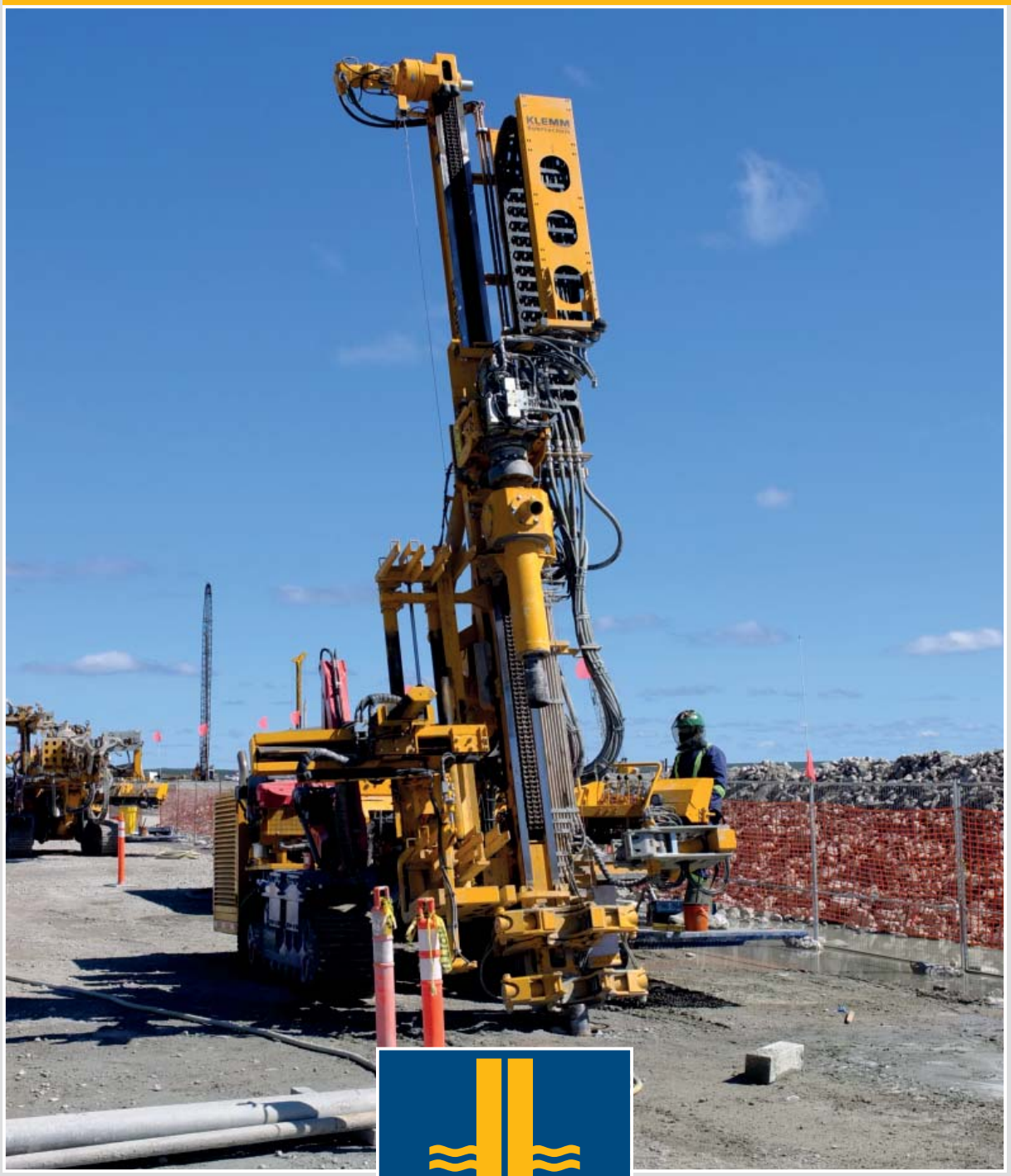
BAUER
Grouting



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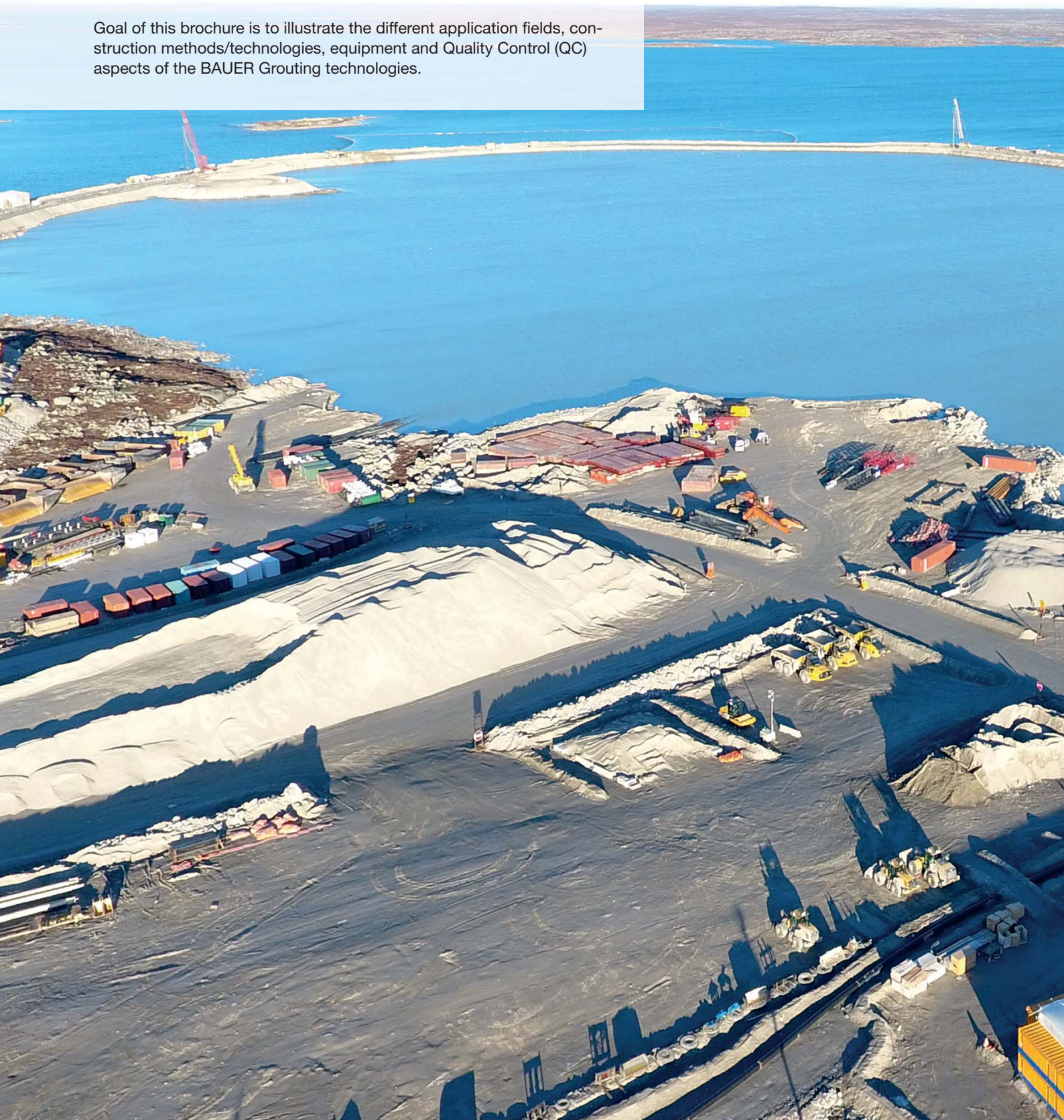
BAUER Grouting

Grouting is a technology used to improve the bearing capacity and/or the tightness of in-situ ground conditions using small diameter borings. This improvement can be achieved by filling cavities, fissures or pores, or by creating and subsequently filling fractures (claquages) using cement based or chemical based fluids.

BAUER Spezialtiefbau GmbH has an extensive expertise and a history of worldwide experience in various, differentiated Grouting technologies.

Goal of this brochure is to illustrate the different application fields, construction methods/technologies, equipment and Quality Control (QC) aspects of the BAUER Grouting technologies.



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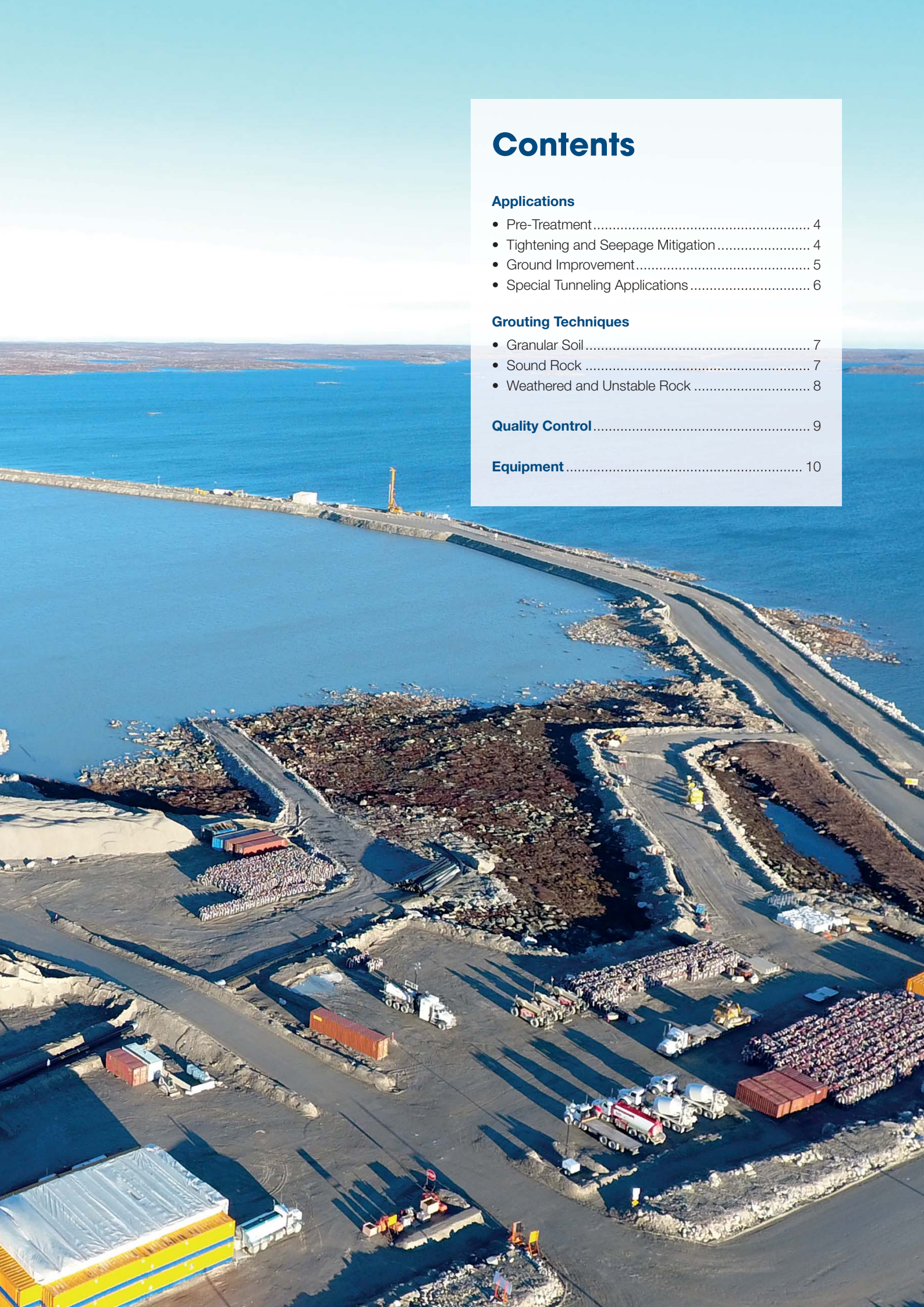
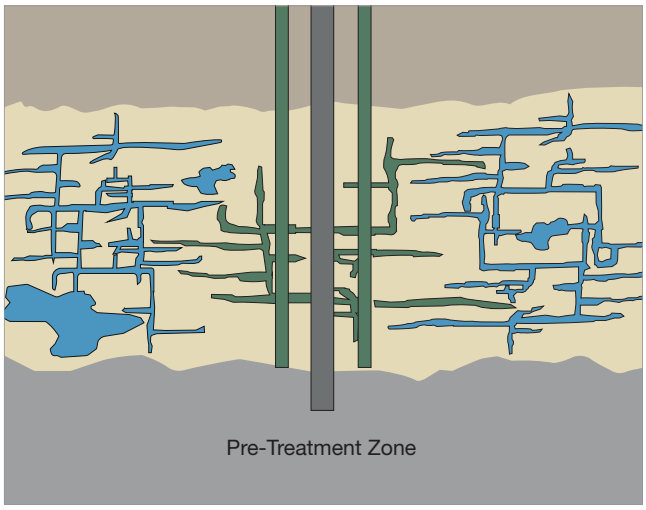


Applications

Pre-Treatment

Grouting for piling and diaphragm walls

Backfilling of cavities and large voids either by gravity or by low pressure grouting by means of sleeve pipe.



Pre-Treatment by grouting

Consolidation grouting underneath dikes and dam foundations

Injection of the first ground layer underneath the foundation that might be impaired by excavation and blasting.

Phunatsangchhu I Dam, Bhutan

Tightening and Seepage Mitigation

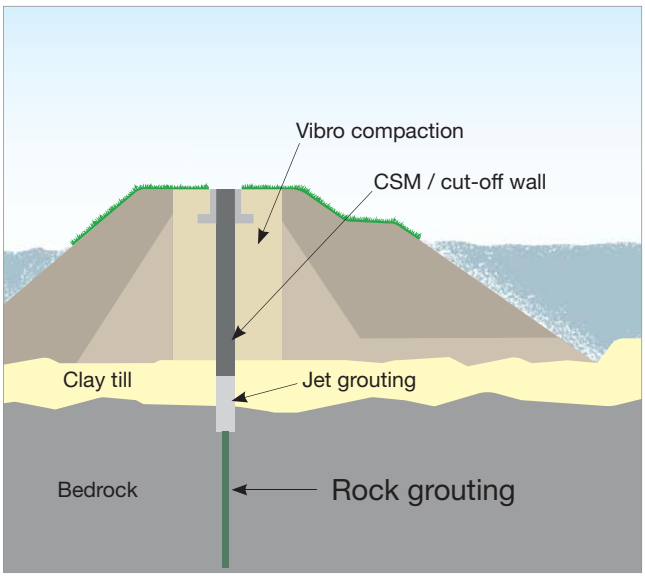
Grouting underneath dam and dike foundations: Granular soil

Pore permeation grouting with tubes-à-manchette (TaM)
Filling of soil pores in order to reduce the permeability and to provide a seepage barrier underneath the dam foundation.

Phunatsangchhu II Dam, Bhutan: TaM grouting in alluvium

Curtain grouting underneath dam and dike foundations: Rock

Fissure grouting
Grouting of fissures and cracks of the rock to provide a seepage barrier underneath the dam foundation.

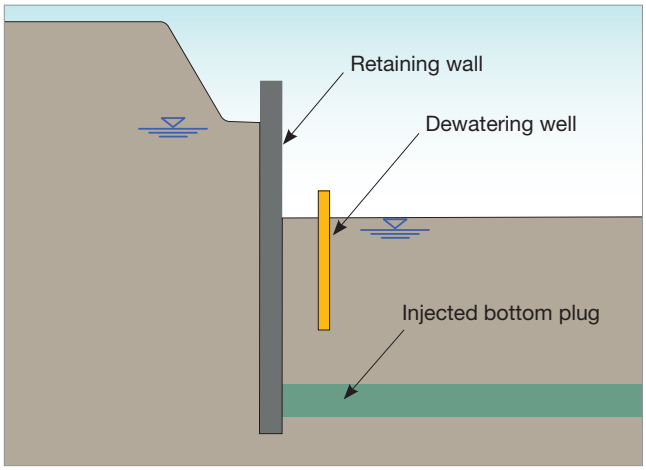


Diavik Diamond Mine A 21, Canada: Dike cross section

Ground Improvement

Pore permeation grouting for horizontal tightening and strengthening of granular soils

Pressure grouting through sleeve pipes (tubes-à-manchette) or single-valve tubes with the scope of creating tight and/or load bearing structures in the ground.

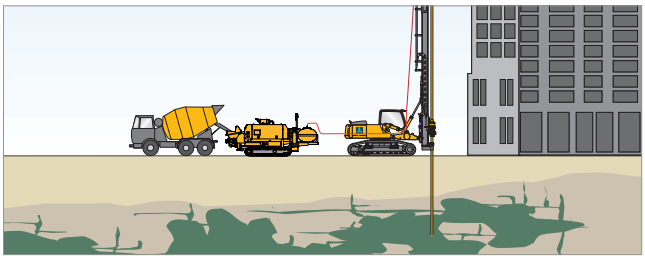


Horizontal grouted base cut-off

Designer Outlet Wolfsburg, Germany: Soft gel slab

Compaction grouting

Compaction grouting is a way to consolidate foundation soil by injecting low mobility grout. This process is used to prevent settlements or to stabilize structures which have settled. Holes are installed by either drilling or a drive string attached with a sacrificial point. Low mobility grout or mortar is injected in upwards stages with a low volume, using high pressure pumps. The injection rod is withdrawn at a controlled rate to give the grout a globular shape. The grout is injected until a predetermined pressure is reached or the ground begins to heave upward.

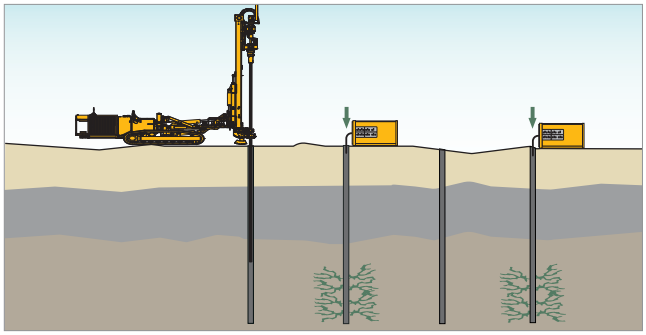


Compaction grouting

Compaction grouting for renovation of a church in Bad Tölz, Germany

Soil fracturing

Pressure grouting through sleeve pipes (tubes-à-manchette) with the scope of compaction and strengthening of the soil creating a net of grouted fissures.



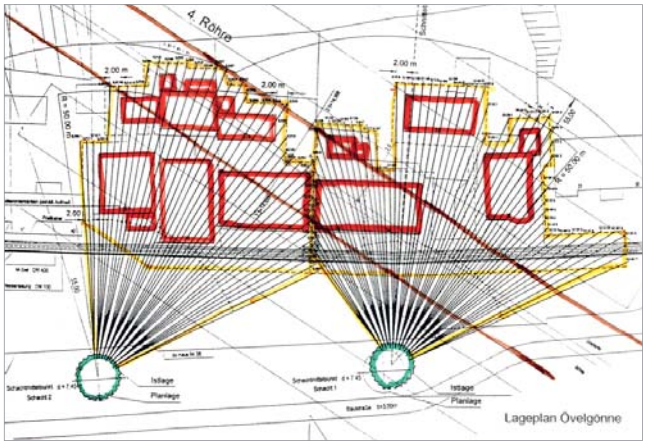
Pipe installation and grouting

Punta Pacifica, Panama: Soil fracturing

Special Tunneling Applications

Grouting for settlement mitigation

Pressure grouting through sleeve pipes (tubes-à-manchette) with the scope of achieving a controlled ground heave to compensate settlements.

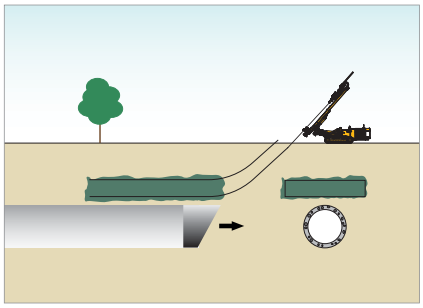


Compensation grouting from 5 shafts at Elbtunnel Hamburg

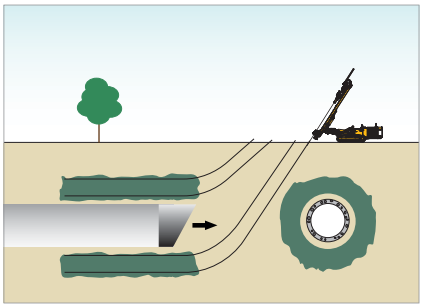
Drilling rig in one shaft at Elbtunnel Hamburg

Grouting combined with Horizontal Directional Drilling (HDD) technique

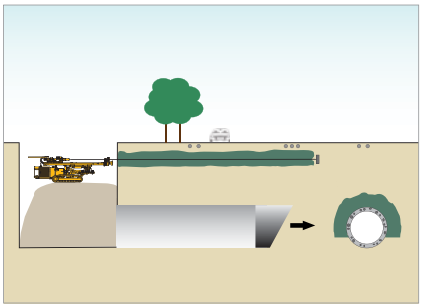
Pressure grouting through sleeve pipes installed inside HDD boreholes.



Compensation grouting without shaft



Grouting around tunnels



Grouting with reduced overburden

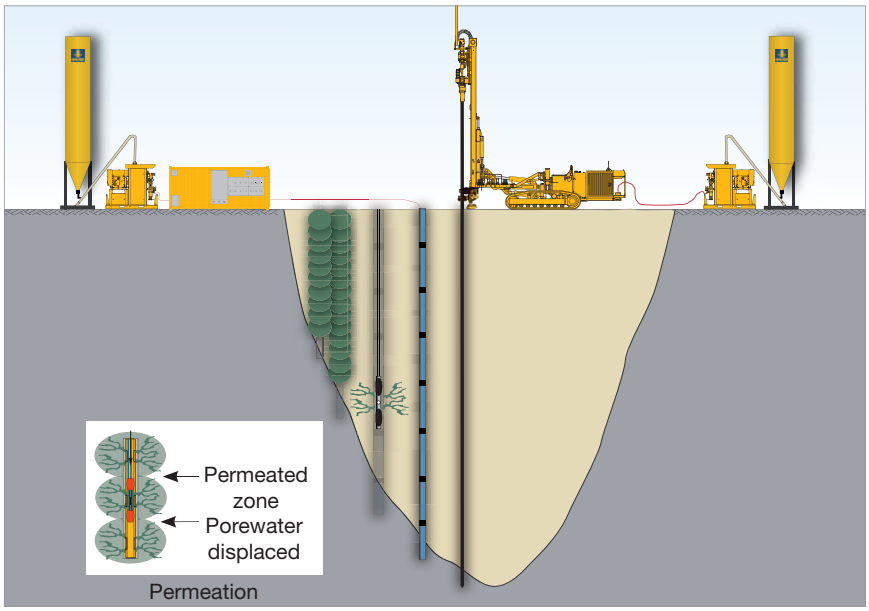
Pedestrian underpass in Abu Dhabi, UAE: HDD guided drilling

Pedestrian underpass in Abu Dhabi, UAE: Tunnel with TaM pipes

Grouting Techniques

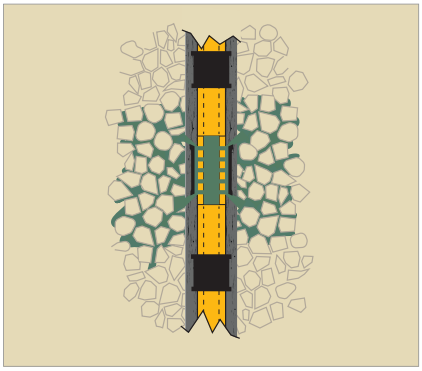
Granular Soil

Grouting with tubes-à-manchette (TaM) with annulus grout



TaM-Grouting phases

Work sequence:
1 Drilling with temporary casing (optional)
2 Placement of annulus grout
3 Installation of TaM
4 Casing extraction (eventual)
4 Additional annulus grouting
5 Grouting of each manchette with double packer

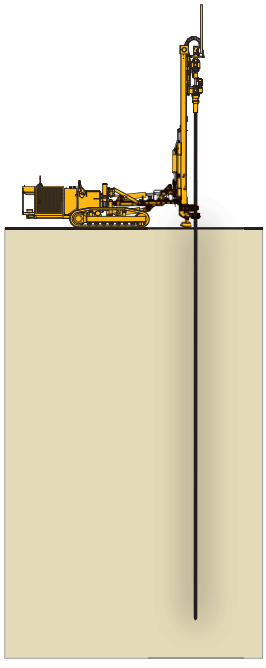


Detail of grouting with TaM

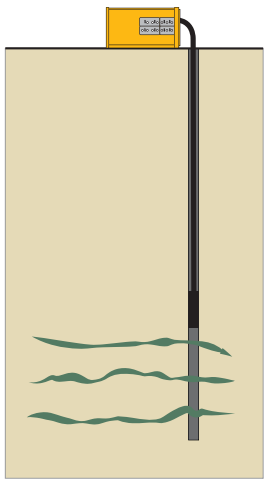
Sound Rock

Upstage grouting

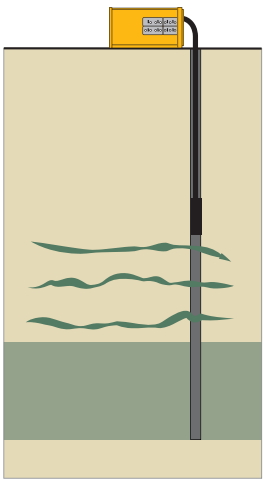
Procedure of drilling a hole to full depth in one operation and grouting from the bottom of the hole towards the surface in successive stages by setting a single packer at predetermined depths.



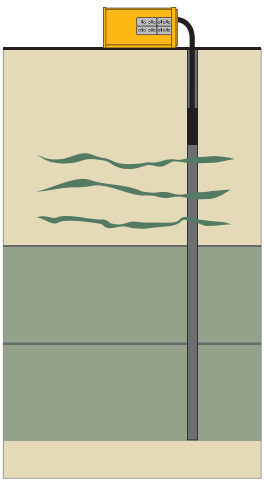
Drilling to depth



Grouting stage 1



Grouting stage 2

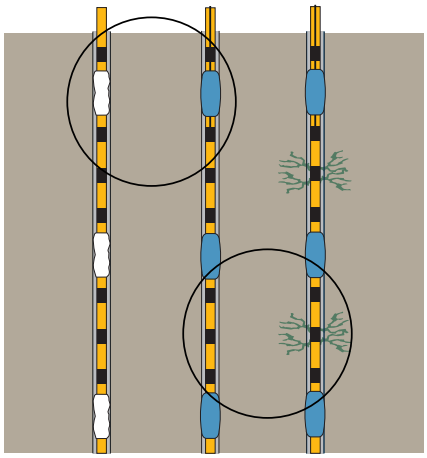


Grouting stage 3 (...)

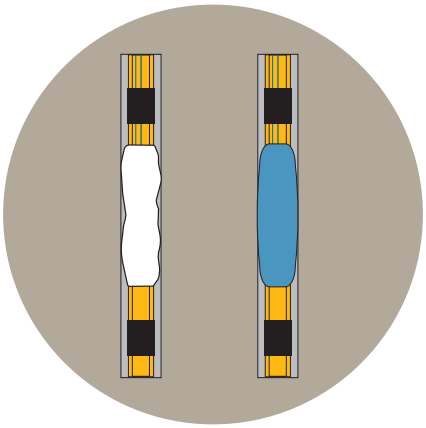
Weathered and Unstable Rock

Multiple-packer, sleeve pipe (MPSP system without annulus grout)

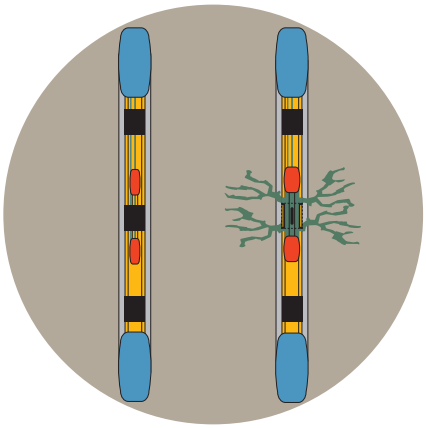
A tubes-à-manchette (TaM) equipped with fabric bags to separate the different grouting stages is placed down to the full depth of the hole. The fabric bags are inflated with cement grout to act as intermediate packers. Prone to collapse, the borehole is cased. The multiple-packer tube can then be put down inside the casing and the casing pulled out of the hole to expose the walls prior to inflating the bags.



Sequence of MPSP



MPSP Grouting phase 1

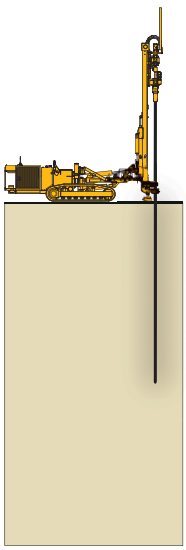


MPSP Grouting phase 2

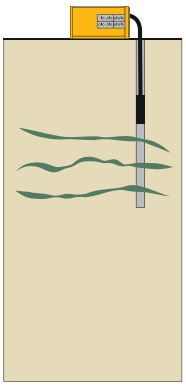
Downstage grouting

Procedure of drilling a hole to a limited depth, setting a single packer and grouting the hole, permitting the grout injected around the hole to set sufficiently to prevent its entering into the hole when the hole is cleaned.

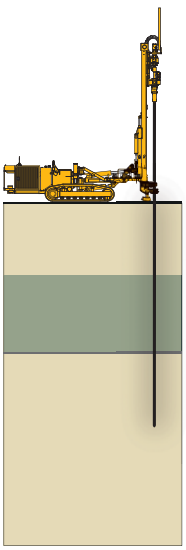
- Re-drilling through the hardened grout.
- Drilling the hole to the next deeper stage.
- Setting the packer at the bottom of the previously grouted stage or as directed by the Engineer and grouting of the new stage.



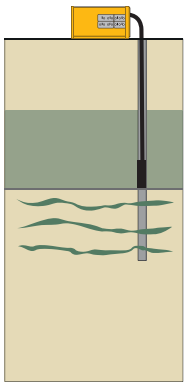
Drilling to end of stage 1



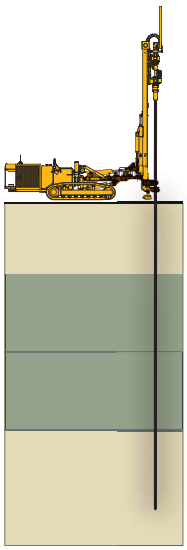
Grouting stage 1



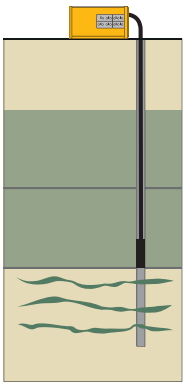
Drilling to end of stage 2



Grouting stage 2



Drilling to end of stage 3



Grouting stage 3 (...)

Quality Control

Grouting requires a high level of Quality Assurance (QA) and Quality Control (QC) measures. Compliance with the Technical Specifications of the project and quality requirements are checked and documented by Bauer‘s QC Management supervised by the Client‘s Quality department.

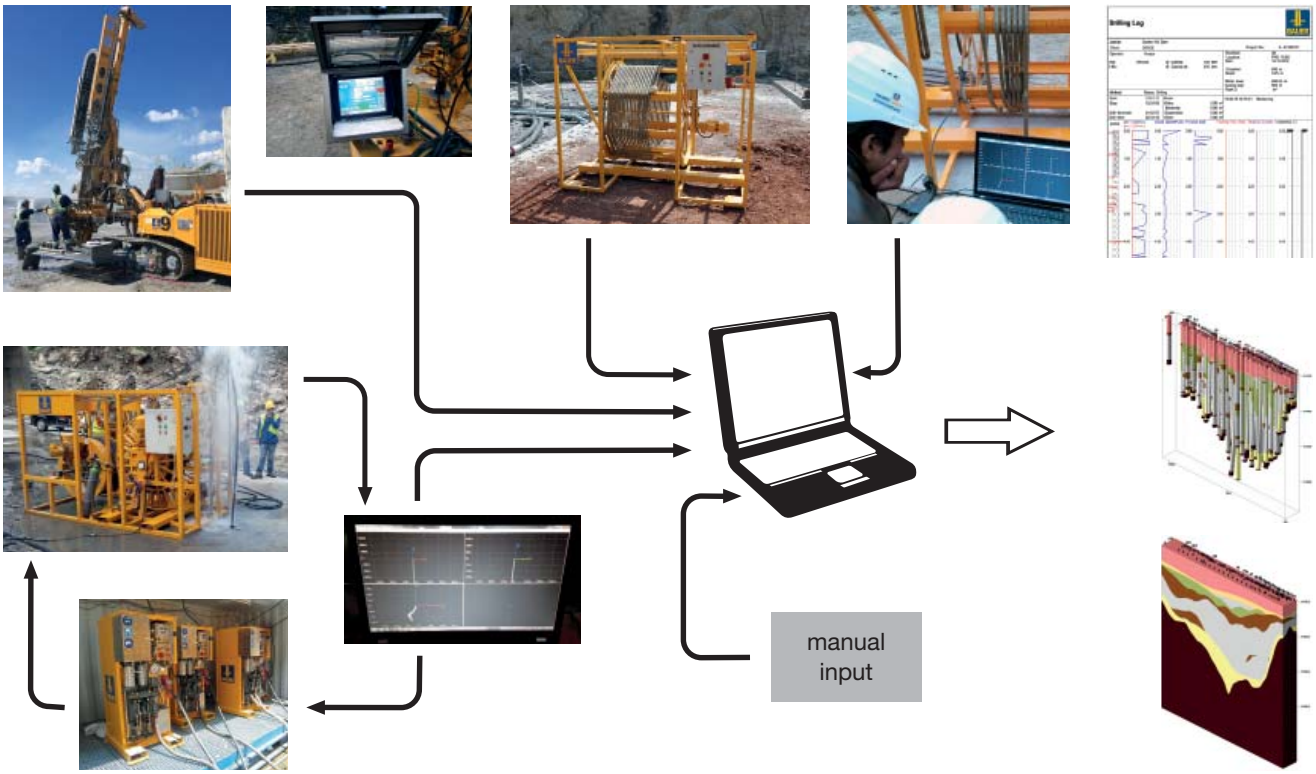
QC Documentation

- Daily report: In this report all site resources including personnel and equipment and all daily activities of drilling and grouting performance including material consumption are summarized.
- Drilling report: Includes information on the drilling fluid, hole position, drill parameters and layer sequence, type of formation, installation of TaM and execution time, borehole-deviation, flushing and water testing data.
- Grouting report: This report will be automatically recorded in the grouting plant and includes the location, date, mix type, grout volume, pressure and pump rate.
- Fresh grout testing report: Includes sampling data, water/cement ratio, specific weight, marsh viscosity and sedimentation ratio.
- Laboratory test report: Includes the results of site tests including cohesion, apparent viscosity, presso-filtration, setting times, gel time and UCS tests.

BAUER b-project Software

The BAUER b-project Software allows the collection of all grouting data including drill parameters, borehole deviation, water tests, grout parameters (flow-rate, pressure, volume), grout test data and production data, with the aim of:

- Verifying the stratigraphy and the permeability before and after grouting
- Verifying and plotting the as-built borehole geometry
- Supervising and guiding the grouting process in real time
- Producing QC instructions and reports
- Producing 2D and 3D plots of the grouted bodies (ABG software).



Schema of grouting data collection system

Equipment

Drilling

Typical drilling equipment for open air works are the Bauer hydraulic drilling rigs of the KLEMM KR 806-series. These modern and extremely compact rigs are particularly suitable for different drilling applications including:

- Rotary drilling
- Rotary drilling with down-the-hole hammer
- Rotary percussion drilling
- Overburden drilling
- Double head drilling rotary/rotary
- Double head drilling rotary/rotary percussion

The drilling rigs are fitted with hydraulic drifters (i.e. Eurodrill HDseries or similar), with different types of drill rods and drill tools to suit the geology and depth required for the individual project and with state-of-the-art equipment for drill parameter recording and borehole deviation measurement.

For drilling from limited spaces (galleries, shafts) the short mast rigs of the Klemm KR 700 series with diesel or electric motors with separate power pack are the most suitable.

Klemm Hydraulic Drill Rig KR 704-1

Klemm Hydraulic Drill Rig KR 806-3F

Batching and Mixing

Bauer utilizes fully automatic and remote controlled plants. The accurate determination of the right grouting equipment depends on ground conditions, the grouting technique and the required grouting material.

MAT mixing plant SCC 40 K

MAT mixing plant SCC 20 K with Mohno pump

MAT mixing plant SCC 20 K with big bag station

Grouting

Grouting pumps can be either hydraulically controlled piston pumps or Mohno type screw pumps.

Piston pumps are normally used in combination with the so called direct method whereas the Mohno pumps are used in combination with the closed loop method.

The injection system is formed by two combined units, the mixing and pumping unit and the data control cabinet. Via data cable the online pressure and grout flow are transmitted to the control cabinet. The grouting process is controlled either at the pump or from the valve unit installed at the hose drum or grout cart nearby the grout hole mouth.

Grouting cart for extreme weather conditions

Hydraulic controlled grouting pumps in container

Hole Washing Device

High pressure hole washing is usually required prior to grouting into rock formations. To this purpose specific equipment with a high capacity pump and hose drum have been developed and constructed.

Hole washing equipment device

Measurement of Borehole Deviation

Grouting structures are advancing into ever-greater depths and are required to comply with strict hole deviation tolerance criteria. There are various systems available for controlling and monitoring the deviation of the borehole from the design direction, like the Shape Accel Arrays (SAAs), for example.

With the Shape Accel Arrays (SAAs) the 2D and 3D shape measures (verticality control) will be performed at each grout hole immediately after the drilling phase.

Inclinometer drum, equipped with SAA scan

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