



# Sprayed Concrete

Solutions for Underground Construction





# Master Builders Solutions from BASF

The Master Builders Solutions brand brings all of BASF's expertise together to create chemical solutions for new construction, maintenance, repair and renovation of structures. Master Builders Solutions is built on the experience gained from more than a century in the construction industry.

The know-how and experience of a global community of BASF construction experts form the core of Master Builders Solutions. We combine the right elements from our portfolio to solve your specific construction challenges. We collaborate across areas of expertise and regions and draw on the experience gained from countless construction projects worldwide. We leverage global BASF technologies, as well as our in-depth knowledge of local building needs, to develop innovations that help make you more successful and drive sustainable construction.

The comprehensive portfolio under the Master Builders Solutions brand encompasses concrete admixtures, cement additives, solutions for underground construction, waterproofing solutions, sealants, concrete repair & protection solutions, performance grouts, performance flooring solutions.

## Global Underground Construction Team

BASF, with its global underground construction team, is a world leader in the provision of reliable, customer-oriented solutions focused on your needs in the tunneling and mining industries. We recognise that your success is underpinned by our ability to deliver solutions that meet or exceed your critical needs. By accompanying you from the start of your project and understanding the issues that are important to you, we can contribute to your success. We support you with product training and quality control, and our professional technical services team is on hand around the clock, helping you with specialist technical advice and trouble shooting.





### Sprayed Concrete – the Most Important Element in Ground Support

Sprayed concrete technology has revolutionized tunnel construction and mining operations since the middle of the 20th century. The development of material science and performance together with advances in spraying equipment technology have made sprayed concrete the building material of choice for today's underground construction projects.

Due to its nature as a spray-applied material, sprayed concrete offers excellent surface sealing and ground strengthening as it perfectly fits the excavation contour, hardening and gaining strength in a remarkably short time frame. It has allowed the construction of subsurface structures that were not possible before.

The development of modern wet-mix sprayed concrete in particular has contributed considerably to this effort. Furthermore, the proven quality of sprayed concrete has led to it being used more and more as a permanent support solution, replacing the traditional cast in-situ inner concrete lining.

### Expert Know-How

Master Builders Solutions provides technical consulting expertise at every project stage from start to finish, covering issues such as geo-technical challenges and design and time constraints. BASF's underground construction specialists bring long-term experience in sprayed concrete application, and work together with laboratory resources to choose the correct product selection. They take a consultative approach to help solve the challenges ahead.

**Mastering underground construction challenges requires the right partner. Continuous innovation and customized solutions ensure that customers using Master Builders Solutions operate successfully, and to the highest safety standards.**



## Sprayed Concrete from Start to Finish



Sprayed concrete applications must ensure safety and be formulated to last. BASF offers a wide range of admixtures for addition during concrete batching and on site.

### At the Batching Plant

#### Superplasticizers

MasterGlenium is a high-performance water-reducing superplasticizer for reduced accelerator consumption, reduced bleeding and lower levels of segregation. Sprayed concrete mixes that combine low water/cement ratios with superior flow and workability allow you to achieve concrete with excellent early strength development as well as high long-term strength and improved durability.

#### Hydration Control

MasterRoc HCA (formerly DELVO®CRETE) is a cement hydration control system for sprayed concrete and other cementitious applications such as grouting and injection. It is capable of maintaining an open time of up to 72 hours, allowing for total flexibility of site logistics.

#### Pumping Aid

MasterRoc TCC 780 is a pumping aid for sprayed concrete mixes with difficult or poorly graded aggregates. It improves the thixotropy of the mix, eliminating the risk of segregation, thus improving pumpability.

### Concrete Improvement

MasterRoc TCC 735 is a chloride-free concrete improving admixture which enhances the quality of sprayed concrete in both plastic and hardened states. Its unique composition ensures better hydration of the cement. As a result, initial shrinkage is substantially reduced, bonding characteristics are enhanced and density and compressive strength are increased.

### Colloidal Silica

MasterRoc MS Colloidal Silica is an amorphous precipitated silica suspension (liquid) designed to improve the properties of sprayed concrete in both the plastic and hardened states.

It improves pumpability and sprayability and reduces rebound, at the same time reducing permeability and improving durability in the hardened state.

### Microsilica

MasterRoc MS microsilica improves the pumpability and workability performance of sprayed concrete mixes in the fresh state while reducing permeability and increasing density and long-term strength performance in the hardened state. It is available in both densified powder and liquid formulations.

### Structural Plastic / Steel Fibers

MasterFiber structural reinforcing fibers greatly improve the load absorption capability and cracking resistance of sprayed concrete, and are available in both steel and polypropylene versions. They are easy to dispense and use, giving even distribution throughout the mix to ensure uniform results.

## On Site

### Pump Lubrication Aid

MasterRoc LUB 1 powder is specially formulated for lubricating concrete pumps, hoses and pipelines prior to concrete pumping or spraying.

### Set Accelerators

MasterRoc SA alkali-free accelerators are added at the nozzle, and accelerate the setting and hardening of the sprayed concrete. They provide high early strength gain and long-term strength development, as well as enhanced durability. Furthermore, they reduce dust and rebound levels.





## Mix Design & Durability



### Mix Design

Creating the optimal concrete solution requires experienced concrete knowledge. Suitable materials for the mix (cement, aggregates, superplasticizer, etc.) and the correct alkali-free accelerator must be chosen to optimize pumpability and spraying performance. Furthermore, project limitations such as transport restrictions and badly graded aggregates, as well as specific project requirements, such as very high early strength to minimize settlement in urban tunneling and faster re-entry in mining, require the variety of admixtures BASF offers to solve these specific challenges.

### Durability

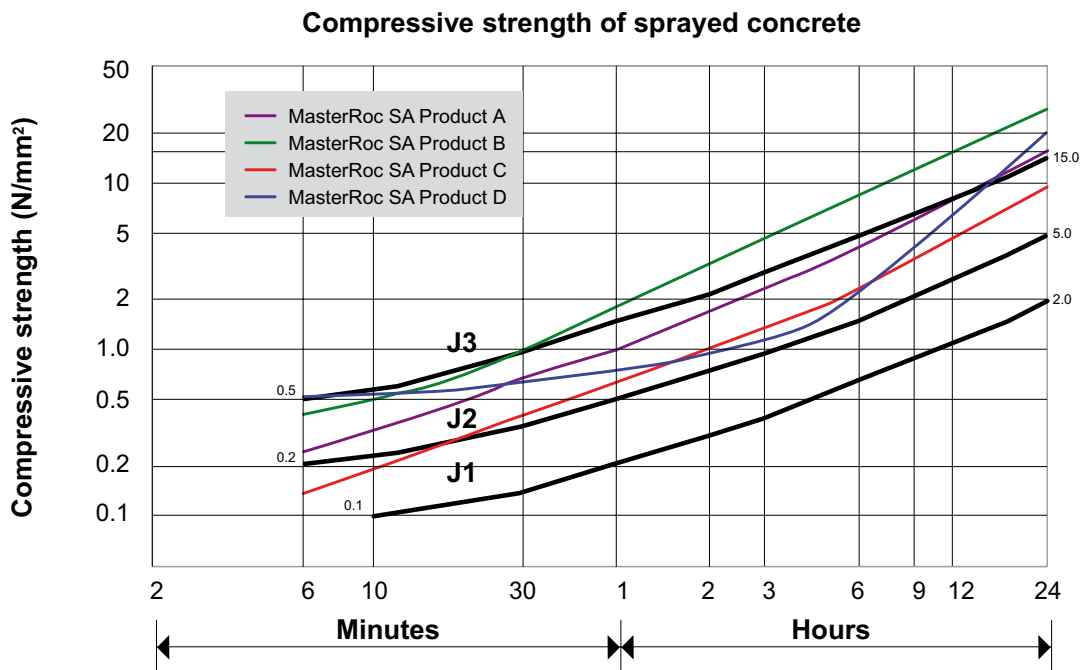
A durable sprayed concrete lining is defined as one that performs in the working environment for the duration of its expected service life. Achieving good durability depends on a variety of factors, especially density and water/cement ratio. Each project requires an adapted solution based on customer requirements and local building material, and BASF's underground construction specialists are here to propose the

right chemistry for a successful result.

As a consequence of the growing use of sprayed concrete as a permanent construction material for tunnel linings, demands on its durability have increased likewise. It offers more flexibility in terms of the geometry and space requirements. Permanent sprayed concrete is a requirement for the innovative composite shell lining design (see page 8).



Sprayed concrete quality testing



Recorded compressive strength developments by selected alkali-free set accelerators in comparison with J1, J2 and J3 standard requirements based on the Austrian Guideline for sprayed concrete

### Alkali-Free Accelerators

The MasterRoc SA series of alkali-free accelerators has been developed in response to the demand for durable, high-quality sprayed concrete that minimizes environmental risk. BASF offers a wide range of accelerators to suit local cements, conditions and site needs.

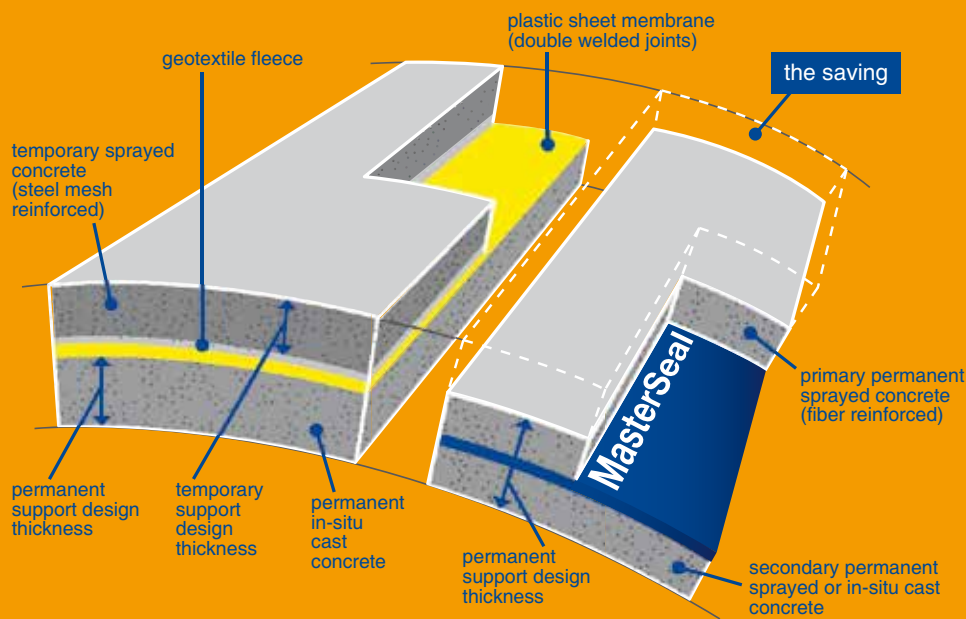
- High performance with relatively low dosages
- Fast setting and constant early strength development, allowing fast application and high build rates
- Effective where mesh and bar reinforcement is used, enabling elimination of spray shadow
- Allows a dense concrete structure to be built with high final strength
- Highly durable sprayed concrete for permanent support
- Ability to spray in areas with low water ingress
- Sprayable in ground-freezing projects
- pH value of around 3 makes the product non-aggressive for increased worker safety
- Low dust and rebound for a healthier working environment

It is essential to use automated spraying equipment which incorporates an integrated dosing system to ensure accurate dosage control.

BASF strives to offer innovative solutions through continual product development dedicated to tunneling and mining needs. Part of BASF's Research & Development Community, a dedicated underground construction development team focuses its efforts on tailoring the properties of sprayed concrete's microstructure.



## Design Optimization: The Composite Shell Lining



State-of-the-art sprayed concrete technology and innovation in sprayable waterproofing membranes have enabled tunnel engineers to design a considerably more economical tunnel lining system, the composite shell lining (CSL) system. It is a further development of the single shell lining system, and consists of two concrete linings, primary (outer) lining and secondary (inner) lining, and a double-bonded spray-applied waterproofing membrane embedded between them. CSL systems can be used for tunnels located in ground with limited, manageable water ingress, or for tunnels where water ingress has been treated with pre-injection. Although the composite shell lining is predominantly used in tunnel construction, it is suitable for all underground structures.

The primary sprayed concrete lining of a CSL system is designed as a permanent solution, and the two bonded concrete linings allow the thickness of the secondary lining to be significantly reduced, leading to considerable savings. The most important savings result from less excavation being necessary, a reduced volume of construction materials and no need for formwork. Additional savings in comparison to conventional waterproofing sheet membranes result from higher flexibility of the construction and reduced long-term maintenance costs.





### Project Solution: Metro Lausanne, Switzerland

The final structural lining design of the Tunnel de Viret, part of the extended M2 line of the Metro Lausanne, was built using the composite shell lining system. The main challenge was to excavate underneath the city, including the cathedral and the ground water table beneath it. For this reason, a waterproofing solution which minimizes the risk of water drainage was needed to avoid ground settlement and damage to the cathedral.

Permanent sprayed concrete was used with the MasterSeal 345 spray-applied waterproofing membrane, creating a composite shell lining. The thickness of the secondary lining was considerably reduced in comparison to the original lining design, leading to a 23% reduction in the total lining thickness. No defects or water ingress have been reported to date since construction in 2008.

### Additional project benefits:

- Considerable cost savings per linear tunnel meter
- Reduction of construction time by two months
- No formwork needed for the secondary lining through use of sprayed concrete



# Sprayable Waterproofing Membrane



MasterSeal 345 is a double-bonded sprayable waterproofing membrane, and establishes a new concept for waterproofing. The bonded waterproofing membrane, which is used for the composite shell lining, can resolve technical problems which have proved difficult with conventional sheet membranes, by preventing the migration of water on either side of the membrane. It can be applied to existing tunnels for refurbishment, and is especially suited to projects where space is limited due to the clearance outline. It also brings great benefits for new concrete structures,

particularly those with complex geometries such as tunnel intersections and cross passages, offering a flexible and continuous waterproofing system without discrete joints, water stops or compartmentalization. Furthermore, MasterSeal 345 is also compatible with most other waterproofing systems.

It is simple to apply with conventional dry spraying equipment allowing application rates of up to 80 m<sup>2</sup> per hour by hand or even up to 150 m<sup>2</sup> per hour by means of automated robotic equipment.

## MasterSeal 345 key properties:

- Tensile strength: 4 MPa
- Adhesive strength: 1.2 MPa
- Elongation: 100%
- Watertight up to 20 bar



Composite shell lining:  
crack bridging



### Training and Education

BASF provides technical sprayed concrete training courses centrally in the Hagerbach underground facility in Switzerland. The courses are organized as demonstration workshops in realistic underground settings. These workshops are “show-and-tell” sessions and aim to visualize and explain the technical performance and application of our sprayed concrete solutions. In addition, tailored training is organized for individual projects worldwide when required by customers, also for the application of MasterSeal 345, including design aspects.

### Technical Services

BASF provides more than simply a range of products. Assisting customers in selecting the appropriate system and methodology as well as providing initial supervision and site training of the customers’ personnel is an essential part of our concept. BASF cooperates globally with leading equipment manufacturers to ensure that products meet placing performance requirements and to provide the best, most cost-effective and complete technology solution.

More brochures on our underground construction solutions are available at [www.ugc.basf.com](http://www.ugc.basf.com)

Documentation available on request:

- Reference list
- Project reports
- Technical data sheets
- Design guidelines
- Method statements



# Master Builders Solutions from BASF for the Construction Industry

## **MasterAir**

Complete solutions for air-entrained concrete

## **MasterBrace**

Solutions for concrete strengthening

## **MasterCast**

Solutions for the manufactured concrete product industry

## **MasterCem**

Solutions for cement manufacture

## **MasterEmaco**

Solutions for concrete repair

## **MasterFinish**

Solutions for formwork treatment

## **MasterFlow**

Solutions for precision grouting

## **MasterFiber**

Comprehensive solutions for fiber-reinforced concrete

## **MasterGlenium**

Solution for hyperplasticized concrete

## **MasterInject**

Solutions for concrete injection

## **MasterKure**

Solutions for concrete curing

## **MasterLife**

Solutions for enhanced durability

## **MasterMatrix**

Advanced rheology control solutions for self-consolidating concrete

## **MasterPel**

Solutions for watertight concrete

## **MasterPolyheed**

Solutions for high-performance concrete

## **MasterPozzolith**

Solutions for water-reduced concrete

## **MasterProtect**

Solutions for concrete protection

## **MasterRheobuild**

Solutions for superplasticized concrete

## **MasterSeal**

Solutions for waterproofing and sealing

## **MasterRoc**

Solutions for underground construction

## **MasterSet**

Solutions for retardation control

## **MasterSure**

Solutions for workability control

## **MasterTop**

Solutions for industrial and commercial floors

## **Master X-Seed**

Advanced accelerator solutions for pre-cast concrete

## **Ucrete**

Flooring solutions for harsh environments

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