C.P. MK 725130 (GB) 07/11

HEADQUARTERS
MAPEI SpA
Via Cafiero, 22
20158 Milan - Italy
Tel. +39 02 37673.1
Fax +39 02 37673.214
Internet: www.mapei.com
E-mail: mapei@mapei.it

MAPEI

Repairs to *bridges and viaducts*

Repairs to ***bridges and viaducts***

MAPEI

www.mapei.com

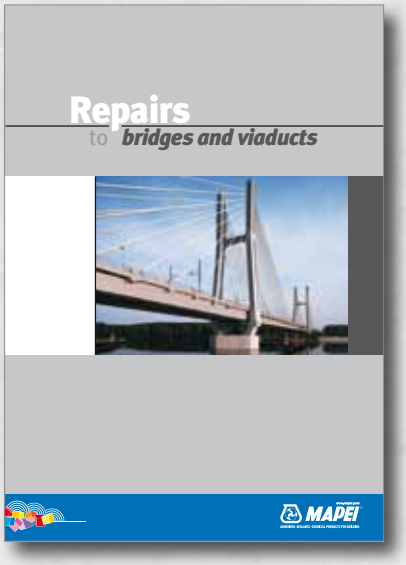
MAPEI®

ADHESIVES · SEALANTS · CHEMICAL PRODUCTS FOR BUILDING

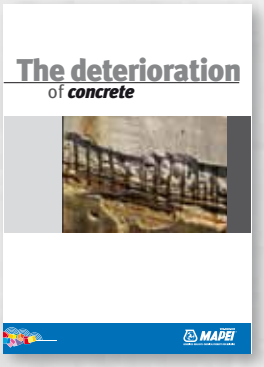
Mapei produces a series of technical manuals so that the subject of the deterioration of concrete may be analysed in depth, and to offer a professional approach to the problems regarding repair work.

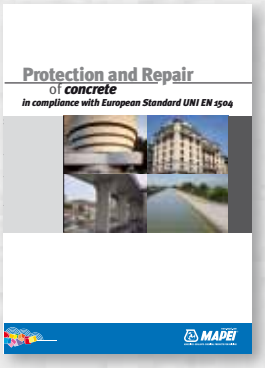
The subject of this manual is:

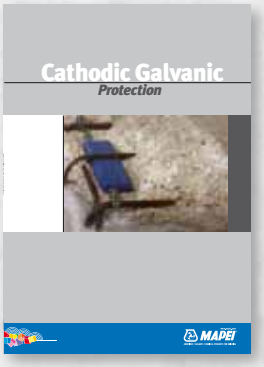
Repairs to bridges and viaducts

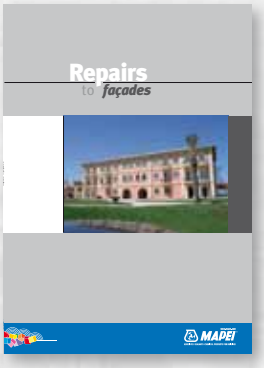


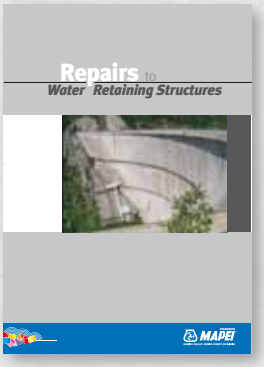
The other manuals available in the series are:

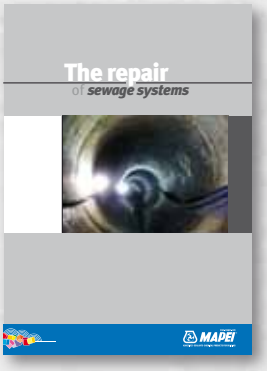












The manuals are available upon request.

Repairs to *bridges and viaducts*

Index

1| Introduction

When the subject of large-scale maintenance of infrastructure is discussed, we are inclined to think about the new, important projects which are being installed all over the country. Not everybody realises that there is another important aspect, which relates to maintenance on existing on infrastructure. In fact, each year the authority which manages the road networks has to invest a considerable amount of money into maintenance and repair work for the existing network which is currently in use, and a large number of these operations are carried out on structures such as bridges and viaducts.

The durability of such structures are severely tested by the enormous load cycles from the traffic in circulation, flooding conditions, aggressive atmospheric agents and the gases which are present in the air. This means that their state of conservation, and in the worst cases their static safety, are put in serious danger. For example, structures built using what are now considered out-of-date design criteria, such as road and railway bridges built in the 19th Century, and the first structures built using reinforced concrete and pre-stressed reinforced concrete in the 20th Century, are highly subject to problems caused by heavy deterioration. We must also consider the fact that the type and volume of traffic has changed enormously from when the structure was built up to today, and that they were built using materials which are inadequate for today's standards, or were built by keeping the costs as low as possible. Therefore, it is quite clear that special attention must be paid to the reliability of these infrastructures, and to intervene where necessary. In many cases, these structures are part of a network which carries heavy volumes of traffic. Apart from the safety issues, when repair work is carried out, there is also the problem of potential traffic congestion when traffic needs to be interrupted to replace or repair the structures.

All the structures in the road system must be well conserved to avoid compromising design responsibility, safety when the structures are in use and the implementation of maintenance operations. If the condition of a structure is not well monitored, it will be subject to such a degree of deterioration that normal maintenance operations will no longer be sufficient, and it will be necessary to carry out a more complex and heavier intervention, at a much higher cost. One way of preventing such problems is to have a detailed inspection programme which periodically singles out maintenance operations required on the structures, thus guaranteeing, apart from the safety of road-users, lower overall maintenance costs.

One of the most important parts of assessing the state of deterioration is a visual inspection, which also singles out the causes of the deterioration:

- intensity of circulating traffic;
- aggressive environment;
- climatic factors;
- excessive loads;

- occasional impacts;
- insufficient drainage system for rainwater.

Amongst all the possible causes of deterioration, road decks suffer most from the effects of atmospheric agents and the presence of water in general. Water due to atmospheric phenomena, with a certain level of pollution and, very often, the presence of de-icing salts, are extremely aggressive for concrete, as are thermal cycles both during the day and night, and during the different seasons of the year. The deterioration of concrete shows up in a number of ways, with the progressive erosion and crumbling of the surface, corrosion of the metal reinforcement and the formation of rust, swelling of the cortex area of the concrete, etc.
Apart from the different causes of deterioration, the problem often shows up at different times, which is why all the structures must be carefully checked on a regular basis in order to identify both routine maintenance and extra maintenance requirements.
Below is a list of methods for the repair of bridges and viaducts:

- Preparation of the substrate;
- Protection of reinforcement rods;
- Positioning new reinforcement;
- Repairing concrete using thixotropic mortar;
- Repairing concrete using castable mortar;
- Repairing concrete using cementitious binders;
- Smoothing off concrete surfaces;
- Protecting and decorating concrete structures.

Each of these methods require different types of products, which are all suitable for achieving the required result, and the choice of which one of these to use depends on the location, the thicknesses to be repaired, on-site organisation, etc.
To make sure that repair work is efficient and long-lasting, having the most suitable products available is not always sufficient. Deterioration to a structure may be due to a multitude of causes, and only if these causes are well known, may we be sure that repair work will be resistant and long-lasting. Regarding this issue, the diagnosis of deterioration is a fundamental phase in the list of operations to be carried out.
Through a detailed analysis of a structure it is possible, and also absolutely essential, to define the type of aggression, the penetration depth of polluting agents and the characteristics of the concrete used for the structure. After these operations, it is then possible to carry out the repair work.

photo 1
Hydro-scarifying operations on a viaduct pile

2| Preparing the substrate

Preparation of concrete surfaces on the external vertical faces of piles and abutments to make them suitable for repair or cladding, with a hydro-scarifying unit with jets of water at a variable pressure of from 1400 a 2500 bar. The unit is mounted on an automatic system for raising and lowering the unit using a system of pulleys and/or telescopic arms, which removes the swollen and loose parts of the deteriorated concrete and the surface oxide from the exposed metallic reinforcement, without compromising the stability of the structure.

Generally, every concrete surface which needs to be repaired requires preparation of the substrate. Which type of demolition technique to use will be evaluated according to the area and type of intervention. Manually, if the repair work is small; mechanically, such as with a pneumatic hammer or grinder; hydro-scarifying, if the area to be repaired is large and the substrate must be in perfect condition.

3| Protecting reinforcement rods

3.1| Protection using MAPEFER

Description*: two-component, anti-corrosion cementitious mortar for protecting reinforcement rods.*

photo 2
Hydro-scarifying operations on a viaduct pile

Apply MAPEFER on perfectly clean, rust-free reinforcement rods to bring the pH level back to more than 12, the minimum level required to guarantee passivation of the reinforcement rods. The mortar creates an impermeable, protective barrier against water and the aggressive agents present in the atmosphere. Apply MAPEFER by brush in two coats. The second coat may be applied 90-120 minutes after the first coat, and preferably within 24 hours. The total thickness of the two coats must be at least 1.5-2 mm. During this operation, it is inevitable that some of the concrete around the reinforcement rods will also be coated with MAPEFER. This will not create any kind of problem, since MAPEFER does not modify the adhesion of the repair mortar which, in normal environmental conditions, may be laid 4-5 hours after applying MAPEFER or even later, according to organisation of the site. The product meets the minimum requirements for EN 1504-7 regarding the protection against corrosion of reinforcement.

MAPEFER has the following performance characteristics:

table 1

Characteristics	Performance of product
Density (kg/m^3):	1900
pH of mix:	> 12.6
Brookfield Viscosity:	20000 mPa•s (6 rotor - 10 rpm)
Pot life:	approx. 1 hour (at 20°C)
Bond strength to concrete (MPa):	> 2.5
Bond strength to sand-blasted steel (MPa):	> 2.5
Consumption:	120 g/m (approx. 2 mm of product applied on ø 8 mm rebar)

3.2| Protection using MAPEFER 1K

Description*: single component, anti-corrosion cementitious mortar for protecting reinforcement rods.*

Apply MAPEFER 1K single component, anti-corrosion cementitious mortar on perfectly clean, rust-free reinforcement rods to bring the pH level back to more than 12, the minimum level required to guarantee passivation of the reinforcement rods. MAPEFER 1K creates a protective, waterproof barrier and protection against aggressive agents present in the atmosphere.
After preparation, apply MAPEFER 1K by brush in two coats. We recommend completely

photo 3
Application of anti-corrosion mortar on reinforcement rods

covering the surface of the reinforcement with an even layer. The total thickness of the two coats must be at least 2 mm. During this operation, it is inevitable that some of the concrete around the reinforcement rods will also be coated with MAPEFER 1K. This will not create any kind of problem, since MAPEFER 1K does not modify the adhesion of the repair mortar which, in normal environmental conditions, may be laid 4-5 hours after applying MAPEFER 1K or even later, according to organisation of the site.
The product meets the minimum requirements for EN 1504-7 regarding the protection against corrosion of reinforcement.

MAPEFER 1K has the following performance characteristics:

table 2

Characteristics	Test method	Minimum requirements according to EN 1504-7	Performance of product
Density of the mix (kg/m^3):	/	/	1,800
pH:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Waiting time before applying repair mortar:	/	/	6-24 hours (at +20°C)
Bond strength to substrate (MPa):	EN 1542	/	> 2.5 (after 28 days)
Slip-resistance of reinforcement rods: - Load with reference to a movement of 0.1 mm:	EN 15184	load equal to at least 80% of load on reinforcement with no protection	meets specifications
Resistance to corrosion: 10 condensation cycles in water; 10 cycles in sulphur dioxide according to EN ISO 6988; 5 days in saline mist according to EN 60068-2-11	EN 15183	after the series of cycles, the protected rods must be corrosion-free. Penetration of rust at the ends of the steel rods with no protection must be < 1 mm	meets specifications
Consumption (g/m):	/	/	100 (approx. 2 mm of product applied on a ø 8 mm improved-adherence rebar)

4| Positioning new reinforcement

Diagnosis of the structure also includes the reinforcement rods, since they are a fundamental part of the concrete. According to the results of the analysis, we can then decide which type of intervention must be carried out. A simple cleaning operation and application of a protective layer of a passivating product could be required. If the reinforcement is seriously compromised, on the other hand, with corrosion which has reduced its section by more than 30%, it will be necessary to place new reinforcement to strengthen the structure. Where necessary, new reinforcement will be placed for the cast concrete to integrate the structure, and will become an integral part of the substrate by inserting a series of connectors. The dimensions and amount of reinforcement will result from the calculation of the reinforcement required for the piles.

photo 4
Positioning new reinforcement

Mapei mortars for repairing concrete

		BRIDGES AND VIADUCTS								
		Repairs to piles	Repairs to beams	Repairs to the internal face of floor slabs	Repairs to the external face of floor slabs	Repairs to pulvinoes	Repairs to reinforced concrete bearing elements	Repairs to kerbs	Repairs to joints in motorways	Fixing inspection shafts and manholes in place
Normal-setting thixotropic mortars	Mapegrout T60	•	•	•	•	•	•	•		
	Mapegrout Easy Flow	•	•	•	•	•	•	•		
	Mapegrout Easy Flow GF	•	•	•	•	•	•	•		
	Mapegrout BM	•	•	•	•	•	•	•	•	
	Mapegrout LM2K	•	•	•		•				
Rapid-setting thixotropic mortars	Mapegrout SV T									•
Normal-setting castable mortars	Mapegrout Hi-Flow					•	•	•	•	•
	Mapegrout Hi-Flow GF					•	•	•	•	
	Mapegrout Hi-Flow TI 20 + Fibres R60					•	•	•	•	•
Rapid-setting castable mortars	Mapegrout SV									•
	Mapegrout SV Fiber + Fibres R38					•	•		•	•
Cementitious binders	Stabilcem	•	•		•	•	•			
	Stabilcem SCC	•	•		•	•	•			
	Stabilcem SP	•	•		•	•	•			

5| Repairing concrete using thixotropic mortars

5.1| Repairs using MAPEGROUT EASY FLOW

Description*: single component, fibre-reinforced, compensated-shrinkage, sulphate-resistant thixotropic mortar, particularly suitable for repairing concrete structures with a rendering machine.*

Particularly suitable for*: repairing concrete structures by application with a rendering machine; particularly suitable when easy pumping over long distances and to elevated positions is required.*

Rebuilding of demolished parts by applying MAPEGROUT EASY FLOW on substrates saturated with water, but with a dry surface.

Thanks to its special composition, MAPEGROUT EASY FLOW is particularly suitable for repairing concrete structures when repair mortar is applied by spray, where the characteristics of the work (considerable height of the structure under repair, such as viaduct piles), the morphology of the site area (little space available to position mixing and pumping units in the vicinity of the structure under repair) and for site organisation requirements, mortar which is easy to pump over long distances and up to considerable heights is required.

To improve expansion in the open air during the first few days of the curing cycle,

photo 5
Mapegrout Easy Flow
applied by spray

MAPEGROUT EASY FLOW must include 0.25% of MAPECURE SRA special liquid admix, which has the property of reducing hydraulic shrinkage and the formation of micro cracks.
Layers of MAPEGROUT EASY FLOW thicker than 3 cm must only be applied after installing electro-welded metallic mesh of at least 10x10 cm and 5 mm diameter and after roughening the surface of the concrete, making sure that the concrete around the reinforcement is at least 2 cm thick. Thinner layers may be applied if there is no reinforcement, but the surface of the substrate must be well roughened before application to contrast expansion.
The mortar may be applied by spray with a suitable worm-screw or piston-type rendering machine, such as a Turbosol or a Putzmeister.
The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

MAPEGROUT EASY FLOW has the following performance characteristics:

table 3

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2,200
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Mechanical characteristics using 17% of water:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 60 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 8 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	27 (after 28 days)
Bond strength to substrate (MPa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Crack resistance:	"O-Ring Test"	/	no cracks after 180 days
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	<5
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.25
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles)	> 2
Reaction to fire:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	18.5 (per cm of thickness)

▶ 5.2| Repairs using MAPEGROUT EASY FLOW GF

Description*: single component, shrinkage-compensated, sulphate-resistant, thixotropic, inorganic fibre-reinforced mortar for repairing concrete structures where higher ductility is required.*

Particularly suitable for*: repairing and/or enlarging sections of concrete structures using a rendering machine, applied at thicknesses of up to 5 cm without supporting reinforcement mesh. This product is particularly suitable when easy pumping over long distances and to elevated positions is required.*

Repairing deteriorated concrete structures and/or enlarging sections in concrete structures using MAPEGROUT EASY FLOW GF applied with a rendering machine. Thanks to its special composition, MAPEGROUT EASY FLOW GF is particularly suitable for repairing concrete

MAPEGROUT EASY FLOW GF has the following performance characteristics:

table 4

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2,200
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Mechanical characteristics using 16% of water:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 60 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 11 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	27 (after 28 days)
Bond strength to substrate (MPa):	EN 1542	≥ 2 (after 28 days)	≥ 2 (after 28 days)
Crack resistance:	"O-Ring Test"	/	no cracks after 180 days
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	<5
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.25
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles))	> 2
Reaction to fire:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	18.5 (per cm of thickness)

structures when repair mortar is applied by spray, where the characteristics of the work (considerable height of the structure under repair, such as viaduct piles), the morphology of the site area (little space available to position mixing and pumping units in the vicinity of the structure under repair) and for site organisation requirements, mortar which is easy to pump over long distances and up to considerable heights is required.
In fact, after mixing MAPEGROUT EASY FLOW GF with water, it forms a mortar with a thixotropic consistency which is very easy to apply, even on vertical surfaces, at thicknesses of between 1 and 5 cm without the need for dolly rods and formwork. To improve expansion in the open air during the first few days of the curing cycle, MAPEGROUT EASY FLOW GF must include 0.25% of MAPECURE SRA special liquid admix, which has the property of reducing hydraulic shrinkage and the formation of micro cracks.
The mortar is usually applied using either a piston or worm-screw spray rendering machine, such as a Turbosol or a Putzmeister.
The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

5.3| Repairs using MAPEGROUT T60

Description*: fibre-reinforced, sulphate-resistant thixotropic mortar for repairing concrete.*

Particularly suitable for*: repairing deteriorated, normal concrete structures and reinforced cement structures subject to attack by sulphur. Hydraulic structures, repairs to concrete around reinforcement rods and applications on ceilings, such as the inside face of floor slabs.*

photo 6
Structure repaired using Mapegrout T60

Repairing deteriorated, normal concrete structures and reinforced cement structures subject to attack by sulphur using MAPEGROUT T60. Apply on substrates saturated with water, but with a dry surface. When this product is mixed with water, it forms a thixotropic mortar which is easy to apply on vertical surfaces, even in thick layers, without formwork. To improve expansion in the open air during the first few days of the curing cycle, MAPEGROUT T60 may include 0.25%-0.5% of MAPECURE SRA special admix, which has the property of reducing plastic and hydraulic shrinkage and the formation of micro cracks. If there is insufficient boundary support, filling layers of more than 20 mm must only be applied after inserting dolly rods and roughing the surface of the concrete. A layer of at least 20 mm thick must be applied over the rods.

MAPEGROUT T60 has the following performance characteristics:

table 5

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2200
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Mechanical characteristics using 17% of water:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 60 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 8 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	27 (after 28 days)
Bond strength to substrate (MPa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Crack resistance:	"O-Ring Test"	/	no cracks after 180 days
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	< 5
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.25
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles))	> 2
Fire resistance:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	18.5 (per cm of thickness)

MAPEGROUT T60 may be applied by spray with a suitable worm-screw or piston-type spray rendering machine, such as a Turbosol or a Putzmeister.
The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

5.4| Repairs using MAPEGROUT BM

Description*: two-component cementitious mortar with a low modulus of elasticity for the restoration of concrete.*

Particularly suitable for*: repairing deteriorated parts in concrete, the corners of beams and pillars and the front edges of balconies. Filling rigid joints, for example between footings and pillars.*

photo 7
Mapegrout BM applied by spray

Repairing deteriorated cortices of concrete structures which are subject to small deformations under load, thermal cycles or which are exposed to particularly harsh climatic conditions using MAPEGROUT BM. Apply on substrates saturated with water, but with a dry surface.
The maximum thickness to be applied for each layer is approximately 35 mm. For thicknesses of more than 30 mm, we recommend using electro-welded mesh embedded in the mortar.
The product is applied by trowel or by spray without formwork, even on vertical surfaces or

ceilings. The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

MAPEGROUT BM has the following performance characteristics:

table 6

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2100
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 47 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 10 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	22 (after 28 days)
Bond strength to substrate (MPa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	<10
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.25
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles))	> 2
Fire resistance:	Euroclass	according to value declared by manufacturer	E
Consumption (kg/m^2):	/	/	approx. 21 (per cm of thickness)

5.5| Repairs using MAPEGROUT SV T

Description*: quick-setting and hardening, compensated-shrinkage thixotropic mortar for repairing concrete and fixing drains, manholes and urban fittings in place.*

Particularly suitable for*: repairing concrete elements, including those with a slope. Fixing inspection shafts and manholes in place, repairing pavements and fixing lamp-posts and fences in place. Anchoring protective barriers and crash barriers in place. Fixing grated covers for run-off channels in place.*

MAPEGROUT SV T is a single component, pre-blended, compensated-shrinkage thixotropic mortar in powder form, made from special hydraulic binders, high-strength cement, graded aggregates and special additives. MAPEGROUT SV T is suitable where large thicknesses

photo 8
An example of the application of Mapegrout SV T

need to be applied (up to 5 cm), in specially-prepared areas without the use of formwork.
Thanks to its rapid hardening properties, it may be stepped on and opened to rubber-wheeled traffic after only 2 hours from application at a temperature of 23°C. Thanks to its special composition and the additives contained in the product, the mortar has high mechanical qualities even after a long period of time, is waterproof and is highly resistant to abrasion. Apply the product using a trowel in the pre-prepared area. The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural morta.

MAPEGROUT SV T has the following performance characteristics:

table 7

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2250
pH of mix:	/	/	> 12
Pot life of mix:	/	/	approx. 10 min. (at 20°C)
Mechanical characteristics using 13% of water at 20°C:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 45 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 6 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	25 (after 28 days)
Bond strength to substrate (MPa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Thermal compatibility to freeze/thaw cycles with de-icing salts, measured as adhesion according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles)	> 2
Fire resistance:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	approx. 20 (per cm of thickness)

5.6| Repairs using MAPEGROUT LM2K

Description: *two-component, thixotropic, fibre-reinforced, cementitious mortar with a low modulus of elasticity and added organic corrosion inhibitor for repairing concrete, applied in a single layer at a thickness of from 3 to 20 mm.*

Particularly suitable for: *smoothing over surface defects in cast concrete, such as gravel clusters, spacer holes, construction joints, etc. Repairing deteriorated elements, such as beams, piles and pulvinoes.*

MAPEGROUT LM2K is a pre-blended thixotropic cementitious mortar with corrosion inhibitor made from two pre-dosed components to be mixed together.
Component A (powder) is made from cement, selected, mixed aggregates, synthetic fibres and special additives which reduce both plastic shrinkage and final hygrometric shrinkage.

photo 9
Application of MAPEGROUT LM2K

MAPEGROUT LM2K has the following performance characteristics:

table 8

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R3 class mortar	Performance of product
Density of mix (kg/m^3):	/	/	2080
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Compressive strength (Mpa):	EN 12190	≥ 25 (after 28 days)	≥ 38 (after 28 days)
Flexural strength (Mpa):	EN 196/1	/	≥ 7 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 15 (after 28 days)	17 (after 28 days)
Bond strength to substrate (Mpa):	EN 1542	≥ 1.5 (after 28 days)	≥ 2 (after 28 days)
Resistance to accelerated carbonatation:	EN 13295	Depth of carbonatation ≤ the reference concrete (MC 0.45 type water/cement ratio ≤ 0.45) according to UNI 1766	meets specifications
Thermal compatibility to freeze/thaw cycles with de-icing salts measured as bond strength EN 1542 (MPa):	EN 13687/1	≥ 1.5 (after 50 cycles)	≥ 2
Reaction to fire:	Euroclass	value declared by manufacturer	E
Consumption (kg/m^2):	/	/	approx. 21 (per cm of thickness)

Component B (liquid) is a solution of synthetic resin in water.
After hardeining, Mapegrout LM2K has the following properties:

- Low modulus of elasticity;
- Excellent bond strength to old concrete (< 2 MPa) if dampened with water before application, and to reinforcement rods, especially if treated beforehand with MAPEFER or MAPEFER 1K;
- High dimensional stability and, therefore, low risk of cracking during the plastic phase and when hardened;
- Resistance to aggressive agents in the atmosphere (e.g. CO_2).

The product meets the minimum requirements of EN 1504-3 for R3-class structural mortar.

5.7| Summary of the main characteristics of thixotropic repair mortars

	THIXOTROPIC MORTARS					
Characteristics	**Mapegrout Easy FLow**	**Mapegrout Easy Flow GF**	**Mapegrout T60**	**Mapegrout BM**	**Mapegrout LM2K**	**Mapegrout SV T**
Standards class according to EN 1504-3	R4	R4	R4	R4	R3	R4
Maximum size of aggregate	2.5 mm	2.5 mm	2.5 mm	2.5 mm	2.5 mm	2.5 mm
Mixing ratio	16.5% - 17.5% of water	15.5% - 16.5% of water	16.5% - 17.5% of water	Comp. A : Comp.B 5.3 : 1	Comp. A : Comp.B 10 : 2.1	12.5% - 13.5% of water
Density of mix	2200 k g/m^3	2200 kg/m^3	2200 kg/m^3	2100 kg/m^3	2080 kg/m^3	2250 kg/m3^3
Application temperature range	from +5°C to +35°C	from +5°C to +35°C	from +5°C to +35°C	from +5°C to +35°C	from +5°C to +35°C	from +5°C to +35°C
Pot life of mix	approx 1h	approx 1h	approx 1h	approx 1h	approx 1h	approx 10'
Compressive strength	> 60 MPa after 28 days	> 60 MPa after 28 days	> 60 MPa after 28 days	> 47 MPa after 28 days	≥ 38 MPa after 28 days	45 MPa after 28 days
Flexural strength	> 8 MPa after 28 days	11 MPa after 28 days	> 8 MPa after 28 days	> 10 MPa after 28 days	> 7 MPa after 28 days	> 6 MPa after 28 days
Compressive modulus of elasticity	27 GPa after 28 days	27 GPa after 28 days	27 GPa after 28 days	22 GPa after 28 days	17 GPa after 28 days	25 GPa after 28 days
Bond strength on concrete according to EN 1766	> 2 MPa after 28 days	> 2 MPa after 28 days	> 2 MPa after 28 days	> 2 MPa after 28 days	> 2 MPa after 28 days	> 2 MPa after 28 days
Thermal compatibility to freeze-thaw cycles with de-icing salts, measured as bond strength according to EN 1542	> 2 MPa	> 2 MPa	> 2 MPa	> 2 MPa	> 2 MPa	> 2 MPa
Maximum thickness applied by hand	35 mm	50 mm	40 mm	35 mm	20 mm	50 mm
Consumption	18.5 kg/cm^2 per cm of thickness	18.5 kg/cm^2 per cm of thickness	18.5 kg/cm^2 per cm of thickness	21 kg/cm^2 per cm of thickness	21 kg/cm^2 per cm of thickness	20 kg/cm^2 per cm of thickness

6| Repairing concrete using castable mortar

6.1| Repairs using MAPEGROUT HI-FLOW

Description*: fibre-reinforced, shrinkage-controlled mortar for repairing concrete.*

Particularly suitable for*: repairs in thick layers to concrete structures. Structural reintegration of concrete beams and pillars by casting into formwork, floor slabs and floors.*

MAPEGROUT HI-FLOW is used to repair concrete structures where high thicknesses and special conformations of deterioration require the use of a castable mortar. Apply on substrates saturated with water, but with a dry surface. When mixed with water, MAPEGROUT HI-FLOW forms a highly-fluid mortar, suitable for application by casting into formwork with no risk of segregation, including when applied at high thicknesses. To improve expansion in the open air during the first few days of the curing cycle, MAPEGROUT HI-FLOW must include 0.25% of MAPECURE SRA special liquid admix, which has the property of reducing hydraulic shrinkage and the formation of micro cracks. Pour the mortar into the formwork in a continuous flow from one side only, in order to help all air to be expelled.

The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

photo 10
Structure repaired using Mapegrout HI-FLOW

MAPEGROUT HI-FLOW has the following performance characteristics:

table 9

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2350
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Mechanical characteristics using 13% of water:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 75 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	12 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	27 (after 28 days)
Bond strength to substrate (MPa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Crack resistance:	"O-Ring Test"	/	no cracks after 180 days
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	<5
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.08
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles)	> 2
Fire resistance:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	approx. 21 (per cm of thickness)

6.2| Repairs using MAPEGROUT HI-FLOW GF

Description: *castable, compensated-shrinkage cementitious mortar reinforced with inorganic fibres, for repairing concrete structures where higher ductility is required.*

Particularly suitable for: *repairing motorway, road and railway viaduct piles. Repairing the lower spigots on pre-compressed beams for viaducts. Reintegrating floor slabs after removing deteriorated areas by scarifying. Repairs to concrete floors.*

MAPEGROUT HI-FLOW GF, is a one-component pre-blended mortar made from high-strength cement, selected graded aggregates, special additives and synthetic and inorganic fibres.
When MAPEGROUT HI-FLOW GF is mixed with water, it forms a fluid mortar which is suitable for casting into formwork without segregating at a thickness of between 1 and 5 cm. No electro-welded mesh is required as a support. MAPEGROUT HI-FLOW GF

may also include 0.25% of MAPECURE SRA, a special admix with the property of reducing plastic and hydraulic shrinkage and the formation of micro cracks. The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

photo 11
Application of Mapegrout HI-FLOW GF

MAPEGROUT HI-FLOW GF has the following performance characteristics:

table 10

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of mix (kg/m^3):	/	/	2350
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
pH of mix:	/	/	> 12.5
Compressive strength (Mpa):	EN 12190	≥ 45 (after 28 days)	≥ 65 (after 28 days)
Flexural strength (Mpa):	EN 196/1	/	10 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	27 (after 28 days)
Bond strength to substrate (Mpa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Resistance to accelerated carbonatation:	EN 13295	Depth of carbonatation ≤ the reference concrete (MC 0.45 type water/cement ratio ≤ 0.45) according to UNI 1766	meets specifications
Thermal compatibility to freeze/thaw cycles with de-icing salts measured as bond strength EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles)	> 2
Reaction to fire:	Euroclass	value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	approx. 21 (per cm of thickness)

6.3| Repairs using MAPEGROUT HI-FLOW TI 20 + FIBRES R60

Description: *castable, shrinkage-compensated, fibre-reinforced, high-ductility cementitious mortar, used in combination with stiff steel fibres for repairing concrete.*

Particularly suitable for: *repairing concrete structures where high thicknesses are required, by casting into formwork at a thickness of up to 5 cm without the need for reinforcement mesh.*

Structural reintegration of pillars, beams, pulvinoes and reinforced concrete bearing elements, reintegration of floor slabs and repairs to concrete floors.

photo 12
Application of
Mapegrout HI-FLOW TI 20 + Fibre R60

Repairs where high thicknesses are required, or when repairs to complicated shapes require the use of a free-flowing mortar, using MAPEGROUT HI-FLOW TI 20 + FIBRES R60.

Apply on substrates saturated with water but with a dry surface. When MAPEGROUT HI-FLOW TI 20 is mixed with water and 4.5% of FIBRES R60, it forms a highly fluid mortar which is suitable for casting into formwork, without segregation, at a thickness of between 1 and 5 cm, and does not require electro-welded mesh as a support. To improve expansion in the open air during the first few days of the curing cycle, MAPEGROUT HI-FLOW TI 20 must include 0.25% of MAPECURE SRA special liquid admix, which has the property of reducing hydraulic shrinkage and the formation of micro cracks.

Pour MAPEGROUT HI-FLOW TI 20 into the formwork in a continuous flow from one side only, in order to help all air to be expelled.

The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

MAPEGROUT HI-FLOW TI20 + FIBRES R60 has the following performance characteristics:

table 11

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2300
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 1 hour (at 20°C)
Mechanical characteristics using 14% of water:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 70 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 16 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	27 (after 28 days)
Bond strength to the substrate (MPa):	EN 1542	≥ 2 (after 28 days)	≥ 2 (after 28 days)
Impeded contraction in open air (μm/m):	UNI 8147 mod.	/	> 400 (after 1 day)
Crack resistance:	"O-Ring Test"	/	no cracks after 180 days
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	< 5
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.3
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa):	EN 13687/1	≥ 2 (after 50 cycles)	> 2
Toughness: - load at first cracking: - toughness index:	ASTM C1018	none	> 20 kN I_{20} > 20
Fire resistance:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	approx. 20 (per cm of thickness)
CHARACTERISTICS OF THE FIBRES			
Length (mm):	/	/	30
Diameter (mm):	/	/	0.6
Tensile strength (MPa):	/	/	> 1200
Modulus of elasticity (GPa):	/	/	210

6.4| Repairs using MAPEGROUT SV FIBER + FIBRES R38

Description: *castable, shrinkage-compensated, quick-setting/hardening, high-ductility cementitious mortar applied at temperatures as low as -5°C, used in combination with stiff steel fibres for repairing concrete.*

Particularly suitable for: *repairing concrete structures where high thicknesses and special conformations of deterioration require the use of a free-flowing mortar, including at low temperatures. Repairs to concrete floors. Repairing hydraulic structures (breather channels, canals and forced run-off channels).*

Casting MAPEGROUT SV FIBER into leak-proof formwork, at a thickness of from 10 to 50 mm. MAPEGROUT SV FIBER must be mixed with rigid, stiff, hooked fibres in brass-plated steel called FIBRES R38 with the following characteristics:

- Length: 30 mm
- Diameter: 0.38 mm
- Tensile strength: >2,.600 MPa

When MAPEGROUT SV FIBER is mixed with water and 2.5% of fibres, it forms a fluid mortar which is suitable for casting into formwork, without segregation, at a thickness of between 10 and 50 mm.
If the thickness to be repaired is higher than 50 mm, suitably-sized gravel according to the

photo 13
Repairing a floor using Mapegrout SV Fiber

thickness to be rebuilt must be added at a rate of 30% to 50% in weight of the mortar. The cast mortar must be reinforced as required with metallic reinforcement inserted at approximately half the thickness of the mortar, and must be connected to the old reinforcement rods. Also, the surfaces of the element under repair must be saturated with water. The product meets the minimum requirements of EN 1504-3 Standards for R4-class structural mortar.

MAPEGROUT SV FIBER has the following performance characteristics:

table 12

Characteristics	Test method	Minimum requirements according to EN 1504-3 for R4 class mortar	Performance of product
Density of the mix (kg/m^3):	/	/	2400
pH of mix:	/	/	> 12.5
Pot life of mix:	/	/	approx. 20 min. (at 20°C)
Mechanical characteristics using 13.5% of water and 20°C:			
Compressive strength (MPa):	EN 12190	≥ 45 (after 28 days)	> 70 (after 28 days)
Flexural strength (MPa):	EN 196/1	/	> 20 (after 28 days)
Compressive modulus of elasticity (GPa):	EN 13412	≥ 20 (after 28 days)	29 (after 28 days)
Bond strength to the substrate (MPa):	EN 1542	≥ 2 (after 28 days)	> 2 (after 28 days)
Crack resistance:	"O-Ring Test"	/	no cracks after 180 days
Resistance to accelerated carbonatation:	EN 13295	depth of carbonatation ≤ than the reference concrete (MC 0.45 type water/cement ratio = 0.45) according to UNI 1766	meets specifications
Impermeability to water: - penetration depth - (mm):	EN 12390/8	/	< 5
Capillary absorption (kg/m^2 • h$^{0.5}$):	EN 13057	≤ 0.5	< 0.35
Slip-resistance of reinforcement rods: - bonding stress - (MPa):	EN 15184	/	≥ 25
Thermal compatibility to freeze-thaw cycles with deicing salts, measured as bonding according to EN 1542 (MPa)	EN 13687/1	≥ 2 (after 50 cycles)	> 2
Toughness: - load at first cracking: - toughness index:	ASTM C1018	none	> 20 kN I_{20} > 20
Fire resistance:	Euroclass	according to value declared by manufacturer	A1
Consumption (kg/m^2):	/	/	approx. 20 (per cm of thickness)
CHARACTERISTICS OF THE FIBRES			
Length (mm):	/	/	30
Diameter (mm):	/	/	0.38
Tensile strength (MPa):	/	/	> 2.600

6.5| Summary of the main characteristics of castable repair mortars

	CASTABLE MORTARS			
Characteristics	**Mapegrout Hi-Flow**	**Mapegrout Hi-Flow GF**	**Mapegrout Hi-Flow TI 20 + Fibre R60**	**Mapegrout SV Fiber + Fibre R38**
Standards class according to EN 1504-3	R4	R4	R4	R4
Maximum size of aggregate	2.5 mm	2.5 mm	2.5 mm	2.5 mm
Mixing ratio	13% - 14% of water	14% - 16% of water	14% - 16% of water	13.5% - 14.5% of water
Density of mix	2350 kg/m^3	2350 kg/m^3	2300 kg/m^3	2350 kg/m^3
Application temperature range	from +5°C to +35°C	from +5°C to +35°C	from +5°C to +35°C	from +5°C to +35°C
Pot life of mix	approx 1h	approx 1h	approx 1h	from 15' to 1 h
Compressive strength	> 75 MPa after 28 days	> 65 MPa after 28 days	> 70 MPa after 28 days	> 70 MPa after 28 days
Flexural strength	12 MPa after 28 days	10 MPa after 28 days	> 16 MPa after 28 days	> 20 MPa after 28 days
Compressive modulus of elasticity	27 GPa after 28 days	27 GPa after 28 days	27 GPa after 28 days	29 GPa after 28 days
Bond strength on concrete according to EN 1766	> 2 MPa after 28 days	> 2 MPa after 28 days	> 2 MPa after 28 days	> 2 MPa after 28 days
Thermal compatibility to freeze-thaw cycles with de-icing salts, measured as bond strength according to EN 1542	> 2 MPa	> 2 MPa	> 2 MPa	> 2 MPa
Maximum thickness applied by hand	40 mm	50 mm	50 mm	50 mm
Consumption	21 kg/cm^2 per cm of thickness	21 kg/cm^2 per cm of thickness	20 kg/cm^2 per cm of thickness	20 kg/cm^2 per cm of thickness

7| Repairing concrete using cementitious binders

7.1| Repairs using STABILCEM

Description*: expansive, super-fluid cementitious binder for mixing injection slurry, mortar and concrete.*

Particularly suitable for*: preparing compensated-shrinkage fluid concrete and beton for casing into formwork. Injection applications, below foundations and filling rigid joints.*

Repairs using controlled-shrinkage, high-strength consolidating slurry, mortar and pumped concrete using STABILCEM super-fluid cementitious binder to prepare injected slurry, mortar, beton and concrete.

STABILCEM has the following performance characteristics:

table 13

Characteristics	Performance of product
Density of the mix (kg/m^3):	2230
Slump flow (UNI 7044-72) (%):	160-180
Bleeding:	none
Compressive strength (MPa):	> 62
Flexural strength (MPa):	> 9 (after 28 days)
Dosage of binder: - injection slurry (kg/dm^3) - mortar and beton (kg/cm^3): - concrete (kg/m^3):	 1.6 (of cavities to be filled) 350-550 300-400

7.2| Repairs using STABILCEM SCC

Description*: cementitious binder for mixing self-compacting, volumetrically-stable beton and concrete, used for repairing concrete structures.*

Particularly suitable for*: preparing self-compacting, shrinkage-compensated, high-strength concrete and beton, applied by pumping or casting, without the need to vibrate the cast concrete.*

Increasing the section of piles using self-compacting, high-strength, pozzolanic-reaction volumetrically-stable concrete without segregation.

Concrete applied using a concrete pump or by casting into formwork, without the need of vibrating the cast concrete.

STABILCEM SCC special binder must be used to prepare the concrete, a specially formulated product to guarantee no shrinkage during the first few weeks of the curing cycle, including in open air.

photo 14
An example of concrete prepared using Stabilcem SCC

Beton and concrete prepared using STABILCEM SCC have the following characteristics:

table 14

Characteristics	Performance of product
Volume mass of the mix (kg/m^3):	2300
Slump flow (cm):	72
Compressive strength (Mpa): after 18 h at 10°C: after 18 h at 15°C: after 18 h at 20°C: after 1 day at 10°C: after 1 day at 15°C: after 1 day at 20°C: after 28 days at 10°C: after 28 days at 15°C: after 28 days at 20°C:	 > 2 MPa > 10 MPa > 18 MPa > 8 MPa > 18 MPa > 24 MPa > 55 MPa > 55 MPa > 55 MPa
Bleeding:	none
Restrained expansion (UNI 8148 mod.): (open-air curing at 20°C and 55% R.H.): after 24 hours: after 90 days:	 300 µm/m < 100 µm/m
Impermeability according to ENI 12390-8 penetration of water:	< 5 mm
Beton must be impermeable to water and conform to the exposition classes according to EN 206-1 Standards:	XC1-XC4, XS1-XS3, XD1-XD3, XF1-XF4, XA1-XA3
Dosage of binder: beton (kg/m^3): concrete (kg/m^3):	 600 500-600

According to the type of aggregate available and performance characteristics required, the dose of binder must be between 550 and 600 kg/m^3. The concrete is prepared on site or a in a cement-mixing plant, and must include from 25 to 35 kg/m^3 of calcium oxide-based expanding agent, and 5 kg/m^3 of MAPECURE SRA glycol-based curing admix, which has the property of containing shrinkage by reducing the surface tension of the capillary pores in the cementitious paste, and DYNAMON SP3 super-plasticiser or similar admix, according to the surrounding temperature, so that the formwork may be removed approximately 14 hours after casting.
The mix must contain inert materials with a good grain-size distribution with a maximum diameter of 15 mm, and a water/binder ratio of ≤ 0.35.

7.3| Repairs using STABILCEM SP

Description*: lightly expansive, cementitious binder for mixing mortar and beton, for the repair of concrete structures.*

Particularly suitable for*: preparing low-shrinkage, high-strength pumpable mortar and beton. For example, repairing bridge structures and joints, beams and kerbs on viaducts by applying pumped material.*

STABILCEM SP is a cementitious-based binder in powder form with special additives, used instead of normal cement to prepare high quality mortar. The use of STABILCEM SP allows for the preparation of mortar which does not segregate, which has a low water/cement ratio and high compressive strength. According to the type of work to be carried out and the consistency chosen, the mortar may be applied using traditional techniques or with a concrete pump.

450 g of STABILCEM SP with 1,350 g of normal sand and 225 g of water have the following performance characteristics:

table 15

Characteristics	Performance of product
Density (g/cm^3):	2.25
Slump flow (UNI 1015/3) (mm):	180
Compressive strength (MPa) (after 28 days):	> 43
Flexural strength (MPa) (after 28 days):	> 8

7.4 Summary of main characteristics of mortars made with cementitious binders

	CEMENTITIOUS BINDERS
Characteristics	**Stabilcem**
Mortar made from Stabilcem:	Mixing water: 225 g Stabilcem: 450 g Normalised sand: 1350 g
Slump flow (UNI 7044-72) (%)	160-180
Weight (kg/l)	2,23
Bleeding	absent
Compressive strength (MPa)	> 62 after 28 days
Flexural strength (MPa)	> 9 after 28 days
Bonding slurry made from Stabilcem:	Stabilcem: 2000 g water: 620 g
Flow-cone (EN 445):	20 - 30 seconds
Weight (kg/l)	2-2.1
Compressive strength (MPa)	> 80 after 28 days
Flexural strength (MPa)	> 8 after 28 days
Expansion in plastic phase according to Standard UNI 8996/89 (%)	≥ 0.3

	CEMENTITIOUS BINDERS			
Characteristics	**Stabilcem SCC**			
Dosage of Stabilcem (kg/m³)	515	550	600	655
Dosage of aggregates (kg/m³)	1615	1530	1470	1435
Dosage of water (kg/m³)	240	215	230	230
Density (kg/m³)	2367	2298	2303	2318
Water/binder ratio	0.47	0.39	0.38	0.35
Slump flow (cm)	71	74	72	76
Compressive strength after 28 days (MPa)	49	53	55	57
Shrinkage according to UNI 6555 (mm)	435	445	440	468
Impermeability to water according to ENV 206	no	yes	yes	yes

	CEMENTITIOUS BINDERS
Characteristics	**Stabilcem SP**
Composition of mix:	Stabilcem SP: 450 g water: 225 g normalised sand: 1350 g
Slump flow (EN 1015/3) (mm)	180
Density of mix (kg/m^3)	2250
Bleeding:	absent
Compressive strength (MPa)	> 43
Flexural strength (MPa)	> 8

Mapei mortars for smoothing, levelling, protecting and waterproofing concrete

	Product	Monofinish	Mapefinish	Mapelastic	Mapelastic Smart
Type	Normal setting	•	•	•	•
	Rapid setting				
Application	Trowel/Flat trowel	•	•	•	
	Roller/Brush				•
Where to use	Natural finish smoothing layer	•	•		
	Flexible finishing and smoothing layer			•	•
	Smoothing out surface defects	•	•		
	Localised repairs				
	Abrasion resistance		•		
	Protection against aggressive agents	•	•	•	•

8| Smoothing, protecting and waterproofing concrete surfaces

8.1| Protecting and waterproofing with MAPELASTIC

Description*: two-component, flexible cementitious mortar for protecting and waterproofing concrete surfaces, balconies and swimming pools.*

Particularly suitable for*: waterproofing and protecting concrete structures, including those subject to small deformations, render and cementitious screeds.*

Water tanks, bathrooms, showers, balconies and retaining walls.

Protecting against the penetration of water and aggressive atmospheric agents, seawater, de-icing salts and sulphate salts.

Waterproofing and protecting structures using MAPELASTIC. After mixing together the two components which make up MAPELASTIC to form a homogenous, lump-free product, apply according to the type of intervention to be carried out. The product may be applied manually using a smooth trowel or, in the case of large surface areas, as in this case, by spray using a rendering machine with a smoothing and levelling fitting.

One of the following machines may be used to apply the product by spray:

1. Turbosol T6 or similar;
2. Agres Jolly;
3. Putzmeister S5 EV/TM/2.

photo 15
An example of the application of Mapelastic on a bridge pile

Whatever type of the above equipment is used, a fitting for smoothing and levelling fitting must be used with a 10 mm diameter nozzle, with an air compressor with a capacity of 800 l/min.
Dampen the surface, spray on a layer of at least 2 mm of MAPELASTIC within 60 minutes of mixing and finish off with a flat trowel.
Thanks to the high content and quality of the synthetic resins, the hardened layer of the product remains highly flexible under all environmental conditions.
The product meets the minimum requirements of EN 1504-2.

MAPELASTIC has the following performance characteristics:

table 16

Characteristics	Performance of product
Mixing ratio:	component A : component B = 3 : 1
Density of the mix (kg/m^3):	1700
Pot life of mix:	1 hour (at 20°C)
Bond strength to concrete (MPa): - after 28 days at 20°C and 50% R.H.: - after 7 days at 20°C and 50% R.H. + 21 days in water:	 1.1 0.6
Impermeability (EN12390/8 Mod) (1.5 atm for 7 days):	waterproof
Elongation according to DIN 53504 Mod: - after 28 days at 20°C and 50% R.H. (%):	 30
Vapour diffusion resistance coefficient (μ):	1,500
Resistance to freeze/thaw cycles of the treated concrete (UNI 7087):	more than 300 cycles
Resistance to calcium chloride (after 60 days in a 30% CaCl solution), measured by checking the loss in compressive strength of a protected concrete sample with a water/cement ratio of 0.4:	no loss in performance
Resistance to sodium chloride (after 60 days in a 10% NaCl solution), measured by checking the Cl- ion penetration in a protected concrete sample with a water/cement ratio of 0.8 (mm):	≤ 2
Resistance to carbonatation (after 60 days in a 30% CO2 solution), measured by checking the carbonatation penetration in a protected concrete sample with a water/cement ratio of 0.8 (mm):	≤ 2
Fracture covering capacity: Crack bridging at failure of the film layer without reinforcement: - after 28 days at 20°C and 50% R.H.: - after 7 days at 20°C and 50% R.H. + 21 days in water: - after 7 days at 20°C and 50% R.H. + 18 months in water:	 width 0.8 mm width 0.6 mm width 0.5 mm
Crack-bridging at breakage of film reinforced with glass fibre mesh:	width 1.5 mm
Crack-bridging at breakage of film reinforced with non-woven fabric:	width > 3 mm
Consumption (kg/m^2): - manual application: - spray application using rendering machine:	 approx. 1.7 (per mm of thickness) approx. 2.2 (per mm of thickness)

8.2| Protecting and waterproofing with MAPELASTIC SMART

Description*: two-component, high-flexibility cementitious mortar, applied by brush or with a roller, for waterproofing concrete surfaces such as foundations, retaining walls, balconies, terraces, bathrooms and swimming pools, and for protecting against the penetration of aggressive agents.*

Particularly suitable for*: waterproofing and protecting concrete structures, may be applied by brush which makes it particularly suitable for waterproofing irregular-shaped surfaces. Waterproofing hydraulic structures and retaining walls. Protecting against the infiltration of water and aggressive atmospheric agents, seawater, de-icing salts and sulphate salts.*

photo 16
Mapelastic Smart
applied with a roller

Protecting new concrete structures, and concrete structures repaired using special mortar from the MAPEGROUT or PLANITOP ranges using MAPELASTIC SMART. When the two components are mixed together, a blend with a plastic consistency is obtained. It may be applied by brush or roller, or by spraying with a worm screw rendering machine with a smoothing and levelling fitting, on both horizontal and vertical surfaces at a thickness of approximately 2 mm per layer. Thanks to the high content and quality of the synthetic resins, the hardened layer of MAPELASTIC SMART remains constantly flexible under all environmental conditions.

The product meets the minimum requirements of EN 1504-2.

MAPELASTIC SMART has the following performance characteristics:

table 17

Characteristics	Performance of product
Mixing ratio:	component A : component B = 2 : 1
Density of the mix (kg/m^3):	1600
Pot life of mix:	1 hour (at 20°C)
Bond strength to concrete (MPa): - after 28 days at 20°C and 50% R.H.: - after 7 days at 20°C and 50% R.H. + 21 days in water:	 1.7 0.9
Impermeability (EN12390/8 Mod) (1.5 atm for 7 days):	waterproof
Elongation according to DIN 53504 Mod: - after 28 days at 20°C and 50% R.H. (%):	 130
Fracture covering capacity: Crack-bridging at failure of the film layer without reinforcement: - after 28 days at 20°C and 50% R.H.: - after 7 days at 20°C and 50% R.H. + 21 days in water:	 width 2.5 mm width 1.6 mm
Crack-bridging at failure of the film layer without reinforcement at -10°C - after 28 days at 20°C and 50% R.H.	 width 0.8 mm
Crack-bridging at breakage of film reinforced with non-woven fabric: - after 28 days at 20°C and 50% R.H.:	 width > 3 mm
Crack-bridging at breakage of film reinforced with non-woven fabric at -10°C: - after 28 days at 20°C and 50% R.H.:	 width 1.5 mm
Consumption (kg/m^2): - application by brush or roller:	 approx. 1.6 (per mm of thickness)

8.3| Protecting with MAPEFINISH

Description*: two-component cementitious mortar for finishing off concrete.*

Particularly suitable for*: evening out surface defects in cast concrete before being painted over. Smoothing and levelling off concrete repaired using mortar from the MAPEGROUT range. Protecting concrete against weak aggressive agents from the surrounding environment.*

Protecting and evening out surfaces in MAPEFINISH two-component cementitious mortar for finishing off concrete. When the two components are mixed together, a free-flowing mix is obtained which may be easily applied, even on vertical surfaces, at a thickness of up to

photo 17
Smoothing layer using Mapefinish

2-3 mm in one single layer. Thanks to its high content of synthetic resin, MAPEFINISH has high bonding strength to all concrete surfaces and, once hardened, forms a tough, compact, layer which is impermeable to water and harmful gases present in the atmosphere (CO_2 - SO_2 - nitrous oxides) and is resistant to freeze-thaw cycles.

The product meets the minimum requirements of EN 1504-3 Standards for R2-class non structural mortar and EN 1504-2.

MAPEFINISH has the following performance characteristics:

table 16

Characteristics	Performance of product
Density of the mix (kg/m^3):	1.900
pH of product:	> 12.5
Pot life of mix:	1 hour (at 20°C)
Bond strength to substrate (MPa):	2.5 (after 28 days)
Consumption (kg/m^2):	2 (per mm of thickness)

8.4| Protecting with MONOFINISH

Description*: single component, normal-setting cementitious mortar for smoothing concrete.*

Particularly suitable for*: protective and smoothing layers on concrete surfaces. Application on strong, concrete and rendered surfaces.*

Protecting and smoothing surfaces using MONOFINISH. Application by trowel and finishing with a sponge float. Smoothing layers with MONOFINISH must also be applied on the surfaces which are not under repair, to form a uniform, homogenous substrate ready for successive dressing layers, paint or resin-based anti-corrosion treatment.

The product meets the minimum requirements of EN 1504-3 Standards for R2-class non structural mortar and EN 1504-2.

photo 18
Smoothing layer using Monofinish

MONOFINISH has the following performance characteristics:

table 19

Characteristics	Performance of product
Density of the mix (kg/m^3):	1650
pH of product:	12.5
Pot life of mix:	1 hour (at 20°C)
Brookfield viscosity (mPa • s):	300-600
Compressive strength (MPa):	> 20 (after 28 days)
Dynamic modulus of elasticity (MPa):	< 18.000 (after 28 days)
Bond strength to substrate (MPa):	2.5 (after 28 days)
Taber abrasion according to ASTM D 4060-84 Standards - after 200 cycles with 500 g weight (H22 disk) expressed as loss in weight (g):	≤ 3 (after 28 days)
Consumption (kg/m^2):	1.4 (per mm of thickness)

8.5| Summary of main characteristics of mortars for smoothing and levelling concrete

	MORTAR FOR FLEXIBLE SMOOTHING AND LEVELLING LAYERS ON CONCRETE	
Characteristics	**Mapelastic**	**Mapelastic Smart**
Certification principles according to EN 1504-2	PI, MC and IR	PI, MC and IR
Mixing ratio	Comp. A : Comp.B 3 : 1	Comp. A : Comp.B 2 : 1
Density of mix	1700 kg/m^3	1600 kg/m^3
Density after application by spray	2200 kg/m^3	2200 kg/m^3
Application temperature range	da +5°C a +35°C	da +5°C a +40°C
Pot life of mix	1 h	1 h
Bond strength on concrete according to EN 1542	1 MPa	1.3 MPa
Thermal compatibility to freeze-thaw cycles with de-icing salts, measured as bond strength according to EN 1542	0.8 MPa	0.9 MPa
Static crack-bridging according to EN 1062-7 expressed as maximum width of crack	> 0.5 mm (-20°C)	> 2.5 mm (+20°C)
Dynamic crack-bridging according to EN 1062-7	No failure of test piece after 1,000 crack cycles with movement of crack from 0.1 to 0.3 mm (mapelastic reinforced with Mapetex sel at -20°C)	No failure of test piece after 2,000 crack cycles with movement of crack from 0.2 to 0.5 mm (+20°C)
Permeability to water vapour according to EN ISO 7783-1	Sd: 2.4 μ: 1200	Sd: 3.6 μ: 1800
Impermeability to water expressed as capillary absorption according to EN 1062-3 (kg/m^2*h$^{0.5}$)	< 0.05	< 0.05
Permeability to carbon dioxide (CO_2) according to EN 1062-6 - diffusion in equivelant air thickness Sdco2 (m)	> 50	> 50
Consumption	By hand: 1.7 kg/m^2 per mm of thickness By spray: 2.2 kg/m^2 per mm of thickness	By hand: 1.6 kg/m^2 per mm of thickness By spray: 2.2 kg/m^2 per mm of thickness

	MORTARS FOR SMOOTHING AND LEVELLING CONCRETE	
Characteristics	**Monofinish**	**Mapefinish**
Certification principles according to EN 1504-2	MC and IR	MC and IR
Maximum size of aggregate	0.4 mm	0.4 mm
Mixing ratio	18% - 19% of water	Comp. A : Comp.B 4 : 1
Density of mix	1700 kg/m^3	1900 kg/m^3
Application temperature range	from +5°C to +35°C	from +5°C to +35°C
Pot life of mix	approx 1 h	approx 1 h
Compressive strength	> 25 MPa after 28 days	> 35 MPa after 28 days
Flexural strength	> 6.5 MPa after 28 days	> 10 MPa after 28 days
Bond strength on concrete according to EN 1766	≥ 2 MPa after 28 days	≥ 2 MPa after 28 days
Thermal compatibility to freeze-thaw cycles with de-icing salts, measured as bond strength according to EN 1542	≥ 2 MPa	≥ 2 MPa
Thickness applied	from 1 to 3 mm	from 1 to 3 mm
Consumption	1.4 kg/m^2 per mm of thickness	2 kg/m^2 per mm of thickness

9| Protecting and decorating concrete surfaces

9.1| MALECH

Description*: micronised acrylic resin-based base layer in water dispersion.*

Particularly suitable for*: base preparation of surfaces before applying the final colouring coat, to regulate absorption of the substrate and improve bonding. May also be used in the permanent AQUAFLEX SYSTEM capping cycle of asbestos cement. This product is also odourless, which makes it particularly suitable in closed or poorly ventilated environments.*

Once MALECH has been applied, it penetrates deeper down into the substrate than conventional water-based products, and thanks to its special formulation, guarantees consolidation of dust on the surface to be treated. MALECH's high penetration depth also slows down the formation of efflorescence.
Apply the product using traditional techniques; brush, roller or spray.

9.2| ELASTOCOLOR PRIMER

Description*: solvent-based, high-penetration reconsolidating primer for crumbly and dusty substrates, and curing agent for repair mortar.*

Particularly suitable for*: consolidating surface dust by impregnating absorbent surfaces. Suitable for promoting bonding before applying finishing products from the ELASTOCOLOR range of products.*

Fixing treatment for crumbly and dusty surfaces, such as cementitious render and concrete surfaces, using ELASTOCOLOR PRIMER. Thanks to its special properties, the product penetrates easily into absorbent substrates and guarantees excellent insulation and good bonding for successive coats of paint.

9.3| Protecting and decorating surfaces using ELASTOCOLOR PAINT

Description*: flexible acrylic resin-based paint in water dispersion for protecting and decorating concrete.*

Particularly suitable for*: application on cracked façades or concrete with deformation problems. Protects concrete structures against the phenomenon of carbonatation.*

Painting surfaces by applying ELASTOCOLOR PAINT. Dilute ELASTOCOLOR PAINT with 10-15% of water and mix using a low-speed drill until it is completely blended. Once mixed as

photo 19
An example of the finish obtained on a viaduct pile using Elastocolor Paint

ELASTOCOLOR PAINT has the following performance characteristics:

table 20

Characteristic	Performance of product
Density of mix (kg/m^3):	approx. 1,400
Brookfield viscosity (mPa • s):	16,000 (rotor 6 – 20 revs)
Dry solids content (%):	approx. 65
Waiting time between each coat:	24 hours
Resistance to abrasion when damp (DIN 53778):	> 10,000 cycles
Vapour diffusion resistance coefficient (DIN 52615) (μ):	545
Resistance to passage of vapour of a 0.2 mm-thick layer in equivalent metres of air Sd (DIN 52615) (m):	0.109
Capillary action water absorption coefficient W (DIN 52617) (kg/m^2 • h$^{0.5}$):	0.1
Sd • W = 0.109 • 0.100 (kg/m • h$^{0.5}$): The value of Sd • W must be less than 0.1 and respect Kienzle's theory (DIN 18550):	0.011
CO_2 diffusion resistance factor (BASF test method) (μs):	1,320,594
Resistance to the passage of CO_2 RG (BASF test method) (m):	462.21
Elongation at failure (%): - after 14 days at 23°C: - after 7 days at 23°C + 7 days at 60°C: - after 7 days at 23°C + 7 days in water: - after 7 days at 23°C + 7 days at -10°C: - after 7 days at 23°C + 7 days at 60°C + 7 days at -10°C: - after 7 days at 23°C + 7 days at 60°C in water + 7 days at -10°C: - after 7 days at 23°C + 7 days at 60°C + 7 days in water + 7 days at -10°C + 7 days at 23°C:	 392 220 662 434 567 512 192
Crack-bridging ability at start cracking point for a 0.3 mm thick dry film (prEN 1062-7 mod.) (mm):	approx. 1.8
Resistance to accelerated aging (colour RAL 7032) after 1,000 hours exposure to a Weather-Ometer (ASTM G26/A):	Δ E < 2.5
Consumption (kg/m^2):	0.2 – 0.4 (per coat)

above, the product may be applied using traditional application techniques: by brush, roller or spray.
For effective, complete covering of the surface, apply at least two coats. Under normal humidity and temperature conditions, wait 24 hours between each coat.
ELASTOCOLOR PAINT is available in a wide range of colours, created using the COLORMAP® automatic colouring system.

9.4| MAPECOAT E23

Description*: two-component epoxy primer for protecting concrete, before applying polyurethane finishing products.*

Particularly suitable for*: thanks to its high dry solids content, good anchorage and consolidation of concrete surfaces and mineral-based substrates. Recommended for the first coat in epoxy and polyurethane cycles.*

MAPECOAT E23 has a high residual dry solids content, and is recommended as an anchoring and consolidating primer for concrete surfaces and mineral-based substrates.
MAPECOAT E23 is an epoxy resin-based paint containing selected pigments. It is used as a primer on steel-cement elements subject to high chemical, mechanical and atmospheric stress.
MAPECOAT E23 is applied in a single coat by brush, roller, spray or the airless spray system.

9.5| Protecting and decorating surfaces using MAPECOAT PU33

Description*: two-component, flexible, polyurethane resin-based coating.*

Particularly suitable for*: protecting concrete, and protecting and waterproofing civil and industrial flat and sloping roofs.*

Protecting and waterproofing concrete using MAPECOAT PU33 which, thanks to its special composition, is highly resistant to industrial environments and atmospheric agents in general, is highly flexible, highly resistant to tearing, resistant to micro cracks in the substrate, impermeable to water while remaining permeable to water vapour, keeps its colour very well and is easy to apply. Once completely hardened, MAPECOAT PU33 is resistant to the aggressive action of UV rays and impedes penetration of CO_2. MAPECOAT PU33 is resistant to freezing weather conditions, and gives an attractive finish to the treated surface. It should be applied after the MAPECOAT E23 coat, and not directly on the substrate.
The product must be applied in two coats using a brush, roller or by spray to form a dry thickness layer of at least 400 µm.

MAPECOAT PU33 has the following performance characteristics:

table 21

Characteristics	Performance of product
Density of the mix (kg/m^3):	approx. 1,300
Dry solids content (%):	58 ± 2
Waiting time between each coat:	12-24 hours
Permeability to C02 equivalent air thickness (EN1062/6 method A) (m):	≥ 300
C02 resistance coefficient (EN1062/6 method A) (μ):	> 800,000
Tensile strength (UNI 8202/8) (MPa):	> 2
Shore A hardness (UNI EN ISO 868):	≥ 40
Crack-bridging according to Italferr specifications (thickness 400 μm):	intact with 1 mm opening
Impermeability to water according to Italferr specifications (kPa 500) (thickness 400 μm):	no penetration after 6 hours
Resistance to UV radiation after 200 hours:	no flaking or reduction in shine
Bond strength to concrete (MPa):	> 3.5
Elongation at breakage (UNI 8202/8) (%):	> 300
Final hardening time:	7 gg
Consumption (kg/m^2):	1.14 (two coats for a dry thickness of 400 μm)

Notes:

Notes: