

Tunnel Boring Machine (TBM)

Solutions for Underground Construction



Master Builders Solutions®

At Master Builders Solutions®, we are a leading global provider of responsible solutions for the construction industry, driven by our vision — Inspiring people to build better.

We deliver value-added technologies and industry-leading R&D capabilities to enhance the performance of construction materials while enabling the reduction of CO₂ emissions in concrete production. Our comprehensive portfolio includes concrete admixtures, cement additives, and specialised solutions for underground construction, all under the trusted Master Builders Solutions® brand.

Through close collaboration across disciplines and regions, we leverage global innovations and deep local knowledge to develop solutions tailored to the needs of the construction industry. Drawing on experience from countless projects worldwide, we are committed to helping our customers achieve success and advance sustainable construction.

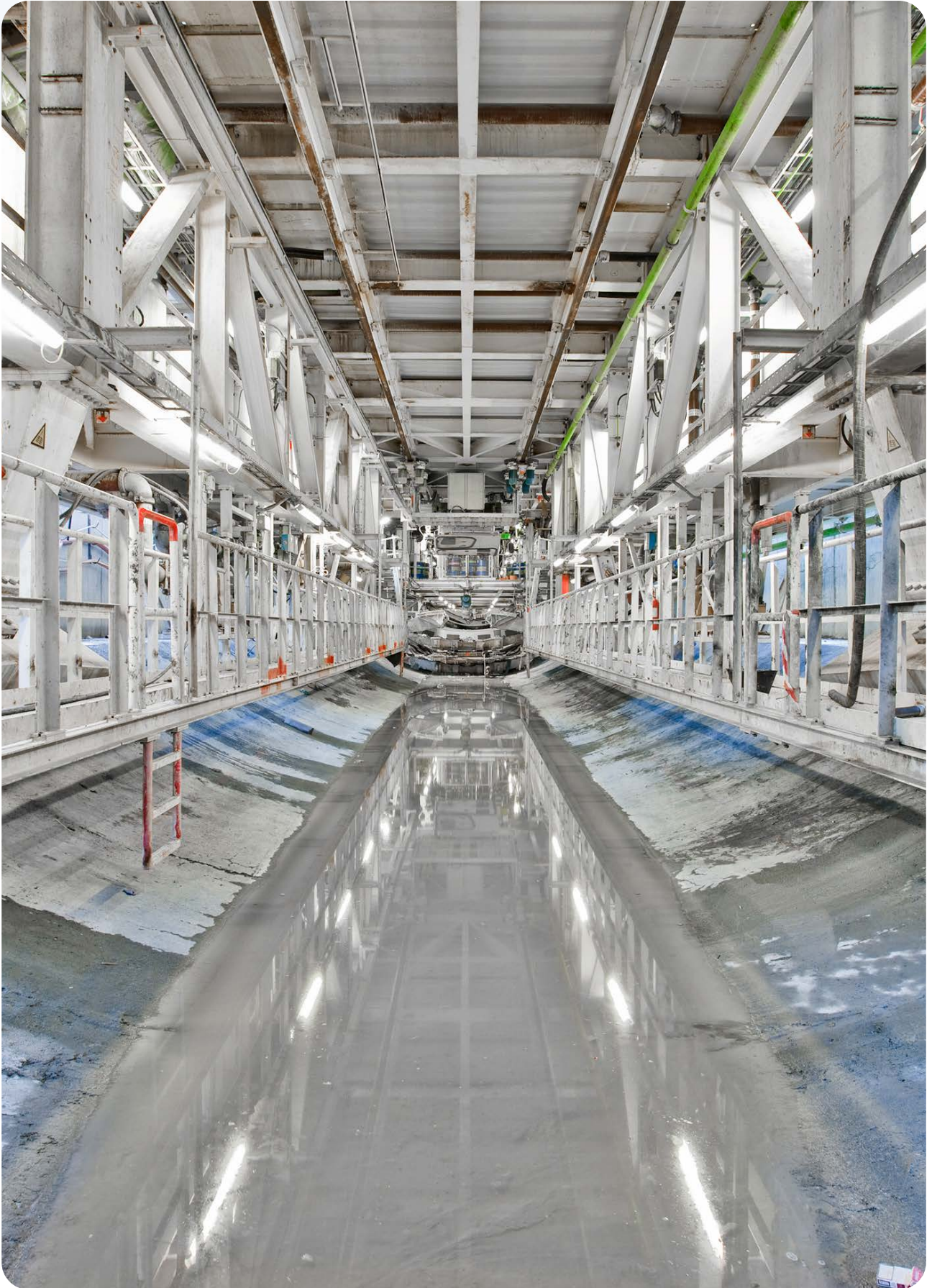
With a legacy dating back to 1909, Master Builders Solutions® has more than 1,700 employees and 37 production sites globally, including over 150 employees and 6 production facilities across Australia and New Zealand. We are dedicated to supporting our customers in meeting today's challenges and building towards a decarbonised future.

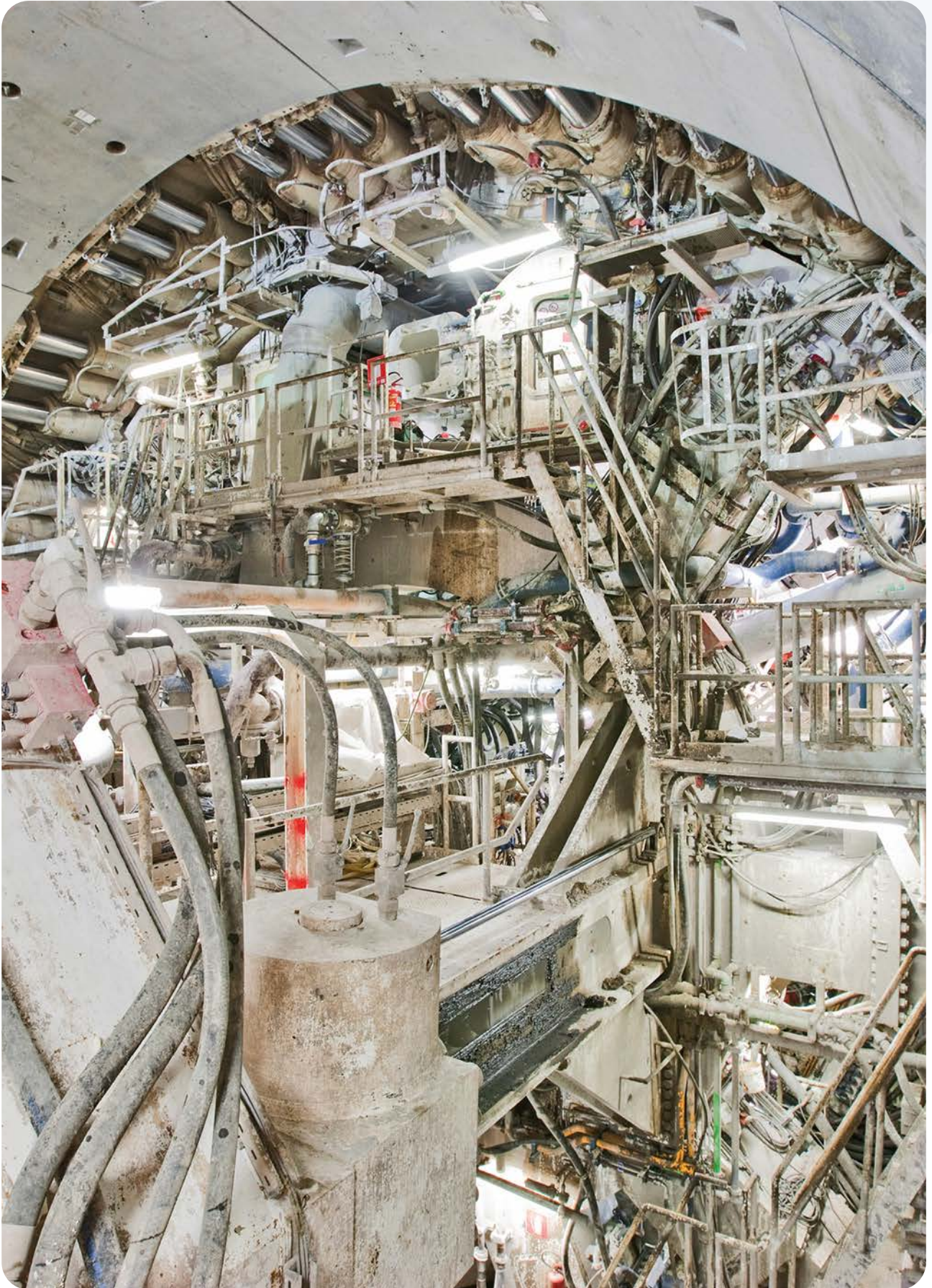
Global Underground Construction Team

At Master Builders Solutions® our global underground construction team delivers reliable customer-focused solutions for the tunnelling and mining industries across Australia, New Zealand, and worldwide. We understand that your success depends on our ability to meet and exceed critical project requirements. From project initiation through to completion, we work alongside you to address key challenges and deliver tailored solutions. Our commitment extends beyond products as we provide comprehensive product training, quality control, and 24/7 access to our professional technical services team who offer specialist advice and on-site troubleshooting when you need it most.

Our comprehensive portfolio:

- Concrete admixtures
- Cement additives
- Chemical solutions for underground construction





Specialty Chemicals for Safe and Efficient TBM Tunneling

Mechanised tunnelling is the safest and fastest method of tunnelling, especially under difficult geological conditions and in urban areas. Optimum TBM (Tunnel Boring Machine) performance is achieved by combining mechanical and chemical engineering.

Soil Conditioners

EPB (Earth Pressure Balance) tunnelling requires the correct use of soil conditioners to reduce cutterhead torque, minimise tool abrasion, and increase advance rates. A selection of advanced foams, polymers, and anti-clay agents provides solutions for every geological condition.

Anti-Wear & Anti-Dust

Both hard rock and soft ground TBMs may experience excessive cutter wear and elevated cutting tool temperatures. Newly developed anti-wear agents extend cutter life and ensure a dust-free working environment, particularly in hard rock conditions.

Tail Sealants

The TBM tail shield must be effectively sealed against water, soil, and annulus grout ingress. Tail sealants have been developed to ensure reliable sealing in combination with the brush system, with the largest TBM diameter to date reaching 17.6 metres.

Main Bearing Greases

The TBM main bearing is the most valuable component and requires reliable protection and lubrication. Sealing and lubrication greases are available, including versions made from renewable raw materials, helping to meet the highest environmental standards.

Annulus Grouts & Concrete Segments

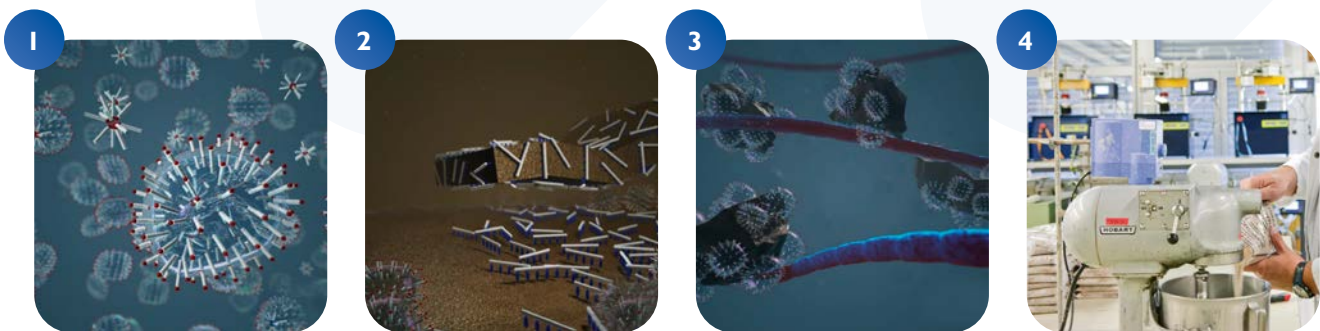
Safe and reliable annulus grout applications require careful selection of accelerators, retarders, and stabilisers. High early-strength development is critical for concrete segment production. A wide range of concrete admixtures is available for both annulus grouting and segment manufacturing.

Injection, Stations, Cross Passages & Cutterhead Intervention

To stabilise geological fault zones and prevent water ingress, a comprehensive range of injection products is available, particularly suited for pre-injection. Sprayable membranes provide a cost-effective composite shell lining for cross passages, access and escape routes, and utility caverns. They are also used for cutterhead interventions, creating an effective barrier against compressed air loss.

Soil Conditioners

Earth Pressure Balance (EPB) tunnel boring machines require soil conditioners tailored to the geology to ensure safe advancement and maximum TBM efficiency. Cost-effective soil disposal, and even the re-use of excavated material, is becoming increasingly important. The Master Builders Solutions® team provides expert support and service, backed by local laboratory facilities.



1. Foams:

**MasterRoc® SLF 30, 32, 34, 41, 47, 50,
and recent introductions 325, 419, and 543**

Torque and wear reduction are essential for safe and economical TBM tunnelling. MasterRoc® SLF foams ensure maximum performance and can be tailored to the specific geology encountered

2. Anti-Clay Foams & Polymers:

MasterRoc® ACP I27, I47, I43, 2II, and 2I4

MasterRoc® ACP represents the leading technology for efficient and cost-effective EPB tunnelling in clayey soils. The range includes both pure anti-clay additives and formulated products based on foams and polymers. Continuous development ensures that this technology remains at the forefront of the industry.

3. Strong Advanced Thickeners:

MasterRoc® SWA 710, and 750

Stabilising polymers designed to address high water content, high water pressure, unstable ground, and sharply graded soils. These environmentally friendly polymers can be applied through the foaming system or injected separately into the chamber or screw..

4. Laboratory Testing & Expert Support

Safe and efficient tunnelling begins at the planning stage. Comprehensive laboratory testing of project site soils prior to excavation is critical. These tests enable contractors to select the most suitable products and determine the optimal foam parameters for the TBM.



Challenging Project Solutions

1



Galleria Sparvo, Italy

An EPB TBM with a 15.55 m diameter cutterhead advanced through clay, claystone, and sandstone, with sections containing gas. The key to successful soil conditioning was the effective reduction of torque, even under mixed-face conditions and EPB pressures of up to 3.5 bar, using MasterRoc® SLF 4I and MasterRoc® ACP I43..

2



Alaskan Way Viaduct Replacement Tunnel, Seattle / WA (USA)

One of the world's largest EPB TBMs (Ø 17.5 m) was used to construct a double-deck road tunnel beneath the city of Seattle. The alignment mainly comprised cohesionless, poorly graded sand and gravel, with sections of cohesive clay and silt. These conditions were particularly challenging due to the large TBM diameter and required exceptional soil conditioning performance. The high half-life of MasterRoc® SLF 50 maintained consistent soil characteristics throughout the excavation chamber and screw conveyor, while MasterRoc® ACP I47 was successfully applied to manage the cohesive clay zones.

3



Toronto Metro Extension, Canada

A total of four TBMs were launched, with MasterRoc® SLF 47 and MasterRoc® ACP I27 and 2II playing a key role in overcoming challenging, high-clogging clay conditions. The TBMs advanced at over 80 mm/min, consistently achieving production rates exceeding 30 m/day. Cutterhead torque remained well below the installed limit, significantly reducing energy consumption. EPB pressures reached 2 to 2.5 bar, with very low to no surface settlement recorded.

Anti-Wear & Anti-Dust

In both hard rock and soft ground tunnelling, TBMs often experience excessive wear. The Master Builders Solutions® team was among the first to develop specialised solutions to reduce wear and dust on tunnel boring machines. Early identification of these challenges is essential to implement effective countermeasures, minimising wear on the cutterhead and screw conveyor. For optimal application of MasterRoc® ABR additives, a semi-automatic foam system is required, specially designed for use on hard rock TBMs.



1. Anti-wear and Anti-dust: MasterRoc® ABR 5 / Anti-dust: MasterRoc® ABR 2 and 7

Tunnelling efficiency is improved by protecting steel tools, reducing cutter blocking, and lowering tool temperatures during excavation. Current site results show approximately 25% wear reduction and a dust-free working environment for personnel.



2. Anti-clogging: MasterRoc® ABR 5 and 7

The water sprinkler system typically used to reduce cutter temperatures and dust levels often causes fine soil particles to clog and block the cutters. MasterRoc® ABR prevents clogging by fine particles and keeps all steel surfaces clean.



3. Wear Prediction

Until the development of the Soft Ground Abrasion Tester (SGAT), predicting wear in compacted soft ground was not possible. The SGAT now allows detailed study of the effects of varying soil moisture content, anti-wear agents, and soil conditioners. These results are used to optimise TBM performance on site.



Challenging Project Solutions

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1. Westerly Tunnel – Cleveland, Ohio, USA

The Westerly Tunnel, part of Project Clean Lake, is a sewer tunnel constructed using a Lowsuns Single Shield TBM through the Chagrin Shale formation. The Chagrin Shale consists of siltstone, silty grey shale, and soft grey clay shale. It is classified as a weak to medium-strong rock with a compressive strength ranging from 34 MPa to 100 MPa. MasterRoc® ABR 7 is primarily used as a dust suppressant.

2



2. Faroe Islands, Denmark

One Robbins main beam hard rock TBM was used in the Faroe Islands for the Eidi Water Transfer Project in granite formations. MasterRoc® ABR 5 was predominantly used to reduce dust levels inside the tunnel and improve working conditions.

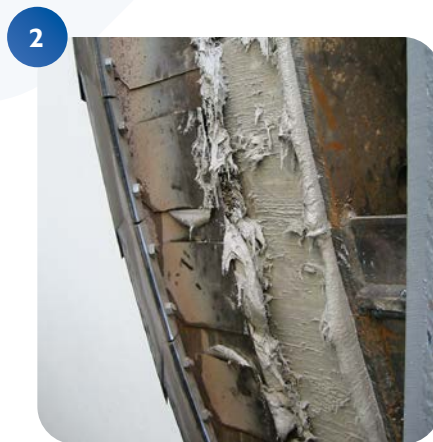
Tail Sealants

Reliable and cost-efficient sealing of the TBM tail shield is essential for smooth tunnelling operations. Regardless of soil conditions or the type of annulus grout used, MasterRoc® TSG tail sealants effectively prevent the ingress of water, soil, and annulus grout into the TBM. Master Builders Solutions® offers an inert tail sealant that does not produce any negative effects on concrete or EPDM gaskets.



1. Driving Grades: MasterRoc® TSG 6 and 800

Both products offer excellent adhesion to metal and concrete surfaces, even underwater. To ensure complete sealing around the shield circumference, the driving grade must flow effectively between injection points. Consumption of MasterRoc® TSG depends on several factors, including concrete segment roughness, tunnel layout, and the condition of the brushes, typically ranging from 0.8–1.2 kg/m² of segment surface.



2. First Fill Grade: MasterRoc® TSG 7 and 870

The specially designed first fill sealant plays a crucial role. Once applied to the newly installed brushes, it protects them by preventing the penetration of water, soil, and annulus grout. Additionally, it maintains brush flexibility, which is essential to accommodate the movements of the tail shield.

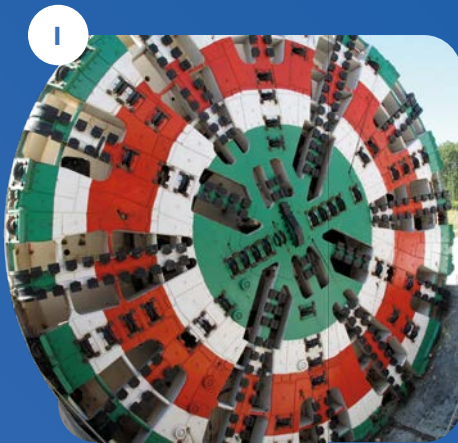


3. Product Design and Performance

MasterRoc® TSG, based on high-molecular polymers, natural fillers, and fibres, provides excellent water spray-off resistance (ASTM D 4049) and a sealing capacity above 34 bar (Matsumura test). TSG 800 and TSG 870 are fire-resistant, ensuring safety during tunnel excavation. MasterRoc® TSG is proven worldwide on Herrenknecht, Robbins, Lovat/CAT, Hitachi, Mitsubishi, and Kawasaki TBMs.

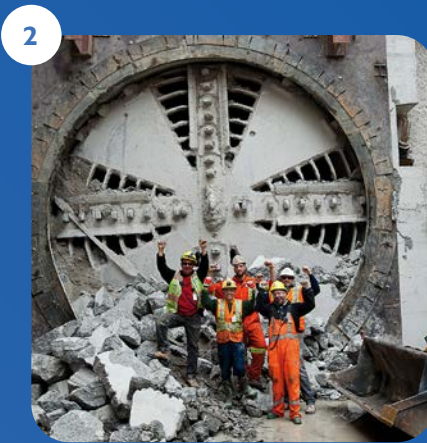


Challenging Project Solutions



Galleria Sparvo, Italy

An EPB TBM with a 15.55 m diameter cutterhead advanced through clay, claystone, and sandstone, with sections containing gas. The two-component annulus grout reached a maximum pressure of 4.5 bar. MasterRoc® TSG 6 and 7 successfully sealed the TBM throughout its 2,500 m advance.



Toronto Metro Extension, Canada

Several EPB TBMs used MasterRoc® TSG 6 driving grade and TSG 7 first fill grade during their advance in Toronto. The two-component annulus grout reached a pressure of 4.5 bar. A particular challenge was the very low temperatures encountered at the start shaft.



Taverne, France

The convertible TBM used MasterRoc® TSG 6 driving grade in both EPB and hard rock modes. Consumption reached approximately 1.2 kg/m² of segment surface in EPB mode and around 0.5 kg/m² in hard rock mode. TSG 7 first fill grease provided effective brush protection throughout the 3,800 m advance.

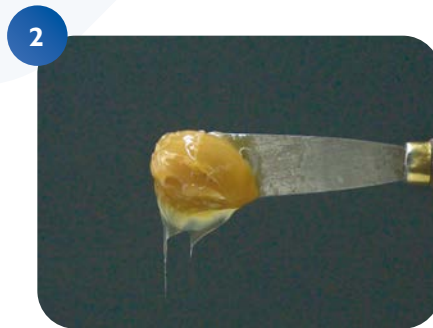
Main Bearing Greases

The main bearing is the most expensive component of a TBM and requires careful maintenance. To ensure the highest quality, Master Builders Solutions® produces its greases exclusively at select, specialised sites worldwide. All MasterRoc® EPB and BSG greases are Merkel-certified. In addition to standard greases (EPB/BSG II), highly biodegradable greases made from renewable raw materials (EPB/BSG I) have also been developed.



1. Protection of the Main Bearing

Two types of greases are generally used together: main bearing lubricants (EP greases) and main bearing sealants. Sealants offer stronger adhesion to metal surfaces and greater wash-off resistance than EP greases but provide less lubrication. The consumption of both greases depends on the recommendations of the TBM supplier.



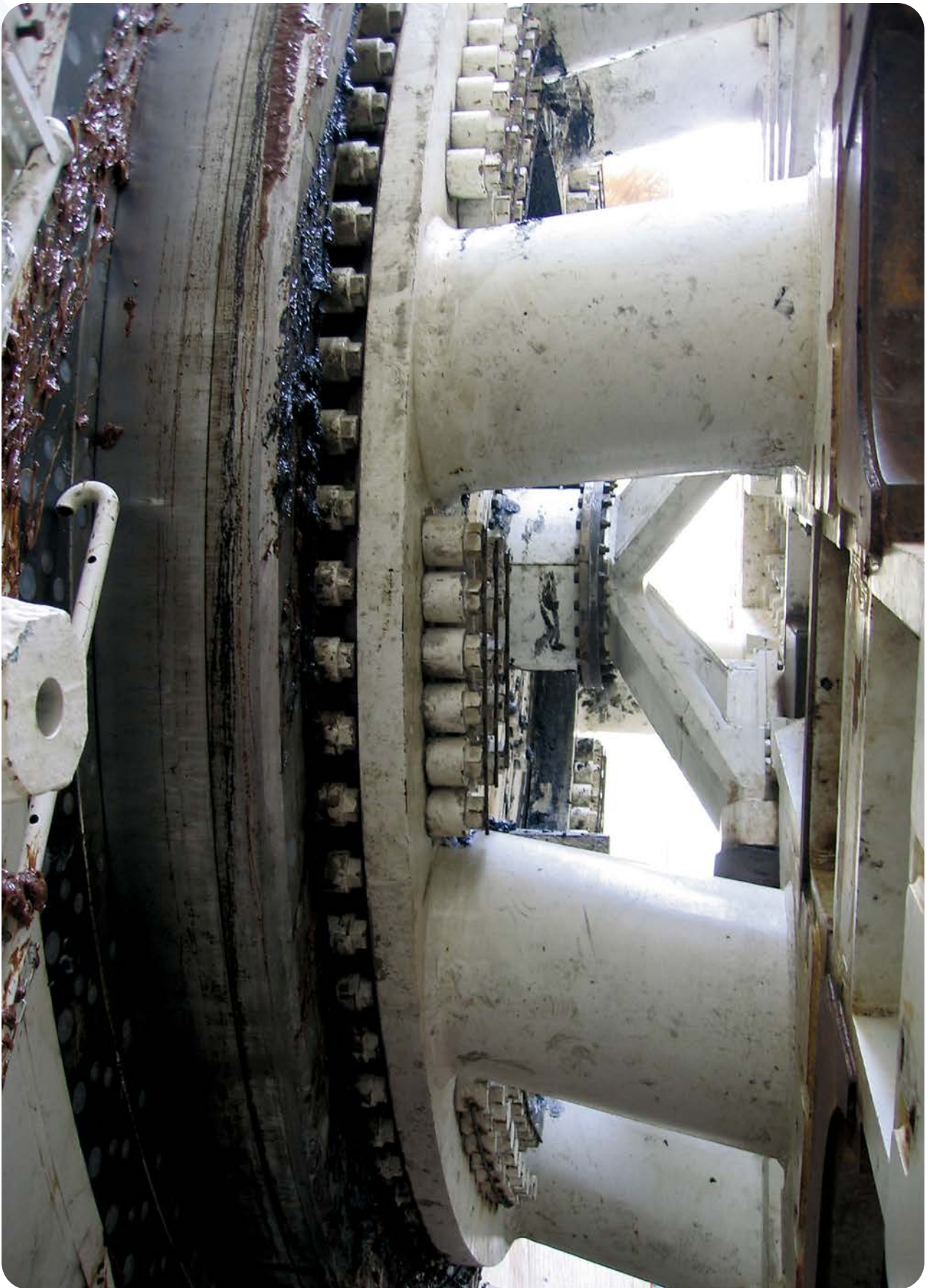
2. Main Bearing Lubrication: MasterRoc® EPB I and II

Lubricants based on synthetic or vegetable oils contain antioxidants, corrosion inhibitors, and EP/AW additives. They provide excellent mechanical stability, load-carrying capacity, and corrosion protection, making them suitable for heavily loaded bearings and wet environments. Key properties include a 4-ball wear (DIN 51350:5) of approximately 0.5 mm and a water spray-off (ASTM D 4049 @ 25°C) of less than 15%.



3. Main Bearing Sealing: MasterRoc® BSG I and II

Sealants are excluder greases that effectively protect the main bearing by preventing water and soil from entering the sealing system. Formulated with synthetic or vegetable oils, they resist high water and ground pressures while providing good lubrication, excellent pumpability, and strong adhesion to all surfaces. Key properties include a 4-ball wear (DIN 51350:5) of less than 0.9 mm and a water spray-off (ASTM D 4049 @ 25°C) of approximately 3%.



Annulus Grouts & Concrete Segments

When the segmental lining is installed inside the TBM, the space between the ground and the segments — the annulus gap — must be filled efficiently and reliably to prevent settlement. In most cases, this gap is filled with a cementitious grout, for which Master Builders Solutions® offers a full range of admixtures.

Concrete quality is critical for segment production, especially as modern tunnels are designed for a 100-year service life. High-performance concrete additives are essential to ensure durability and enable efficient production.



1. Annulus Grout Additives

The primary purpose of annulus grouts is to minimise surface settlement. Additionally, the grout protects the outer surface of the segments and the EPDM gaskets, while supporting the segments to prevent floating. The use of retarders, accelerators, superplasticisers, and air entrainers ensures a reliable and easy-to-handle grout formulation.



2. Shield Stabilisation and Lubrication

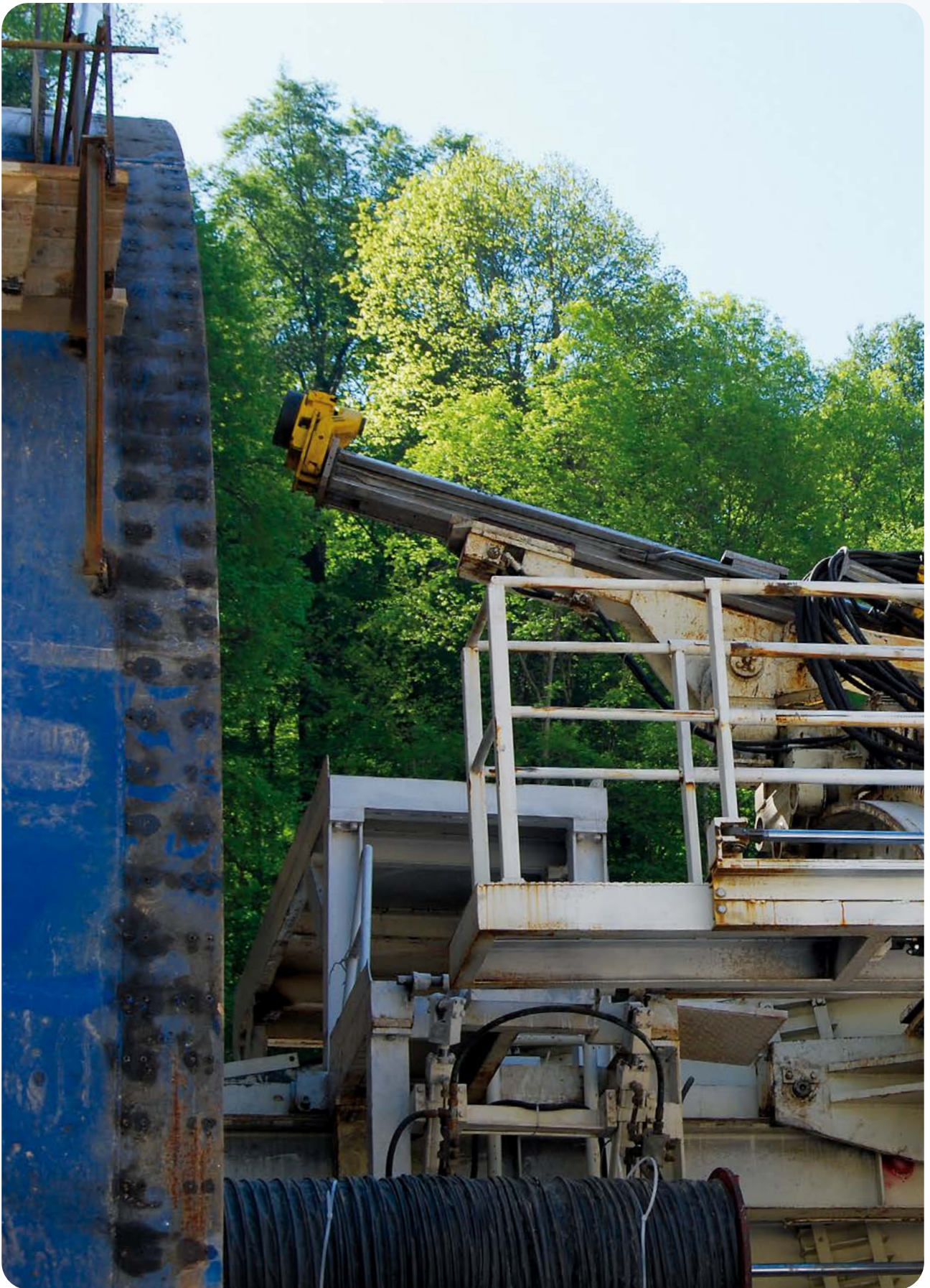
For projects with large TBM diameters or highly unstable ground conditions, shield stabilisation grout helps reduce surface settlement and prevents shield blockage. Polymerised bentonite or sand suspensions are ideal for this application. MasterRoc® SWA polymers can also be used to inhibit clay swelling and lubricate the shield.



3. Segment Concrete

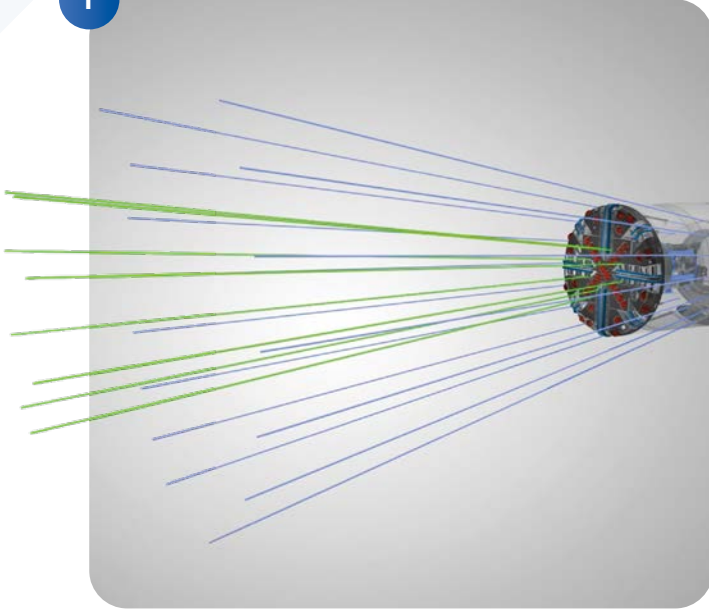
MasterGlenium® superplasticisers and MasterFinish® form release agents reduce concrete curing time and allow for earlier demoulding, resulting in shorter production cycles. This lowers energy consumption, increases productivity, and improves work safety. Additionally, concrete durability is enhanced.





Injection

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1. Pre-Injection

Pre-injecting the ground is a key measure to stabilise fractured rock and prevent water ingress, especially in geological fault zones. It is essential that the TBM is equipped with all necessary systems before tunnelling begins, as retrofitting is costly, time-consuming, and often only partially feasible. This includes drilling and mixing equipment, as well as drill jigs that pass through the shield and, if necessary, the cutterhead. Master Builders Solutions® offers microcements and colloidal silica to penetrate low-permeability ground, providing the most economical and technically suitable solution for each geological situation. This proven concept also meets environmental standards for drinking water, as demonstrated in the Arrowhead Project, USA.

2



2. Post-Injection

Post-injection on a TBM is used for void filling, water stopping, and concrete repair. MasterRoc® MP 367 Foam, a polyurea silicate, is ideal for void filling due to its low adhesion to metal TBM components. MasterRoc® MP 355 polyurethane is used for water stopping, while acrylic resin MasterRoc® MP 707 is suited for crack and curtain injection.

Further details are available in the Master Builders Solutions® Injection brochure.

Mastering underground construction challenges requires the right partner. Continuous innovation and customised solutions ensure that customers using Master Builders Solutions® achieve successful operations while meeting the highest safety standards.

Stations & Cross Passages



Stations and Cross Passages

Master Builders Solutions® offers a unique solution with the MasterRoc® MSL 345 sprayable waterproofing membrane, providing design flexibility for complex geometries such as tunnel intersections, station tunnels, access tunnels, and cross passages. When placed in a sandwich structure between two sprayed concrete layers, MasterRoc® MSL 345 enables design optimisation by creating a double-bonded composite shell lining. Special design guidelines are available to support all projects.

Know-how & Service



Training and Education

We regularly provide technical injection training at the Hagerbach underground facility in Switzerland. Courses include demonstration workshops in realistic underground settings and practical training for injection operators. The workshops are hands-on “show-and-tell” sessions designed to demonstrate application methods and the technical performance of our injection systems.

Practical operator training is offered exclusively to customers using Master Builders Solutions® injection systems. Participants work in small groups under the guidance of experienced instructors to develop practical skills for the correct execution of injection works. Tailored training for

specific projects is also available worldwide upon request.

Technical Services

We provide more than just a range of products. Assisting customers in selecting the right injection system and defining the appropriate injection method, as well as providing initial supervision and on-site training for customer personnel, is a key part of our approach. We collaborate closely with equipment and injection accessory suppliers to deliver the best, most cost-effective, and complete technology solutions. Our solutions are backed by local research, development, and testing conducted at our Seven Hills facility, ensuring they are tailored to meet the specific demands of the ANZ market.

More brochures on our underground construction solutions are available at:

ugc.master-builders-solutions.com

Documentation available on request:

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



Master Builders Solutions® for the Construction Industry

MasterAir®

Complete solutions for air entrained concrete

MasterCast®

Solutions for the manufactured concrete product industry

MasterCem®

Solutions for cement manufacture

MasterCO₂re™

Solutions for low-clinker concrete

MasterEase®

Low viscosity for high performance concrete

MasterFinish®

Solutions for formwork treatment and surface improvement

MasterFlow®

Solutions for precision grouting

MasterFiber®

Comprehensive solutions for fiber reinforced concrete

MasterGlenium®

Solutions for high performance concrete

MasterKure®

Solutions for concrete curing

MasterLife®

Solutions for enhanced durability

MasterMatrix®

Advanced rheology control for concrete

MasterPel®

Solutions for hydrophobization, anti-efflorescence and surface protection

MasterPolyheed®

Solutions for mid-range concrete

MasterPozzolith®

Solutions for water-reduced concrete

MasterRheobuild®

Solutions for high strength concrete

MasterRoc®

Solutions for underground construction and surface improvement

MasterSet®

Solutions for set control

MasterSuna®

Solutions for sand and gravel in concrete

MasterSure®

Solutions for extraordinary workability retention

Master X-Seed®

Advanced accelerator solutions for concrete

Quantified sustainable benefits. Advanced chemistry by Master Builders Solutions®.

Let the numbers do the talking: We have portrayed some of our most eco-efficient product solutions for concrete and precast production, construction, civil engineering, and flooring.

sustainability.master-builders-solutions.com



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