ITA TUNNELLING AWARDS 2018

Innovative Backfill Grout for Dilative Soils

Germany

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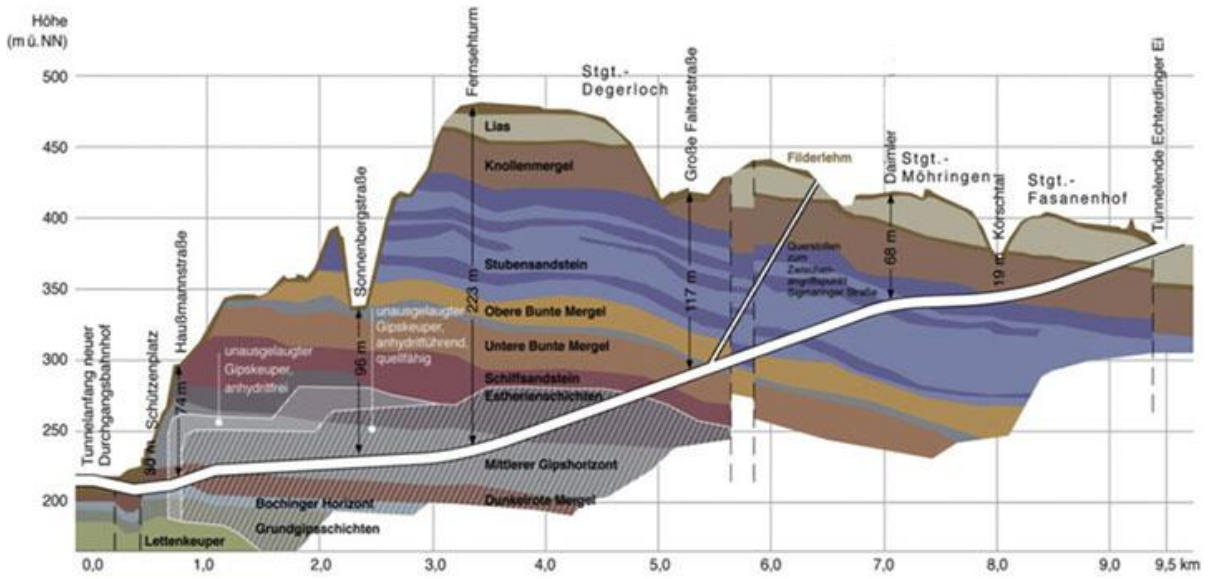
Agenda

- **Introduction**
- **Practical Example Backfill Grout for „Unteren Fildertunnel“**
- **Binder on Geopolymer Basis**
- **Performed Initial Assessment – Lab Trials**
- **Results of the First Tunnel Drive**
- **Conclusion**

Introduction

- Mechanical tunnel drive in connection with segment lining shows increasing relevance worldwide
- So far backfill grout isn't included in the durability design of the construction object by default
- Nevertheless we recognize increasing consideration of backfill grout in the overall concept of securing long-term durability
- Increasing understanding that grout can be an intelligent material and not just a filler for embedding stones (e.g. drainage capable grout)

Practical Example Backfill Grout for „Unterer Fildertunnel“



Unterer Fildertunnel –
special requirement meets innovation

Practical Example Backfill Grout for „Unteren Fildertunnel“

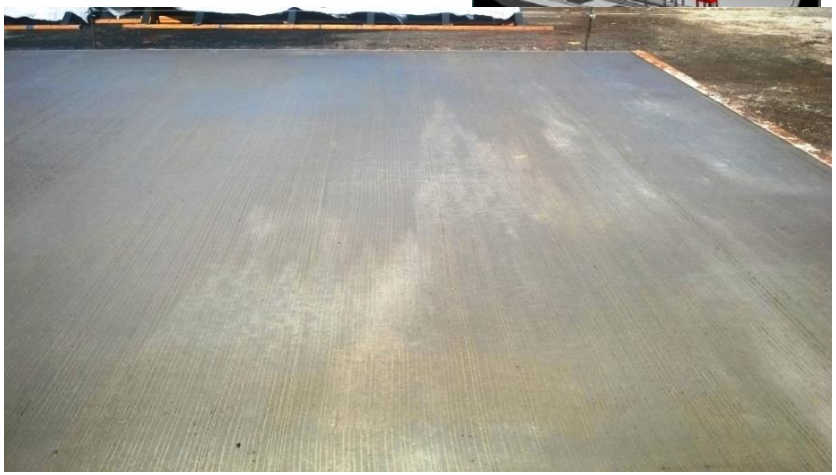
Requirements Backfill Grout

- High volume stability
- No water release / **preventing of swelling** (anhydrate horizon)
- Durability 100 years
- High sulfate resistance
- Environmental sustainability
- Safety in practical application

Solution

- Usage of a binder on geopolymer basis
- Usage of a phosphate additive

Wagners Earth Friendly Concrete – Wellcamp Airport



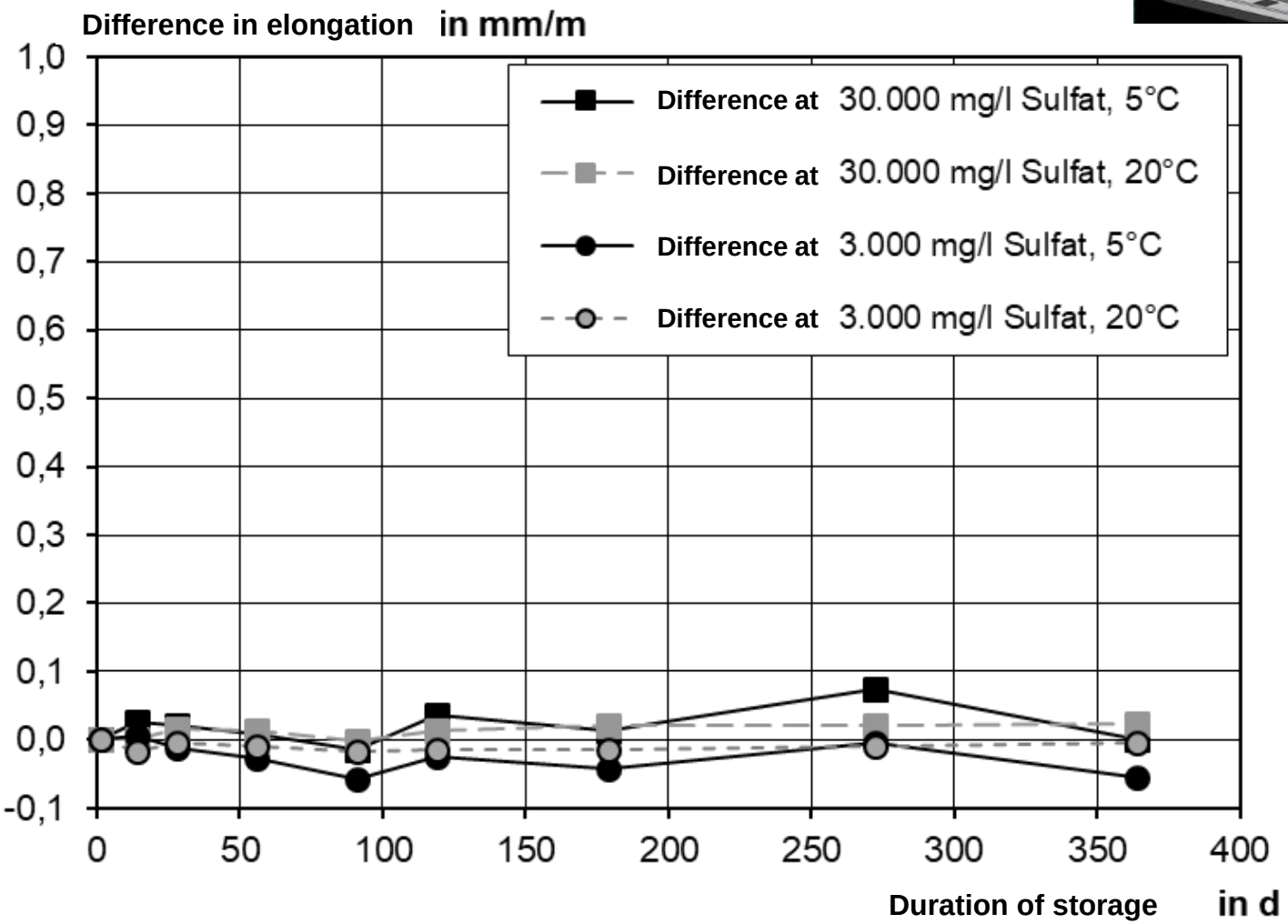
Mixture Optimization and Initial Tests

- Characterization of basic materials (ibac)
- Development of mix-design and optimization (site, MC, BUI)
- Mechanical properties (RUB)
- Water release, shrinkage, sources of surrounding anhydrate layer (ibac, BUI)
- Durablity (ibac, BUI)
- Effect of phosphate additive (ibac, MC, FIB, BUI)
- Environmental sustainability (ibac, BUI)

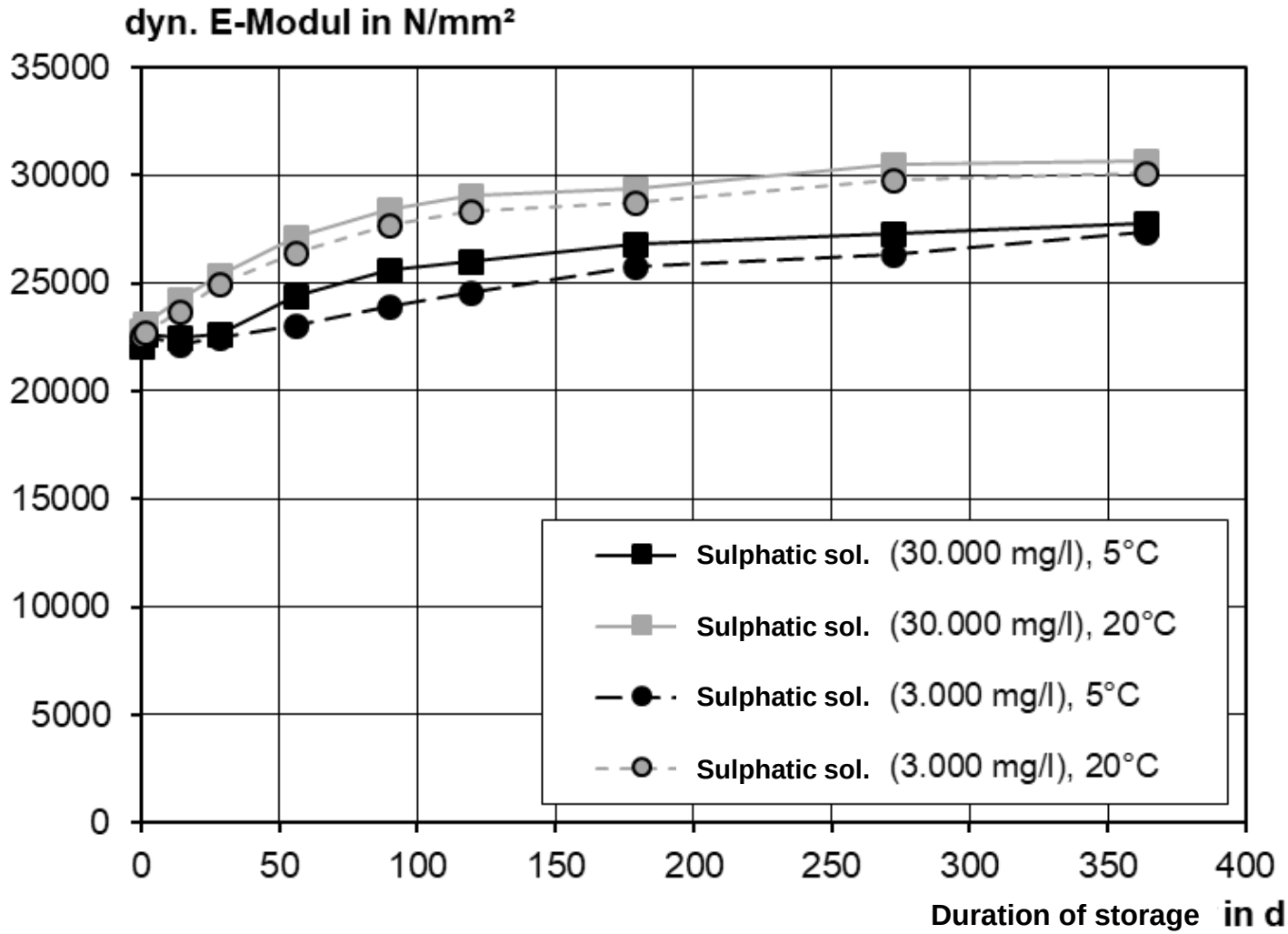
Basic Materials and mortar composition

Material	Type	Unit	Content
Binder	Slag / Fly ash	kg/m³	~ 500
Activator 1	Sodium silicate	M.-% v. b.	10
Activator 2	Alkaline phosphate	M.-% v. b.	2,5
w/b	-	-	0,45
Plasticizer	Matched substance	M.-% v. b.	0,5
Aggregate	Quartzitic and calcitic sand/grit (7 mm)	kg/m³	~ 1.350

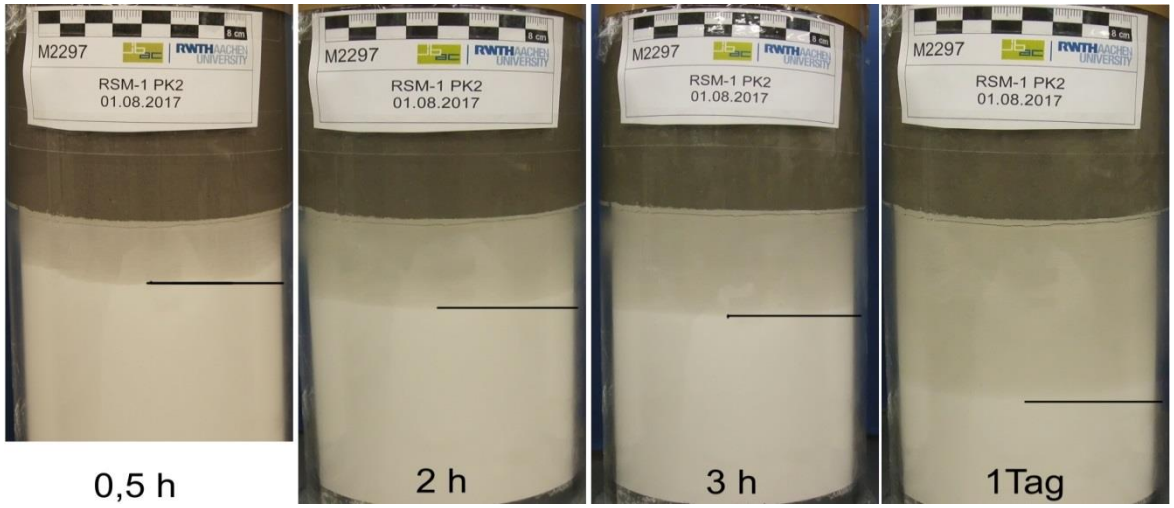
Sulphate Resistance – Difference in Elongation



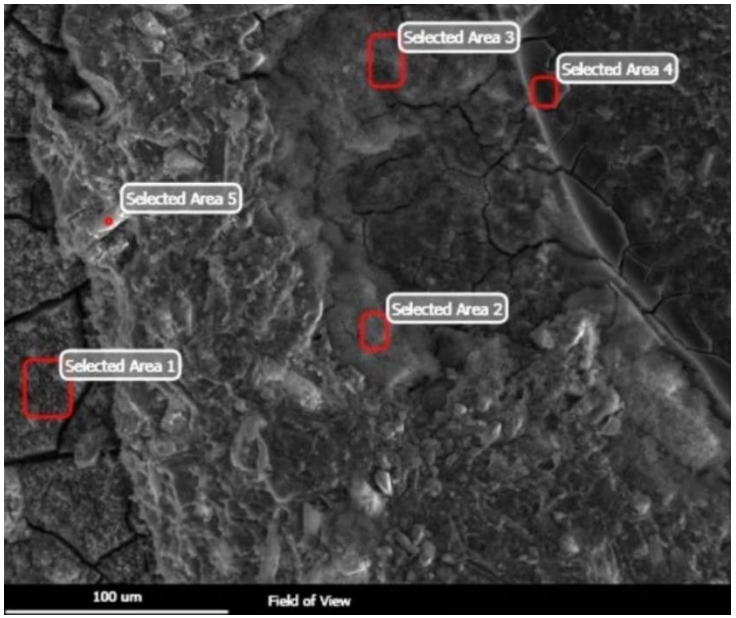
Sulphate Resistance – Dynamic E-Module

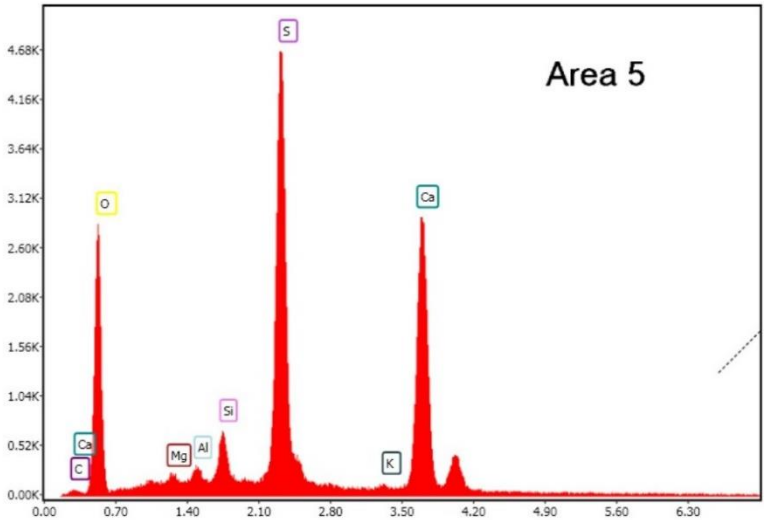


Water Release



Effect of Phosphate Additive





Source: F. A. Finger-Institut

- At presence of sodium or potassium phosphate the solubility of Sulphate declines significantly
- This can be proven by solubility products and the „law of mass“
- The anhydrite of the soil doesn't pass over into solution when getting in contact with the grout
- As a result, the anhydrite isn't swelling and

Duration of storage

Effect of Phosphate Additive

Why choosing phosphate solution?

- Solubilities:

Lp_{Gipsym} = $[Ca^{2+}]\,[SO_4^{2-}] = 10^{-4,32}$

$Lp_{Phosphate}$ = $[Ca^{2+}]^3\,[PO_4^{3-}]^2 = 10^{-32,7}$

- At presence of phosphate and sulfate the sulfate concentration goes down to 1/40000

Initial Trial – Large-Scale Trial

Results of the first tunnel drive

- No stresses were measured
- Perfect workability until the backfill grout is activated – good pumpability even after several days
- Environmental friendly – confirmed by everyday external supervision
- Material consumption exactly as calculated

Conclusion

- The production of backfill grout using a binder on geopolymer basic is possible and working very well on site
- The addition of an activator can happen at the pilaster strip – so you can react flexible when facing changing operating conditions
- Grout stays workable above ground – significant cost reduction if TBM stands still (less cleaning costs)
- Usual mixing unit can be used
- Also working as 2K-system without supporting grain for smaller diameters (e.g. metros)
- As expected, the grout shows a very high Sulphatic resistance by existing environmental sustainability
- Water release is significantly lower compared to a classical 1K-grout
- The usage of an phosphate additive prevents the conversion of anhydrite to gypsum – from our knowledge **exclusive solution for such conditions**

Project Partner

MC
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