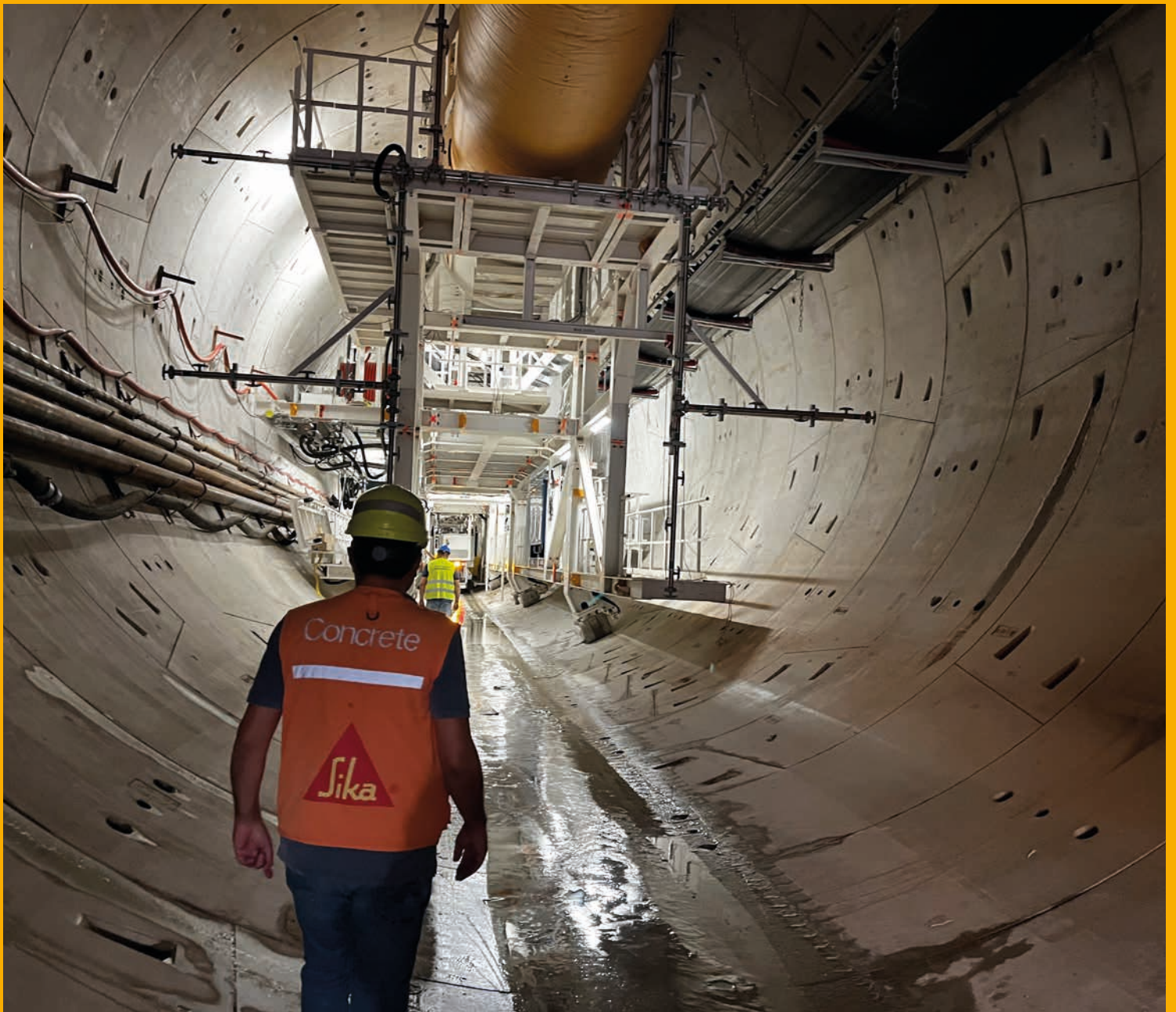




TUNNELING

SIKA SOLUTIONS FOR MECHANIZED EXCAVATIONS

BUILDING TRUST



SIKA SOLUTIONS FOR MECHANIZED EXCAVATIONS





The Sika consolidates a collective expertise to develop tailored solutions for new and old underground constructions: from excavation, to maintenance, repair, and renovation. Drawing on 120 years experience in the construction industry, Sika is founded on a wealth of knowledge.

The foundational core of Sika solutions emerges from the collective knowledge and experience of our global community of construction experts within the company.

We integrate precise elements from our portfolio to address your unique construction challenges. Our collaborative approach spans expertise and regions, tapping into the wealth of experience derived from numerous construction projects worldwide.

We harness the power of global Sika technologies, combined with our deep understanding of local building requirements, to pioneer innovations that enhance your success and propel sustainable construction forward. The Sika AG brand's extensive portfolio includes concrete admixtures and additives, chemical solutions for underground construction, waterproofing solutions, sealants, concrete repair and protection solutions, performance grouts, and performance flooring solutions.

SIKA TUNNELLING AND MINING TEAM

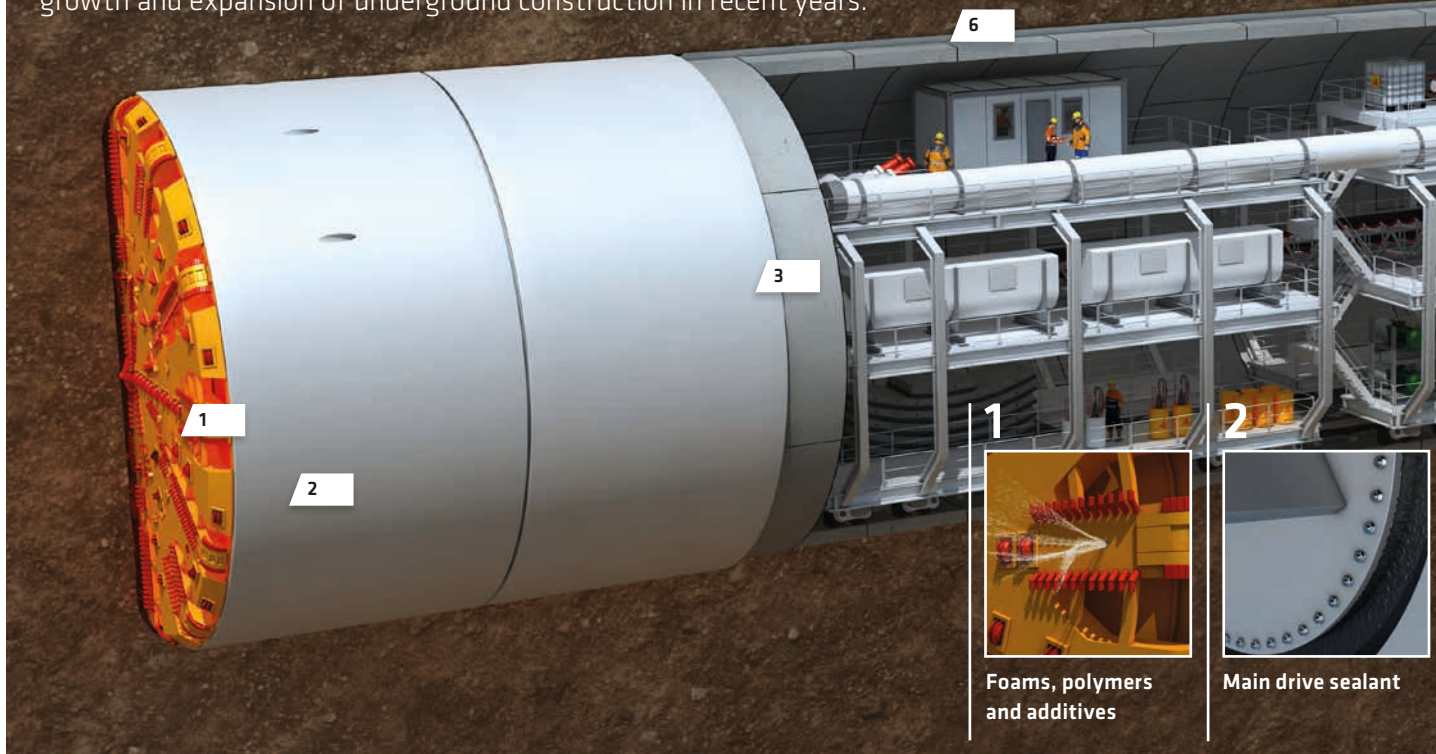
Sika group, equipped with its global underground construction team, delivers dependable, customer-centric solutions tailored to the tunneling industry worldwide. From the start of your project, we engage with you to comprehend the crucial aspects that matter to your objectives, actively contributing to your success: we acknowledge that it hinges on our ability to provide solutions that not only meet but go beyond your essential requirements. Our support extends beyond product delivery, encompassing training, materials control, site trials and a dedicated technical services team available 24/7 to offer specialized advice and troubleshooting.

A WIDE PORTFOLIO WITH EVERY SOLUTION

- TBM solutions
- Shotcrete accelerators
- Concrete admixtures
- Cementitious and polymeric mortars
- Rails fixing systems
- Injections
- Waterproofing membranes
- Sealing and bonding products
- Composite structural concrete strengthening

SIKA SOLUTIONS 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.

Soil conditioners (EPB TBMs)

Basic foaming agents	Foaming agents with lubrication polymers	Foaming agents with anti-day polymers
Premium	Premium	Premium
SS-1118 TBM	SS-1111 TBM	SS-1514 TBM
Standard	Standard	Standard
SS-1113 TBM	SS-1112 TBM	SS-1518 TBM

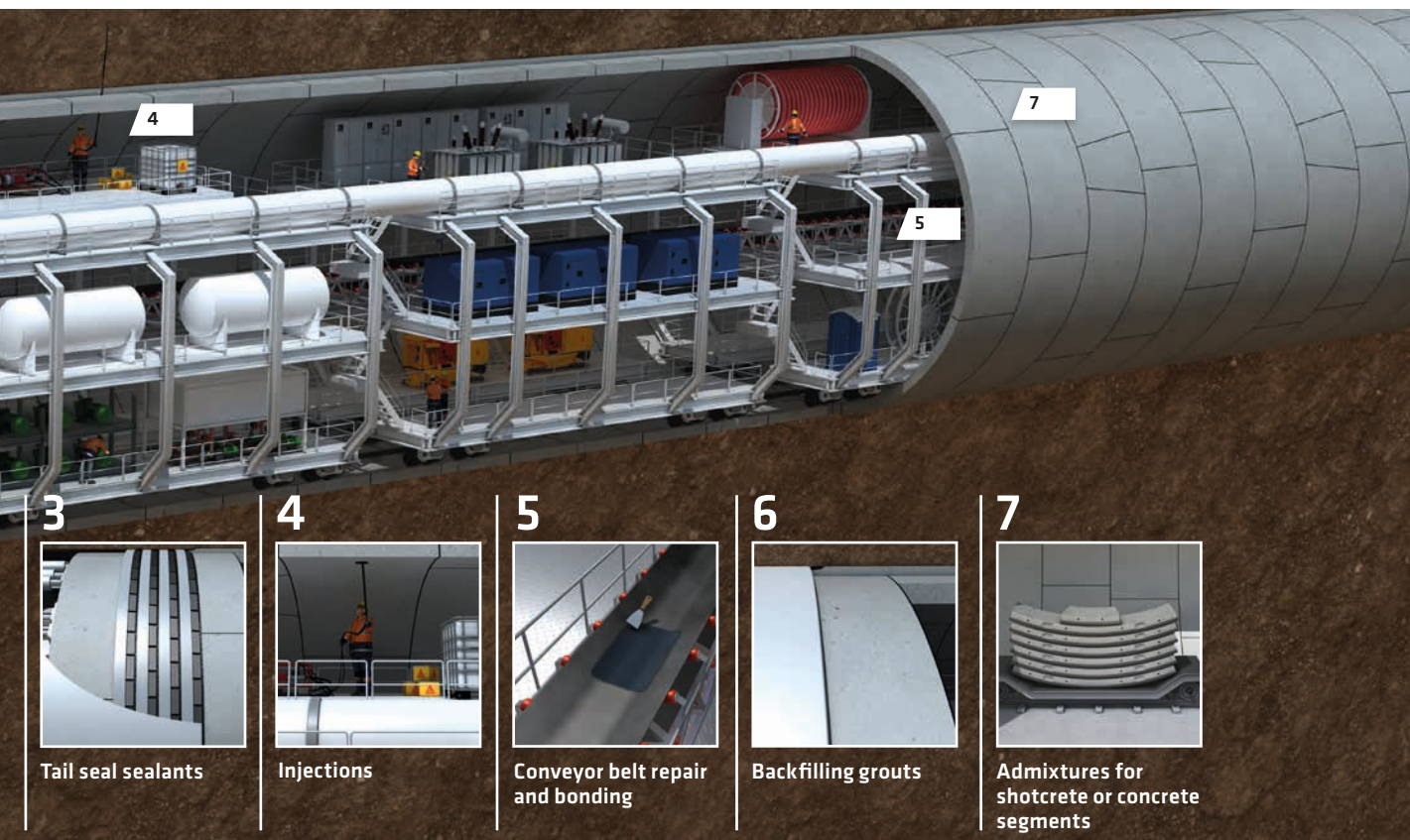
New Gen
SS-1215 TBM
New Gen
SS-1219 TBM

Granular Soil

Cohesive Soil

Any Soil

Rock & Abrasive Soil



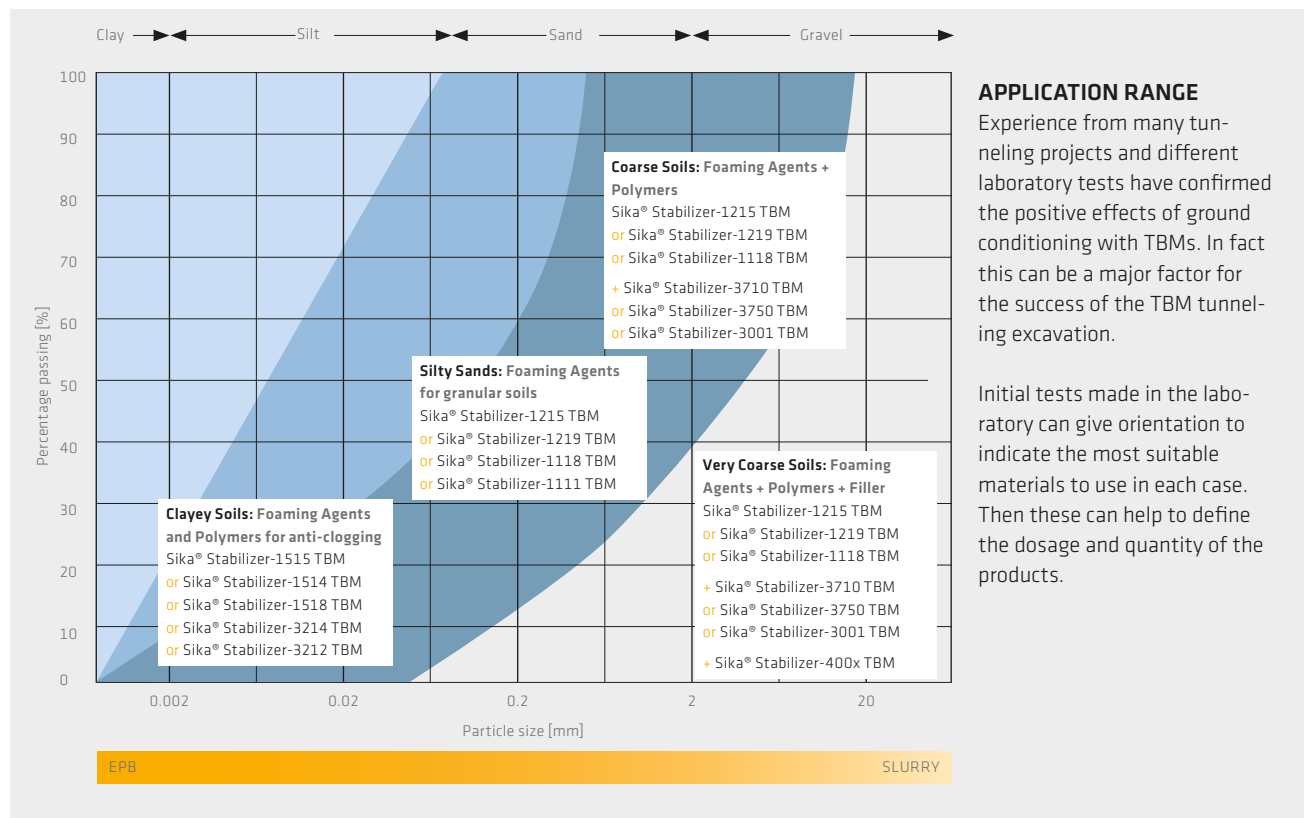
		Rock TBM	Shield TBM	Any TBM	Slurry TBM	Shield TBM
Pure anty-day polymers	Super water absorber polymers	Anti abrasion foaming agents	Tail sealant greases	Main bearing greases and lubricants	Slurry	Backfill grouts (2k)
Premium	Premium	Premium	New Gen PG	MD – Syn	Betonite	Retarder
SS-3214 TBM	SS-3710 TBM	SS-1513 TBM	SS-2231 TBM	SS-2031 TBM	SS-4001 TBM	SS-5010 TBM
Standard	Standard	Standard	New Gen FF	L-Syn	Extender	Accelerator
SS-3212 TBM	SS-3001 TBM	SS-1516 TBM	SS-2131 TBM	SS-2032 TBM	SS-4601 TBM	SS-6018 TBM
	Saline water		Old Gen PG		Extender	Low CO ₂
	SS-3750 TBM		SS-2232 TBM		SS-4602 TBM	SS-7100 TBM
			Old Gen FF		Thinner	
			SS-2132 TBM		SS-4501 TBM	
					Flocculant	
					SS-4141 TBM	

PG: Pumping grade
FF: First filling

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 / USE OF FOAM



APPLICATION RANGE

Experience from many tunneling projects and different laboratory tests have confirmed the positive effects of ground conditioning with TBMs. In fact this can be a major factor for the success of the TBM tunneling excavation.

Initial tests made in the laboratory can give orientation to indicate the most suitable materials to use in each case. Then these can help to define the dosage and quantity of the products.

Contact your Sika Tunneling support team for a proper choice of the most suitable soil conditioning solution. We will provide you with supporting pre-investigations in our local, regional and global labs.

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.

Foaming agents from the range Sika® Stabilizer TBM are liquid conditioning foaming agents which have been formulated to be used with earth pressure balance machines (EPB) for modifying the properties of the excavated soil.

To fulfill specific increasing environmental expectations and try to reduce the ecological impact of soil conditioned and excavated by the TBM after its disposal. Sika is producing a variety of conditioning solutions from the Sika® Stabilizer 1000 TBM range, with environmentally friendly composition and fast biodegradability profile.

POLYMERS

Typical Sika polymer applications in the TBM excavation process are for:

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

Water absorbing polymers, viscosity modifiers or stabilizers for foams from the range Sika® Stabilizer TBM are specially formulated for the use in TBM tunneling.

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.

The range Sika® Stabilizer TBM also counts with special liquid products such as cutter cleaners, defoaming agents or friction reducers.

BACKFILLING GROUTS

SIKA IS ACTIVELY INVOLVED AROUND THE WORLD in different tunneling projects, providing a wide range of technologies for TBM backfilling according to each project's specific requirements.

TWO COMPONENT BACKFILLING GROUT

The two-component backfilling grout is created by combining a mixture of water/cement, bentonite, and retarder (component A) with an accelerator (component B). This blending of the two components occurs just before injection through the tailskin, where the mixture undergoes a rapid transformation from a creamy liquid to a gel in approximately 10-20 seconds. The final grout has long term compressive strength comparable to the surrounding ground and has the ability to fill every gap and void before setting and hardening.

Various Sika admixtures and stabilizers, such as Sika® Stabilizer 5000 TBM range, SikaTard® and Plastiment®, can be employed to achieve the desired flow and retarded set effects. Additionally, Sika® Stabilizer 6000 TBM range of products or Sigunit® accelerators are used to control gel, set and hardening time of the grout.

ONE COMPONENT BACKFILLING MORTAR

Excavation with shield Tunnel Boring Machines (TBMs) involves the installation of precast concrete segments to create the tunnel lining, leaving an annular gap between these segments and the surrounding ground. Properly filling this annulus is crucial as it ensures a uniform contact with the ground, facilitates load transfer from the TBM back-up, and contributes to waterproofing the tunnel.

Various types of filling materials have been developed for this purpose, including hydraulically setting mortar and two-component grout. Sika provides a comprehensive range of stabilizers and admixtures for batching backfilling mortars, including Sika® Stabilizer 5000 TBM Range and Sika Tard®, Sika ViscoCrete®, SikaFume®, and Plastiment®.

PEA-GRAVEL

Pea-gravel backfilling is commonly employed method in hard rock TBM projects to fill the annular gap between the excavated tunnel lining and the surrounding rock. It consists of a mixture of pea-sized gravel and grout. The stabilization of the grout flow allows a good filling in secondary injections. This can be achieved with Sika® Stabilizer 5000 TBM range of retarders. In case of water flow the grout can as well be accelerated with Sika® Stabilizer 6000 TBM range of accelerators.



LOW CO₂ GROUT SOLUTIONS

INTRODUCING LOW CO₂ FOOTPRINT Backfilling grouts – Revolutionizing Tunneling with Sustainable Grouting. Our cutting-edge technologies in backfilling grouts applications for Tunnel Boring Machines (TBMs) redefine industry standards by prioritizing environmental responsibility.

Engineered with alternative binders, our formulations minimize carbon footprint without compromising on performance. Sika® Stabilizer 7100 TBM ensures load transfer, volume integrity but also excellent pumpability while optimizing efficiency.

Embrace a sustainable future with our innovative solutions, meeting the demands of both construction and environmental stewardship. With Sika sustainability meets performance, ensuring a seamless tunneling experience leaving at the same time a positive impact on the planet. Join the movement towards responsible construction practices with Sika® Stabilizer TBM solutions.



TAIL SEALANT GREASES

Metal brushes in the TBM tail shield require proper maintenance and sealing against water, soil, and backfill grout ingress. Our tail sealant greases are designed to ensure:

- Reliable pressure-proof sealing between the tail shield and external ground conditions
- Anti Wash-Out properties
- Pumpability, adhesion to metal parts, and consistency
- Fire-resistant performance

Modern tail shield greases must be technically performant, easy to pump, and cost-efficient to align with high TBM production rates, avoiding unplanned stoppages and extra costs.

Sika tail shield greases prevent ground water, soil, and backfill grout from entering the TBM, offering inert and eco-friendly options without negative effects on the concrete lining and EPDM gaskets.

PRODUCT DESIGN AND PERFORMANCE

Sika® Stabilizer greases consist of high-molecular polymers, natural fillers, and fibers. Key properties include consistency, pumpability, adhesion, and sealing capacity above 34 bar (Matsumura sealing test).

Sika® Stabilizer greases have been successfully used on various TBMs worldwide, sealing diameters up to 17.47 meters to date.



NEW GENERATIONS OF TAIL SEALANT GREASES

Pumping grade: Sika® Stabilizer-2231 TBM

First fill: Sika® Stabilizer-2131 TBM

Fire-resistant, with higher performance and reduced density, ensuring excellent adhesion to metal and concrete surfaces. Adaptable to any TBM pumping system and chemically compatible with similar products.

WORLD CLASS QUALITY TAIL SEALANT GREASES

Pumping grade: Sika® Stabilizer-2232 TBM

First fill: Sika® Stabilizer-2132 TBM

High-density greases for enhanced performance in critical geologies with high groundwater pressure. Adaptable to any TBM pumping system and chemically compatible with similar products.

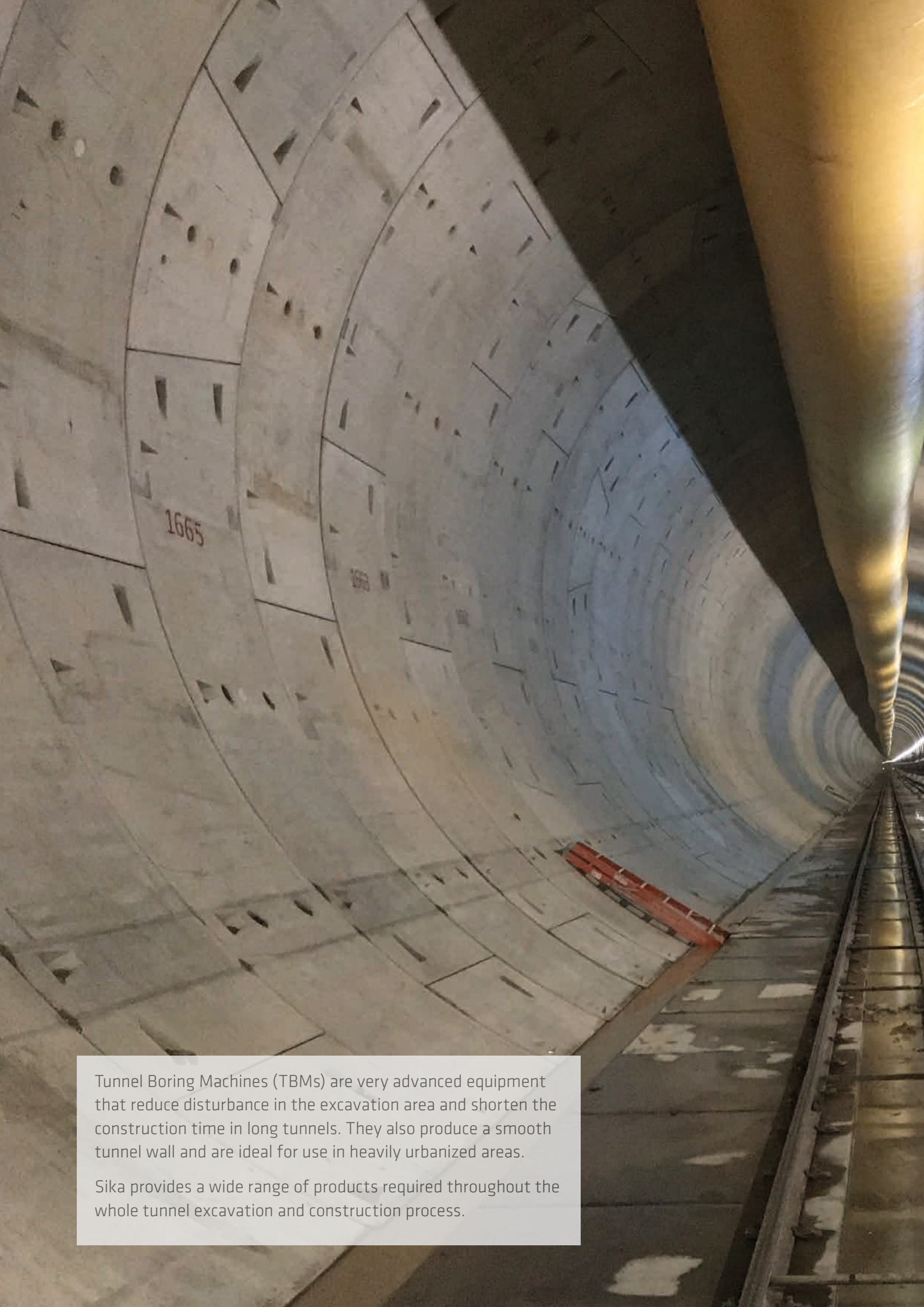
FACTORS INFLUENCING GREASE CONSUMPTION

TBM and tunnel conditions impact grease performance.

Examples include:

- Brush conditions
- Air trapped in the TBM grease pumping system
- Quality of installed tunnel lining
- Roughness of external tunnel lining surface
- Backfill grout pressure
- Number of strokes and waiting times at PLC





Tunnel Boring Machines (TBMs) are very advanced equipment that reduce disturbance in the excavation area and shorten the construction time in long tunnels. They also produce a smooth tunnel wall and are ideal for use in heavily urbanized areas.

Sika provides a wide range of products required throughout the whole tunnel excavation and construction process.



SLURRY TBM

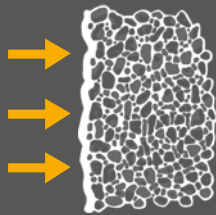
SLURRY TBM PORTFOLIO

Slurry TBMs remove the excavated material by using a bentonite-based suspension, also called slurry or mud. The excavated soil is pumped out along with the slurry to a Separation Treatment Plant (STP) situated outside the tunnel where the slurry is separated from the muck for recirculation. The support pressure in the excavation chamber is precisely managed using an automatically controlled air cushion. Face stability is the major issue to keep under control during mining, and pressurised bentonite with the help of our additives provide the adequate face support for tunnelling in safety.

In its function as a support medium, the task of the drilling fluid is to form a zone of low permeability at the front of the excavation. While the counteraction against the ground water pressure is principally secured, the excess slurry pressure must be transferred to the soil skeleton to counteract the earth pressure. The pressure transfer can be achieved in two ways:

1

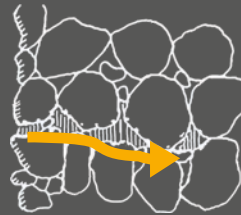
With a membrane



The **FILTER CAKE** membrane forms a thin impermeable layer directly on the wall, transforming excess slurry pressure into effective support stress in low permeability grounds. The slurry creates only a surface impermeabilization, typically several millimeters thick.

2

or, with a penetration zone



In **PENETRATION ZONE FORMATION**, excess slurry pressure transfers to the soil skeleton along the entire penetration depth through shear stresses between suspension and soil grains in moderately to highly permeable grounds. The slurry penetrates ground pores before stopping and setting, constituting the impermeable interface. This zone varies from several tens of centimeters to a few meters in thickness.



BENTONITE – Sika® Stabilizer-4000 TBM RANGE

Sika provides a diverse range of sodium bentonites, spanning low to high plasticity, suitable as binders and viscosity improvers with varying swelling properties. All Sika bentonites are guaranteed through an ISO 9001:2000 certified quality management system.

VISCOSITY MODIFIER ADMIXTURES

BENTONITE EXTENDER – Sika® Stabilizer-4601 TBM (FRESH WATER) / Sika® Stabilizer-4602 TBM (SALINE WATER)

Water-soluble polymers, ensure filter cake formation and reducing filtrate losses. These polymers restructure soils with poor grading and low fines content, enhancing mud rheological properties. They increase soil plasticity and cohesion, improving pressure balance in the working chamber for better ground stability and slurry extraction.

BENTONITE THINNER – Sika® Stabilizer-4501 TBM

A water-soluble polymer acting as a powerful thinner agent. It adsorbs onto clay platelet surfaces, preventing bentonite and heavy clays from gelation, addressing clogging and adhesion issues. It eliminates the risk of TBM blockage under high pressure and temperature conditions, both at the cutterhead and in pumping lines.



FLOCCULANT FOR SOLID/WATER SEPARATION – Sika® Stabilizer-4141 TBM

A very high molecular weight polyacrylamide-based low-anionic flocculant powder. It efficiently facilitates solid-liquid separation with a high to very high precipitation rate. Predominantly used for effective and fast solid-liquid separation, it can be applied separately or in combination with a cationic flocculant.



MAIN DRIVE SEALANTS

MAIN BEARING GREASES AND LUBRICANTS

The main bearing, being the most costly component of the TBM, requires effective protection and lubrication. Our renewable raw material version of main bearing sealants and lubrication greases sets a benchmark for the industry's environmental standards.

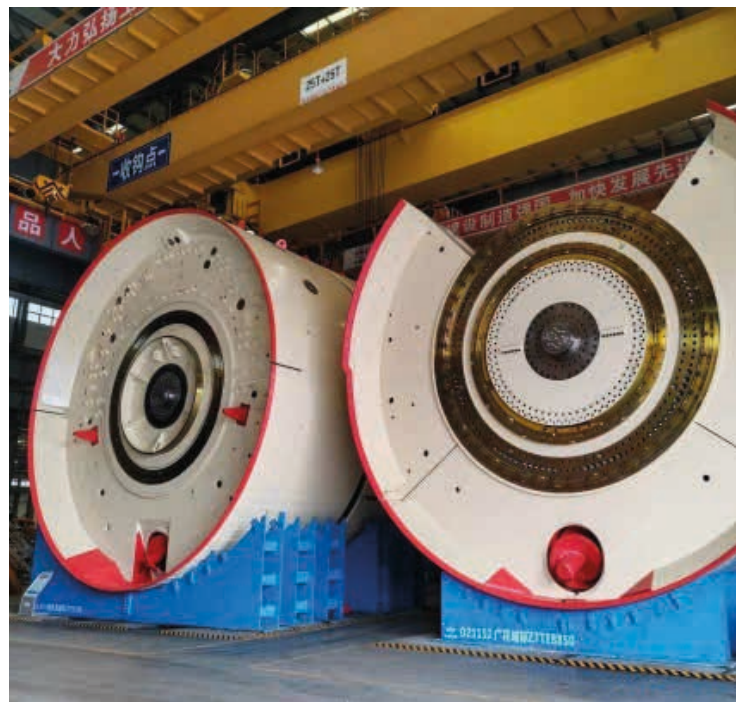
To uphold the highest quality, we produce our sealant greases at selected global sites with a continuous supply of premium raw materials. All Sika greases and lubricants are non-hazardous, ensuring worker safety and environmental friendliness. They hold Merkel certification, meeting the 85 NBR B248 standard.

MAIN BEARING SEALING – Sika® Stabilizer-2031 TBM

Our excluder grease shields the main bearing by preventing water and soil from entering the TBM sealing system. Formulated to resist high water and ground pressure, it exhibits excellent lubrication and pumping properties with superior adhesion. Key properties include a 4-ball wear (DIN 51350:5) <0.9mm and water spray off (ASTM D 4049 @ 25°C) <4%.

MAIN BEARING LUBRICATION – Sika® Stabilizer-2032 TBM

Our lubricant incorporates antioxidants, corrosion inhibitors, and EP/AW additives. It offers exceptional mechanical stability, load-carrying capacity, and corrosion protection, making it suitable for heavy-loaded bearings and wet environments. Key properties include a 4-ball wear (DIN 51350:5) 0.5mm and biodegradation >80%.



SIKA AND THE MICROTUNNELING WORLD

TUNNEL BORING MACHINES (TBMs) are commonly found with diameters from 5 to 17 meters and increasing. There are also the micro TBMs which are smaller, have an excavation diameter up to 4 meters and are extensively used today to construct kilometres of underground infrastructure worldwide.



Microtunneling is a fast alternative to conventional pipe installation systems. It is a fully automated method of boring and pipe installation without the need for disturbing the surface. Micro TBMs start at diameters from a few centimetres and increase up to 4 meters. They are typically used for excavation of many of the vital utility facilities such as fresh water, wastewater, oil, gas, communications and electricity.

Projects with micro TBMs do not require trench excavation work. It is a technique especially suited for minimising disruption in densely populated areas, crossing difficult geological zones, penetrating through ground with high water levels, under rivers or generally overcoming obstacles where room for construction is restricted. The use of micro TBM is increasing more and more and has the advantage of limiting the environmental impact compared to traditional excavation methods. It is a fast method of continuous excavation with minimal interruptions.

Sika is offering a wide range of products for the micro tunnelling excavation.



INJECTIONS

TBM PRE-EXCAVATION INJECTIONS:

- Stabilize fractured geology with high void or cavity content
- Control groundwater in front of TBM
- Inject behind segments for tail brushes and tail seals replacements

SikalInject®-501 DE:

- Two-component silicate foam-resin with a high foaming factor (up to 30 times)
- Fast reaction time (~25 sec)
- Treated with a flame-retardant; foams with or without water
- Cured foam is easily cuttable by TBM cutting tools

SikalInject®-668:

- Two-component compact silicate resin with a short reaction time (around 40 sec)
- Cures to a high-strength solid resin without foam development
- Presence of water does not affect the product; safe curing even underwater
- Excellent adhesion, even on damp surfaces
- Used for demanding rock consolidation and controlling over-blasting in tunneling and mining.
- Cuttable and plannable; available in a thixotropic grade: SikalInject®-668 TX for overhead applications, bolting, and anchoring injections.





INJECTIONS DURING TBM EXCAVATION & POST-TBM EXCAVATION AND GROUNDWATER CONTROL

SikalInject®-210 DE:

- Very fast two-component structural polyurethane foam
- Excellent water-blocking performance, even at high flow rates and pressures
- Ideal for annular gap sealing and permanent waterproofing behind the elements
- Can be used with thixotropic additive SikalInject® TX 21 for increased viscosity and safe water displacement in case of strong water flow.

POST-TBM EXCAVATION INJECTIONS AND GROUND CONSOLIDATION

SikalInject®-304 DE:

- Acrylate-based, three-component injection resin
- Developed to penetrate and consolidate low permeability ground
- Water-like viscosity efficiently penetrates rock and sand-filled structures
- Reaction time can be adjusted from seconds up to ~30 minutes based on application requirements



ADMIXTURES FOR SHOTCRETE

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

High performance, quick setting repair mortars for dry-spray application to concrete, stone and mortar substrates. Specially designed for application as ready-mixed gunite mortar for stopping severe water ingress and securing operations in the prevention of rock-falls during underground structure construction.

Sika® 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.





ADMIXTURES FOR CONCRETE AND INNER SECONDARY LINING

IN SHIELD 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 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 range water reducer, a low water/cement ratio can be achieved that will result in increased early strengths and increased durability.

After just a few hours concrete reaches sufficient strengths for proceeding with production cycle. 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. In such cases, Sikagard® products are used to provide a high level of protection.

CONCRETE FOR DOUBLE SHELL 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 such as Sikament®, SikaTard® and SikaPlast® are also used to meet specific demands.

EMBRACE SUSTAINABILITY

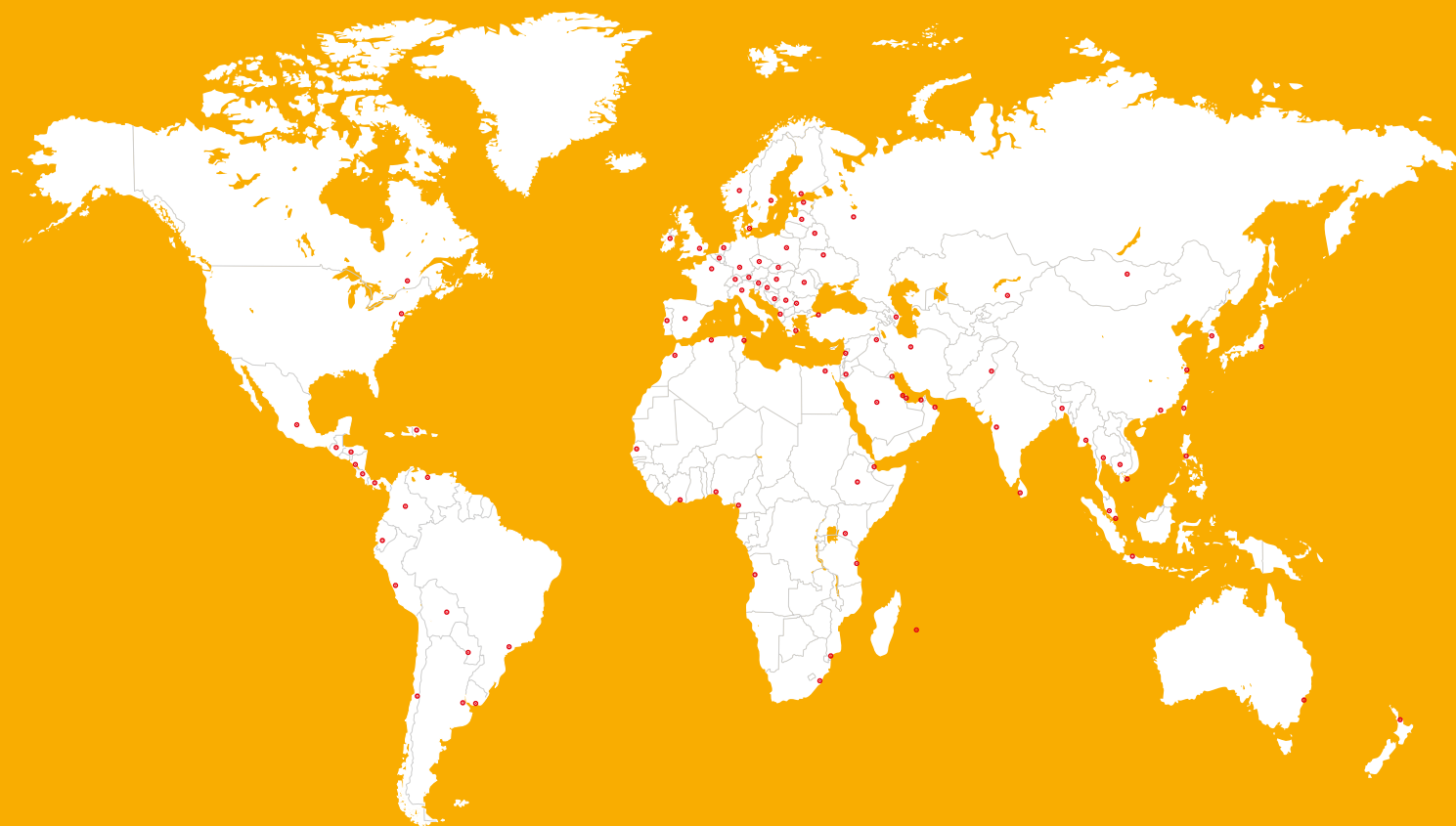
Enhance Concrete Mixes to the next level of low carbon footprint. Connect with your local Sika Team for expert guidance on eco-friendly concrete mix designs tailored for precast segments and concrete lining. Our solutions not only reduce carbon footprint but also elevate performance and durability. Let us enable the way for a more sustainable construction future.

Contact us today to explore innovative and environmentally responsible concrete solutions.





GLOBAL BUT LOCAL PARTNERSHIP



FOR MORE INFORMATION:



www.sika.com/tbm

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, industrial flooring as well as roofing and waterproofing systems.

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



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BUILDING TRUST

