CONCRETE PROTECTION & REPAIRS

Guidelines and Product Systems

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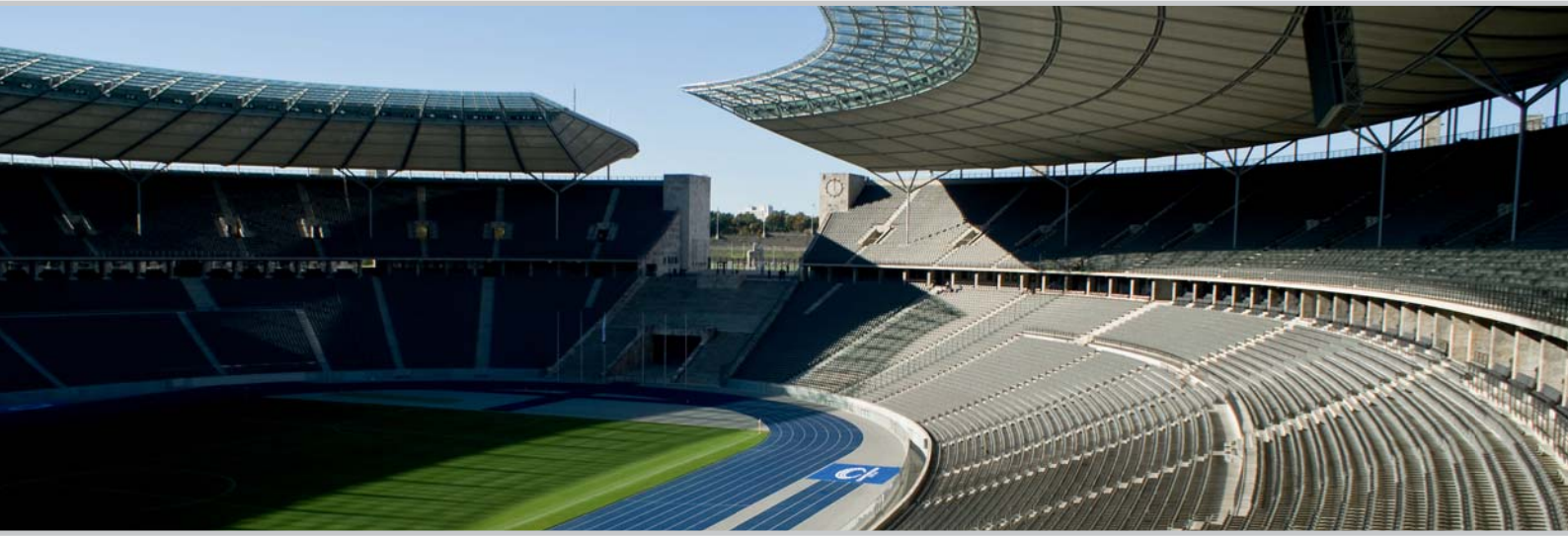


NOTHING LASTS FOREVER

Even Concrete Needs Protection and Must Be Repaired

The production of compression resistant building elements made of water resistant mortar, and pieces of stone that hardened in formwork, made its breakthrough in the 1st century AD and became the standard for late Roman architecture. Thus the Roman "concrete", also called "Opus caementitium" after Vitruvius, was born. Throughout Europe, fantastic and monumental buildings were constructed that are still admired nearly 2,000 years later: temples, theatres, cisterns, aqueducts, sewer systems, thermal baths, roads, harbour facilities, tunnels, bridges and houses.

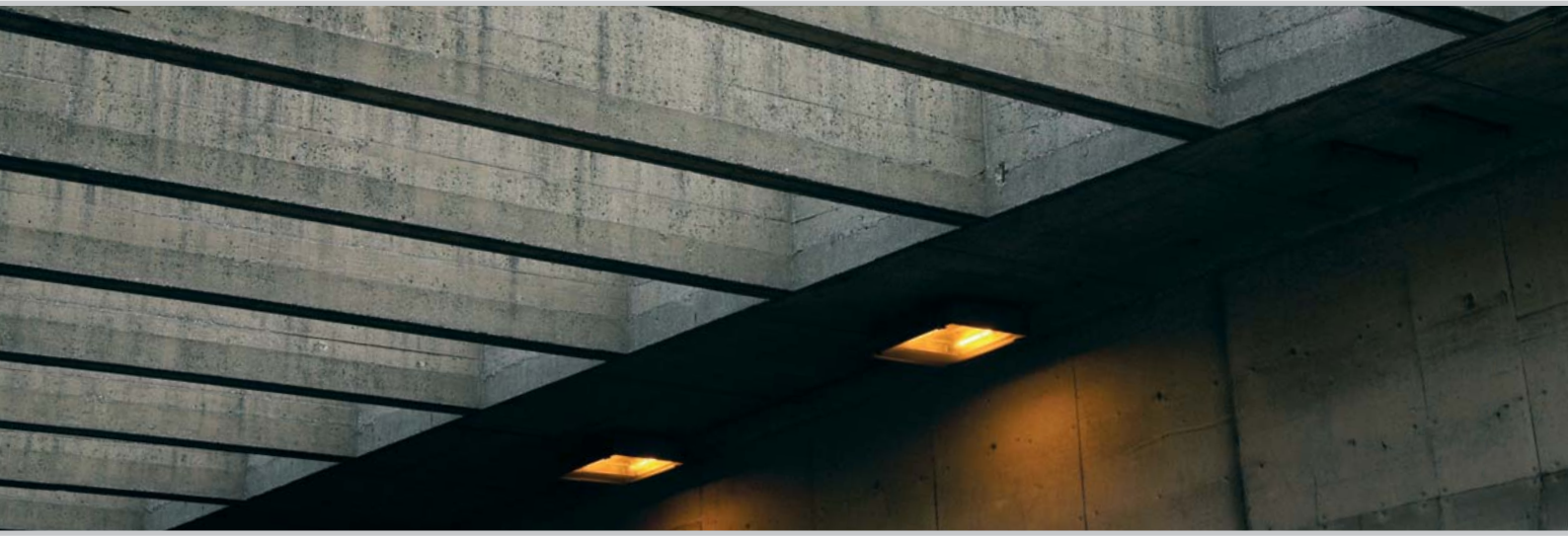
Concrete construction technology was consigned to oblivion during the Middle Ages and only rediscovered around 1700. Since then, concrete has been continuously developed and improved and is now the building material of today.

Despite high quality construction and resistance, damage can occur even to concrete. Repairs and additional protection are therefore necessary.

Among the causes of damages to concrete structures it is necessary to distinguish between environmental factors and production faults. Environmental factors can be exhaust gas pollution, acid precipitation, frost and de-icing salts. These bring about a modification of the chemical properties that cause the reinforcement steel to start rusting. Shrinkage cracks, pipes, gravel pockets and cover are typical production faults that also favour the corrosion of the reinforcement steel.

Due to the numerous causes of and types of damage to reinforced concrete structures there have been different principles for repairs for many years. In Germany, these are described in the guideline "Protection and Repair of Concrete Building Elements" (Repair Guideline) issued by the German Committee for Reinforced Concrete (DAfStb) and the European standard series EN 1504 (in Germany DIN EN 1504) "Products and Systems for the Protection and Repair of Concrete Structures".
While the repair guideline "Protection and Repair of Concrete Building Elements" issued by the German Committee for Reinforced Concrete only recognised four repair principles, there are eleven repair principles in the European standard.

With the introduction of EN 1504, specifiers are given a considerably greater degree of freedom. The specifier selects a repair principle for the respective measure taking boundary conditions into account and then selects a corresponding procedure from part 9 of the standard.



DAMAGE MECHANISMS IN CONCRETE STRUCTURES

Corrosion of Concrete and Steel

Damage to reinforced concrete structures can be subdivided into: damage of the concrete itself (concrete corrosion); and damage that results from corrosion of the steel reinforcement (steel corrosion).

Concrete corrosion
In general it is influences from outside that can lead to a destruction of concrete without any concomitant steel corrosion. Examples are:

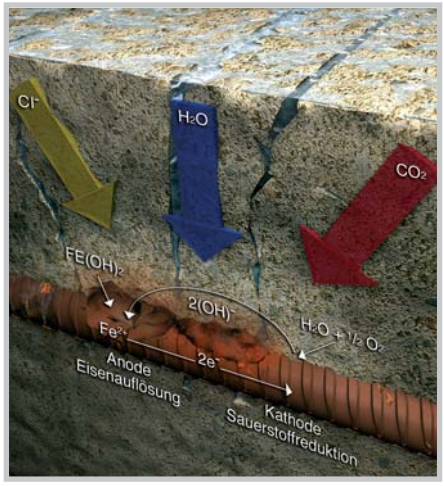
- Frost attack with and without deicing salts
- Chemical attack
- Wearing

The different types of concrete corrosion are classified depending on the ambient conditions to which the concrete is exposed, (according to DIN EN 206-1/DIN 1045-2).

Steel corrosion
In young concrete, the steel is protected from corrosion through the high alkalinity of the pore water (pH ≥ 12.5). In this pH range, a microscopically thin layer of oxide forms on the surface of the steel which suppresses disintegration.

If the pH value of the concrete falls below 10 through carbonation (because it has absorbed CO2), or the chloride content exceeds a critical limit value, this "natural" corrosion protection is lost in locally or over larger areas. Once this state has been reached and moisture (as an electrolyte) and oxygen (which is nearly always present) are present at the same time, corrosion results.

Since corrosion products are larger in volume than the starting materials, the concrete that covers the steel often bursts.



The principle of reinforcement Corrosion:
■ = Air (CO_2)
■ = Moisture (H_2O)
■ = Salts (CI)

Prerequisites for the corrosion process in steel reinforcement are:

- Electrical conductivity in the metal (always present)
- Anodic disintegration of the steel must be possible (the pH value falls below 10)
- Electrolytic conductivity around the metal (water)
- Differences in stress and potential (practically always present)
- Oxygen in the electrolyte (always present except in underwater areas)

NEW RULES AND THEIR IMPLEMENTATION

Current Standards and Rules

After the binding entry into force of the Construction Products Regulation on 01.07.2013, which has the goal to abolish trade barriers and promote the free circulation of construction products within the European single market, construction products must be put into circulation with CE marking and a Declaration of Performance in accordance to a harmonised European standard.
A decision by the European Court of Justice has established that national regulations cannot set requirements that contradict the harmonised European standard. As a consequence, from 16/10/2016 the Ü symbol for construction products in accordance with harmonised European standards con no longer be used.

DIN EN 1504

DIN EN 1504 was introduced in the years between 2004 and 2008 and in the harmonised parts 2 through 7 regulates products and systems for the protection and repair of concrete structure. The conformity of the products and systems with the corresponding parts of the standard is shown through the CE marking. In the non-harmonised part 9 of the standard, to which the product-related parts 2 through 7 refer to, the "General principles for use of products and systems" are expounded. The national implementation of Part 9 will in future be regulated by the DAfStb "Maintenance Guideline" the first draft of which is currently available.

The Maintenance Guideline of the DAfStb (German Committee for Reinforced Concrete)

Contrary to the current Maintenance Guideline, the new regulation puts more emphasis on the newly introduced application range of maintenance. In this context the planned remaining useful life plays a major role in the choice of a suitable maintenance concept, which can range from regular servicing and inspection up to complex repair works with inspection intervals. For the repair part the methods and principles from DIN EN 1504-9 will apply since sufficient experience with them is already available. Further methods and principles in comparison with the European standard were also introduced.

On the basis of the definition of the exposure classes that according to DIN EN 206-1 describe the external influences on a building element as well as those coming from the concrete substrate, for each repair a project-specific requirement for the materials to be used is derived.

The introduction of old concrete classes allows for the possibility to adjust the concrete replacement systems to the differing substrate properties. This does obviously require a good knowledge of the effective conditions of the building.

Repair measures in accordance with the new standard are always considered structural unless a qualified expert formulates a written explanation of why within the residual useful life no risk for the structural stability is to be expected.

Part 3 contains requirements for the executing firm, among other things, for works in accordance with the “Maintenance Guideline” the qualification of the staff (min. 1 person) on the building site is required. Prove of the qualification is to be given by a certificate (so called SIVV certificate). Depending on the specific works to be carried out further evidence of qualification may be required, e.g. the “nozzle licence”.

Part 3, section 6 divides the types of work to be executed are into different divided monitoring classes depending on their application range.

This monitoring classes determine the frequency of inspection within the framework of self-monitoring.

DURABILITY AS A GUIDE FOR PLANNING

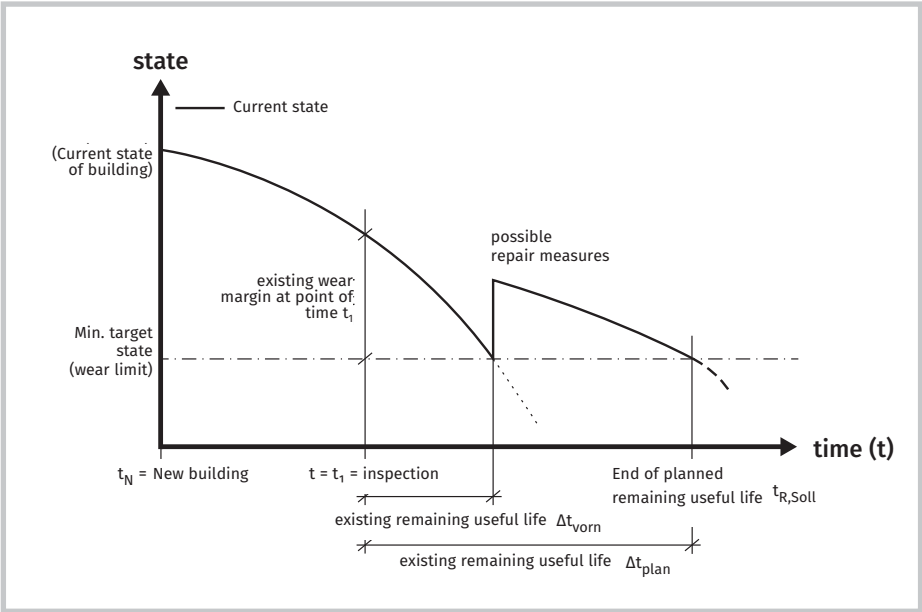
Influence of Surrounding Conditions

Concrete buildings have a planned useful life of 50 years. This implies that during this period the function of building with regard to its structural stability and serviceability is given without significant loss of its utilisation properties, if an adequate level of maintenance is implemented.

The durability scheme has been implemented since 2005 for the planning and construction of concrete structures on the basis of the DIN EN 206-1/DIN 1045-2 standards. The introduction of the so called exposure classes has given planners a tool with which to describe in a targeted way the various chemical and physical influences to which a building or a structural element is exposed. On the basis of the external influences on buildings/structural elements, the choice of building materials, the concrete cover and the frequency of follow-up treatments are then also regulated.

Correct planning (structural design and construction details) is not the only factor to have a great influence on the durability of a building: also the selection of the construction materials and the diligent execution play a major role. With the publishing of the draft of the Maintenance Guideline this approach to durability has been taken up and extended to repairs of concrete building structures.

In addition to external factors also the influences from the concrete substrates are taken into account.



CORROSION OF REINFORCEMENT

Exposure Classes of Building Elements

Denomination	Description of environment conditions	Example
No risk of corrosion or aggression		
X0	Unreinforced concrete without frost aggression, wear or chemical attack	Unreinforced foundations in frost-free areas, unreinforced building elements indoors
Corrosion triggered by carbonation		
XC1	Dry or constantly damp	Interiors with normal air humidity, e.g. kitchen,bathroom; concrete, permanently under water
XC2	Wet, rarely dry	Parts of water containers, foundation elements
XC3	Moderate humidity	Interiors with normal air humidity, e.g. bathrooms, laundries, stables, commercial kitchens
XC4	Alternating wet and dry	Building elements outdoors directly exposed to rain
Corrosion triggered by chlorides, sea water excluded		
XD1	Moderate damp	Building elements in spray areas of traffic surfaces, single garages
XD2	Wet, rarely dry	Saltwater pools, building elements exposed to chloride-containing sewage water
XD3	Alternating wet and dry	Parts of bridges exposed to splash water, directly trafficked parking levels
Corrosion triggered by chlorides from sea water		
XS1	Salt-laden air, but no direct contact contact with sea water	Building elements outdoors in coastal areas
XS2	Constantly below water	Building elements in harbour facilities that are constantly below water
XS3	Tidewater, splash water and spray zones	Quay walls in harbour facilities

CORROSION OF CONCRETE AND CONCRETE EDGES

Exposure Classes of Building Elements

Denomination	Description of environment conditions	Example
Concrete corrosion through frost attack with and without de-icing salts		
XF1	Moderate water saturation **without de-icing salts**	Building elements outdoors
XF2	Moderate water saturation **with de-icing salts**	Building elements in spray or splash water areas of traffic surfaces treated with de-icing salts
XF3	High water saturation **without de-icing salts**	Open water tanks, building elements in the exchange water zone of fresh water
XF4	High water saturation **with de-icing salts**	Horizontal building elements splash water areas of traffic surfaces treated with de-icing salts, scraper ways in waste water treatment plants
Concrete corrosion through chemical attack through natural soils, ground water, sea water and waste water		
XA1	Environment with weak chemical aggression	Tanks of waste water treatment plants, liquid manure basin
XA2	Environment with moderate chemical aggression	Building elements that come into contact with sea water, building elements in soils that attac concrete
XA3	Environment with strong chemical aggression	Feeding tables in agricolture, cooling towers with with flue gas discharge, industrial waste water plants
Concrete corrosion through wear stress		
XM1	Moderate wear	Traffic of pneumatic-tyred vehicles
XM2	High wear	Traffic of pneumatic and solid rubber-tyred fork-lift trucks
XM3	Very high wear	Traffic of elastomer or steel roller-tyred fork-lift trucks, surfaces that are frequently driven over by track vehicles, stilling basins

NOTE: The environment conditons of class XA apply only to natural soild and waters as well as waste water. The classification of the degrees of aggression is based on a water analysis according to DIN 4030. If other types of chemical attack are present, e.g. fertiliser storage, protection measures or solutions based on expert opinion are necessary.
In a chemically very aggressive environment (XA3) additional concrete protection measures must be adopted.

INFLUENCES FROM THE CONCRETE SUBSTRATE

Exposure Classes of Building Elements

Denomination	Description of environment conditions	Example
XW1	Continuous Ständige exposure to fresh or sea water	
XW2	Alternating dry and wet thorugh exposure to fresh or sea water	
Influences from the concrete substrate		
XBW1	Damp from behind without water flow, increased residual moisture	Building elements exposed to water pressure
XBW2	Damp from behind without water flow	Building elements exposed to water pressure
XSTAT	For structural applications	Re-profiling of building elements exposed to water pressure, friction coupled filling of cracks
XDYN	Dynamic loads during application	Trafficked bridges, possibly multi-storey car parks
Cracks		
XCR	Cracks	
W	Crack width in mm	
Δw **LFR** **HFR** **CON**	Crack width change in mm Low frequency, e.g. from temperature High frequency, e.g. from traffic Continuous, e.g. settlements, contraction	Water impermeable concrete building elements, bridges, floor slabs
DY	Humidity level dry	
DP	Humidity level damp	
WT	Humidity level wet	
WF	Humidity level waterflow	

NOTE: The draft of the IH guideline introduces the exposure classes above for repairs of concrete building elements for the first time.

REMMERS PRODUCTS FOR CONCRETE REPAIR

Proven Reliability with Remmers

After the additional national product requirements to the parts of DIN EN 1504 have been abolished, the tried and tested “third party monitoring” will disappear together with the Ü conformity marking. Remmers will continue on a voluntary basis to have the product conformity of its concrete replacement systems monitored by an accredited third party body. The national test certificates and technical approvals received in the past for CE-marked products will lose its validity when the new building regulations come into force. Existing national test certificates and technical approvals, however, can still be used in contracts and private agreements to prove additional product properties that are not included in the CE marking or the declaration of performance.

System Solutions for the Future

Concrete repair mortar

Fair-faced concrete protection OS 1

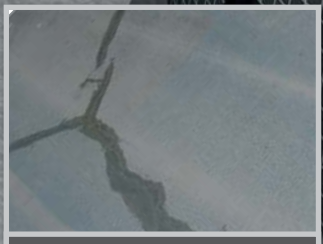
Concrete coating OS 2 – OS 5

Floor coatings OS 8, rigid

Floor coatings
OS 10, strong crack bridging abilities

Floor coatings
OS 11a, flexible, in the open

Floor coatings
OS 11b, flexible, surfaces under cover



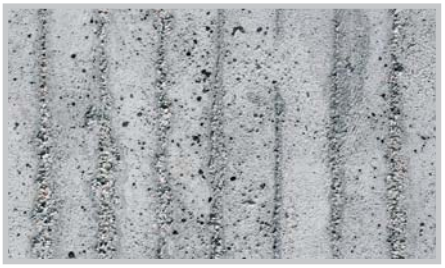
Crack repair
flexible

DAMAGE TO CONCRETE

Repair Principles and Methods

Principles 1 to 6 of DIN EN 1504-9 deal with the repair of damages to concrete structures. Possible causes of these damages are:

- Mechanical effects, e.g. impact, overloading, settlement movements
- Chemical and biological attack from the environment
- Physical effects such as frost damage and damage from de-icing salts, flow of water, thermal crack formation, crystallisation of salts or erosion



Principle according to EN 1504-9	Procedures based on this principle	Principle according to DAfStb Guideline*
Principle 1: Protection against the ingress of substances Prevention of the ingress of corrosion promoting substances (e. g. water, other liquids, vapour, gas, chemicals) and biological forms of life	1.1 Hydrophobisation 1.2 Sealing 1.3 Coating 1.4 Local covering of cracks 1.5 Sealing of cracks 1.6 Conversion of cracks into expansion joints 1.7 Assembly of slabs 1.8 Application of membranes	1.1 Hydrophobisation 1.3 Coating 1.4 Local covering of cracks 1.5 Filling of cracks or voids
Principle 2: Regulating the water balance of the concrete Adjustment and maintenance of concrete moisture within a stipulated value range	2.1 Hydrophobising impregnation 2.2 Sealing 2.3 Coating 2.4 Installation of cover slabs 2.5 Electrochemical treatment	2.1 Hydrophobisation 2.3 Coating 2.6 Filling of cracks or voids
Principle 3: Concrete replacement Restoring a concrete structure with regard to its intended geometric form and function; restoring the properties of a concrete structure by partial replacement of concrete	3.1 Mortar application by hand 3.2 Cross-section replacement by placing concrete 3.3 Spray application of concrete or mortar 3.4 Replacement of building elements	3.1 Manual application on small surfaces 3.2 Concrete placing or pouring 3.3 Spray application 3.4 Replacement of building elements
Principle 4: Reinforcement of concrete structures Increasing or restoring the load-bearing capacity of a building element in the concrete structure	4.1 Adding or replacing steel reinforcement 4.2 Installation of interconnecting and reinforcement bars in the concrete in grooves or drilled holes 4.3 Reinforcement through spliced pieces 4.4 Supplementation of cross-section with mortar or concrete 4.5 Injection of cracks, voids or missing areas 4.6 Filling of cracks, voids or missing areas 4.7 Prestressing with external tendons	4.3 Strengthening by adhesive reinforcement 4.4 Cross-section replacement with mortar or concrete 4.5 Filling of cracks or voids
Principle 5: Increase of physical resistance Increasing resistance against physical or mechanical attack	5.1 Coating 5.2 Sealing 5.3 Application of concrete or mortar	5.1 Coating 5.3 Application of concrete or mortar
Principle 6: Increase of resistance to chemicals Increasing the resistance of the concrete surface to prevent deterioration by chemical substances	6.1 Coating 6.2 Sealing 6.3 Application of concrete or mortar	6.1 Coating 6.3 Application of concrete or mortar

* The numbering of DIN EN 1504-9 was used. Principles for which no experience is available wre not included in the guideline. Additionally introduced principles were added to the existing numeration.

CORROSION OF REINFORCEMENT

Repair Principles and Methods

Principles 7 to 11 of DIN EN 1504-9 deal with the repair of concrete building elements that have been damaged through the corrosion of reinforcement or the presence of substances that favour corrosion within the structure of the concrete. Possible causes of these damages are:

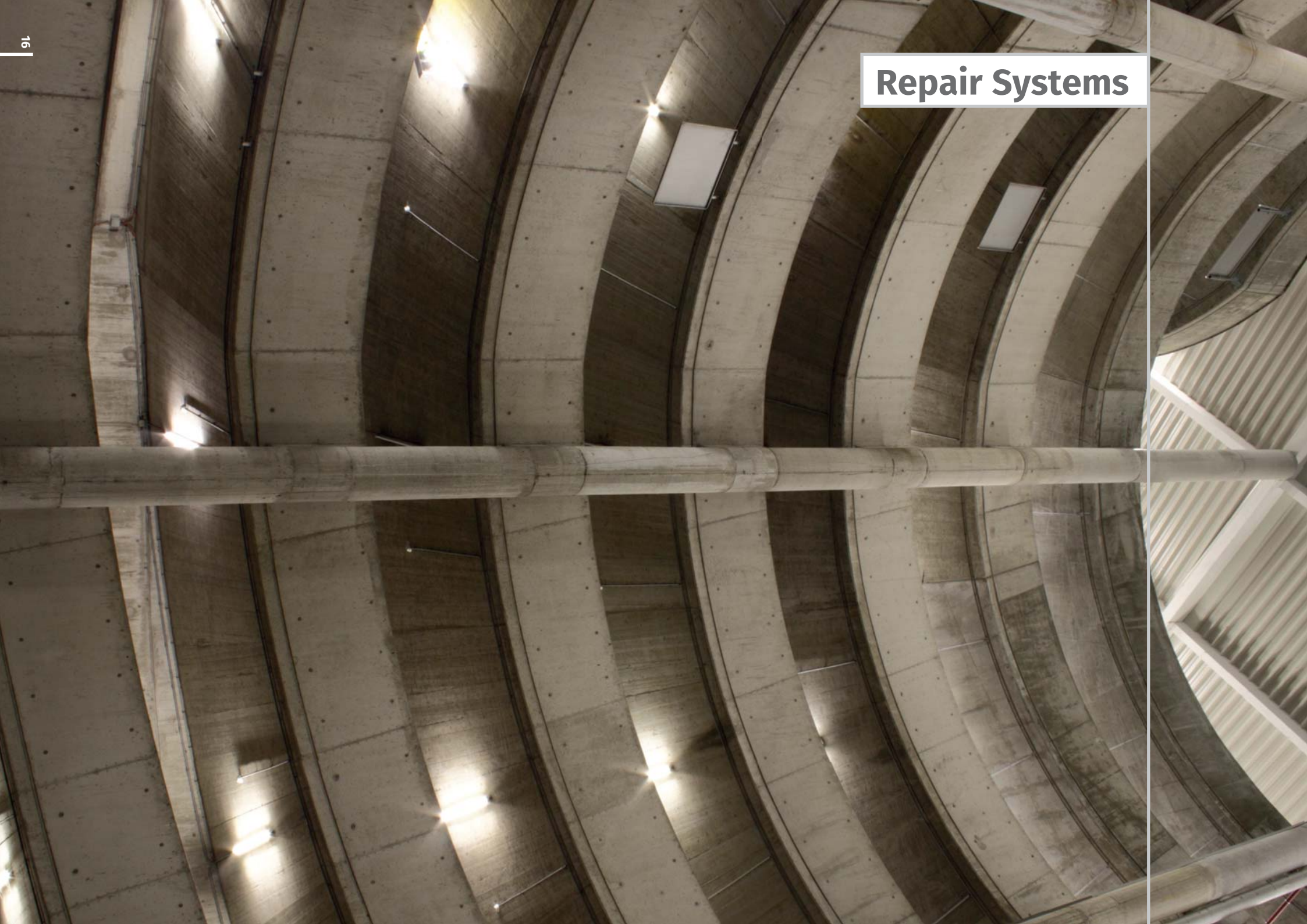
- Scarse or absent concrete cover
- Loss of alkalinity in the concrete cover (carbonation)
- Penetration of corrosion promoting substances (usually chloride ions) in exterior layer of the concrete

If the reinforcement is already corroded or there is a risk that corrosion will form in the future, one or more of the following corrosion protection and repair principles, 7 through 11, must be considered before selecting a suitable repair method.

In addition, the cross-section of the concrete should be repaired according to principles 1 to 6, if necessary.

Principle according to EN 1504-9	Procedures based on this principle	Principle according to DAfStb Guideline*
Principle 7: Preserving or restoring passivity Creating chemical conditions in which the surface of the reinforcement retains its passive state or is returned to a passive state	7.1 Increasing the cover of the reinforcement with additional mortar or concrete 7.2 Replacement of contaminated or carbonated concrete 7.3 Electro-chemical re-alkalisation of the carbonated concrete 7.4 Re-alkalisation of carbonated concrete by diffusion 7.5 Electrochemical chloride extraction	7.1 Increasing the cover of the reinforcement with additional mortar or concrete 7.2 Replacement of contaminated or carbonated concrete 7.4 Re-alkalisation of carbonated concrete by diffusion 7.5 Electrochemical chloride extraction 7.6 Filling of cracks or voids 7.7 Coating 7.8 Local covering of cracks
Principle 8: Increasing electrical resistance Increasing the electrical resistivity of the concrete by lowering moisture content	8.1 Hydrophobisation 8.2 Sealing 8.3 Coating	8.1 Hydrophobisation 8.3 Coating
Principle 9: Control of cathodic areas Creating conditions under which potential cathodic areas of the reinforcement cannot cause any anodic reactions	9.1 Limiting oxygen content (at the cathode) by a sealing impregnation or surface coating	Principle 9 does not apply
Principle 10: Cathodic protection	10.1 Setting up an electric potential	10.1 Setting up an electric potential
Principle 11: Control of anodic areas Creating conditions under which potential anodic areas of the reinforcement are prevented from participating in the corrosion reaction	11.1 Coating the reinforcement with active pigments coatings 11.2 Coating the reinforcement with coatings on a barrier principle 11.3 Applying inhibitors to the concrete and transport to the surface of the steel by impregnation or diffusion	Principle 11 does not apply

Repair Systems



REMMERS BETOFIX R4 / BETOFIX R4 SR

Concrete Repair on Structural Elements

Remmers sets entirely new standards in concrete repair. Betofix not only makes repairs on concrete unbelievably fast, as it allows the execution of all operations from corrosion protection to coating, beyond that it convinces with its particular properties and resistance to all kinds of different stresses. A very crucial property of repair mortars for hydraulic structures exposed to high stress is their chloride migration coefficient.

Chlorides in reinforced concrete very quickly lead to considerable corrosion damage, therefore it necessary to aim for an as high as possible resistance to their penetration. Appropriate tests were originally developed for concrete building elements exposed to salt water; their results, though, can be applied to all concrete building elements that are frequently subjected to contact with water containing de-icing salts. This applies in particular to infrastructures for moving as well as stationary traffic.

Typical examples are multi-storey and underground car parks and especially the bases of pylons and pillars, which are often exposed without protection to the de-icing salt carried in by cars. In these cases, the use of Betofix R4 allows for more than four times the damage-free useful life than, the best comparable product.

The chart on the next page explains the correlation between chloride migration coefficient and the time period to the possible appearance of corrosion damage using Betofix R4 and its best competitor as examples.

Already after 28 days, Remmers Betofix R4 shows results that are twice as good as those of the competing product. As the reaction time progresses the results get better still.

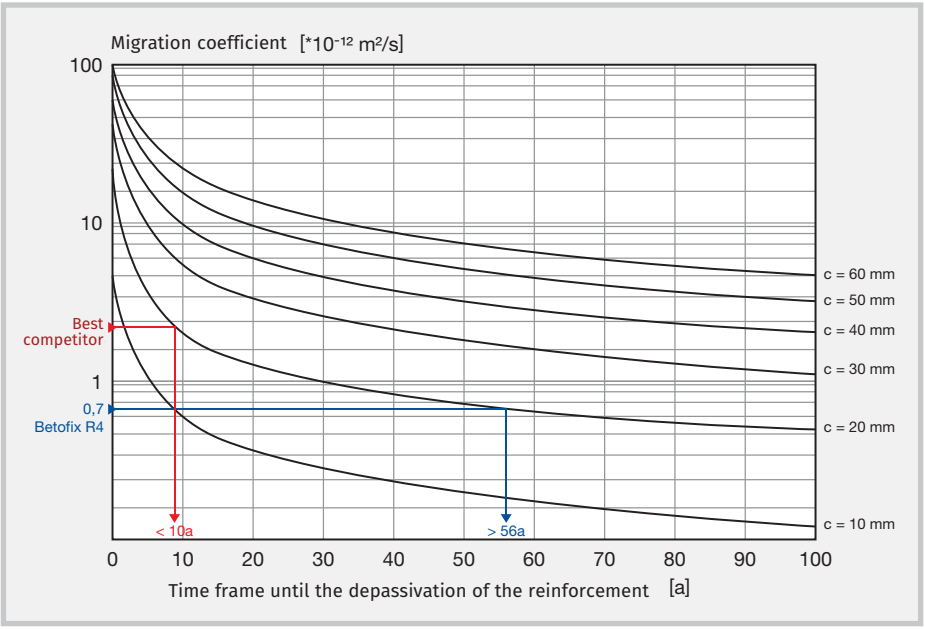
REMMERS BETOFIX R4 / BETOFIX R4 SR

Uncomparably Good Durability under Exposure to Chlorides

The chart shown below is usually used to determine the required migration coefficient as a function of the existing concrete cover, c, and the desired useful life (defined here as the period of time before loss of passivation of the reinforcement). It can however be read in the opposite order as well:

If the migration coefficient and the concrete cover, c, are known, it is possible to read how long it takes for the chloride to advance to the steel reinforcement and thus for corrosion to begin. If we assume a concrete cover of 20 mm, the chloride penetration front would take about nine years to reach the reinforcement if the competing product is used, and as long as 57 years with the use of Betofix R4!

This means that in chloride-polluted areas the useful life with Betofix R4 is 500% longer than with the best comparable product!



Properties

- Extremely durable
- Combines protection against corrosion (with a concrete cover of > 10 mm), bonding layer, coarse and fine mortar
- Load-bearing
- Scratch coat and re-profiling with the same material
- With a concrete cover of more than 10 mm no additional bond layer bonding layer is necessary since Betofix presents an excellent adhesion to the substrate
- For concrete covers of less than 10 mm, the Repair Guideline of the DAfStb requires the adoption of solution C with corrosion protection, i.e. the use of Betofix KHB
- Hardens without cracking also even if applied in thick layers
- Easy over-head application
- Can be feathered seamlessly (limited by max. grain size)
- Can be felted
- Unmatched resistance to chloride penetration according to BAW test: twice as good as the best reference product already after 28 days

Application

Betofix R4:

- Certified repair system according to DIN EN 1504-3 for the requirement class R4 and M3 coording to SIB guideline
- For pillars, slabs, beams, below carriageway surfacing, on bridges and car parks
- Load-bearing
- BASt listed
- Protection against corrosion, bonding layer, coarse and fine mortar in one product
- Approved for hydraulic engineering works according to ZTV-W LB 219

Betofix R4 SR:

- Highly sulphate-resistant binders
- Enhanced sulphate resistance up to exposure class XA3
- Approved for potable water areas according to DVGW worksheets W 270, W 300 and W 347

Betofix R4	
Art. No.	1096
Container size	25 kg
Mixing ratio with water	ca. 2,7 l per 25 kg powder
Grain size	2 mm
Compression strength	≥ 50 N/mm² (after 28 days)
Flexural strength	≥ 8 N/mm² (after 28 days)
Dyn. mod. of elasticity	≥ 25.000 N/mm²
Adhesive power	≥ 2,0 N/mm²
Chloride migration coefficient	$1{,}27 \times 10^{-12}$ (after 28 days) $0{,}70 \times 10^{-12}$ (after 90 days)
Sulphate resistance	XA2 (sulphate content ≤ 1500 mg/l)
Resistance to fire	A1
Working temp.	+5 °C to +25 °C
Working time	ca. 60 min (20 °C)
Application rate	ca. 2,0 kg/m² per mm thick layer
Approvals	–

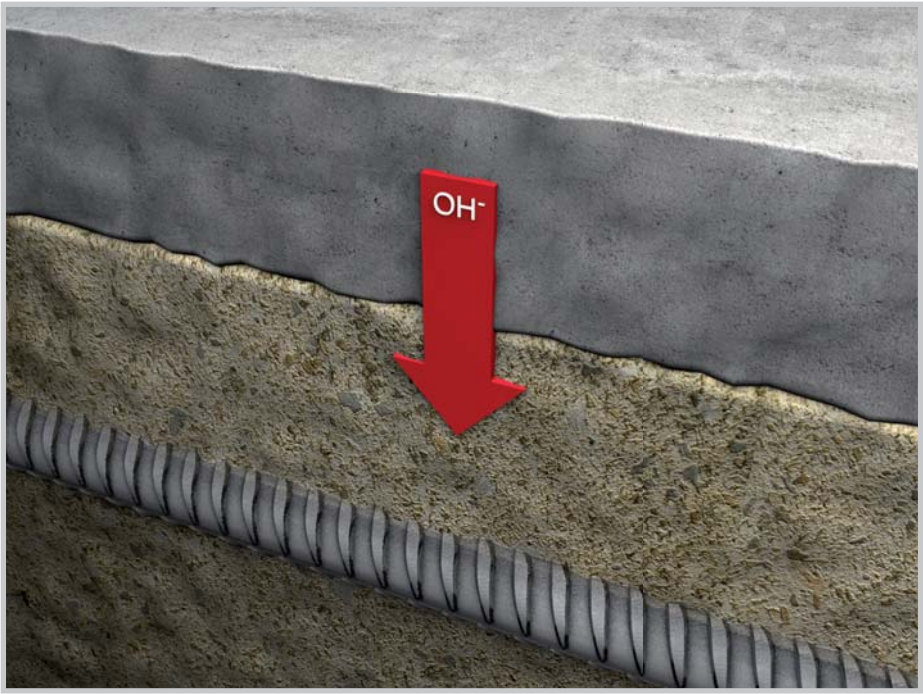
Betofix R4 SR	
Art. No.	1084
Container size	25 kg
Mixing ratio with water	ca. 2,7 l per 25 kg powder
Grain size	2 mm
Compression strength	≥ 50 N/mm² (after 28 days)
Flexural strength	≥ 8 N/mm² (after 28 days)
Dyn. mod. of elasticity	≥ 25.000 N/mm²
Adhesive power	≥ 2,0 N/mm²
Chloride migration coefficient	–
Sulphate resistance	XA3
Resistance to fire	A1
Working temp.	+5 °C to +25 °C
Working time	ca. 60 min (20 °C)
Application rate	ca. 2,0 kg/m² per mm thick layer
Approvals	DVGW W 270 DVGW W 347 DVGW W 300

REMMERS BETOFIX SPCC

Repassivation of Reinforcement by Spray Application

The influence of substances that favour corrosion over the course of decades on the reinforcement rods embedded into the concrete does not only show up as occasional, local damage but rather manifests itself as a widespread aggression to the external areas of the concrete, which can reach as deep as beyond the first reinforcement layer.

For the efficient strengthening of this kind of building elements, in most cases the only sensible solution is an extensive repair measure. This is best done by spraying application or by the wet or dry spray method.



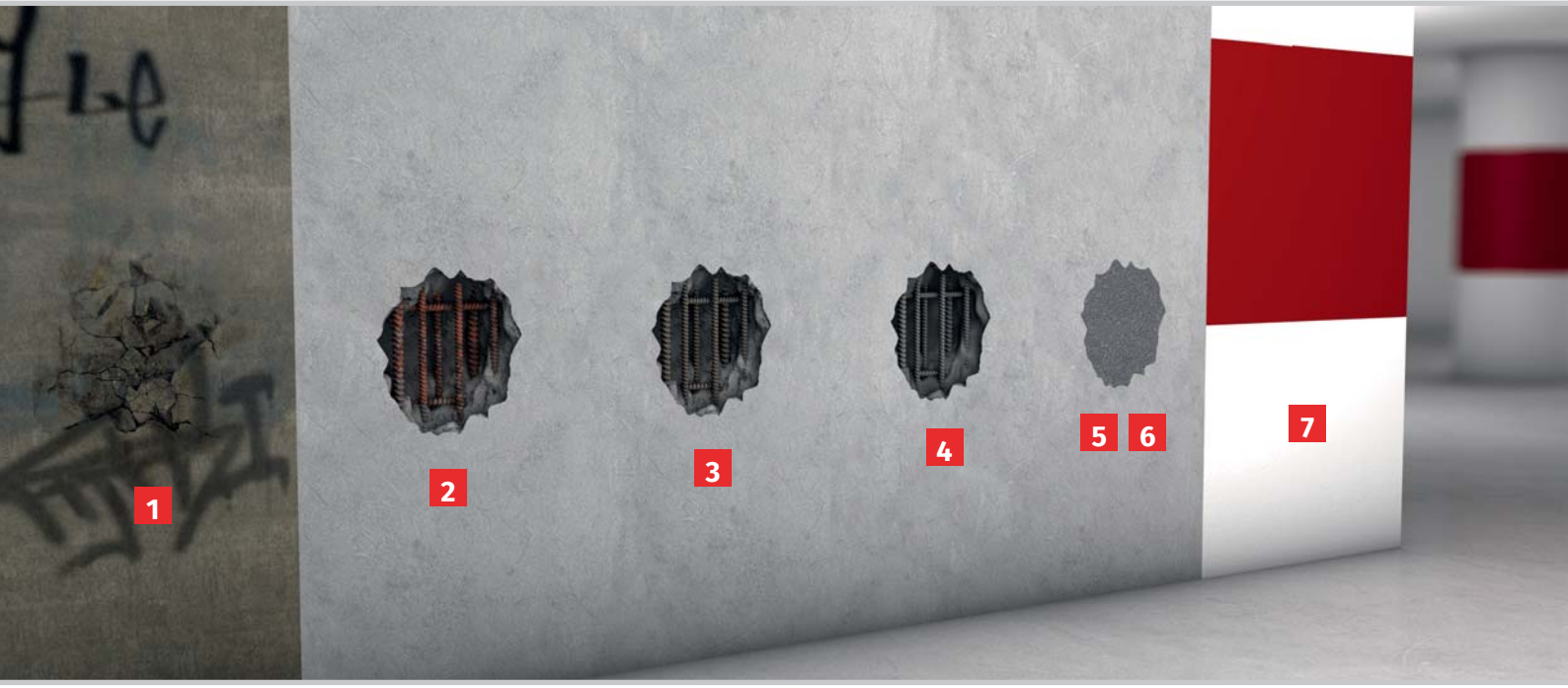
Properties

- Fibre-reinforced SPCC mortar conformant to DIN EN 1504-3
- Resistance class M2/R4
- Reaction to fire A1
- Suitable for humidity classes W0, WF, WA
- Chloride ion content ≤ 0,05 %
- Capillary water absorption ≤ 0,5 kg/(m² $h^{0.5}$)
- Largest grain size 2 mm

Application

- Suitable for the Repair Principle 1, solution R1 of the DAfStb Guideline „Protection and Repair on Concrete Building Elements“
- For use indoors, outdoors and wet areas of old and new buildings
- On vertical surfaces and horizontal surfaces that are worked-on from below

Betofix SPCC	
Art. No.	1100
Container size	25 kg
Apparent density of the fresh mortar	ca. 2,20 g/cm³
Apparent density of the hardened mortar	ca. 2,11 g/cm³ (after 28 days)
Compression strength	≥ 15 N/mm² (after 1 Tag) ≥ 40 N/mm² (after 7 days) ≥ 45 N/mm² (after 28 days)
Flexural strength	≥ 8,0 N/mm² (after 28 days)
Dyn. mod. of elasticity	≥ 25.000 N/mm²
Adhesive power	≥ 2,0 N/mm²
Working temp.	> + 5 °C to + 30 °C
Working time	ca. 60 min (20 °C)
Application rate	ca. 2,0 kg/m² per mm thick layer
Tools	Positive mixer, wet and dry spraying machines



REMMERS BETOFIX RM / BETOFIX R2

Fast Repair – From Corrosion Protection to Coating in One Day

Time is money. It is therefore important to have a fast system that only uses a few coordinated, high-quality products. Betofix from Remmers sets new standards for repairing concrete. From corrosion protection to coating, concrete repairs can be carried out in just one day.

For small repair measures in particular, for example on balcony slabs or parapets, two journeys to the same object make very little economic sense. This makes it all the more important to have a fast product system that relies on few, well matched products, while at the same time having very good workability properties.

1 Cleaning
Cleaning not only improves the appearance of the surface. It also helps remove crusts of soil that store moisture and pollutants and prevent the substrate from drying.

2 Removal of loose material
The corroded reinforcement is completely exposed.

3 De-rusting
Mechanically de-rust corroded reinforcement steel to SA 2 ½.

4 Corrosion protection
Betofix RM/ Betofix R2 modified with Remmers Rust Inhibitor M is applied as a corrosion protection coating to the de-rusted reinforcement steel. Just 30 minutes after the coating is applied, the broken out areas can be closed.

5 Concrete replacement
The broken out areas can be closed in one working operation, without additional filling, with Betofix RM or Betofix R2. After three hours, surface protection can be applied.

6 Protection from water and graffiti
To protect the reinforcement from renewed corrosion, a hydrophobizing agent can be used according to Repair Principle W. This practically eliminates the absorption of water through the surface of the concrete. Semi-permanent Remmers Graffiti Protection facilitates the removal of graffiti on treated surfaces.

7 Coating or scumble
Remmers Concrete Acrylic, an opaque, matt, protective coating on a pure acrylic base, or Remmers Historic Grout Scumble, a semi-opaque coating on a silicone resin base, can be applied to old and replaced concrete to inhibit carbonation and prevent water penetration.

Properties

- Can be applied in any thickness in one layer of application
- Can be worked over after 2 – 3 hours
- Combines bonding layer, corrosion protection (with the addition of Rust Inhibitor M), coarse mortar, fine mortar and filler
- Filling layer and re-profiling with the same material
- Excellent adherence to the substrate
- Very easy to apply
- High yielding
- Can be seamlessly feathered out
- Can be felted
- Can be applied over head
- Very low stress, thus crack free

Application

Betofix RM:
- Certified rapid repair system according to DIN EN 1504-3 of the requirement classes R1 and M1 of the DAfStb SIB Guideline

Betofix R2:
- Rapid repair system according to DIN EN 1504-3 df the requirement class R2

Betofix RM / Betofix R2:
- Fully adequate corrosion protection paint with the addtion of Rust Inhibitor M

Betofix RM	
Art. No.	1092
Container size	25 kg
Mixing ratio with water	4,7 l water + 25 kg powder
Apparent density of the fresh mortar	ca. 1,7 kg/dm³
Consistency	can be applied by trowel
Compression strength	> 10 N/mm² (after 28 days)
Bond strength	ca. 1,0 – 3,0 N/mm² (after 28 days)
Mortar class	M1 / R1
Working temp.	+5 °C to +25 °C
Working time	20 °C – ca. 20 min.
Initial set	after ca. 60 min.
Application rate	ca. 1,2 kg/m² per mm thick layer

Betofix R2	
Art. No.	1093
Container size	25 kg
Mixing ratio with water	4,5 l water + 25 kg powder
Apparent density of the fresh mortar	ca. 1,6 kg/dm³
Consistency	can be applied by trowel
Compression strength	> 15 N/mm² (after 28 days)
Bond strength	ca. 1,0 – 3,0 N/mm² (after 28 days)
Mortar class	R2
Working temp.	+5 °C to +25 °C
Working time	20 °C – ca. 20 min.
Initial set	after ca. 60 min.
Application rate	ca. 1,4 kg/m² per mm thick layer

REMMERS BETOFIX HQ 6

Re-profiling by Pouring

The third amendment of the DAfStb Guideline “Protection and Repair of Concrete Building Elements” provides for a new regulation of the re-profiling of concrete building elements with pouring concretes. The products used must meet the requirements of the shrinkage classes SKVB0 or SKVB1.

To ensure bonding, the poured concrete must be reinforced and connected to the existing concrete by connecting anchors. Evidence must be given in regard to the bonding and, if required, the existing constraints. For the re-profiling of building elements exposed to pressure loads, a confining reinforcement must be provided for.

Remmers Betofix HQ6 stands out due to its excellent flow properties, also in cases where the reinforcement rods are very tightly grouped.

Properties

- Pouring concrete according to the DAfStb Guideline “Production and Use of Cement-bound Pouring Concrete and Mortars”
- Compression strength class C50/60
- Shrinkage class SKVB 0
- Slump flow class a3
- Early strength class C
- Reaction to fire A1
- Suitable for the humidity classes W0, WF, WA
- Largest grain 6 mm

Application

- Suitable for re-profiling of concrete building elements after the third amendment of the DAfStb Guideline “Protection and Repair of Concrete Building Elements”
- For use indoors, outdoors and wet areas of old and new buildings
- For embedding supports in concrete in sleeve foundations
- For pouring and bedding machines and steel constructions

Betofix HQ6	
Art. No.	0556
Container size	25 kg
Apparent density of the fresh mortar	ca. 2,30 g/cm³
Apparent density of the hardened mortar	ca. 2,20 g/cm³ (after 28 days)
Compression strength	≥ 10 N/mm² (after 1 Tag) ≥ 40 N/mm² (after 7 days) ≥ 60 N/mm² (after 28 days) ≥ 65 N/mm² (after 90 days)
Slump-flow	≥ 700 mm (after 5 minutes) ≥ 650 mm (after 30 minutes) ≥ 650 mm (after 60 minutes) ≥ 600 mm (after 90 minutes)
Degree of swelling	0,5 Vol-% (after 24 hours)
Largest grain	6 mm
Working temp.	> + 5 °C to + 30 °C
Working time	ca. 90 min (20 °C)
Application rate	ca. 2,1 kg/l void
Tools	Positive mixer, feed pump

REMMERS – SYSTEM SOLUTIONS

Overview of Requirements and Quality Seals

Application Range	Substance Group	Class According to DIN EN 1504-3	Resistance Class (SIB Guideline)		Working Operation
Concrete repair system (cosmetic repairs) for areas that are not relevant to structural stability	PCC	R1 / R2	M1	No structural improvement	Corrosion protection
					Repair Mortar
Concrete replacement system for areas that are relevant to structural stability	PCC I	R4	M2	No structural improvement	Bonding layer
					Concrete replacement
	PCC I + II	R3 / R4			Corrosion protection*
					Concrete replacement
	SPCC	R4			Concrete replacement applied by spraying
	PCC I + II	R3 / R4	M3	Structural improvement	Corrosion protection*
					Concrete replacement

Application range	Substance group	Requirements according to DIN EN 1504-3	Resistance class (SIB Guideline)	Working Operation
Filler	PCC	R1 / R2	M1	Surface filling
Filler	PCC	R1 / R2 / R3	M1 / [M2 / M3]	Surface filling

Application range	Substance group	Requirements according to DIN EN 1504-3		Resistance class (SIB Guideline)		Working Operation
Concrete replacement system	PC	R3 / R4	Structural improvement	M2	No structural improvement	Corrosion protection
						Concrete replacement

Application range	European regulations	National regulations
Pouring mortar for filling voids	–	Requirement according to DAfStb Rili VeBMR
Pouring mortar for reprofiling of building elements	–	Requirement according to DAfStb Rili VeBMR

* In accordance with Construction Product List A, part 1

	Product / Product Systems	BASt Listing	BAW Listing	Marking	Approved for Potable Water Areas (DVGW Codes of Practice W 347, W 270 and W 300)
	Rust Inhibitor M + Betofix RM			CE	
	Rust Inhibitor M + Betofix R2			CE	
	Betofix RM			CE	
	Betofix R2			CE	
	Betofix HB / Betofix KHB			CE	
	Betofix R4 EM			CE	
	Betofix KHB	✔	✔	CE	
	Betofix R4	✔	✔	CE	
	Betofix R4 SR			CE	✔
	Betofix SPCC	✔		CE	
	Betofix KHB	✔	✔	CE	
	Betofix R4	✔	✔	CE	
	Betofix R4 SR			CE	✔

	Product / product systems	BASt listing	BAW listing	Marking	Approved for potable water areas (DVGW Codes of Practice W 347, W 270 and W 300)
	Betofix RM			CE	
	Betofix Filler	✔		CE	

	Product / product systems	BASt listing	BAW listing	Marking	Approved for potable water areas (DVGW Codes of Practice W 347, W 270 and W 300)
	Rust Inhibitor EP 2K				
	Restoration Mortar EP 2K				
	Repair Mortar EP 2K				

	Product / product systems	BASt listing	BAW listing	Marking	Approved for potable water areas (DVGW Codes of Practice W 347, W 270 and W 300)
	Betofix HQ 3			Ü*	
	Betofix HQ 6			Ü*	

Crack Repair Systems

CRACK REPAIR SYSTEMS

Restoring Functionality

A great many damages on concrete structures emerge as a consequence of cracks and cavities that allow the penetration of harmful substances into the substrate. These damaging influences impair the functionality of the concrete and reduce the load bearing capacity of the structure. The most common causes of cracks are:

- Contraction
- Modification of the static conditions through structural settlement
- Residual stress within the building elements
- Length increase through thermal expansion

Drill hole injections or saturation of the damaged areas with suitable crack fillers are possible means to fully restore the functionality of the concrete.

To properly define the goals crack repair measures, extensive knowledge about damp around the edges of the crack, the modifications of the width of the cracks and their course is necessary.

Thanks to their excellent adhesive bonding capacity, high resistance to chemicals and constant viscosity behaviour during the injection, Remmers injection resins are optimally suited for the production of connections with high compressive and tensile pull strength. Before the material can be injected into the cracked area, the cracks must be plugged, so that there is sufficient pressure to distribute the material through the substrate and fill the cracks.

Moreover, Remmers offers various injection resins on a polyurethane basis with which damp of even water-bearing cracks can be closed and sealed. These materials are ideally suited for the creation of elastic connections.

REMMERS INJECTION PRODUCTS

Classification According to DIN EN 1504-5

Product	Purpose of use (filling of cracks)	Allowed minimum crack width	Moisture condition of the crack				Viscosity at 23 °C	Working temperature	
			1	2	3	4			
			Dry	Damp	Wet	Water-bearing		min.	max.
IR PUR 2 K 150	D1 (elastic)	0,2 mm	✔	✔	✔		150 mPa	5 °C	30 °C
IR PUR 250	D1 (elastic)	0,3 mm		✔	✔	✔	250 mPa	5 °C	30 °C
IR PUR 2K rapid	No DIN EN 1504-5 classification possible								
IR Epoxy 360	F1 (friction-locked)	0,2 mm	✔				360 mPa	8 °C	30 °C
Injection Resin 100 -IR Epoxy 100-	F1 (friction-locked)	0,1 mm	✔				100 mPa	8 °C	30 °C
Injection Cement 2K -ICS 2K-	The material is currently being tested								

REMMERS – SYSTEM SOLUTIONS

Crack Injection, Waterproofing and Stopping Water Flows

Filling reason	Condtions of the crack			
	Dry	Damp	Water-bearing, without pressure	Water-bearing, with pressure
Closure	▪ Injection resin 100 (S) -IR PUR 100-	▪ Injection resin 2K (S) -ICS 2K-		
Closure and waterproofing	▪ IR Epoxy 360 (I) ▪ IR PUR 2K 150 (I) [1] ▪ Injection resin 2K (I) [1] -ICS 2K-	▪ IR PUR 2K 150 (I) ▪ IR PUR 250 (I) [2] ▪ Injection resin 2K (I) [1] -ICS 2K-	▪ IR PUR 2K 150 (I) ▪ IR PUR 250 (I) [2]	▪ IR PUR 2K rapid (I) [3] ▪ IR PUR 2K 150 (I)
Limitedly flexible conjunction	▪ IR PUR 2K 150 (I) [1] ▪ IR PUR 250 (I) [1]	▪ IR PUR 2K 150 (I) ▪ IR PUR 250 (I) [2]	▪ IR PUR 2K 150 (I) ▪ IR PUR 250 (I) [2]	▪ IR PUR 2K rapid (I) [3] ▪ IR PUR 2K 150 (I)
Friction coupled conjunction	▪ IR Epoxy 360 (I) ▪ Injection resin 2K (I) [1] -ICS 2K-	▪ Injection resin 2K (I) -ICS 2K-		
Plugging	▪ BH 100 + AddTX	▪ MT 100 + AddTX	If necessary, close cracks with Rapid Hardener	If necessary, close cracks with Rapid Hardener

1) The edges of the crack must be wetted beforehand
2) Plugging is usually not necessary
3) Application of the side of the building element exposed to the water. Additional waterproofing injection necessary

I = Injection S = Saturation

Surface Protection Systems

SURFACE PROTECTION SYSTEMS

Big Benefits with Great Creative Freedom

Preventing the penetration of damp into construction materials is a method that has been used for centuries to protect buildings from damages. Already Vitruvius in his "De Architectura Libri Decem" described the use of natural oils to make mortars water-repellent and therefore more resistant. Today this task has been taken over by modern protective substances, the efficiency and durability of which is ensured by high-quality active agents and binders.

Coatings and impregnations serve as protective layers with different functions. Besides building up a shield against the penetration of harmful substances, e.g. salts but also CO_2, into the concrete as well as the simultaneous regulation of the moisture content and the increase of the electric resistance, they can also improve the physical resistance of concrete.

An additional feature is the possibility of rigid or flexible crack bridging as well great creative freedom with a variety of certified surface protection systems from OS 1 to OS 11.

REMMERS FUNCOSIL IC

OS 1 (OS A) – Hydrophobizing Impregnation

Properties

- Easy to apply thanks to cream technology
- Water-repellent
  $w \leq 0{,}1\ kg/(m^2\ h^{0.5})$
- Highly concentrated (80% active ingredient content)
- Excellent protection against frost/de-icing salt loads
- Solvent-free, water based and compatible with the environment

Application

- Hydrophobising agent with a deep effect and primer for concrete and reinforced concrete in bridge, road and building construction
- Hydrophobizing impregnation according to DIN EN 1504-2 / DIN V 18026, BASt-listed and certified according ZTV-ING, TL / TP
- Voluntary quality assurance in analogy to the requirements for the attainment of the National Test Certificate

Funcosil IC	
Art. No.	0710
Container size	5 l, 30 l
Appearance	milky, white, creamy
Active ingredient content	ca. 80 % (m/m)
Density	ca. 0.9 kg/l
pH value	ca. 8
Flash point	ca. 74 °C
Tools	brush, lambskin roller, can be sprayed airless
Working temp.	+10 °C to +25 °C
Airless nozzle	no. 523; 50° spraying angle; bore 0.023 inch Nr. 421; 40° spraying angle; bore 0,021 inch
Airless system input pressure	50 – 60 bar
Application rate	min. 200 ml/m²

REMMERS CONCRETE ACRYLIC

OS 2 (OS B) / OS 4 (OS C) – Coating

Properties

- Very good hiding power
- Very durable
- Reduces water absorption
- Reduces carbon dioxide diffusion
- Reduces the penetration of substances that attack concrete and steel, thus improving resistance to frost and de-icing salts

Application

- Surface protection system for concrete in accordance with DIN EN 1504-2 / DIN V 18026, BASt-listed and certified according to ZTV-ING, TL / TP
- Voluntary quality assurance in analogy to the requirements for the attainment of the National Test Certificate

Concrete Acrylic -Color PA-	
Art. No.	6500, 6529, 6530
Container size	5 l, 15 l
Colour	white, colour collection, special colours
Binders	pure acrylate
Pigments	light-fast , alkali-resistant oxide pigments / titanium dioxid
Extender	mineral fillers
Density	ca. 1.3 kg/l
pH-value	ca. 9.0
Dilution agent	water
Tools	brush, lambskin roller, can be sprayed airless
Working temp.	> +5 °C
Application rate	min. 300 ml/m² per coat

REMMERS OS CONCRE-FILL / BETOFIX FILLER

OS 4 (OS C) / OS 5a (OS D II) – Levelling layer

Properties

OS Concre-Fill
Levelling layer of up to 1 mm on old but load-bearing coatings
- Good adhesion
- Can be applied by roller, brush and trowel

Betofix Filler
Levelling layer of up to 10 mm on mineral sunstrates
- High early strength
- Good adhesion and smoothability
- Hardens with low stress and without cracking

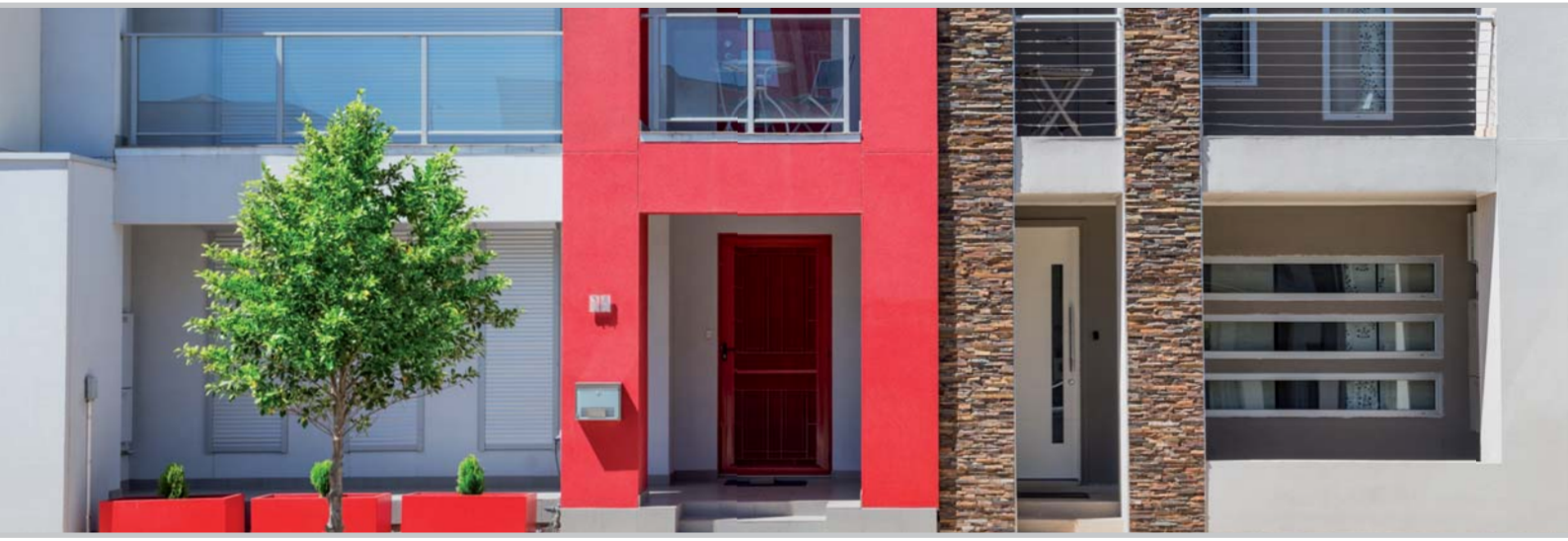
Application

- Levelling filler / intermediate coat of a surface protection system for concrete according to DIN EN 1504-2 / DIN V 18026, BASt-listed and certified according to ZTV-ING, TL / TP
- Voluntary quality assurance in analogy to the requirements for the attainment of the National Test Certificate

OS Concre-Fill -Color PA Fill-	
Art. No.	6490
Container size	15 l
Colour	white
Binders	Pure acrylate
Solid content	ca. 75 %
Pigments	titanium dioxide
Extender	mineral fillers
Dilution medium	water
Tools	brush, paint roller, trowel, can be applied by airless spraying
Working temp.	> + 8 °C
Application rate	ca. 400 – 900 ml/m² per coat

Betofix Filler -Betofix Fill-	
Art. No.	1008
Container size	5 kg, 25 kg
Colour	grey
Binders	hydraulic
Solid content	–
Pigments	–
Filler	mineral fillers
Water demand	ca. 15 %
Tools	trowel, float
Working temp.	> + 5 °C < + 30 °C
Application rate	ca. 1,75 kg/m²/mm layer thickness

Remmers OS 4 (OS C) – Coating with enhanced water tightness (with levelling layer)			
System 1 On old, load-bearing substrates	Levelling layer / to 1 mm	OS Concre-Fill -Color PA Fill-	min. 0,9 l/m² (2 applications)
	Coating	Concrete Acrylic -Color PA-	min. 0,3 l/m² (2 applications)
System 2 On mineral substrates	Levelling layer / to 10 mm	Betofix Filler -Betofix Fill-	min. 3,6 kg/m²
	Coating	Concrete Acrylic -Color PA-	min. 0,3 l/m² (2 applications)
Remmers OS 5a (OS D) – Coating with low crack-bridging ability (with levelling layer)			
System 1 On old, load-bearing substrates	Levelling layer / to 1 mm	OS Concre-Fill -Color PA Fill-	min. 0,9 l/m² (2 applications)
	Coating	Elastoflex Facade Paint -Color Flex-	min. 0,75 l/m² (3 applications)
System 2 On mineral substrates	Levelling layer / to 10 mm	Betofix Filler -Betofix Fill-	min. 3,6 kg/m²
	Coating	Elastoflex Facade Paint -Color Flex-	min. 0,75 l/m² (3 applications)



REMMERS ELASTOFLEX FACADE PAINT

OS 5a (OS D II) – Coating

Properties

- Highly crack-bridging
- Highly water-repellent and water vapour diffusion-open
- Highly CO_2-inhibiting

Application

- Coating for concrete building elements in accordance with DIN EN 1504-2 / DIN V 18026, BASt-listed and certified according to ZTV-ING, TL / TP
- Voluntary quality assurance in analogy to the requirements for the attainment of the National Test Certificate
- Coating with scarce crack bridging ability for surfaces that are not walked on and closed to traffic
- With OS Concre-Fill directly on clean, load-bearing existing water proofing layers
- Combined with Betofix Filler also for levelling layers up to 10 mm

Elastoflex Facade Paint -Color Flex-	
Art. No.	2976, 2978
Container size	15 l
Colour	white, colour collection
Binders	UV cross-linking acrylate copolymer
Pigments	light-fast, alkali-resistant oxide pigments
Extender	mineral fillers
Density	ca. 1,35 kg/l
pH-value	> 8,5
Thinning medium	water
Tools	brush, roller, can be applied by airless spraying
Working temp.	> +5 °C
Application rate	min. 750 ml/m² (3 applications)

REMMERS – SYSTEM SOLUTIONS

Overview of Surface Protection Systems

Facade Coating System Denomination	Description according to Rili-SIB, DIN V 18026	Working Operation	
OS 1 (OS A)	Hydrophobizing impregnation	Hydrophobization	
OS 2 (OS B)	Coating for surfaces that are not walked on and are closed to traffic (with scratch coat or levelling layer)	Priming	
		Coating	
OS 4 (OS C)	Coating for surfaces with increased water-tightness that are not walked on and closed to traffic (with scratch coat or levelling layer)	System 1	Filling layer
			Coating
		System 2	Filling layer
			Coating
OS 5a (OS DII)	Coating with scarce crack-bridging ability for surfaces that are not walked on and closed to traffic (without scratch coat or levelling layer)	System 1	Filling layer
			Coating
		System 2	Filling layer
			Coating

Flooring System Denomination	Description according to Rili-SIB, DIN V 18026	Working Operation	
OS 8	Rigid coating for trafficked surfaces, exposed to heavy mechanical loads	System 1 water-vapour-proof	Filler priming coat
			Blinding
			Sealing
		System 2 water-vapour-proof	Priming
			Wear layer
			Blinding
			Sealing
OS 10	Waterproofing system with high crack bridging ability below protection and cover layers on surfaces that are walked on and are open to traffic	Priming	
		Intermediate layer	
		Wear layer	
		Blinding	
		Sealing	
OS 11a (OS Fa)	(primarily on open-air car parks) Coating with enhanced dynamic crack bridging ability for surfaces that are walked on and are open to traffic, exposed to outdoor weather (two-layer system)	Sealing	
		Priming	
		Blinding	
		Intermediate layer	
		Wear layer	
		Blinding	
OS 11b (OS Fb)	(primarily on surfaces indoor, only roofed over) Coating with enhanced dynamic crack bridging ability for surfaces that are walked on and are open to traffic, not exposed to outdoor weather	Priming	
		Blinding	
		Wear layer	
		Blinding	
		Sealing	

* Not valid any longer for CE-marked products. Existing test certificates can used in private contracts to prove additional properties.

	Product / Product Systems	BASt Listing	Marking	National Test Certificate	Ü Marking
	Funcosil IC	✔	CE	*	**
	Impregnation Primer -Primer H-	✔	CE	*	**
	Concrete Acrylic -Color PA-		CE		
	OS Concre-Fill -Color PA Fill-	✔	CE	*	**
	Concrete Acrylic -Color PA-		CE		
	Betofix Filler -Betofix Fill-	✔	CE	*	**
	Concrete Acrylic -Color PA-		CE		
	OS Concre-Fill -Color PA Fill-	✔	CE	*	**
	Elastoflex Facade Paint -Color Flex-		CE		
	Betofix Filler -Betofix Fill-	✔	CE	*	**
	Elastoflex Facade Paint -Color Flex-		CE		

	Product / Product Systems	BASt Listing	Marking	National Test Certificate	Ü Marking
	Epoxy-Primer PF New + 0,1 – 0,3 mm quartz sand		CE	*	**
	0,3 – 0,8 mm quartz sand in excess				
	Epoxy Color Top		CE		
	Epoxy WD Base		CE	*	**
	Epoxy WD Base + 0,1 – 0,3 mm quartz sand		CE		
	0,3 – 0,8 mm quartz sand in excess				
	Epoxy Color Top (LE)		CE		
	PUR Primer OS pro		CE	*	**
	PUR Hybrid OS pro		CE		
	PUR Color VS OS pro		CE		
	0,6 – 1,2 mm quartz sand in excess				
	PUR Top OS pro		CE		
	Epoxy Primer OS 11	✔	CE	*	**
	0,3 – 0,8 mm quartz sand				
	PUR Color OS 11 ZS		CE		
	PUR Color OS 11 VZ + 20 % 0,1 – 0,4 mm quartz sand		CE		
	0,3 – 0,8 mm quartz sand				
	Epoxy Top OS 11 oder PUR Top OS 11		CE		
	Epoxy Primer OS 11	✔	CE	*	**
	0,3 – 0,8 mm quartz sand				
	PUR Color OS 11 ZS + 30 % 0,1 – 0,4 mm quartz sand		CE		
	0,3 – 0,8 mm quartz sand				
	Epoxy Top OS 11		CE		

** According to an ECJ judgment no additional national requirements for building products may be added to harmonised standards. This means that the known Ü mark can no

779 / 12.16 GB