METHOD STATEMENT
Concrete Repair

NOVEMBER 2022 / SIKA LIMITED / ROB DOHERTY

BUILDING TRUST

CONTENTS

1 SCOPE

This method statement describes the step-by-step procedure for repairing concrete structures using the Sika® MonoTop®, and Sika® EpoCem® range ready to use mortar products by manual and machine application.

2 SYSTEM DESCRIPTION

The Sika® concrete repair range is a system of products consisting of a bonding primer, reinforcement corrosion protection layer, repair mortar and levelling or smoothing mortar.

USES

- Bonding primers for promoting adhesion of a repair mortar to concrete.
- Reinforcement corrosion protection applied to steel reinforcement bars in concrete (EN 1504 Principle 11, Method 11.1).
- Repair and reinstatement of damaged or contaminated concrete on buildings, bridges, infrastructure, and super structure works (EN 1504 Principle 3, Methods 3.1 and 3.3).
- Increasing bearing capacity of a concrete structure by adding mortar for strengthening (EN 1504 Principle 4, Method 4.4).
- Preserving or restoring passivity of steel reinforcement bars in concrete (EN 1504 Principle 7, Methods 7.1 and 7.2).
- Increasing cover to reinforcement bars with additional mortar.
- Thin layer render.
- For pore sealing or levelling a concrete surface prior to adding a protective coating.
- Repair of minor defects.

CHARACTERISTICS / ADVANTAGES

- Pre-mixed for quality.
- 1-component products, only add water.
- Adjustable consistencies.
- Versatile range of performances.
- Low shrinkage.
- Products which are easily surface finished.
- Products with classified performance classes.
- Systems with high resistance to water and chloride penetration.
- Products which can be hand or machine applied.
- Compatible systems with Sikagard® concrete protection products.

2.1 REFERENCES

This method statement has been written in accordance with the recommendations contained in European Standards EN 1504: Products and systems for the protection and repair of concrete structures, and the following relevant parts:

EN 1504 Part 1:	Definitions, requirements, quality control and evaluation of conformity
EN 1504 Part 3:	Structural and non-structural repair
EN 1504 Part 7:	Reinforcement corrosion protection
EN 1504 Part 10:	Site application of products and systems, and quality control of works

2.2 LIMITATIONS

- Products shall only be applied in accordance with their intended use.

- Local differences in some products may result in some slight performance variations. The most recent and relevant local Product Data Sheet (PDS) and Material Safety Data Sheet (MSDS) shall apply.
- For specific construction / build information, refer to the Architects', Engineer's or Specialist's details, drawings, specifications, and risk assessments.
- All work shall be carried out as directed by a Supervising Officer or a Qualified Engineer.
- This method statement is only a guide and shall be adapted to suit local products, Standards, legislations or other requirements.

3 PRODUCTS

Sika MonoTop®	1-component, ready to use repair mortar, bonding primer or reinforcement corrosion protection.
Sika EpoCem®	3-component, ready to use bonding primer, reinforcement corrosion protection or fairing coat.
SikaCem®	1-component, ready-to-use dry spayed micro repair concrete.

3.1 SYSTEM BUILD-UP

A Sika® repair system comprises a range of products to suit the needs

Bonding Primers and Reinforcement Corrosion Protection	
Sika MonoTop®-1010	1-component for normal use
SikaTop® Armatec®-110 EpoCem®	3-component for demanding requirements
Concrete Repair Mortars (all 1-component)	
Sika MonoTop®-4012	R4 high performance CC mortar for classical applications
Sika MonoTop®-615	R3 lightweight PCC mortar
Sika MonoTop®-630 Rapid	R4 fast setting high early strength mortar
Sika MonoTop®-614 F	R4 high flow low shrinkage mortar
Pore Sealer and Levelling Mortars	
Sika MonoTop®-3020	1-component R3 PCC mortar for normal use
Sikagard®-720 EpoCem®	Dense 3-component R3 PCC mortar with high resistance and protection
Dry Sprayed Micro Repair Concretes (all 1-component)	
SikaCem® 133 S Gunite	1-component R4 polymer modified DWI approved micro repair concrete
SikaCem® 133 F Gunite	1-component R4 fibre reinforced high performance micro repair concrete
SikaCem® 133 Rapid Gunite	1-component R4 polymer modified fast setting micro repair concrete

3.2 MATERIAL STORAGE

Materials shall be stored properly in undamaged original sealed packaging, in dry, cool conditions. Refer to specific information contained in the product data sheet regarding minimum and maximum storage temperatures.

4 EQUIPMENT

4.1 MATERIALS

Sufficient quantities of Sika® repair materials	Refer to Section 11
Sufficient clean water	For mixing 1-component, pre-wetting substrate and cleaning

4.2 ESSENTIAL EQUIPMENT

Hand tools	Trowels, floats, brushes for mortar application
Spraying equipment*	Refer to 4.5
Concrete removal	Traditional tools, hammer-drill or suitable mechanical equipment for removing damaged or contaminated concrete (Refer to Section 7.1)
Measuring cylinder	For accurate measurement of mixing water
Mixing equipment	Refer to Section 4.4
Mixing vessel	Minimum ~18 - 20 litres per 25 kg bag
Sponge or pressurised air (oil free)	Wipe / blow away excess water from substrate
Curing	Membrane or similar to protect fresh mortar
Cleaning	Brush, low pressure water
Waste disposal	For paper bags and excess material
Pre-wetting	Low pressure water, sponge, Birchmeier pump

4.3 ADDITIONAL EQUIPMENT

Formwork	To profile application
Sealant	For sealing formwork
Spraying equipment	Mechanical application of mortars
Cleaning Equipment	Suitable for removing corrosion off reinforcement
Suitable profile	For levelling large surfaces

4.4 MIXING EQUIPMENT

Double mixer with spindle paddles

medium quantities

Forced action pan mixer

large quantities

4.5 SPRAYING EQUIPMENT (IF REQUIRED)

The following spraying equipment are suitable for Sika's ready to use mortars:

1. Hopper Gun
2. Spiral Pump and Compulsory Mixer (wet spraying or 'Shotcrete')
3. Gunite and Dry Process Shotcrete (for the SikaCem® Range)
4. Mixing Pump (trials are required at first with these machines as mixing time is reduced)

Advantages:

- Consistent mortar quality
- Minimal spray mist and low environmental impact
- High capacity (~60 m delivery length, ~20 m delivery head, ~20 litre / minute)
- Low rebound <10%
- Low disposal costs
- Less surveillance effort

4.5.1 HOPPER GUN (ONLY FOR BONDING PRIMER)

Hopper gun specifications vary; typically, a general specification may be as follows:

- Requires independent air compressor (refer to manufacturer's requirements)
- Approximate air flow 2 – 3 Bar
- Hopper capacity ~1 litre
- Nozzle diameter at least 3 times the largest grain size

The following hopper gun(s) are recommended for use with Sika MonoTop®-1010:

Manufacturer	**Spray Machine**
Graco	**Hopper Gun**
Supplier Name	Spray Direct
Address	Unit 14 Parkwood Industrial Estate Heronden Road Maidstone Kent ME15 9YR
Telephone	0345 873 0263
Website	www.spraydirect.co.uk

Table 1 – U.K. supplier of hopper guns.

4.5.2 SPIRAL PUMP AND COMPULSORY MIXER (WET SPRAYING OR 'SHOTCRETE')

There are different types of wet spraying machines to select from. These include:

- Mixing pump

- Rotor Machines
- Screw Pumps
- Piston Pumps
- Double Piston Pumps
- Squeeze Pump

The following three wet spraying machine(s) are examples of pumps that can be used with Sika® ready to use mortar products:

Manufacturer		Spray Machine
	Putzmeister	**S 5**
Supplier Name	Markham (Sheffield) Ltd.	
Address	Marspal House Lawn Court Carlton in Lindrick Worksop Nottinghamshire S81 9ED	
Telephone	01909 730861	
Website	www.markham-sheffield.co.uk	
	Allentown	**MR-450**
Supplier Name	Markham (Sheffield) Ltd.	
Address	Marspal House Lawn Court Carlton in Lindrick Worksop Nottinghamshire S81 9ED	
Telephone	01909 730861	
Website	www.markham-sheffield.co.uk	
	Putzmeister	**SP11 LMR Worm Pump**
Supplier Name	Markham (Sheffield) Ltd.	
Address	Marspal House Lawn Court Carlton in Lindrick Worksop Nottinghamshire S81 9ED	
Telephone	01909 730861	
Website	www.markham-sheffield.co.uk	

Table 2 – U.K. supplier of wet spraying (shotcrete) machines.

4.5.3 GUNITE AND DRY PROCESS SHOTCRETE (FOR THE SIKACEM® RANGE)

Manufacturer		Spray Machine
Markham		**Markham Piccola Gunite Machine**
Supplier Name	Markham (Sheffield) Ltd.	
	Marspal House	
	Lawn Court	
Address	Carlton in Lindrick	
	Worksop	
	Nottinghamshire	
	S81 9ED	
Telephone	01909 730861	
Website	www.markham-sheffield.co.uk	
UELZENER		**T115 Vessel Type Gunite Machine**
Supplier Name	Markham (Sheffield) Ltd.	
	Marspal House	
	Lawn Court	
Address	Carlton in Lindrick	
	Worksop	
	Nottinghamshire	
	S81 9ED	
Telephone	01909 730861	
Website	www.markham-sheffield.co.uk	

Table 3 – U.K. supplier of dry spraying (Gunite) machines.

4.5.4 CONTINUOUS MIXING PUMP

Mixing pumps combine mixing and spraying in one high output machine. Besides air (compressor) and electricity (power current), water supply to the pump is required. Depending on the material, application and consumption, different versions of mixing pumps are possible. As mixing time is usually reduced, it is important to analyse the sprayed mortar in detail (petrographic analysis, etc.), when first using a mixing pump of a certain manufacturer. Choosing the correct mixing pumps depends on material, ceiling height, dust reduction requirements, material supply (One-Way Containers, Bulk Bags, etc.) and pump capacity. One example of mixing pump is the inoCOMB Cabrio 2.0 from Inotec AG.

Manufacturer		Spray Machine
Inotec		**inoCOMB Cabrio 0.2**
Supplier Name	Inotec GmbH	
Address	Daimlerstraße 9-11 DE-79761 Waldshut-Tiengen Germany	
Telephone	+49 160 / 9492 5237	
Website	www.inotec-gmbh.com	
Sika		**Sika PumpFix**
Supplier Name	Sika AG + Inotec GmbH	
Address	Tüffenwies 16 8048 Zürich Schweiz	
Telephone	+41 79 958 09 81	
Website	https://che.sika.com/	
Putzmeister		**Thom-Katt TK 20 (with detachable mixer)**
Supplier Name	Markham (Sheffield) Ltd.	
Address	Marspal House Lawn Court Carlton in Lindrick Worksop Nottinghamshire S81 9ED	
Telephone	01909 730861	
Website	www.markham-sheffield.co.uk	

Table 4 – High Output Mixing Pumps.

The above machines have been tested and confirmed to be compatible with Sika MonoTop®-4012.

The following tests are recommended for validating machine and mortar compatibility:

- Flow Spread (e.g., EN 12350-5 or EN 1015-3)
- Density (e.g., EN 12190)
- Shrinkage (e.g., EN 12617-4)
- Compressive Strength (e.g., EN 12190)
- Water Content (dried to constant mass using oven or microwave)
- Slump (e.g., EN 12350-2)
- Slump Flow (without blows)
- Air Void Content

4.5.5 NOZZLE

The type and size of nozzle varies for different mortar applications and shall be selected depending on the type of mortar to be sprayed. Refer to machine manufacturer's recommendations.

Nozzles shall be designed for:

1. Maximum grain size of mortar
2. Admixtures (e.g., liquid or fibres)
3. Continuous control of water: powder mixing ratio (dry process)

There are different types of nozzles for different machines as illustrated below:

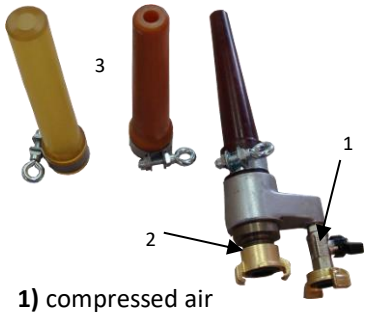
Wet Spraying (repair)
 **1)** compressed air **2)** fresh mortar **3)** Variable size nozzles (diameter: 12 mm)
Uses: • Repair mortars • Levelling mortars

Table 5 – Different types of nozzles.

4.5.6 AIR COMPRESSOR EQUIPMENT

Compressed air (> 2 m^3/min) is used to project the mortar at high velocity onto the substrate. Refer to the machine manufacturer's requirements.

Air from the equipment shall be clean, dry and free from oil or contamination.

The air shall remain continuous at not less than the operating pressure and volume rate specified by the machine manufacturer.

5 HEALTH AND SAFETY

5.1 RISK ASSESSMENT

The risk to health and safety from falling objects or defects in the structure shall be properly assessed.

Platforms and temporary structures shall provide a stable and safe area to work. Do not take any unnecessary risks!

5.2 PERSONAL PROTECTION

Work Safely!

Handling or processing cement products may generate dust which can cause mechanical irritation to the eyes, skin, nose and throat.

Appropriate eye protection shall be worn at all times while handling and mixing products.

Approved dust masks shall be worn to protect the nose and throat from dust.

Safety boots, gloves and other appropriate skin protection shall be worn at all times.

Always wash hands with suitable soap after handling products and before food consumption.

FOR DETAILED INFORMATION REFER TO THE MATERIAL SAFETY DATA SHEET

5.3 FIRST AID

Seek immediate medical attention in the event of excessive inhalation, ingestion or eye contact causing irritation. Do not induce vomiting unless directed by medical personnel.

Flush eyes with plenty of clean water occasionally lifting upper and lower eyelids. Remove contact lenses immediately. Continue to rinse eye for 10 minutes and then seek medical attention.

Rinse contaminated skin with plenty of water. Remove contaminated clothing and continue to rinse for 10 minutes and seek medical attention.

FOR DETAILED INFORMATION REFER TO THE MATERIAL SAFETY DATA SHEET

6 ENVIRONMENT

6.1 CLEANING TOOLS / EQUIPMENT

Clean all tools and application equipment with water immediately after use. Hardened material may only be removed mechanically.

6.2 WASTE DISPOSAL

Do not empty surplus material into drains. Avoid runoff onto soil or into waterways, drains or sewers. Dispose unwanted material responsibly through licensed waste disposal contractors in accordance with local legislation and / or regional authority requirements.

FOR DETAILED INFORMATION REFER TO THE MATERIAL SAFETY DATA SHEET

7 SUBSTRATE PREPARATION

7.1 CONCRETE

The concrete substrate shall be thoroughly clean, in a good sound condition and free from dust, loose material, surface contamination and materials which reduce bond. Delaminated, weak, damaged and deteriorated concrete shall be removed by suitable means. If necessary, some sound concrete may also be removed but not to the detriment of the structural integrity and only as directed by a Supervising Officer or Qualified Engineer.

Methods of cleaning, roughening and concrete removal are summarised as follows:

■ Intended use □ For certain intended uses	Cleaning	Roughening	Removal
Hammer and chisel			■
Breaker (until 15 mm depth)		■	■
Grit and sand blasting	■	■	
Water cleaning with low pressure (max. 180 bar)	■		
Water cleaning with high pressure (max. 800 bar, until 2 mm depth)		■	
Water blasting with high pressure (max.1100 - 2000 bar)			■
Not Suitable:			
Pneumatic devices (hydraulic breaker, pneumatic hammer etc.)	-		
Diamond grinder	-		

Table 6 – Summary of concrete cleaning, roughening and removal methods.

Appropriate tool selection will depend on the type and extent of damage as well as the substrate quality and shall be agreed with the Supervising Officer or qualified Engineer.

Note: Hydro-demolition is a preferred fast and effective method of removing concrete which usually results in no micro cracking of the concrete.

As defined in EN 1504-10, water jet categories are as follows:

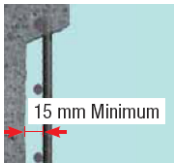
- **Low Pressure** – Up to 18 N/mm^2 (MPa) / 180 bar / ~2,600 PSI
  - Used for cleaning concrete and steel substrate.
- **High Pressure** – from 18 to 70 N/mm^2 (MPa) / 700 bar / ~10,000 PSI
  - Used for cleaning steel substrate and for removal of concrete.
- **Very High Pressure** – from 80 to 120 N/mm^2 (MPa) / 1200 bar / ~17,000 PSI
  - Used for concrete removal when low water volume is available.

Where: 1N/mm^2 = 10 bar = 145 PSI (lbf/in^2)

Concrete removal shall be kept to a minimum and shall not reduce the structural integrity of the structure. Pneumatic equipment or tools which can damage concrete due to an intense vibration shall not be used.

The extent of concrete removal shall be in accordance with the chosen principle and method contained in EN 1504-9.

Depth: In the case of repair and restoration, the depth of contamination shall be established and taken into account when determining the depth of concrete removal.



Removal of concrete shall continue to expose full circumference of the steel reinforcement to a minimum depth of 15 mm behind the back of the rebars. If corrosion appears only on the surface, remove concrete only until midway around the rebars. The rebar does not need to be exposed if CCS (Cathodic Corrosion Protection 10.1 in EN 1504) or electrochemical procedures (procedure 7.3 and 7.5 in EN 1504) are to be used. Gravel pockets (honeycombing), detachments, coatings, etc. need to be removed (see EN 1504-10 A.3.2.3).

Length: Breaking out shall continue along the reinforcement until non-corroded steel is reached as directed by the supervising officer or qualified engineer.

Edges: Edges around the patch repair shall be cut at an angle of >90° to avoid undercutting and a maximum angle of 135° to reduce the possibility of debonding.

Surface texture: The surface of the concrete substrate shall be roughened to minimum 2 mm or to the maximum grain size of the applied product. This assures adequate bonding which can be tested in accordance with EN 1766: Clause 7.2 for horizontal surfaces.

If a smoothing coat is required, the whole application surface shall be properly prepared. Appropriate cleaning procedures consist of low-pressure water blasting, abrasive grit and sand blasting, or high-pressure water blasting to remove a laitance layer.

7.1.1 TESTING THE PREPARED SUBSTRATE

Micro-cracked or delaminated concrete including damage caused by cleaning, roughening or removal techniques shall be removed or repaired if it might reduce bond or structural integrity. Micro cracks can be detected by wetting the surface and allowing it to dry. Dark lines on the dried surface indicate cracks as they retain the water.

The finished surface shall be visually inspected prior to application and can be tapped lightly using a metal hammer to detect delaminated concrete. The supervising officer or qualified engineer shall be informed immediately of any loose, cracked or damaged surfaces. In these circumstances, repair materials shall not be applied without prior written consent of the supervising officer or qualified engineer.

7.2 STEEL REINFORCEMENT / REBAR

The steel reinforcement shall be thoroughly clean and free from rust, scale, mortar, concrete, dust and other loose and deleterious material which reduces bond or contributes to corrosion. Tie wire and nails shall also be removed. Suitable preparation methods for steel reinforcement are high pressure water cleaning, grit or sand blasting. A steel brush is not a suitable method to remove corrosion products from the rebar.

Figure 1: Substrate preparation by concrete removal with high water pressure and placing of formwork (shown on the right side of the photo).

The whole circumference of the bar shall be uniformly cleaned, except where structural considerations prevent this. Cleaning shall not damage in anyway the structural integrity of the steel. Immediately notify the supervising officer or qualified engineer if there is a possibility of damaging the steel by cleaning.

- Exposed bars contaminated with chloride or other deleterious material shall be cleaned by low pressure water jet (18 - 70 MPa / 800 bar / ~8,700 PSI) and checked afterwards to ensure the contamination has been totally removed.
- If a reinforcement corrosion protection layer in the form of an active coating (Method 11.1 as defined in the European Standard EN 1504-9) is to be applied, then the steel reinforcement shall be cleaned to Sa 2 defined by ISO 8501-1.
- Cleaned bars shall be protected against further contamination prior to application of a reinforcement corrosion protection layer.

Loss of reinforcement cross-sectional area due to corrosion, or any other damage, shall immediately be brought to the attention of the supervising officer or qualified engineer prior to any further work. Any further action such as replacing reinforcement bars shall only be carried out in accordance with the direct instruction of the supervising officer or qualified engineer. The scope of this method statement does not include replacement of steel reinforcement bars (Sika can supply products for this purpose – please contact your local Representative for more information).

7.3 PRE-WETTING SUBSTRATE

Depending on the water absorbency of the concrete substrate, the surface shall be pre-wetted and saturated with clean low-pressure water or a wet sponge 1 or 3 days in advance. For a minimum period of 2 hours before application, constant pre-wetting is required, ensuring that all pores and pits are adequately wet. The surface shall not be allowed to dry before application. Otherwise, the necessary water the concrete repair mortar needs for hydration could be extracted, and the mortar dries out.

Just before application, remove excess water by using a clean sponge for small areas or air pressure for large areas. Ensure there is no standing water on the surface. The surface shall achieve a dark matt appearance without glistening and surface pores and pits shall not contain water (saturated surface dry). Use pressurised air (oil free) to blow away excess water in difficult to reach areas.

For application in early morning, pre-wet the substrate one day in advance until the capillaries are fully saturated and continue the next day (< 2h). A sprinkler system that runs during the night is another option.

Figure 2: Finalising the pre-wetting of the substrate by removing any excess water with a sponge.

Formwork (for large areas)

Formwork can be used to regulate the thickness of the application or to reprofile the required shape of the concrete surface. The formwork shall be capable of withstanding the load imposed by the applied mortar.

Formwork shall be clean and fixed in place as soon as possible after the substrate has been prepared. If required, a Sika® Separol® release agent shall be applied to the formwork before placing into position. Do not contaminate the substrate with the release agent and reduce bond of the material from spillage or run-off.

Working areas shall be well illuminated. Adjoining areas shall be adequately protected against overspray.

8 MIXING

Do not use water beyond the stated maximum and minimum limits. In determining the mixing ratio, the wind strength, humidity, ambient and substrate temperature and required consistency shall be taken into consideration. Only clean and clear water can be used. Do not use regained or treated water. Use the mixing equipment described in Section 4.4. Mixing shall always be carried out in accordance with the recommendations contained in the latest product data sheet (PDS). Depending on the mixing equipment, the mixing time may vary.

8.1 FOR SPRAYING APPLICATION

- **SPIRAL PUMP AND COMPULSORY MIXER**

The material is pre-mixed by hand or compulsory mixer before it is added in the spiral pump. Use a suitable sized mixer according to demand and application rate of the spray machine. On large applications, a pan mixer can be used to mix greater quantities more efficiently. During the application, there shall be no interruption in the mortar supply. The pot-life of the mortar shall not exceed the time required to apply the mortar on the substrate. Pot-life shall be determined by tests on the job site according to the ambient temperature and climate conditions.

Figure 3: Mixing and pouring into the pump for pumping.

- **MIXING PUMP**

A mixing pump combines the pumping and the mixing process. Special consideration must be taken regarding the right water pressure, constant material supply, material temperature, climate conditions, etc. Even though the

mixing time is usually reduced, when used correctly, a mixing pump can lead to high-quality application of the mortar.

Figure 4: Inotec mixing pump with dust free material supply in one-way containers (OWC).

9 APPLICATION

The product and system shall be appropriate for the type of substrate, structure and exposure conditions which are required.

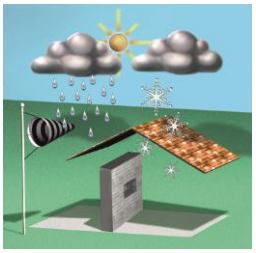
9.1 BEFORE APPLICATION

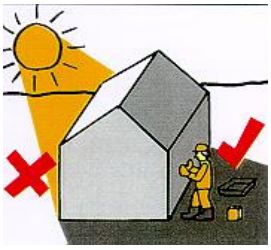
Working space shall be clean and tidy with no obstructions.

Record the substrate, ambient temperature and relative humidity. Check pot-life information on the bag or in the product data sheet and allow for climatic conditions (e.g., high / low temperatures and humidity). Make sure material is not expired.

External applications shall be adequately protected. Do not apply mortar repair in direct sun, windy, humid or rainy conditions or if there is a risk of frost within 24 hours in unprotected areas.

Calculate the required volume for the application and then using the equation in Section 11 of this method statement, calculate the yield of the product. Make sure there is enough material on job site to carry out the work.





9.2 REINFORCEMENT CORROSION PROTECTION

Where reinforcement corrosion protection is required, apply material to the whole circumference of the steel reinforcement bar in two layers. Wait until the first layer has dried before applying the second layer. Use a mirror to inspect behind the back of the bars to ensure full coverage. Take care not to splash or apply material on a dry (not pre-wetted) concrete substrate behind the bars. Refer to the relevant product data sheet for more information.

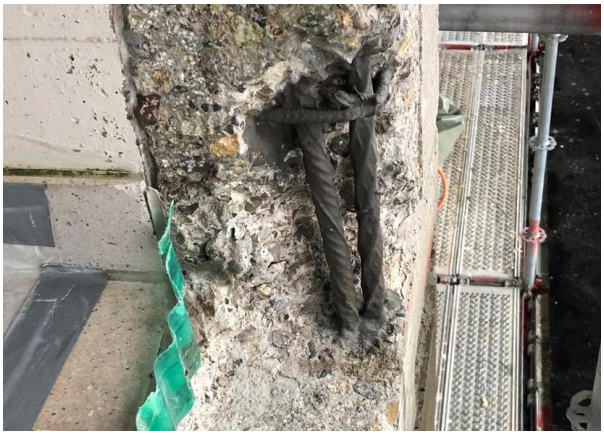


Figure 5: Applied corrosion protection SikaTop® Armatec®-110 EpoCem® on steel rebars.

9.3 BONDING PRIMER

The substrate surface shall be pre-wetted in accordance with Section 7.3.

Bonding primers can be applied by hand pressing the material firmly into the surface using a brush or using a hopper gun (see next section) for larger areas.

The following repair mortar shall be applied wet-on-wet to the bonding primer. Ensure the substrate surface is fully covered behind the reinforcement bars. For large applications use only a bonding primer with long open time (e.g., SikaTop® Armatec-110 EpoCem®) referring to the product data sheet.

When applying a bonding primer, ensure all voids and pits are filled and areas behind reinforcement bars are covered.

9.3.1 HOPPER GUN PROCESS

The pre-mixed quantity of mortar is fed into the hopper. The mortar is conveyed onto a substrate with help of compressed air. Usually, a small valve on the air connector is used to regulate the air flow rate. Too little air and the material will 'splutter' and not spray adequately. Too much air will produce turbulence in the sprayed material, causing separation of the grains and result in an increase in rebound.

The spray distance from the substrate is dependent on air pressure, nozzle opening size and type of hopper gun. Refer to the machine manufacturer's instructions before use. As a general rule, set the nozzle opening to two or three times larger than the maximum mortar grain size. Hold the nozzle at 90 degrees and approximately 100 mm to 300 mm away from the substrate. It is advisable to test spray an area before starting the main application.

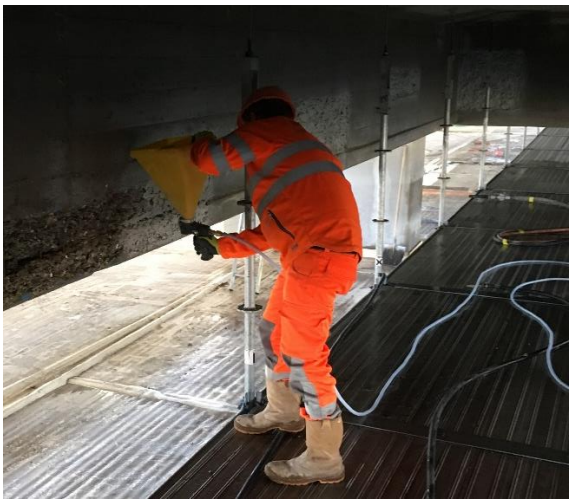


Figure 6: Application of bonding primer Sika MonoTop®-1010 with Hopper gun.

9.4 CONCRETE REPAIR / REPROFILING MORTAR

Sika® Repair mortars are well suited for hand and machine application. In general, spray application leads to a denser packed mortar, and therefore usually a higher quality.

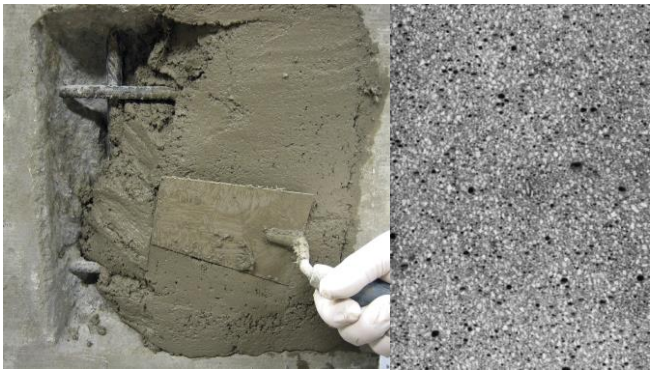


Figure 7: Hand applied mortar.

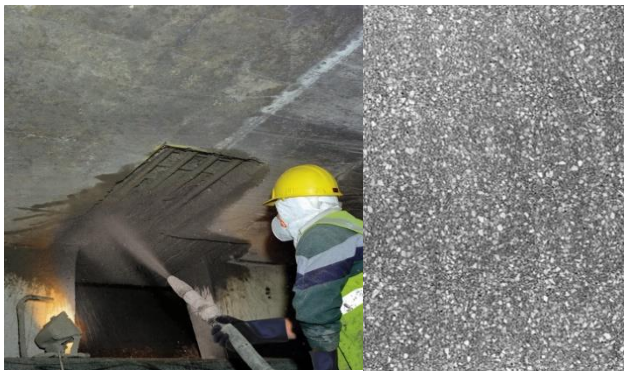


Figure 8: Machine applied mortar - more densely packed.

9.4.1 HAND APPLIED REPAIR MORTARS

On a well-prepared substrate, the repair mortar shall be pressed firmly or thrown into the repair area. Ensure all the substrate pores and pits are filled.

Check pot-life and adjust as necessary the water to powder ratio to suit temperature and application conditions.

When the repair depth exceeds the maximum layer thickness of the repair material, then layers may be built up on top of one another to increase the overall construction depth. The first layer shall be hardened, and exothermic reaction of the material completed. The first layer shall be at ambient temperature before applying the second layer.

Do not smooth the first layer before applying a second layer. The first layer shall have sufficient roughness to provide a mechanical key for subsequent mortar layers.

Ensure the repair mortar covers the whole circumference of the reinforcement bars and there are no voids left behind the back of the bars.

Finish the surface with a wooden or PVC float. Do not overwork the finished surface as this will produce a cement rich surface texture, which may cause the formation of random (crazing) cracking in the surface.

Figure 9: Hand application of repair mortar Sika MonoTop®-4012.

9.4.2 SPRAY APPLIED REPAIR MORTARS

Spray application is usually used for high volume application, where it can lead to a much shorter application time and consistent quality. Repair mortars may be applied using the wet spray (‘shotcrete’) or dry spray (‘Gunite’) techniques, depending on the product. Before using any spray equipment for the first time, always read the manufacturer’s information before starting.

9.4.2.1 PRE-WET THE MACHINE

Once the wet spray machine is set up, the pump, hose and pipe shall be lubricated to prevent suction using SikaPump®-Start-1, a slurry mortar mix or cement. The slurry mix shall not contain too much water to cause sedimentation. Do not spray the lubricating slurry or pre-wetting mixes on the application area.

9.4.2.2 SET UP MORTAR CONSISTENCY

Test the mortar consistency on a test area (e.g., a big pot) and perform a slump test. The nozzle shall be always directed away from the application area until the mix is correctly adjusted. Allow some repair mortar waste until the material reaches the recommended consistency. When using a mixing pump, take special consideration for the right water pressure.

A high viscosity mortar mix can cause the application to slump on the surface. A dry, low viscosity mortar may not be conveyed by the pump, and it can cause a stoppage. Continue to spray away from the application area until all the lubricating slurry has been emptied from the hose or pipe. Once all the lubricating slurry has been used the main application can begin.

The nozzle operator adjusts the amount of high-pressure air required to produce a homogenous mass of mortar on the application substrate. Too much high-pressure air will result in an increase of rebound and wasted mortar. Too little air will not provide sufficient compaction of the mortar on the application surface.

9.4.2.3 SPRAYING OPERATION

CONTINUING SPRAY APPLICATION

Always maintain a non-interrupted flow of mortar through the pump machine, do not stop-start. If the flow of the spray becomes intermittent, the nozzle shall be directed away from the substrate until the spray becomes constant again. Adjust as necessary the water to powder ratio to suit temperature and application conditions.

SPRAYING DISTANCE AND ANGLE

The nozzle shall be held at the correct distance (approximately 200 – 500 mm, the exact distance dependents on air pressure, nozzle opening size and type of spraying equipment) and at 90 degrees to the surface. Layers of sprayed mortar shall be built up on the concrete substrate making several passes with the nozzle (circular motion). A free top edge on a thick layer application shall be finished at 45 degrees to the surface. Always use good working practices and nozzle manipulation to apply each layer.

SPRAYING MOTION

For vertical, or near vertical applications, spraying shall commence from the bottom up. On curved overhead surfaces, mortar shall be applied from the shoulder to the crown. No sprayed mortar shall be applied onto surfaces containing rebound. All rebound material shall be removed from the working area and not re-used.

SPRAY AROUND REBARS

When spraying behind steel reinforcement bars, the nozzle shall be held closer to the substrate surface at an angle to prevent rebound entrapment behind the bars. The applicator shall ensure the bars are fully encapsulate with no voids left between the bar and substrate.

DEFECTS

Pockets, sags, or other defects in the sprayed mortar shall be cut out using appropriate method, carefully removed and re-sprayed. It is recommended the area of re-spray shall not be less than 300 x 300 mm.

CONDITIONS

Protect the hose or pipe from direct sunlight. If necessary, lay a moist material over the top of the hose as protection, and do not allow drying.

Figure 10: Spray application of Sika MonoTop®-4012.

9.5 FINISHING / PREPARING FOR LEVELLING MORTAR

If no levelling coat is to be applied on top of the repair mortar, refer to Section 9.7.1 “Finishing”, otherwise prepare the repair mortar surface with a wooden or PVC float. Do not overwork the finished surface as this will produce a cement rich surface texture, which may cause the formation of random (crazing) cracking in the surface. The surface must be rough enough for the following cementitious coat to ‘claw’ itself onto the repair mortar (the roughness has to be at least the diameter of the maximum grain size of the cementitious coat).

9.6 REMOVAL OF FORMWORK

The formwork shall not be removed until sufficient strength has been achieved. This time depends on the material characteristics and climate conditions. As guidance, the formwork around a normal setting mortar at 21°C / 55% relative humidity conditions may be removed approximately 12 to 24 hours after application.

Formwork shall only be removed with the agreement of the supervising officer or qualified engineer.

9.7 SMOOTHING / LEVELLING MORTARS

Smoothing mortars can be applied by hand, by hopper gun or by mechanical spray equipment for large areas.

A smoothing coat shall be applied over the whole prepared concrete surface (including repair and non-repaired areas). Any laitance on the surface shall be removed (Section 7.1) and surface pre-wetted in accordance with Section 7.3.

Wait until the repair material has properly hardened before applying a smoothing coat.

Use a notched trowel to apply the mortar by hand in a vertical direction onto the surface. Hold the trowel at an acute angle to the surface and use different sized toothed trowels to regulate the application thickness. Do not to disturb the mortar bond on the concrete substrate.

Toothed Trowel Size	Approximate Application Thickness	
	30°	45°
10 mm	~5.0 mm	~7.0 mm
5 mm	~2.5 mm	~3.5 mm
2 mm	~1.0 mm	~1.5 mm

Table 7 - Approximate application thickness guide.

When the first layer is hard, apply the second layer between the vertical lines. The hardness can be tested by the ease at which a fingernail can be inserted into the mortar. The waiting time between the layers depends on the experience of the applicator.

An alternative is to apply double the thickness with notched trowels and smooth the surface right away.

Finish surface with damp sponge, wooden or plastic (PVC) float after the material has set. Do not apply additional water on, or overwork, the finished surface as this will cause discoloration and random (crazing) cracking.

Figure 11: Application of Sika MonoTop®-3020 by spray and hand application.

9.7.1 FINISHING

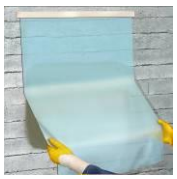
Finish the surface off with a damp sponge, a wooden or a plastic float after the material has set. Do not apply additional water on the surface as this will cause discoloration and cracking.

Figure 12: Finishing the levelling mortar Sika MonoTop®-3020 with a sponge.

9.8 LAYER THICKNESS / MULTIPLE LAYERS

Do not exceed the specified maximum layer thickness of the repair mortar. When the repair depth exceeds the maximum layer thickness of the repair material, then layers may be built up on top of one another to increase the overall construction depth. The first layer shall be hardened and be at the ambient temperature before applying the second layer (after approximately 24 hours). Do not smooth the first layer before applying a second layer. The first layer shall be cleaned before applying subsequent mortar layers to remove dirt and loose material. Use adequate water pressure (150 – 200 bar Roloc nozzle) or compressed air. The first layer shall not be damaged.

9.9 CURING



Cure with proper curing methods for 3 days or spray with appropriate curing compound (once any surface water has evaporated) or appropriate curing method. Curing methods include damp jute or hessian, plastic sheets or other suitable membranes.

The application shall be protected from wind, rain, frost and direct sunlight. The curing period is dependent on climate conditions. In warm temperatures with low humidity, the application shall be protected from premature drying.

9.10 APPLICATION LIMITS

- Avoid application in direct sun and / or strong winds.
- Do not add water over the maximum recommended dosage.
- Always check the material's pot-life and adjust for climate conditions.
- Temperature of the repair mortar and substrate shall not significantly differ.
- Where the structure is subject to dynamic loading, it is recommended for overhead applications to use repair systems specially tested for this situation (e.g., Sika MonoTop® 4012).

10 INSPECTION, SAMPLING, QUALITY CONTROL

As part of 'Good Practice', the contractor shall provide a QC report containing the following recommended data. For more detailed information refer to EN 1504-10 Annex A, or any other local standards or legislation which may apply.

10.1 SUBSTRATE QUALITY CONTROL - BEFORE AND AFTER PREPARATION

The following checks should be carried out before and after preparation.

Characteristic	References	Frequency	Parameters
Cleanliness of Concrete	Visual	After preparation and immediately before application	No contamination, loose particles or defects
Cleanliness of Steel Bars	DIN EN ISO 8501-1	After preparation and immediately before application	No rust, scale or contamination. [Grade Sa 2 or SA 2 ½ for methods 11.1 or 11.2]
Delaminating Concrete	Hammer Sounding	After preparation	No delaminating concrete
Roughness	Visual or EN 1766 on horizontal surfaces	After preparation	Minimum roughness 2 mm (repair area) No laitance (smoothing mortars)
Surface Tensile Strength of the Substrate	EN 1542	After preparation works	> 1.0 N/mm² for structural repair

Table 8 - QC summary before and after preparation.

10.2 BEFORE, DURING AND AFTER APPLICATION

The following checks should be carried out before during and after the application.

Characteristic	References	Frequency	Parameters
Packaging	Visual	Every bag	No damage
Dry product aspect	Visual	2 bags per 10	Loose, no lumps and not compacted
Mixed material	Visual	Every mix	Homogeneous, no lumps, no un-mixed dry powder
Precipitation	Record	During application	Keep records and provide protection
Wind Strength	Record	Daily	Less than 8 m/sec, or provide protection
Batch Number	Visual	All bags	Keep records
Ambient Temperature	Record	Twice a day	Keep records
Substrate Temperature	Record	Twice a day	Keep records
Material Temperature	Record	Twice a day	Keep records
Water Ratio	Record	All bags	Keep records
Humidity	Record	Twice a day	Keep records

Table 9 - QC summary before during and after application.

10.3 PERFORMANCE TESTING

The following table can be used on the job site to check the adequacy of the application:

Characteristic	References	Frequency	Parameters
Compressive Strength on 40x40x160 prisms	EN 12190	3 prisms per batch	Within PDS limits
Cracking	Visual	28 days after application	No cracking on application
Presence of Voids / Delaminating	EN 12504-1 Hammer sounding or *ultrasonic testing	After application	No delaminating concrete
*Adhesive Bond ('pull off') (non-laboratory performance)	EN 1542 (Acc EN 1504-10 Table A.2)	Min 3 on a test area	$\geq$1.5 N/mm² (structural use) $\geq$0.8 N/mm² (non-structural use)

* Optional testing

Table 10 - QC summary of performance testing.

11 YIELD AND CONSUMPTION

The number of bags required for the work shall be determined by the Contractor. It is the responsibility of the Contractor to have enough mortar on the job site to complete the application.

The yield of a product can be determined from the following equation (assuming no wastage):

Equation: $$\text{yield (litres)} = \frac{\text{(weight of powder (kg) + weight of water (kg))}}{\text{density of mixture (kg/l)}}$$

Given: weight of water: 1 litre = ~1 kg

Example:

Calculate consumption of a bag weighing 25 kg mixed with 3.6 litres of water, when the density of the fresh material is 2.1 kg/l.

1 bag of 25 kg yields: $\frac{(25 + 3.6)}{2.1}$ = **~13.6 litres of mortar**

Therefore, the number of bags required for $1m^3$ of mortar will be:

Nº of bags required per $1m^3$ = (1/yield) x 1000

(1/13.6) x 1000 = **~74 bags**

Consumption of a product can be calculated as follows:

Calculate how many kg of powder is required to cover a 10 mm thick application over an area 1 m^2 (assuming no wastage):

Weight of mixed mortar (kg)	= volume (m^3) x density (kg/m^3)
	= (1 x 0.01) x 2100
	= 21 kg (total)
Less weight of water:	
If consumption is 3.6 l / 25 kg	3.6 / (25 x 100) = 14.5%
If water to powder mixing ratio	= 14.5% then:
Required weight of powder	= 21 / ((100+14.5) / 100)
	= **~18.3 kg powder**

11.1 FOR SPRAY APPLICATION

The Contractor shall consider when determining the quantity of mortar any adjustments depending on the chosen spray technique. Examples of possible adjustment to the consumption calculation are illustrated in the table overleaf.

Description	Effect on Consumption[1]	Example	Adjustment to Consumption Calculation
Substrate Preparation	-ve	Roughened surface	Example: A roughened surface of 2mm requires ~2 kg/m² of powder
Reinforcement Bars	+ve	Volume of bars reduces application volume	Example: 16 diameter bars at 150mm centres in both directions = ~6 kg/m² less powder
Mortar in Equipment	-ve	Mortar in hose Mortar in pump	Example of hose volume [3]: ∅50mm x 30m long = ~118 kg powder ∅30 mm x 10m long = ~14 kg powder
Application	-ve	[2] Rebound and Compaction	Example: Hopper gun (negligible) Wet spray ~15% (total)
Over Spray	-ve	Sprayed mortar above the minimum required	Example: An additional 5mm requires ~10 kg/m² powder [4]

(1) Negative (**-ve**) requires more mortar / Positive (**+ve**) requires less mortar.

(2) The total percentage of rebound and compaction is dependent on a number of factors and shall be determined by trials and relevant experience of the contractor.

(3) Does not consider mortar in the pump machine.

(4) Does not take into consideration any other effect e.g., rebound, compaction, etc.

Table 11 – Example of consumption adjustments.

The material consumption graph gives an indication of how much additional material is likely to be required due to surface roughness, waviness, overspray and rebound.

Dry spraying causes a much higher rebound loss, but the pre-wetting and hose cleaning waste from wet spraying can be avoided.

Example: With an intended layer thickness of t = 20 mm, surface roughness of 2 mm, waviness of 2 mm and an overspray of about 1 mm gives a material requirement of around 64 kg/m², assuming rebound of 15%. With a rebound of 25 % the requirement would be 70 kg/m².

A sensible percentage shall be based on trials or relevant experience for each project.

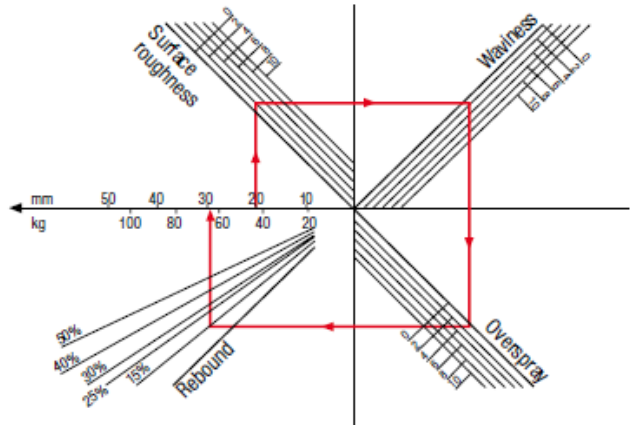


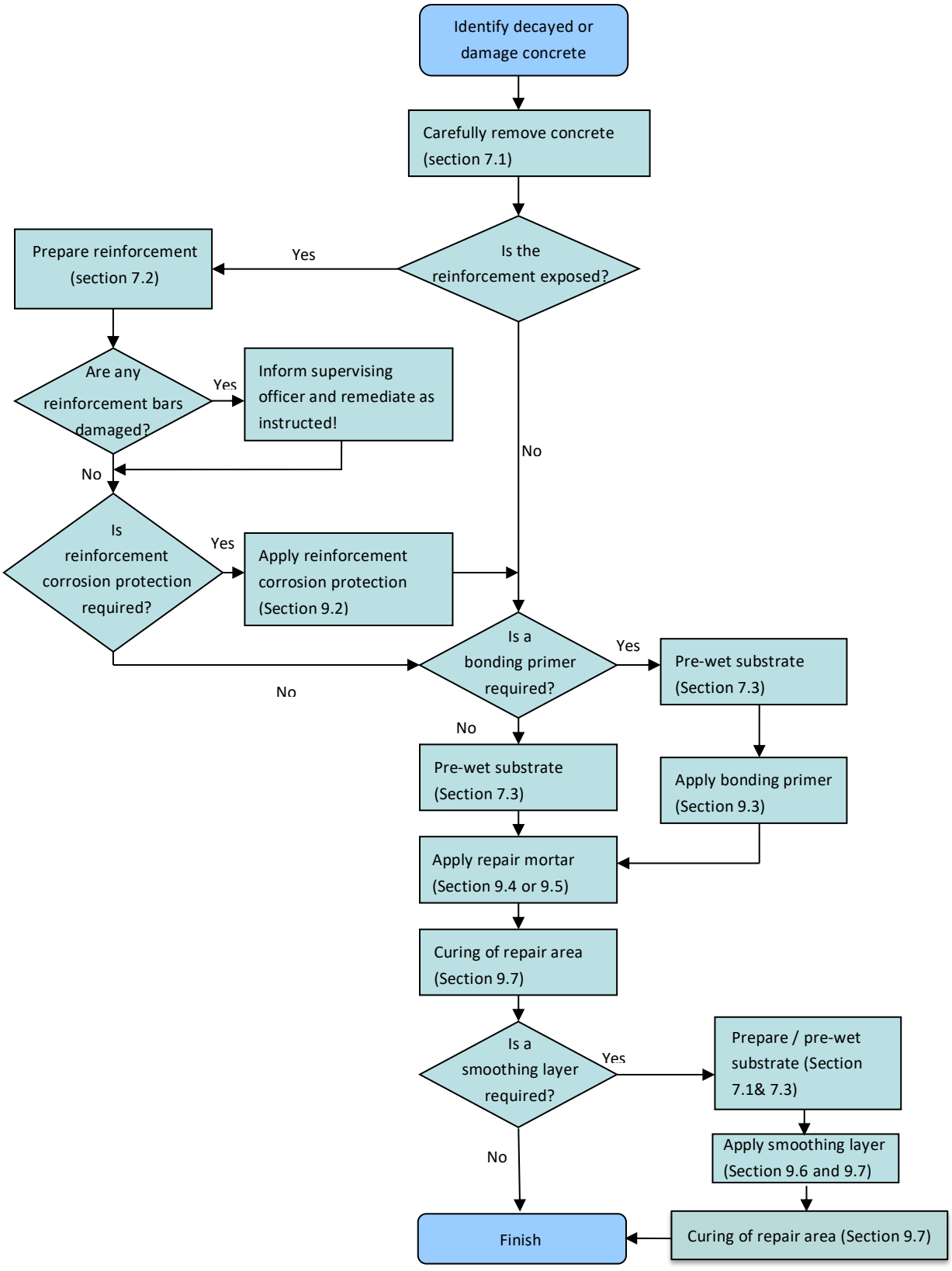
Figure 13: Material consumption graph.

Note: The percentage of rebound is dependent on several factors including the skill and experience of the operative, the pump pressure, nozzle type and the distance and angle of the nozzle from the substrate (5-20 % wet spray).

Rebound quantities are higher for overhead work than on vertical surfaces. Wastage quantities will also include the cut back from material finishing.

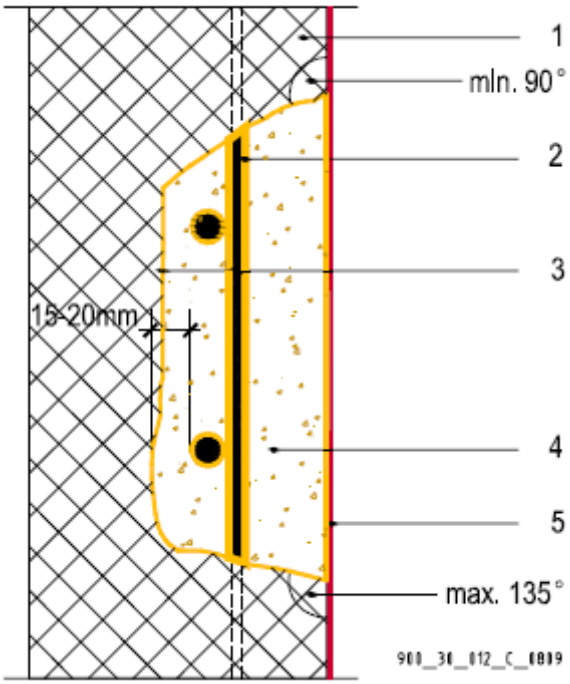
12 CONCRETE REPAIR FLOW CHART

The following is a guide of how to carry out a concrete repair. This is not intended as a definitive guide to repair concrete and shall always be read in conjunction with all Architect's, Engineer's or specialist's specifications together with EN 1504-10, local standards and all relevant product data sheets.



13 TYPICAL DRAWING SHOWING SYSTEM BUILD-UP

This detail is for illustration purposes only and shall not be used as a construction drawing.



1. Host / Parent Concrete Structure
2. Reinforcement Corrosion Protection Layer
3. Bonding Primer
4. Repair Mortar
5. Smoothing / Levelling Mortar

Figure 14: System build-up.

14 REDUCING THE RISK OF A BLOCKAGE

The table below illustrates possible causes and suggestions for minimising the risks:

Item	Possible Cause of Blockage	Minimising Risk Action
Pump Machine	▪ Maintenance ▪ Rust and corrosion ▪ Unclean ▪ Incorrect assembly	▪ Service regularly (refer to instructions) ▪ Inspect all parts for wear and / or damage ▪ Remove all hardened material ▪ Assemble in accordance with instructions
Hose / Pipe and Nozzle	▪ No compaction ▪ Damaged hoses ▪ Kinks and bends ▪ Blocked hose ▪ Extreme temperatures ▪ Suction	▪ Correct nozzle selection ▪ Keep two hoses / pipes and nozzles ▪ Lay to straight or gentle curves ▪ Thoroughly clean hose and nozzle ▪ Protect from extreme high / low temperatures ▪ Thoroughly pre-wet hose ▪ Do not use fast accelerated mortars ▪ Use a short length hose (where possible) ▪ Use hose with uniform diameter
Pre-Wetting Hose / Pipe	▪ Grains stuck in pump	▪ Sedimentation in slurry ▪ Worm too small for maximum grain size
Pre-Mixed Mortar	▪ Large grain size ▪ Mortar too dry ▪ Lumpy mortar ▪ Sedimentation ▪ Defective powder ▪ Admixtures / fibres ▪ Different characteristics	▪ Read spray equipment instructions ▪ Read relevant product data sheet ▪ Mix mortar 3 minutes until homogeneous ▪ Store materials correctly ▪ Use Sika compatible admixtures ▪ Use consistent mixing ratio
Climatic Conditions	▪ Extreme temperatures ▪ Hardening fast ▪ Mortar is too viscous	▪ Read mixing instructions in product data sheet ▪ Work at night ▪ Check mortar setting time ▪ Protect from direct sunlight ▪ Protect from rain
Packaging	▪ Contaminating the mix	▪ Take care when opening bags ▪ Prevent packaging entering mixing
Pauses and Breaks	▪ Hardening of mortar in machine and pipe	▪ Plan breaks before starting ▪ Never leave mixed mortar unattended ▪ Discuss daily spray objectives ▪ Keep a continuous flow of material when spraying ▪ No stop-starts on application area
Job Site Contamination	▪ Foreign particles ▪ Changing products ▪ Different mortar characteristics	▪ Protect mixer and pump hopper ▪ Clean thoroughly when swapping mortars ▪ Do not oil parts in contact with mortar (refer to manufacturer's instructions)

Table 12 – Examples of preventing blockages.

CHECK LIST FOR SPRAY APPLICATIONS (FOR GUIDANCE BUT NOT LIMITED TO ITEMS ON THIS LIST)

IMPORTANT NOTE The Contractor is responsible for preparation of the work s,; to ensure the proper functioning and quality of the spray equipment and application .

Job Reference	Telephone N°	Job Reference
Name	Position	Date

HEALTH AND SAFETY	Yes	COMMENT	No
Risk assessment?			
Personnel protective equipment / first aid?			
Cleaning / waste disposal?			
GENERAL PLANNING			
Logistics e.g. transport, access, etc.?			
Contractor' s method statement?			
Mortar selection / product data sheet(s)?			
Application size / volumes?			
Resources?			
APPLICATION PLANNING			
Working area e.g. clean, illuminated, protected etc?			
Prepared substrate / reinforcement bars?			
Pre-wetting substrate?			
Formwork?			
SPRAY MACHINE			
Manufacturer / type?			
Compatibility e.g. mortars, equipment etc?			
Capacity?			
Clean?			
Working instructions?			
Power?			
Accessories?			

HOSE / PIPE	Yes	COMMENT	No
Compatibility e.g. diameter, length?			
Undamaged?			
Lubricating slurry?			
NOZZLE			
Type?			
Compatibility?			
Clean?			
Water pressure?			
MIXING (WET SPRAY PROCESS			
Machine type?			
Location?			
Protection e.g. sun, rain, etc.?			
MISCELLANEOUS			
Approvals e.g. Engineer, authority etc?			
Water supply e.g. pre-wetting, cleaning, mixing?			
Material e.g. storage?			
Tools e.g. equipment, stoppages etc?			
Surface finishing?			
Equipment spares e.g. hose, pipe, nozzle etc?			
Curing?			

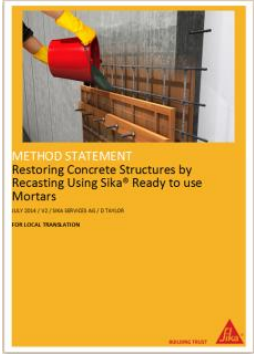
Notes:

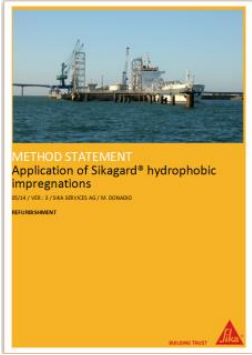
Notes:

15 LEGAL NOTE

The information, and, in particular, the recommendations relating to the application and end-use of Sika products, are given in good faith based on Sika's current knowledge and experience of the products when properly stored, handled and applied under normal conditions in accordance with Sika's recommendations. in practice, the differences in materials, substrates and actual site conditions are such that no warranty in respect of merchantability or of fitness for a particular purpose, nor any liability arising out of any legal relationship whatsoever, can be inferred either from this information, or from any written recommendations, or from any other advice offered. The user of the product must test the products suitability for the intended application and purpose. Sika reserves the right to change the properties of its products. The proprietary rights of third parties must be observed. All orders are accepted subject to our current terms of sale and delivery. Users must always refer to the most recent issue of the local Product Data Sheet for the product concerned copies of which will be supplied on request.

FOR MORE INFORMATION:





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