



Chemistry, shotcrete and manipulators around the TBM

CIA Seminar Brisbane, July 2009



The Chemical Company

BASF Construction Chemicals
Lars Langmaack



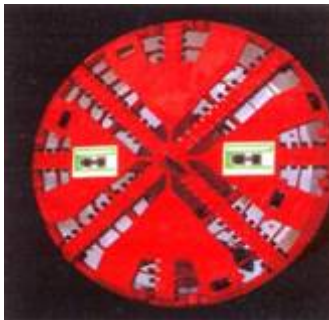
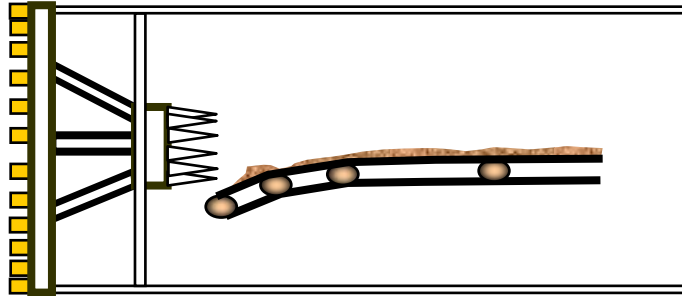
MEYCO GROUP OF COMPANIES

TBM design vs. geology

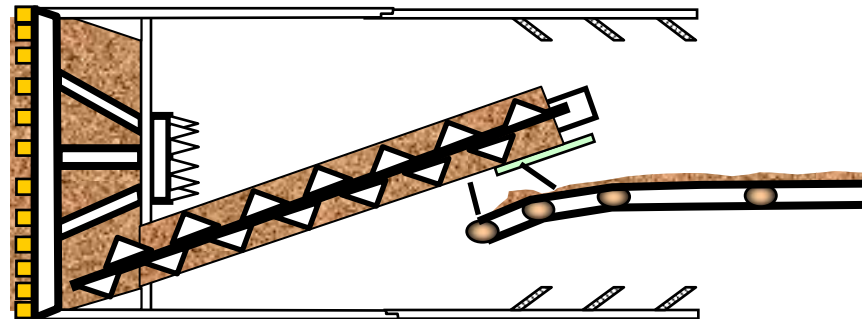
3 main types



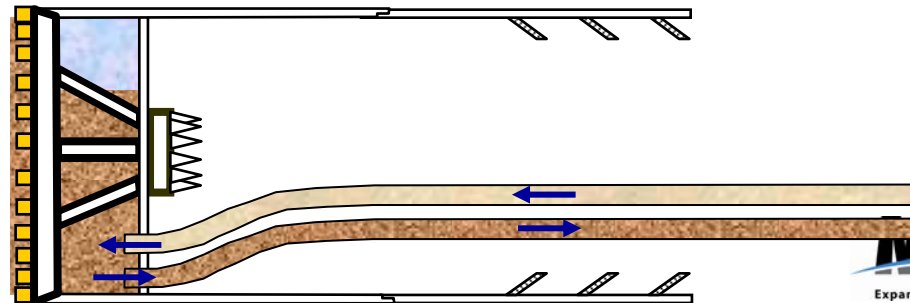
Hard rock



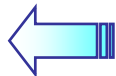
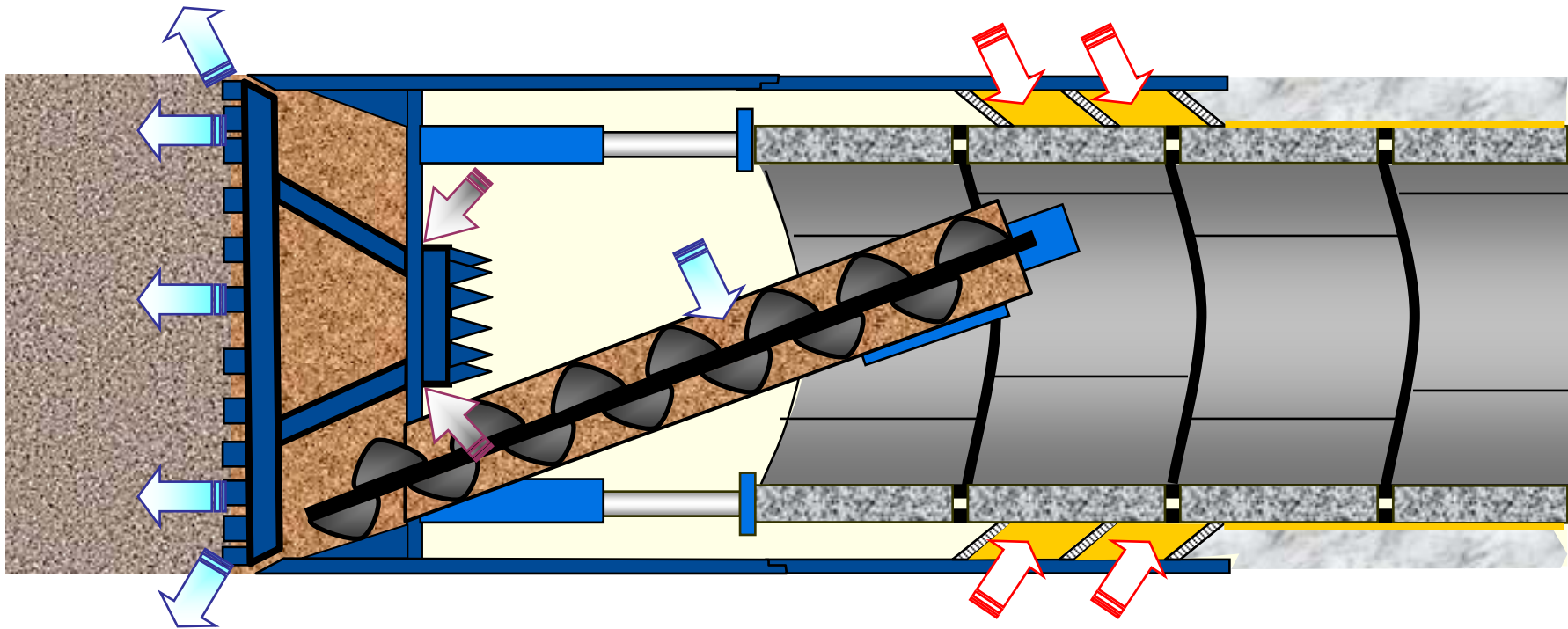
EPB



Slurry



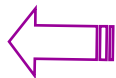
Sealing the TBM



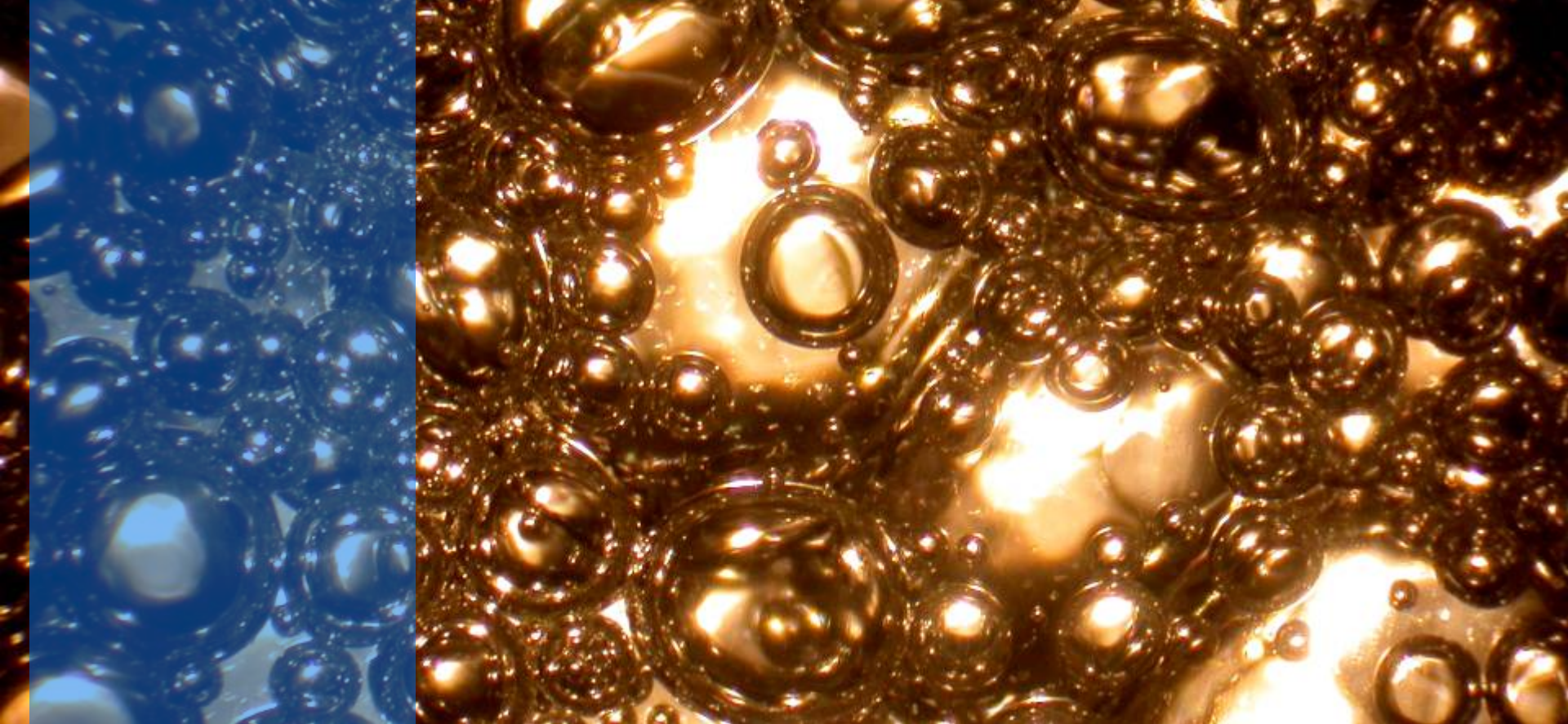
Water / foam / polymer / anti-clay-agent



Tail sealant



Excluder grease / main bearing sealing grease



Soil Conditioning Foams and Polymers



The Chemical Company



Partnership with BASF

Soil Changes With foam



Dry sand & granite chips



+ Water



+ Soil conditioning

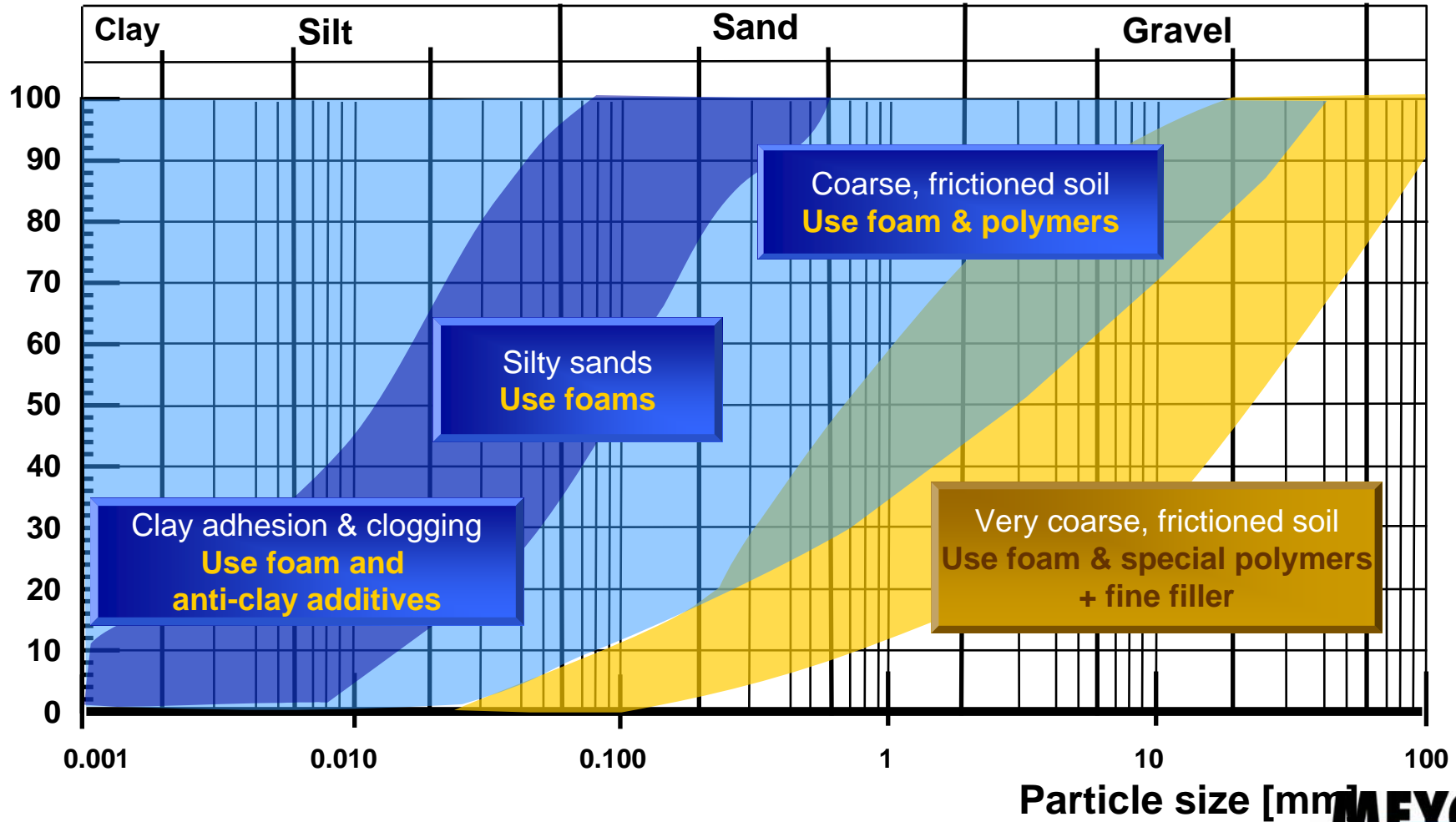
Injection Points

At the TBM cutterhead



Actual range of EPB use

Weak ground under groundwater pressure



World's biggest EPB TBM, MHI

Madrid M30 motorway project, Spain

BASF
The Chemical Company



MEYCO
Expanding Horizons Underground

World's biggest EPB TBM, S-300

Herrenknecht Madrid M30 motorway project, Spain

BASF
The Chemical Company



MEYCO
Expanding Horizons Underground

Toulouse Metro project

Conditioned soil comparison



Dry excavation



Homogeneous & plastic soil
with **MEYCO SLF 30** and
Rheosoil 211

How do polymers work ?



Polymer SLF P2



Effect of structuring polymers



2.5 bar sea water pressure
use of foam



2.5 bar sea water pressure
use of foam & polymer



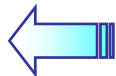
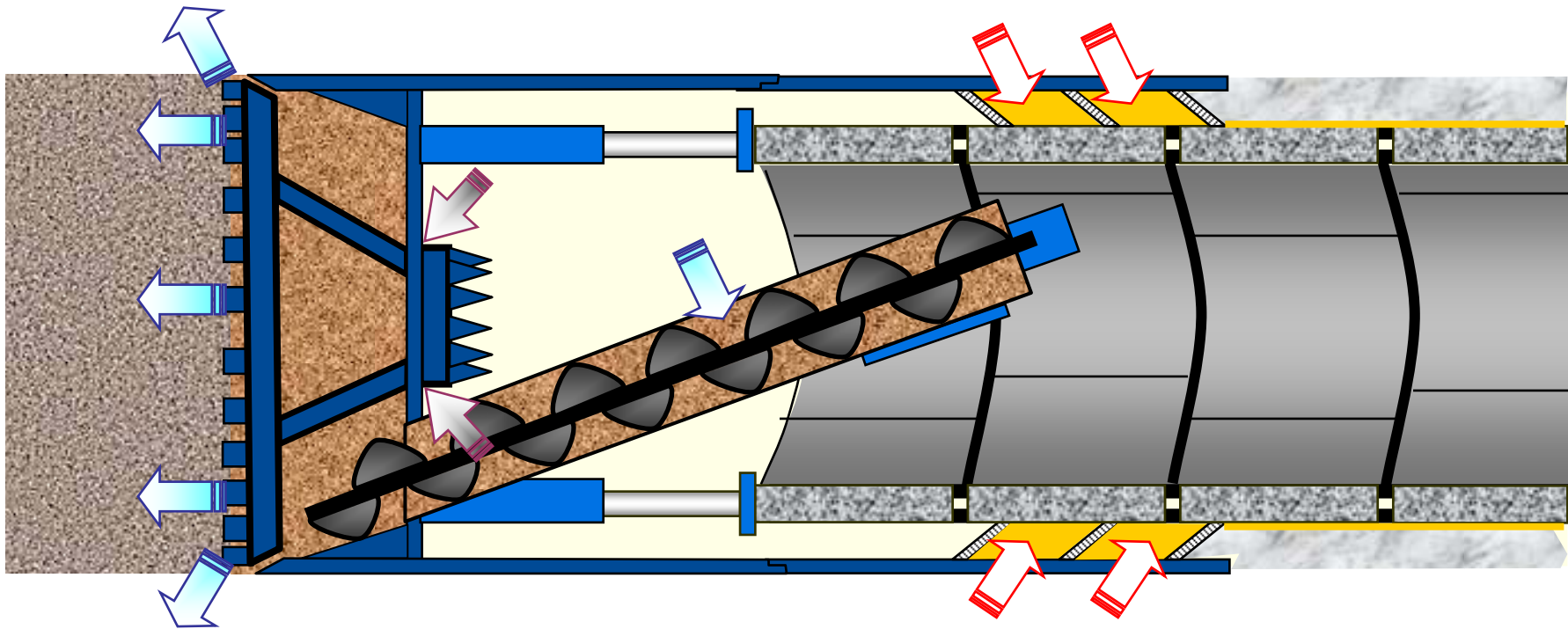
NAT 2008 San Francisco Short Course Annulus Grouts

Lars Langmaack, BASF Construction Chemicals
UGC Underground Construction Group



ANALYSIS AND DESIGN

Sealing the TBM



Water / foam / polymer / anti-clay-agent



Tail sealant



Excluder grease / main bearing sealing grease

Why annulus grout is important

- To give early stability as construction occurs
- To prevent heave / flotation of the lining
- To take early load in the build area
- To reduce settlement, especially in non-cohesive soils
- To prevent segmental misalignment and the rupturing of gaskets
- To eliminate / reduce water ingress to avoid secondary injection (costly)

Required Performance of annulus grout

- **Good flowability**
- **Good pumpability over pumping distance**
- **Workability may be required from 4 - 24 hours**
- **No bleeding (<1% bleed of free water)**
- **Anti-washout properties**
- **Easy to mix and transport**
- **Easy cleaning of the grout channel (tailskin)**
- **Durable and no shrinkage**
- **Economical mix and total economical solution**

Annulus grout materials

- **Cement**
- **Fine aggregates**
- **Water**
- **PFA (fly ash)**
- **Limestone dust**
- **Blast Furnace Slag**
- **Bentonite**
- **Colloidal silica**
- **Admixtures**

... here it is!!



„Standard“ grouts

VALSUGANA MALTA BACK FILLING

Mix	Composizione
CEM II/A-L 42,5R	450 kg/m ³
water	320 l/m ³
sand	1200 kg/m ³
Additivo Superfluidificante Glenium 20	2,0 l/m ³
Air entrainer Micro Air 200	3,0 l/m ³
retarder Pozzolith BM	0,4 l/m ³
Marsh cone (13 mm)	38 s
Bleeding at 3 h	0,0 %
Open time	5 h
density	1970 kg/m ³

VALSUGANA MALTA BACK FILLING

BASF
The Chemical Company



MEYCO
Expanding Horizons Underground

Accelerated grouts

“JAPANESE” system

Typical mix design (kg/m³):

Cement : 230-280kg

Bentonite 60kg (Wyoming Bentonite 30kg)

Water: 800-860 kg (wcr approx. 3.5)

Stabilizer: 2.5-3 l/m³ **POZZOLITH 89**

Added at the injection point: 60-80 kg Sodium Silicate **MEYCO FIX GA 10**

- Computerized system, the grout pumps starts when the TBM is moving
- Cement/Bentonite solution stable for 24 hours (can be 2-3 days)
- Can be pumped over long distance
- Instant gelling when Component B is added gives early support

METRO NAPOLI

BOIACCA BACK FILLING

Componenti	Mix 1	Mix 2	Mix 3
CEM IV/B (P) 32,5R	250 kg/m³	260 kg/m³	250 kg/m³
Fly ash	580 kg/m³	---	150 kg/m³
Calcerous filler	---	1000 kg/m³	---
Bentonite	---	20 kg/m³	30 kg/m³
water	600 l/m³	440 l/m³	830 l/m³
Additivo GLENIUM PF	2,0 l/m³	5,0 l/m³	---
Accelerante MEYCO SA 162	42,0 kg/m³	22,5 kg/m³	30 kg/m³
retarder DELVO	500 g/m³	1000 g/m³	500 g/m³
1h compressive strenght MPa	plastic clay	0,10	plastic clay
24h compressive strenght MPa	0,20 – 0,40	> 1,0	0,10

METRO NAPOLI BOIACCA BACK FILLING

BASF
The Chemical Company



MEYCO
Expanding Horizons Underground

Pea gravel grouting

GALLERIA IDRAULICA – VAL VIOLA BOIACCA PEA GRAVEL

Mix	Composizione
CEM I 52,5R	1075 kg/m³
water	620 l/m³
Additivo Superfluidificante Rheobuild 561	6,5 l/m³
density	1730 kg/m³
Marsh cone (4,7 mm)	46 s
Marsh cone after 120 minutes (4,7 mm)	52 s
Bleeding at 2 h	4,0 %
Compressive strength at 28 d	33,0 MPa

Hard rock – Val Viola



Hard rock – Val Viola



GALLERIA IDRAULICA
VAL VIOLA
BOIACCA PEA GRAVEL





MEYCO ABR anti-abrasion and anti-dust technology



The Chemical Company



PROTECTING YOUR INVESTMENT

Site Example:

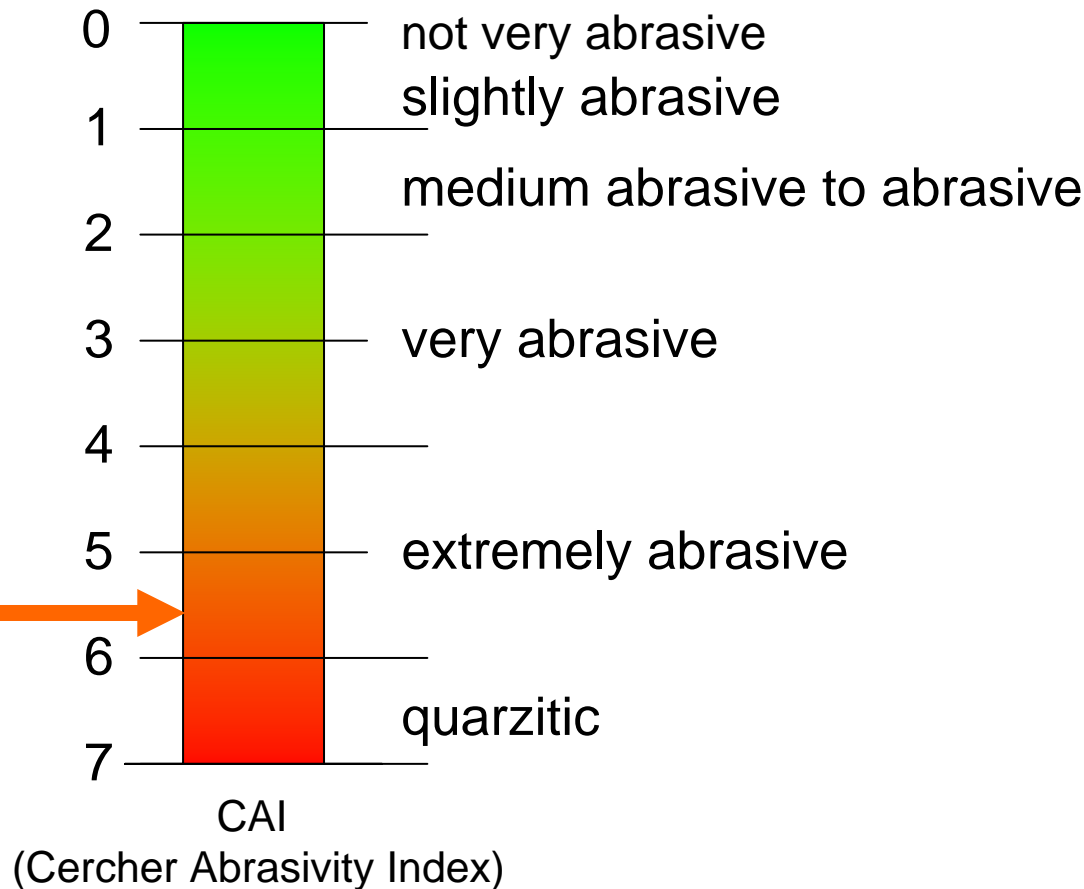
Guadarrama high speed rail tunnel

- Four hard rock TBM machines
 - diameter: 9.5 m
 - 2 x Herrenknecht
 - 2 x Wirth
- Two TBMs drive from the north, the other two drive from the south
 - total length: 56 km
- Geology:
 - mainly granite, high quartz content
 - 100-200 MPa
 - very high abrasivity



Guadarrama Rock

Abrasivity index



Guadarrama project, Spain

BASF
The Chemical Company



MEYCO
Expanding Horizons Underground

Situation with only using water



Number of cutters changed typically varied from 5-28 per day

High maintenance cost, lot of down time



Due to the high temperature, cutters can get blocked (failure of bearing seal)

workers changing cutters



High temperature and high dust level. Time consuming disc cutter change

Use of MEYCO ABR on the TBM



MEYCO ABR 5

Benefits

Without ABR



Disappearance of dust
longer life time of electronics,
healthier working conditions

With ABR



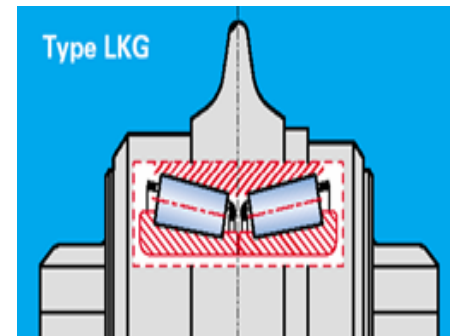
Clean & cool cutters
easy & quick to change
no muck clogging



Drastic reduction of cutter
temperature (150→70°C)
no cutter blockage
15% wear reduction
reduced TBM downtime



Type LKG





Advanced Spraying Equipment

 **BASF**
The Chemical Company

MEYCO
Expanding Horizons Underground

Partnership with BASF

Our Value Proposition to the Market

Dry Spraying | MEYCO® Piccola | MEYCO® GM



Spraying Mobile | MEYCO® Poca



Spraying Unit | MEYCO® Oruga



Wet Spraying | MEYCO® Altera



Spraying Mobile | MEYCO® Cobra



Spraying Manipulator | MEYCO® Robojet



Wet Spraying | MEYCO® Suprema



Spraying Mobile | MEYCO® Potenza



Robotic Spraying | MEYCO® Logica



Dosing unit | MEYCO® Mixa



Spraying Mobile | MEYCO® Roadrunner



MEYCO® Spraying Systems



Our Value Proposition to the Market

From wet to dry, from low to high volume spraying, for hand application or robotic spraying, we offer the solution.



TBM Installations

Hallandsåsen
Early 90's

Ring beam plus
emergency
rigs behind head
and possibility to
poke through head

Together with
Supremas



TBM Installations



Steg Raron, Lötschberg, CH

TBM Installations

Steg Raron, Lötschberg, CH
Twin Spraying Manipulators
together with
MEYCO Supremas



TBM Installations

Alp Transit Project Lötschberg (CH)



TBM Solution Project Steg/Raron (CH)



TBM Solution Project Steg/Raron (CH)

Wet-mix sprayed concrete application for TBM excavation; the solution from MEYCO® Equipment

- Two spraying robots mounted on a circular beam structure which can move in the tunneling direction.
- The entire tunnel surface above the invert segment can be sprayed.
- The two spraying robots are each fed individually by a MEYCO® SUPREMA sprayed concrete pump and have an individual concrete logistics line.



■ Circular beam structure for wet-mix sprayed concrete application on the TBM back-up. High capacity and the best concrete quality.

Mix design for wet-mix sprayed concrete on the TBM back-up (joint venture MaTrans, Steg/Raron):

Aggregates*	0-4 mm %	60
Aggregates*	4-8 mm %	40
Cement	Juracime CEM I 52.5	425 kg/m ³
Superplasticizer	Rheobuild® T3	1.2%
Accelerator	MEYCO® SA170	5-6%
Silica fume	Microsilica powder	30 kg/m ³
Steel fibres	Dramix 65/35	35 kg/m ³

* (The aggregates are prepared from crushed tunnel excavation material)

TBM Installations

Bodio Faido

Split pumping/dosing
system

Spraying head



TBM Installations

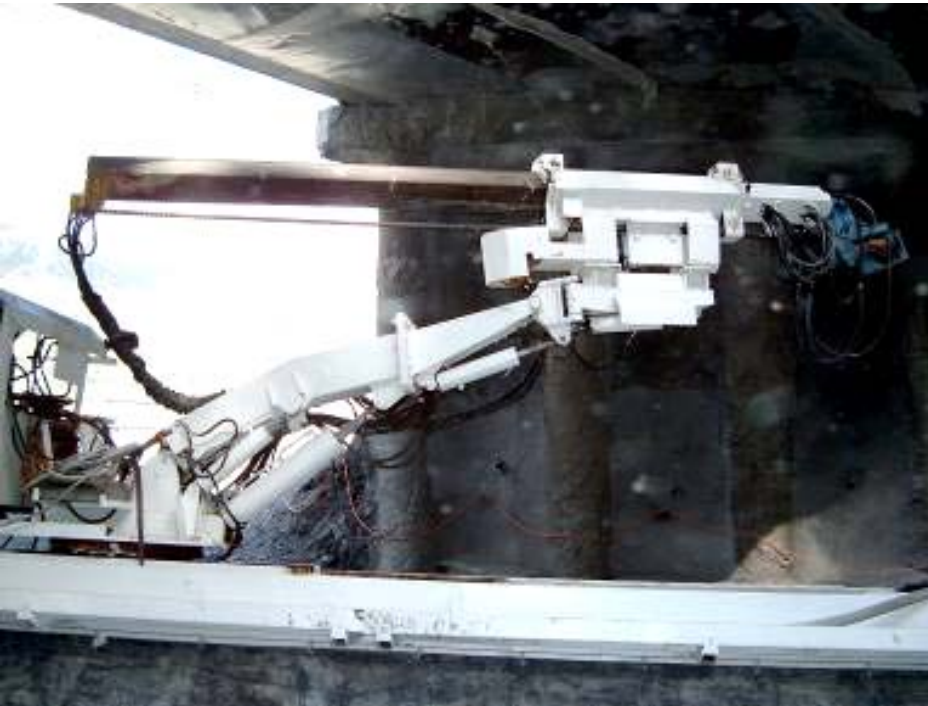


Maurice LeMaire, France,
Herrenknecht TBM
Special manipulator
mounted on central pipe



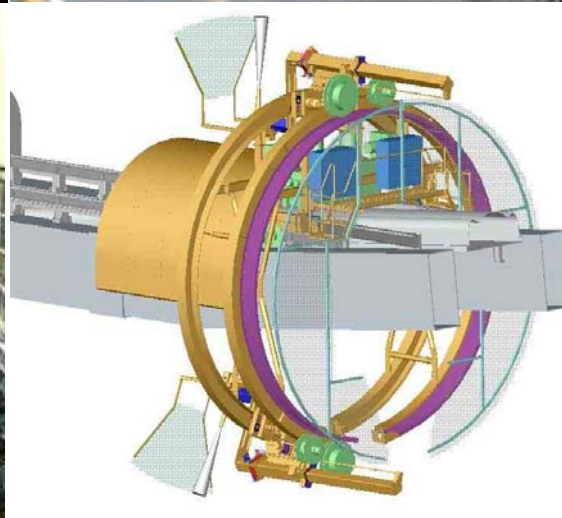
Mixdesign
Aggregates 0/4mm: 800kg
 4/10mm: 950kg
Cement: 420kg
Water: 200 l
Superplasticiser: 1 l

TBM Installations



Visp, Switzerland

TBM Installations



Liaoning, China

Complete spraying
systems including
modified
manipulators and
Supremas

Tailor-made solutions for TBMs

Complete spraying systems as consisting of:

- **Concrete pump**
- **Accelerator dosing system**
- **Delivery and nozzle system**
- **Spraying manipulator**

The solution:

- **MEYCO delivers engineering, manufacture, commissioning and training as well as complete spares service.**
- **Repairs and reconditioning of the complete system when the project is finished.**

Tailor-made solutions for TBMs

**Spraying machine (pump)
MEYCO Suprema, either with
30 m³/h or 20 m³/h theoretical
capacity**

**Computer controlled pumping
and dosing systems for very
low-pulsation pumping and
accurate dosing.**

**Can be mounted as a unit or
(normally) split**



Tailor-made solutions for TBMs

Dosing unit can also be separately mounted

Dosing unit for liquid additives. Integrated proportioning unit, infinitely variable controlled through the PLC system, fully integrated into the flow rate adjustment.

Setting of the desired values by using keyboard.



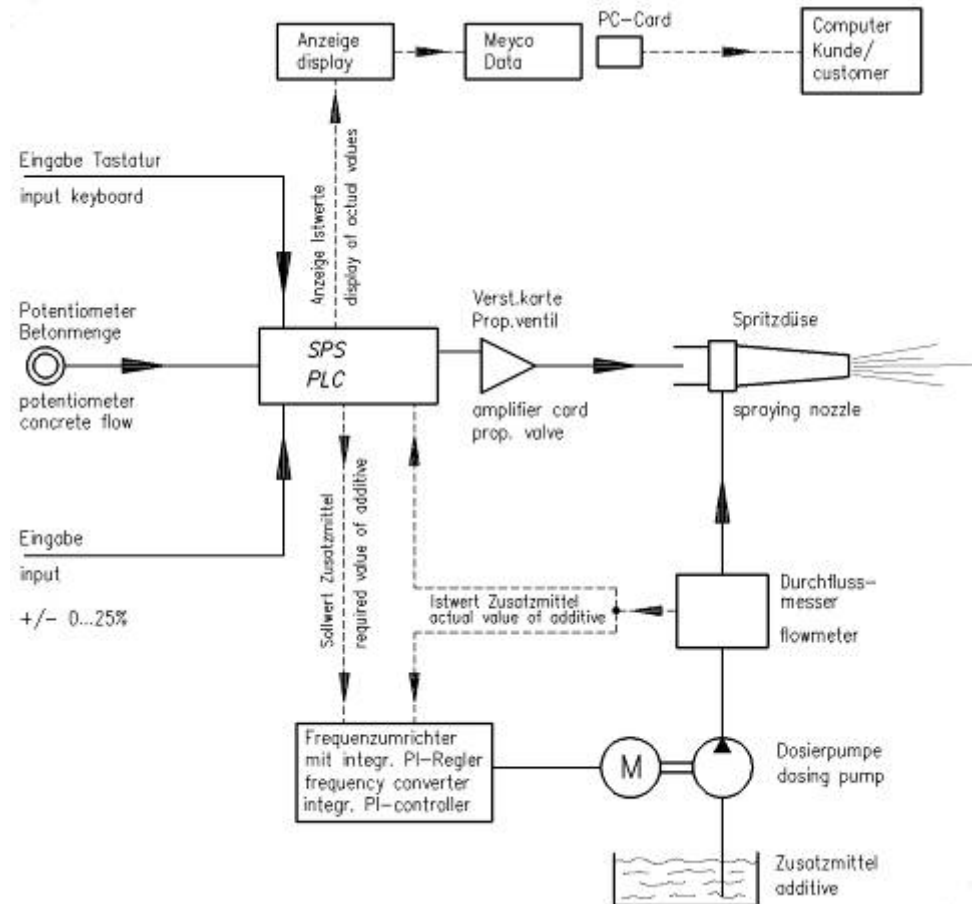
Tailor-made solutions for TBMs

Adjustment, once set, the desired amount of additive will be held constant through the interaction of

- flowmeter
- frequency converter
- controller

The additive pressure is secured by a pressure switch.

Suitable for new generation alkali-free accelerators.



Tailor-made solutions for TBMs

A project getting underway is West Qinling, China where twin rail tunnels of 10.3 m diameter are to be bored.

Each TBM will be equipped with ring-beam mounted dual spraying manipulators with a spraying area length of 8 metres. The spraying heads will run on carriages along a lattice beam



TBM Installations

**4 MEYCO Suprema 30s
specially constructed to be
accommodated perfectly
within the TBM back-up rig.**

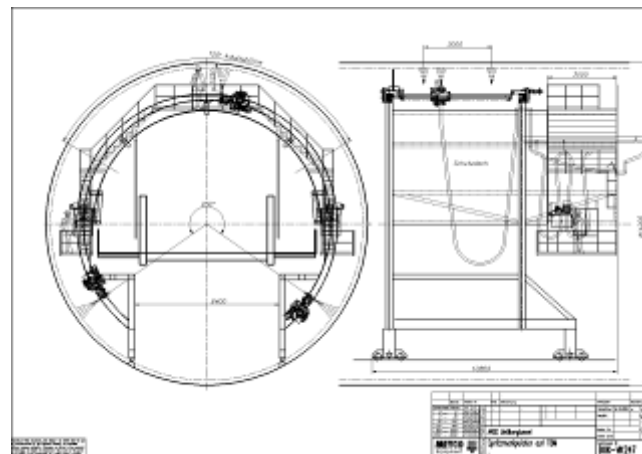
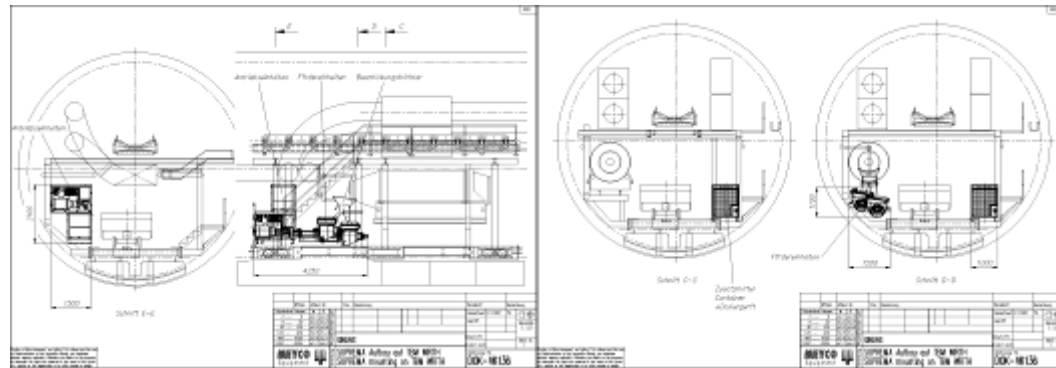
**MEYCO will also provide
installation expertise and
local after-sales support
services for the spraying
operations.**



Tailor-made solutions for TBMs

MEYCO designs and constructs tailor-made spraying systems for integration within TBMs.

MEYCO cooperates worldwide with companies such as Herrenknecht and Robbins on many special projects, the Jinping HEPP for example.



TBM Installations

MEYCO can also plan and be on site to install the delivery system which is often quite complex.

Preparation and planning are important as often hoses, pipes and bends need to have special lengths or radius.



On-site Support

- Commissioning
- Repairs
- Training
- Consulting (wear & spare parts etc.)



**MEYCO products conform
to EU standards**



**MEYCO is certified
ISO 9001 + ISO 14001**



Visit us at <http://www.meyco.basf.com>