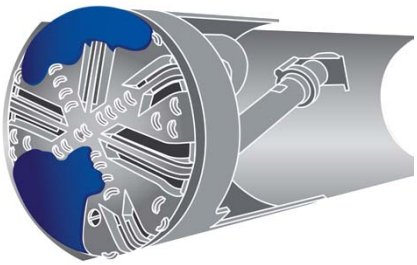
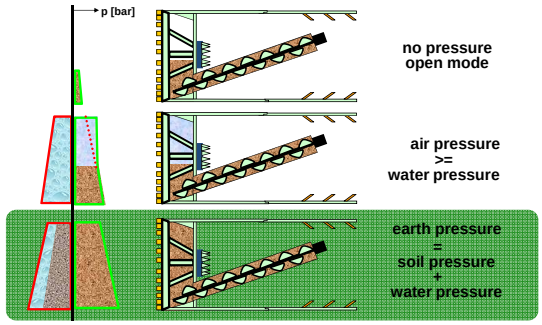
Soil conditioning agents



Earth Pressure Balance TBM (EPB)

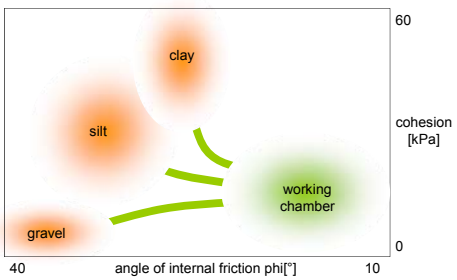
'EPB' driving modes in soft ground



Especialidades químicas para TBM

	Greases	Sealants	Soil conditioning	
Chemistry	Mineral & vegetable oil based	Oil & mineral fillers based	Surfactants anionic & nonionic	Thickeners, poly-meric & biopolymeric
Products	MEYCO EPB series MEYCO BSG series	MEYCO TSG series	RHEOSOIL series MEYCO SLF series MEYCO ABR series	MEYCO SLF P series
In TBM used at	Main bearing	Tail shield	Tunnel face, cutter head, working chamber, screw conveyor	
Main purpose	Lubrication, sealing	Sealing	Soil: lubrication, liquefaction, dispersion; dust reduction, wear reduction	
Image				

Soil conditioning and soil mechanics



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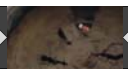
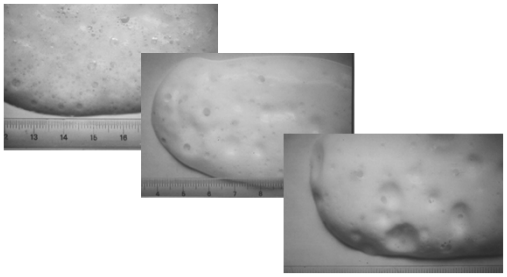
Reasons for Soil Conditioning

Avoid surface settlement and/or collapse Enable proper EPB mode		Increase security
Reduce cutterhead torque (requiments)		Save energy Decrease costs
Increase TBM speed Decrease clogging & adhesion effects		Save energy & time Decrease costs
Reduce dust, ventilation, wear		Save energy Increase security

Tunnel Foam Appearance

MEYCO SLF Group



Soil conditioning agents

1. Foams	**Allow** filling of the working chamber **Increase** the TBM speed **Decrease** abrasion, torque
2. Anti-clay-additives	**Decrease** clogging, adhesion, transport problems **Increase** the TBM speed
3. Polymers	**Increase** soil adhesion, impermeability **Decrease** liquid soil consistency **Decrease** settlements

Why use different foams?

Foams have different properties:

- air incorporation properties
- half life time
- anti-clay behaviour
- ion-sensibility (Ca, Na, ...)
- rheological behaviour
- soil draining behaviour

Lab tests have to be carried out prior to site use!

Soil Changes

with MEYCO Fix SLF soil conditioning agents

dry soil + water + soil conditioning

Soil Rheology Change

with MEYCO SLF Foam

Sandy Gravel — Sandy Gravel with Foam

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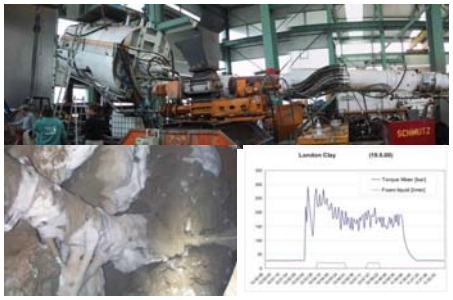
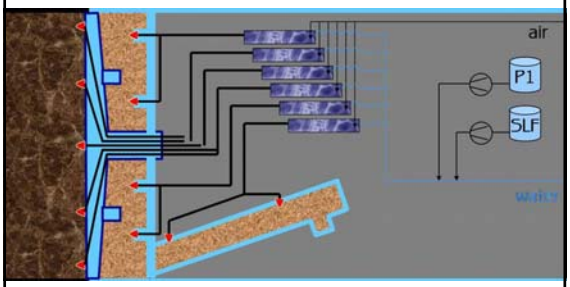
Torque Reduction

with MEYCO SLF foam in clay soil



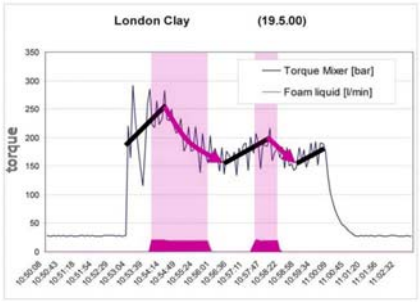
Soil conditioning system

Schematic view



Torque Reduction

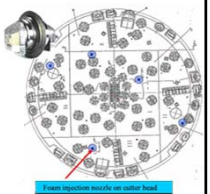
with MEYCO SLF Foam in Clay Soil, Herrenknecht test rig



Dosing of soil conditioning agents

Injection Points

at the TBM cutterhead



Foam generator

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Anti-clay

MEYCO® RHEOSOIL

Toulouse Metro Line B

Without Rheosoil 211:
- empty working chamber
- air pressure support
- impossible to manage water ingress using sand lenses
- plugging of the cutterhead

With Rheosoil 211:
- full working chamber
- 1,5-2,5 bar EPB
- soft material
- no clogging
- increase of speed
- decrease of torque

Anti-clay additives

Use in clay and clayey soils

Problem
- adhesion on metal surfaces
- agglomeration (cohesion) of soil chips to big blocks

Consequence
- clogging of the cutterhead
- clogging in the working chamber

Result
- low TBM speed
- high maintenance & revision costs

The M30 project, Spain

twin tunnel M30 ring road connection south of Madrid, the project being worth 740 million Euro.

Change of soil behaviour

with Rheosoil anti-clay additives

Bologna cay + water & foam

Bologna clay + foam & Rheosoil

Mitsubishi Heavy Industries TBM

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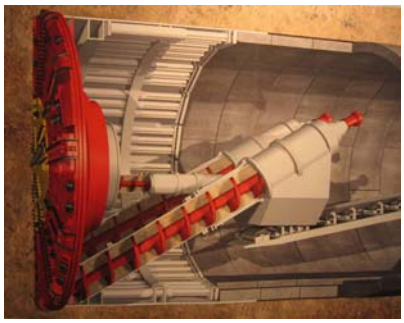
Herrenknecht S-300 TBM

Clean tools with Rheosoil

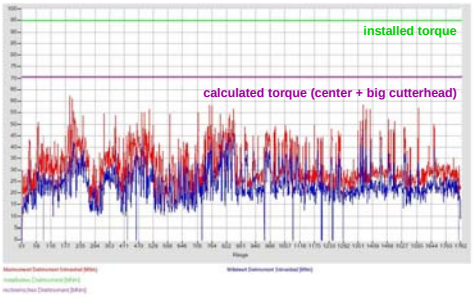
HK Cutterhead

clean tools **clean disk housing**

Herrenknecht S-300 design



Torque values M-30 North



Clean tools with Rheosoil

MHI Cutterhead

Footprints

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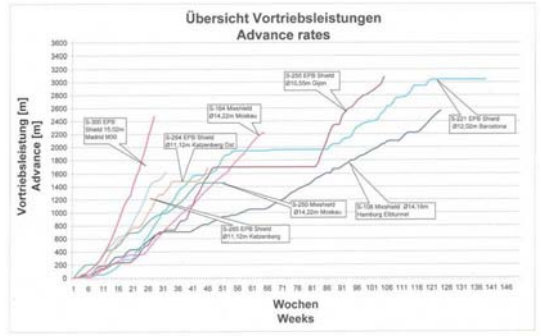
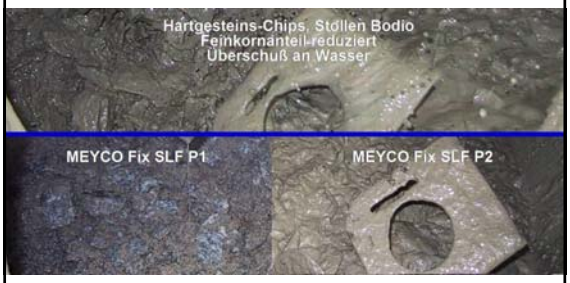


What can polymers do ?



The Metro TorontoTTC project, CAN

Without Rheosoil:
- empty working chamber
- air pressure support
- impossible to manage water ingress by sand lenses
- plugging of the cutterhead

With Rheosoil:
- full working chamber
- 1,5-2,5 bar EPB
- soft material
- no clogging
- increase of speed
- decrease of torque

Singapore Metro - Polymer P1

only foam used
water content too high

foam with 5% SLF P1
too much Polymer
big blocks

foam with 3.5% SLF P1
improved situation
2-3% polymer would be excellent

Polymers

MEYCO® SLF P1 Medium liquid soils
MEYCO® SLF P2 Water binding, increasing soil adhesion, stabiliser

Aviles Collector, Spain

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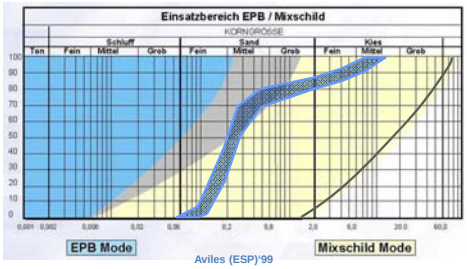
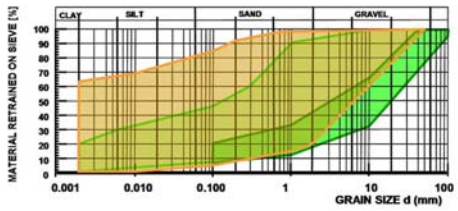
Aviles Collector, sieve curve



Aviles (ESP)'99
Lovat EPB, Ø=3.4m
2.5 bar sea water
Foam + Polymer

EPB-drives in very variable geology

examples



LYON 1997
NFM EPB, Ø=10.98m
1.5-3 bar water pressure
Foam + Polymer + **Bentonit**

BARCELONA 2003
Herrenknecht EPB, Ø=12.06m
up to 1.0 bar water pressure
Foam + Polymer + **Filler**

Effect of structurizing polymers

2,5 bar sea water pressure
use of foam

2,5 bar sea water perssure
use of foam & polymer

Barcelona L9
UTE GORG

TBM characteristics:

diameter = 12,06 m

pressure = 110 MNm

Torque = 38 MNm

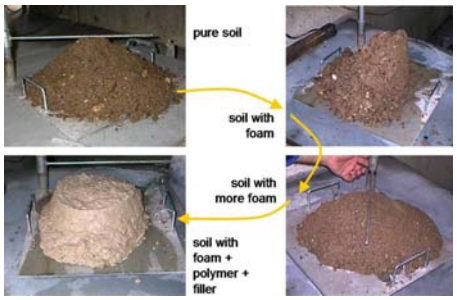
power = 5,32 MW

35% open shield

EPB mode in heterogeneous geology

Barcelona Metro L9

Laboratory tests



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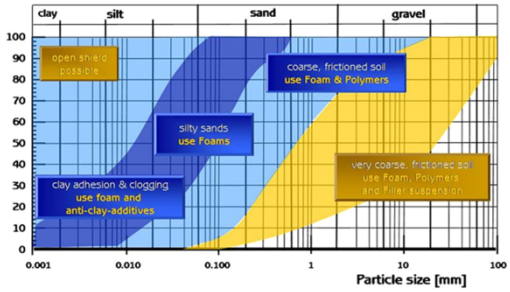
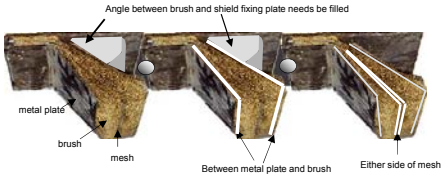
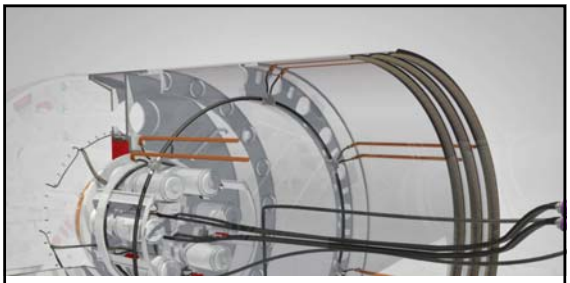
Actual range of EPB use

Weak ground under groundwater pressure



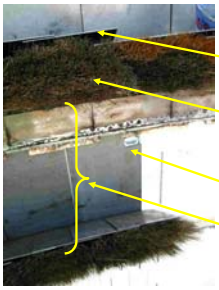
MEYCO® FIX TSG7





Tail shield Greases

Where is TSG injected?



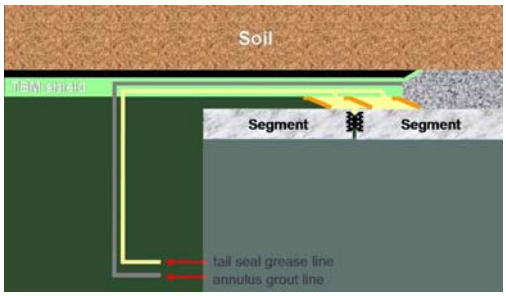
Protection plates

Brass brushes

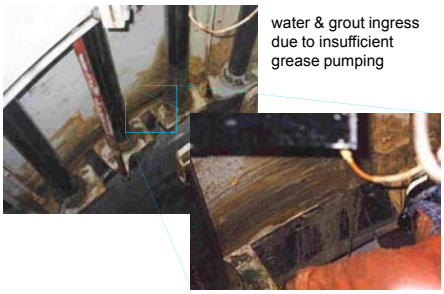
TSG injection hole

Chamber created by 2 rows of brushes

Where is TSG injected?



Why is it important to seal the tail end?



water & grout ingress due to insufficient grease pumping

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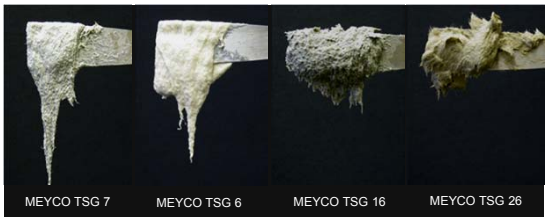
Different BASF tail sealant types



- 1st fill grease
- stiff but pumpable
- not mixable with annulus grout

- driving grade
- highly resistant against water
- allrounder

- driving grade
- highly resistant against water
- different rheology

- fire resistant
- eco-friendly because 100% oil-free
- passes waterpressure tests

Why is an annulus grout important

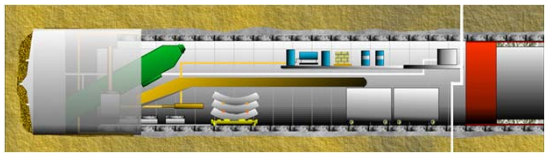
- To give early stability as construction occurs
- To prevent heave / flotation of the lining
- To take early load in the build area
- To reduce settlement, especially in non-cohesive soils
- To prevent segmental misalignment and the rupturing of gaskets
- To eliminate / reduce water ingress to avoid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

Grout mixing test with TSG7

MEYCO TSG:
grout is not mixable with tail sealant, brushes are well protected in case of grout ingress

competition:
grout is mixable with tail sealant, risk of brush hardening in case of grout ingress

Filling of the annulus gap



- For this purpose a pressurized mortar or grout is used which we call backfill grout or annulus grout.
  Generally the strength only needs to match or slightly exceed the shear strength of the surrounding soil.
- This allows the natural stress in the ground to be maintained.
  Less stress displacement causes less soil movement and surface settlement.

Annulus Grouts

ABR5
Anti-Abrasion and -Dust Technology

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Typical situation in hard rock TBM excavation

excessive wear is a direct cost issue
- cutter cost
- maintenance cost (cutter changes are time consuming)
- damaged cutters can lead to cutter head damages

down time
- the more frequent cutters have to be changed, the more down time it means for the TBM
- during down time the tunnel does not make any progress

dust & temperature
- not good for the worker's health
- reduce life-time of equipment
- expensive exhausting

Site Example: Guadarrama High Speed Rail Tunnel

- 4 hard rock TBM machines diameter: 9.5m
  2 x Herrenknecht
  2 x Wirth
- 2 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

The Guadarrama project, Spain

Situation only using water

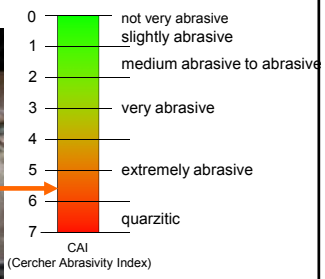
number of cutters changed typically varied from 5-28 per day

high temperature and high dust level time consuming disc cutter change

high maintenance cost, lot of down time

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

Guadarrama Rock



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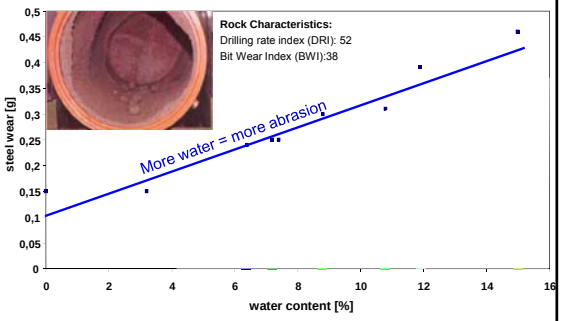
Results
wear – dust – temperature

Ball Mill Testing



Why using ABR5?

current practice: injecting water

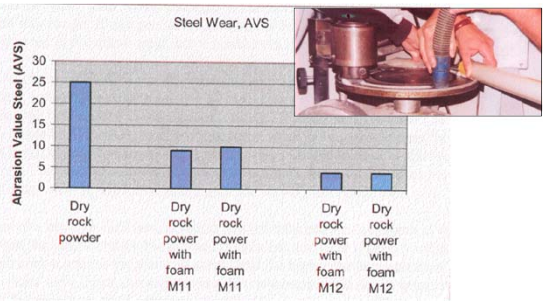
- *lots of dust is not cached by the water*
- *the cutter temperature can still be higher than 100°C*
- *the use of water contributes to higher cutter wear.*

use of MEYCO® Fix ABR5 makes the difference

- effective dust suppression makes the working environment healthier and increases the life time of the electronic equipment
- cutter temperature can be reduced down to 60-80°C (depending on the conditions) due to better heat transfer and mucking out
- increase of life time of the cutter sealing
- decrease of wear due to lubrication effect and reduced water injection
- decrease of TBM downtime due to reduced maintenance needs

ABR Benefits

Steel wear testing (AVS)



Environmental Studies

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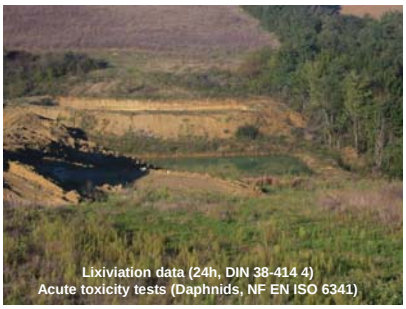
Construction & Sustainability

Landfill with excavated soil

Emission possibilities

ground water | landfill | working environment

Surface water collection



Lixiviation data (24h, DIN 38-414 4)
Acute toxicity tests (Daphnids, NF EN ISO 6341)

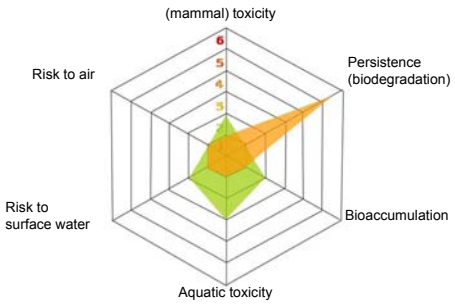
Aquatic Toxicity

what do LC_{50}/EC_{50} data mean?

algues | daphnia magna | rainbow trout

General Risk Characteristics

important factors of eco-compatibility



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Environmental Risk Assessments !

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