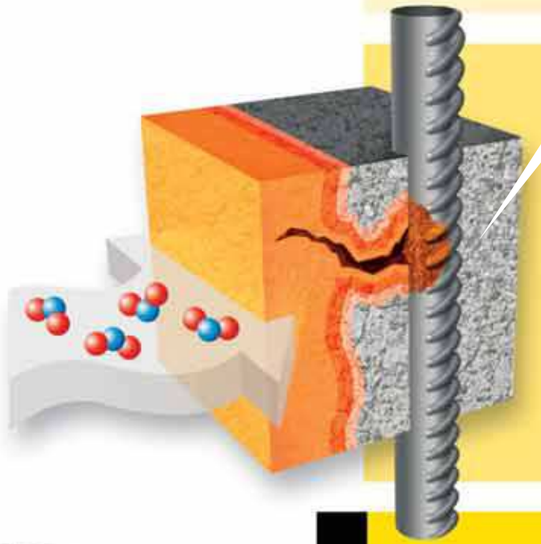
Result

As corrosion continues and the steel rusts, eventually this causes the concrete to crack and spall.



Initially

Steel protected in a high-alkaline, chloride-free environment.



Carbonation

Carbonation can reduce the pH of the concrete to less than 9.5, minimizing the corrosion protection usually provided to reinforcement by an alkaline concrete. Carbonation is commonly found on vertical surfaces such as building façades and balcony edges. Carbonation is also found on horizontal surfaces.

Repair & Protection Options

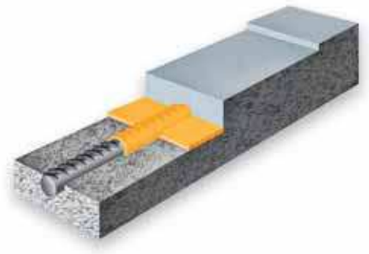
- Repair & protect with Sika repair mortars, Sika FerroGard 903 and Sikagard anti-carbonation coatings
- Galvanic protection with Sika Galvashield XP and CC anodes
- Electrochemical re-alkalization treatment
- Cathodic protection with Sika Ebonex

Sika Full System Repair and Protection

1 Treat Any Exposed Steel

Sika Armatec® 110 EpoCem protects against corrosion and improves the bond of repair mortars.

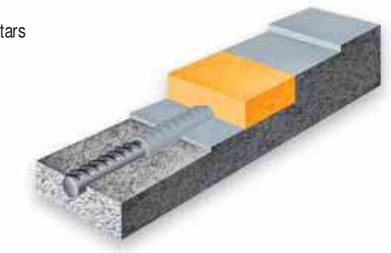
- Protects reinforcement in a high alkaline cementitious environment and adds “effective” cover
- Contains corrosion inhibitors
- Can be applied to the damp surfaces
- Increases barrier to water and chlorides
- Fully compatible with load transfer requirements



2 Repair the Spalls

Sika repair mortars are easy-to-use “pre-packaged” mortars for replacing the concrete in spalled areas.

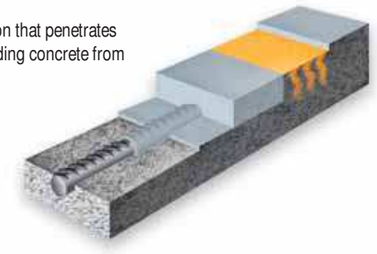
- Wide range to suit application requirements
- High quality
- Low shrinkage
- Excellent bond
- SikaTops contain the penetrating corrosion inhibitor, **Sika FerroGard® 901**



3 Protect from Future or Latent Damages

Sika FerroGard® 903 is a corrosion inhibiting impregnation that penetrates and protects not only the repair area, but also the surrounding concrete from future corrosion due to latent damages.

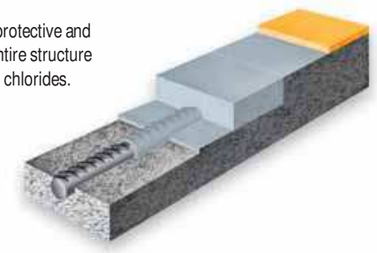
- Active cathodic and anodic passivation
- Totally nitrite free (non-toxic)
- Can penetrate up to 3" in 28 days
- Easy to apply



4 Protect from Future Carbonation/Chloride Exposure

Sikagard® 550W, 670W, SikaColor and Elastocolor are protective and decorative high performance coatings which protect the entire structure from the harmful effects of carbonation, water ingress and chlorides.

- 550W and Elastocolor bridge dynamic moving cracks
- 670W and SikaColor are capable of light foot traffic
- Effectively halts carbonation
- Breathable
- Prevents water and chloride ingress
- Enhances the appearance
- Gives excellent design opportunities with durable color

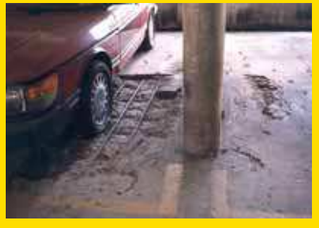


CASE STUDY

Project
Algonquin Hotel, New Brunswick, Canada
Description of Structure
This internationally respected seaside hotel was completely rebuilt in 1915 after the original wooden structure built in 1889 burned to the ground. The hotel is constructed of reinforced concrete, has four and six story sections as well as a 90 foot tower.
Problem
Beach sand and sea water were used in the concrete mix. Shallow rebar and a very aggressive salt water sea environment all contributed to accelerated corrosion of the reinforcing steel. Freezing and thawing was also a major contributor to the problems which required annual maintenance to the façade. Eventually, structural components of the building were damaged.
Solution
Repairs were completed in between the busy seasons which run from May through September. SikaTop 111 and 122, polymer-modified repair mortars were used to repair the spalls. SikaTop 121 was used as a leveling coat to ensure a good surface for the coating. SikaTop 144, a cement based waterproofing coating, was used to protect all unrepaired areas of the building and to help hide the completed repairs. Finally, Sikaflex-1a, a one-part polyurethane, elastomeric sealant was used to seal joints at windows and door frames as well as control joints.

CASE STUDY

Project
Cleveland Police Parking Garage, Cleveland, Ohio
Description of Structure
Two-story, below grade parking facility built in the 1970’s located in downtown Cleveland.
Problem
After years of exposure to deicing salts, the heavily reinforced slab-on-grade was contaminated with a high level of chlorides. As a result of steel corrosion, delamination of concrete was prevalent throughout.
Solution
The delaminated concrete, which was approximately 50% of the 50,000 sf slab-on-grade, was removed to sound concrete. Embedded corrosion rate monitoring was installed in order to monitor both the immediate and long-term effectiveness of the repairs. The exposed reinforcing steel was cleaned. Sika Armatec 110 EpoCem, a three component, epoxy-modified rebar coating and bonding agent was applied to the exposed steel to provide added protection and to the substrate to assist in bonding. Ready mix concrete was used given the easy access and volume of repairs. Sika FerroGard 903, a surface-applied, penetrating corrosion inhibitor was applied, in particular, to mitigate active corrosion in the unrepaired areas of sound concrete which was also contaminated with chlorides. Sikadur 22, Lo Mod, a low modulus, medium viscosity, 100% solids, epoxy resin binder was squeegeed out over the entire surface to a thickness of approximately 3/16” to provide an excellent surface barrier to prevent infiltration of future water and chlorides. Black beauty aggregrate was broad-cast into the wet epoxy for skid-resistance and aesthetics.



Sika FerroGard® 903

Description of Technology
Surface-applied corrosion inhibitor that contains amino alcohols, organic and inorganic inhibitors.

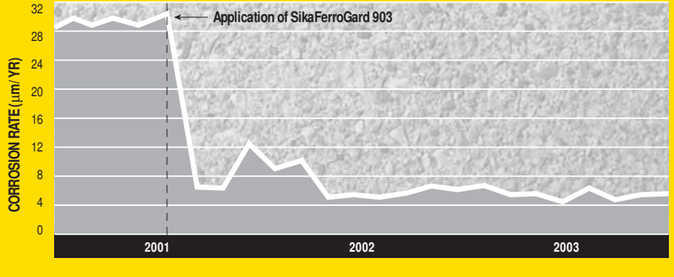
How It Works
Sika FerroGard 903 is designed to penetrate hardened concrete, attach by adsorption to the reinforcing steel, form a protective layer on the steel resulting in the reduction of the corrosion rate.

Best Use
- Low to medium chloride content (typically less than 6 lb./cy at the level of the steel)
- Early maintenance
- Budget constraints
- Protection of areas particularly outside the area of the repairs
- Depth of steel and cover concrete permeability allow for adequate penetration

CASE STUDY

Project
Maverick Beach Resort, Ormond Beach, Florida
Description of Structure
The Maverick Beach Resort, built in the early 1970's, is a seven story, cast-in-place, conventionally reinforced concrete structure with a masonry façade located on the beach.
Problem
The balconies had been removed and replaced in 1987. This large building; however, continued to suffer from corrosion accelerated by chlorides. The source of the chlorides was salt spray from the sea water.
Solution
Delaminated concrete primarily along the edges of the elevated walkways and the columns was removed and repaired. Sika MonoTop 611, a one-component, polymer-modified, silica fume enhanced pumpable, pourable repair mortar was used along the walkways and SikaTop 123, a two-component, polymer-modified, non sag mortar containing Sika FerroGard was used for the column repairs. Achilles IES remote monitoring probes provided by C-Probe Technologies were installed to monitor the performance of the repair system. Sika FerroGard 903, a surface-applied, penetrating corrosion inhibitor was applied, primarily, to mitigate active corrosion in the unrepaired, chloride-contaminated areas of otherwise sound concrete. A waterproofing coating was also applied to prevent future ingress of moisture and chlorides and to prevent the steel's environment from getting increasingly worse.

CORROSION RATE VALUES



TEST DATE
Monitoring and data provided by C-Probe Technologies Ltd.

Sika Galvashield® XP and CC

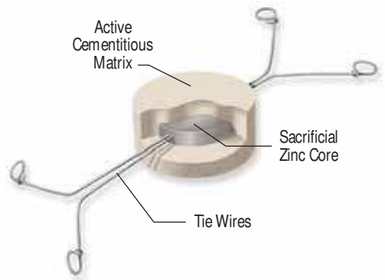
Sika Galvashield®
Description of Technology
Embedded galvanic anodes for corrosion protection of reinforcing steel in concrete structures.

How It Works
Sika Galvashield® galvanic anodes consist of a zinc core surrounded by a specially formulated cementitious mortar. The zinc core corrodes preferentially to the surrounding rebar, providing galvanic corrosion protection to the reinforcing steel.

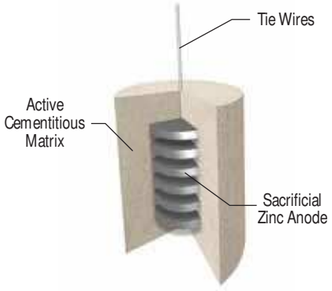
Best Use
Galvashield XP anodes
- Corrosion prevention at the "ring anode" or "halo-effect" adjacent to spall repairs
- Placed at the perimeter within the repair
- Interface of new full-depth slab replacement and existing concrete
- Joint replacements
- Highly chloride contaminated concrete

Galvashield CC anodes
- Cored and inserted within sound concrete
- Targeted corrosion control at "hot spots"
- Installed in a grid pattern provides general corrosion protection
- Highly chloride contaminated concrete

Sika Galvashield XP Anode



Sika Galvashield CC Anode



CASE STUDY

Project
Seaside Condominium, Melbourne, Florida
Description of Structure
Seven story, conventionally reinforced concrete building located on the beach.
Problem
Elevated chloride levels combined with hot and humid conditions caused aggressive patch accelerated corrosion of this structure on the east coast of Florida. Concrete spalling and delaminations were evident only a few years after concrete repairs were completed.
Solution
For the second repair program, Galvashield XP anodes were installed around the perimeter of the concrete repairs to prevent new corrosion activity from occurring in the adjacent contaminated concrete. After the repairs were complete, Sika Galvashield CC anodes were installed on a grid pattern in the remaining unrepaired areas of the balconies and walkways to provide an active corrosion control system.

Case study provided by Vector Corrosion Technologies.

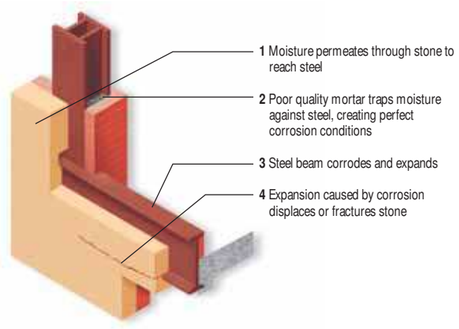
Sika Ebonex®

Description of Technology
Sika Ebonex® is a discrete impressed current cathodic protection anode consisting of a ceramic/titanium composite with an internal gas venting system.

How It Works
Sika Ebonex® discrete anodes are drilled, inserted and distributed as required and are designed to protect steel elements in a structure from corrosion. The current from Sika Ebonex anodes cathodically protects the surrounding steel.

Best Use
- Use to stop corrosion
- Heavily reinforced elements
- Deeply embedded steel
- Aggressive environments
- High chloride environments
- Beams and columns
- Historical steel frame buildings, generally built between 1900 and 1950

How Historical Steel-Framed Buildings Fail



Example of steel beam corrosion causing failure of the decorative terra cotta facade.

The Arkwright House, Manchester, United Kingdom was cathodically protected using Ebonex in 1998.

CASE STUDY

Project
Pembina Highway Overpass, Winnipeg, MB, Canada
Description of Structure
Interchange overpass for Highway 75 and 1.
The structure is conventionally reinforced and was built in the 1970's.
Problem
The piers and columns on this structure owned by the Manitoba Department of Highways and Transportation was highly contaminated with chloride de-icing salts but were still in good structural condition.
Solution
Impressed current cathodic protection (ICCP) was cost-effectively provided using Sika Ebonex® discrete ceramic anodes. The built-in ventilation system with Sika Ebonex anodes allowed them to be installed into holes drilled to the center of the contaminated columns and piers. This approach eliminated the need to have anodes installed over the entire surface area of the structure as is required with alternate ICCP systems. After the system is energized, the anodes provide long-term ICCP to the surrounding reinforcing steel.

Case study provided by Vector Corrosion Technologies.

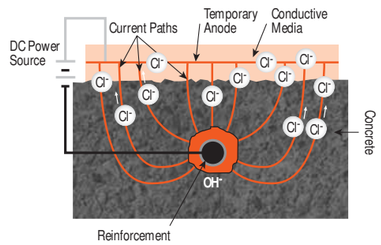
Norcure® System of Chloride Extraction and Re-Alkalization

Description of Technology
The Norcure® Chloride Removal and Re-Alkalization System removes chloride ions from chloride contaminated concrete and raises the pH of carbonated concrete.

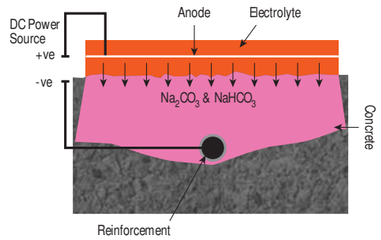
How It Works
Electrochemical Chloride Extraction
A low voltage DC electric field is established between a temporary external anode and the reinforcing steel within the concrete. Negatively charged chloride ions are repelled away from the rebar and migrate out of the concrete toward the external anode. At the same time, alkaline hydroxyl ions are generated at the rebar/concrete interface restoring the passive alkaline environment around the reinforcing steel. When the process is complete, the system is removed, leaving the reinforcing steel in a chloride free, non-corrosive environment.

Electrochemical Re-Alkalization
A low voltage DC electric field is established between a temporary external anode and the reinforcing steel within the concrete. A high alkaline solution is used as the electrolyte. The electrolyte is electrochemically drawn into the concrete to raise the pH of the concrete cover. When the process is complete, the system is removed leaving the reinforcing steel in an alkaline environment.

Electrochemical Chloride Extraction



Re-Alkalization



Best Use

Electrochemical Chloride Extraction
- High chloride areas where corrosion inhibitor treatment may be difficult
- Permanent system not preferred
- Long term power not available

Re-Alkalization
- Early stages of carbonation
- Permanent system not preferred
- Long term power not available

CASE STUDY

Project
I-480 bridge substructure, Omaha, Nebraska
Description of Structure
1.5 mile elevated section of Interstate Route 480 in downtown Omaha.
The structure was built in the early 1970's.
Problem
The Nebraska Department of Roads was planning a major structure rehabilitation of the I-480 overpass in downtown Omaha. The scope of the work included a deck replacement with a 40+ year design life; however, the concrete substructure was showing signs of distress. Faced with the potential on-going substructure repairs after the completion of the major deck reconstruction, the Department designed a substructure rehabilitation program with a similar life expectancy as the new deck. Evaluation of the concrete piers indicated the presence of active rebar corrosion. However, the piers were in generally good condition (a significant portion of the concrete was not spalled or delaminated).
Solution
Norcure ECE was used to significantly reduce the amount of chloride ions in the structure and to passivate the active corrosion. After the treatment process was complete, the system was removed and Sikagard Elastocolor, an elastic, crack-bridging, waterproofing acrylic protective coating was applied to provide protection from future chloride contamination and to enhance the aesthetics of the entire structure. In addition to providing long-term corrosion mitigation, the Norcure ECE system allowed the project to be completed two years earlier when compared to removing and replacing the contaminated piers.

Case study provided by Vector Corrosion Technologies.