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Construction

A Guide to the Concrete Repair European Standards BS EN 1504 Series

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Introduction

BS EN 1504 - standards for products and systems for the protection and repair of concrete structures – definitions, requirements, quality control and evaluation of conformity provides a comprehensive set of standards for concrete repair.

The 10 documents which form BS EN 1504 are complex and provide information not only to those specifying and applying products but also for the manufacturer.

These guidance notes are aimed to provide information to all those involved with concrete repairs.

This guide extracts the key components of each document relevant to the specifier and applicator in a brief easily understood format. If more detail is required then reference should be made to the relevant standard.

Sika have carried out seminars to applicators and consultants in the UK based on this guide. It is clear that although these documents are to be implemented by 2009, the industry has not fully embraced them.

Hopefully this guide will generate your interest in the standards and prepare you for implementation.

If you would like Sika to carry out a seminar on this subject, please call or email our Technical Department on **01707 394444** or email: technical@uk.sika.com

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1.0 Overview of BS EN 1504 Documents

BS EN 1504-9 products and systems for the protection and repair of concrete structures - Definitions, requirements, quality control and evaluation of conformity.

Each standard is commonly sectioned as follows:

- Foreword
- Introduction
- Scope
- Normative reference
- Terms and definitions

These sections should be reviewed by all.

The standards that relate specifically to products and systems and are generally common throughout are:

- Performance characteristics for intended uses
- Requirements

Again these sections should be reviewed by all.

The following sections are specifically aimed at the manufacturer and CE approved inspection body:

- Sampling
- Evaluation of conformity
- Marking and labeling

This guidance document is focused on the terms & definitions, performance characteristics and requirements.

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The 10 documents forming the BS EN 1504 Series are listed below

	Content	Status
Part 1	Definitions	Released 2005
Part 2	Surface protection systems	Released 2004
Part 3	Structural and non structural repair	Released 2005
Part 4	Structural bonding	Released 2004
Part 5	Concrete injection	Released 2004
Part 6	Products and systems for grouting anchor reinforcement	Released 2006
Part 7	Reinforcement corrosion protection	Released 2006
Part 8	Quality control and evaluation of conformity	Released 2004
Part 9	General principles for use of products and system	Released 1997 ENV
Part 10	Site application of products and systems and quality control of the works	Released 2003

2.0 BS EN 1504 Principles

There are 11 Corrosion Principles related to Defects in Concrete and Remediation of Reinforcement Corrosion

- Defects in Concrete
  - 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

- Remediation of Reinforcement Corrosion
  - Principle 7 (RP) Preserving or restoring passivity
  - Principle 8 (IR) Increasing resistivity
  - Principle 9 (CC) Cathodic control
  - Principle 10 (P10) Cathodic protection
  - Principle 11 (CA) Control of anodic area

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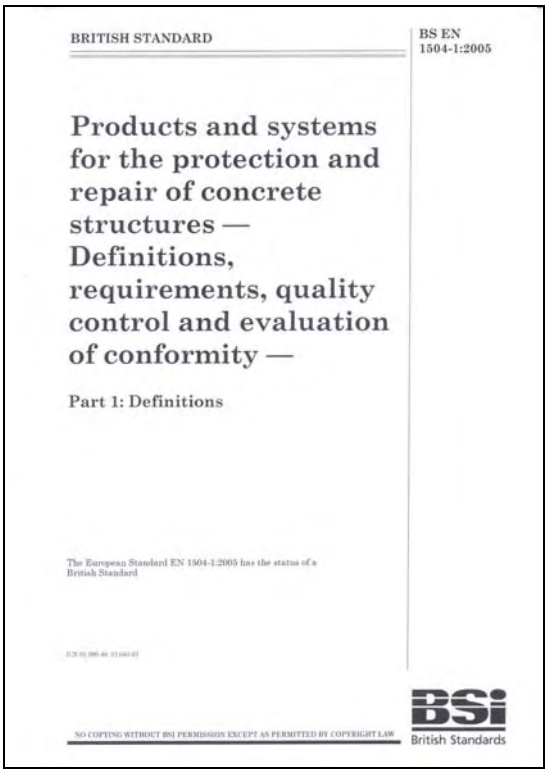
3.0 BS EN 1504-1


BRITISH STANDARD

BS EN 1504-1:2005

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 1: Definitions

The European Standard EN 1504-1:2005 has the status of a British Standard

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BSI British Standards

BS EN 1504-1 provides terms and definitions used within the standards.

Terms are divided into the following groups:

3.1 General
3.2 Main categories of products and systems
3.3 Main chemical types and constituents of protection and repair products and systems

3.1 **Refer to standard.**

3.2 **Main categories of products and systems**

- ▲ Anchoring
- ▲ Injection products and systems
- ▲ Non structural repair products and systems
- ▲ Reinforcement protection
- ▲ Structural bonding
- ▲ Structural repair
- ▲ Surface protection systems

3.3 **Main chemical types and constituents by protection and repair products and systems**

- ▲ Additions
- ▲ Additives
- ▲ Admixtures
- ▲ Coatings
- ▲ Hydraulic binders (H)
- ▲ Hydraulic mortars and hydraulic concretes (CC)
- ▲ Hydrophobic impregnations
- ▲ Impregnation
- ▲ Polymer hydraulic cement mortars or concretes (PCC)
- ▲ Polymer mortars and polymer concretes (PC)
- ▲ Reactive polymer binder (P)

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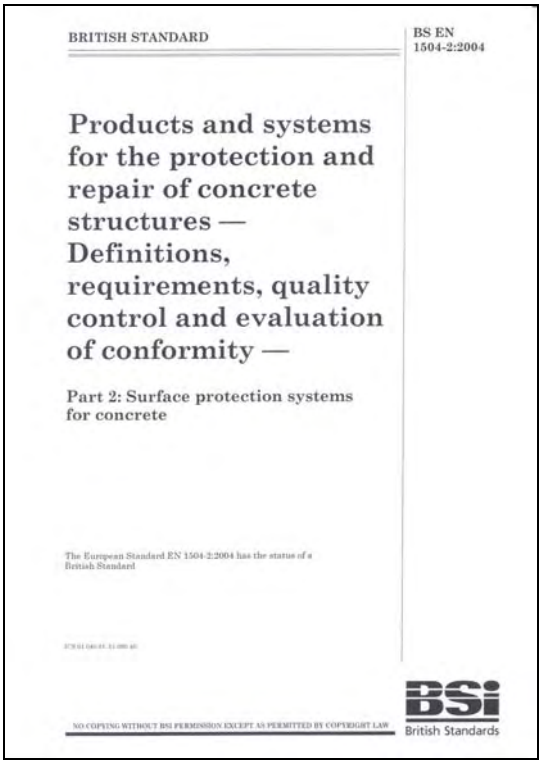
4.0 BS EN 1504-2
Surface Preparation Systems for Concrete


BRITISH STANDARD

BS EN 1504-2:2004

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 2: Surface protection systems for concrete

The European Standard EN 1504-2:2004 has the status of a British Standard

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BSI British Standards

BS EN 1504-2 provides specifications for products and systems.

Surface protection systems are used as "methods" for the following "principles" presented in BS DDENV 1504-9.

▲ Principle 1 (PI) Protection Against Ingress
1.1 Hydrophobic impregnation (H)
1.2 Impregnation (I)
1.3 Coating (C)

▲ Principle 2 (MC) Moisture Control
2.1 Hydrophobic impregnation (H)
2.2 Coating (C)

▲ Principle 5 (PR) Physical Resistance/ Surface Improvement
5.1 Coating (C)
5.2 Impregnation (I)

▲ Principle 6 (RC) Resistance to Chemicals
6.1 Coating (C)

▲ Principle 8 (IR) Increasing Concrete Resistivity
8.1 Hydrophobic impregnation (H)
8.2 Coating (C)

Table 1

Table 1 – Performance characteristics for surface protection products and systems related to the "principles" and "methods" defined in 1504-9

No.	Test methods defined in	Principles / Performance Characteristics / Methods	1. Ingress protection			2. Moisture control		5. Physical Resistance		6. Chemical Resistance	8. Increasing resistivity	
			1.1 (H)	1.2 (I)	1.3 (C)	2.1 (H)	2.2 (C)	5.1(C)	5.2(I)	6.1 (C)	8.1 (H)	8.2 (C)
1	2	3	4	5	6	7	8	9	10	11	12	13
1	EN 12617-1	Linear shrinkage			□		□	□		□		□
2	EN 12190	Compressive strength						□		□		
3	EN 1770	Coefficient of thermal expansion			□		□	□		□		□
4	EN ISO 5470-1	Abrasion resistance						■	■			
5	EN ISO 2409	Adhesion by cross-cut test [a]			□		□	□		□		□
6	EN 1062-6	Permeability to CO_2			■							
7	EN ISO 7783-1 EN ISO 7783-2	Permeability to water vapour		□	■		■					■
8	EN 1062-3	Capillary absorption and permeability to water		■	■		■	■	■	□		■
9		Adhesion after thermal compatibility										
	EN 13687-1	Freeze-thaw cycling with de-icing salt immersion		□	□		□	□	□	□		□
	EN 13687-2	Thunder-shower cycling (thermal shock)		□	□		□	□	□	□		□
	EN 13687-3	Thermal cycling without de-icing salt impact		□	□		□	□	□	□		□
	EN 1062-11:2002	4.1: Aging: 7 days at 70 °C		□	□		□	□	□	□		□
10	EN 13687-5	Resistance to thermal shock			□			□		□		
11	EN ISO 2812-1	Chemical resistance		□	□							
12	EN 13529	Resistance to severe chemical attack								■		
13	EN 1062-7	Crack bridging ability			□		□	□		□		□
14	EN ISO 6272-1	Impact resistance						■	■			
15	EN 1542	Adhesion strength by pull-off test		□	■		■	■	■	■		■
16	EN 13501-1	Fire classification of construction products and building elements — Part 1: Classification using test data from reaction to fire test		□	□		□	□	□	□		□
17	EN 13581	Resistance against freeze-thaw salt stress of impregnated hydrophobic concrete (Determination of loss of mass)	□			□					□	
18	EN 13036-4	Slip/skid resistance		□	□		□	□	□	□		□
19	see Table 3	Depth of penetration	■	■		■			■		■	
20	EN 1062-11:2002	4.2: Behaviour after artificial weathering			□		□	□		□		□
21	EN 1081	Antistatic behaviour			□		□	□		□		□
22	EN 13578	Adhesion on wet concrete			□		□	□		□		
23	EN 13580	Water absorption and resistance to alkali test for hydrophobic impregnation	■			■					■	
24	EN 13579	Drying rate for hydrophobic impregnation	■			■					■	
25	subject to national standards and national regulations	Diffusion of chloride ions	□	□	□							

H Hydrophobic impregnation
I Impregnation
C Coating
■ characteristic for all intended uses
□ characteristic for certain intended uses within the scope of ENV 1504-9:1997 (see also Tables 3, 4, 5)

[a] This test is for comparison to the pull-off test see note to item 5 in Table 5

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Product Overview for Surface Protection Systems

Hydrophobic Impregnations

- ▲ To produce a water repellent surface
- ▲ Pores and capillaries internally coated – not filled
- ▲ No film or change in concrete appearance
- ▲ Silanes or siloxanes
- ▲

Hydrophobic Impregnations (Characteristics for all intended uses only – minimum requirements)

Principle / Performance Characteristics	Ingress Protection (P1)	Moisture Control (P2)	Physical Resistance (P5)	Chemical Resistance (P6)	Increase Resistivity (P8)
Depth of Penetration Class 1: <10mm Class 11: ≥10mm	■	■	-	-	■
Water absorption <7.5% Resistance to alkali <10%	■	■	-	-	■
Drying Rate Class 1: >30% Class 11: >10%	■	■	-	-	■

Impregnations

- ▲ To reduce surface porosity and strengthen the surface
- ▲ Pores and capillaries are partially or totally filled
- ▲ Discontinuous thin film of organic polymers
- ▲ Sodium silicates

Impregnations (Characteristics for all intended uses only – minimum requirements)

Principle / Performance Characteristics	Ingress Protection (P1)	Moisture Control (P2)	Physical Resistance (P5)	Chemical Resistance (P6)	Increase Resistivity (P8)
Capillary absorption and permeability to water <0.1kg/m^2.h$^{0.5}$	■	-	■	-	-
Depth of Penetration ≥5.0mm	■	-	■	-	-
Adhesion strength by pull off test Average (N/mm^2) Vertical: ≥0.8 (0.5 minimum) Horizontal without mechanical load: ≥1.0 (0.7 minimum) Horizontal with mechanical load: ≥1.5 (1.0 minimum)	-	-	■	-	-
Abrasion Resistance Taber test 30% improvement compared to a non impregnated sample	-	-	■	-	-
Impact Resistance Class I ≥4 Nm No cracks or delamination after impact Class II ≥10 Nm Class III ≥20 Nm	-	-	■	-	-

Note: when capillary description to water is <0.01g/m^2.h$^{0.5}$ - diffusion of chlorides not expected

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Coatings

- A continuous protective layer
- Thickness 0.1mm-5.0mm
- Typically organic polymers

Coatings (Characteristics for all intended uses only – minimum requirements)

Performance Characteristics / Principle	Ingress Protection (P1)	Moisture Control (P2)	Physical Resistance (P5)	Chemical Resistance (P6)	Increase Resistivity (P8)
Permeability to CO_2 SD>50m	■	-	-	-	-
Permeability to water vapour Class I: SD<5.0m (permeable to water vapour) Class II: 5m≤SD≤50m Class III: SD>50m (not permeable to water vapour)	■	■	-	-	■
Capillary absorption and permability to water W<0.1kg/m^2.h$^{0.5}$	■	■	■	-	■
Resistance to severe chemical attack Class I: 3 days without pressure Class II: 28 days without pressure Class III: 28 days with pressure	-	-	-	■	-
Impact resistance After impact loading no cracks or delamination Class I: >4Nm Class II: ≥10Nm Class III: ≥20Nm	-	-	■	-	-
Adhesion strength by pull off Average (N/mm^2) **Crack bridging or/flexible systems** / **Rigid Systems** Without trafficking ≥0.8 (0.5 minimum) / ≥1.0 (0.7 minimum) With trafficking ≥1.5 (1.0 minimum) / ≥2.0 (1.5 minimum)	■	■	■	■	■
Abrasion resistance Taber test ≤3000 mg abrading	-	-	■	-	-

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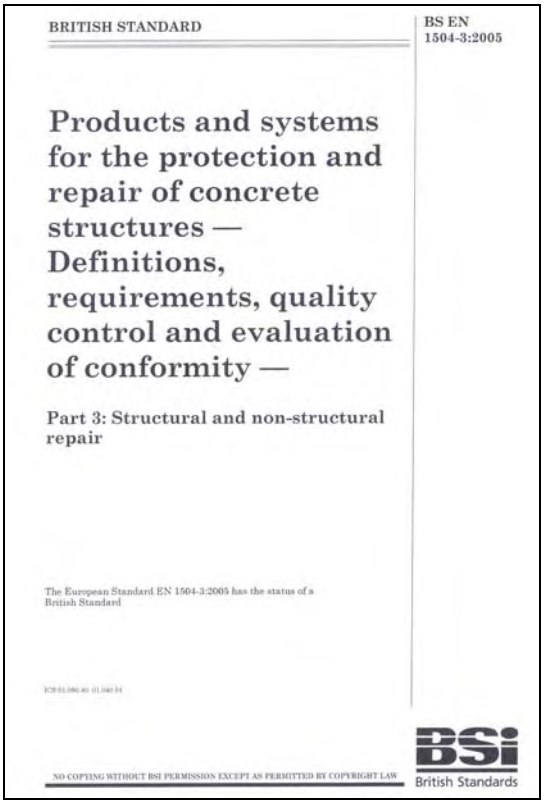
5.0 BS EN 1504-3
Structural and Non-Structural Repair


BRITISH STANDARD

BS EN 1504-3:2005

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 3: Structural and non-structural repair

The European Standard EN 1504-3:2005 has the status of a British Standard

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BSI British Standards

BS EN 1504-3 provides performance characteristics and requirements for structural and non-structural repair products under the following 3 repair principles.

- ▲ Principle 3
  Concrete Restoration
- ▲ Principle 4
  Structural Strengthening
- ▲ Principle 7
  Preserving or Restoring Passivity

Repair Mortar Classification

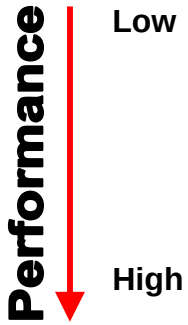
4 Classifications

Class R1 – Non Structural

Class R2 – Non Structural

Class R3 – Structural

Class R4 – Structural



Repair Mortar Classification (Characteristics for all intended uses only – minimum requirements)

Item	Requirement			
	Structural		Non-Structural	
	Class R4	Class R3	Class R2	Class R1
Compressive Strength	≥ 45 MPa	≥ 25 MPa	≥ 15 MPa	≥ 10 MPa
Chloride Ion Content	≤ 0,05%		≤ 0,05%	
Adhesive Bond	≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa	
Restrained shrinkage Expansion	Max average crack width <0.05mm No crack width >0.1mm No delamination			No requirement
	≥ 2,0 MPa	≥ 1,5 MPa	≥ 0,8 MPa	
DURABILITY Carbonation Resistance (not required if coated)	d_K ≤ Control concrete C(0,45)			Not required
Elastic Modulus	≥ 20 GPa	≥ 15 GPa	Not required	

Notes:

= For structural strengthening Principle 4 only

The above table provides information on the minimum performance characteristics for all intended uses.

For other intended uses such as special environmental exposure conditions, trafficked areas which are uncoated, the following characteristics are also included:

- Thermal compatibility
- Skid resistance
- Coefficient of thermal expansion
- Capillary absorption

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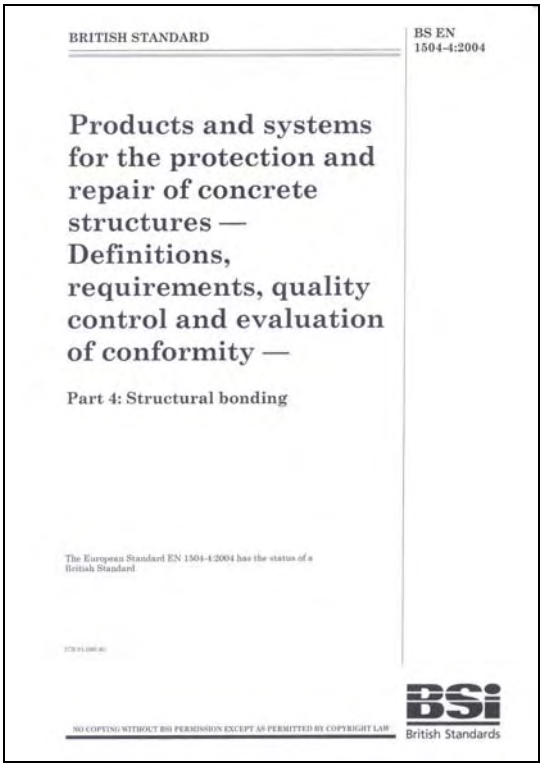
6.0 BS EN 1504-4
Structural Bonding


BRITISH STANDARD

BS EN 1504-4:2004

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 4: Structural bonding

The European Standard EN 1504-4:2004 has the status of a British Standard

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BSI British Standards

BS EN 1504-4 covers the following 3 areas of structuring bonding.

- ▲ Bonding of external steel or composites to concrete for strengthening purposes
- ▲ Bonding of hardened concrete to hardened concrete (precast units)
- ▲ Casting of fresh concrete to hardened concrete to form composite bond

- ▲ Products suitable for application are polymer mortars or polymer concretes

Structural Bonding (Characteristics for all intended uses only – minimum requirements)

Principle / Performance Characteristics	Bonding Plate Reinforcement		Bonding Mortar for Concrete	
		Requirement		Requirement
ADHESION				
● Plate to plate	■	Pull off test bonded joint 14.0N/mm²	-	
● Plate to concrete	■	Pull off test bonded joint 14.0N/mm²	-	
Hardened concrete to hardened concrete	-		■	Fracture in concrete
Fresh concrete to hardened concrete	-		■	Fracture in concrete
DURABILITY				
● Thermal cycling	■	Steel to steel - no failure	■	Compressive shear load at failure of concrete specimens ≤ tensile strength of concrete
● Moisture cycling	■		■	
DESIGNER INFORMATION				
● Open time	■	Declared value ±20%	■	Declared value ±20%
● Workable life	■	Declared value	■	Declared value
● Modulus of elasticity in compression	■	≥2000 N/mm²	■	≥2000 N/mm²
● Compressive strength	-		■	≥30 N/mm²
● Shear strength	■	≥12 N/mm²	■	≥6 N/mm²
● Glass transition temperature (tg)	■	≥40°C	■	≥40°C
● Coefficient of thermal expansion		≤100x10⁻⁶ per k	■	≤100x10⁻⁶ per k
● Shrinkage	■	<0.1%	■	<0.1%

Note: Declared value stated by manufacturer

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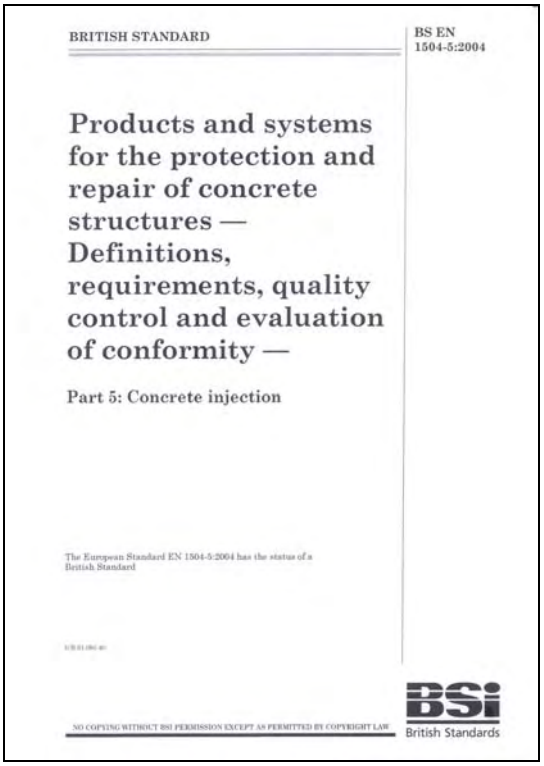
7.0 BS EN 1504-5
Concrete Injection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BS EN 1504-5:2004

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 5: Concrete injection

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BSi British Standards

BS EN 1504-5 provides guidance on the concrete injection of cracks, voids and interstices in accordance with the following 2 principles.

- Principle 1 (PI) Protection Against Ingress
  - Filling cracks
- Principle 4 (SS) Structural Strengthening
  - Injecting cracks, voids or interstices
  - Filling cracks, voids or interstices

Objectives of concrete injection

- Achieve impermeability
- Avoid penetration of aggressive agents to avoid corrosion
- Strengthen the structure by strengthening the concrete

The injection products are categorised to achieve the following performance conditions

- Force transmitting (F)
  - Transmit forces through product
- Ductile (D)
  - Flexible to accommodate movement
- Swelling (S)
  - Swell repeatedly by water adsorption

Injection products – 2 types

- Reactive Polymer Binder (P)
  - 2-3pt Resins
  - Epoxies, polyurethanes, acrylics, polyesters
- Hydraulic Binder (H)
  - Cementitious

A general guide to typical injection products used are as follows:

(F) Epoxies, polyesters and cementitious
(D) Polyurethanes and acrylics
(S) Polyurethanes and acrylics

Crack widths considered in standard (measured on surface)

- 0.1mm, 0.2mm, 0.3mm, 0.5mm, 0.8mm

Injection products for force transmitting filling of cracks (F)

(Characteristics for all intended uses only - minimum requirements)

Performance characteristics	Performance requirements
BASIC CHARACTERISTICS	
Adhesion by tensile bond strength (H, P)	H - >2.0 N/mm^2 >0.6 N/mm^2 for void filling P - Cohesive failure in substrate
Volumetric shrinkage (P)	<3%
Bleeding (H)	<1% of initial value after 3 hours
Volume change (H)	-1% +5% volume
WORKABILITY CHARACTERISTICS	
Injectability into dry medium	Refer to Table 3a
Injectability into non-dry medium	Refer to Table 3a
Viscosity (P)	Declared value
Time of efflux (H)	Declared value
REACTIVITY CHARACTERISTICS	
Workable time (H, P)	Declared value
Tensile strength development for polymers (P)	Declared value
Setting time (H)	Declared value
DURABILITY	
Adhesion by tensile bond strength after thermal and wet-drying cycles (H, P)	H - <30% initial value P - Cohesive failure in substrate
Compatibility with concrete (H, P)	H - <30% initial value P - Cohesive failure in substrate

(H) Injection product formulated with hydraulic binder
(P) Injection product formulated with reactive binder

Note: Declared value is stated by manufacturer

Injection products for ductile filling of cracks (D)

(Characteristics for all intended uses only - minimum requirements)

Performance characteristics	Performance requirements
BASIC CHARACTERISTICS	
Adhesion and elongation capacity of ductile injection product (P)	Adhesion declared value Elongation >10%
WORKABILITY CHARACTERISTICS	
Injectability into dry medium (P)	Refer to Table 3b
Injectability into non-dry medium (P)	Refer to Table 3b
Viscosity (P)	Declared value
REACTIVITY CHARACTERISTICS	
Workable time (H, P)	Declared value
DURABILITY	
Compatibility with concrete (P)	No failure by compressive testing Lost deformation work <20%

(P) Injection product formulated with reactive polymer binder

Note: Declared value is stated by manufacturer

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Injection products for swelling fitted filling of cracks (S)

(Characteristics for all intended uses only - minimum requirements)

Performance characteristics	Performance requirements
BASIC CHARACTERISTICS	
Watertightness	Watertight Normal application: 2 x 10^5 Pa Special application: 7 x 10^5 Pa
WORKABILITY CHARACTERISTICS	
Viscosity (P)	≤ 60 Mpa.s
Expansion ratio and rate by water storage (P)	Declared value
REACTIVITY CHARACTERISTICS	
Workable life (P)	Declared value
DURABILITY	
Sensitivity to water: expansion ratio caused by water storage (P)	Constant level during water immersion
Sensitivty to wet-drying cycles (P)	After wet and dry cycles - no change after water immersion
Compatibility with concrete (P)	Refer to Table 3c

(P) Injection product formulated with reactive polymer binder

Note: Declared value is stated by manufacturer

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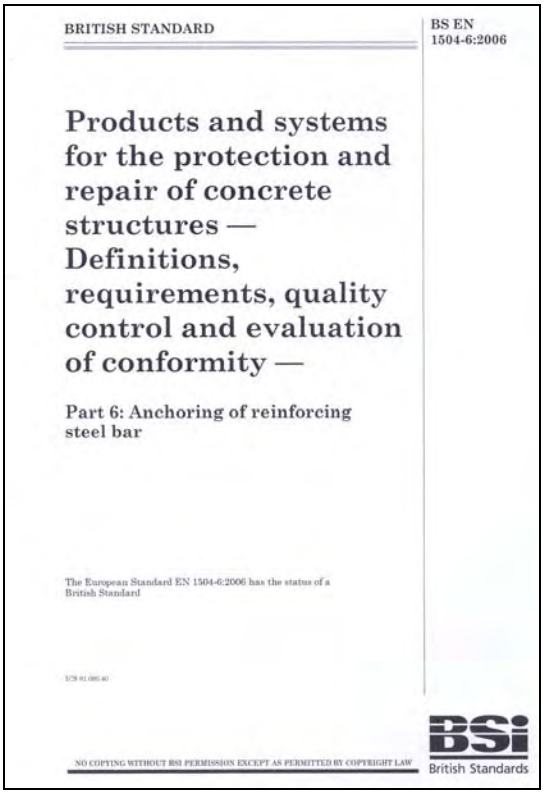
8.0 BS EN 1504-6: Anchoring of Reinforcing Steel Bar


BRITISH STANDARD

BS EN 1504-6:2006

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 6: Anchoring of reinforcing steel bar

The European Standard EN 1504-6:2006 has the status of a British Standard

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BSI British Standards

BS EN 1504-6 provides guidance on how to anchor steel bars into concrete for structural applications.

- Product types
  - Hydraulic binders (cementitious)
  - Synthetic resins
- Product Consistency
  - Fluid
  - Paste

Performance of anchoring products for all intended uses

Performance Characteristics	Performance Requirements
Pull Out	Displacement ≤0.6mm @ load of 75 kN
Chloride ion content	≤0.05%
Glass transition temperature[a]	>45°C or 20°C above maximum ambient temperature of structure in service, whichever is higher
Creep under tensile load[a]	Displacement ≤0.6mm after continuous loading of 50kN after 3 months

[a] for PC products only

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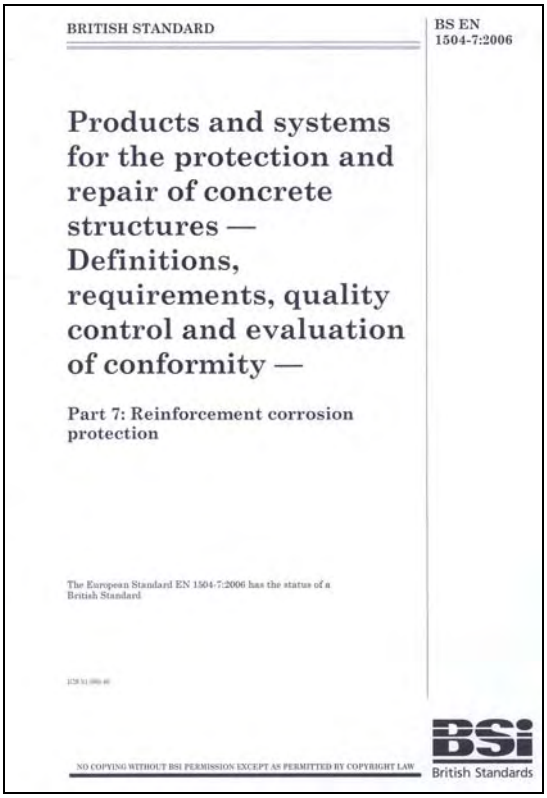
9.0 BS EN 1504-7
Reinforcement Corrosion Protection


BRITISH STANDARD

BS EN 1504-7:2006

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 7: Reinforcement corrosion protection

The European Standard EN 1504-7:2006 has the status of a British Standard

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BSI British Standards

BS EN 1504-7 provides requirements for the protection of existing uncoated steel reinforcement and embedded steel in concrete structures under repair.

The standard does not cover pre-stressing and stainless steels. Coatings are categorised as follows:

Active Coatings

- ▲ Electrochemically active pigments
  - ▲ Function as inhibitors
  - ▲ Localised cathodic protection

Barrier Coatings

- ▲ Isolate reinforcement from pore water

Performance of coatings for all intended uses

Performance Characteristics	Performance Requirements
Corrosion protection	Coated zones are free of corrosion and rust creep @ plate edge <1.0mm

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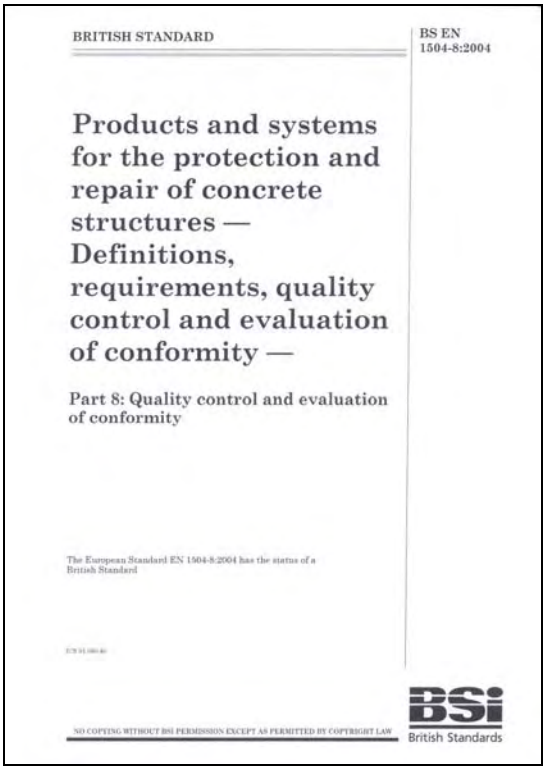
10.0 BS EN 1504-8
Quality Control and Evaluation of Conformity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BS EN 1504-8:2004

Products and systems for the protection and repair of concrete structures — Definitions, requirements, quality control and evaluation of conformity —

Part 8: Quality control and evaluation of conformity

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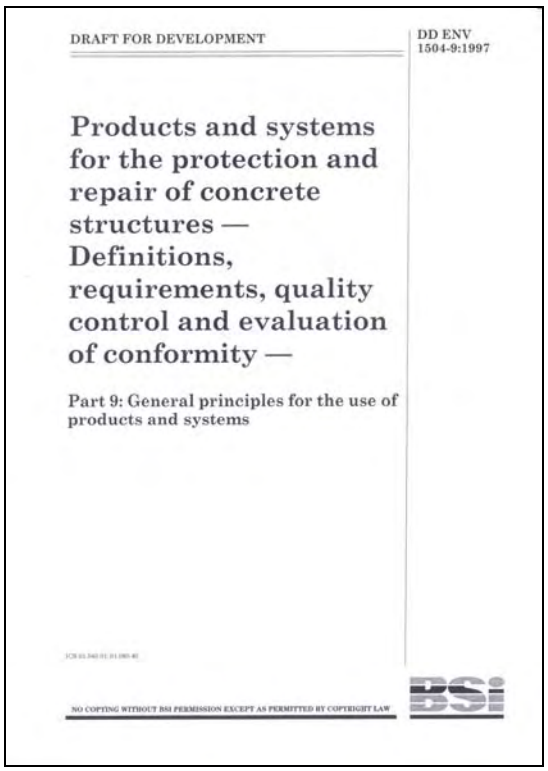
BS EN 1504-8 contains information for the manufacture on the following subjects.

- ▲ Specifies procedures for quality control and evaluation of conformity
- ▲ CE marking and labelling

11.0 BS DDENV 1504-9
General Principles for the Use of Products and Systems


DRAFT FOR DEVELOPMENT

DD ENV 1504-9:1997

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

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BSI

BS DDENV 1504 defines the principles for protection and repair of concrete structures which have suffered or may suffer damage or deterioration

The standard also provides guidance on the key stages in the repair and protection process

1. Assessment of defects
2. Identification of the causes of defects
3. Objectives of protection and repair
4. Selection of the appropriate principles and methods
5. Properties of products and systems (1504 parts 2-7)
6. Maintenance management

PRINCIPLES AND METHODS RELATED TO DEFECTS IN CONCRETE

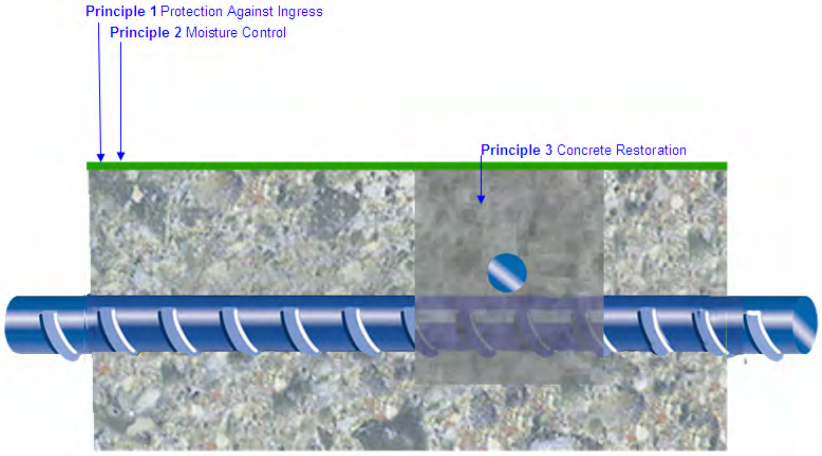
Table 1

PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 1 (P1)	**Protection Against Ingress** Reducing or preventing the ingress of adverse agents, eg water, other liquids, vapour, gas, chemicals and biological agents	1.1 Impregnation 1.2 Surface coating with and without crack bridging ability 1.3 Locally bandaged cracks 1.4 Filling cracks 1.5 Transferring cracks into joints

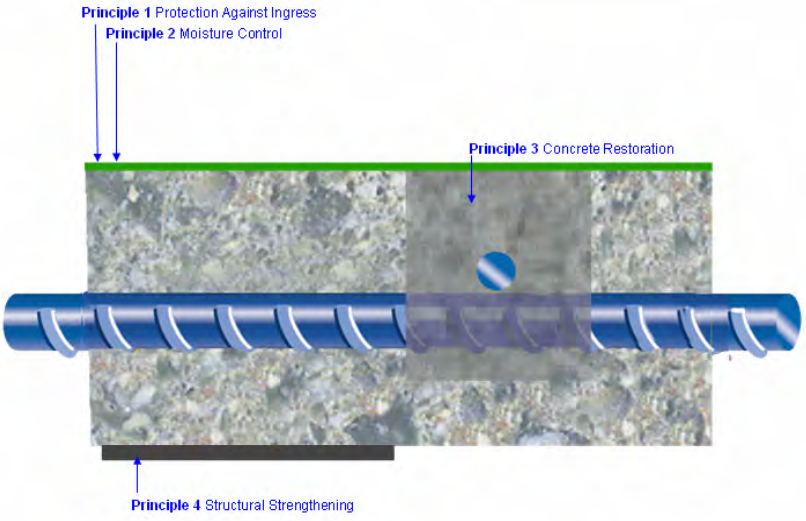
PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 2 (MC)	**Moisture Control** Adjusting and maintaining the moisture content in the concrete within a specified range of values	2.1 Hydrophobic impregnation 2.2 Surface coating 2.3 Sheltering or overcladding 2.4 Electrochemical treatment

Construction

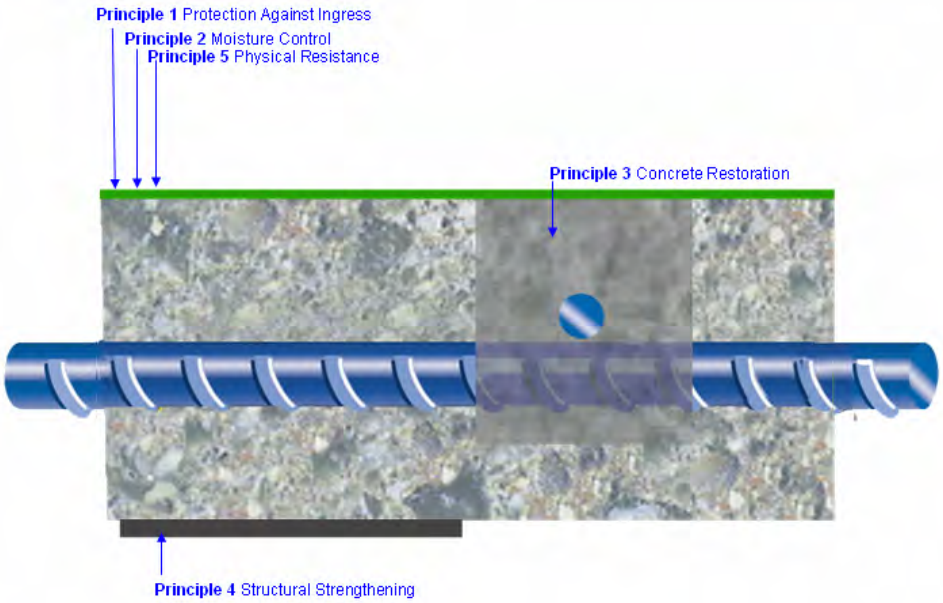
PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 3 (CR)	**Concrete Restoration** Restoring the original concrete of an element of the structure to the originally specified shape and function Restoring the concrete structure by replacing part of it.	3.1 Applying mortar by hand 3.2 Recasting with concrete 3.3 Spraying concrete or mortar 3.4 Replacing elements



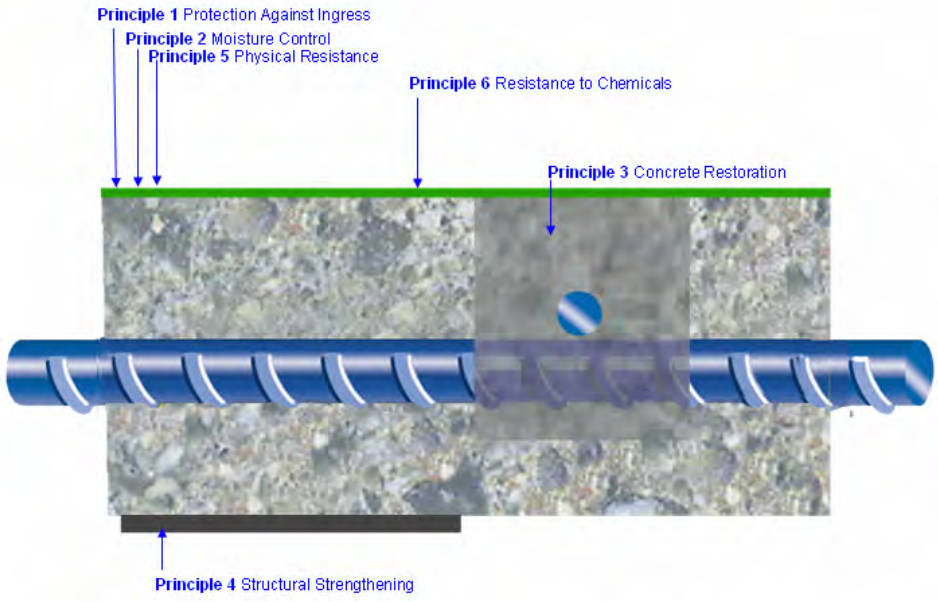
PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 4 (SS)	**Structural Strengthening** Increasing or restoring the structural load bearing capacity of an element of the concrete structure	4.1 Adding or replacing embedded or external reinforcing steel bars 4.2 Installing bonded rebars in preformed or drilled holes in the concrete 4.3 Plate bonding 4.3a Structural fabrics 4.4 Adding mortar or concrete 4.5 Injecting cracks, voids or interstices 4.6 Filling cracks, voids or interstices 4.7 Prestressing – (post tensioning)



PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 5 (PR)	**Physical Resistance** Increasing resistance to physical or mechanical attack	5.1 Overlays or coatings 5.2 Impregnation



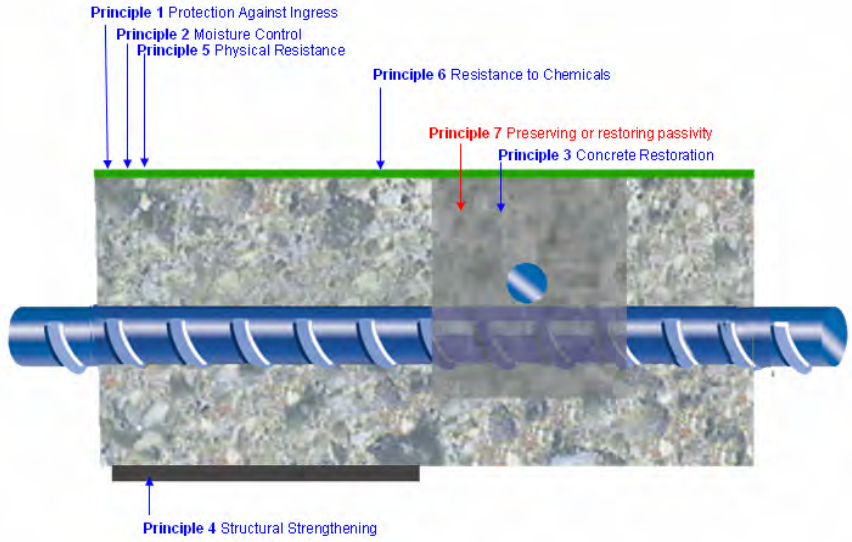
PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 6 (RC)	**Resistance to Chemicals** Increasing resistance of the concrete surface to deteriorations by chemical attack	6.1 Overlays or coatings 6.2 Impregnation



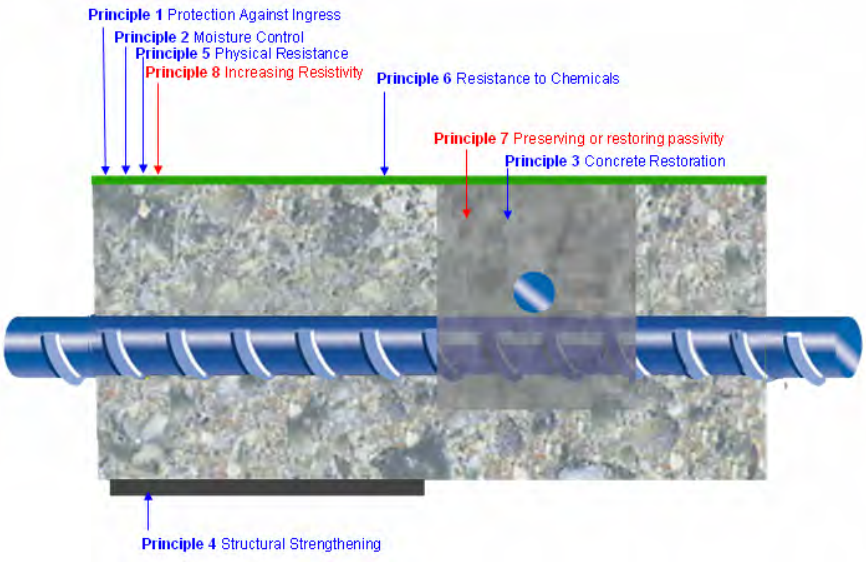
Construction

Table 2

PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 7 (RP)	**Preserving or Restoring** Creating chemical conditions in which the surface of the steel reinforcement is maintained in or is returned to a passive condition	7.1 Increasing cover to reinforcement with additional cementitious mortar or concrete 7.2 Replacing contaminated or carbonated concrete 7.3 Electrochemical realkalisation of carbonated concrete 7.4 Realkalisation of carbonated concrete by diffusion 7.5 Electrochemical chloride extraction

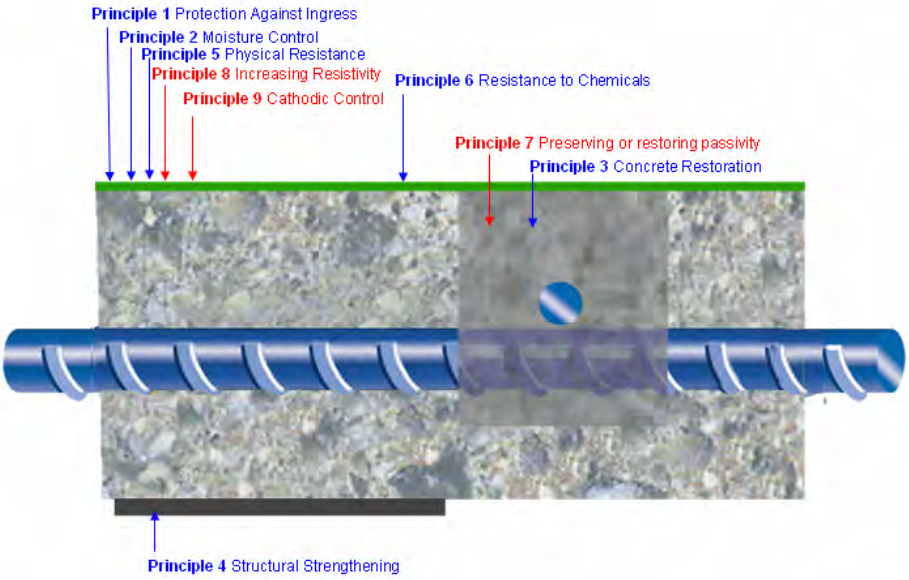


PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 8 (IR)	**Increasing Resistivity** Increasing the electrical resistivity of the concrete	8.1 Limiting moisture content by surface treatments, coating or sheltering

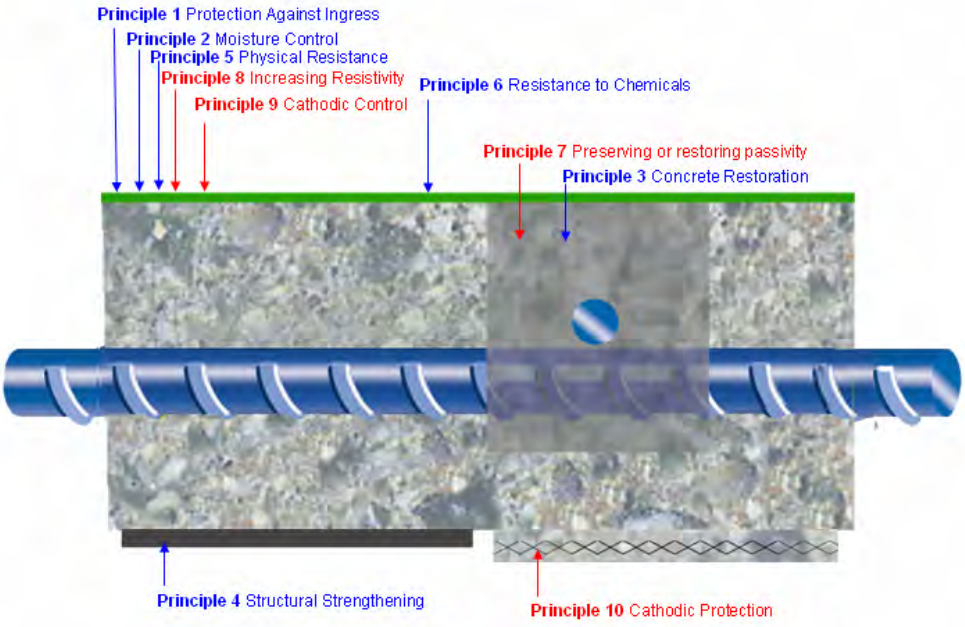


Construction

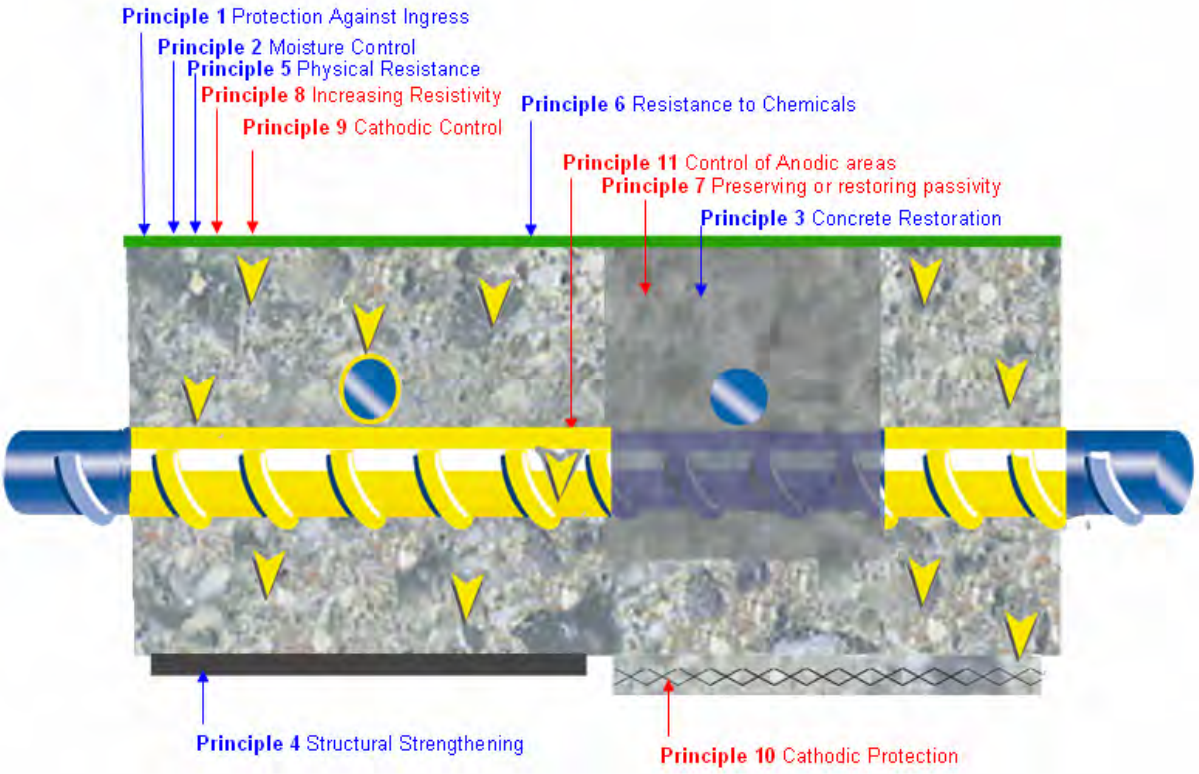
PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 9 (CC)	**Cathodic Control** Creating conditions in which potentially cathodic areas of reinforcement are unable to drive an anodic reaction	9.1 Limiting oxygen content (at the cathode) by saturation or surface coating



PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 10 (CP)	**Cathodic Protection** Polarising the steel reinforcement cathodically so as to reduce the rate of anodic reaction	10.1 Applying electrical potential

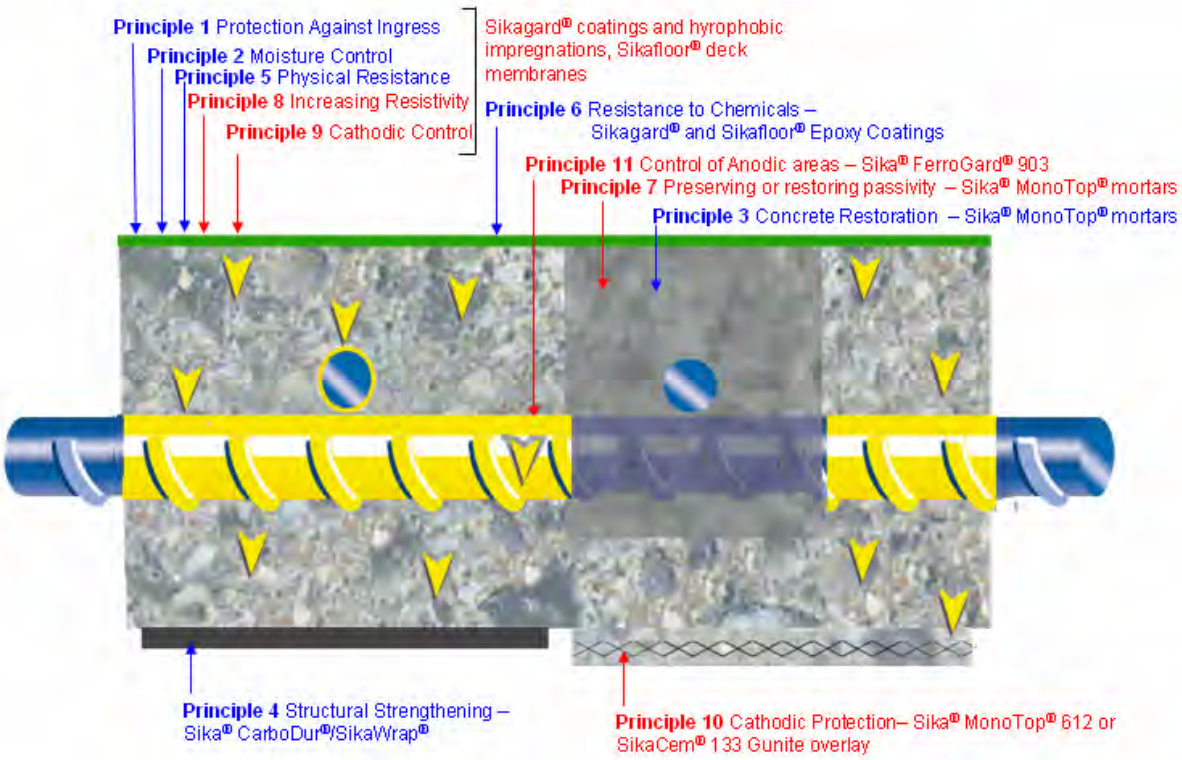


PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE
Principle 11 (CA)	**Control of Anodic Areas** Creating conditions in which potentially anodic areas of reinforcement are unable to take part in the corrosion reaction	11.1 Painting reinforcement with coatings containing active pigments 11.2 Painting reinforcement with barrier coatings 11.3 Applying inhibitors to the concrete



Construction

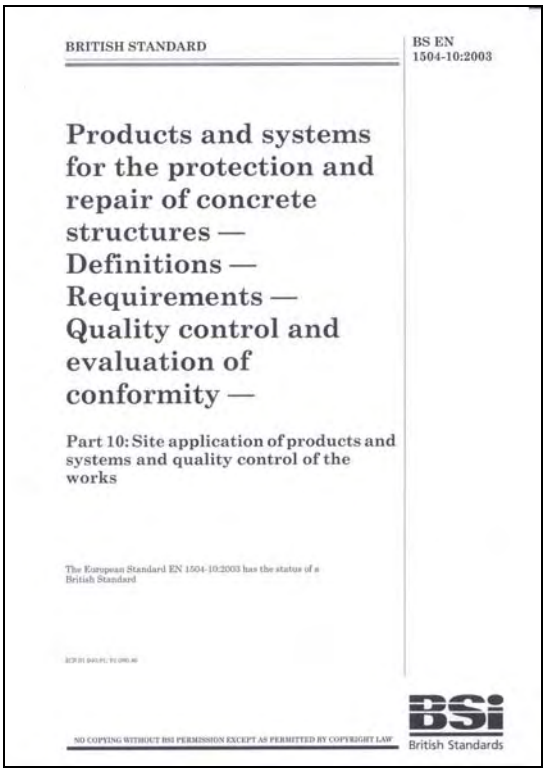
12.0 Sika Product & System Solutions to BS EN 1504-9



Construction

13.0 BS EN1504-10
Site Application of Products and Systems and Quality Control of the Works

BS EN 1504-10 recognises the execution of the work is an important and integral part of the protection and repair process. The standard specifies how the work shall be carried out.


BRITISH STANDARD

BS EN 1504-10:2003

Products and systems for the protection and repair of concrete structures — Definitions — Requirements — Quality control and evaluation of conformity —

Part 10: Site application of products and systems and quality control of the works

The European Standard EN 1504-10:2003 has the status of a British Standard

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BSI British Standards

For each principle and method covered in the previous standards, there are appropriate clauses in BS EN 1504-10 that covers:

- Preparation
- Application
- Quality

Clauses contained in this document can assist in the development of specifications. clauses include:

- Preparation of Concrete
  - Cleaning
  - Roughening
  - Concrete removal
- Preparation of Reinforcement
  - Cleaning
- Application of Products and Systems
  - Bonding
  - Hand applied mortar and concrete
  - Sprayed mortar or concrete
  - Cast mortar or concrete
- Curing
- Cracks and Joints
- Surface Coatings and other treatments
  - Smoothing coatings
  - Surface coatings
- Anchoring
- Plate Bonding

Construction

The previously mentioned clauses are expanded below to highlight the key aspects of the document.

Preparation of Concrete

- GENERAL
  weak, damaged deteriorated, micro-cracked or delaminated concrete removed
- CLEANING
  free from dust, loose material, surface contamination and materials which reduce bond

Techniques

- mechanical, percussion and abrasion
- grit and sand blasting
- water blasting with low pressure up to ~18mpa (2700psi)
- low water volumes up to 60mpa (9000psi)

Roughening

- Appropriate for the products and systems to be applied and shall be specified

Techniques

- Mechanical, percussion and abrasion
- Grit and sand blasting
- Water blasting with high pressure up to 60MPa (9000psi)
- Roughening up to 15mm in depth

Concrete Removal

- Kept to a minimum in accordance with method chosen and shall be specified
- Provide uncontaminated cover on all sides of the reinforcement
- Edges to cut to a minimum angle of 90° and maximum of 135°
- Clearance around corroded reinforcement to substrate – 15.0mm or maximum aggregate size of repair material plus 5.0mm
- Chloride contaminated concrete removed on all sides of corroded rebar for minimum 20mm
- Concrete removal 50mm beyond extent of corrosion along length of bar (from cleaning clause)
- Typing wire fragments, nails and other metal debris removed

Techniques

- Mechanical, percussion
- Hydrodemolition
  - High pressure up to 60MPa (9000psi)
  - Very high pressure up to 110MPa (16500psi)

Construction

Preparation of Reinforcement

- Extent of any cleaning, coating, removal or replacement shall be specified
- Rust, scale, mortar, concrete, dust and other deleterious material which reduces bond or contribute to corrosion shall be removed
- Whole circumference shall be cleaned
- When contaminated by chlorides, clean by water under low pressure below18MPa (2700psi) unless electrochemical methods of protection and repair are to be used
- For active pigment coatings prepare to SA2
- For barrier coatings prepare to SA2½

Application of Products and Systems

Bonding Primer

- Temperature of substrate and repair material should not differ
- Hydrodemolition roughness is greater than any other technique and therefore bonding primer generally not required
- Site adhesion values between repair material and substrate:
  - Structural repair 1.2-1.5MPa
  - Non structural minimum 0.7MPa
- Texture surface of repair material before it has set prior to subsequent layers or apply bonding primer to achieve site adhesion values

Hand Applied Mortar and Concrete

- Cementitious systems used without bonding primer shall be pre-wetted but free from surface water
- Mortar is worked well into substrate and compacted without inclusion of entrapped air pockets, so that strength is achieved and reinforcement protected against corrosion

Sprayed Mortar or Concrete

- Sprayed concrete and mortar can be applied by the wet or dry process and shall comply with the relevant standard for sprayed concrete
- Sprayed concrete or mortar should be applied at an angle as close as possible to 90° to the substrate and at a distance of between 0.5 and 1.0m between the nozzle and the substrate

Cast Mortar or Concrete (Flowable)

- Formwork shall be watertight and allow air and bleed water to escape
- Shall not be vibrated

Curing

- ▲ Comply with ENV 13670-1
- ▲ Curing compounds shall not be used where they adversely affect subsequently applied products and systems
- ▲ Perforated hoses to feed water to hessian covered with transparent plastic sheeting
- ▲ Temperature gradient is as flat as possible to avoid thermal cracking

Cracks and joints

- ▲ Filling cracks can be by injection soaking or vacuum techniques
- ▲ Before filling any cracks, contamination such as oil or other contaminants must be removed
- ▲ Sealing of cracks with bandages may be preferable if cracks are contaminated, too small for filling or if longitudinal and/or shear movements are more than 25% of the crack width
- ▲ Cracks may require to be converted into joints if considerable changes in crack width are expected, eg due to thermal effects or structural movement

Surface Coatings

- ▲ Smoothing coatings shall be applied and cured to fill uneven surface and surface pores before coatings are applied
- ▲ Coatings shall be applied within the specified maximum and minimum thickness

Anchoring

- ▲ Anchors shall not be installed in cracked concrete

Plate Bonding

- ▲ Plate bonding shall be carried out in accordance with BS EN 1504-4 and any other relevant EN or European Technical Approval

Quality Control Tests and Observations

- ▲ 9 control tests are considered

Key on-site tests are:

Characteristics	Maximum and Minimum Parameter
Temperature of substrate	Depends on material but usually between 5°-30°C
Wind strength	Less than 8M/sec
Dew point	Depends on material but usually no application at temperatures less than 3°C above dew point
Degree of filling of cracks	80% is normally acceptable
Adhesion mortars and concrete	It depends but can never be greater than the surface tensile strength of the substrate. Site values within the range of 1.2-1.5MPa for structural repair and a minimum value of 0.7MPa for non structural repair are acceptable
Adhesion surface coatings	It depends on and can never be greater than the surface tensile strength of the substrate

14.0 CONCLUSIONS

- Full implementation date 2009
- The industry has not embraced documents
- Little demand for CE marked repair products
- For products to conform to BS EN 1504 series they have to be CE marked.
  - Labelling and product data sheets
- Current Sika concrete repair mortar product data sheets integrates the European Standard clauses
- Sika have a Product selector to select products in accordance with the guidelines outlined in BS EN 1504-9 Series

CONCRETE REPAIR EUROPEAN STANDARDS 1504-9 SERIES
Principles and Methods Related to Defects in Concrete & Reinforcement Corrosion
SIKA PRODUCT SELECTOR

PRINCIPLE NO	PRINCIPLE DEFINITION	METHODS BASED ON THE PRINCIPLE	SIKA PRODUCTS
Principle 1 (PI)	**Protection Against Ingress** Reducing or preventing the ingress of adverse agents, eg water, other liquids, vapour, gas, chemicals and biological agents	1.1 Impregnation 1.2 Surface coating with and without crack bridging ability 1.3 Locally bandaged cracks 1.4 Filling Cracks 1.5 Transferring cracks into joints 1.6 Erecting external panels 1.7 Applying membranes	Sikafloor Curehard 24 Sikagard 680S, Sikagard 550W, Sikagard ElastoColor 675W, SikaColor 671W, Sikagard AntiGraffiti System, SikaTop Seal 107 Sikadur Combiflex System Sikadur 52 (<.5mm), Sikadur 32 (>0.5mm), Sikadur 31 (>5.0mm) Sikaflex AT range SikaTack Panel System Sikafloor 400N, Sikafloor 350 Elastic, Sikafloor 261
Principle 2 (MC)	**Moisture Control** Adjusting and maintaining the moisture content in the concrete within a specified range of values	2.1 Hydrophobic impregnation 2.2 Surface coating 2.3 Sheltering or overcladding 2.4 Electrochemical treatment	Sikagard 700S Aquastop, Sikagard 702W Aquaphobe Sikagard 680S, Sikagard 550W, Sikagard 545W Elastofil, Sikagard ElastoColor 675W, SikaColor 671W, Sikagard AntiGraffiti System, SikaTop Seal 107 SikaTack Panel System System N/A
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	3.1 Applying mortar by hand 3.2 Recasting with concrete 3.3 Spraying concrete or mortar 3.4 Replacing elements	Sika MonoTop 612, Sika MonoTop 615 Sika Armorex Armorcrete Sika MonoTop 612, SikaCem 133 Gunite Sika Armorex Armorcrete
Principle 4 (SS)	**Structural Strengthening** Increasing or restoring the structural load bearing capacity of an element of the concrete structure	4.1 Adding or replacing embedded or external reinforcing steel bars 4.2 Installing bonded rebars in preformed or drilled holes in the concrete 4.3 Plate bonding 4.3a Structural fabrics 4.4 Adding mortar or concrete 4.5 Injecting cracks, voids or interstices 4.6 Filling cracks, voids or interstices 4.7 Prestressing - (post tensioning)	System N/A Sika AnchorFix 1, Sika AnchorFix 2, Sikadur 42, Sikadur 33 Sika CarboDur Plate Bonding System SikaWrap System Sika MonoTop 612, Sika MonoTop 615 Sikadur 52 (<.5mm), Sikadur 32 (>0.5mm) Sikadur 52 (<.5mm), Sikadur 32 (>0.5mm) Sika CarboDur System
Principle 5 (PR)	**Physical Resistance** Increasing resistance to physical or mechanical attack	5.1 Overlays or coatings 5.2 Impregnation	• Horizontal - Sikafloor Systems (depends on requirements) • Vertical - Sikagard Systems (as 1.2 above) Sikafloor Curehard 24
Principle 6 (RC)	**Resistance to Chemicals** Increasing resistance of the concrete surface to deteriorations by chemical attack	6.1 Overlays or coatings 6.2 Impregnation	Sikagard 62, Sikagard 63N, Sikafloor 390, Sikafloor 381AS Sikafloor 390AS Sikafloor Curehard 24
Principle 7 (RP)	**Preserving or Restoring Passivity** Creating chemical conditions in which the surface of the steel reinforcement is maintained in or is returned to a passive condition	7.1 Increasing cover to reinforcement with additional cementitious mortar or concrete 7.2 Replacing contaminated or carbonated concrete 7.3 Electrochemical realkalisation of carbonated concrete* 7.4 Realkalisation of carbonated concrete by diffusion 7.5 Electrochemical chloride extraction	Sika MonoTop 612, 615, Sika Armorex Armorcrete, SikaCem 133 Gunite Sika MonoTop 612, 615, Sika Armorex Armorcrete, SikaCem 133 Gunite Sika MonoTop 612, 615, Sika Armorex Armorcrete, SikaCem 133 Gunite Sika MonoTop 612, 615, Sika Armorex Armorcrete, SikaCem 133 Gunite Sika MonoTop 612, 615, Sika Armorex Armorcrete, SikaCem 133 Gunite
Principle 8 (IR)	**Increasing Resistivity** Increasing the electrical resistivity of the concrete	8.1 Limiting moisture content by surface treatments, coating or sheltering	Sikagard Protective Coatings (as 1.2 above) Sikafloor Deck Membranes, Sikafloor 261, 350 and 400N Sikagard Hydrophobic Impregnations (as 2.1 above) SikaTack Panel Cladding system
Principle 9 (CC)	**Cathodic Control** Creating conditions in which potentially cathodic areas of reinforcement are unable to drive an anodic reaction	9.1 Limiting oxygen content (at the cathode) by saturation or surface coating	Sikagard Protective Coatings (as 1.2 above) Sikafloor Deck Membranes, Sikafloor 261, 350 and 400N
Principle 10 (CP)	**Cathodic Protection** Polarising the steel reinforcement cathodically so as to reduce the rate of anodic reaction	10.1 Applying electrical potential	Sika MonoTop 612, SikaCem 133 Gunite CP Overlays with mesh
Principle 11 (CA)	**Control of Anodic Areas** Creating conditions in which potentially anodic areas of reinforcement are unable to take part in the corrosion reaction	11.1 Painting reinforcement with coatings containing active pigments 11.2 Painting reinforcement with barrier coatings 11.3 Applying inhibitors to the concrete	Sika Armatec 110, Sika MonoTop 610 Reinforcement Coatings Icosit 6630 Sika FerroGard 903 (also Cathodic control)

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ISO 14001 ISO 9001

For A3 laminated version contact: Sika Limited – Technical Department

Construction

The information contained herein and any other advice are given in good faith based on Sika's current knowledge and experience.

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