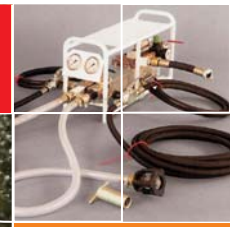
MINOVA



Technical Meeting

HKIE Geotechnical Dev.

Application of Chemical Grouts to Tunnel Repair – Latest Technology

Vincent Chien / Thorsten Tatzki

23 May 2007

The Speaker

Vincent Chien

C-Eng, Working for Minova in Taiwan

Thorsten Tatzki

C-Eng, head office in Germany

Tunnel jobsites

Chemical grouts are new, the tasks are old!

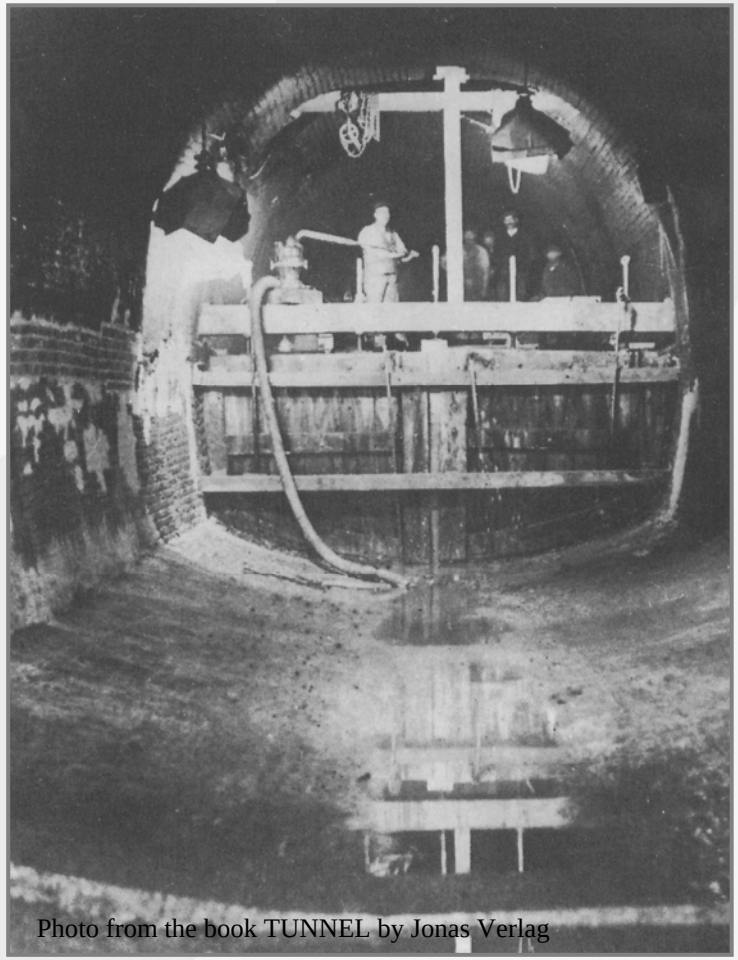


Photo from the book TUNNEL by Jonas Verlag

Tunnel repairing about 1910

Blisworth Tunnel / England

Content

Our topics for today….

- Crack repairing
- Damaging situation after concreting
- Injection hoses
- Injection plates
- Repairing different joint types
- Overview and costs

Who is Minova-CT?

Our traditional roots are based in the German coal mining industry.

We have a long history:

2004 Minova CarboTech GmbH

2000 CarboTech Fosroc ...

1985 CarboTech Berg und Tunnelbau ...

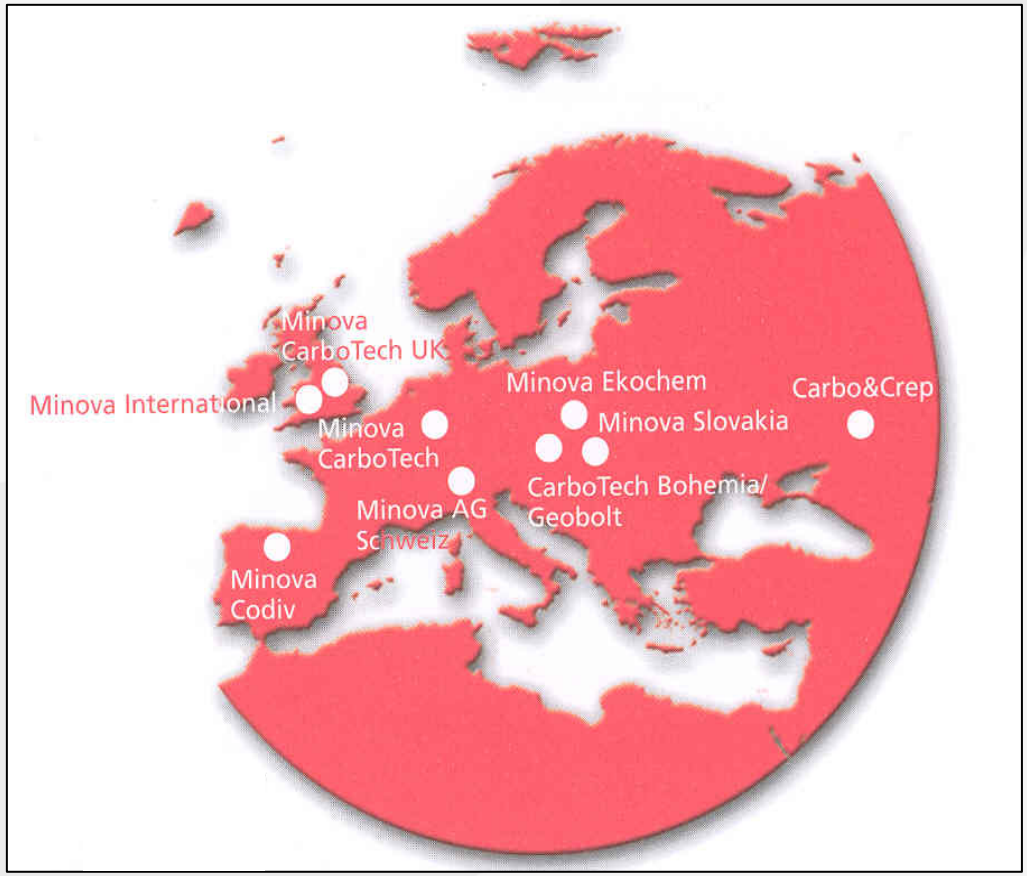
1968 Deutsche Bergbauforschung GmbH

> 35 years experiences

Who is Minova-CT?

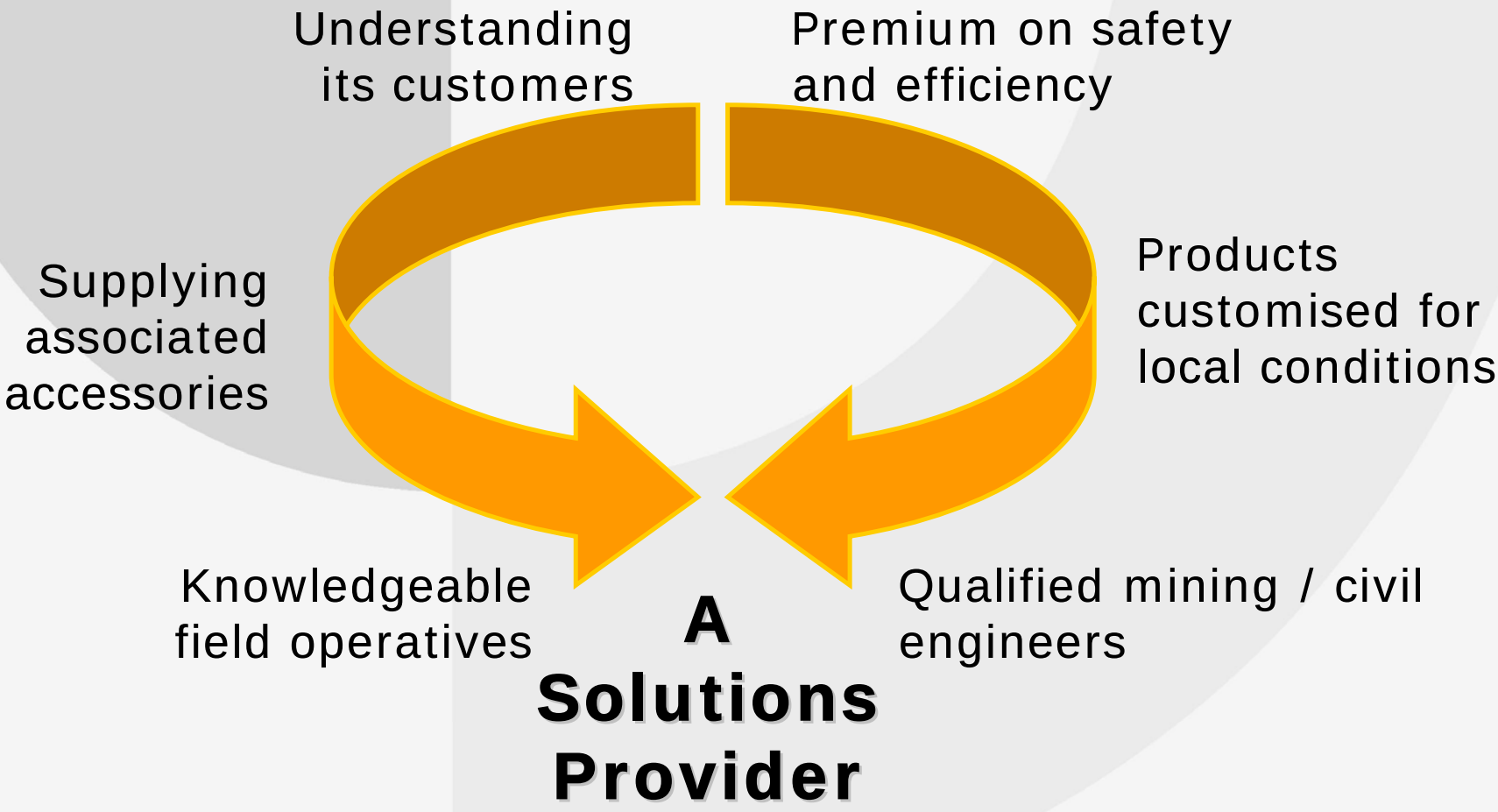
... the Minova-Group

- more than 1,300 heads in 60 countries
- 13 plants worldwide
- the **biggest supplier in chemicals for mining**



ORICA
A member of the Orica Group

Who is Minova-CT?



Crack repairing

Chemical grouts were used for:

Sealing rock formations against water or gas

Waterproofing in construction pits

Cavity filling

Crack injection according to the ZTV Riss

Injection of self drilling bolts

Large area sealing against humidity in basements

Injection of grouting hoses in joints

...

Traditional roots:

German coal mine

But today we find these products in a lot of different fields.

More than one effect: Consolidation and Sealing or Bolting and Consolidation in one step.

Crack repairing

Reason for cracks:

- ☒ Building settlement
- ☒ Mistakes during the concreting
- ☒ Mistakes during the hardening
- ☒ Wrong calculation of the static
- ☒ Missing joints
- ☒ ...

We have do understand the reason for the damaging!

minimal crack width:

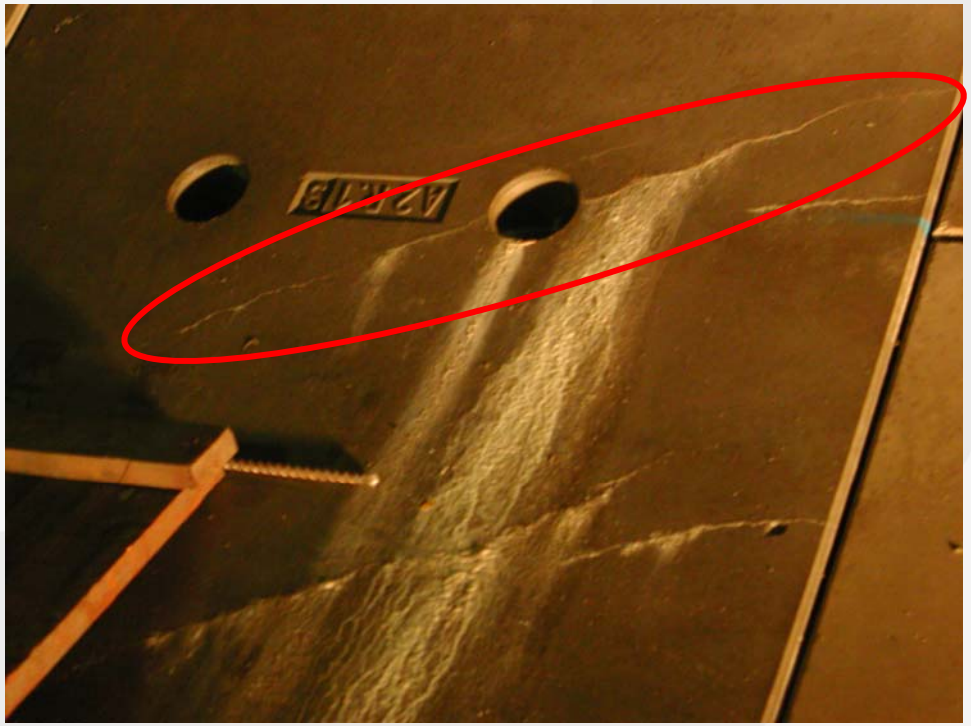
PUR:	0,3 mm	AY:	< 0,1 mm
EP:	0,1 mm	ZL:	0,8 mm (Zementleim)

Damaging situation

Final Tunnel shell with wet areas

Detail: Water is behind the concrete shell!

Damaging situation



Final Tunnel shell with cracks: Corrosion!

Damaging situation

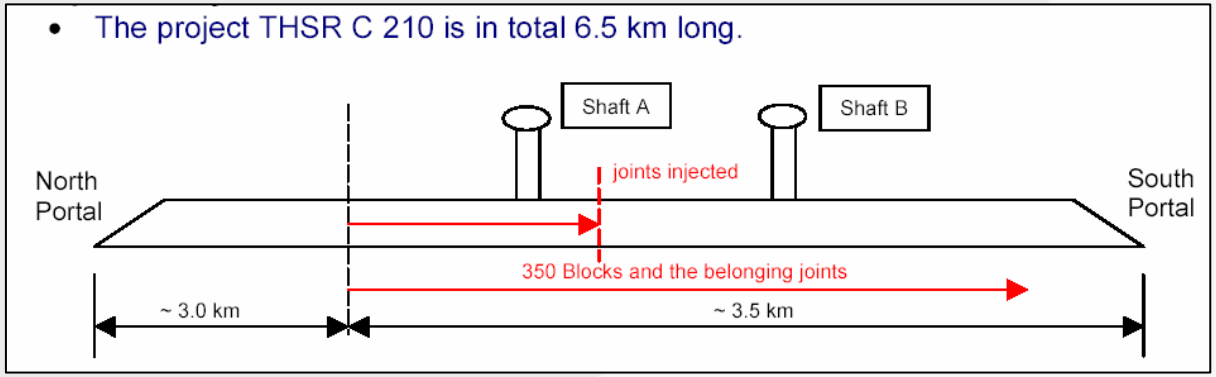
Crack Injection with Acrylate

Linkou Tunnel

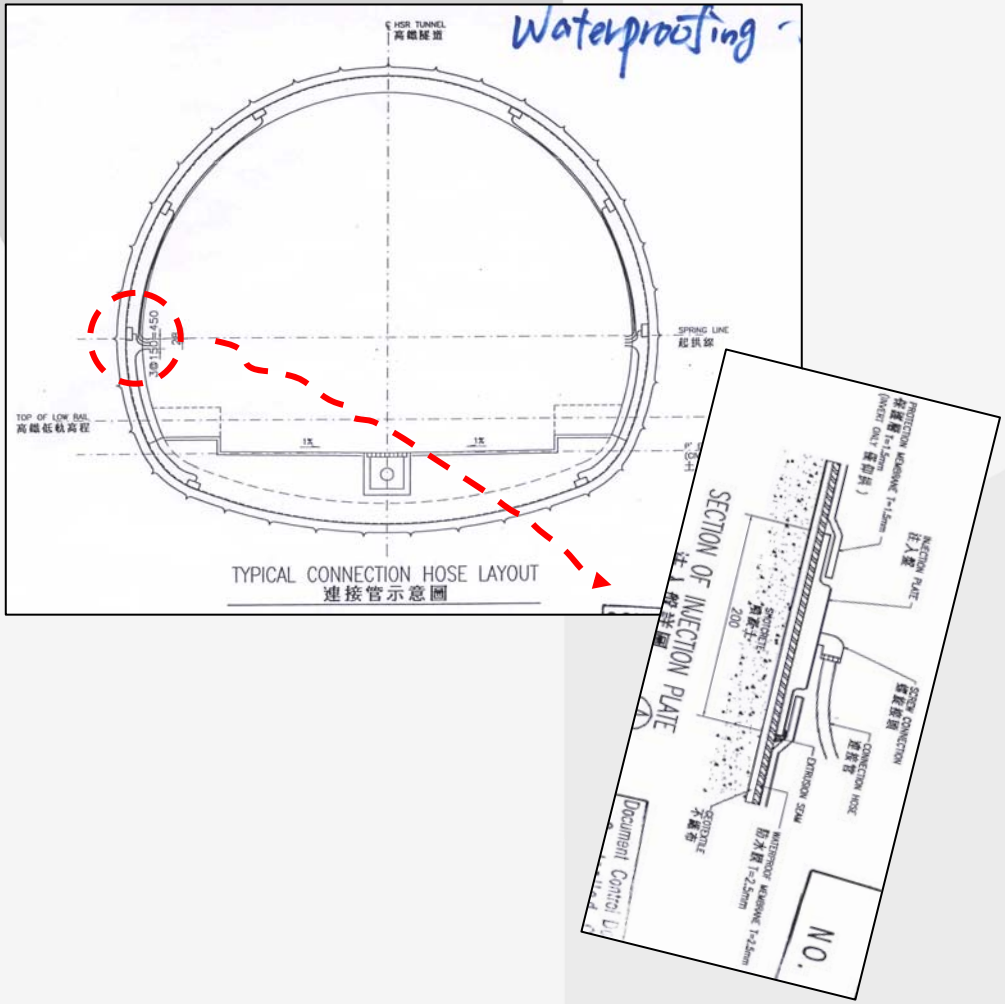
Injection Work

Railway tunnel / Taiwan

- Injection of injection hoses in block joints
- Injection of special plate construction, 24 for one tunnel block



Linkou Tunnel



The special design of the HDPE – membrane was done with:

Tunnel consultant

Membrane producer

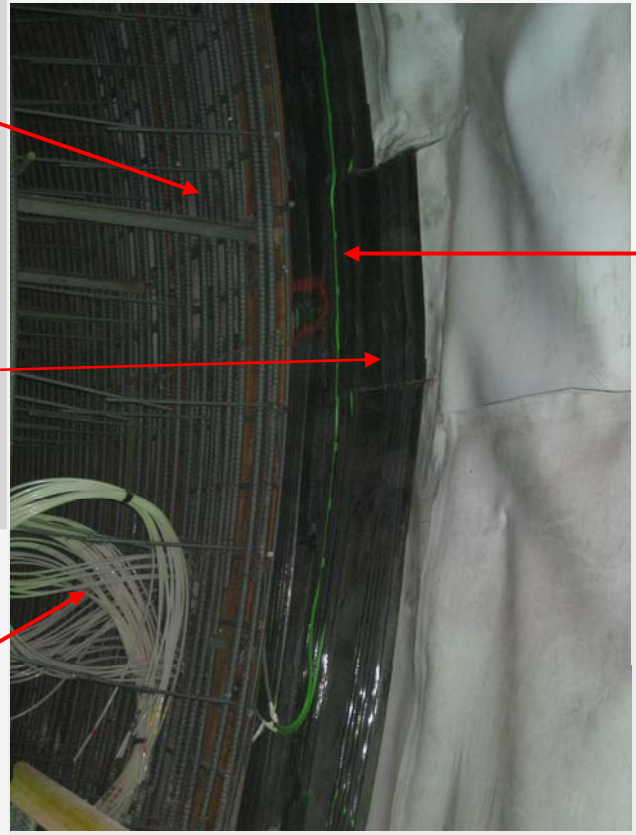
Grout producer

Similar System to Linkou Tunnel

Reinforcement bars

PVC water stop with fixing element for PREDIMAX

Filling hoses for injection plate



PREDIMAX

Injection hose

Detail Block joint with PVC water stop and HDPE membrane (grey)

Linkou Tunnel

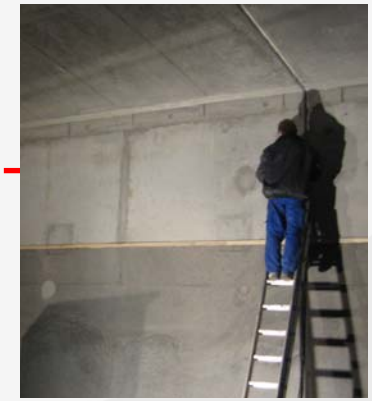
Injection CarboCrack Seal NV and CarboStop F

Railway tunnel / Taiwan

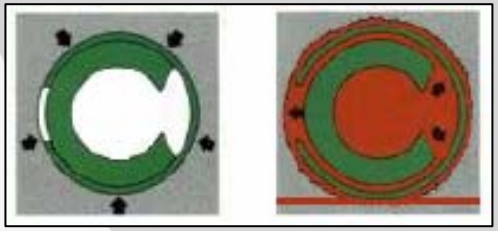
- Injection of the injection hoses in the block joints
- CarboCrackSeal NV
  joint is only wet
- CarboStop F
  joint with pressure water

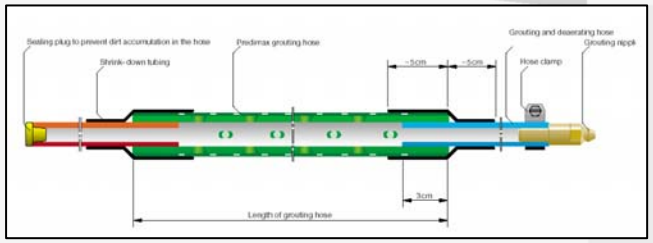
Injection hose

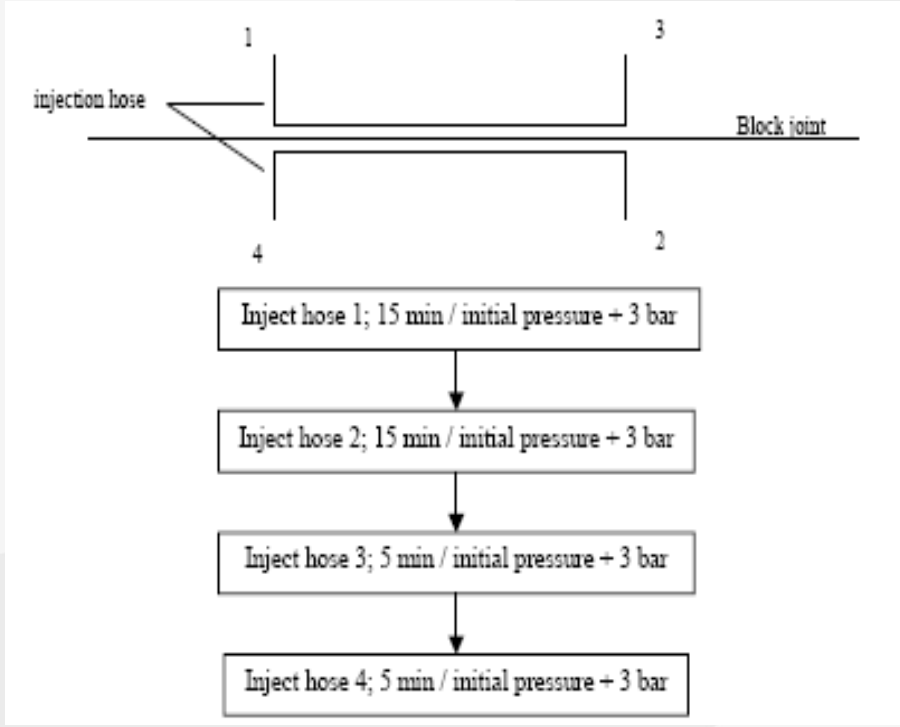
Construction joint in different steps – practice pictures



Injection hose







Detail for injection work with injection hose: Pressure + Time are important!

Injection Plates

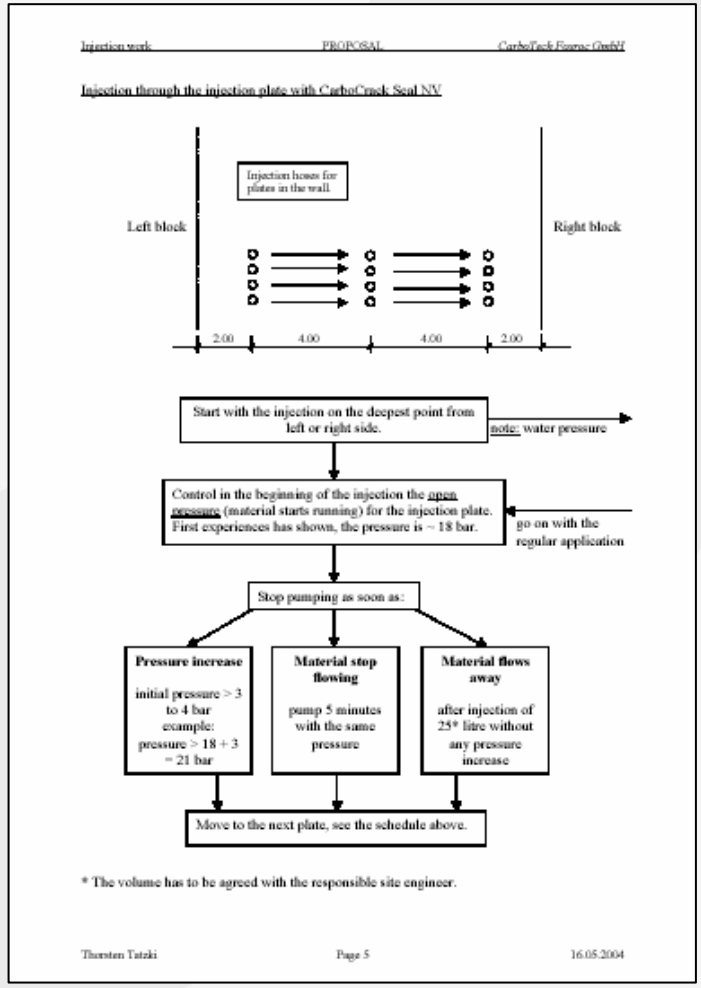
Injection CarboCrack Seal NV

Railway tunnel / Taiwan

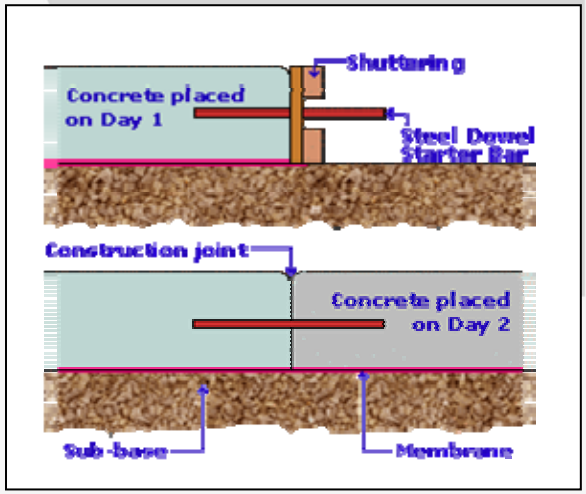
- Injection between tunnel lining and HDPE membrane
- Initial pressure + 3 bar
- Maximum 25 litre
  - Injection pump 1 comp. CT-ET I
  - Work in two shifts

Injection Plates

Example of a flow chart for injection work: Plate injection to seal the existing HDPE membrane with one and two component PU resin.



Repairing different joint types



Joints to find in constructions:

Construction joints: assist in the construction and in the placement of concrete, e.g. wall - basement

Expansion joints: prevent concrete from crushing, displacing…, e.g. ramp - basement

Contraction joints: regulate the cracking controlling of concrete due to natural shrinkage, e.g. joints in a long concrete slab

Further joints like sliding joints, joggle joints, crack control joints (Dummy joints),…

Repairing different joint types

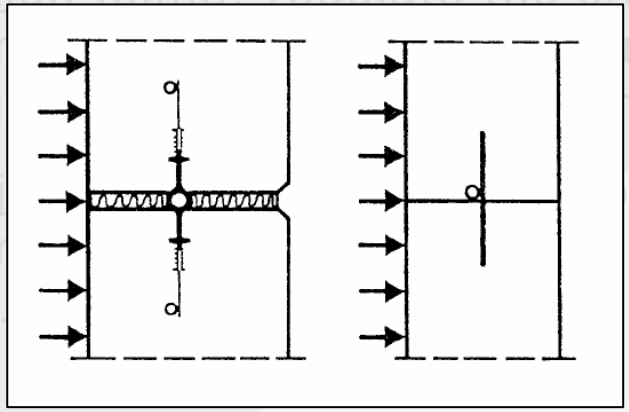
Principal one injection hose in the joint

Principal two injection hose = each on one concrete segment

Joints to find in constructions:

Construction joints: assist in the construction and in the placement of concrete, e.g. wall - basement

Expansion joints: prevent concrete from crushing, displacing…, e.g. ramp - basement

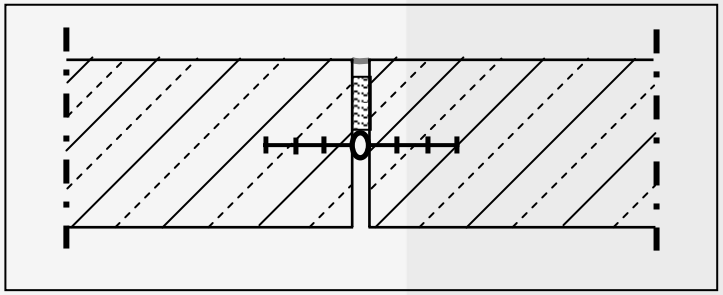


Repairing different joint types

Sealing of PVC waterbars in expansion joints

Typical damaged joint:

Water flows under pressure out of the joint, the PVC waterbar is without any function.



Repairing different joint types

Repairing different joint types

Site overview: Parking Garage in 2. Level

Repairing different joint types

Injection technic:

Acrylate pump with mixed components A and B

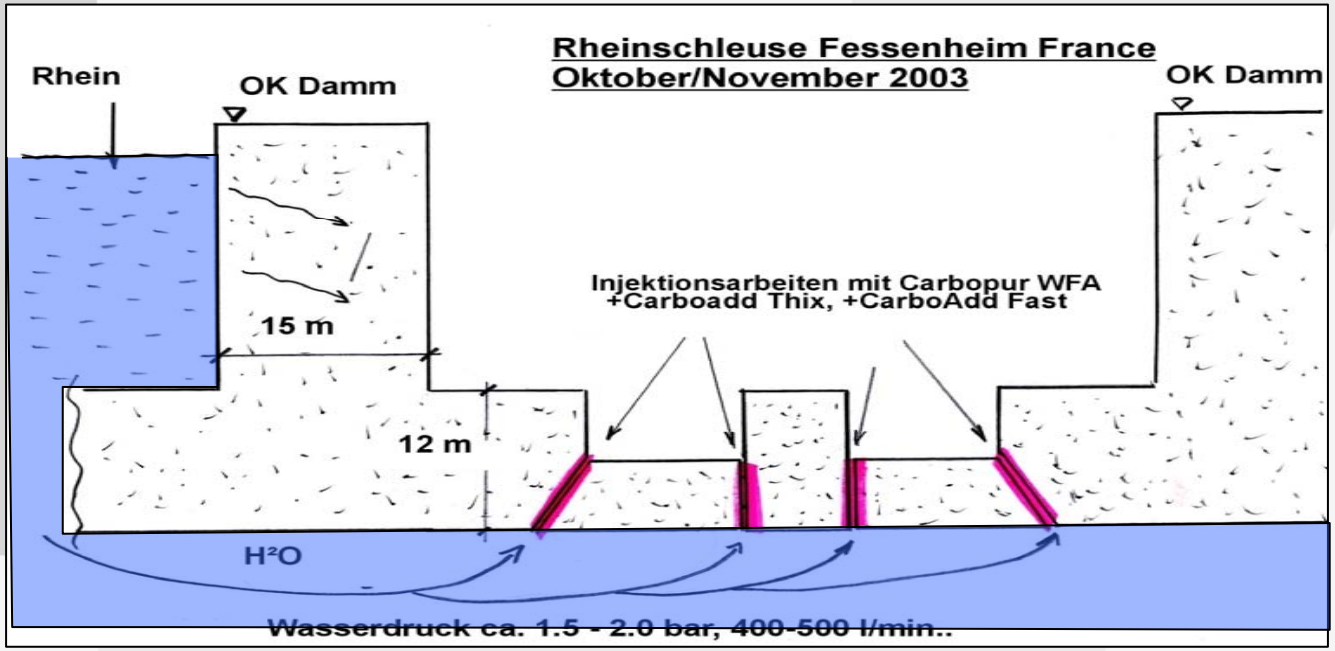
Repairing different joint types

Injection:

Packer with CarboCryl Hv
Grouting up to a penetration at the surface or at he next packer.

Consumption: max. 20 l/lfm

Repairing different joint types



Problem

- Concrete and joints are porous due to the influence of the water
- Lock repairing need a stop of the water before the work can start

Repairing different joint types

Preparation injection work

Repairing different joint types

Injection CarboPur WFA
And CarboAdd Fast / Thix

River lock / France

- Sealing of joints with ~2.0 bar water pressure and volume of 450 L/min.
- Injection pump CT-GX 45-II

Overview and costs

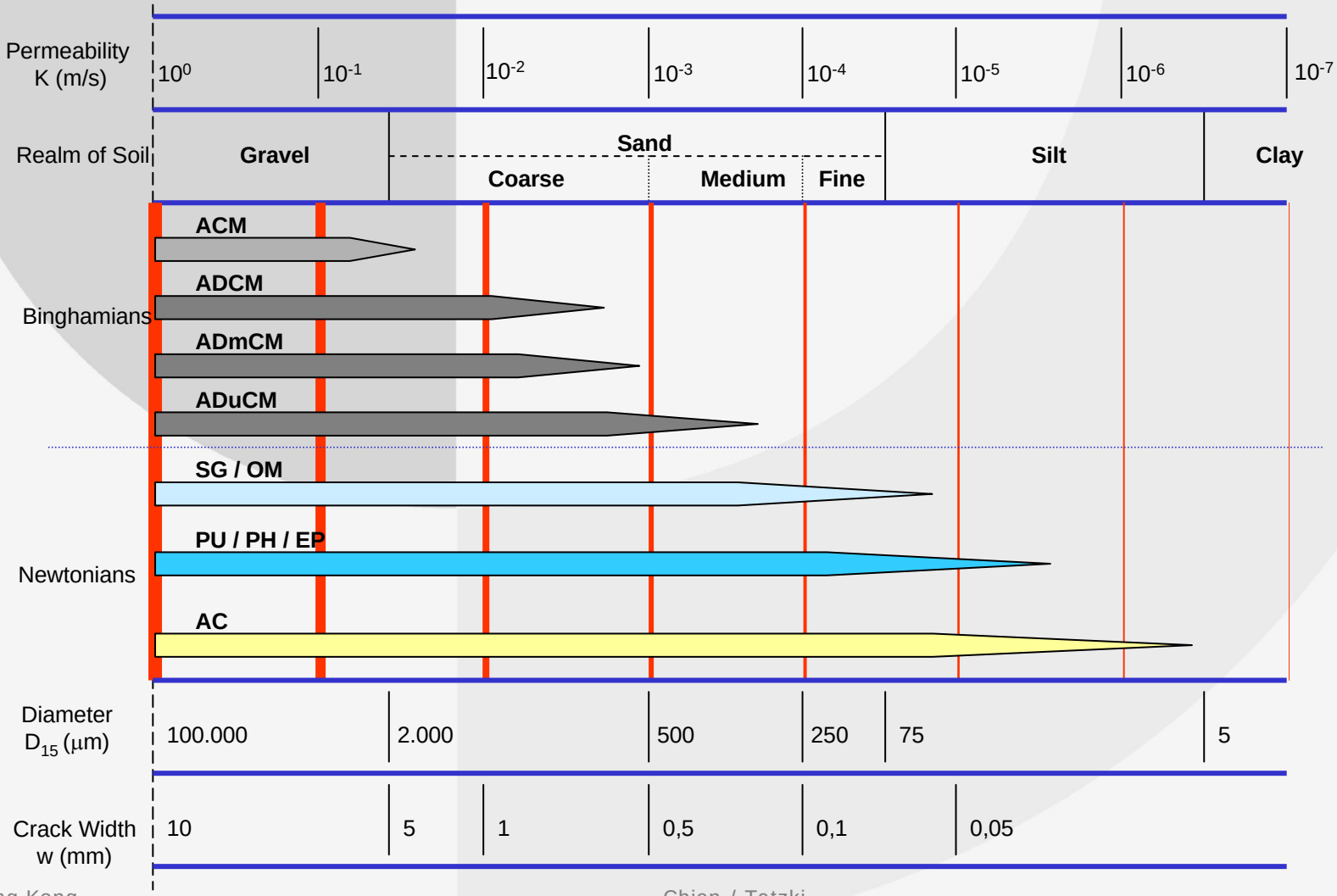
Binghamian Fluids (Suspensions)

• Cement Mixes	(PCM)	Cement + Water
• Cement and Admixtures	(ACM)	PCM+Admixtures
• Cement and Additives	(ADCM)	ACM+Additives

Newtonian Fluids (Solutions)

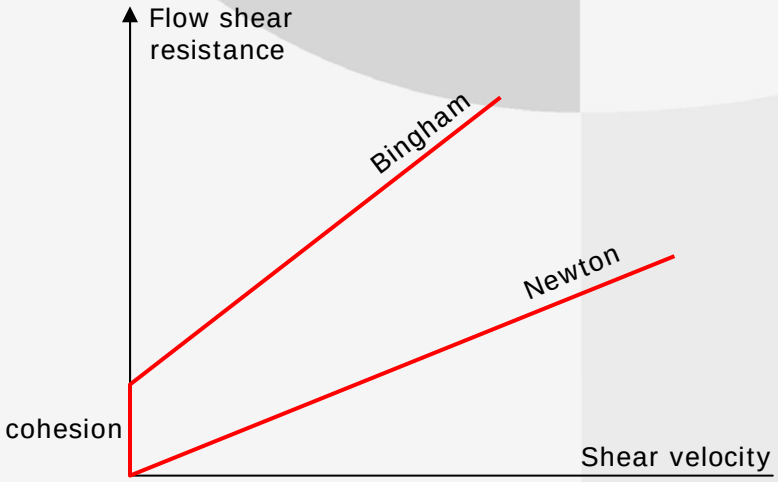
• Epoxy Resins	(EP)	Resin + Hardener
• Methacrylic Resins	(AC)	Resin + Hardener + Catalyst
• Organomineral Resins	(OM)	Resin + Silicate Catalyst
• Polyurethane Resins	(PU)	Resin + Polyol Catalyst
• Phenolic Resins	(PH)	Resin + Catalyst
• Silicate Gels	(SG)	Silicates + Alluminates

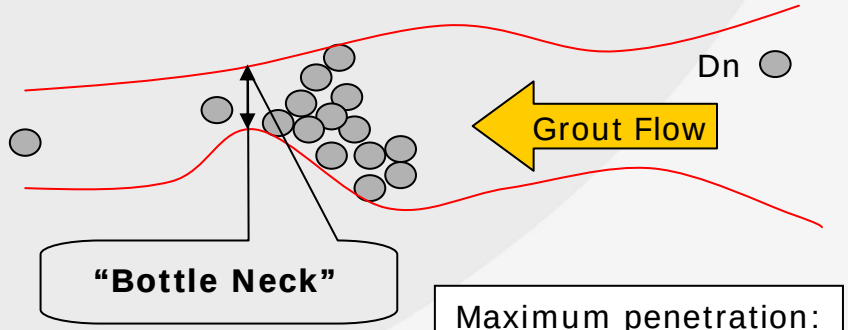
Overview and costs



Overview and costs

Binghamian Fluids (Suspensions)		Newtonian Fluids (Solutions)	
Cement Mixes	(PCM)	Epoxy Resins	(EP)
Cement and Admixtures	(ACM)	Methacrylic Resins	(AC)
Cement and Additives	(ADCM)	Organomineral Resins	(OM)
		Polyurethane Resins	(PU)
		Phenolic Resins	(PH)
		Silicate Gels	(SG)





Maximum penetration:
3 times to 5 times Dn

Overview and costs

Crack repairing

in concrete structures

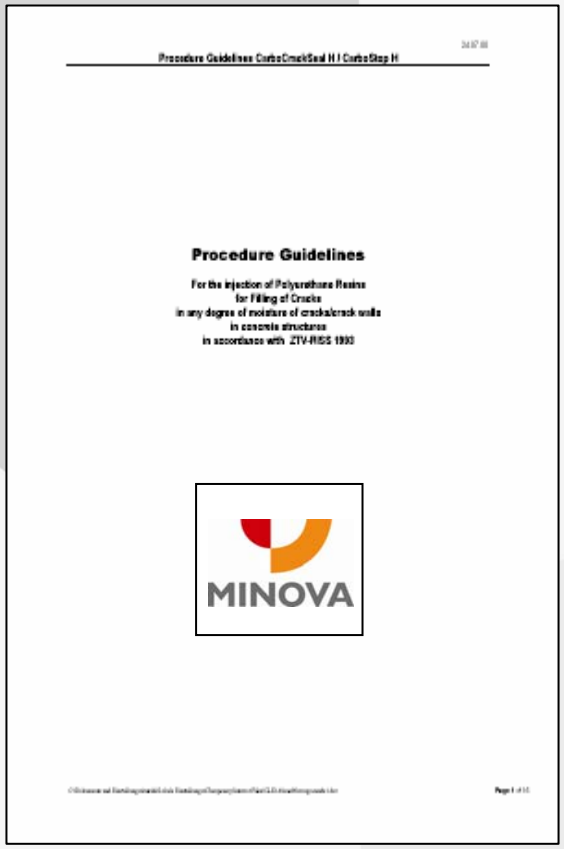
Overview and costs

Latest technology for crack filling: CarboCrack Seal

1. Crack wet / dry: Injection of low viscose PU resin in one or two component method.
2. Crack water flowing: Injection of one comp. PU to stop the water. Finally injection see point 1.

Important to know is the reason for the crack.

Overview and costs


Procedure Guidelines CarboCrackSeal H / CarboStop H

Procedure Guidelines

For the injection of Polyurethane Resins
for Filling of Cracks
in any degree of moisture of cracks/crack walls
in concrete structures
in accordance with ZTV-RISS 1998

MINOVA

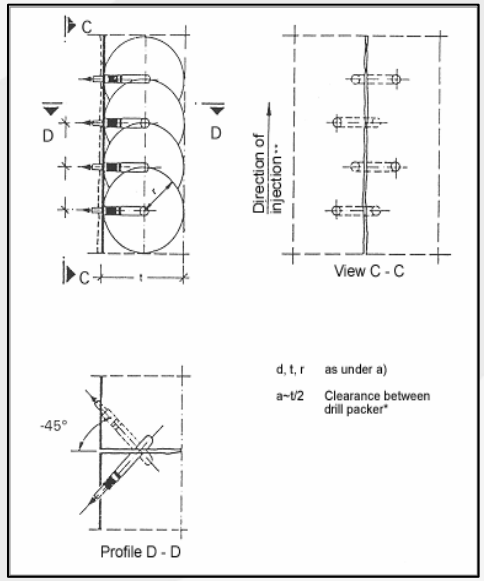
Procedure Guideline:

Our low viscous Polyurethane and the application:

CarboCrack Seal H

CarboCrack Seal NV

CarboCrack Seal T



Overview about grouts

Acrylates Gel

Two Component Application, non foaming

Chain reaction = Polymerisation:
Resin is stimulated by a starter to form a chain.

Overview and costs

Which grout is required?

1.) Depends from the injection target

2.) Depends from the access (e.g. packer,…)

3.) Site parameter

Different targets:

☑ Filling

☑ Sealing

☑ Bonding

☑ Elastic connection (sealing)

Site parameter:

☑ Dry, wet or pressure water

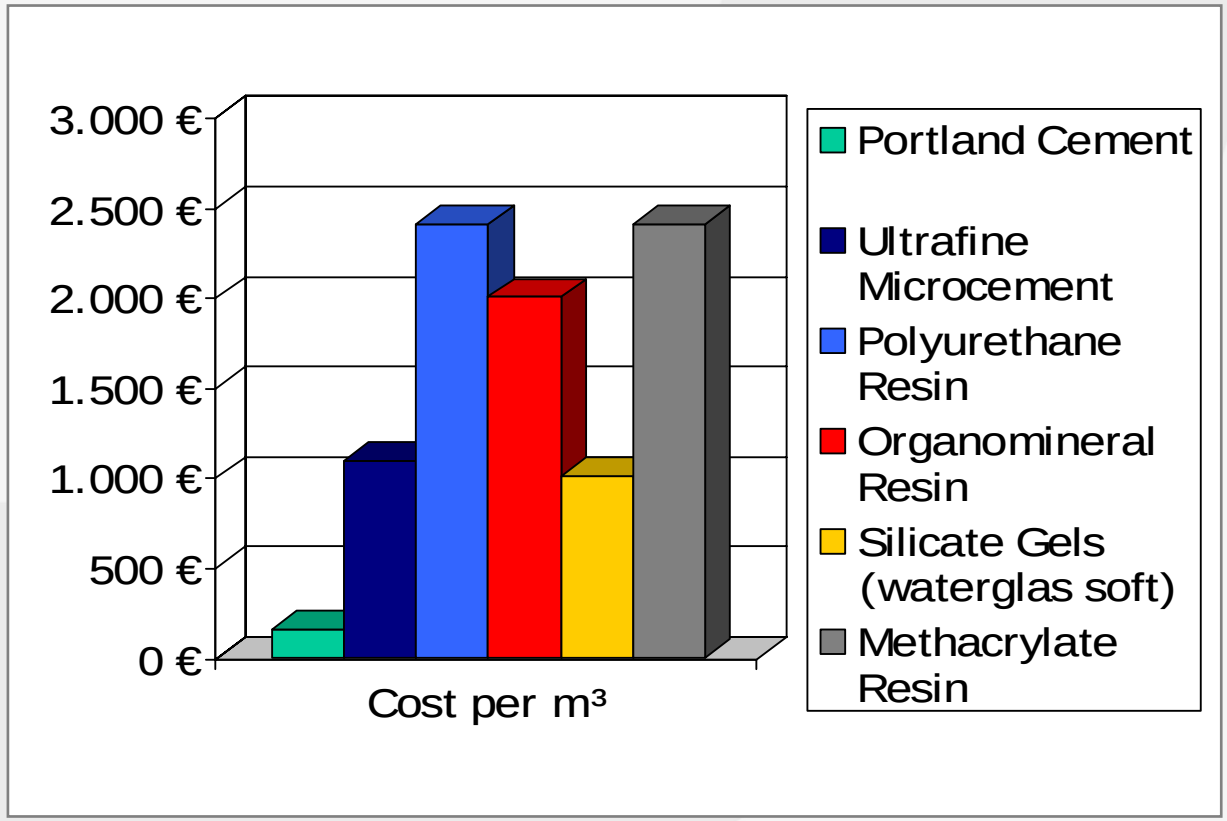
☑ Cavities, size of the joint, gap

Overview and costs

!

Target / Parameter	Filling	Sealing	Bonding	Elastic conect.
Dry	EP, PU, C, FC, (AY)	EP, PU, C, FC, (AY)	EP, C, FC	PU
Wet	PU, C,FC, (AY)	PU, C, FC, (AY)	C, FC	PU,
Pressure water	PU, C, FC	PU, C, FC	C, FC	PU

Overview and costs



* These figures are not valid for each case and are based on common experience.

Overview and costs

Binghamian

Low Cost
Easy to Appl
High E Modu

Limited Penetration
Long Setting times
Behaviour
able
obsite Costs

+ ← → −

High Penetra
Self Penetrat
Fast Setting
Non Washab
Low Jobsite Costs

Unit Price
Applicators
Modulus

Conclusion:

Whenever regular cement gout does not work, chemical grouts are a good alternative:

Salt or aggressive water

Water pressure

Difficult penetration

Less space on the jobsite

Flexible material required ...

Overview and costs

- Post – grouting can be 10 to 50 times more expensive than pre – grouting.
- You do not have to seal if you can control the water:

  TBM sites = ~ 0.5 m³/min

  Drill and blast = ~ 2 – 2.5 m³/min

  [Dry tunnel has 1 l – 30 l/min for 100m]
- Sealing of the first 80 – 90% costs easy the same like the remaining 10 – 20%.
- Grout quantity varies between 20 – 250 kg/m excavation

* These figures are not valid for each case and are based on common experience.

Final results - Consultant

(1) Consultant and specialists for using grouts should **work together**

(2) Excavation in difficult areas with a pre – and post - **grouting schedule**

(3) Combination of suitable grouts – one type of grout cannot solve all problems!

(4) Standby of material for an urgent application, the extra costs are small in comparison to two days of excavation standstill

(5) Use only **qualified contractor** for injection work

Final results - Applicator

(1) Drilling team and injection team belong together!

(2) Only **trained people** have to work with grouts. (own protection)

(3) Use **quality** possible environmental friendly grouts. - We have only one world!

(4) Injection system starts from the pump to the final packer or self drilling bolt. That must be a tested **high pressure system**. (Pump pressure easy > 50 bar)

(5) Record the injection work with pictures, technical drawings, flow and pressure measuring.

Thank you for your attention...

... and we are looking forward to welcome you in our world.

Minova CarboTech GmbH

Am Technologiepark 1

45307 Essen

www.minova-ct.com