REFURBISHMENT
PROTECTIVE COATINGS
FOR CONCRETE
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.
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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.

<table>
<thead>
<tr>
<th>Natural Draft Cooling Tower Refurbishment Scenarios 20'000 m²</th>
<th>Scenario 1 Cost orientated</th>
<th>Scenario 2 Retrofitting with durable system</th>
<th>Scenario 3 Durability orientated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial construction</td>
<td>No protection</td>
<td>No protection</td>
<td>Full protection with proven coating and adequate surface preparation</td>
</tr>
<tr>
<td>After 20 years</td>
<td>Full refurbishment</td>
<td>Full refurbishment</td>
<td>Refreshing coat only</td>
</tr>
<tr>
<td>Inadequate surface preparation</td>
<td>proper surface preparation</td>
<td>proven protective coatings</td>
<td></td>
</tr>
<tr>
<td>highly solvented coatings</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Every 10 years</td>
<td>Full refurbishment as after 20 years</td>
<td>No requirement</td>
<td>No requirement</td>
</tr>
<tr>
<td>Every 20 years</td>
<td>Refreshing coat only</td>
<td>Refreshing coat only</td>
<td></td>
</tr>
</tbody>
</table>

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*Image 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.

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.
The greater resource efficiency of scenario 2 and 3 allows saving of 600 tons of CO₂ 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 CO₂ per km targeted for 2015).

CONCLUSION

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

- 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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SIKA AT WORK
TURÓW POWER PLANT, POLAND

TECHNICAL ARTICLE
Albert Barnes House, London, UK

TECHNICAL ARTICLE
Concrete bridges in Jutland, Denmark

TECHNICAL ARTICLE
THE LÄMERSHAGEN BRIDGE A2 MOTORWAY, GERMANY
# Concretes 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.

<table>
<thead>
<tr>
<th>Water Ingress</th>
<th>Freeze / Thaw Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dynamic and Static Load</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
<td>Some structures such chemical plants or sewer systems 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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wide Temperature Variation</th>
<th>Fire</th>
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<tbody>
<tr>
<td>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.</td>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Carbon Dioxide</th>
<th>Chlorides Ingress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide (CO₂) reacts with the Calcium Hydroxide (Ca(OH)₂) in the pore liquid of the cement matrix of concrete structures and deposits as calcium carbonate (CaCO₃). This process known as carbonation reduces the protection of embedded steel reinforcement, when the process reaches the reinforcement bars.</td>
<td>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.</td>
</tr>
</tbody>
</table>
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 protection of 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

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

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

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).

\[ \text{Ca(OH)}_2 + \text{CO}_2 \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]

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 associated with low concrete cover.

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).
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.
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.

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<table>
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<th>Types of Damage/Defects (Examples)</th>
<th>Possible Principles/Methods EN 1504-9</th>
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<tr>
<td>Concrete spalling/scaling of concrete surface</td>
<td>Principle 3: Concrete restoration (Method 3.1/3.2/3.3)</td>
</tr>
<tr>
<td>Steel reinforcement corrosion</td>
<td>Principle 7: Restoring passivity (Method 7.1/7.2)</td>
</tr>
<tr>
<td>Structural cracks</td>
<td>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)</td>
</tr>
<tr>
<td>Non-structural cracks</td>
<td>Principle 1: Filling of cracks (Method 1.5)</td>
</tr>
<tr>
<td>Chemical attacks</td>
<td>Principle 6: Adding mortar or concrete (Method 6.3)</td>
</tr>
</tbody>
</table>

For the Repair
- Principle 3: Concrete restoration (Method 3.1/3.2/3.3)
- Principle 7: Restoring passivity (Method 7.1/7.2)
- 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)
- Principle 1: Filling of cracks (Method 1.5)
- Principle 6: Adding mortar or concrete (Method 6.3)

For the Protection
- Principle 1: Protection against ingress (Methods 1.1/1.2/1.3)
- Principle 5: Physical resistance (Method 5.1/5.2/5.3)
- 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)
- 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)
- 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:
- 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.
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 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.).

Sika MonoTop® CONCRETE REPAIR MORTAR SYSTEM

![Diagram of 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 over-coating
## Sika MonoTop® RANGE FOR COST-EFFECTIVE SOLUTIONS

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

<table>
<thead>
<tr>
<th>Test methods</th>
<th>Principles</th>
<th>Protection against ingress</th>
<th>Moisture control</th>
<th>Increasing Physical Resistance</th>
<th>Resistance to chemicals</th>
<th>Increasing resistivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN 12617-1</td>
<td>Linear shrinkage</td>
<td>1.3 (C)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>EN 12190</td>
<td>Compressive strength</td>
<td>1.3 (C)</td>
<td></td>
<td></td>
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<tr>
<td>EN 1770</td>
<td>Coefficient of thermal expansion</td>
<td>1.3 (C)</td>
<td></td>
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<tr>
<td>EN ISO 5470-1</td>
<td>Abrasion resistance</td>
<td>1.3 (C)</td>
<td></td>
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</tr>
<tr>
<td>EN ISO 2409</td>
<td>Adhesion by cross-cut test</td>
<td>1.3 (C)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>EN 1062-6</td>
<td>Permeability to CO₂</td>
<td>1.3 (C)</td>
<td></td>
<td></td>
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<tr>
<td>EN ISO 7783-1</td>
<td>Permeability to water vapour</td>
<td>1.3 (C)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>EN 1062-3</td>
<td>Capillary absorption and permeability to water</td>
<td>1.3 (C)</td>
<td></td>
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</tr>
<tr>
<td>EN 13687-1</td>
<td>Adhesion after thermal compatibility</td>
<td>1.3 (C)</td>
<td></td>
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<td>EN 13687-2</td>
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<td>EN 13687-3</td>
<td>Thunder-shower cycling (thermal shock)</td>
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<td>EN 1062-11.2002</td>
<td>Thermal cycling without de-icing salt impact</td>
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<td>EN 1062-11.2002</td>
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<td>EN 1062-11.2002</td>
<td>4.2: Behaviour after artificial weathering</td>
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<td>EN ISO 2812-1</td>
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<td>EN 13529</td>
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<td>EN 1062-7</td>
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<td>EN ISO 6272-1</td>
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<td>EN 1542</td>
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<td>Part 1: Classification using test data from reaction to fire test</td>
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<td>EN 13578</td>
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Key: ■ Characteristic for all intended uses  ■ Characteristic for certain intended uses within the scope of EN 1504-9:2008
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 ($\text{CO}_2$) into the concrete.

If $\text{CO}_2$ 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 $\text{CO}_2$ 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](image-url)

Evolution of carbonation depth over time when different coatings are being used:
- No protection
- A basic decorative paint with no protection performance ($S_D = 1.2 \text{ m}$)
- A protective coating complying with the threshold of EN 1504-2 ($S_D = 50 \text{ m}$)
- A complete stop of the carbonation progression (equivalent to an $S_D$ 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 CO₂ or even direct water ingress).
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 CO₂ 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
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\textsubscript{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, SOx and NOx 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
- 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
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.

<table>
<thead>
<tr>
<th>Aesthetic Parameters</th>
<th>Performance Parameters</th>
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<tbody>
<tr>
<td>Color retention*</td>
<td>UV resistance*</td>
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<tr>
<td>Dirt pick up resistance</td>
<td>Crack bridging</td>
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<tr>
<td>Long term performance</td>
<td></td>
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</tbody>
</table>

**Legend:**  
xxx: 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.

<table>
<thead>
<tr>
<th>Product details</th>
<th>Aesthetic Parameters</th>
<th>Performance Parameters</th>
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<tbody>
<tr>
<td><strong>Sikagard®-550 W Elastic</strong></td>
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<tr>
<td><strong>Sikagard®-545 W ElastoFill + Sikagard®-550 W Elastic</strong></td>
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<td><strong>Sikagard®-675 W ElastoColor</strong></td>
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<td><strong>Sikagard®-720 EpoCem®</strong></td>
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<td><strong>SikaTop® Seal-107</strong></td>
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<td><strong>Sikagard® WallCoat T</strong></td>
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<td><strong>Sikagard®-260 W PU</strong></td>
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<td><strong>Sikagard®-62 + Sikagard®-363</strong></td>
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<td><strong>SikaCor SW-500</strong></td>
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<td><strong>Sikalastic®-152</strong></td>
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## Sika Product Selection Guide

### Aesthetic Parameters
- Color retention*
- UV resistance*
- Dirt pick up resistance
- Crack bridging
- Long term performance

### Performance Parameters
- Mechanical cleaning resistance
- VOC
- Hand application
- Machine application

### Usage Parameters
- Civil engineered structures
- Buildings
- Tunnels
- Marine structures

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<thead>
<tr>
<th>Application Parameters</th>
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<th>Hand application</th>
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CASE STUDIES

VIADUCT BRIDGE BERNE, 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® FeroGard®-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: Eric 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

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**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 Sika-gard®-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.

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