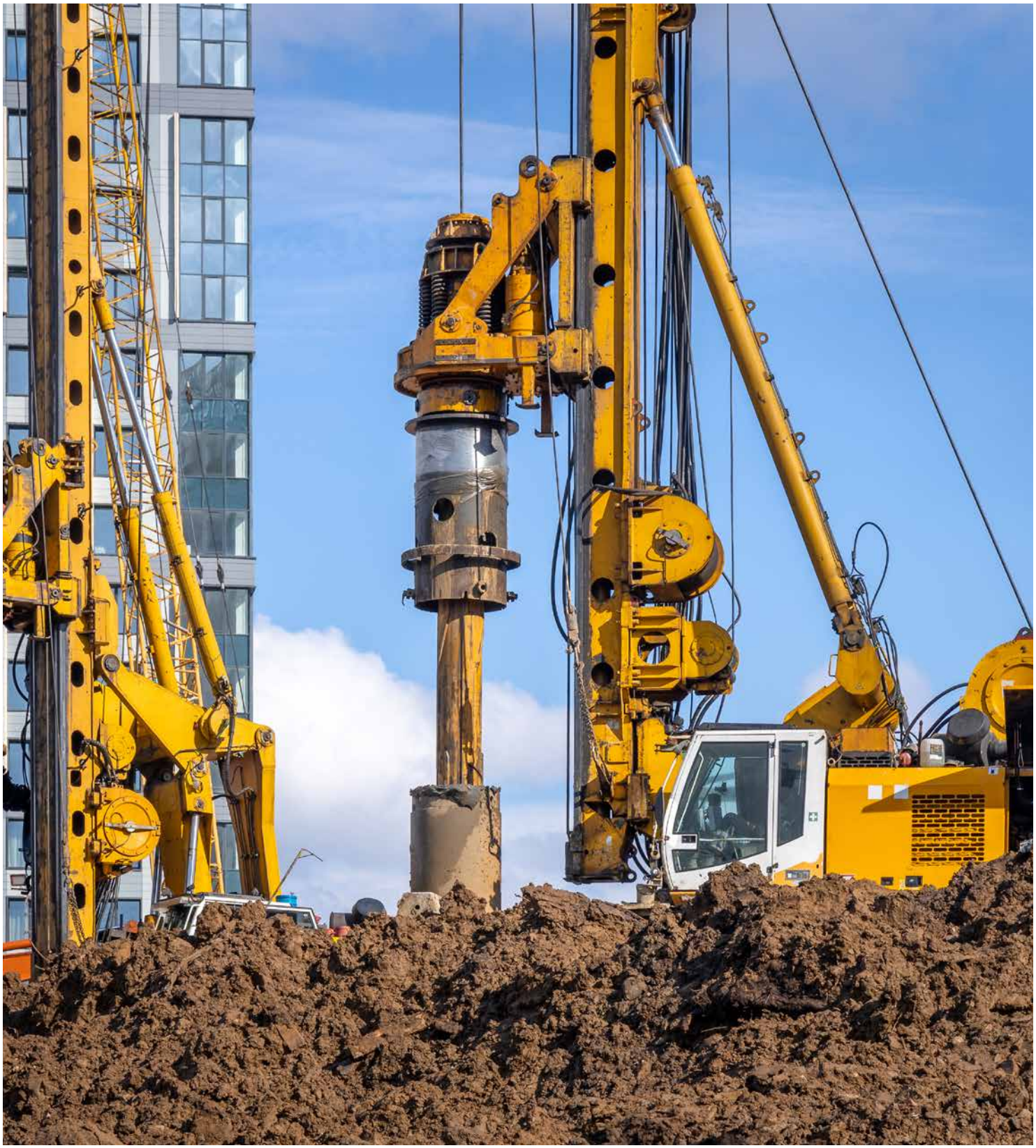
MASTER® BUILDERS SOLUTIONS

Foundation Engineering

Technologies to Improve Soils and Foundations

A brand of MBCC GROUP



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Foundation Engineering and Ground Improvement

When designing underground structures such as foundations, embankments, excavations or slopes, the foundation soil may be unable to withstand the loads transmitted by the structures, leading to problems such as high settlements, poor bearing capacity and high water permeability. Such issues are particularly likely to occur where there are eathquakes, landslides, rainy events or climate changes.

Ground improvement entails a range of techniques (both mechanical and chemical) to improve the density, permeability, deformability, and the shear resistance of the soil in order to prevent or reduce the undesired effects.

Many recent technological developments have made ground improvement more efficient and cost effective. Techniques such as injection, soil deep-mixing, jet grouting, anchoring and bored piles are some of the most widely used mechanical soil improvement technologies.

Injections, deep-mixing and jet grouting involve injecting a binder (conventional or chemical) or mixing it at a certain pressure and depth to form a hardened solid material.

For foundation engineering, anchors can be used as support structures which can be mechanically coupled with the soils (in a passive or active manner) via a binder to resist movement of the retaining structure.

Bored (or drilled) piles are installed by drilling a cylindrical hole to the required depth and subsequently filling it with concrete. They are needed when the top layers of the soil are highly compressible, when soils are expansive and collapsible or when the structure is subjected to strong uplift forces.

Through years of research and development, Master Builders Solutions has created a range of additives aimed to improve the deployment and longevity of these various foundation engineering and ground improvement techniques.

Added Value:

- Permeation and strenghtening of very fine soils (i.e. k-values of 10^{-6} m/sec)
- Improvement of deep soil mixing in clayey soils
- Improvement of hydrodynamic performance of jet grouting
- Robust materials for ground anchors
- Improvement of water retention for concrete in bored piles
- Grouts with low CO_2 impact

Grouting Solutions

The MasterRoc product line from Master Builders Solutions offers market-leading innovations for foundation engineering and ground improvement. Our reliable, customer-focused solutions include a variety of compelling technologies for efficient and cost effective construction.

Performance Characteristics	MasterRoc MP 355 series	MasterRoc MP 358 series	MasterRoc MP 300 Series	MasterRoc MP 309	MasterRoc MP 320 series	MasterRoc Microfine and ultafine cements
Product Category	Single-component Polyurethane	Two-component Polyurethane	Acrylics	Acrylics	Colloidal Silica	Microfine Cement
Main Application	Ground stabilization (coarse sand and gravel), Water migration prevention	Strata consolidation	Water migration prevention, Pre-excavation ground consolidation	Ground stabilization (silty and sandy soils), Pre-excavation ground consolidation	Ground stabilization (silty and sandy soils), Pre-excavation ground consolidation	Ground stabilization, Water migration prevention
Ground Excavation Characteristics	Yes	Yes	No	Yes	Yes	Yes
Mixing Ratio	Accelerator at up to 10% of resin by volume	1:1 by volume	Various with accelerator, hardener, and water	Various with accelerator, hardener, and water	Accelerator at 10% by volume	Water cement ratio 0.5 - 1.0
Particle Size (µm)	N/A	140	N/A	N/A	0.004 - 0.016	D95 of 12 - 20
Viscosity (cP or mPa.s)	320	Part A: 300 / Part B: 300 (estimated viscosity of the mixed material is 300, right after mixing)	2 to 13	13	10	N/A (dry powder)
Reaction Time / Setting Time / Gel Time	10 sec to 5 min	30 sec to 80 s	10 sec to 9 min	1 to 9 min	10 min to 2 hr	2 hr to 2.5 hr
Cured Material Appearance	Rigid foam	Rigid material	Flexible soft gel	Hard-elastic solid	N/A	Rigid material
Adhesive / Bond Strength	Excellent	Excellent	Excellent	Good	N/A	N/A
Strength	Low to medium	Flexural: 870 psi (6 MPa)	Compressive - over 1300 psi (9 MPa)	Compressive - over 1300 psi (9 MPa)	About 0.5 MPa at 28 days (UCS)	Above 10 MPa at 28 days (UCS)
Chemical Resistance	N/A	N/A	Acids and bases	Acids, bases, solvents and fuels	N/A	N/A
Pot Life after Activation	N/A	N/A	8 hr	5 hr	N/A	0.5 hr
Pump Required	Single-component injection pump	Two-component injection pump with a static in-line mixer	Two-component injection pump	Two-component injection pump	Single or two-component injection pump	Colloidal mixer
Additional Notes	Mixed product requires moisture/water to activate	Less water sensitive	Resin can be split with water (up to 1:3)	N/A	N/A	N/A

Our Products in Detail

Acrylic Resins	Properties/Details	Low to Medium Water Ingress	High Water Ingress	Permeation Grouting	Pre-injection Grouting	Small Void Fill	Strata Consolidation	Cavity Filling	Rock Bolt Anchor Resin	Cable Bolt Anchor Resin
MasterRoc MP 300	Low viscosity, very flexible gel with adjustable water to resin ratios 1:1 to 3:1	●		●	●		●			
MasterRoc MP 304	Low viscosity, very flexible	●								
MasterRoc MP 307 CE	Low viscosity, adjustable setting time, rubber-like	●								
MasterRoc MP 309	Low viscosity, high compressive strength			●	●		●			
Hydrophobic One-Component Polyurethane										
MasterRoc MP 355 1K	High expansion, semi-rigid foam, used with MasterRoc MP 355 1K accelerator	●		●		●				
MasterRoc MP 355 1K DW	High expansion, flexible foam, used with MasterRoc MP 355 1K accelerator	●				●				
Two-Component Polyurethane										
MasterRoc MP 355	Fast reaction time, dense cured material	●					●			
MasterRoc MP 355 w/ Accel 10	Dense, high foam expansion factor, rapid reaction	●	●			●	●			
MasterRoc MP 355 w/ Accel 25	Strong foam, low foam expansion factor	●	●							
MasterRoc MP 358 SC	Dense, foam expansion factor 3, rapid strength gain	●				●	●			
Two-Component Polyurea Silicate										
MasterRoc MP 368	Rapid strength development, high density resin, not water-sensitive						●			
MasterRoc MP 368 TIX	Thixotropic behavior, not water-sensitive	●					●			
MasterRoc MP 367	High Foam Expansion Factor, fast reaction, not water-sensitive					●	●	●		
Microfine/Ultrafine Cement										
MasterRoc MP 650	Microfine cement - 2 h set time			●	●	●				
MasterRoc MP 800	Ultrafine cement - 2 h set time			●	●	●				
MasterRoc MP 900	Ultrafine cement - 2 h set time			●	●	●				
Colloidal Silica										
MasterRoc MP 320/325	Ultra low viscosity, one-component resin			●	●	●				
Rock Bolting										
MasterRoc RBA 380	Two-component thixotropic resin, rapid strength								●	●
MasterRoc RBA 387	Extremely fast-reacting thixotropic resin, rapid strength gain, suitable for cold weather applications								●	●

Chemical Grouting Accessories	
MasterRoc MP 230 CLN	Pump cleaner, equipment preservation agent
MasterRoc MP 304 Part B	Optional component used with acrylic resins (MasterRoc MP 300, MP 304 and MP 307 CE) for increased bond and decreased shrinkage in wet and dry cycling
MasterRoc FLC 100	Powdered rheoplastic additive for nonshrink cement grout
MasterRoc EQ 512 PK	Mechanical packer for high pressure chemical grout, 1/2 in. (13 mm) diameter
MasterRoc EQ 558 PK	Mechanical packer for high pressure chemical grout, 5/8 in. (16 mm) diameter
MasterRoc EQ 250 OR	Oakum rope, 2 in. (50 mm) diameter

This guide shows the relative performance and properties of MasterRoc injection products. Depending on the jobsite conditions, the performance obtained may be different from the performance shown in this guide. Contact your local sales representative for additional information on the performance of Master Builders Solutions MasterRoc line of products.

Ground Reinforcement: Anchors and Nailing

Anchors and nails are tensile elements commonly used in civil engineering projects to resist lateral, uplift or pullout forces or to generate confining pressure.

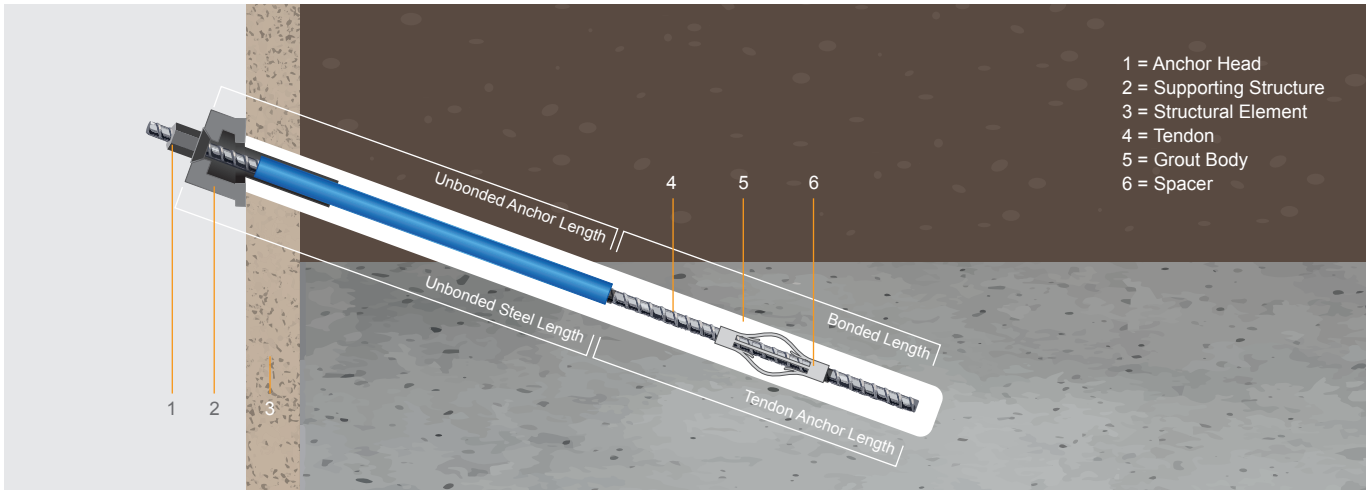
They are structural elements used to anchor retaining walls, bulkheads and structures in general to the ground and to support excavation fronts. They are also used in the stabilization and consolidation of slopes subject to landslides and for rock walls. An anchor consists of a suitably designed reinforcing element (with strands, bars or pipes), inserted into a special hole in the ground. The element intersects the plane where slipping could occur, anchoring itself to the mass of stable ground. The anchor is connected to the soil with a binder.

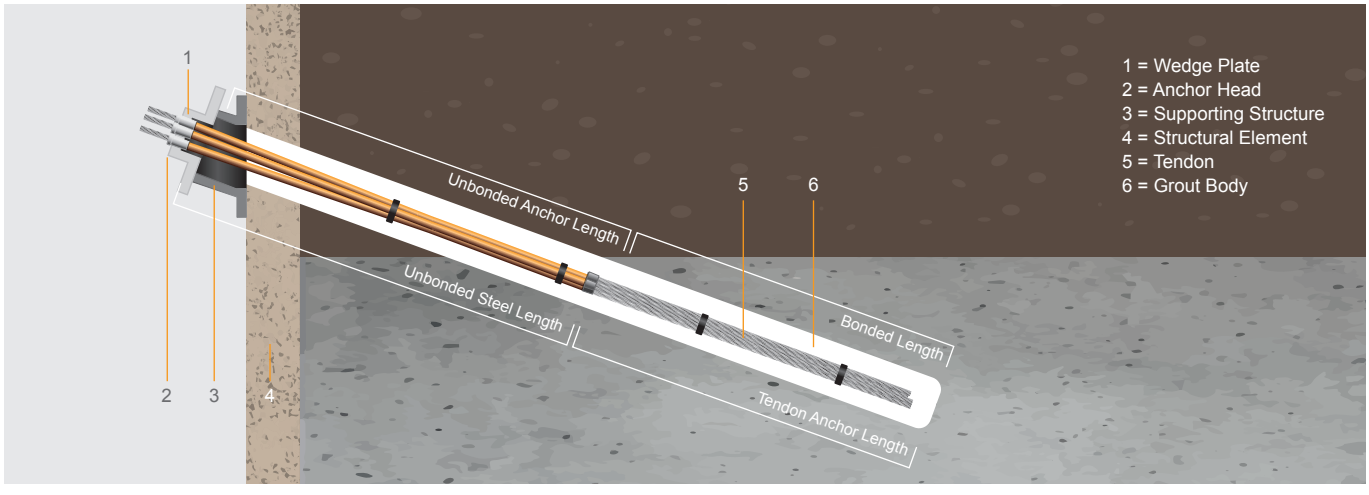
Anchors can operate as follows:
a) passive – they are pre-tensioned
b) active – are tensioned by a design force

In the first case, the action of the anchor is triggered by its deformation, induced by the displacement of the ground.

In the second case, however, the anchor is already active before further displacements of the surrounding ground, which only increase the stress on it.

The main components for passive anchors (above) and active anchors (below):





Typical fields of application are:

- Rock and slope stabilization
- Intra-urban construction
- Tiebacks for sheetpiles, slurry walls and similar temporary excavation support systems
- Excavations (deformation resistant)
- Uplift control in hydraulic structures (dams, weirs and spillways)
- To prevent flotation of underwater structures
- To prevent heave due to swelling soils

The tensile elements are inserted in the ground, connected to a structure and bonded to soil or rock in order to resist uplift or pull-out forces.

Typically, soil reinforcement involves stress transfer all along the reinforcing elements. However, soil and rock anchors transfer an uplift or pull-out force via a bar or cable in a good bearing stratum.

The tensile elements may be classified according to stress transfer, function or performance criteria:

- Bearing-type or friction anchors
- Prestressed (active support) where the working load generates a small variation in the tendon force, or unstressed (passive support) where considerable changes are expected under working load;
- Temporary or permanent anchors

Tests used to evaluate performance can measure the following parameters:

- Creep under constant load or stress relaxion at constant deformation
- Deformation upon reloading
- Load transfer to the ground
- Permanent deformation remaining after anchor test

The performance of ground reinforcement depends on several factors. Master Builders Solutions provides a full range of grouting products to provide high performance ground anchors, with specialized solutions for vibration damping, underwater construction and high strength applications. Our formulations include high performance properties such as early strength, extended working life at high temperatures, shrinkage compensation, corrosion protection and predictable performance.

MasterFlow® grouts are shrinkage compensated pre-bagged cementitious grouts suitable for post tensioned structures, cable duct grouting and anchoring. Additional applications for geotechnical works include rock bolts, cable anchors and forepoling for underground structures and slope stabilization.

MasterRoc® FLC 100 is the industry standard for anchors and post tensioned cable grouting. It is a chloride-free admixture in powder form which is added to cement to produce a pumpable, non-shrink, non-segregating, impermeable grout, providing high strength and a high bond to steel. It protects cables against corrosion from aggressive agents and stress.

MasterRoc® TIX series is a shrinkage compensated cementitious grout for the encapsulation of fully-bonded rock dowels in both underground and above ground applications.

Deep Soil Mixing / Jet Grouting

Deep soil mixing

Deep soil mixing is a versatile in-situ ground improvement method which involves mechanically mixing the soil (including soft clays, silts and fine-grained sands) with a cementitious binder in order to increase the soil's mechanical properties.The tensile elements are inserted into the ground, connected to a structure and bonded to soil or rock to resist uplift or pull-out forces.

Jet grouting

Jet grouting is a ground improvement method whereby a high velocity jet (consisting of binders) is used to remould the soil structure and simultaneously mix cement grout with the in-situ soil.

Geotechnical challenges

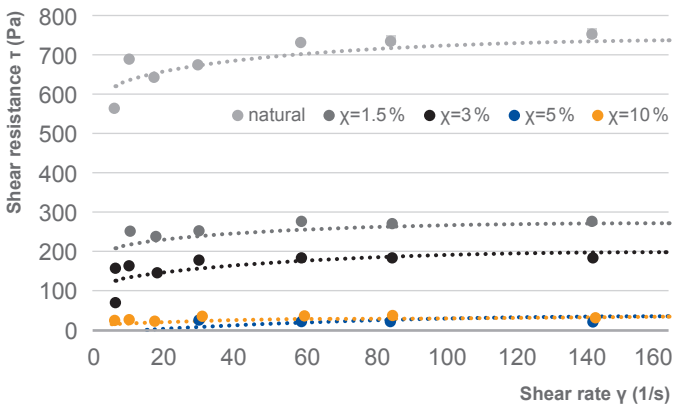
The engineering properties of the stabilized soil do not only depend on the characteristics of the binder. It is possible to stabilize organic or clay-rich soils, but more difficult than stabilizing granular soils. Clayey soils normally require more cement and the unconfined compressive strength achieved is generally lower than the strength achieved in cohesionless soils.

Solutions for clayey soils:

The MasterRoc® GE 50 series are products which:

- Reduce the clogging and adhesion potential of clayey soils
- Improve the workability of the excavated clayey soil

The workability of a swelling clay is improved by adding varying amounts of MasterRoc GE 50, expressed as a percentage of the dry weight of soils.



MasterRoc GE 50 improves the homogeneity of the mixture. Adding 3% MasterRoc GE 50 by dry weight to a clayey soil with a consistency of 50% creates a soil with a water/cement ratio of 0 with the same unconfined resistance as a clayey soil without MasterRoc GE 50 which has a water-ratio of 1.

Improving the hydrodynamic efficiency of jet grouting

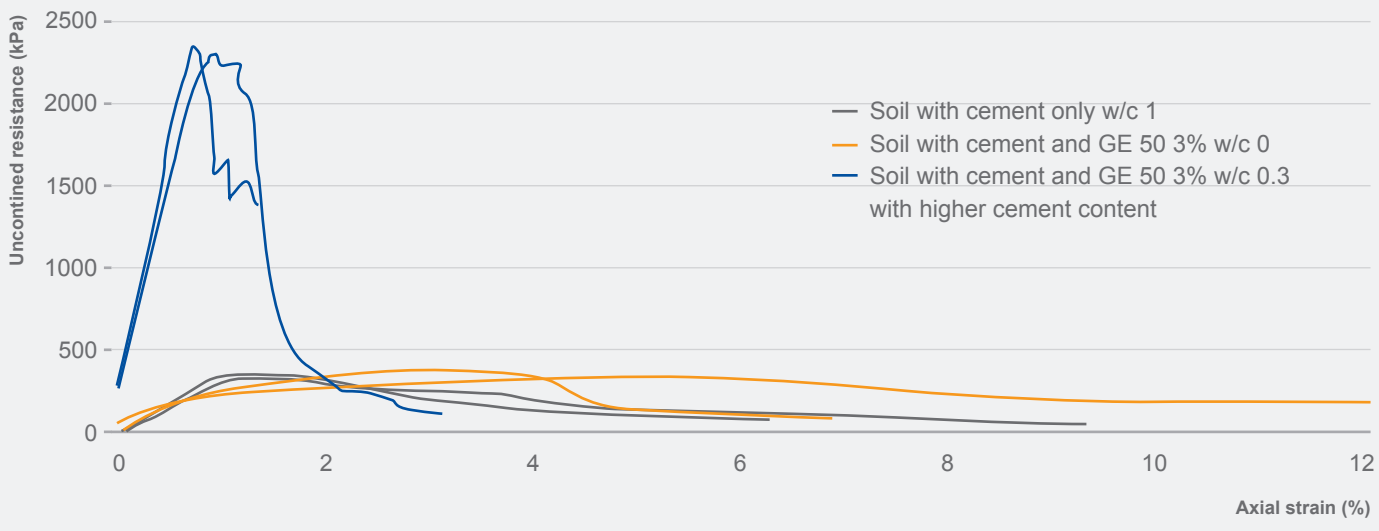
The evolution of hydrodynamic properties of the jet, and thus the cutting efficiency of jet grouting, can be expressed in terms of longitudinal and transverse velocity profiles. At the exit from the nozzle, streamlines are basically parallel and have an almost constant velocity. Thereafter, the velocity of threads progressively reduces due to the viscous-turbulent interaction of the jet with the surrounding fluid. Considering the velocity decay of a submerged jet in the diffusion zone along the longitudinal axis of the jet and in each transverse section, the parameter λ quantifies the interaction between the jet and the surrounding fluid. This parameter λ is the surviving fraction of the velocity at the nozzle. λ is linked (among others) to the dynamic viscosity coefficient of the grout.

MasterRoc® GE 15 is able to keep the parameter to a value where the hydrodynamic efficiency (and therefore the effectiveness of the jet stream) is high. MasterRoc GE 15 has a different chemical structure from the traditional high range water reducing. The alkalinity created by the cement allows the polymers of MasterRoc GE 15 to “open up and progressively release” additional polymer chains that will prevent the early flocculation or stiffening of the mix. This mechanism allows to obtain, compared to traditional high-water reducing admixtures, considerably longer workability and reduction of mixing water content.

Strength enhancer

Master X-Seed® is a strength-enhancing admixture that improves strength development in cement while supporting sustainable construction. Compared to other setting accelerators, Master X-Seed does not have a lasting effect on the rheology, even with highly flowable concrete mixes with extended workability. The strength-enhancing property of Master X-Seed admixture allows the proportion of cementitious material in a grout to be reduced, while maintaining the same compressive strength development as the reference concrete. Using less cement reduces CO_2 emissions.

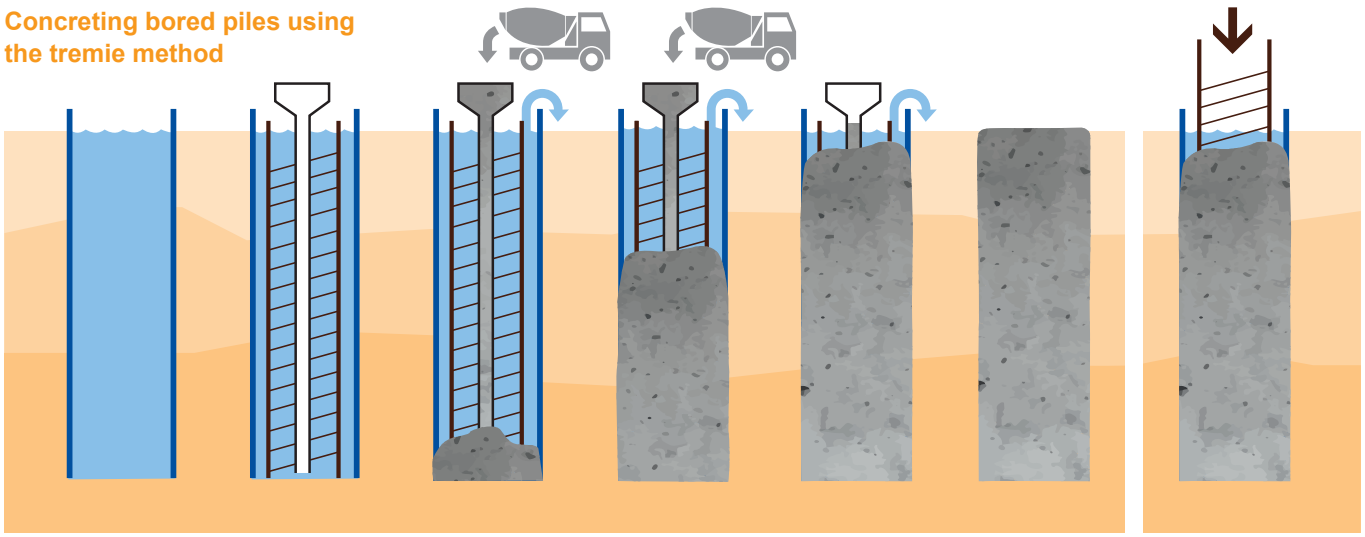
Appearance	Viscous liquid
Colour	Brown
pH	6.0 – 7.0
Specific gravity	1.10
Viscosity (cP)	< 130 cP
Chloride content	< 0.01 %



Innovative Concrete Admixtures for Deep Foundation Construction

The standard procedure in deep foundation construction is to use bored concrete piles or pile walls. In unstable ground conditions, or where the ground is prone to subsidence, this serves to reliably distribute structural loads onto a suitable bearing stratum.

Concreting bored piles using the tremie method



Excavation of diaphragm wall / bored pile, including any required piping

Installation of reinforcement cage

Concreting of bored pile through tremie pipe using a hopper, starting at the base of the borehole

Removal of segmental pipes as concreting progresses

Depending on project requirements, the insertion of a reinforcement cage may be required subsequent to concreting

To ensure sufficient structural integrity and maximum durability of the foundation, the concrete used in the construction of bored piles has to meet a variety of flowability and stability requirements. The innovative concrete admixtures offered by Master Builders Solutions are perfectly geared to such requirements.

The combined use of the latest generation of plasticizers (MasterSure LDP) and stabilizers (MasterMatrix FC 500) in deep-foundation construction enables groundbreaking synergy effects on the rheology and water retention of the concrete:

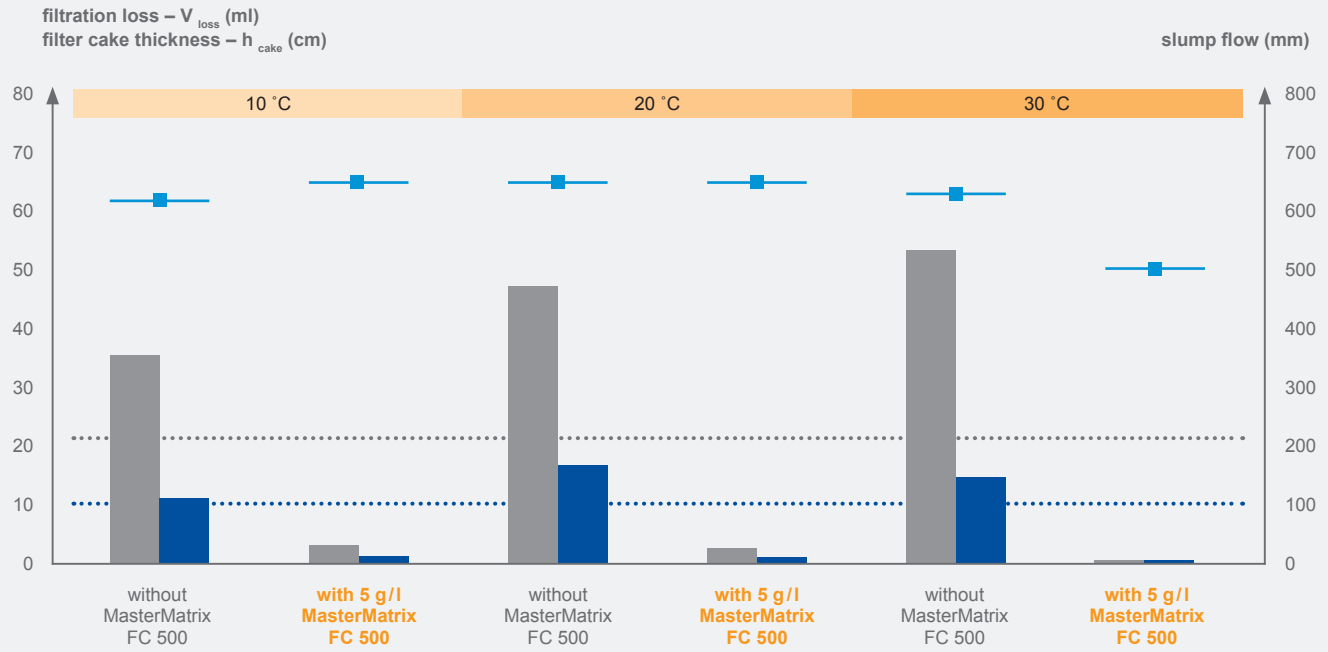
Benefits:

- Extremely low concrete viscosity for easy pumping
- Maximum flowability in self-compacting concretes
- Robust, high-performance concrete
- Highly extended workability time of 6 hours or more
- Effective water retention

MasterMatrix FC 500 for Reliable Water Retention

MasterMatrix® FC 500 is a novel stabilizer for use in deep foundation operations. High hydrostatic pressure during the concreting of bored piles (up to 70 m) can result in water being pressed out, resulting in lower quality bored piles. MasterMatrix FC 500 prevents this by combining maximum water retention with low viscosity and good temperature stability.

Water retention with MasterMatrix FC 500



- **tremie concrete mix composition**
- 300 kg/m³ CEM III A 42.5 N
- 100 kg/m³ fly ash
- 675 kg/m³ sand
- 1009 kg/m³ aggregate fraction
- water/cement ratio: 0.68

filtration loss
threshold value
filter cake thickness
threshold value
slump flow (mm)

Benefits:

- Excellent water retention that reduces segregation and bleeding for an even load transfer
- Polymer network effectively counteracts absorbent or cohesive substrates
- Very good workability, irrespective of mixing intensity or head of pressure
- Optimum temperature stability to support changes in application conditions and deliver robust concrete properties

Know-how and Service

Training and education

Master Builders Solutions brings extensive know-how gained through worldwide experience in solving challenging situations in tunneling and mining. In addition, support is offered frequently for clients, contractors and consultants by offering technical training courses and specialized seminars. Whenever required, and especially in the case of large projects, tailored on-site training can be organized.

Technical services

Master Builders Solutions supplies more than just specialty products for underground construction and mining, assisting in the selection of the most suitable combination of products for each project specific geology, as well as providing start-up supervision and site support.

More brochures on our underground construction solutions are available at https://ugc.master-builders-solutions.com

Documentation available on request:

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

Master Builders Solutions

Global Underground Construction Team
Master Builders Solutions, with its global underground construction team, provides reliable, customer-oriented solutions focused on your needs in the tunneling and mining industries all Global underground construction team Master Builders Solutions, with its global underground construction team, provides reliable, customer-oriented solutions focused on your needs in the tunneling and mining industries all over the world. We recognize 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. over the world. We recognize 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.

The Master Builders Solutions brand brings all of our 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 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 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 and solutions for on- and offshore wind energy.

Our comprehensive portfolio

- Concrete admixtures
- Cement additives
- Chemical solutions for underground construction
- Waterproofing solutions
- Sealants
- Concrete repair and protection solutions
- Performance grouts
- Wind turbine grouts
- Performance flooring solutions

Master Builders Solutions 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

MasterEase
Low viscosity for high performance concrete

MasterEmaco
Solutions for concrete repair

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

MasterInject
Solutions for concrete injection

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

MasterProtect
Solutions for concrete protection

MasterRheobuild
Solutions for high strength concrete

MasterRoc
Solutions for underground construction

MasterSeal
Solutions for waterproofing and sealing

MasterSet
Solutions for set control

MasterSphere
Solutions for guaranteed freeze-thaw resistance

MasterSuna
Solutions for sand and gravel in concrete

MasterSure
Solutions for extraordinary workability retention

MasterTop
Solutions for industrial and commercial floors

Master X-Seed
Advanced accelerator solutions for concrete

Ucrete
Flooring solutions for harsh environments

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

Master Builders Solutions Deutschland GmbH
Salzachstr. 17
68199 Mannheim, Germany
ugc@mbcc-group.com

Master Builders Solutions Admixture Systems US, LLC
23700 Chagrin Blvd
Beachwood, OH 44122, USA
P +1-216-839-7500
admixtures@mbcc-group.com

Master Builders Solutions Brasil Indústria e Comércio de Químicos para Construção Ltda.
Rua Costa Barros, 3089, Sitio Pinheirinho,
Vila Prudente
03210-001, Sao Paulo, Brazil
P +55 (11) 3164-4277
sac.eb@mail.mbcc-group.com

MB Solutions Singapore Pte. Ltd.
1 Harbourfront Avenue #07-07/08
Keppel Bay Tower
Singapore, 098632
P +65 6232 4888

Master Builders Solutions Construction Chemicals LLC
Head Office: Dubai Investments Park,
PO Box 37127
Dubai
United Arab Emirates
P +971 4 8090800
ugc@mbcc-group.com

MBS-08-2021-UGC-0097-EN