A fresh approach on low CO_2 binders

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&
Agathe Robisson

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Faculty of Civil & Environmental Engineering

Research Unit of Building Materials
E207-1

Building Materials & Materials Technology

Head of the research unit

Univ.Prof. PhD

A. Robisson

- Behavior of complex fluids
  - Heterogeneities
  - Rheology
- Mechanics of soft materials
- Fracture of concrete

Ass.Prof. Dipl.-Ing. Dr. techn.

K. Deix

- Mechanical testing
- Structural damage
- Precast concrete
- Wood-concrete composites
- Mercury Porosimetry Analysis

Dipl.-Ing. Dr. techn.

J. Kirnbauer

- Design and optimization of:
  - UHPC, SCC
  - fiber reinforced concrete
- Mechanical testing
- Durability

Asst. Prof. PhD

T. Liberto

- Rheology of dense suspensions
- Particle interactions
- Sustainable cementitious materials
- Cement chemistry

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Building Materials & Materials Technology

Laboratories

Small and large high intensity concrete mixers

Isothermal calorimetry

Hg Porosimeter

Particle analysis

Rheology + Imaging (PIV)

Mechanical testing

From fresh cementitious materials to solid set structures

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Building Materials & Materials Technology

Projects

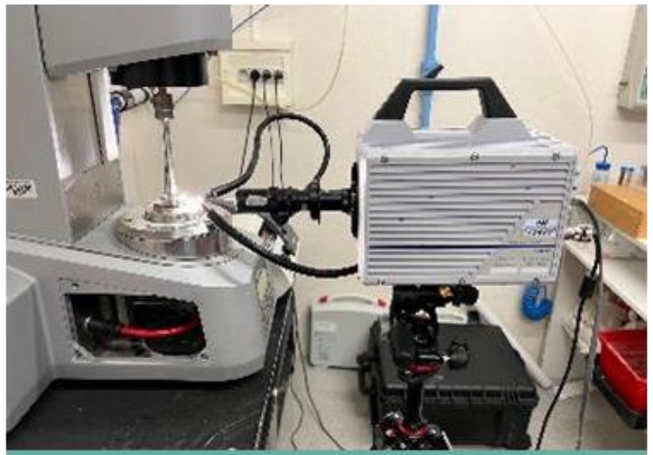
Renovation & reinforcement of old mortars

Cement bonded wood-particle panels

Characterization of the concrete to concrete interface

Milled clay concrete

Water permeable pavers



Global and local rheology of cement slurries

Infiltration in porous media

Alkali activated slag mortar

From fresh cementitious materials to solid set structures

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Future scenario

for a more sustainable construction industry

locally sourced alternative cementitious materials with variable chemical compositions

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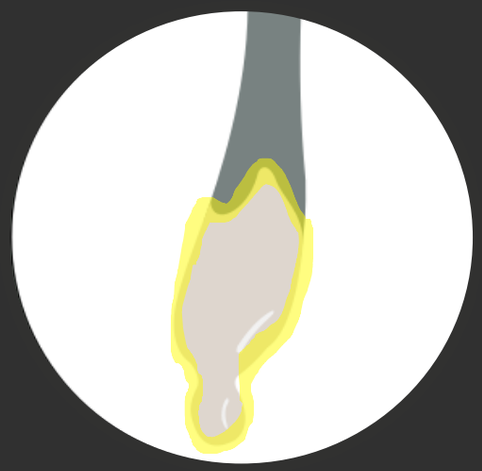
Rheology of dense cementitious suspensions



study of the fresh properties of pastes

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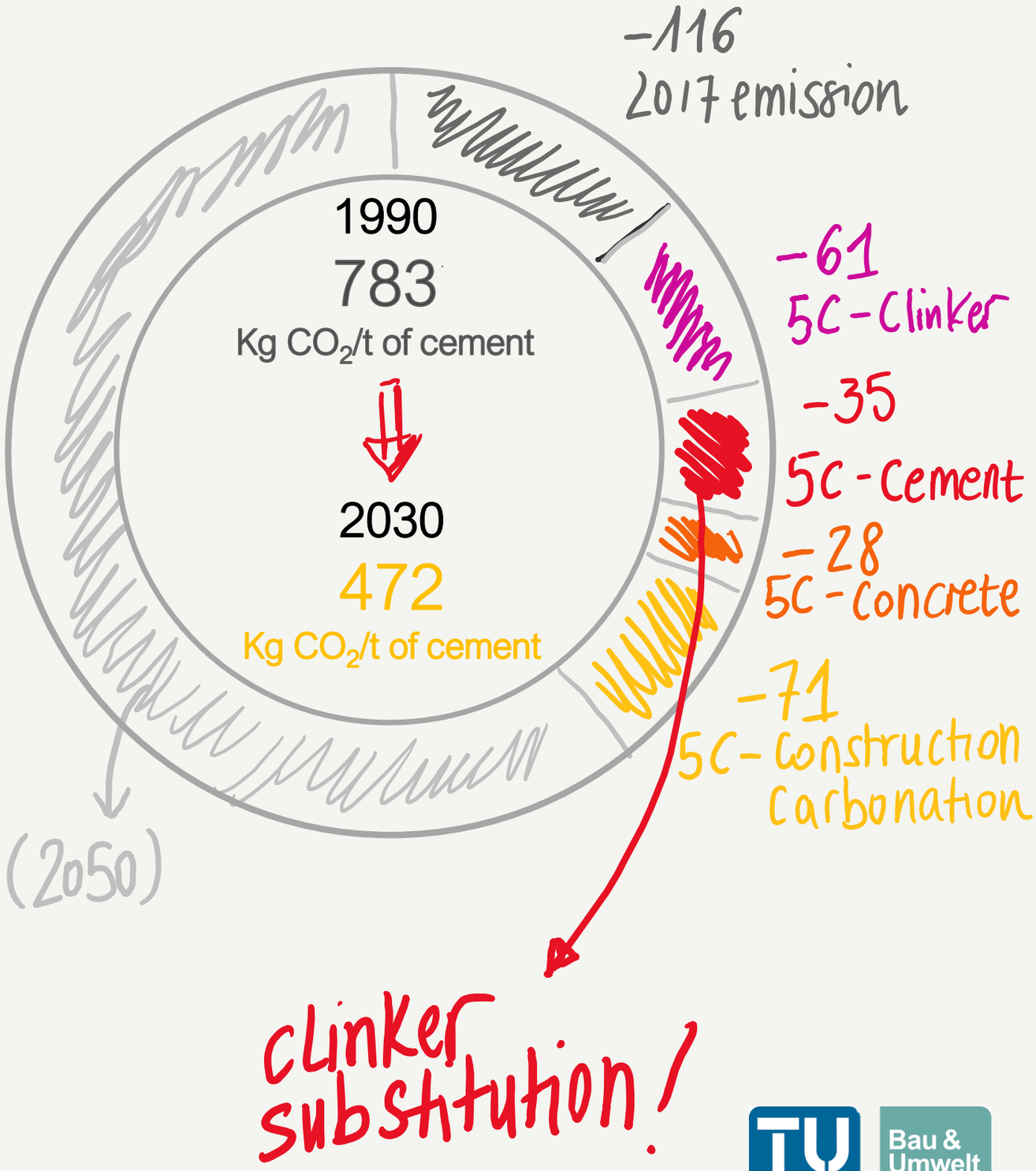
CEMBUREAU 2030 Roadmap



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Rheology to study the cohesion evolution (reactivity) of sustainable cementitious materials

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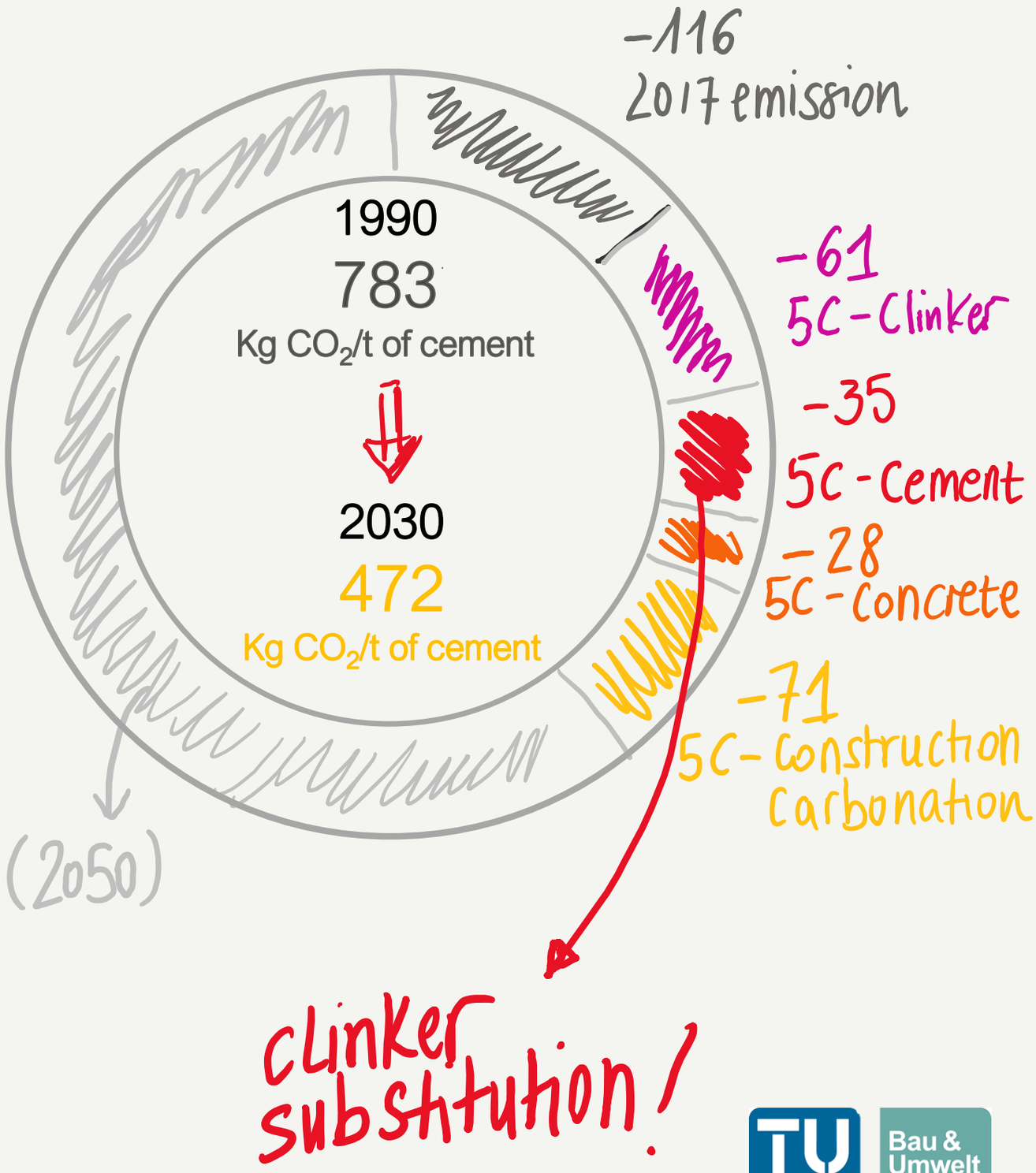
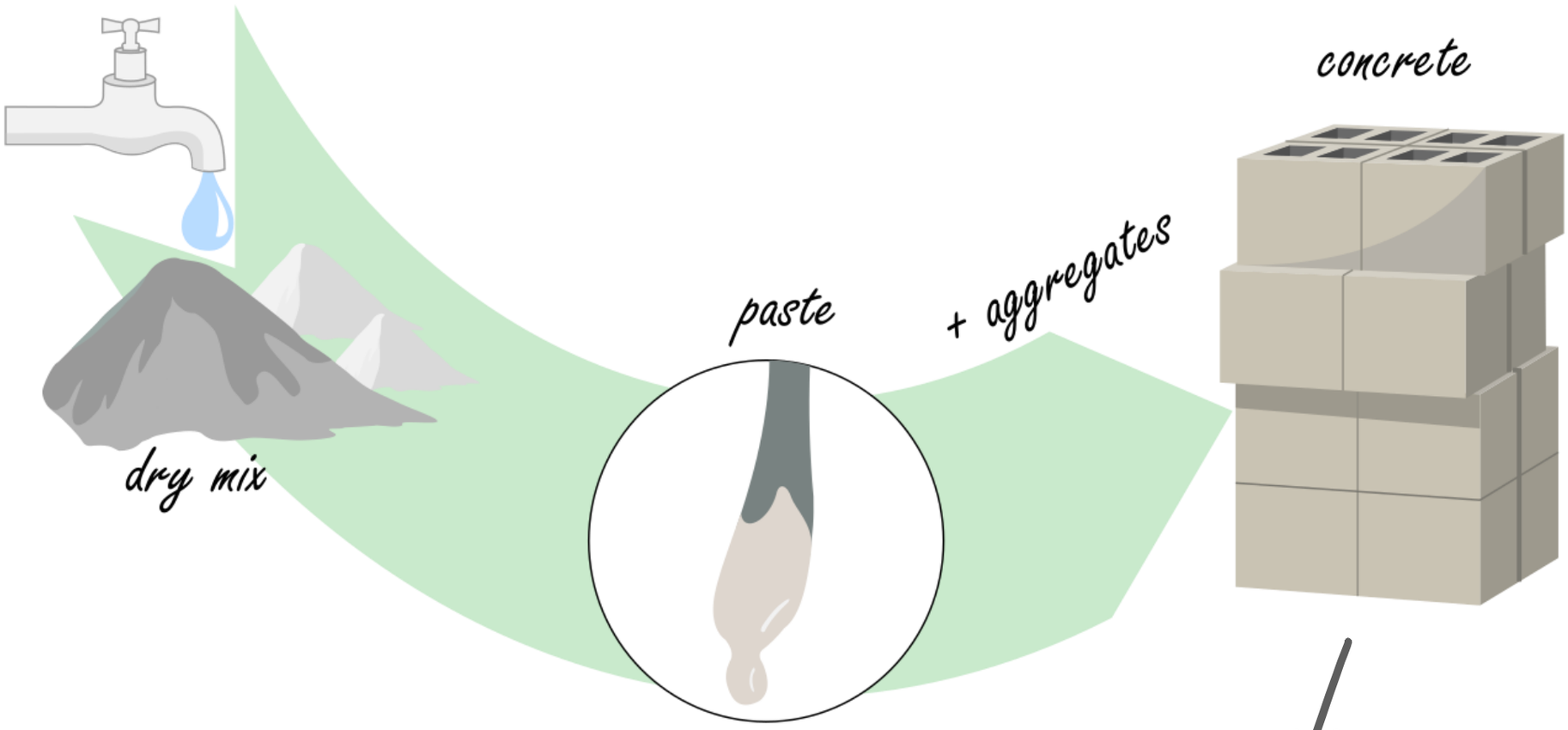
CEMBUREAU 2030 Roadmap



Partial/total clinker substitution

Supplementary Cementitious Materials (SCM): slag, fly ashes, clay…



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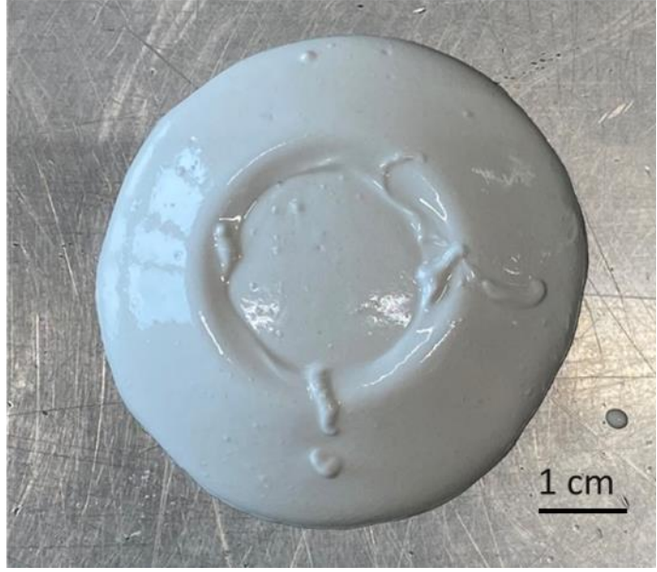

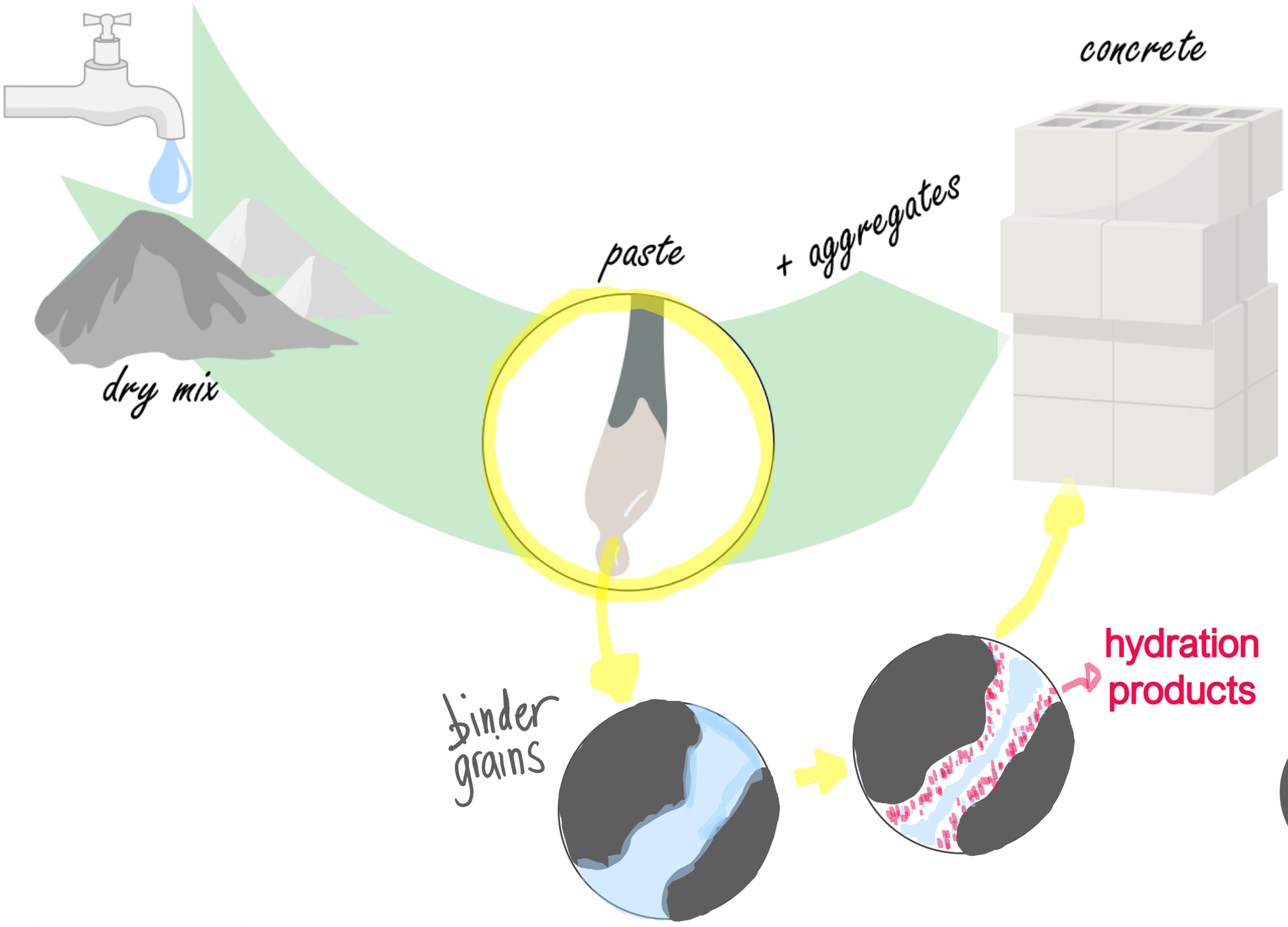

Partial/total clinker substitution

Supplementary Cementitious Materials (SCM):
slag, fly ashes, clay…

Measure the paste cohesion in time

concrete

paste + aggregates

dry mix

track hydration products formation

EARLY STAGE

binder grains

hydration products

1 HOUR

28 DAYS

PASTE COHESIVITY (↕)

Partial/total clinker substitution

Supplementary Cementitious Materials (SCM)
slag, fly ashes, clay…

Measure the paste cohesion in time

early reactivity

concrete

paste + aggregates

dry mix

track hydration products formation

EARLY STAGE

binder grains

hydration products

1 HOUR

PASTE COHESIVITY (↕)

28 DAYS

Ongoing studies on low CO_2 binders

Measurements of hydration products

fresh paste RHEOLOGY

at **early age**

PASTE COHESIVITY (±)

&

solid MECHANICAL PROPERTIES

28 days +

= qualitative correlation!

Ongoing studies on low CO_2 binders

Measurements of hydration products

fresh paste RHEOLOGY

at **early age**

&

solid MECHANICAL PROPERTIES

28 days +

= qualitative correlation!

Slag (GGBS)

(local) CLAY

Recycled Bricks

Recycled Concrete

Biochar

Liberto, T., Dalconi, M.C., Dal Sasso G., Bellotto, M., Robisson A. (2023), *Journal of American Ceramic Society.*
Streit E., Liberto, T., Kirchengast, I., Korjenic, A. (2023), **Bauphysik**
Daneshvar, D., Liberto, T., Dalconi, Stöllinger, W., Kirnbauer, J., Robisson A. (2023), *Case Studies in Construction Materials.*
Liberto, T., Nenning, A., Bellotto, M., Dalconi, M. C., Dworschak, D., Kalchgruber, L., ... & Dziadkowiec, J. (2022), *Langmuir.*
Liberto, T., Bellotto, M., and Robisson, A. (2022). *Cement and Concrete Research.*

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Ongoing studies on low CO_2 binders

A novel approach toward a sustainable construction industry to select promising low CO_2 binders

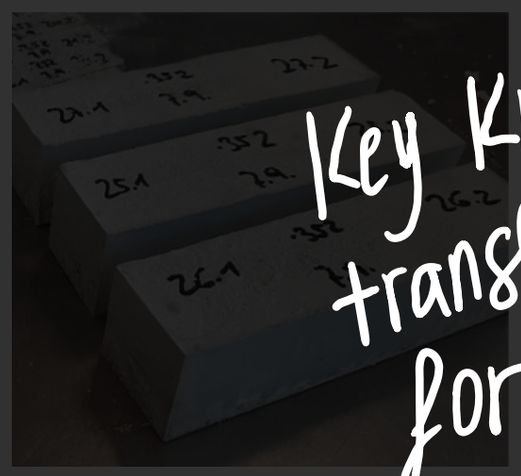
RHEOLOGY

at **early age**

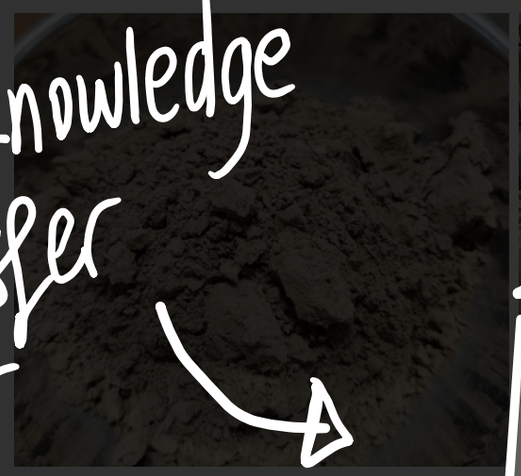
MECHANICAL PROPERTIES

28 days +

qualitative correlation!



Slag (GGBS)



(local) CLAY

Key knowledge transfer for

Biochar

Liberto, T., Dalconi, M.C., Dal Sasso G., Bellotto, M., Robisson A. (2023), *Journal of American Ceramic Society.*
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From left to right:
Dana Daneshvar, Subhransu Dhar, Johannes Kirnbauer, Jeannine Leimer, Benedetta Costa, Matthias Pudelko, Benjamin Marksteiner, Agathe Robisson, Michaela Herndl, Karl Deix, Teresa Liberto, Meriton Ramizi

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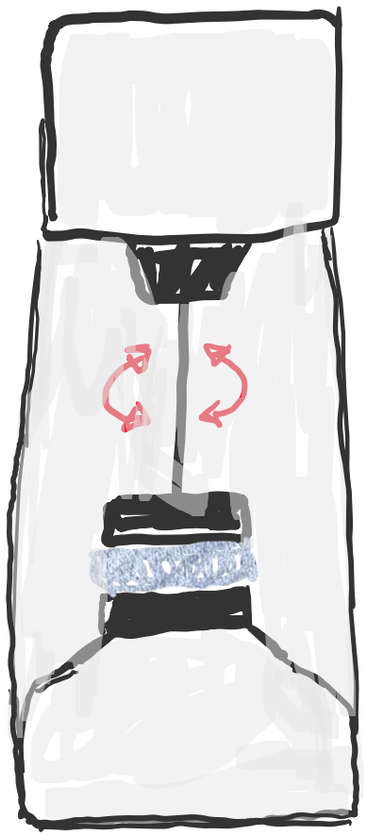
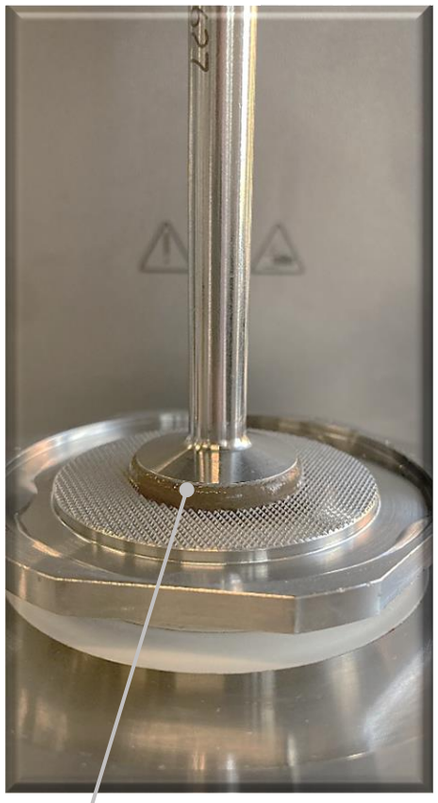
https://www.bs.tuwien.ac.at/home/

Backup slides

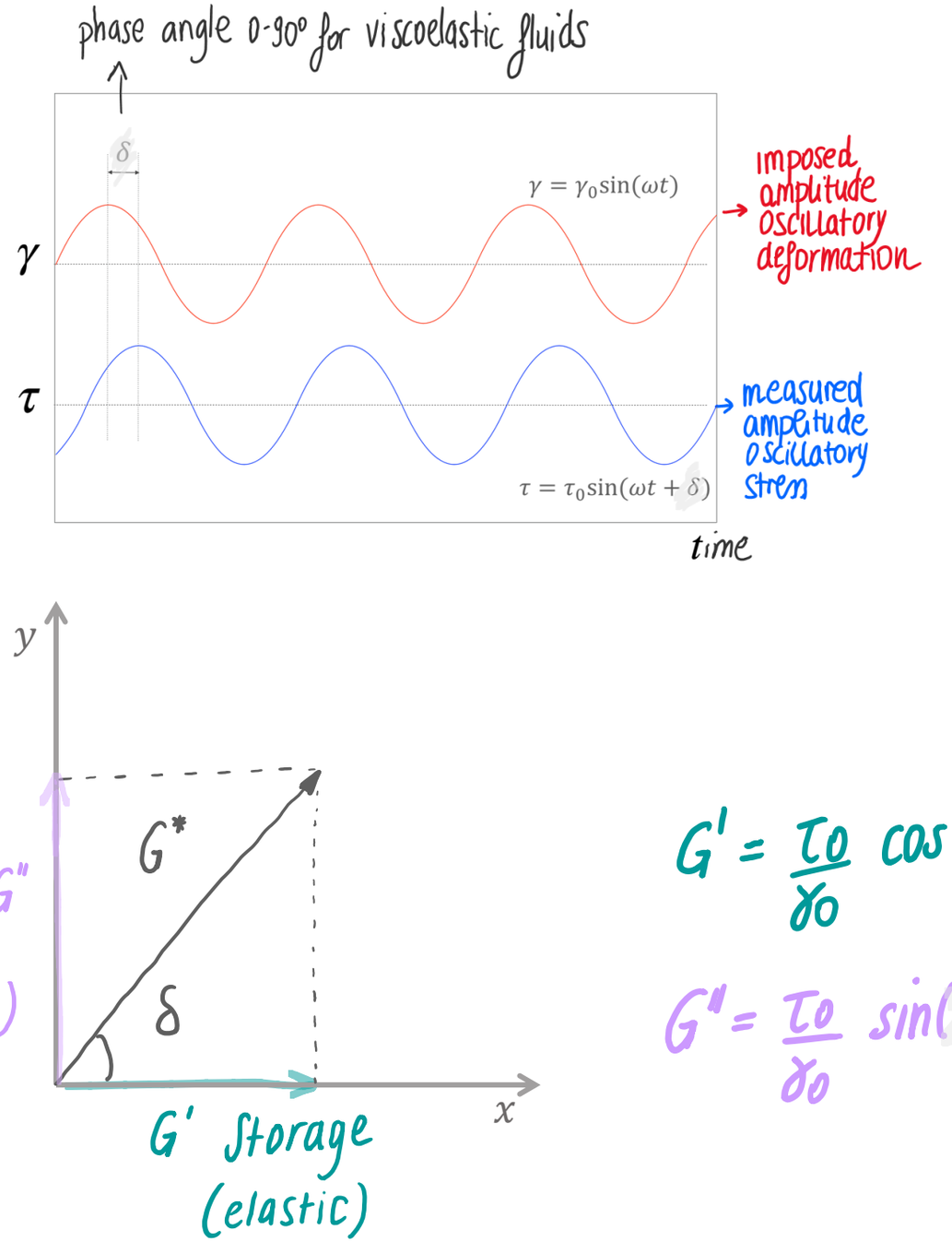
SAOS: small amplitude oscillatory shear



Min torque 0.5 nNm
(Max 230 mNm)



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

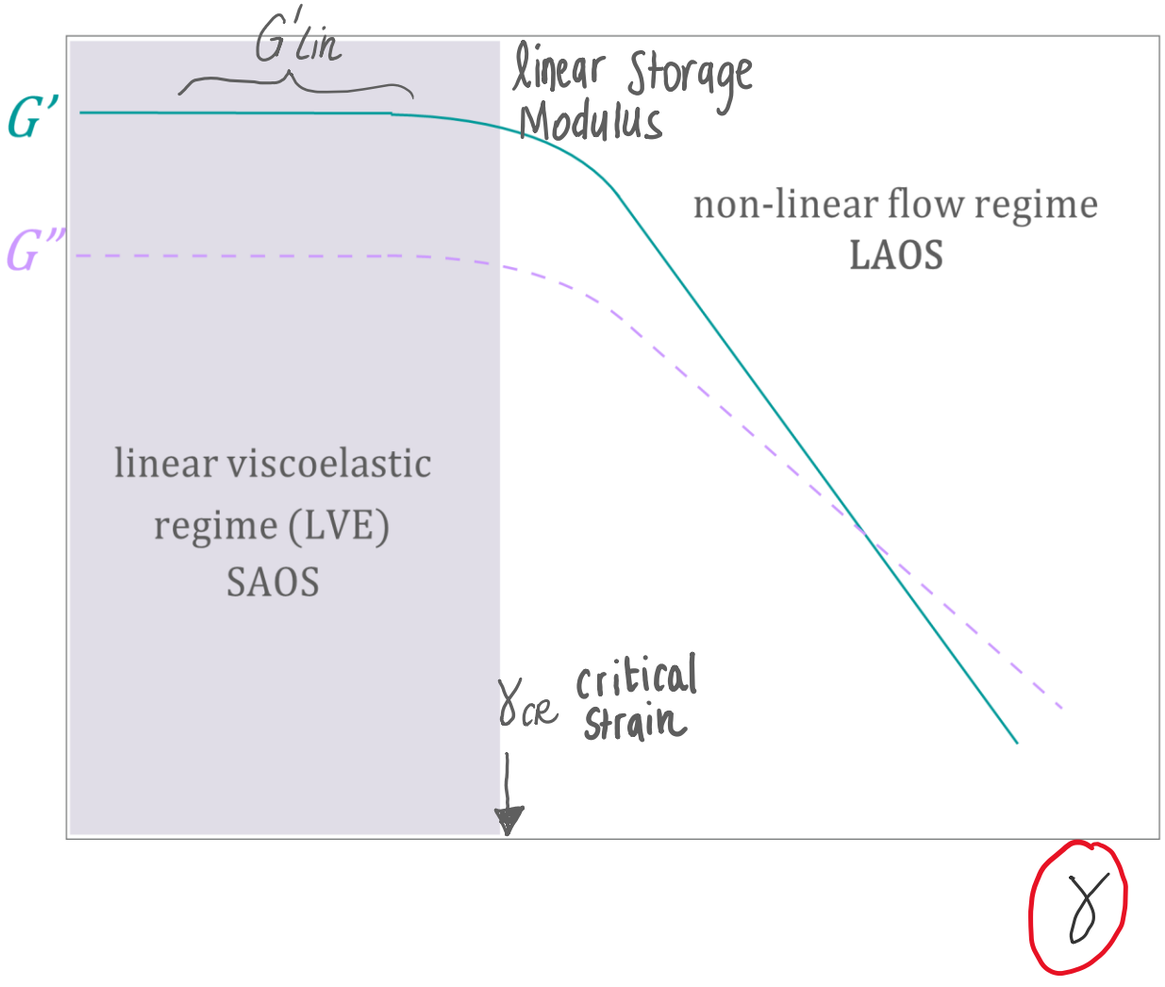


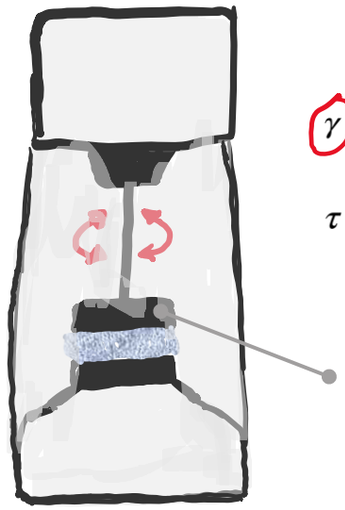
$$G' = \frac{\tau_0}{\gamma_0}\cos(\delta)$$

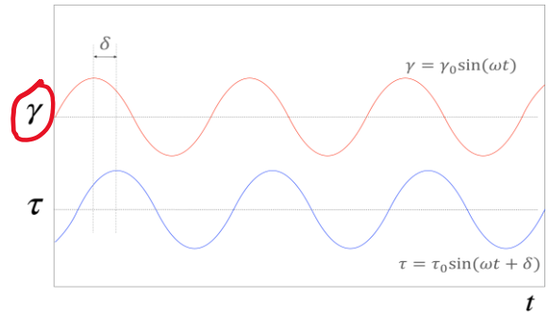
$$G'' = \frac{\tau_0}{\gamma_0}\sin(\delta)$$

SAOS: small amplitude oscillatory shear

- Amplitude Sweep

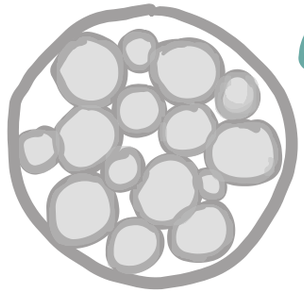






$$G^* = \frac{\tau^*(t)}{\gamma^*(t)} = G' + iG''$$

to probe the interaction at the nanometer scale

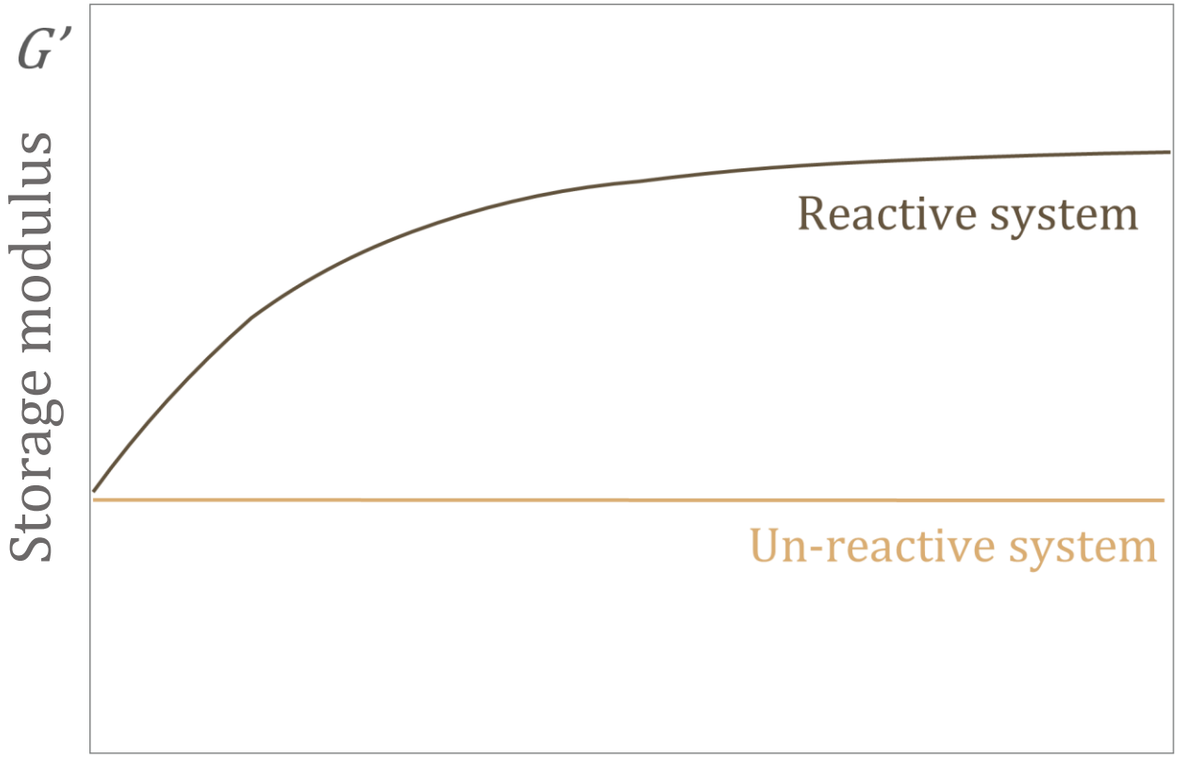


"at rest" G'Lin, γcr

- Range of amplitude oscillatory deformation γ = 10^{-5} - 1
- Constant frequency (1Hz)
- Fresh sample (duration <2-3 minutes)

SAOS: small amplitude oscillatory shear

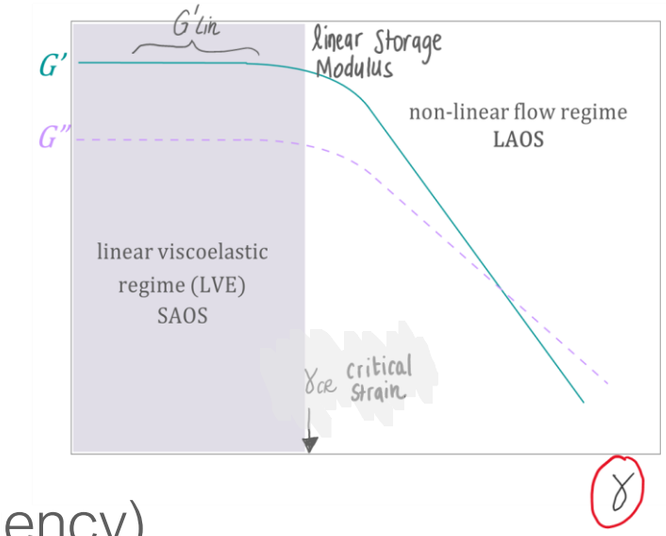
- Time Structuration



after 1h of testing:

to follow the structural buildup of the paste (physico-chemical evolution)

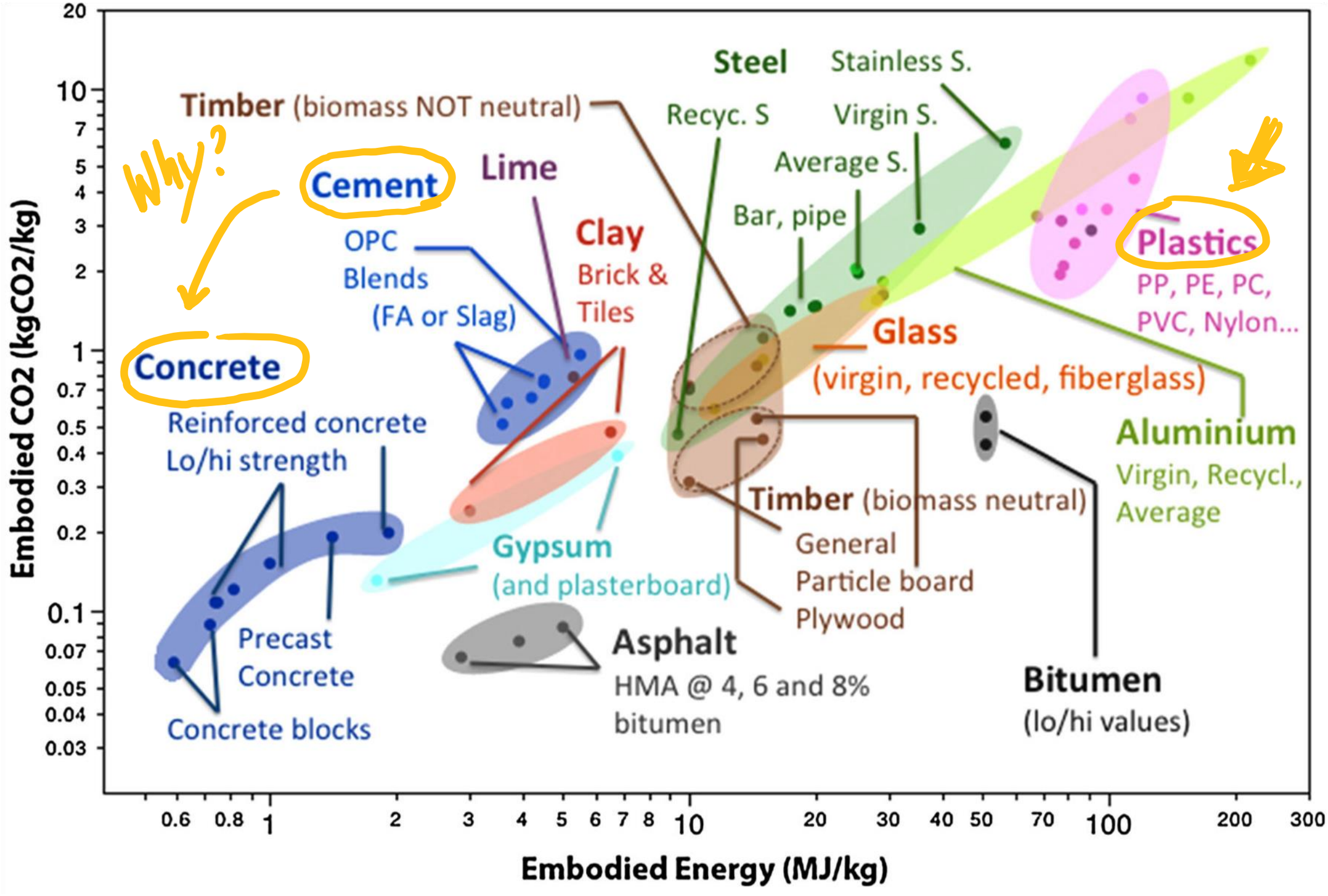
- Amplitude Sweep



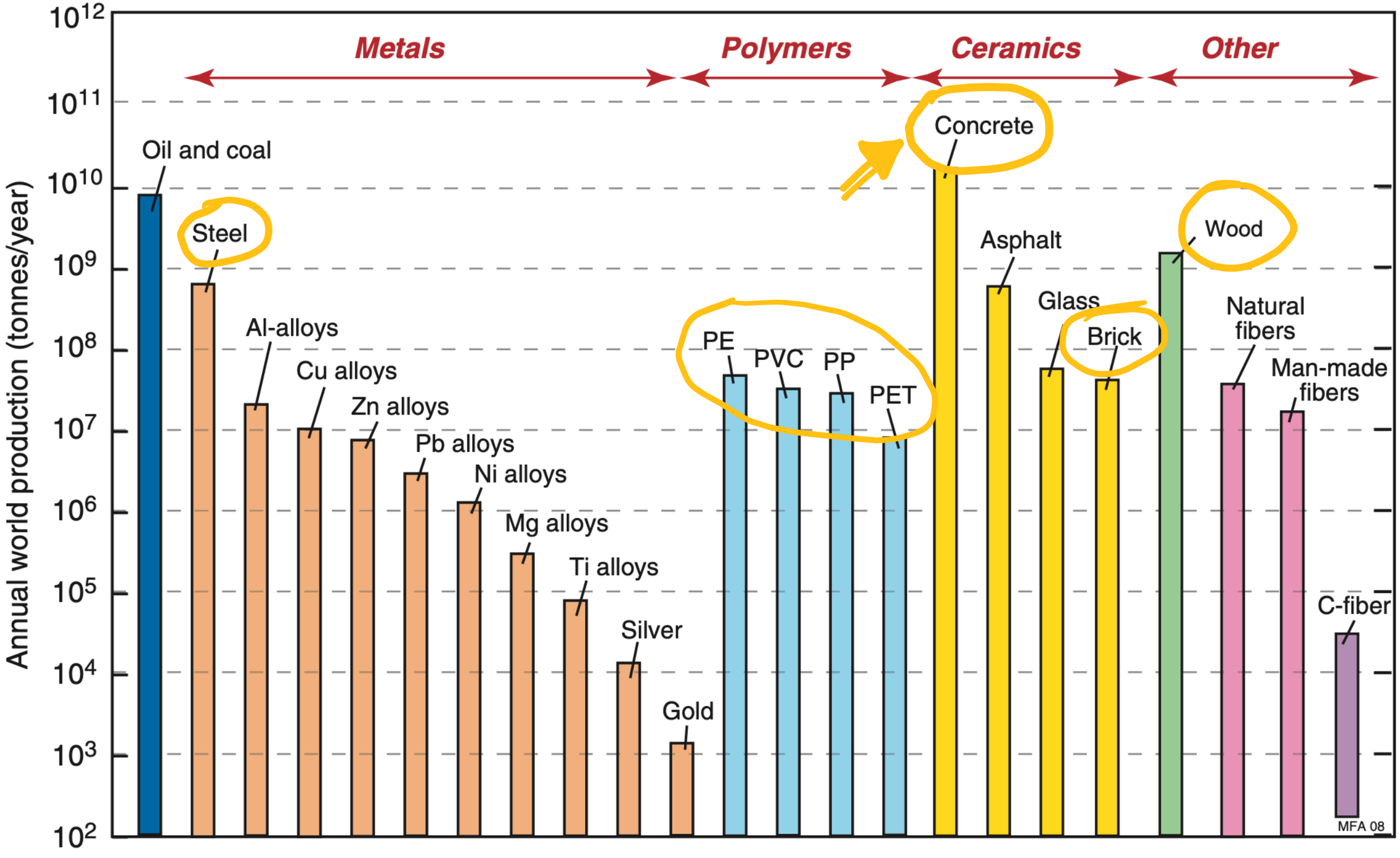
  - Imposed (small) amplitude deformation $\gamma < \gamma_{ce}$ (at a fixed frequency)

What is the difference?

Why?



Barcelo et al. Mater Struct. (2014)



M. F. Ashby, Materials and the Environment, 2009