Sicherheit in Technik und Chemie

Bundesanstalt für Materialforschung und -prüfung

10.03.2021

POTENTIALS OF POLYSACCHARIDES TO CONTROL THE RHEOLOGY OF CONCRETE

Wolfram Schmidt

www.bam.de

Congratulations – 30 years of Conference Series "Rheology of Building Materials"

https://www.150.bam.de

Thank you for 30 years of

- Interesting talks
- Exciting discussions
- Hosting the "rheology family"

Photo: Schleibinger

Photo: Schleibinger

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Polysaccharides

Role of polysaccharides in rheology

Past presentations on polysaccharides on this conference by the presenter:

- Influences of modification (2011)
- Casting robustness (2015)
- Sustainability(2017)

2011

2015

2017

Polysaccharides

Role of polysaccharides in rheology

Past presentations on polysaccharides on this conference by the presenter:

- Influences of modification (2011)
- Casting robustness (2015)
- Sustainability(2017)
- Future casting technologies will require new admixture groups that can tailor the rheology at every process step.

https://tu-dresden.de/bu/bauingenieurwesen/ifb/forschung/spp2005

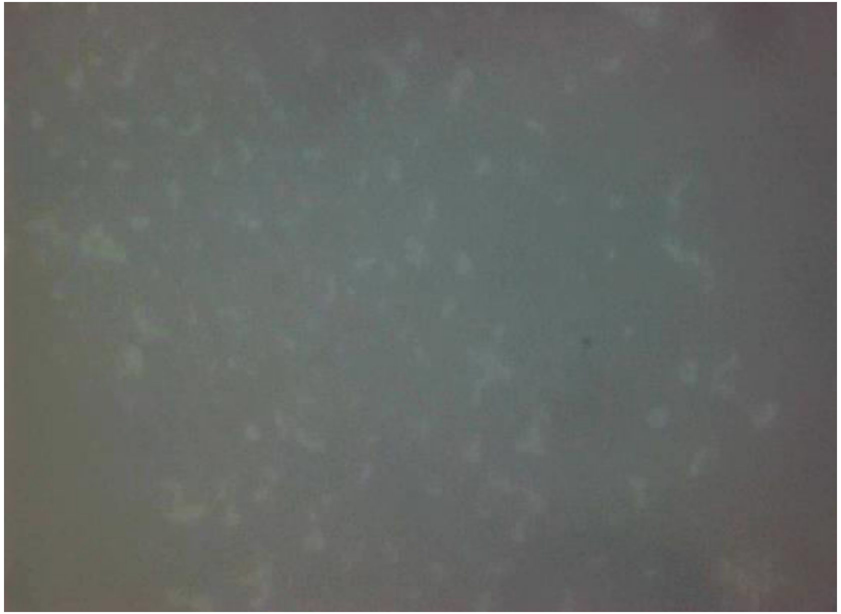
Polysaccharides

Role of polysaccharides in rheology

Superplasticizers can disperse particles and thus reduce the yield stress.

This alone cannot sufficiently create the rheological specifications required for more industrialised processing.

Polysaccharides can become an important group of novel agents in concrete technology.

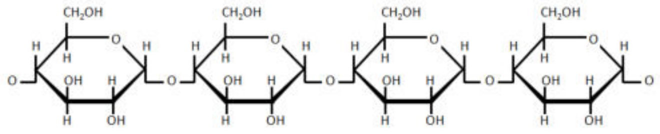


Polysaccharides

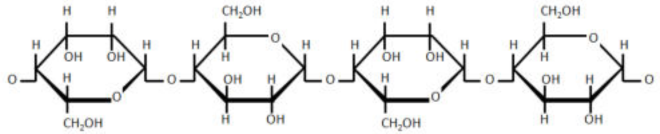
What are polysaccharides?

- Polysaccharides are macromolecules consisting of monosaccharides (sugar)
- The most important ones occurring in nature are cellulose and starch, which consist of glucose only.

Starch



Cellulose



Polysaccharides

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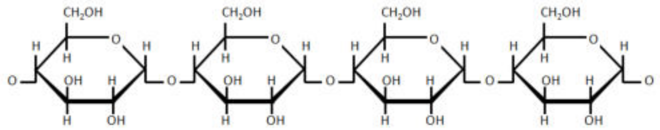
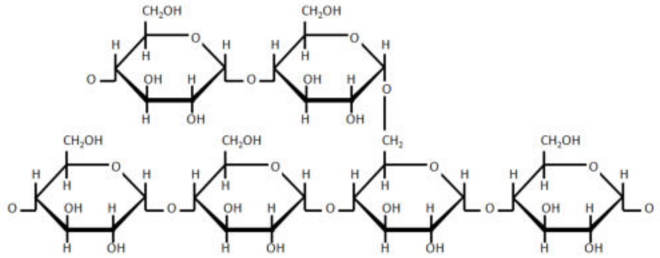
- The most important ones occurring in nature are cellulose and starch, which consist of glucose only.

- Often polysaccharides are branched.

Starch



Amylose (linear, small)



Amylopectin (branched, huge)

Polysaccharides

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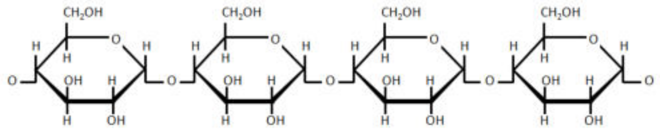
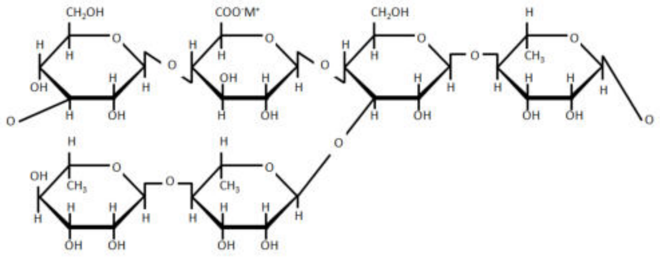
- Often polysaccharides are branched.
- More complex polysaccharides used in construction are e.g. diutan gum and guar gum

Starch



Diutan gum

Glucose Glucuronate Glucose Rhamnose



Rhamnose Rhamnose

Starch

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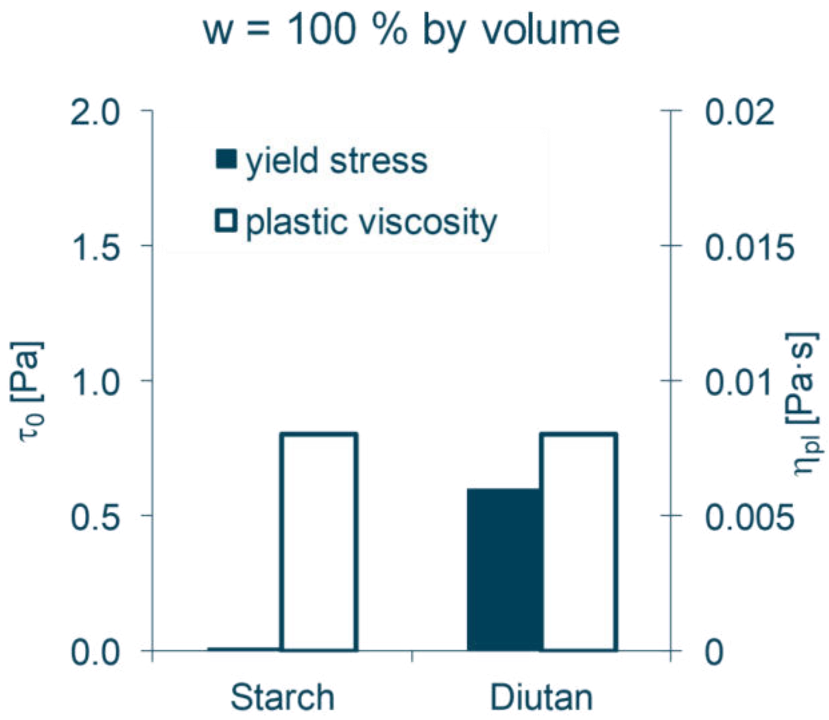
Starch

Effect in liquid phase



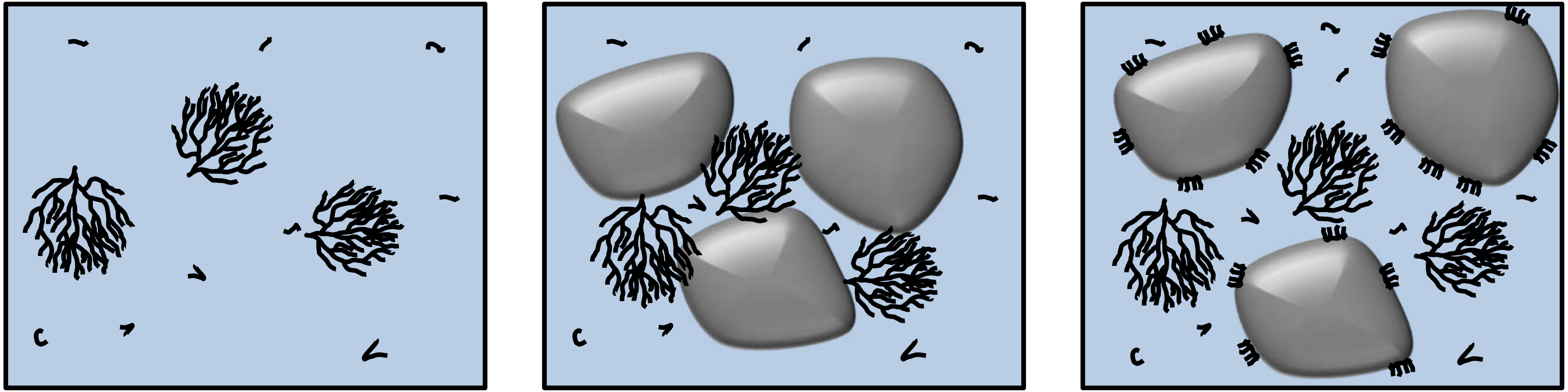
Starch

Diutan gum

Starch

Peculiarity of starch

No particles | **In presence of particles** | **In presence of PCE**

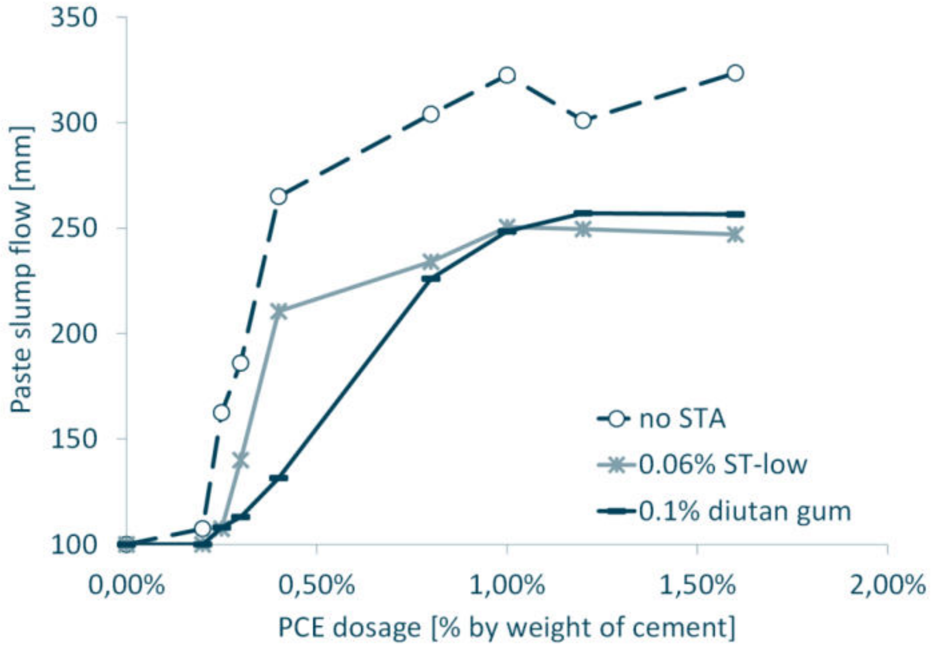


Starch

Yield stress and particle interactions

- With increasing particle volume fraction, the effect of starch becomes stronger.

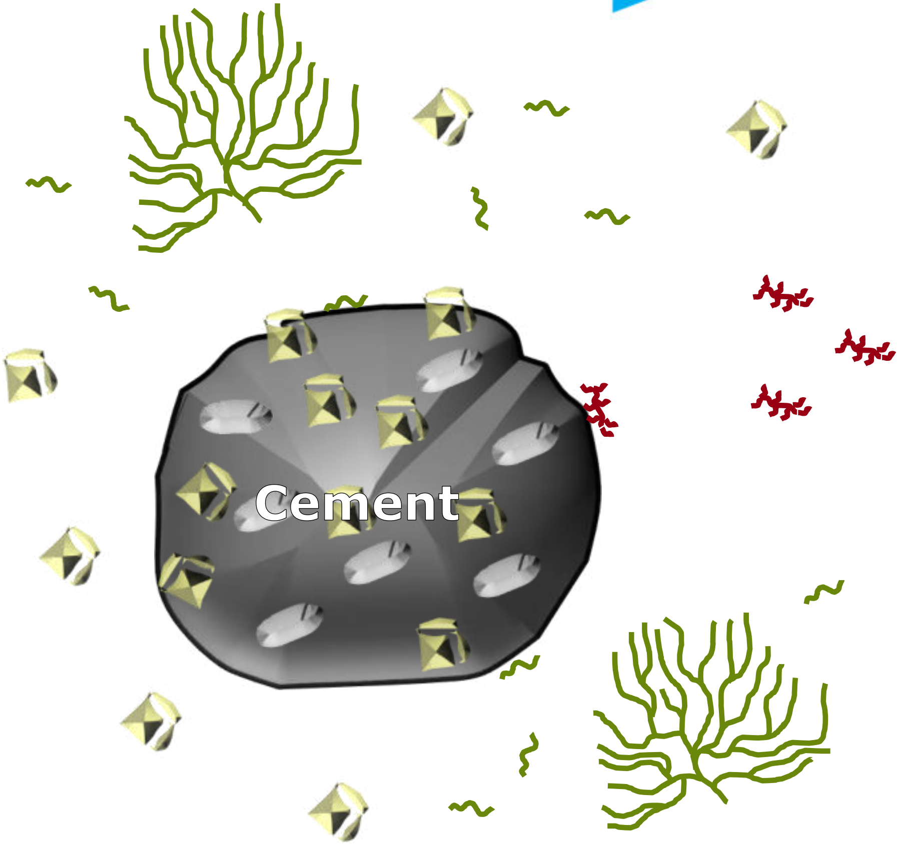
- At very low w/p it is stronger than diutan gum.



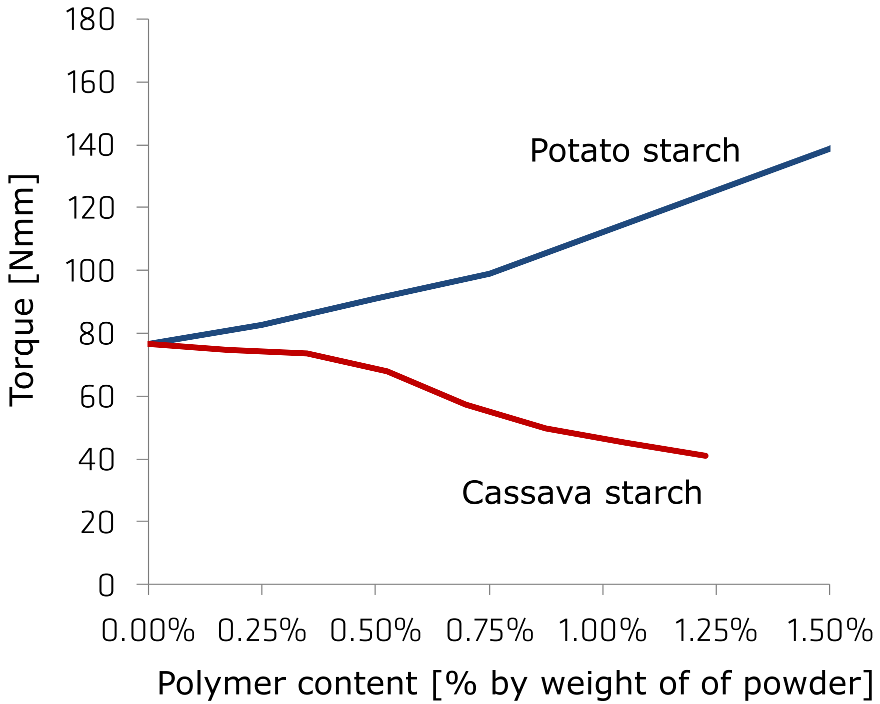
Starch

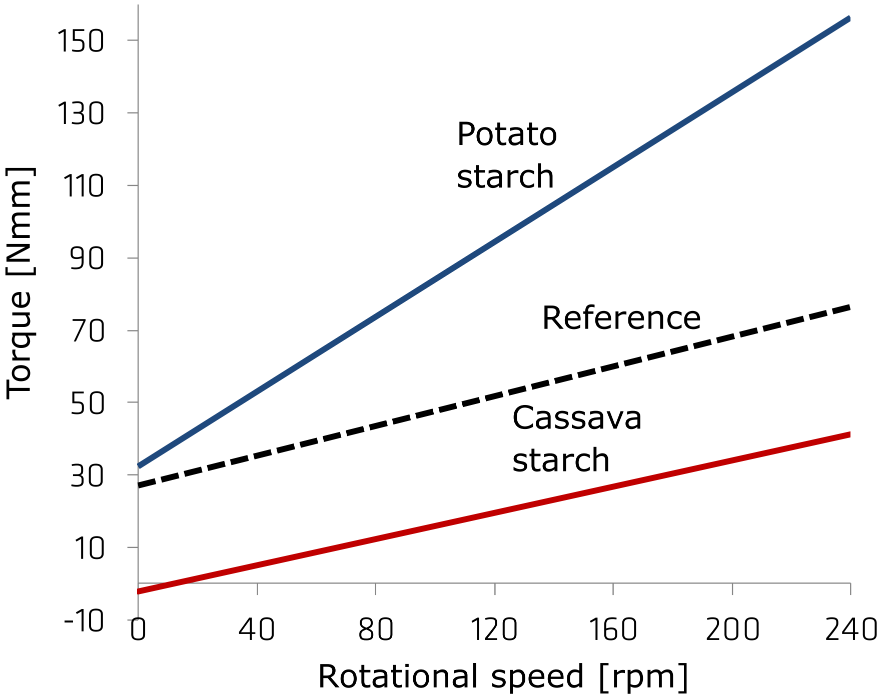
Influencing factors

- Application (liquid/solid)
- Ratio of amylose and amylopectin
- Size and/or Mw of amylopectin
- Mode of modification
- Degree of substitution
- Presence of other polymers, e.g. PCE
- Adsorption
- Time / cement hydration



Starch
Role of polysaccharides in rheology





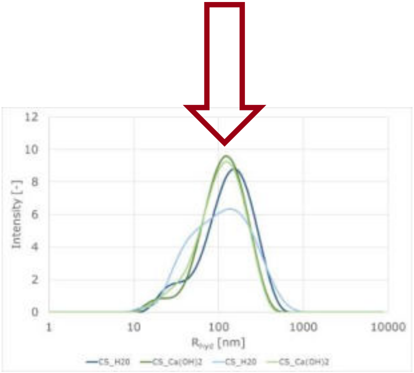
Starch

Role of polysaccharides in rheology

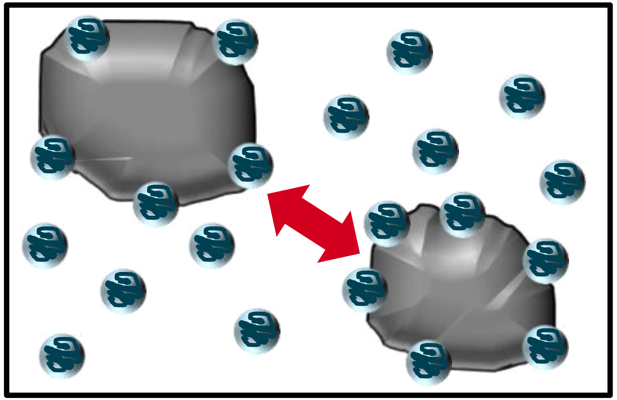
Cassava starch

→ Negative zeta potential with Ca^{2+}

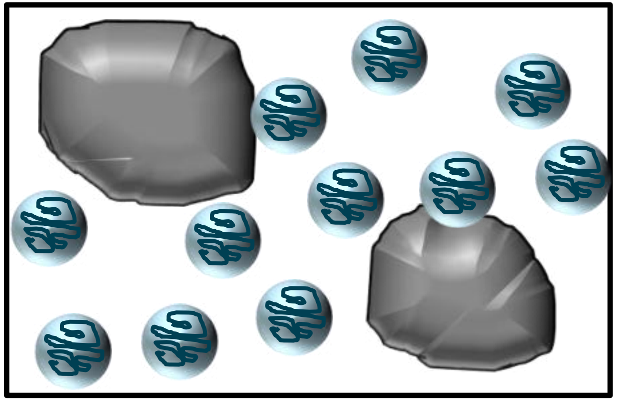
→ R_{hyd} ~ 100 nm



Cassava



Potato



Starch
Role of polysaccharides in rheology

https://youtu.be/4H-0R75Zyv0?list=PLKqa3Uo_GQNs0mogyrcCYusuYtbJWOcT3

Starch

Role of polysaccharides in rheology

Potentials:

- inexhaustible global availability
- great variability
- low cost

https://youtu.be/4H-0R75Zyv0?list=PLKqa3Uo_GQNs0mogyrcCYusuYtbJWOcT3

Acacia gum

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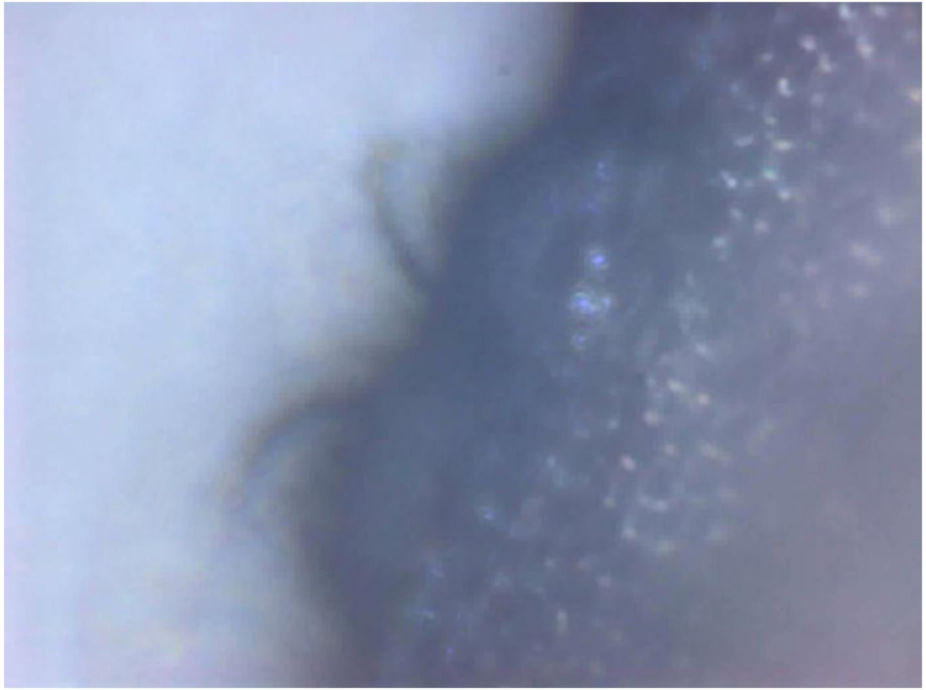
Acacia gum

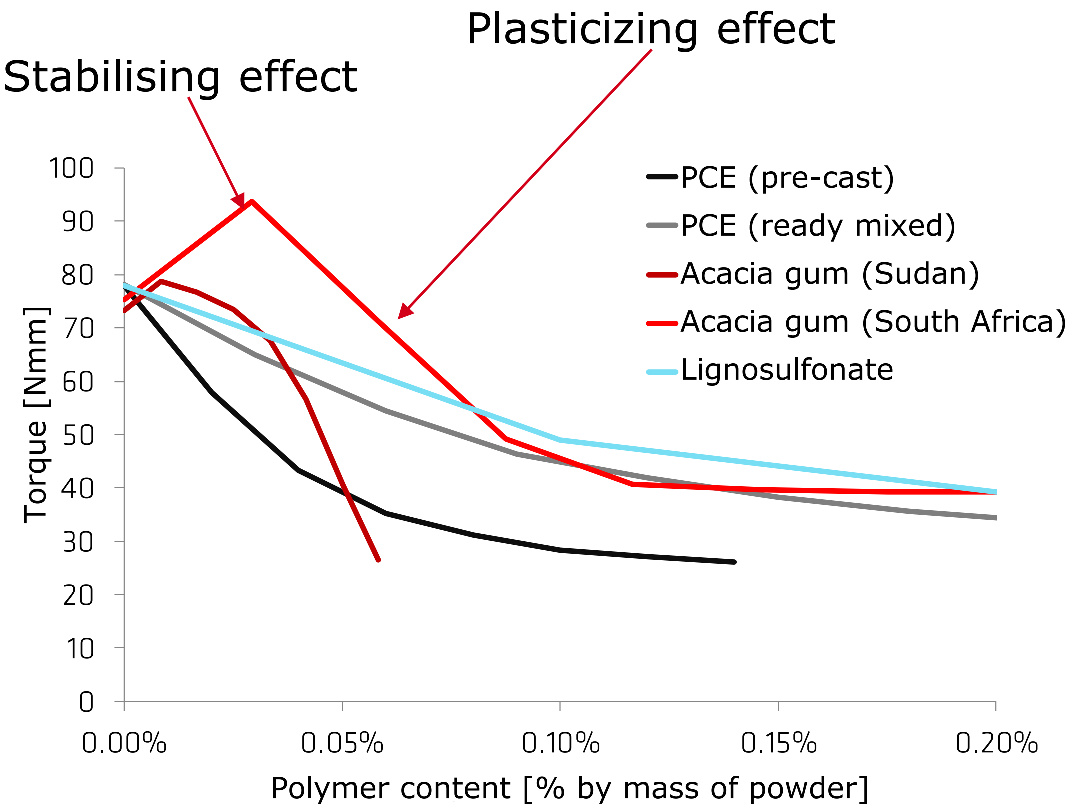
Typical uses and properties

- Easily water soluble gum
- Grows in the tropical and subtropical regions of Africa, India, and the Americas
- Typical use in food industry and cosmetics
- ¾ of the global consumption is produced in Sudan



Acacia gum

Effect in cementitious materials

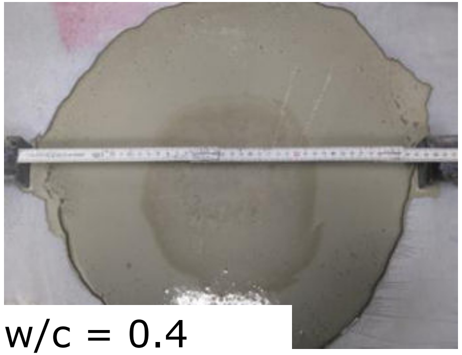


Acacia gum
Performance specifications

Workabilty depends on:

- Dosage of gum
- Mixing intensity
- Mixing duration
- Particle volume fraction
  - No plasticizing effect at very low w/c
  - Plasticizing effect at moderate w/c

w/c = 0.3
0.35% GA



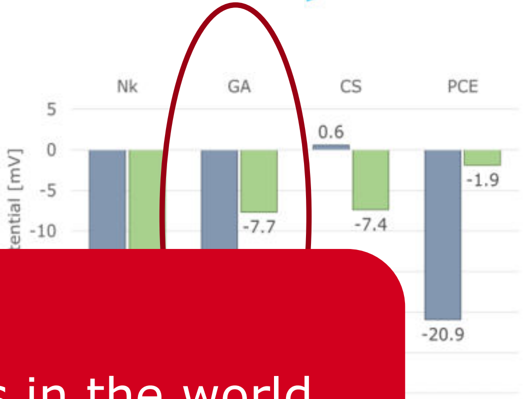
w/c = 0.4
0.35% GA

Acacia gum
Performance specifications

Acacia gum

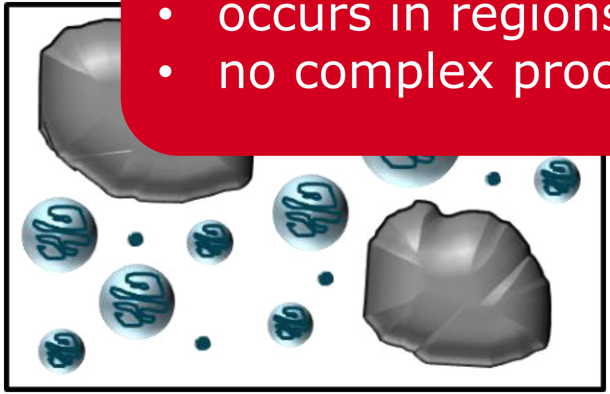
→ Negative zeta potential

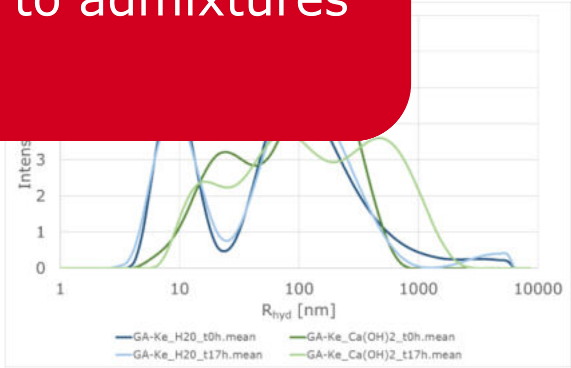
→ W



Potentials:

- not yet commercialised in many regions in the world
- occurs in regions with restricted access to admixtures
- no complex processing required





Triumfetta pendrata A. Rich

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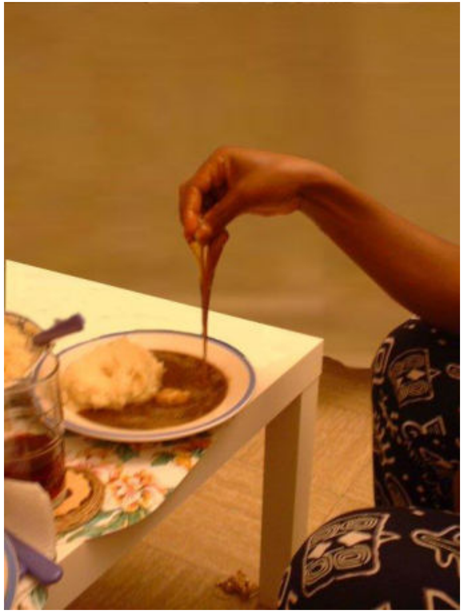
Triumfetta pendrata A. Rich

What is it?



Par Tatoute — Travail personnel,
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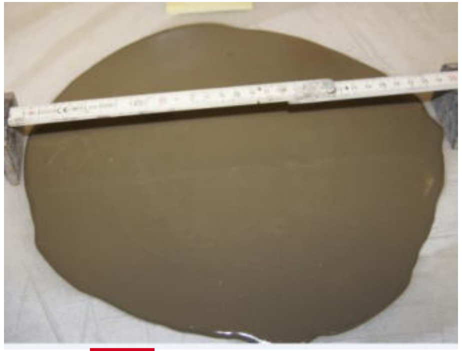
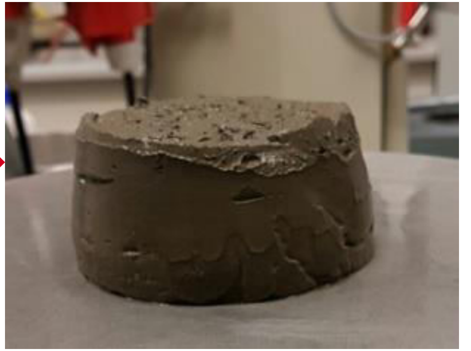
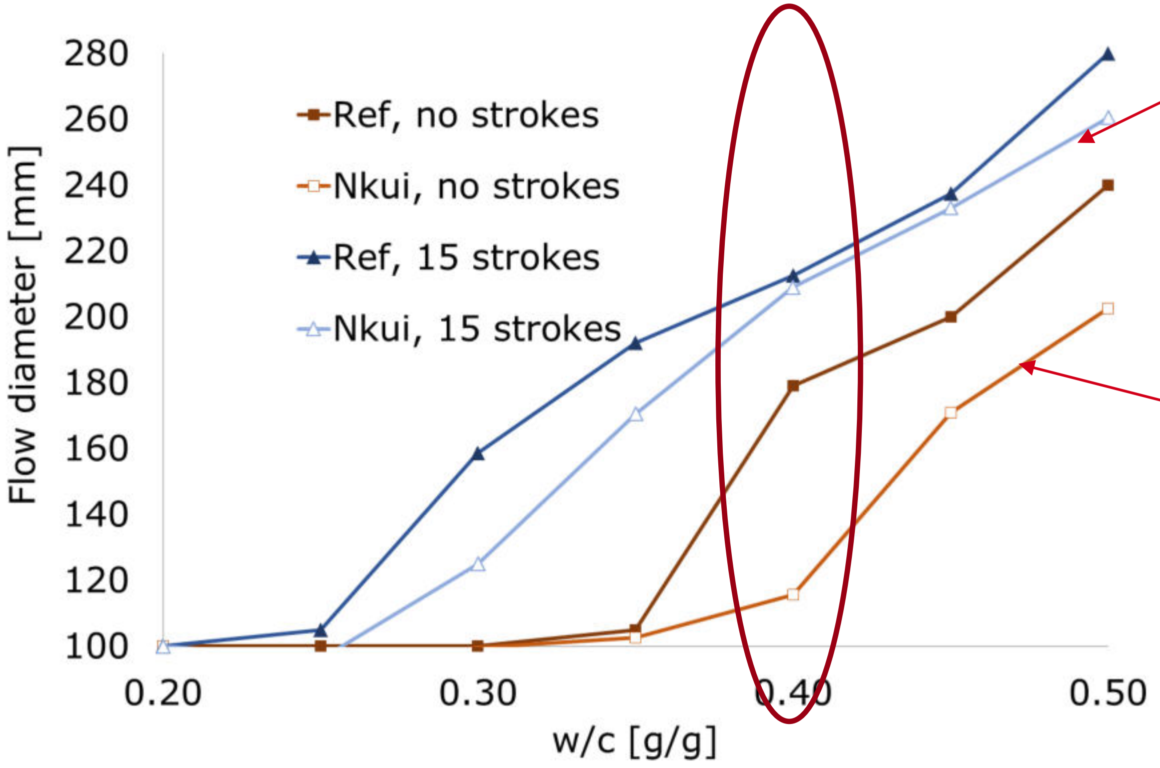


0.08% Nkui



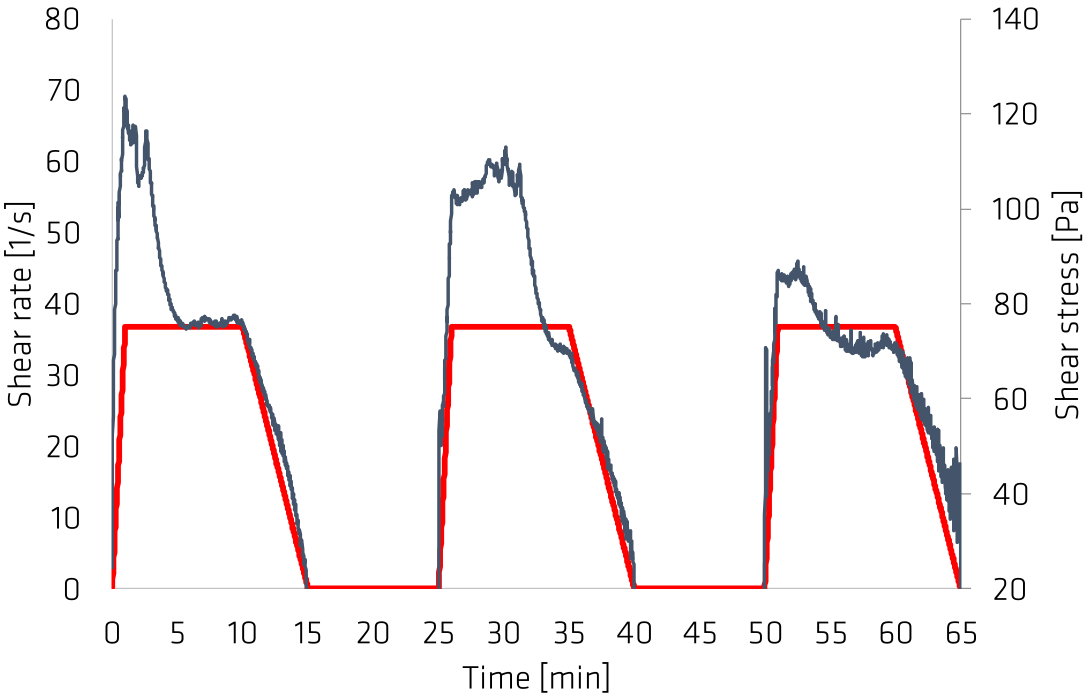
Triumfetta pendrata A. Rich
Thixotropy



Similar flowability after 15 x lifting and dropping

Significant flow reduction only under gravity load

Triumfetta pendrata A. Rich
Thixotropy

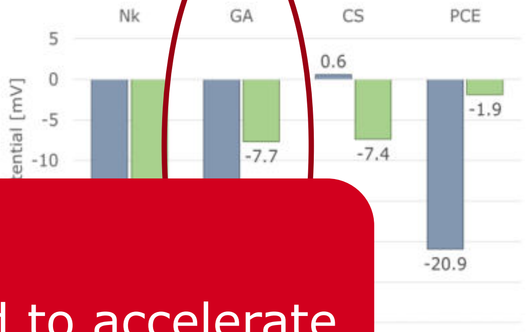


Triumfetta pendrata A. Rich
Thixotropy

Triumfetta pendrata A. Rich

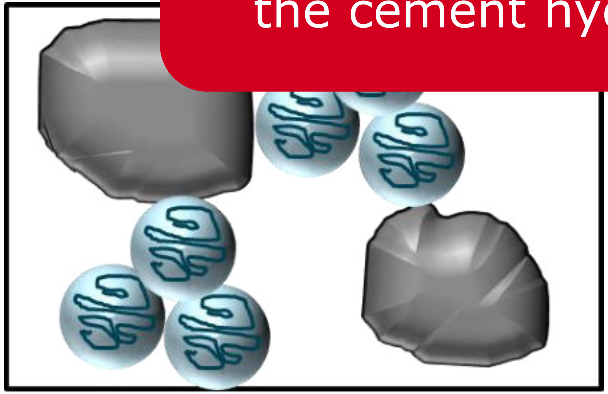
→ Negative zeta potential

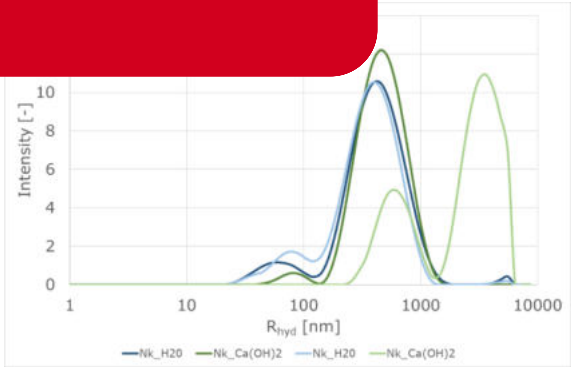
→ Wit



Potentials:

- Rapid structural build-up without need to accelerate the cement hydration





Summary and outlook

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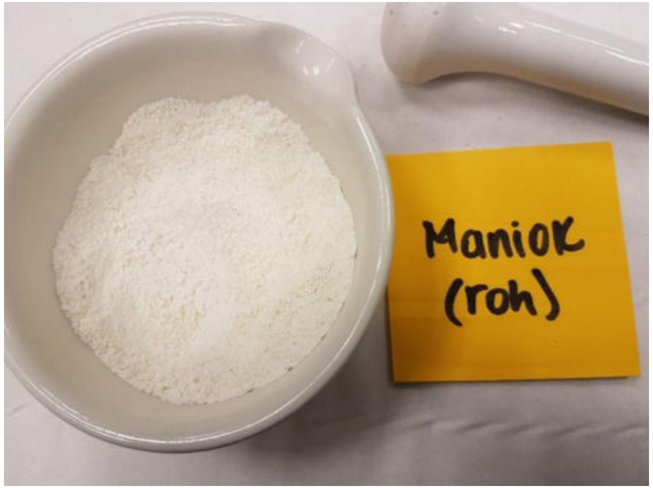
Summary and outlook

Biopolymers vs. synthetic polymers

Polysaccharides have enormous potentials as rheology modifiers

- Starch
- Acacia gum
- Bark gum of Triumfetta

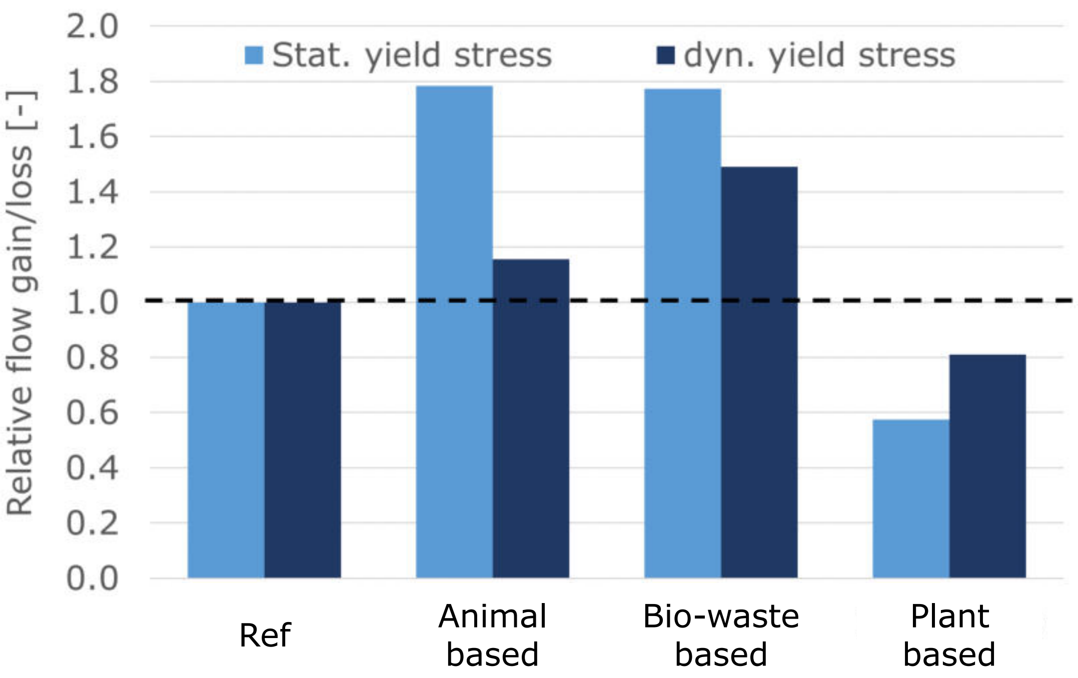


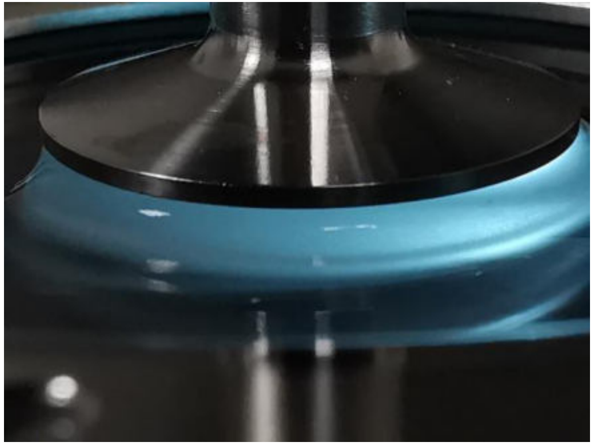
The approach is different from synthetic polymers, which can be tailored to the application:

1. first understanding of basic mode of operations
2. Identify ideal use

Summary and outlook

New sources need to be identified

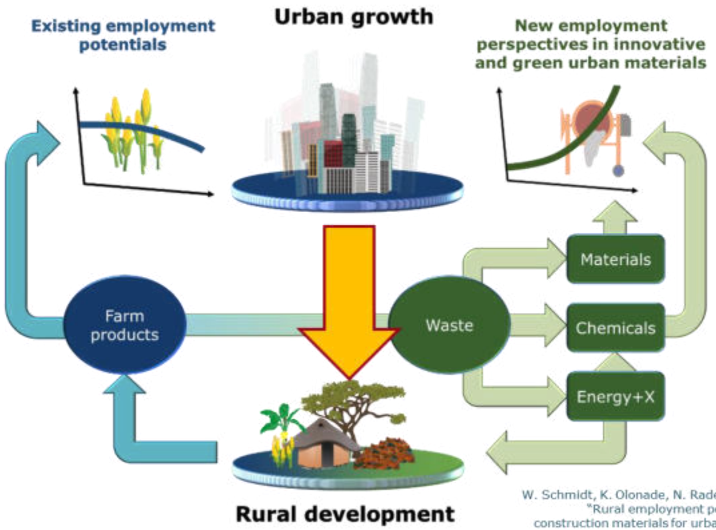




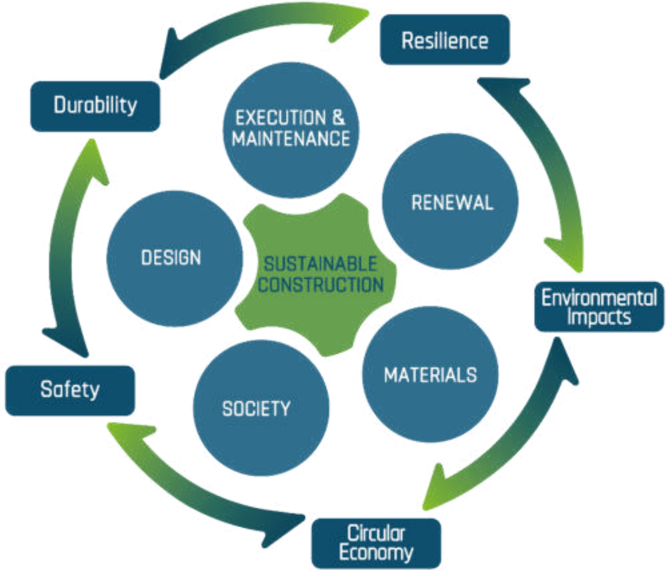
Summary and outlook
Sustainability potentials

GLOBE Global Consensus on Sustainability in the Built Environment

Circularity – environment - socio-economic equity



W. Schmidt, K. Olonade, N. Radebe, F. Zando, and V. Ssekamatte, "Rural employment perspectives from susainable, green construction materials for urban development, 6/2020," Rural 21



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Thank you for your attention.

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