Rheological Characterization of Different Clay Minerals for Sustainable Pourable Clay Concrete

Deep Dive

Baustofflehre und Werkstofftechnologie

E207 Institut für Werkstofftechnologie, Bauphysik und Bauökologie

Forschungsbereich Stahlbeton- und Massivbau

E212 Institut für Tragkonstruktionen

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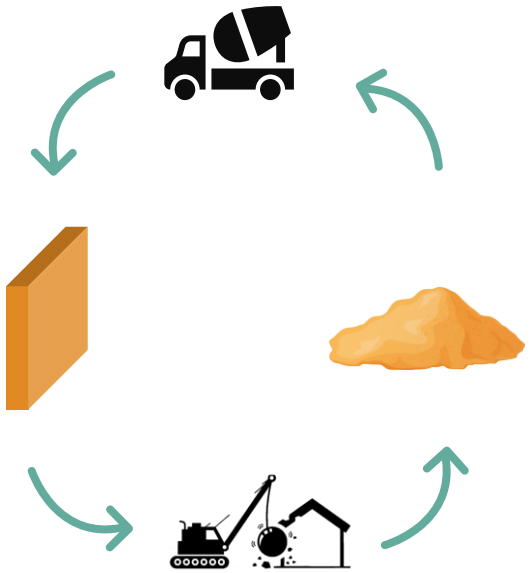
Motivation

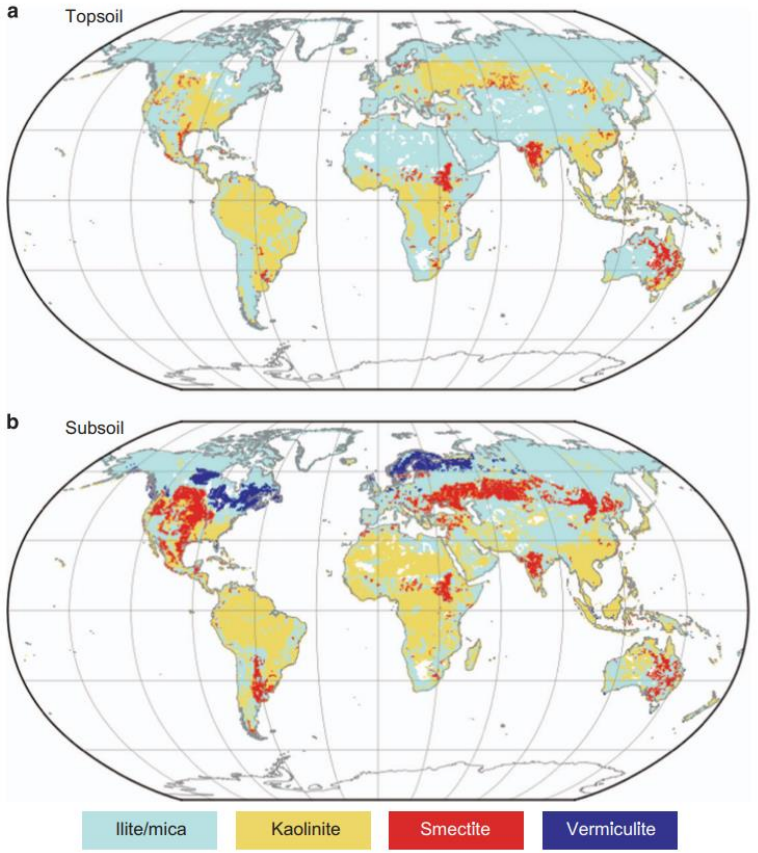
- Reduction of CO_2-Emissons

Raw Earth		0,02 $kgCO_2/kg$
Cement		0,83 $kgCO_2/kg$
Concrete		0,13 $kgCO_2/kg$
Carrots		0,1 $kgCO_2/kg$
Beef		13-21 $kgCO_2/kg$

- Unlimited Recyclability



- High Availability Worldwide



Distribution of the most abundant clay-size mineral group

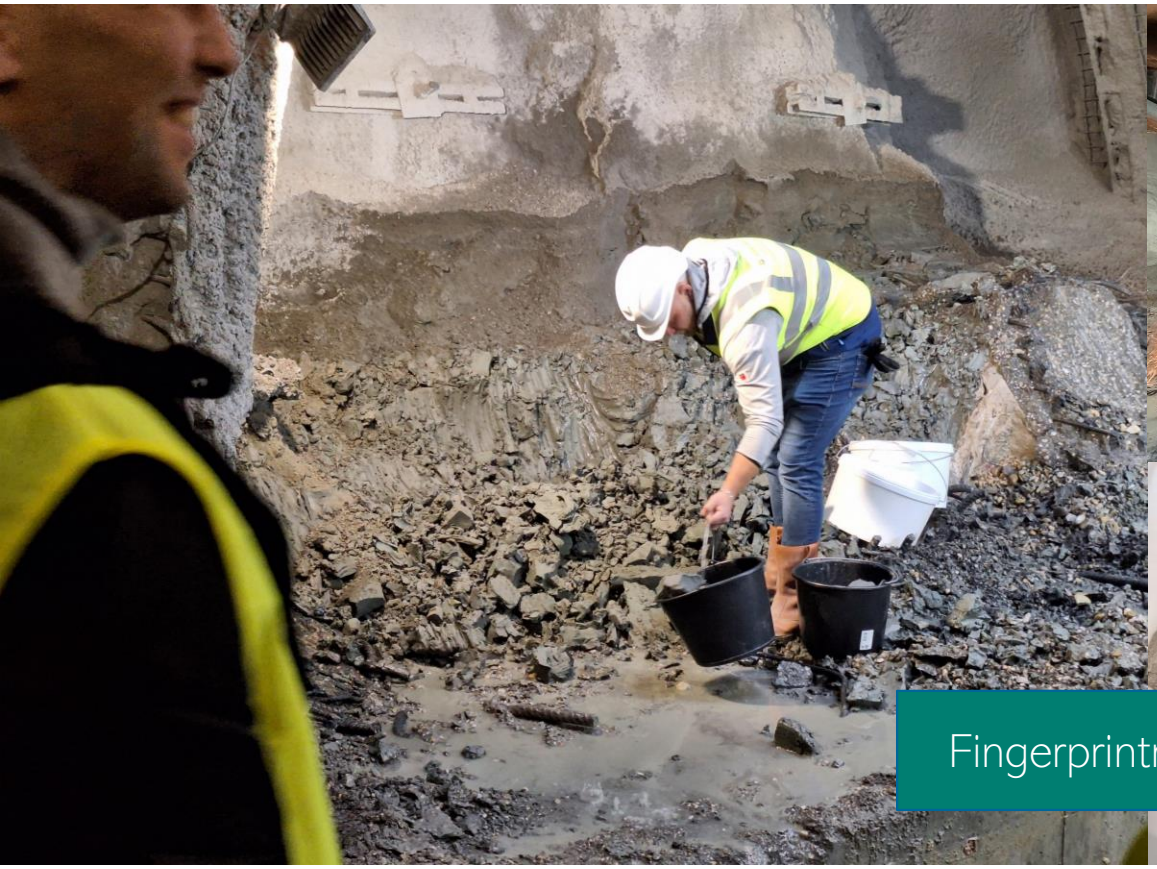
Henri Van Damme, Hugo Houben (2018) Earth concrete. Stabilization revisited,Cement and Concrete Research,Volume 114,Pages 90-102 https://doi.org/10.1016/j.cemconres.2017.02.035.
Jones, Craig & Hammond, Geoffrey. (2008). Embodied energy and carbon in construction materials. Proceedings of The Ice - Energy. 161. 87-98. 10.1680/ener.2008.161.2.87.
https://de.statista.com/statistik/daten/studie/1197342/umfrage/obst-und-gemuese-co2-fussabdruck/

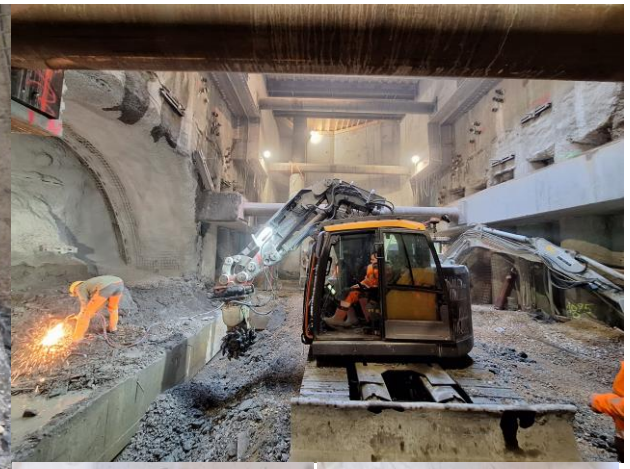
Ito A, Wagai R. Global distribution of clay-size minerals on land surface for biogeochemical and climatological studies. Sci Data. 2017 Aug 22;4:170103. doi: 10.1038/sdata.2017.103. PMID: 28829435; PMCID: PMC5667577.

BasaltClayCrete

Cement has been used

Overall Goal





Fingerprintmethod?

DEUTSCHE NORM Juni 2023

DIN 18940

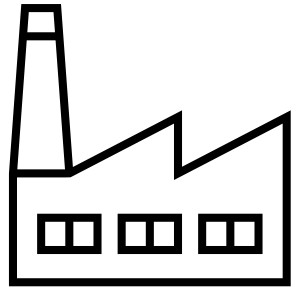
DIN

ICS 91.080.30

**Tragendes Lehmsteinmauerwerk –
Konstruktion, Bemessung und Ausführung**

Load-bearing earth block masonry –
Construction, design and execution

Maçonnerie porteuse en terre crue –
Construction, dimensionnement et exécution



Gesamtumfang 25 Seiten

DIN-Normenausschuss Bauwesen (NABau)

www.din.de
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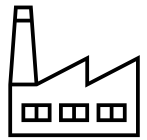
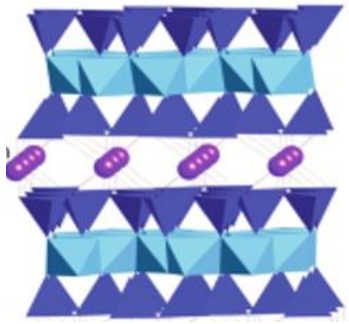
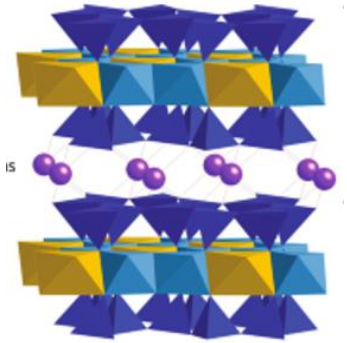


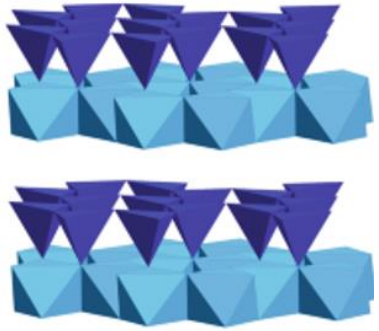
Methods



Illite or Mica group



Smectite group e.g. Montmorillonite



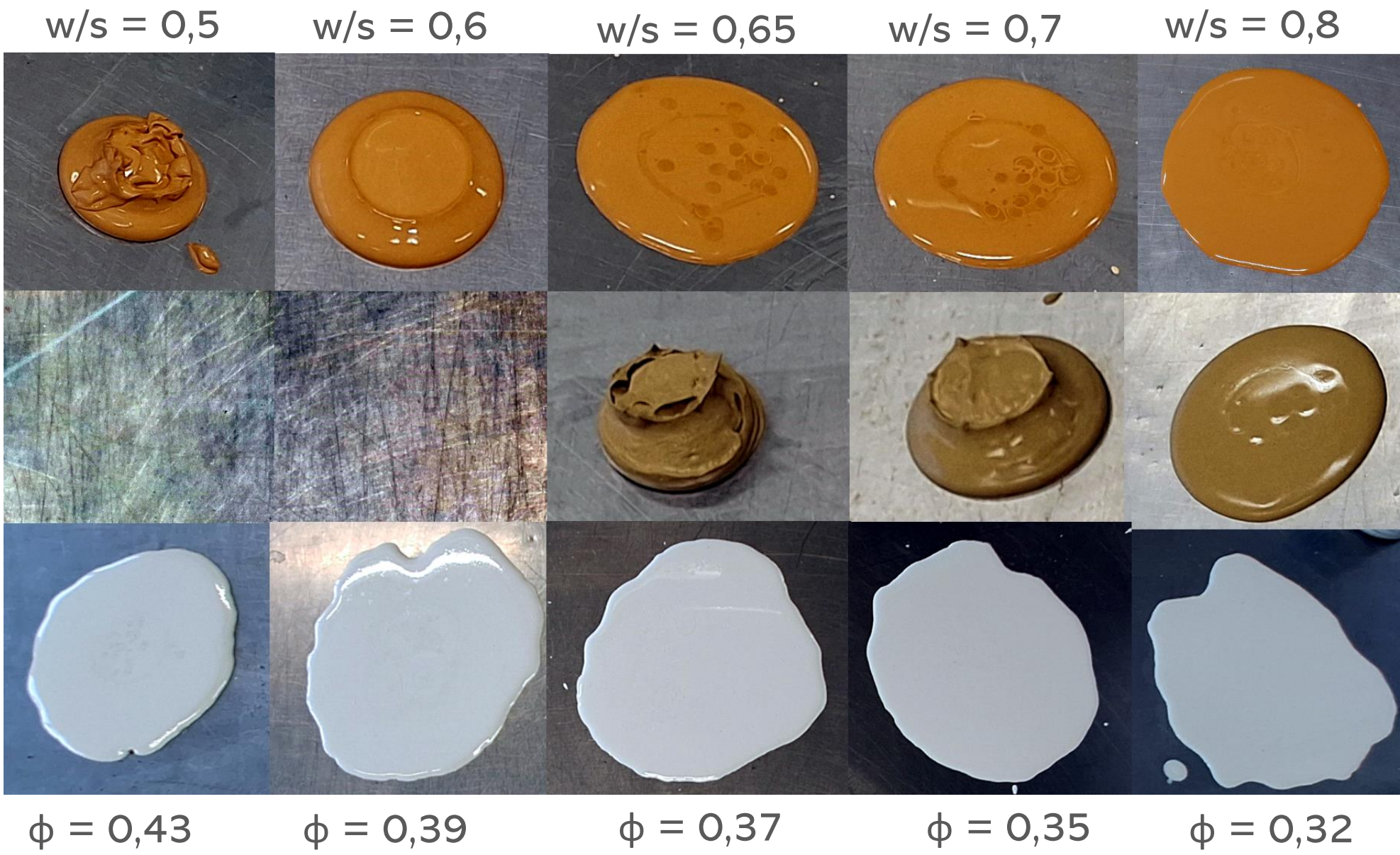
Kaolinite

Method 1: Spread tests

Clay is a highly diverse material

Method 2: Rheology
SAOS – Small Amplitude Oscillatory Shear

Results – Spread Test



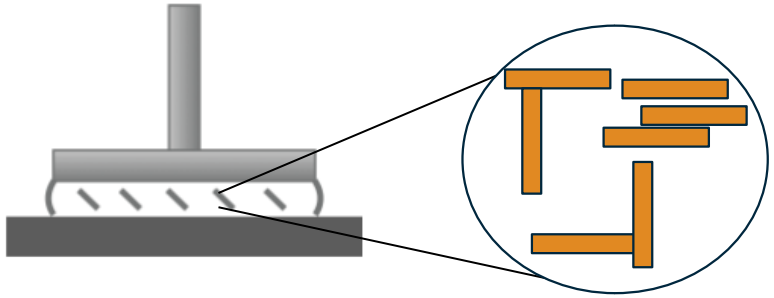
SAOS – Small Amplitude Oscillatory Shear

Ideal viscous

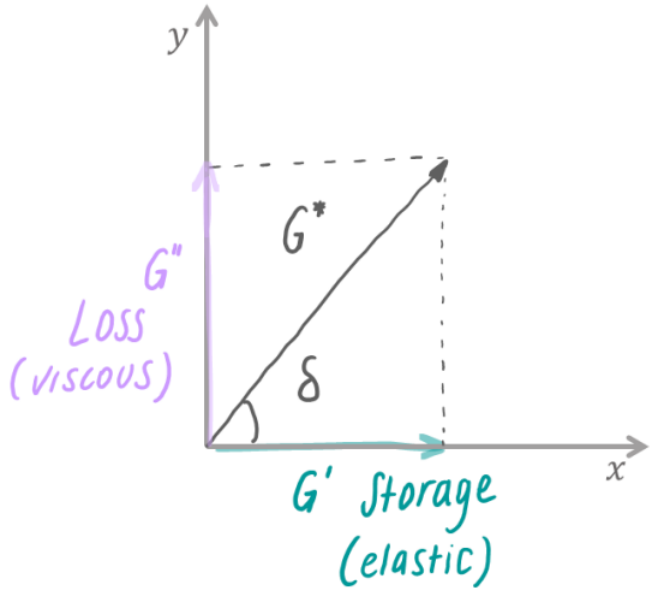
Ideal elastic

A small (nm scale) deformation is imposed i.e. the paste is at rest

Quick macroscopic tests (~5 min) offer insights
into microscopic properties e.g. paste cohesion, particle interactions

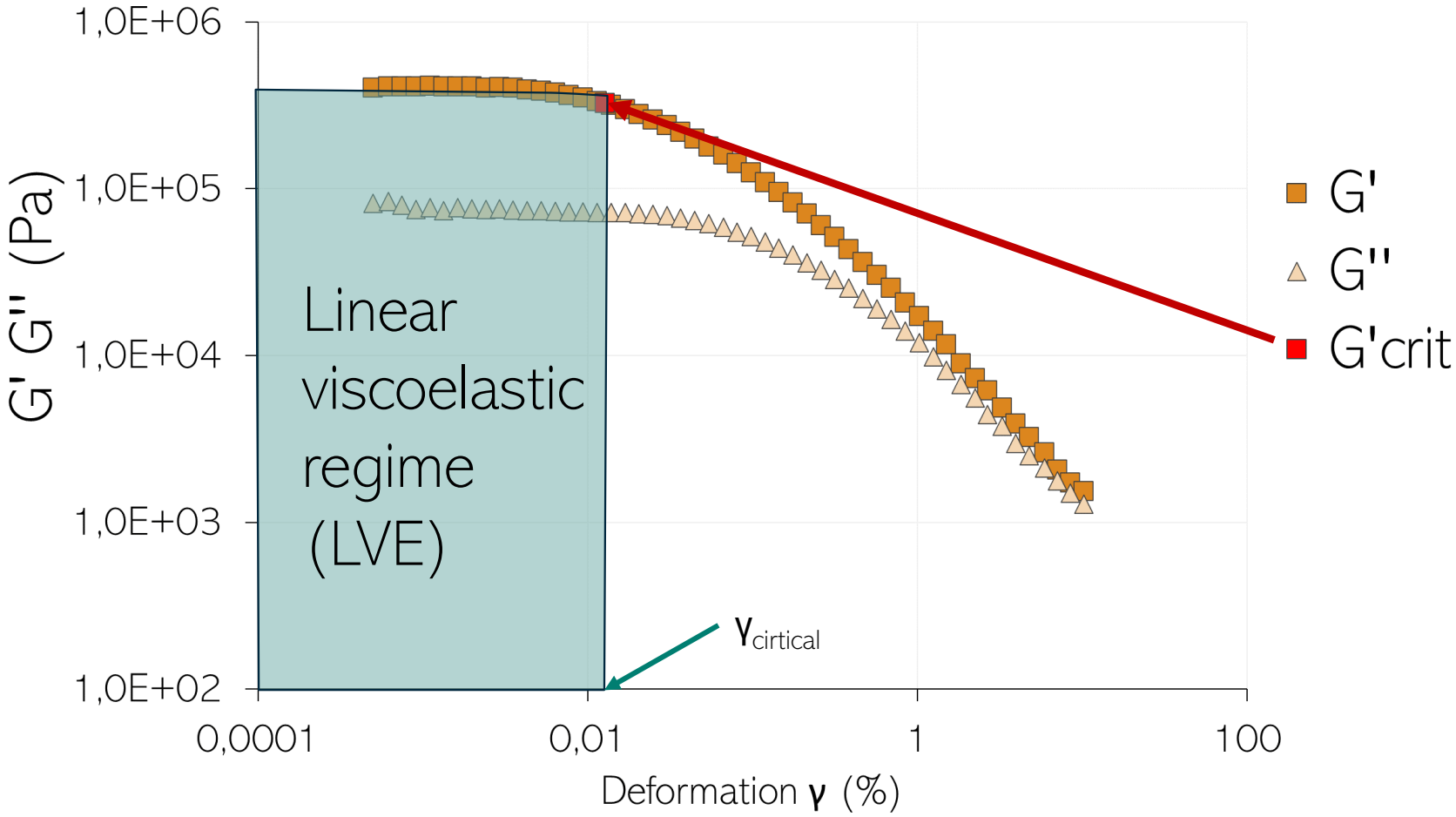


$$G^* = \frac{\tau^*(t)}{\gamma^*(t)} = \boldsymbol{G'} + i\boldsymbol{G''}$$

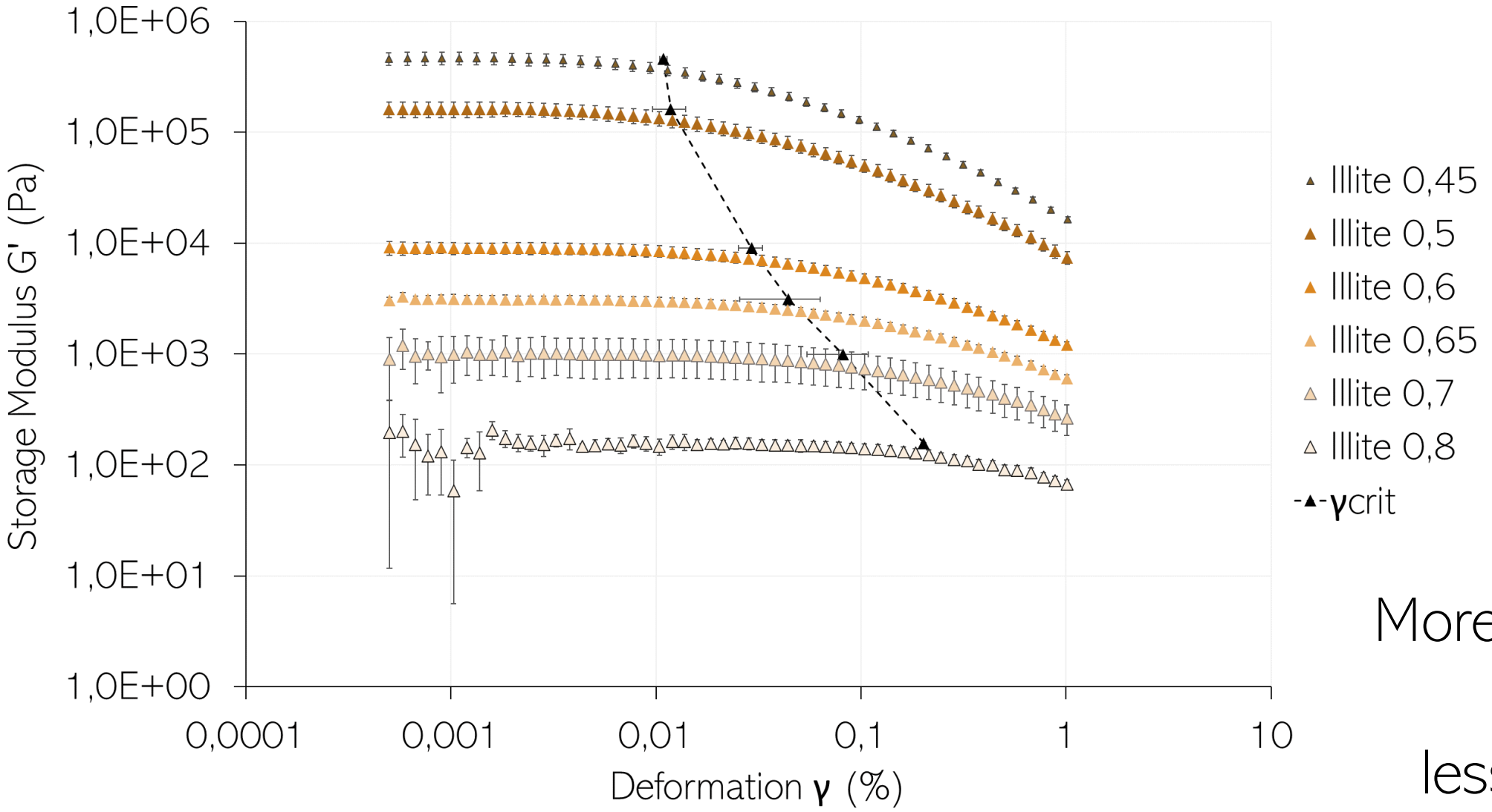


SAOS – Small Amplitude Oscillatory Shear

- Testing the range of deformation until the end of the linear behaviour is reached (Linear Viscoelastic Regime) to understand the network of the system.



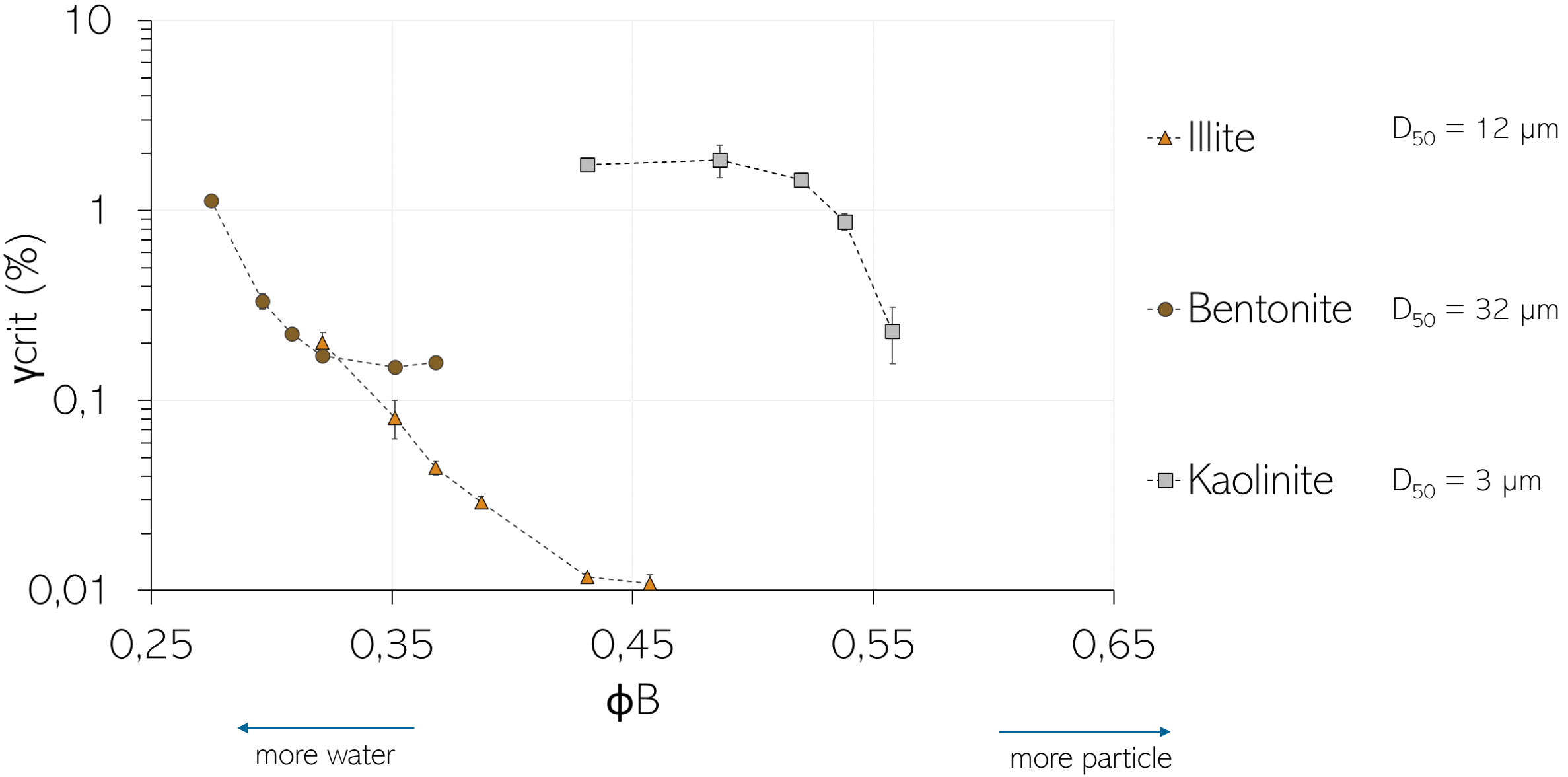
Results – SAOS Tests



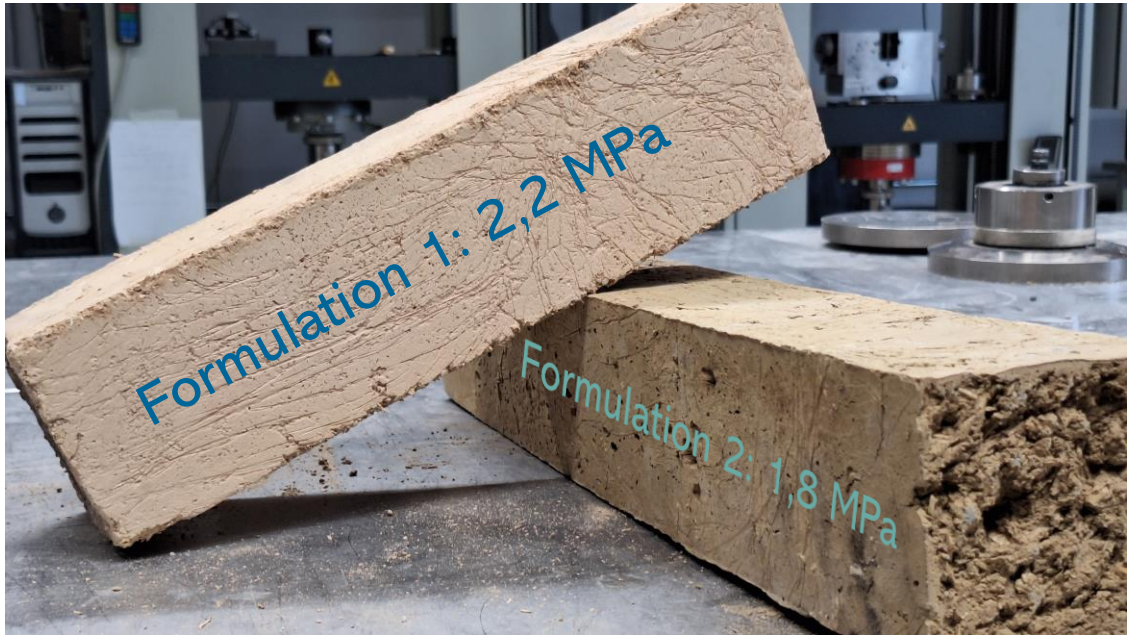
w/b ↑
G' ↓
γ_{crit} ↑

More deformable
&
less cohesive

Results – SAOS Tests



Preliminary Compressive Strength Tests



Formulation 1:
2 parts Clay “FAC”
2 parts 0-4
1 parts 0-1
1 part straw
1,5 parts H_2O
3 spatulas Na-HMP

Formulation 2:
4 parts clay “Comelle”
1 parts H_2O
1 part straw
100 ml Soda+Tanin

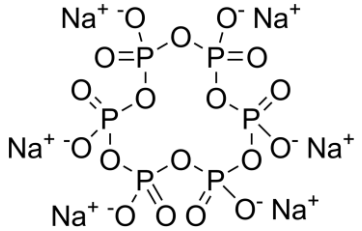
Preliminary observation

- Different types of clay have different rheological behaviour (Spread test and SAOS).
  - Granulometry ? Chemical composition & interaction ?

- Compressive tests on non optimized mixes deliver good strength results.
  - Optimization of the packing & the amount of dispersant

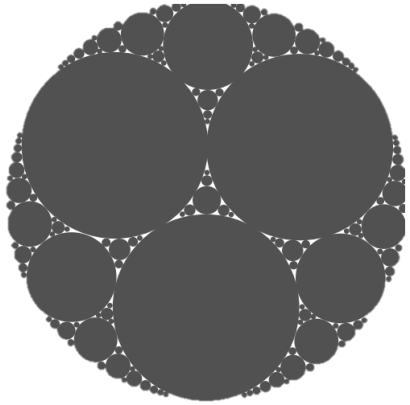
Next steps

XRD



Dispersant Na-HMP

https://www.researchgate.net/publication/303090661_Ionic_Strength_and_Temperature_Dependence_of_the_Dilution_Heat_of_Hexametaphosphate_Sodium_Salt



Optimization of the granular packing

Brochure Beton Argile Environnemental

Further measurements (e.g. 50:50 mixes, real clays and correlating to XRD, PSD)

THANK YOU FOR YOUR ATTENTION