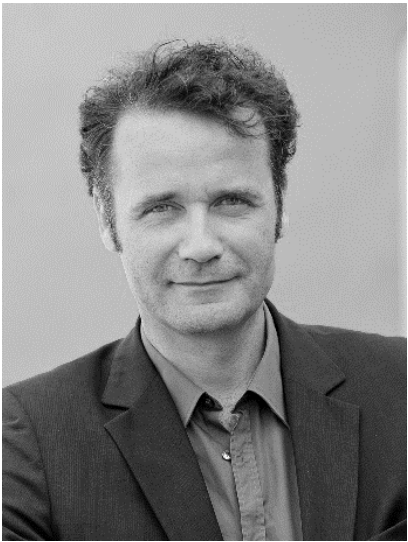


Selective Paste Intrusion

Influence of changing ambient temperatures on the cement paste rheology

Alexander Straßer | TUM, Chair of Materials Science and Testing | 3rd March 2022

Team Additive Manufacturing at the Chair of Materials Science and Testing



Prof. Dr.-Ing.
C. Gehlen



Dr.-Ing. Thomas
Kränkel



Carla Matthäus,
M.Sc.

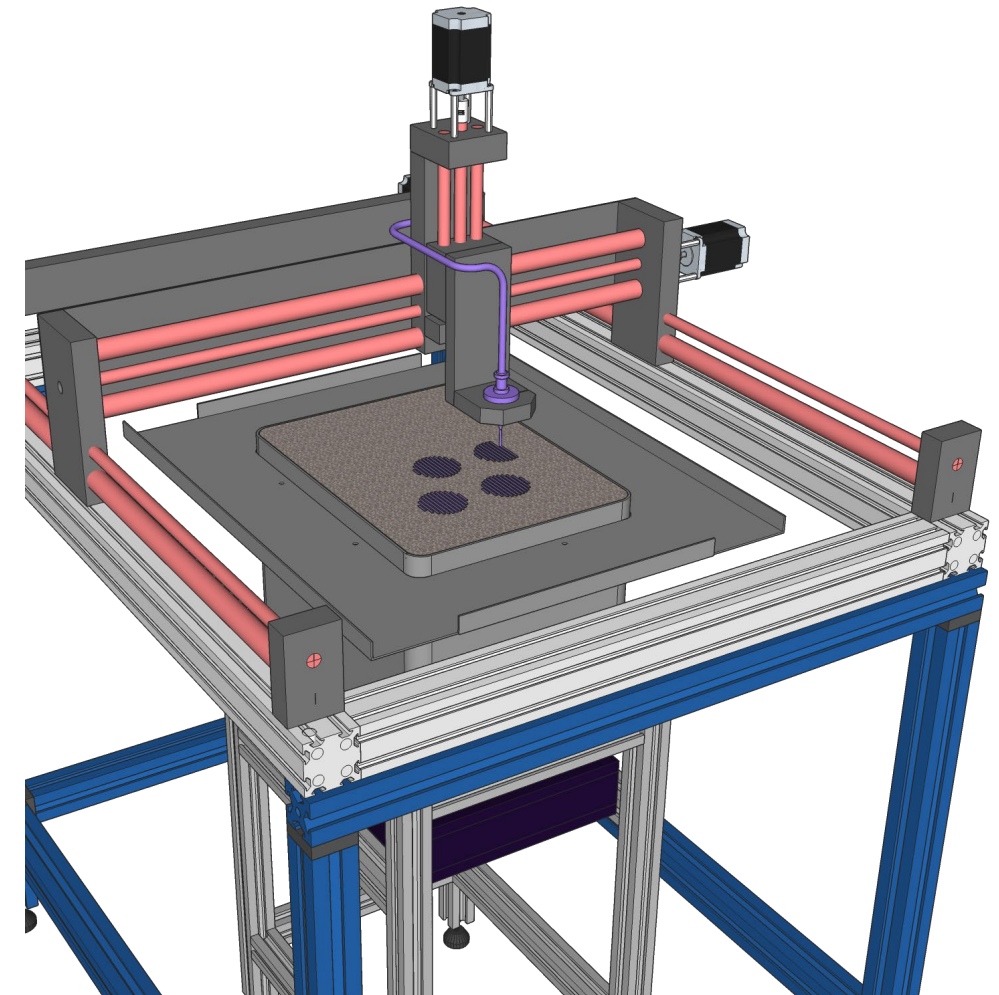
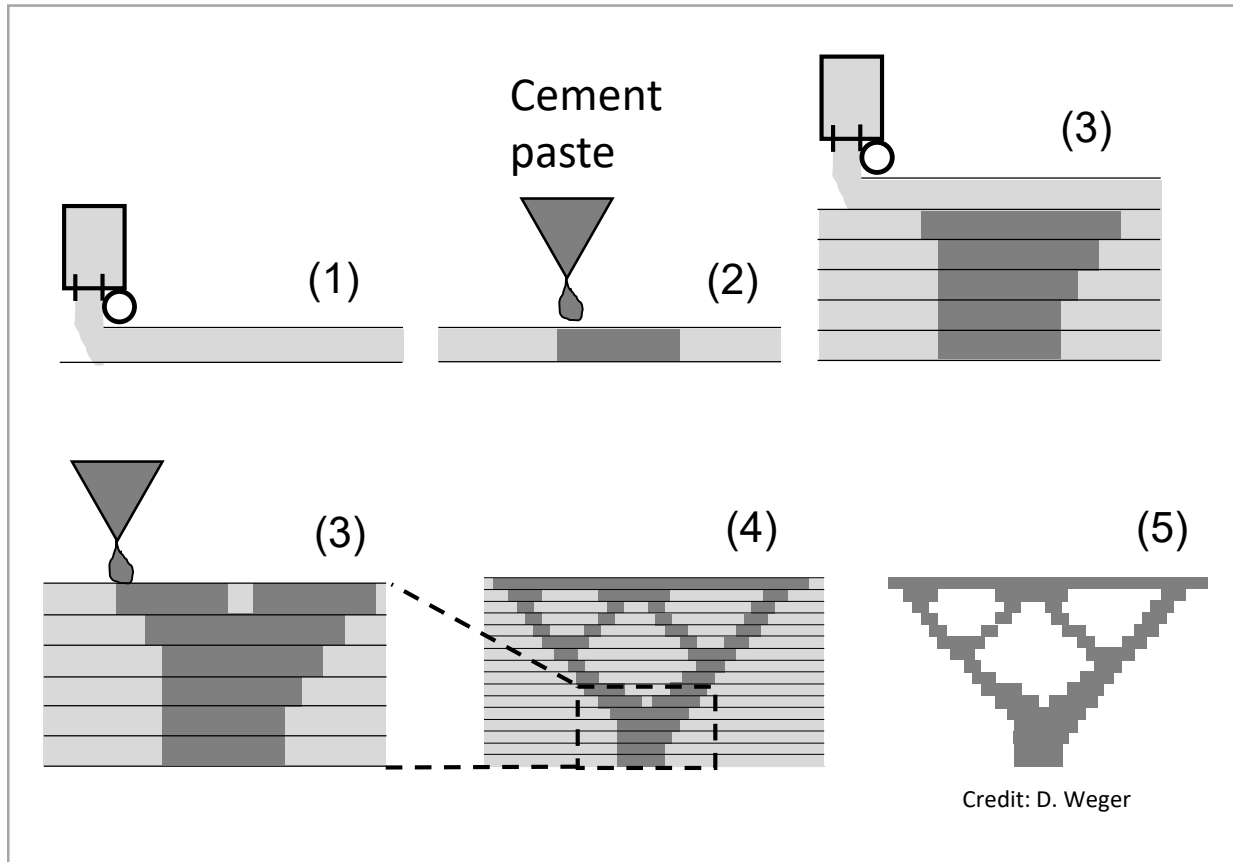


Maximilian Hecht,
M.Sc.



Alexander Straßer,
M.Sc.

Concept Selective Paste Intrusion

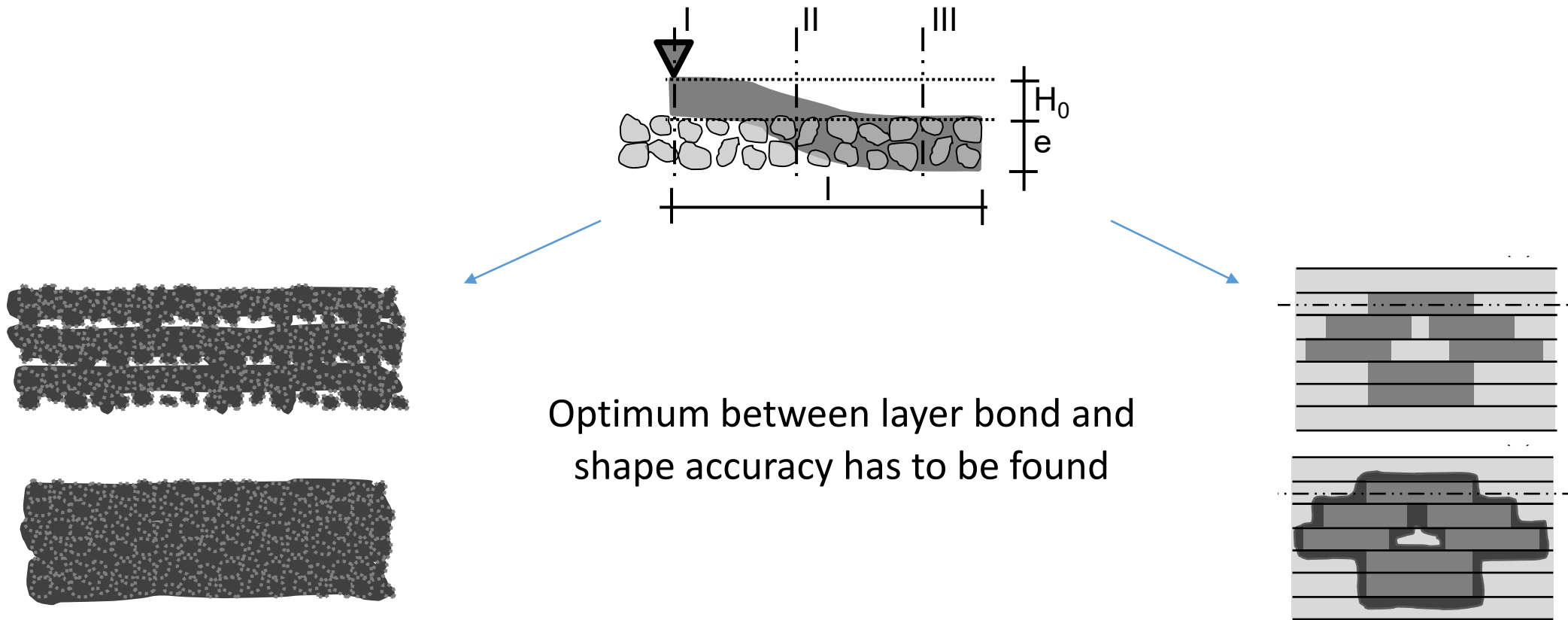


Credit: D. Talke

Selective Paste Intrusion provides freedom in form



Workability and intrusion depth of the cement paste



Credit: D. Weger

Correlation between yield stress and shape accuracy

Examples

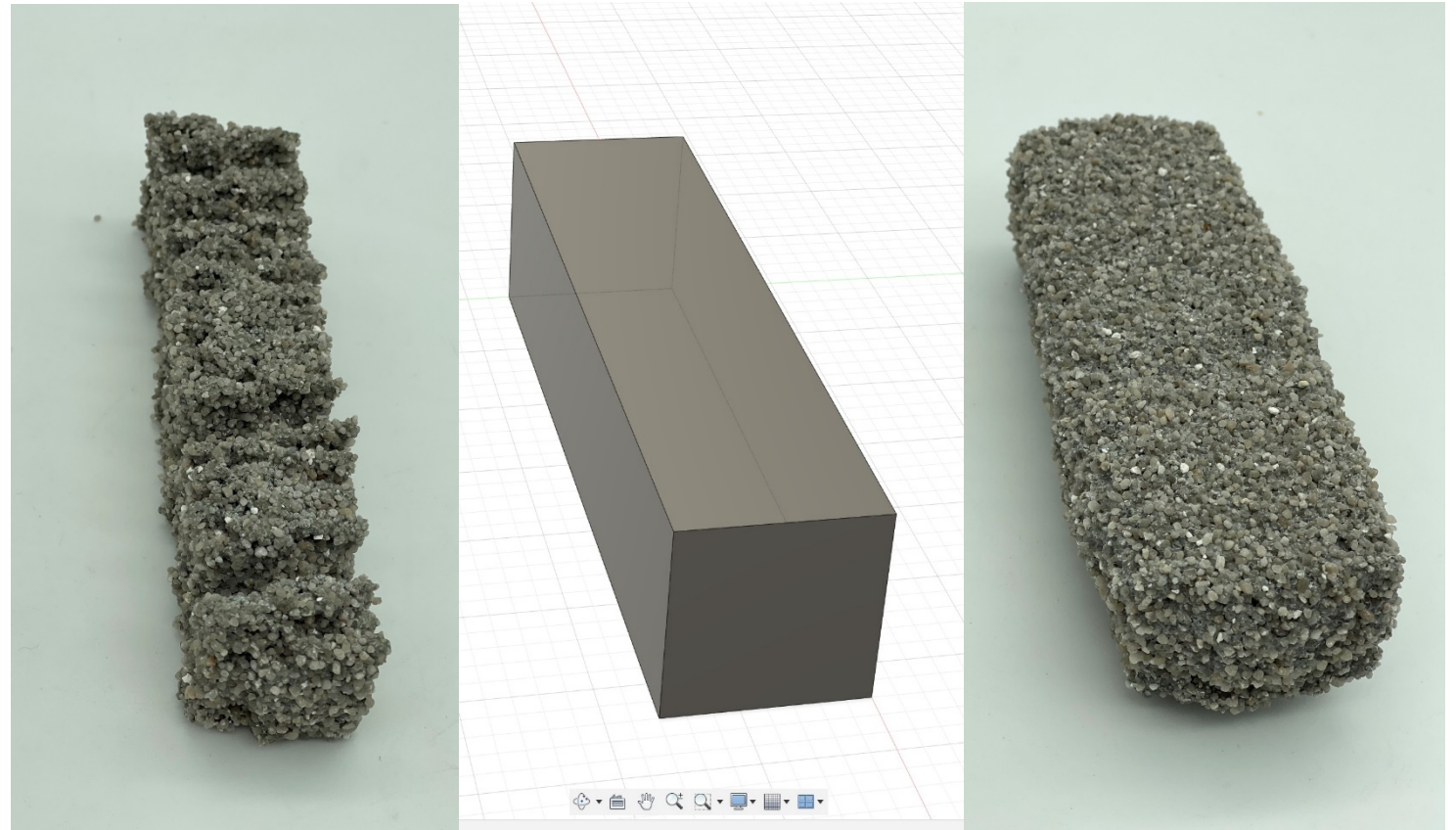
PRINTED SPECIMEN

Too high yield stress (too low workability)

- Defects
- Plugged nozzles
- Bad layer-bonding
- Geometry smaller than designed

Too low yield stress (too high workability)

- Geometry larger than designed
- Bad shape accuracy



Credit: Alexander Straßer

Stability of rheological properties towards changing temperatures

Methods and Set-Up

OVERVIEW

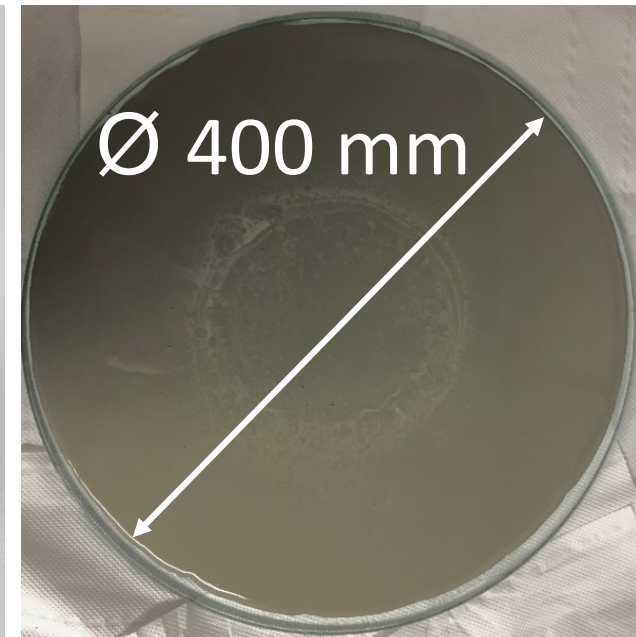
- Measurement of mini-slump flow and yield stress
- Produce referencing cement paste
- Simulation of ambient temperature change through changing water temperature (target values in fresh state)
- Comparison of results and evaluation of penetration depth through the model by Weger

Produce referencing cement paste

mini-slump flow

HAEGERMANN-CONE

- Adjustment to **400 mm** mini-slump flow at 20 °C



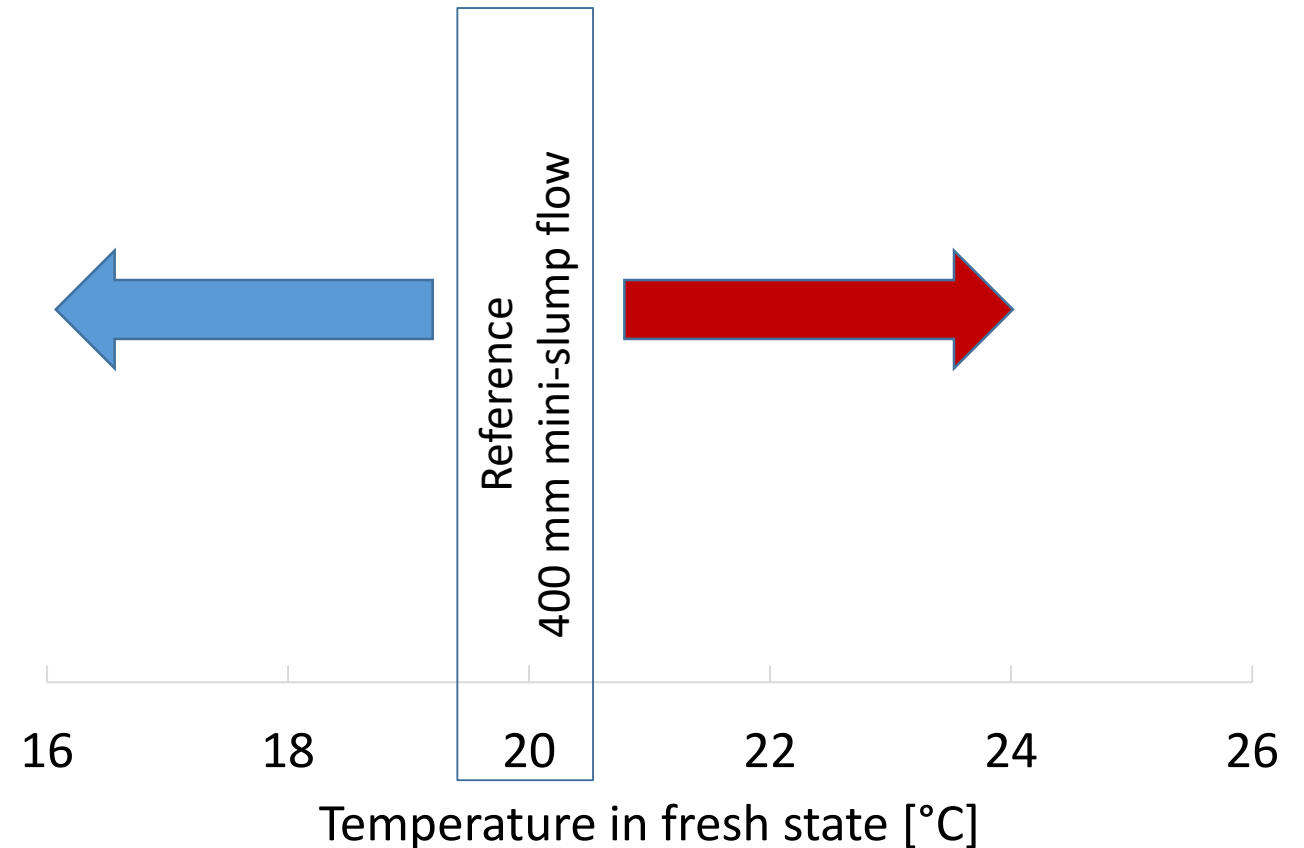
Credit: Alexander Straßer

Simulation of ambient temperature change

Ambient temperature change

INFLUENCE ON RHEOLOGY

- Change cement paste temperature in fresh state through adjustment of water temperature
- Temperature range between 16 °C and 26 °C (2 °C steps)
- Determination of mini-slump flow and yield stress



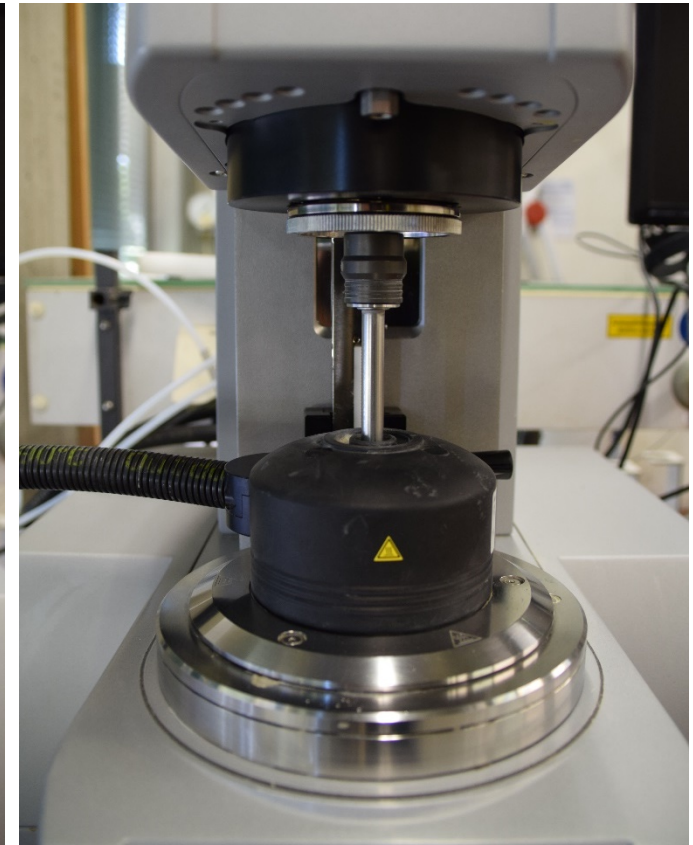
Credit: Alexander Straßer

Determination of the yield stress

Rheometer

PARALLEL PLATE MEASSURING SYSTEM

- Use Peltier-Hood
- Defined shear rate/
measurement profile
- Measuring shear stress
- Calculate yield stress
(Herschel/Bulkley-Model)



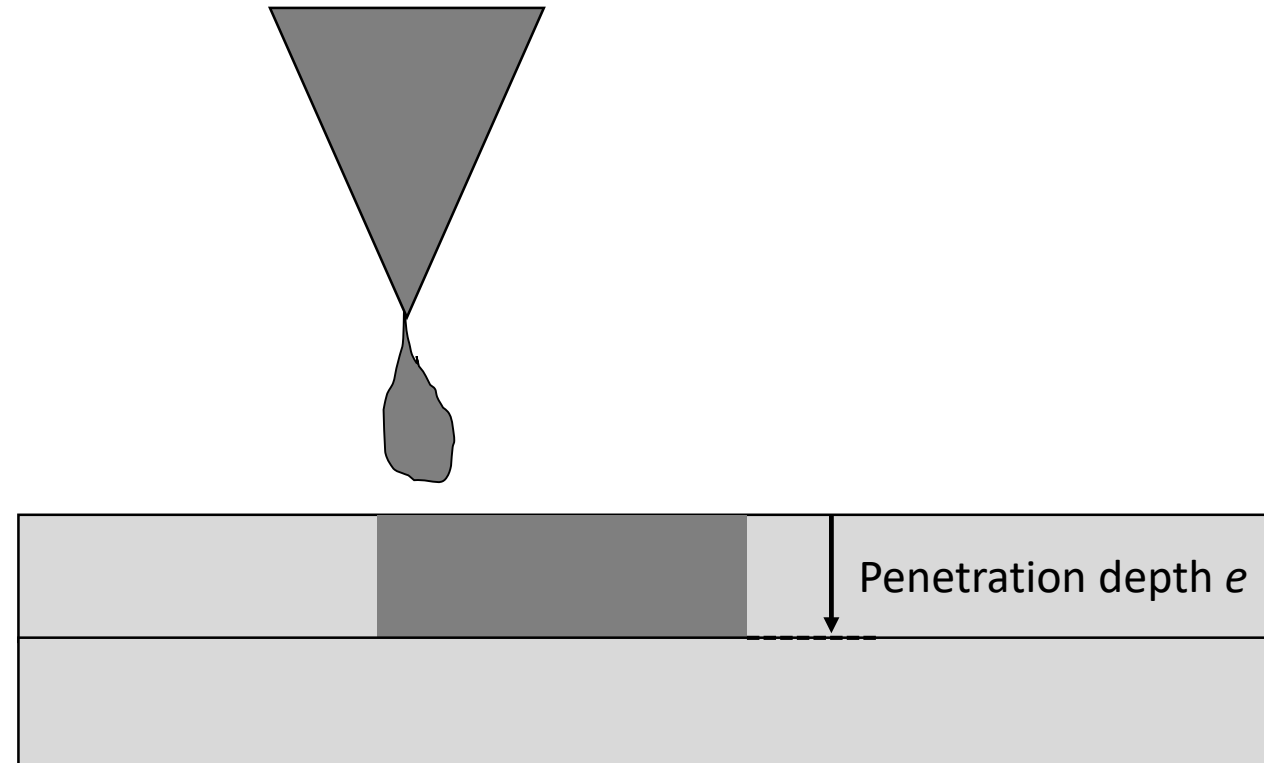
Credit: Alexander Straßer

Comparison of results and evaluation of penetration depth

Penetration depth

MODEL BY WEGER

- Use values of yield stress
- Model based on Darcy's law
- Penetration depth depend on grain size



Credit: Daniel Weger

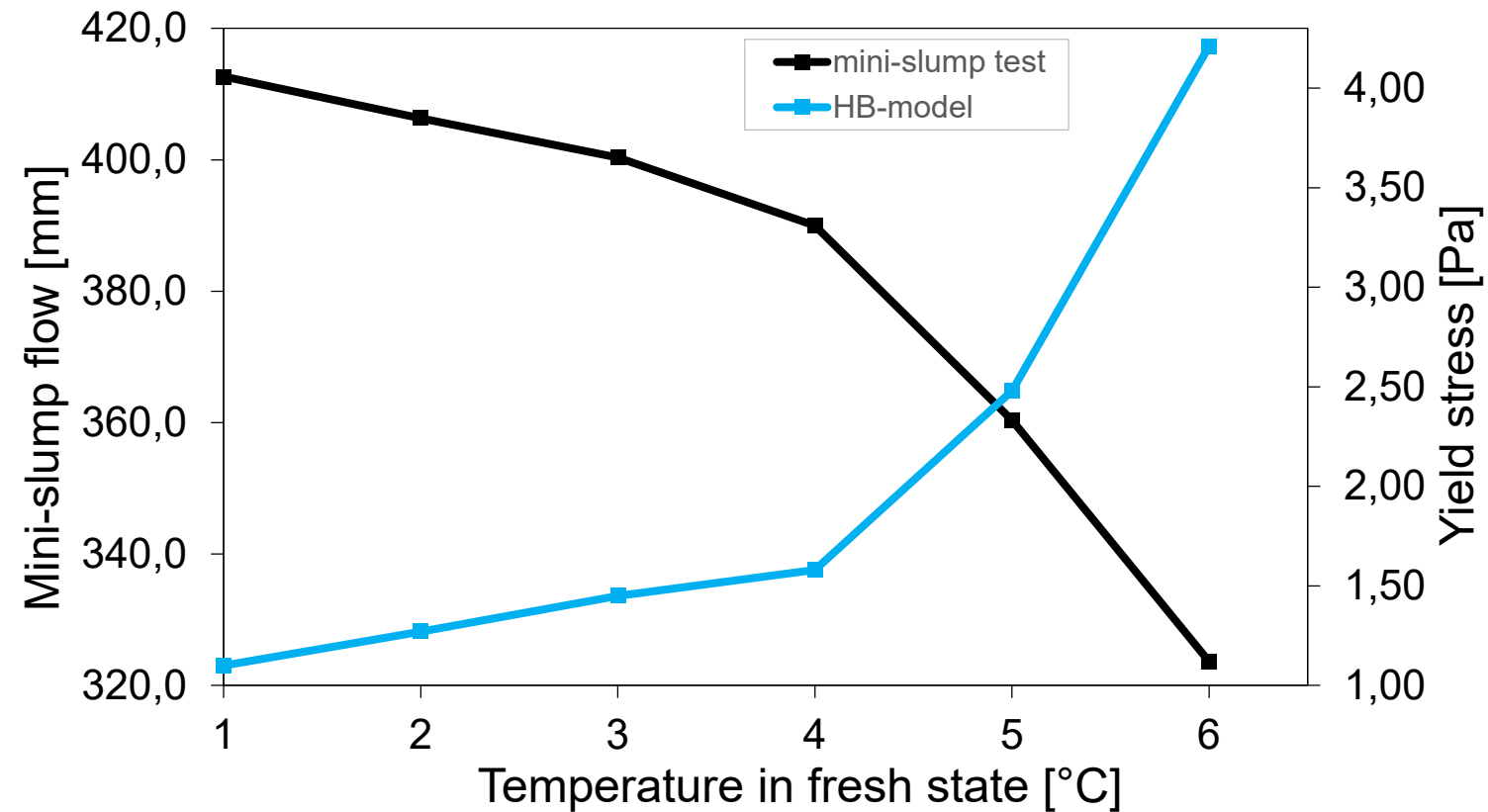
Measurement of workability

Mini-slump flow and yield stress

RESULTS

With increasing temperature...

- Decreasing mini-slump flow
- Increasing yield stress
- Above 22 °C disproportional values



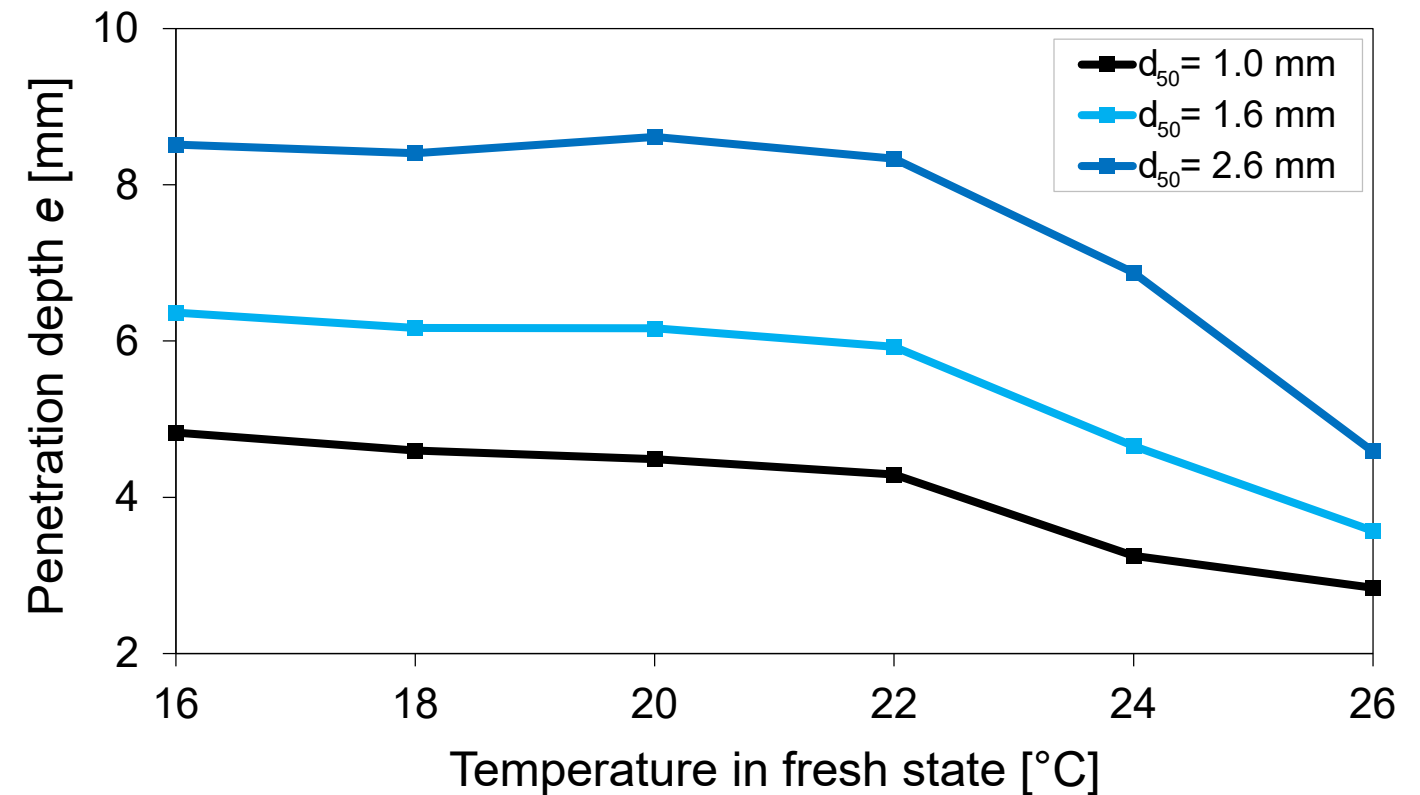
Credit: Alexander Straßer

Evaluation of penetration depths with model by Weger

Penetration depth

RESULTS

- The penetration depths depend on the aggregate grain size.
- Decrease of penetration depth above 22 °C



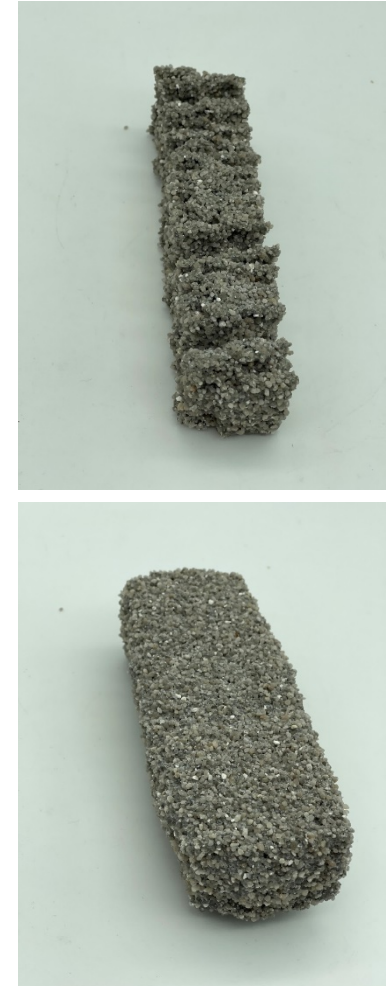
Credit: Daniel Weger

Summary and Conclusion

- Adjusted rheological properties are crucial for high print quality
- Changes in temperature influences rheological properties
- Cement paste rheology is sensitive to temperature influence
- The temperature of the raw materials may need to be adjusted

Outlook

- Clarifying the change at 22 °C
- Optimize cement paste formulation for higher robustness
- Test actual penetration depths; compare results with calculated values
- Extending the model through simulation-based model
- Test on the SPI-printer; verifying the actual print quality (compare pictures slide 7)
- Adjustment of printer settings for different ambient temperatures



Selective Paste Intrusion

Alexander Straßer | TUM, cbm | alexander.strasser@tum.de