Nanotechnology for Simple, Successful Concrete Repair

A specifiers' guide

BASF
The Chemical Company

Causes of Concrete Deterioration

Repair and refurbishment: An overview

It has been estimated that over 25% of the annual Asia Pacific construction budget is spent on the repair and refurbishment of existing structures, buildings and facilities. As the infrastructures ages, and budget and resource restrictions on new build become ever tighter, this figure can only increase further. The repair of deteriorating reinforced concrete structures is a vital part of this wider picture.

Reinforcement corrosion due to carbonation

(loss of alkalinity around the reinforcing steel)

Typical causes:

- acid rain
- carbon dioxide, sulphur dioxide and other atmospheric pollutants

Other factors:

- low quality or insufficient depth of cover concrete
- inadequate or no curing
- location, and age of structure
- prevailing climatic conditions

Chloride induced corrosion of reinforcing steel

NB: Chlorides can cause severe damage and loss of structural integrity even when concrete cover is not carbonated.

Typical causes:

- marine environments; direct contact with seawater or through wind borne chlorides
- de-icing salts
- cast-in chlorides from contaminated mixing water, aggregates or incorrect admixture usage

Other factors:

- high porosity, low quality concrete
- condition of concrete e.g. presence of cracking
- prevailing wind direction, location and length of exposure

Physical deterioration of concrete

Typical causes:

- surface scaling, delamination and cracking from freeze thaw cycling or thermal movement
- drying shrinkage during hardening
- abrasion or erosion from wind or water borne agents
- physical settlement
- impact
- seismic damage

Other factors:

- location and environment
- compressive strength and density of design concrete

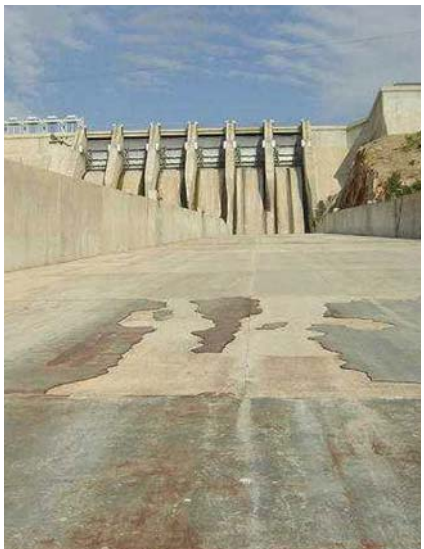
Other causes of deterioration of concrete

Typical causes:

- alkali-aggregate reaction
- poor curing
- inadequate or excessive vibration during concrete placement causing segregation, bleeding or honeycombing
- shutterwork or reinforcement movement during concrete placement
- poor design detailing
- chemical attack by aggressive chemicals such as acids or sugars or even soft water
- biological attack in sewers
- stray currents or bimetallic corrosion

Other factors:

- poor quality, alkali-reactive aggregates
- location and environment
- temperature, concentration and length of exposure to chemicals
- change of use, or exposure conditions from original design
- quality of design concrete and any protective coatings used



Concrete Repair - Existing Situation

Concrete repair strategies

There can be many causes of deterioration in a concrete structure. Concrete repair is a specialist activity requiring fully trained and competent personnel at all stages of the process. Up until now there has been no common European Standard in this field. Often simple “patch and paint” strategies have been employed as short term cosmetic repairs which have failed to address the root cause of the problem and have, as a result, often failed to meet clients’ expectations.

The need for a European norm

Unsatisfactory understanding and diagnosis of concrete deterioration, incorrect repair specifications and the wrong choice of repair products/techniques have lead to dissatisfaction from building owners, and the creation of a European norm - a world first.

The new European norm EN 1504 will standardize repair activities and provide an improved framework for achieving successful, durable repairs, and, satisfied clients.

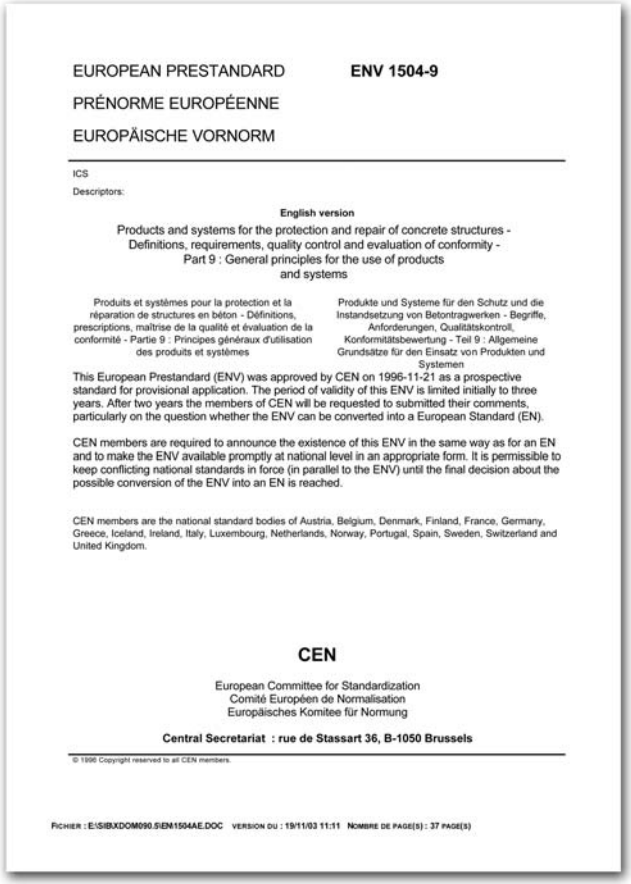
Importantly, the norm (date of full harmonisation: 31.12.2008) deals with ALL aspects of the repair process including:

- definitions and repair principles
- the need for accurate diagnosis of causes before specification of the repair method
- detailed understanding of the needs of the client
- product performance requirements, test methods, material production control and evaluation of conformity
- site application methods and quality control of works

Accurate diagnosis and integrated solutions to meet clients' needs - a simple recipe for success!

ENV 1504, Part 9: General Principles for the use of Products and Systems

Part 9 of EN 1504 provides specifiers with general principles for the repair and protection of reinforced concrete



EUROPEAN PRESTANDARD **ENV 1504-9**

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

ICS

Descriptors:

English version

Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 9 : General principles for the use of products and systems

Produits et systèmes pour la protection et la réparation de structures en béton - Définitions, prescriptions, maîtrise de la qualité et évaluation de la conformité - Partie 9 : Principes généraux d'utilisation des produits et systèmes

Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken - Begriffe, Anforderungen, Qualitätskontroll, Konformitätsbewertung - Teil 9 : Allgemeine Grundsätze für den Einsatz von Produkten und Systemen

This European Prestandard (ENV) was approved by CEN on 1996-11-21 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submitted their comments, particularly on the question whether the ENV can be converted into a European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

CEN members are the national standard bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

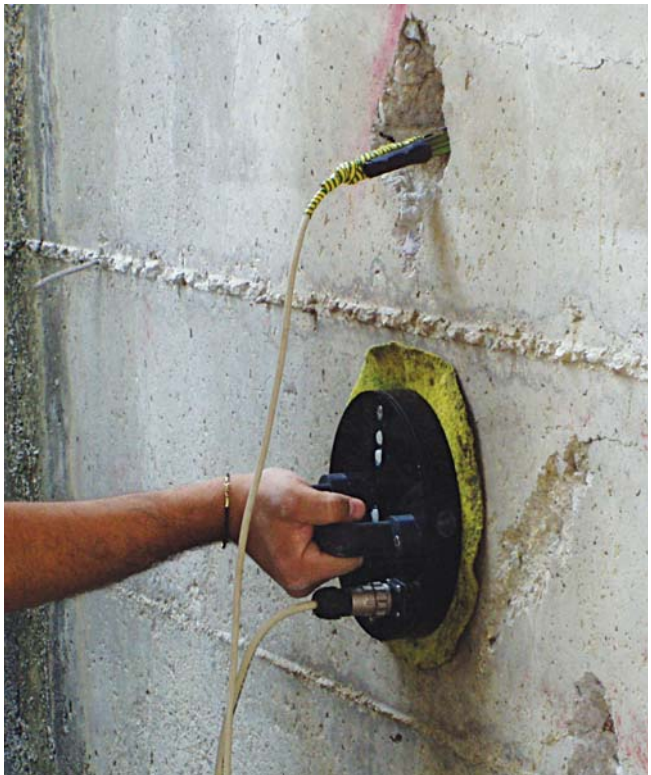
European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

Central Secretariat : rue de Stassart 36, B-1050 Brussels

FICHIER : E:\SIBXDOM090.SI\EN1504AE.DOC VERSION DU : 19/11/03 11:11 NOMBRE DE PAGE(S) : 37 PAGE(S)

Principle 1 (PI)	**Protection against Ingress**
Principle 2 (MC)	**Moisture Control**
Principle 3 (CR)	**Concrete Restoration**
Principle 4 (SS)	**Structural Strengthening**
Principle 5 (PR)	**Physical Resistance**
Principle 6 (RC)	**Resistance to Chemicals**
Principle 7 (RP)	**Preserving or Restoring Passivity**
Principle 8 (IR)	**Increasing Resistivity**
Principle 9 (CC)	**Cathodic Control**
Principle 10 (CP)	**Cathodic Protection**
Principle 11 (CA)	**Control of Anodic areas**

The 11 fundamental principles of repairing and protecting reinforced concrete.



Emaco® Nanocrete: A New Generation of Concrete Repair Products

Concrete replacement mortars: EN 1504, part 3

One of the most important Principles within part 9 of EN 1504 is principle 3: the restoration of damaged concrete with formulated repair mortars. The Emaco® brand of pre-bagged concrete repair mortars has consistently been at the forefront of the search to provide cost effective, long term solutions to this problem.

In fact, the first Emaco® products were introduced in Italy as early as the 1970's: the first time that the concept of repairing concrete with specially formulated, concrete like materials was seen. Over the past 30 years or so not only has the understanding of deterioration in reinforced concrete improved, but also, the requirements of the repair materials, and the procedures of application have also been developed.

The new Emaco® Nanocrete range represents the next generation of concrete repair mortars with exceptional properties:

- improved bond strengths
- improved densities and impermeability
- reduced shrinkage
- improved tensile strengths and reduced cracking tendency
- improved compatibility with concrete
- improved thixotropy
- easier and quicker application and finishing
- reduced application problems
- reduced costs

The concept of applied nanotechnology has been used for the first time in the Emaco® Nanocrete range of formulated repair mortars; hence our claim...

NANOTECHNOLOGY

for simple, successful, concrete repairs

EN 1504-3:2005 (E)

Table 3 — Performance requirements for structural and non-structural repair products

Item No.	Performance characteristic	Reference substrate (EN 1766)	Test method	Requirement			
				Structural		Non-Structural	
				Class R4	Class R3	Class R2	Class R1
1	Compressive strength	None	EN 12190	≥ 45 MPa	≥ 25 MPa	≥15 MPa	≥10 MPa
2	Chloride ion Content	None	EN 1015-17	≤ 0,05 %		≤ 0,05 %	
3	Adhesive bond	MC(0,40)	EN 1542	≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa [a]	
4	Restrained shrinkage / expansion [b c]	MC(0,40)	EN 12617-4	Bond strength after test [d e]			No requirement
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa [a]	
5	Carbonation [f] Resistance	None	EN 13295	d_k ≤ control concrete (MC(0,45))		No requirement [g]	
6	Elastic modulus	None	EN 13412	≥20 GPa	≥15 GPa	No requirement	
7	Thermal compatibility [f h] Part 1, Freeze-thaw	MC(0,40)	EN 13687-1	Bond strength after 50 cycles [d e]			Visual inspection after 50 cycles
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa	
8	Thermal compatibility [f h] Part 2, Thunder shower	MC(0,40)	EN 13687-2	Bond strength after 30 cycles [d e]			Visual inspection after 30 cycles
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa [a]	
9	Thermal compatibility [f h] Part 4, Dry cycling	MC(0,40)	EN 13687-4	Bond strength after 30 cycles [d e]			Visual inspection after 30 cycles
				≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa [a]	
10	Skid resistance	None	EN 13036-4	Class I : > 40 units wet tested Class II : > 40 units dry tested Class III : > 55 units wet tested		Class I : > 40 units wet tested Class II : > 40 units dry tested Class III : > 55 units wet tested	
11	Coefficient of thermal expansion [i]	None	EN 1770	Not required if tests 7, 8 or 9 are carried out, otherwise declared value		Not required if tests 7,8 or 9 are carried out, otherwise declared value	
12	Capillary Absorption	None	EN 13057	≤ 0,5 $kg \cdot m^{-2} \cdot h^{-0,5}$		≤ 0,5 $kg \cdot m^{-2} \cdot h^{-0,5}$	No requirement

Requirements for Repair Principles 3, 4 and 7:
Method 3.1 - Concrete restoration by applying mortar by hand.
Method 3.2 - Concrete restoration by recasting with concrete.
Method 3.3 - Concrete restoration by spraying mortar or concrete.
Method 4.4 - Structural strengthening by adding mortar or concrete.
Method 7.1 - Increasing cover to reinforcement with additional cementitious mortar or concrete.
Method 7.2 - Replacing contaminated or carbonated concrete.

[a] The value of 0,8 MPa is not required where cohesive failure occurs in the repair material. If cohesive failure occurs a minimum tensile strength of 0,5 MPa is required.
[b] Not required for Repair Method 3.3.
[c] Not required if thermal cycling is undertaken.
[d] Mean value with no single value less than 75 % of the minimum requirement.
[e] Maximum permissible average crack width ≤ 0,05 mm with no crack ≥ 0,1 mm and no delamination.
[f] For durability.
[g] Not suitable for protection against carbonation unless the repair system includes a surface protection system with proven protection against carbonation (see EN 1504-2).
[h] Choice of method depends on the exposure conditions. When a product satisfies Part 1 it is deemed to satisfy Part 2 and Part 4.

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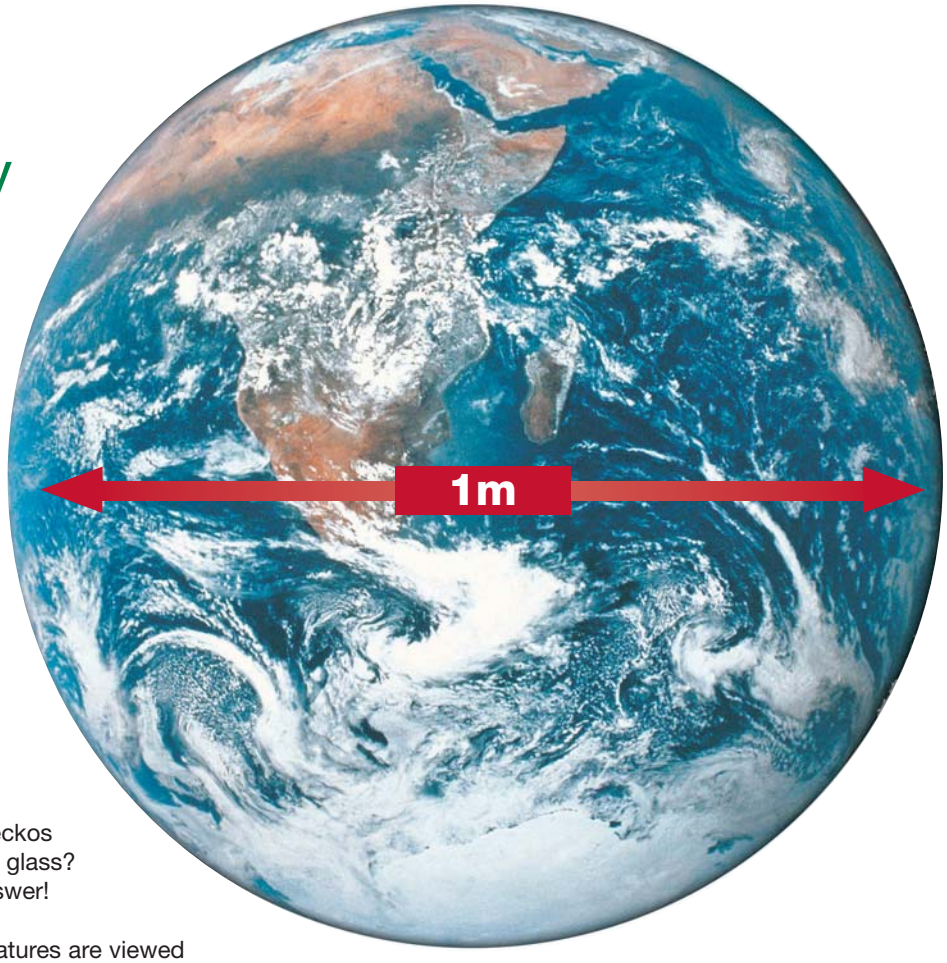
Introduction to Nanotechnology



What is nanotechnology?

Nano = very small.
A nanometre is only **1/1000,000,000 metre** (10^{-9} m). Or to put it in perspective, a human hair is approx. 5,000 nanometres in diameter.

Or to explain it in another way: If the diameter of earth was 1 metre then the diameter of a football would be one nanometre!

Nanotechnology is the technical understanding of the physical world on a very, very, very small scale.

Nanotechnology in nature

Have you ever stopped to wonder how Geckos can run across walls and ceilings, even on glass? Natural, applied nanotechnology is the answer!

When the footpads of these incredible creatures are viewed at the nano-scale you find the finest hairs called setae which allow them to, not only mechanically grip onto imperfections in the surface too small for the human eye to see, but also electronically bond to the surface too!

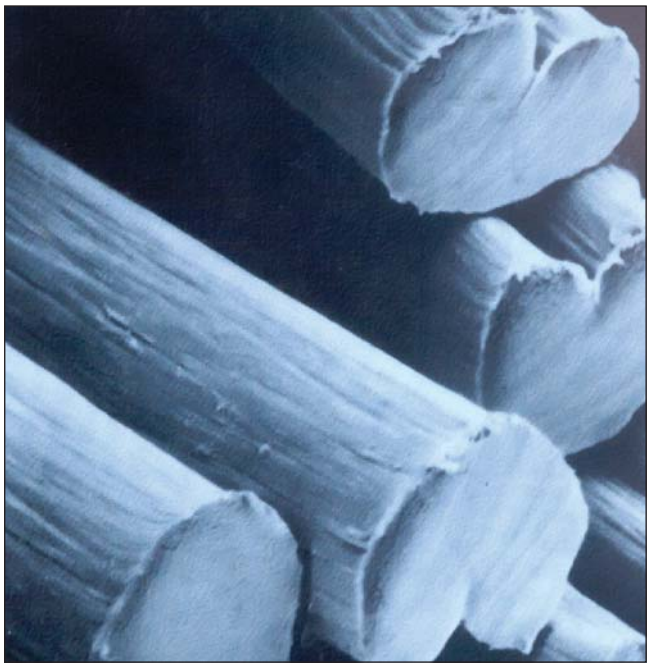
This dual electro/mechanical adhesion mechanism is why we have adopted the Gecko as a symbol for our new range of Emaco® Nanocrete repair mortars.

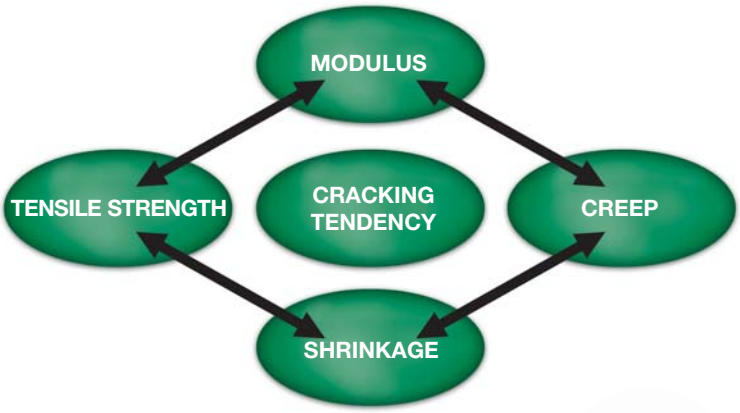
The nanostructures on the footpads of Geckos: Photo of Gecko foot courtesy of Ms Ira Richling, Kronshagen, Germany
REM photo of Gecko foot kindly supplied by Mr G. Alberti, Greifswald, Germany

Reducing Cracking Tendency

When cement products harden they shrink. If these shrinkage stresses ever become greater than the inherent tensile strength of a mortar it will crack.

Applied nanotechnology maintains the balance between these competing forces to prevent cracking.





In addition Emaco® Nanocrete repair mortars are fibre reinforced to control cracking tendency. Many, many different fibre types and sizes were investigated before the final choice was made.

The kidney shaped, ridged surface improves mechanical adhesion while even some chemical bonding can be seen under the most powerful microscopes.

This unique combination ensures that these chosen fibres help to prevent cracking in the cured repair mortar.

The new Emaco® Nanocrete range of products incorporate the latest shrinkage reducing technology to significantly reduce the possibility of cracking occurring on the job site.

Emaco Nanocrete R2: Coutinho ring mould for accelerated crack tendency testing – no cracking after 180 days.
Many other mortars crack within 1 week!

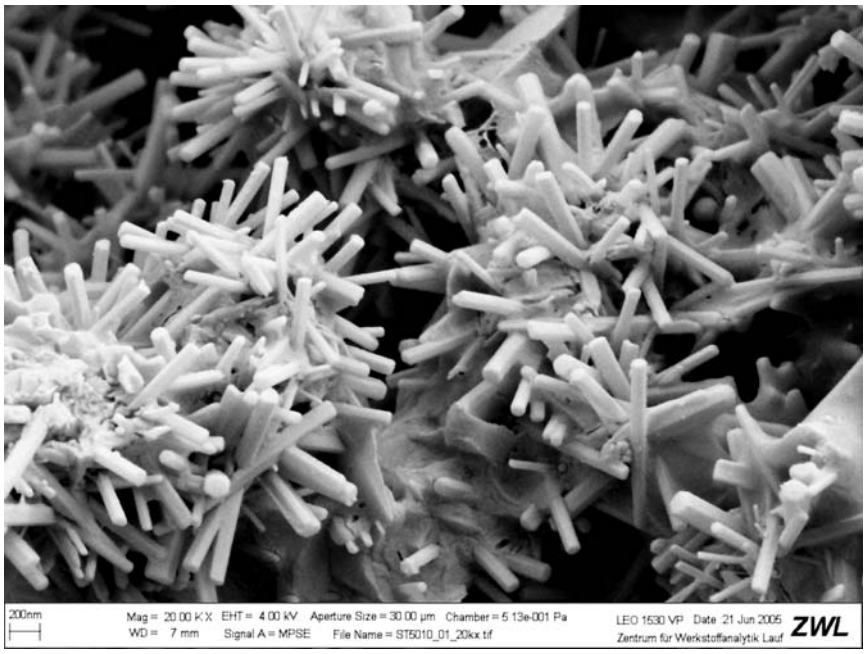
Over 50 years of continuous, technical innovation in the field of cement

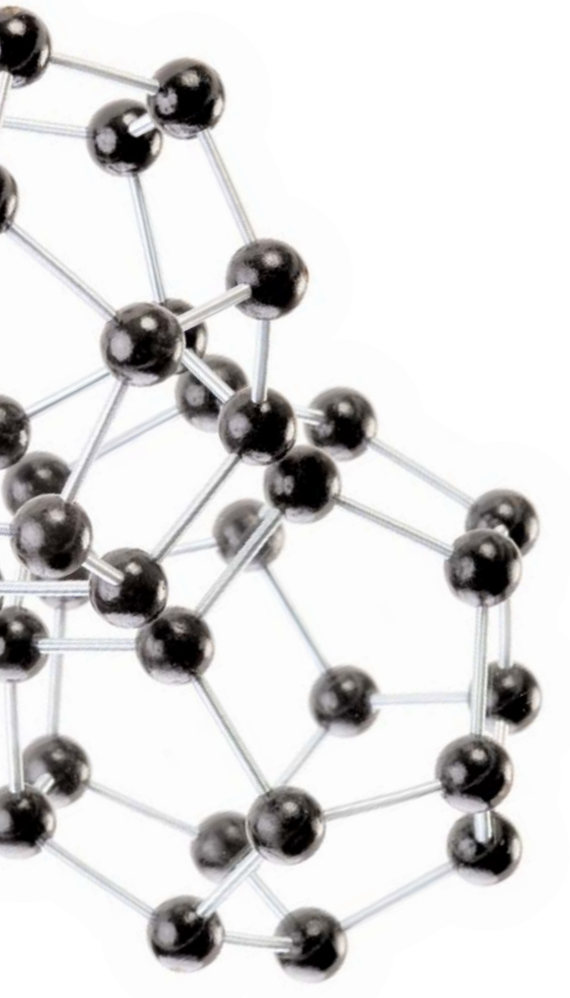
1950's	1960's	1970's	1980's
The first pre-bagged metallic grouts manufactured in the USA under the brand Embeco®. Synthetic air-entrainers for mortars developed in the UK.	SKW Melment® - the world's first organic superplasticiser for concrete.	Emaco® pre-bagged, formulated concrete repair mortars. A European first - repairing concrete with concrete like materials.	PCI-Flexmoertel, the first flexibilised, stress releasing pre-bagged tile adhesive. Setting the standards in Germany and beyond.

Improving Repair Mortars with Nanotechnology

Nanotechnology does NOT mean nano-sized particles:

We do not use any nano-particles in our cement formulations.





Our better understanding of cement hydration, developed over the past 50 years, enables us to improve the quality and density of the nanostructures formed in the cement paste as it hardens. (see photo)

This reduces micro-defects in the hardened cement and improves bond between the cement matrix and the aggregate, and, the cement mortar with the substrate.

Because tensile strengths are improved the possibility of cracking is reduced.

At the macro level of sand and cement, special inorganic additives and best binder packing models are used within all of the products in the Emaco® Nanocrete range to ensure filler gradings are optimised.

This improves technical performance e.g. density, tensile and compressive strength, and freeze thaw resistance.

Practical application properties such as thixotropy, non-slumping and finishing are also improved.

chemistry continues to produce industry changing products

1990's

Glenium® polycarboxylate technology revolutionises ready-mix and pre-cast concrete production. Two component Emaco® Formula systems launched in Italy.

2003

PCI-Nanolight® the first use of applied nanotechnology in a cement system produces a world leading new tile adhesive. Not only extraordinary technical performance: One product for all ceramic tiles and all substrates but also superb application properties.

2006 and beyond

EMACO® NanoCrete

NANOTECHNOLOGY

for simple, successful, concrete repairs

EMACO®

NanoCrete R2

Universal, single component, polymer modified, fast setting, repair and reprofiling mortar

Emaco® Nanocrete R2 is ideal for:

- cosmetic repairs on buildings and structures especially where hand reprofiling is necessary e.g. balcony and beam edge repairs
- minor damage repairs on pre-cast panels
- general repairs where fast setting is needed
- smoothing large areas to achieve aesthetic finish e.g. prior to painting

Multi-use repair product with superb application properties

- superb application properties and feel on the trowel
- lightweight 20 kg sack for easy handling
- smooth, creamy but non-slump mortar
- can be applied horizontally, vertically and overhead
- excellent high build capability:
  - 80 to 100 mm in one layer by hand in vertical patches
  - 70 to 80 mm overhead
  - Tip: for improved build thicknesses apply bond or contact layer of mortar or Emaco® Nanocrete AP using special Emaco® Nanocrete brush
- Levelling coat: minimum layer thickness 3 mm
- perfect for reforming corners or other profiles, without formwork
- multi-use material for convenience on site:
  - can also be used as a large area fairing coat to level out surfaces
  - perfect for cosmetic repairs prior to painting
- fast setting: can be overcoated in only 4 hours at 21 °C
- saves time and labour costs on the job site

Useful facts

- pack size: 20 kg
- water addition: 3.5 to 4.0 litres per bag depending on use
- usage rate: 1 x 20 kg bag covers 1.3 m^2 at 10 mm thick
- open work time: 30 to 45 minutes at 21 °C
- finishing time: with sponge or similar approx. 60 to 90 minutes
- minimum application temperature: > 5 °C
- shelf life: 12 months in unopened sacks
- curing: in hot, dry or windy conditions ensure correct curing

Technical data

- shrinkage compensated, polymer modified, fibre reinforced and contains nanotechnology to minimise shrinkage and possibility of cracking
- compressive strength > 25 MPa at 28 days
- low elastic modulus to reduce differential stresses on low strength concrete structures

EMACO®

NanoCrete R3

Single component, lightweight, polymer modified, high build, fibre reinforced, structural repair mortar

Emaco® Nanocrete R3 is recommended for use:

- where reprofiling by hand is necessary e.g. stair nosings, balcony edges, precast panel edges, beam and column edges
- large area repairs where high build is necessary e.g. building facades
- for horizontal patching in traffic areas

Lightweight and easy to use but strong

- easy lightweight application properties by trowel, hand or spray
- lightweight formulation allows high build in single layers
  - up to 75 mm horizontally, vertically or even 50 mm overhead
  - for improved build thicknesses apply bond or contact layer of mortar or Emaco® Nanocrete AP using special Emaco® Nanocrete brush
- minimum layer thickness 5 mm
- easy to create profiles and corners without formwork
- easy to create fair finish with trowel
- high yield 20 kg sack easy for carrying

Useful facts

- pack size: 20 kg
- water addition: 4.2 to 4.6 litres/bag depending on consistency required
- consumption: each 20 kg bag covers 1.4 m2 at 10 mm thick
- open work time: 45 to 60 minutes at 21 °C
- finishing time: with sponge or similar approx. 90 minutes
- minimum application temperature: > 5 °C
- shelf life: 12 months in unopened sacks
- curing: in hot, dry or windy conditions ensure correct curing

Technical data

- medium strength structural repair (exceeds the requirements of class R3 of EN 1504 part 3) > 35 MPa at 28 days
- lower modulus > 15 GPa at 28 days (class R3 of EN 1504 part 3)
- applied nanotechnology, fibre reinforced and newly developed shrinkage compensation to minimise shrinkage

EMACO®

NanoCrete R4

Single component, very high strength, high modulus, fibre reinforced, shrinkage compensated, expansive, structural repair mortar

Emaco® Nanocrete R4 is ideal for the following repairs:

- columns, piers and cross beams of all bridges, marine and other civil structures
- tunnels, pipes, outfalls and all below ground construction in aggressive ground conditions
- cooling towers and chimneys and other industrial environments
- water treatment and sewerage facilities

Excellent application properties and high strength

- formulated for spray and trowel application
- excellent thixotropy allows vertical and overhead application in layers of up to 50 mm without the need for secondary reinforcement
  - can be applied in thicker layers in smaller patches or where additional reinforcement is present
- no need for bonding slurries or steel reinforcing primer saving time and money!
  - Tip: always pre-soak concrete and apply thin scrape coat or contact layer before building up to required thicknesses
- cement rich formula so easy to create smooth fairfaced finish
- only simple standard surface preparation required

Useful facts

- pack size: 20 kg
- water addition: 3.0 to 3.4 litres/bag depending on consistency required
- usage rate: 20 kg bag covers 1.0 m^2 at 10 mm thick
- open work time: 45 to 60 minutes at 21 °C
- finishing time: with sponge or similar approx. 90 min
- minimum application temperature: > 5 °C
- shelf life: 12 months in unopened sacks
- curing: in hot, dry or windy conditions ensure correct curing

Technical data

- very high compressive strength (class R4 in EN 1504 part 3) > 60 MPa at 28 days
- high strength gain during early age curing > 18 MPa at 24 hours
- high modulus of elasticity (EN 1504 part 3 class R4) > 25 GPa at 28 days
- excellent carbonation resistance
- high sulphate resistance
- low permeability and excellent freeze thaw resistance > 2 MPa tensile bond strength after 50 cycles according to EN 1504 with no delamination
- formulated with new nanotechnology, shrinkage compensation systems, and fibre reinforcement to minimise cracking

EMACO®

NanoCrete

R4 Flowable

Single component, high strength, high modulus, fibre reinforced, shrinkage compensated, flowable structural repair mortar

Emaco® Nanocrete R4 Fluid is designed for the following repairs:

- columns, cross beams and piers of all bridges
- marine and other civil structures
- water treatment and sewerage facilities
- large area structural repairs using the formwork and casting method
- areas of congested reinforcement where hand or spray application is not possible

Flowable but high strength structural repair mortar

- for concrete replacements up to 200 mm thick in one layer
- long open time
- no segregation or bleeding
  - for pourable or pumpable application
- extra low shrinkage for durability
- only simple standard surface preparation required
- high flow for full compaction even in areas with congested steelwork

Useful facts

- pack size: 20 kg
- water addition: 1.0 to 2.0 litres/bag depending on consistency required
- consumption: 20 kg bag covers 0.9 m^2 at 10 mm thick
- setting time: 300 min. (initial), 380 min. (final) at 21 °C
- minimum application temperature: > 5 °C
- shelf life: 12 months in unopened sacks
- curing: in hot, dry or windy conditions ensure correct curing using a MASTERKURE curing compound after removing formwork

Technical data

- very high compressive strength (class R4 in EN 1504 part 3) > 55 MPa at 28 days
- high strength gain during early age curing > 20 MPa at 24 hours
- high modulus of elasticity (EN 1504 part 3 class R4) > 25 GPa at 28 days
- long open time ensures consistent flow of material
- formulated with new nanotechnology, shrinkage compensation systems, and fibre reinforcement to minimise cracking
- high sulphate resistance
- max. grain size < 4 mm

EMACO®

NanoCrete FC

Single component, polymer modified, fast setting levelling mortar

Emaco® Nanocrete FC is used:

- for thin layer repairs, fine finishing and levelling of concrete elements e.g. balconies, building facades, parapet walls, precast panels, beam edges
- for fine finishing and levelling repairs on large vertical and overhead areas where fast setting properties with short over-coating times are needed
- to repair honeycomb areas
- as a blowhole filler in precast industry or anywhere where minor defects in concrete structures have to be repaired
- inside and outside, on vertical and overhead surfaces, in dry and wet environments

Ready-to-use and fast setting

- superb application properties and feel on the trowel
- smooth, creamy but non-slump mortar
- excellent smoothing properties
- can be used down to featheredge
- fast setting: can be over-coated in only 4 hours
- can easily be trowel applied in thickness from 0.5 (blowhole filling) up to 7 mm

Useful facts

- pack size: 20 kg
- water addition: 3.8 – 4.5 litres/bag
- cures to a light concrete grey colour
- consumption: 20 kg bag covers 13 m^2 at 1 mm thick
- open work time: 30 to 45 minutes (at 21 °C)
- finishing time: with sponge or similar approx. after 30 to 60 minutes (depending on layer thickness and temperature)
- minimum application temperature: > 5 °C
- shelf life: 12 months in unopened sacks
- curing: in hot, dry or windy conditions ensure correct curing

Technical data

- good strength development exceeding requirement of class R2 of EN 1504 part 3 > 25 MPa at 28 days
- high strength gain during early age curing > 15 MPa at 24 hours
- low modulus of elasticity
- chloride-free
- low capillary absorption according EN 13057 (< 0.5 kg/m2/h0.5)
- formulated with new nanotechnology shrinkage compensation systems
- fibre reinforced to minimise crack tendency

EMACO®

NanoCrete AP

Single component, cementitious based active protective primer for reinforcement steel and adhesive bonding slurry

Emaco® Nanocrete AP should be used:

- in critical environments or when specified by the engineer
- when steel is visible and available concrete cover is less than 10 mm
- with Emaco® Nanocrete R2 repairs when steel is visible
- to aid bond and application properties of hand applied mortars at extreme thicknesses*
  *NB Emaco® Nanocrete AP is not normally required with Emaco® Nanocrete R4.

Easy and simple to use

- handy re-sealable packaging can also be used for mixing
  - simply mix to a stiff/semi-fluid consistency
  - apply using stiff brush e.g. Emaco® Nanocrete brush
- fast setting to reduce waiting times and reduce costs on job site
  - second coat (only required on rebars) can be applied after only 30 to 90 minutes
  - hand applied repairs can be completed directly in wet second coat
  - NB when spraying repair mortars allow second coat to dry overnight!
- multi-use can also be used as a bonding slurry to improve bond and application thicknesses
  - mix as above to stiff/semi fluid consistency and work well into pre-soaked surface
  - Tip: to save time and costs apply this bonding slurry at the same time as the second priming coat on reinforcing steel!

Useful facts

- pack size: 4 kg and 15 kg re-sealable plastic buckets
- water amount : mix 0.22 to 0.26 litre per kg powder
- open work time: approx. 60 minutes at 21 °C
- overcoat time: 30 to 90 minutes
- consumption : 2 – 3 kg/m²
- shelf life: 12 months in unopened containers

Technical data

- actively passivates the steel and contains active corrosion inhibitors for further protection
- does not affect pull out strength of reinforced steel
- fulfils all requirements for active primers as described in EN 1504 part 7
- polymer modified
- ensures adhesive bond strengths as required by EN 1504 part 3
- bright colour for easy site control

EN 1504 – An Overview

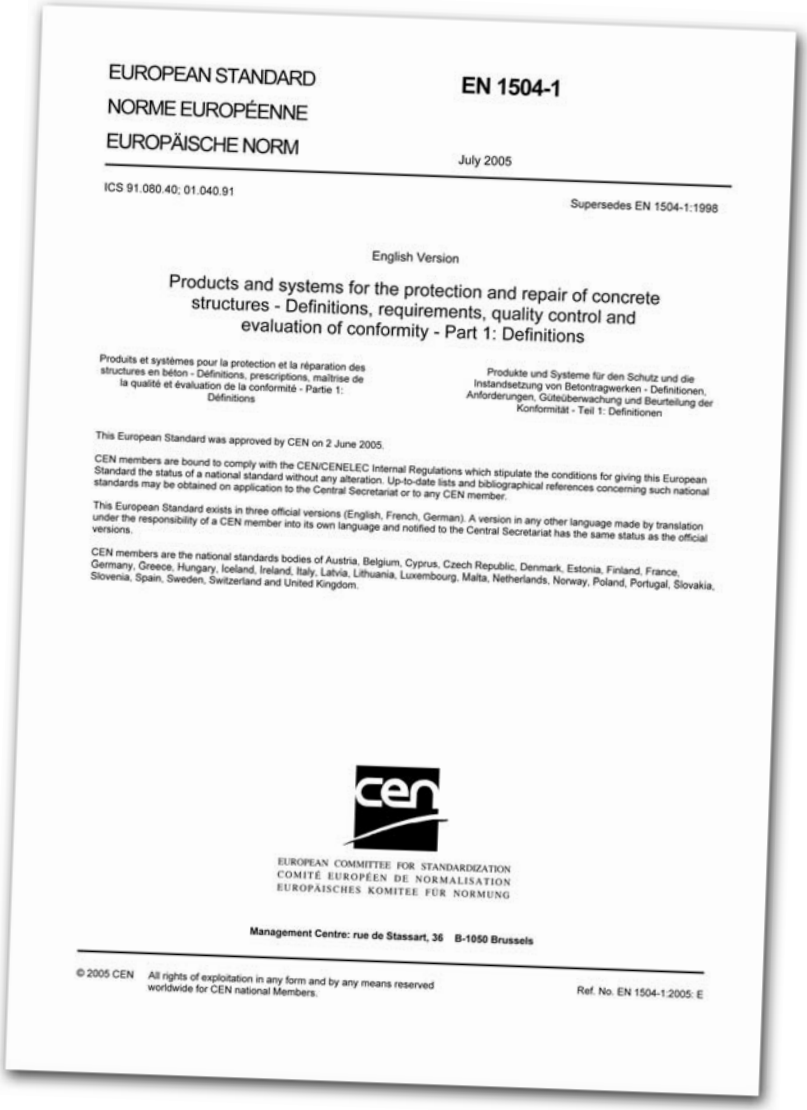
Introduction

The European standard EN 1504 deals with products and systems for the protection and repair of concrete structures and aims to provide information to all of those involved with the repair of concrete.

Not only by specifying product requirements but also by defining concrete repair strategies, methods and definitions, quality control and evaluation of conformity, EN 1504 ensures good quality repair and protection work on the jobsite, which will result in increasing satisfaction of the building owners.

The 10 parts of EN 1504 form a comprehensive document which helps specifying engineers, contractors as well as product manufacturing companies.

Each part of the norm is set-up in a similar way, with the product and manufacturing related parts being extended with specific issues such as product requirements, performance characteristics, sampling, evaluation of conformity and CE-marking and labelling.



EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1504-1

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English Version

Products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity - Part 1: Definitions

Produits et systèmes pour la protection et la réparation des structures en béton - Définitions, prescriptions, maîtrise de la qualité et évaluation de la conformité - Partie 1: Définitions

Produkte und Systeme für den Schutz und die Instandsetzung von Betontragwerken - Definitionen, Anforderungen, Güteüberwachung und Beurteilung der Konformität - Teil 1: Definitionen

This European Standard was approved by CEN on 2 June 2005.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Ref. No. EN 1504-1:2005: E

Front page of part 1 EN 1504

EN 1504, part 1	**terms and definitions within the standard**
EN 1504, part 2	**specifications for surface protection systems for concrete (principles 1, 2, 5, 6 and 8)**
EN 1504, part 3	**performance characteristics for the structural and non-structural repair (principle 3, 4 and 7)**
EN 1504, part 4	**specifications for structural bonding (principle 4)**
EN 1504, part 5	**specifications for concrete injection (principles 1 and 4)**
EN 1504, part 6	**guidance on anchoring of reinforcing steel bars (principle 4)**
EN 1504, part 7	**specifications for reinforcement corrosion protection with active or barrier primers (principles 7 and 11)**
EN 1504, part 8	**quality control and evaluation of conformity for the manufacturing companies**
ENV 1504, part 9	**general principles for the use of products and systems, for the repair and protection of concrete**
EN 1504, part 10	**information on site application of products and quality control of the works**

Concrete repair and protection – basic considerations

ENV 1504, part 9 sets out basic considerations for the specifiers of protection and repair of the un-reinforced and reinforced concrete structures.
This standard identifies key stages in the repair process:

- assessment of the conditions of the structure
- identification of the cause of the deterioration
- deciding the objectives of protection and repair **together** with the building owners
- selection of the appropriate principle(s) of protection and repair
- selection of the methods
- definition of properties of the products and systems
- specification of maintenance requirements following protection and repair

ENV 1504, part 9 - common causes of defects

Deterioration of concrete can be divided into the following categories:

- mechanical causes:
  - impact
  - overload
  - settlement
  - explosion
  - vibration
- chemical causes:
  - alkali-aggregate reaction
  - aggressive agents
    e.g. sulphates, soft water, salts
  - biological degradation
- physical causes:
  - freeze/thaw
  - thermal
  - salt crystallization
  - shrinkage
  - erosion
  - wear

Reinforced concrete structures can suffer also from reinforcement corrosion due to:

- carbonation
- chloride attack
- stray currents

ENV 1504, part 9 - scope of the norm

This part of the EN 1504 European standard defines the basic principles which shall be used, separately or in combination, to protect or repair concrete structures, in air, soil or water.

Defects in Concrete and…

Principles 1 to 6, as specified in the European standard ENV 1504, part 9, provide guideline solutions for the repair and protection of defects caused by the chemical and physical processes specifically relating to concrete.

Principle 1, method 1.2
Masterseal protective coatings, available as rigid, flexible, acrylic, EP or PU materials, protect against all kinds of ingress.

Principle 2, method 2.2
Humidity or moisture in the concrete can be controlled with Masterseal protective coatings: acrylic, EP, PU - rigid or flexible.

Principle 3, method 3.1
Emaco repair mortars: Emaco Nanocrete R4 / R3 / R2 / FC hand applied.

Principle 5, method 5.1
Mastertop coatings: abrasion resistant, and much more.

Principle Nº	Principle definition
Principle 1 [PI]	**Protection against ingress** Reducing or preventing the ingress of adverse agents, e.g. water, other liquids, vapour, gas chemicals and biological agents
Principle 2 [MC]	**Moisture control** Adjusting and maintaining the moisture content in the concrete within specified range of values.
Principle 3 [CR]	**Concrete restoration** - Restoring the original concrete of an element of the structure to the originally specified shape and function. - Restoring the concrete structure by replacing part of it.
Principle 4 [SS]	**Structural strengthening** Increasing or restoring the structural load bearing capacity of an element of the concrete structure.
Principle 5 [PR]	**Physical resistance** Increasing resistance to physical or mechanical attack
Principle 6 [RC]	**Resistance to chemicals** Increasing resistance of the concrete surface to deterioration by chemical attack.

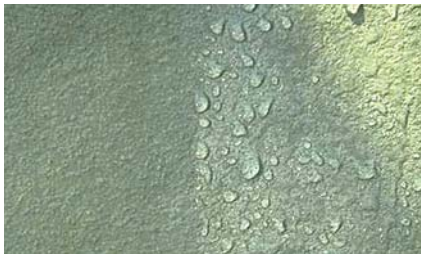
Note: For more detailed information, consult the official document of ENV 1504-9

BASF's European Concrete Repair and Protection Product Range

Methods based on principle	Recommended products*
1.1 Impregnation	**Masterseal®** 501
1.2 Surface coating with and without crack bridging ability	**Masterseal®** 150 / 160
1.3 Locally bandaged cracks	**Masterflex®** 3000
1.4 Filling cracks	**Concresive®** injection materials
1.5 Transferring cracks into joints	**Masterflex®** 700 NP1 / Ultra / NP2
1.6 Erecting external panels	*not applicable*
1.7 Applying membranes	**Conipur® / Conideck®** membranes
2.1 Hydrophobic impregnation	**Masterseal®** 355
2.2 Surface coating	**Masterseal®** 150 / 160 Sonoshield 300H
2.3 Sheltering or overcladding	*not applicable*
2.4 Electrochemical treatment	*not applicable*
3.1 Applying mortar by hand	**Emaco® Nanocrete** R4 / R3 / R2 / FC
3.2 Recasting with concrete	**Emaco® Nanocrete** R4 Flowable
3.3 Spraying concrete or mortar	**Emaco® Nanocrete** R4 / R3 / Shotpatch
3.4 Replacing elements	*not applicable*
4.1 Adding or replacing embedded or external reinforcing steel bars	**Masterflow®** grouts
4.2 Installing bonded rebars in preformed or drilled holes in the concrete	**Concresive®** adhesives
4.3 Plate bonding	**MBrace®** systems and **Concresive®** adhesives
4.4 Adding mortar or concrete	**Emaco® Nanocrete**
4.5 Injecting cracks, voids or interstices	**Concresive®** injection materials
4.6 Filling cracks, voids or interstices	
4.7 Prestressing - (post tensioning)	*not applicable*
5.1 Overlays or coatings	**Mastertop®** flooring systems **Emaco®** resurfacing mortars
5.2 Impregnation	*not applicable*
6.1 Overlays and coatings	**Conipur® / Conideck®** coatings **Ucrete®** flooring **Masterseal®** 150 / 160 / Sonoshield 300H
6.2 Impregnation	*not applicable*

* *Named products not available in all countries. For information on methods without listed products, or other local products contact our technical service department.*

Principle 1, method 1.4
Concresive crack injection rigid: flexible, foaming EP or PU.



Principle 2, method 2.1
Masterseal 303 hydrophobic treatment, silane based emulsion, can be applied in many different situations or conditions.

Principle 3, method 3.2
Emaco repair mortars: Emaco Nanocrete R4 Fluid recasting of elements.

Principle 6, method 6.1
Masterseal systems: 138, 190 - epoxy / 136 - polyurethane / 185 - epoxy-cement.

Defects caused by reinforcement corrosion…

Principles 7 to 11 provide guidance for the repair of, and prevention against, defects caused by corrosion of the reinforcement in concrete.

In addition to these principles, the concrete itself shall be repaired where necessary according to principles 1 to 6.

Principle 7, method 7.1
Increasing reinforcement cover with spray applied Emaco Nanocrete R4.

Principle 8, method 8.1
Hydrophobic treatment using Masterseal 303.

Principle 10, method 10.1
The conductive coating Emaco CP 30 cathodically protects reinforced concrete without significant additional dead load.

Principle 7, method 7.2
Emaco Nanocrete R4/R3 used to replace chloride contaminated concrete.

Principle Nº	Principle definition
Principle 7 [RP]	**Preserving or restoring pasivity** Creating chemical conditions in which the surface of the reinforcement is maintained in or is returned to a passive condition.
Principle 8 [IR]	**Increasing resistivity** Increasing the electrical resistivity of the concrete.
Principle 9 [CC]	**Cathodic control** Creating conditions in which potentially cathodic areas of reinforcement are unable to drive an anodic reaction.
Principle 10 [CP]	**Cathodic protection**
Principle 11 [CA]	**Control of anodic areas** Creating conditions in which potentially anodic reactions of reinforcement are unable to take part in the corrosion reaction.

Note: For more detailed information, consult the official document of ENV 1504-9

Protection and repair of concrete and reinforcement by methods not covered by the standard

NB: The norm accepts that not all repair and protection methods nor all situations can be described. This does not mean, that alternative methods, or use of methods in alternative situations are necessarily unsatisfactory.

BASF's recommended products

Methods based on principle	Recommended products*
7.1 Increasing cover to reinforcement with additional cementitious mortar or concrete	**Emaco® Nanocrete** R4 / R3 / R4 Flowable
7.2 Replacing contaminated or carbonated concrete	**Emaco® Nanocrete** R4 / R3 / R4 Flowable
7.3 Electrochemical realkalisation of carbonated concrete	*not applicable*
7.4 Realkalisation of carbonated concrete by diffusion	**Masterseal®** 550 / 588
7.5 Electrochemical chloride extraction	*not applicable*
8.1 Limiting moisture content by surface treatments, coatings or sheltering	**Masterseal®** 150 / 160 / Sonoshield 300H **Conipur® / Conideck®** membranes
9.1 Limiting oxygen content (at the cathode) by saturation or surface coating	**Masterseal®** 150 / 160 / Sonoshield 300H **Protectosil CIT**
10.1 Applying electrical potential	**Emaco®** CP 10 **Emaco®** CP 30 **Emaco®** CP 60 **Emaco®** CP 15 Grout
11.1 Painting reinforcement with coatings containing active pigments	**Emaco® Nanocrete** AP
11.2 Painting reinforcement with barrier coatings	**Emaco®** S40ZR
11.3 Applying inhibitors to the concrete	**Protectosil CIT**

* *Named products not available in all countries. For information on methods without listed products, or other local products contact our technical service department.*

Principle 9, method 9.1
Masterseal coatings applied directly on the concrete to protect the underlying reinforcement.

Principle 9, method 9.1
Masterseal 136 / 138 / 190 coatings limit the oxygen transport through the concrete.

Principle 9, method 9.1
Corrosion at the cathodic areas of the reinforcement is inhibited by the use of Protectosil CIT.

Principle 10, method 10.1
Activated titanium anodes are embedded in Emaco CP10, specially designed for optimum compatibility with the CP anode.

Principle 11, method 11.1
Active corrosion protection with Emaco Nanocrete AP.

BASF Integrated Concrete Repair Systems:

Renovation of office building in Brussels (B):

Reprofiling of old concrete structure and repair of concrete beams of the balconies
Applied products: Emaco Nanocrete AP, Emaco Nanocrete R4 and Masterseal elastomeric coating

Waste water plant in Marseille (F):

Reprofiling of precast panels, waterproofing and joint sealing
Applied products: Emaco Nanocrete AP, R3 and R4, Masterflex joint sealing and Masterseal waterproofing solutions

Renovation of bridge structure in Castellòn (E):

Repairing of columns, piers and cross beams
Applied products: Emaco Nanocrete AP and Emaco Nanocrete R4

Emaco Nanocrete Project References

Cooling tower (SK):

Structural concrete repair and reprofiling
Applied products: Emaco Nanocrete AP and Emaco Nanocrete R4

Renovation of apartment building in London (GB):

Reprofiling of concrete structure and levelling of balcony soffits
Applied products: Emaco Nanocrete R2 and Emaco Nanocrete R3

Renovation of entrance stair of a private building (CH):

Repairing, reprofiling, waterproofing and tiling of stair steps
Applied products: Emaco Nanocrete R2, waterproofing and tiling products from BASF

Intelligent Solutions from BASF Construction Chemicals

Whatever your construction problem, whatever the structure is you are building, BASF Construction Chemicals has an intelligent solution to help you be more successful.
Our market leading brands offer the widest range of proven technologies to help you build a better world.

Emaco® - Concrete Repair Systems
MBrace® - Composite Strengthening Systems
Masterflow® - Precision and Structural Grouts
Masterflex® - Joint Sealants
Masterseal® - Coatings and Waterproofing
Masterpren® - Sheet Membranes
Concresive® - Resin Based Mortars, Adhesives and Injection Systems
Conica® - Sports Flooring
Conideck® - Hand and Spray Applied Waterproofing Systems
Coniroof® - PU Based Roofing Systems
Conibridge® - PU Based Membranes to Protect Bridge Decks
Mastertop® - Decorative and Industrial Flooring Solutions
Glenium®, Rheobuild® and Pozzolith® - Concrete Admixtures
Ucrete® - Flooring Solutions for Harsh Environments
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Australia
+61 2 8811 4200

China Head Office
+86 21 6485 3300

Indonesia
+62 21 8934339

Japan
+81 3 3582 8815

Korea
+82 31677 3900

Malaysia
+60 3 3344 3388

Pakistan
+92 21 111550550

New Zealand
+64 9414 7233

Philippines
+63 2636 1813-16

Singapore
+65 6861 6766

Taiwan
+886 49 2255 138

Thailand
+66 3845 3020

Vietnam
+84 650 743100

India (Sri Lanka, Bangladesh)
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Further information on BASF is available on the Internet at www.basf.com

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