



CONCRETE PRODUCTS FOR TBM

BUILDING TRUST



SIKA AND THE PRODUCTS FOR TBM

MECHANIZED TUNNELING has become more and more important with the rapid growth and expansion of underground construction in recent years.

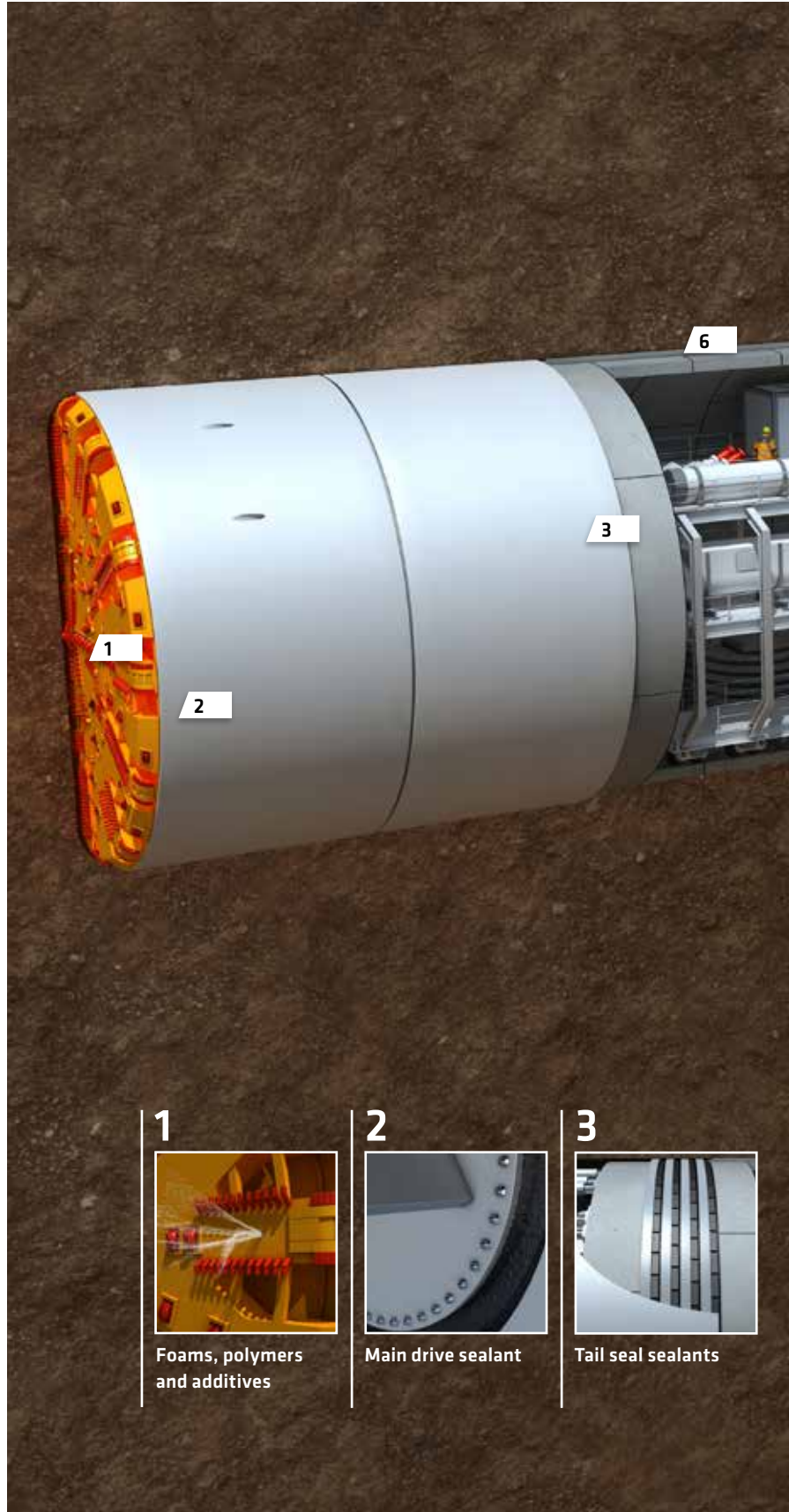
Tunnel Boring Machines (TBMs) are very advanced equipment used as an alternative to “drilling and blasting” through rock and “conventional mechanical excavation” in soft ground.

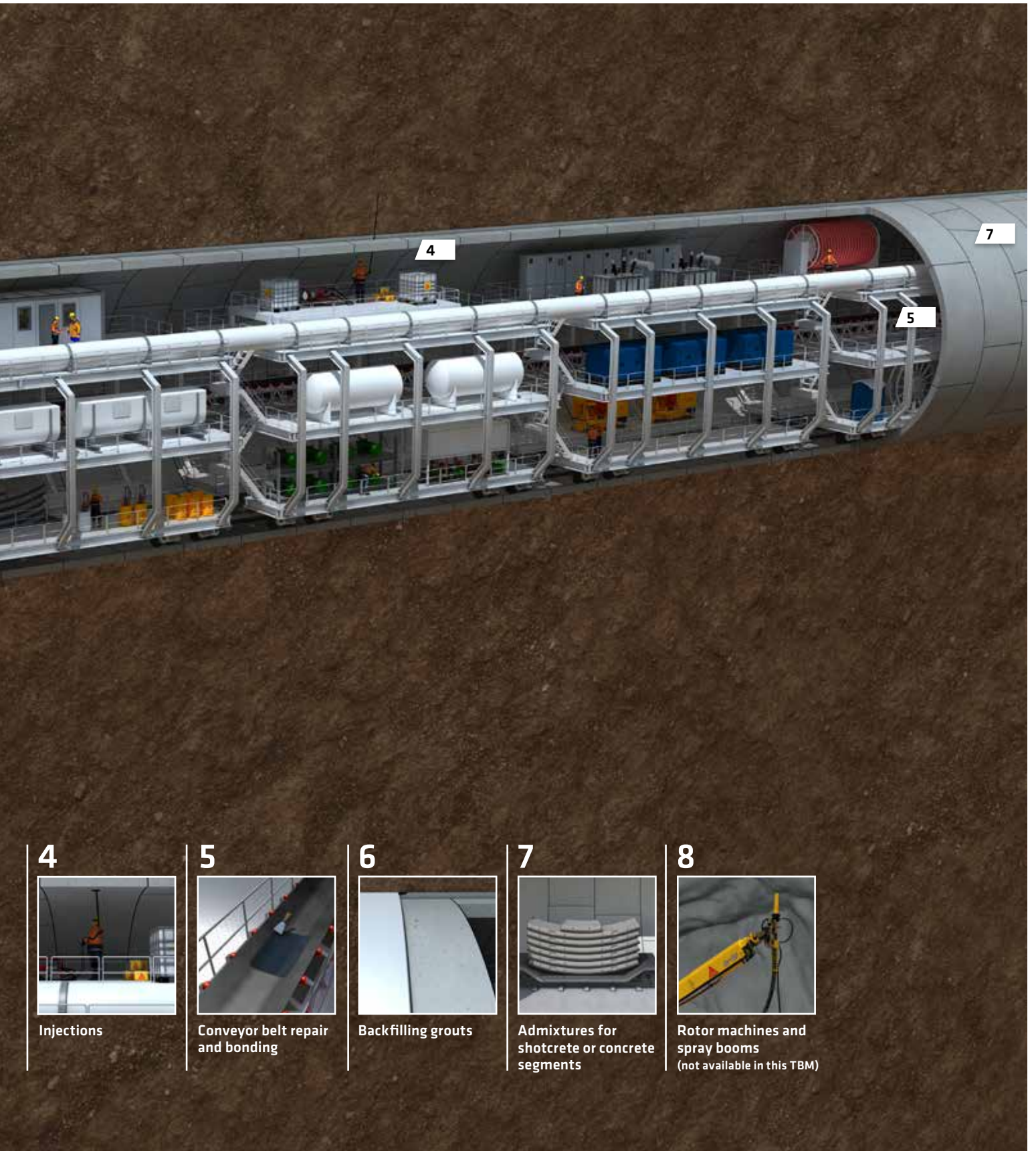
TBMs reduce disturbance in the excavation area, which makes them ideal for use in heavily urbanized areas. They will also produce a smooth tunnel wall that reduces the cost of the final lining.

The total excavation time of long tunnels is also significantly reduced with TBMs in comparison to conventional excavation methods.

A variety of TBMs have been introduced during the past decades. These include the Slurry and the Earth Pressure Balance (EPB) for soft ground, the Grippers for hard rock and the Single Shield TBM for tunneling through rock and other stable, non-groundwater-bearing grounds.

Sika provides a wide range of products that are designed specifically for use with all of these different variants of TBM, and throughout the whole of their tunnel excavation and construction process.





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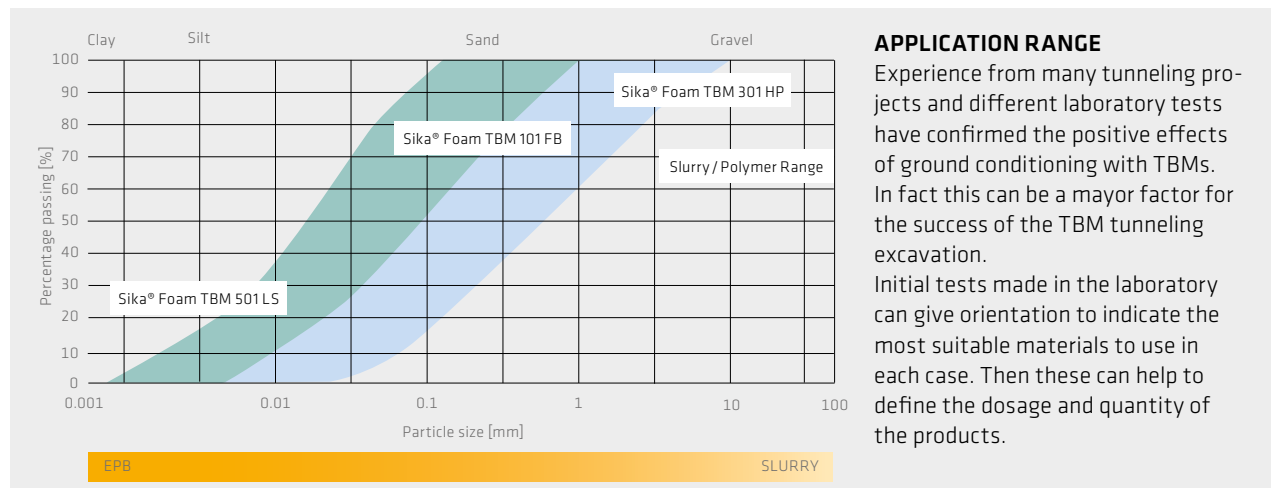


Rotor machines and spray booms
(not available in this TBM)

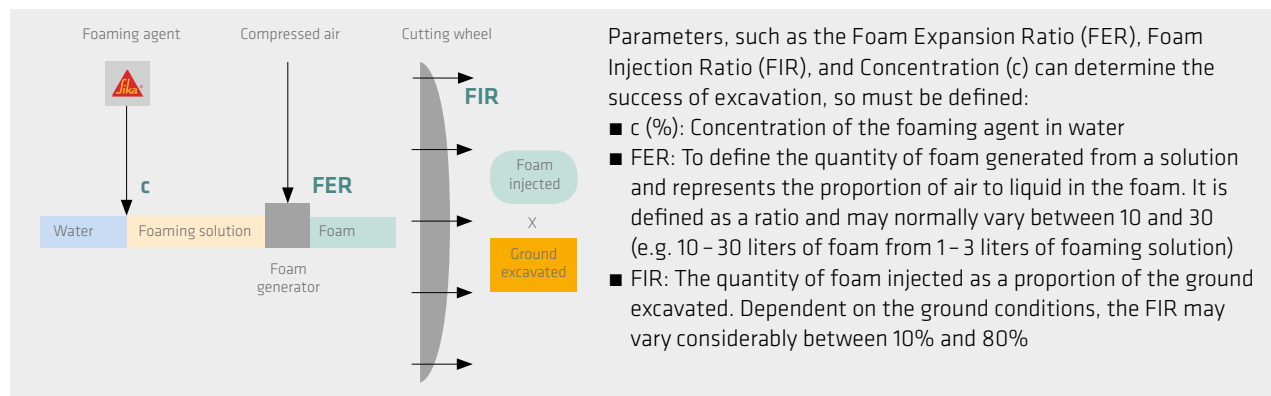
FOAMS, POLYMERS AND ADDITIVES

THE INJECTION OF FOAMS, POLYMERS AND OTHER ADDITIVES into the tunnel face can significantly modify the characteristics of soft ground, including its plasticity, texture and permeability, in order to make the work and progress of the TBM easier and faster. The selection of the best type and quantity of material for this ground conditioning is dependent on the specific geology and the equipment available with the TBM.

APPLICATION RANGE OF EPB-TBM'S / USE OF FOAM



FER AND FIR PARAMETERS



ADVANTAGES OF CONDITIONING

Soft Ground

- Reduction of friction angle
- Short term cohesion
- Lower wear and lower torque
- Short term face stabilization
- Less clogging
- Lower permeability

Hard Rock

- Reduction of dust
- Reduction of disc cutter choking
- Cleaner and faster changing of disc cutters
- Lower wear and lower torque
- Reduced abrasion and wear



FOAMS

As not all ground is ideal for excavation by TBMs the use of ground conditioning foams can allow EPB TBMs to achieve better advance rates, even in heterogeneous grounds containing gravel, sand and water, or under other critical geological conditions.

Sika® Foam TBM 101 FB

Foaming agent for ground with high to low permeability, polymer modified.

Sika® Foam TBM 102 GP

Foaming agent with exceptionally high stability.

Sika® Foam TBM 301 HP

High concentration Foaming agent for highly permeability and fractured soils.

Sika® Foam TBM 401 LC

Universal Foaming agent for medium permeability soils.

Sika® Foam TBM 501 LS

Foaming agent for high cohesive soils.



POLYMERS

Typical applications of Sika polymers in the TBM excavation process are:

- Reduction of "stickiness"
- Reduction of adhesion to metal surfaces
- Reduced segregation in the mixing chamber
- Drying out the ground

Sika® Foam TBM 220 P

Water absorbing powder product, which reduces the risk of filling the pressure chamber with liquefied soil and water.

Sika® Foam TBM 230 L

Water absorbing liquid product, which also reduces the risk of filling the pressure chamber with liquefied soil and water.

Sika® Foam TBM 800 C

Polymer liquid for foam stabilizing and a dispersal aid for fines.

Sika® Foam TBM 900 Bio

Natural polymer liquid viscosifier and stabilizer for foams and other water dispersed fluids.

Sika® Foam TBM 1000 Bio

Natural polymer powder viscosifier and stabilizer for foams and other water dispersed fluids.



ADDITIVES

Although foams are the most widely used materials, they are not the only type of products that can be considered. Additional products may be used to achieve different results during TBM excavation and progress.

Sika® Foam TBM 20

Disc cutter cleaner and clay remover.

Sika® Foam TBM 200

De-foaming agent used in tunnel excavation and muds before disposal.

Sika® Foam TBM 700 WR

Special clay based friction reducer used to keep steel surfaces clean.

MAIN DRIVE AND TAIL SEAL SEALANTS

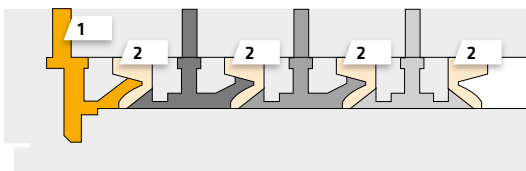
SIKA SEALANTS HAVE BEEN SPECIFICALLY DESIGNED and developed with a hydrocarbon-free, vegetable oil based formulation, which avoids any residual spoil contamination and are also resistant to water and ground pressure.

MAIN DRIVE SEALANT

One of the most important and expensive components of the TBM is probably the main bearing. In order to keep this in good condition, it has to be properly sealed and lubricated. Experience has shown that most failures of TBM main bearings are related to a loss of lubricant, or to the entry of contaminants from outside. For this reason it is absolutely essential to have the system working with reliable products. Sika® Stabilizer TBM H protects the main bearing preventing it from contact with water, mud, dust and foam contamination.

Sika® Stabilizer TBM H

Bearing sealant for TBMs with a strong grab and adhesion to metal surfaces, with extremely high wash-off resistance. It also has good lubrication and pumping properties.



1	2
Sika® Stabilizer TBM H	Seals



TAIL SEAL SEALANTS

Tail seal sealants are injected between the rows of brushes in the gap between the tailskin and the lining segments to prevent water, soil and the backfilling grout from entering the TBM. Sika® Stabilizers are specifically designed to be safe for use in urban areas and elsewhere that the ground water could be in contact with TBM excavations, in order to prevent pollution of the environment.

Sika® Stabilizer TBM TS1

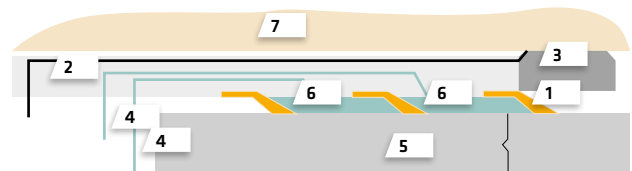
First-fill tail seal sealant.

Sika® Stabilizer TBM TS2

Tail seal sealant for TBMs.

Sika® Stabilizer TBM TS3

Non-flammable tail seal sealant for TBMs.



1	2	3	4	5	6	7
Wire brush	Tailskin	Backfill	Grease lines	Concrete segment	Sika® Stabilizer	Ground



INJECTIONS

SIKA PROVIDES A WIDE RANGE of injection products which are used with TBMs for different applications including soil consolidation, rock stabilization, stopping water ingress, permanent sealing and waterproofing, plus the filling of voids and cavities etc.

Water ingress and wash-out with the development of uncontrolled cavities presents a security risk and potentially major costs for hard rock and gripper TBMs.

SikaFix® injection technologies are highly efficient in solving such problems as the cured material is easily cut by the TBM. The performance is not changed in the presence of water.

SikaFix® 301

This is an acrylate based, 3-component injection resin, specially developed to penetrate and consolidate low permeability structures. SikaFix®-301 has almost water-like consistence and therefore penetrates rock and sand filled structures quickly and very efficiently. Reaction time of the resin can be adjusted from 2 - 15 minutes depending on the application and penetration distances required.

SikaFix® 501

SikaFix®-501 is a 2-component, silicate resin with a high foaming factor of around 30 times (reaction time is around 15 sec.). The product foams with- or without the presence of water. Another important advantage for TBMs with this product is the cuttable nature of the cured foam, as a PU-foam would adhere to the cutter-head of the TBM.

SikaFix®-501 also shows excellent cost performance in comparison to other TBM pre-injection products, and is widely used for to stabilize fractured geology with a high void or cavity content.

SikaFix® 601

SikaFix®-601 is a 2-component, silicate resin with a short reaction time (around 40 sec.), which cures to a high strength solid resin, without the development of any foam. It also has excellent adhesion, even on damp surfaces, therefore SikaFix®-601 is frequently used for demanding rock consolidation and for controlling over-blasting in the tunnels. The product is also available as a thixotropic grade for use in overhead applications and self-drilling bolt injection.



CONVEYOR BELT REPAIR AND BONDING

TUNNELING AND THE MINING INDUSTRY are amongst the largest industrial sectors in the world where rubber conveyor belt systems are widely used. Sika's expertise can provide superior cost-performance options for the bonding and repair of rubber belts and components for many applications.

BELT REPAIR

SikaBond® R&B-100

This 2-component, high-performance elastomeric, synthetic resin based system is specially designed for the repair of textile and steel reinforced rubber conveyor belts. The material is primarily used to fix the commonly occurring, non-structural damage such as holes, cuts and ripped edges caused by the rocks. This significantly extends the service-life of the conveyor belt.

When applied it cures and develops outstanding mechanical properties on a well prepared substrate.

SikaBond® R&B-100 is ideal for fast repairs with a rapid return to service of the conveyor belts.

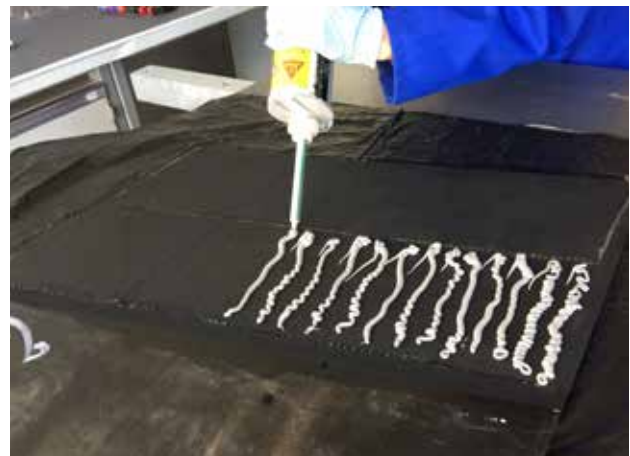


RUBBER BONDING

SikaBond® R&B-200/210

The vulcanization of rubber is time-consuming and can also be an expensive business with a lot of hardware and special know-how involved. Sika is one of the few companies with patented knowledge in this field, plus a global reach to supply outstanding rubber-bonding adhesives.

SikaBond®-R&B-200/210 are fast curing, flexible adhesive systems designed to replace mechanical fixings or fastenings, such as rivets, screws or welding as well as hot vulcanizing itself. They are also suitable for bonding to and/or between many other materials as well as rubber, including metals, hard plastics, glass and wood etc.



BACKFILLING GROUTS

SIKA IS ACTIVELY INVOLVED AROUND THE WORLD in many tunneling projects, providing a wide range of products for TBM backfilling according to each projects specific requirements.

BACKFILLING GROUT

Excavation with shield TBMs means that precast concrete segments are installed to form the tunnel, and an annular gap remains between these segments and the ground. The filling of this annulus is a very important requirement as this ensures homogeneous contact with the ground, transfers load from the TBM back-up and also can help to waterproof the tunnel.

Different types of filling materials have been developed: hydraulically setting mortar and two component grout. Sika offers a complete range of stabilizers and retarders to prepare the backfilling grout: SikaTard®, Sika® ViscoCrete®, SikaFume® and Plastiment®.



TWO COMPONENT GROUT

Two component injection grout is prepared by mixing a blend of water/cement, bentonite and retarder (component A) with an accelerator (component B). These get mixed just before the component A is injected through the tailskin and transforms itself from a creamy liquid to a gel in around 10 – 20 seconds. The final mix has comparable compressive strength to that of the surrounding ground and can fill every gap and void before it sets and hardens.

For the required flow and retarded set effects, Sika's SikaTard® and Plastiment® products are used. SikaSet® or Sigunit® accelerators are then used to control the set and hardening time and process.



ADMIXTURES FOR SHOTCRETE OR CONCRETE SEGMENTS

MODERN SPRAYED CONCRETE UNITS use modern materials handling technology as well as concrete technologies such as admixture chemistry. Increasing demands on cost-effectiveness, the protection of health and the environment have meant that sprayed concrete has been in continuous flux for recent years.

Sika® ViscoCrete®

Products used to reduce the water demand of the concrete, control the workability and increase the durability of sprayed concrete. Strength development is positively influenced by the dual actions of the superplasticizer and the acceleration effect.

SikaTard®

Admixtures developed to regulate the hydration of sprayed concrete which enable an extended workability time, so that continuous spraying with fresh mixes can continue without difficulty for defined periods of time as required.

Sika® Shot

Accelerators are used in sprayed concrete applications such as waterproofing, repair works or fire protection for example. These can be produced as Ready-to use mortars that give flexibility on site as the materials can be stored for relatively long periods and sprayed with comparatively small machines.

Sigunit®

A complete range of alkali-free and alkaline accelerators for shotcrete providing fast strength development according to the required J1, J2 and J3 curves.



IN MODERN TBM CONSTRUCTION the permanent tunnel lining is produced with precast concrete segments. This type of concrete often requires innovative solutions for the mix design.

CONCRETE FOR INNER LININGS

The concrete volume that is required for the inner lining of tunnels is very large cost effectiveness is therefore a significant aspect. The concrete must flow easily so that it can be cast in the molds, it must not bleed or segregate and in order to ensure rapid production and mold turnaround, it must provide high early strength. The requirements of consistence, stability and early strength are controlled by the use of Sika® ViscoCrete® technology. Additional Sika admixtures are also added and used to meet specific demands such as Sikament® and SikaPlast®. If retardation is necessary – SikaTard®, for air entraining – Sika®Aer. SikaFume® Micro Silica increases the density of the mix leading to higher compressive strength and even higher durability.

CONCRETE SEGMENTS

During the production of concrete segments for tunnels, it is important that the concrete can be placed without the formation of hollows or voids. The mix must also have a high early strength to reduce the curing time and de-mold the segments as fast as possible.

With a high plasticizing effect, a low water/cement ratio can be achieved that will result in increased early strengths and increased durability.

After just a few hours the concrete should have sufficient strength. To meet these requirements, special admixtures have been developed using Sika® ViscoCrete® technology. Sika® Separol® release agents are used to ensure easy de-molding and improved concrete surfaces.

In some conditions, the segments forming the permanent lining can be exposed to aggressive influences in the ground water for example, Sikagard®-65 WN, is a water dispersed epoxy coating, designed to provide a high level of protection.



ROTOR MACHINES AND SPRAY BOOMS

ALIVA® EQUIPMENT IS A DIVISION OF SIKA AG IN SWITZERLAND. For more than half a century, Aliva® has been active in the field of shotcrete as a specialist in designing and manufacturing robust and flexible rotary spray machines, concrete pumps, dosing units, telescopic spray booms and special shotcrete spraying systems for TBMs.

ROTOR MACHINES

By conveying through a rotor the material is transported with pressurized air by the thin stream process to the spray nozzle, where it is mixed with water and any additives (e.g. accelerators) can be added.

These Aliva machines have sealing plates made from special steel and an automatic lubrication system that reduces wear and tear, and therefore also downtime and operational costs.

ADVANTAGES OF ALIVA ROTOR MACHINES

- Easy handling and low maintenance
- Long conveying distances possible
- Constant delivery rate and very low pulsation
- Special control cabinet (SPS, additional components, etc.)
- Working pressures and the quantities of materials are continuously displayed on the remote control (AL 267)
- Automatic blockage recognition system (AL 267)
- Also used for backfilling behind concrete segments or filling the annular gap

Aliva®-267

This rotor machine is ideal for processing dry and wet spray concretes. Its modular construction is suitable for both. With its conveying output of 4 - 21 m³/h, it is suitable for TBMs, temporary pit support systems in mining, slope stabilization and rock reinforcement.



SPRAY BOOMS

Aliva® has set new standards with the production of client-specific equipment for tunnel construction. In particular with the Aliva spray-concrete robot (AL-302) and Aliva back-filling grouting equipment (AL-267) for TBMs.

ADVANTAGES OF SPRAY ROBOTS

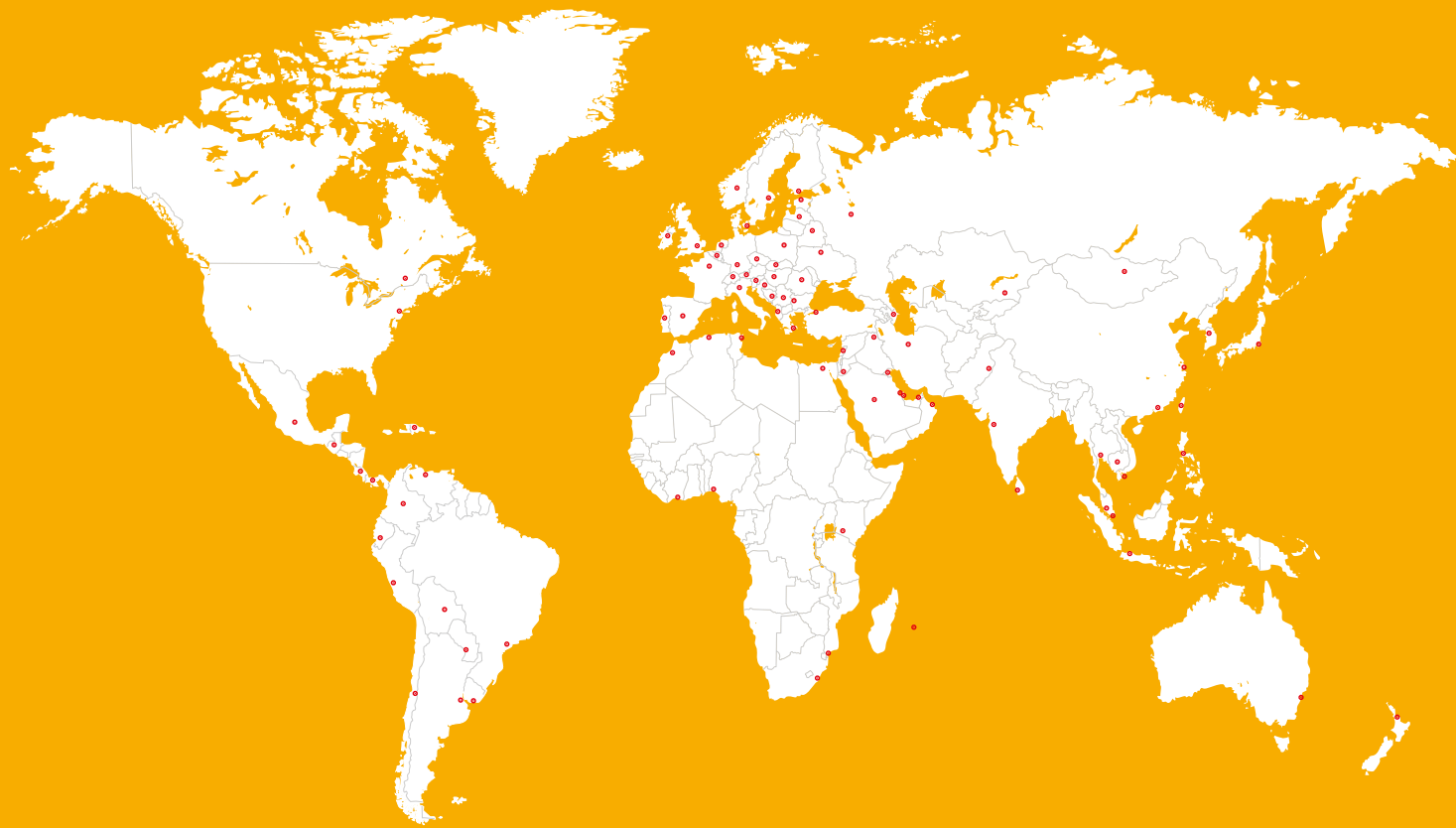
- Designed, engineered and made by Aliva® in Switzerland
- Standardized practical solutions
- Customized solutions
- Flexible in their working range and area
- Spray heads and other accessories on demand
- Concrete and accelerator delivery systems can be included

COMPONENTS OF THE SYSTEM

- Ring mechanism
- Spray robot with a one to threefold telescopic spraying arm
- Aliva®-267 rotor machine
- Customized solutions for TBMs
- Complete systems including the concrete pump and accelerator dosing unit
- Wireless or wired controls



GLOBAL BUT LOCAL PARTNERSHIP



FOR MORE INFORMATION:



WE ARE SIKA

Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika's product lines feature concrete admixtures, mortars, sealants and adhesives, structural strengthening systems, flooring as well as roofing and waterproofing systems.

Our most current General Sales Conditions shall apply.
Please consult the Data Sheet prior to any use and processing.



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