BAM
Bundesanstalt für Materialforschung und -prüfung

Sicherheit in Technik und Chemie

21.02.2017

RHEOLOGY MODIFYING ADMIXTURES FOR CONCRETE TAKEN FROM NATURE

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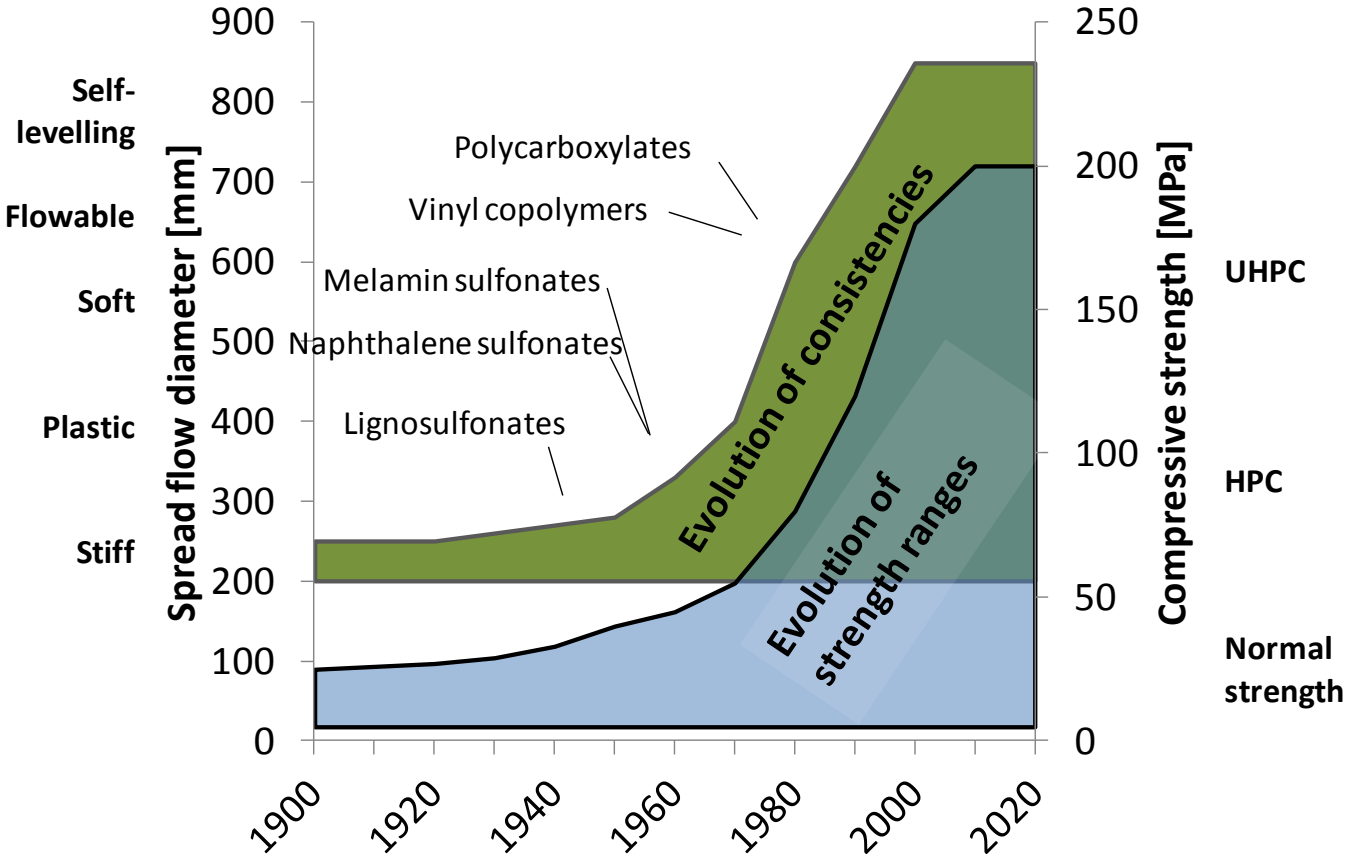
Introduction

Introduction

Relevance of rheology modifying admixtures

– **Strength evolution**



Introduction

Relevance of rheology modifying admixtures

- **Strength evolution**
- **New casting technologies**

Introduction

Relevance of rheology modifying admixtures

- **Strength evolution**
- **New casting technologies**
- **New architecture**

www.bewegteflaeche.de

phæno
by Zaha Hadid, Source: Wikipedia

Introduction

Relevance of rheology modifying admixtures

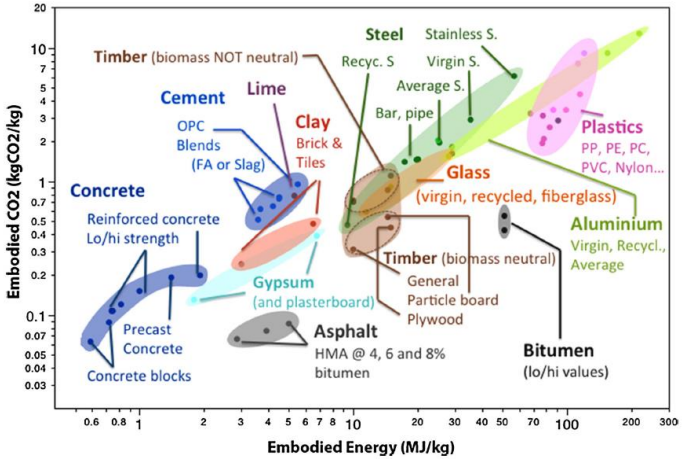
- **Strength evolution**
- **New casting technologies**
- **New architecture**
- **Special applications**

Source: BAM

Introduction

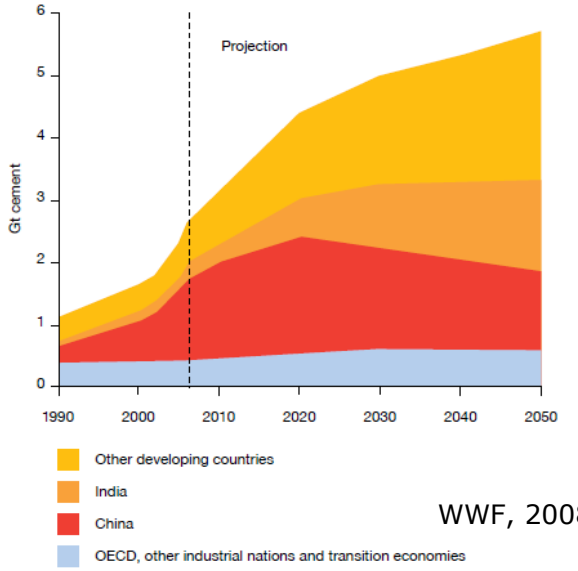
Relevance of rheology modifying admixtures

- **Strength evolution**
- **New casting technologies**
- **New architecture**
- **Special applications**
- **Sustainability and environmental friendliness**



Barcelo et al., 2014

Rheology modifying admixtures are the key to sustainable, and innovative construction.



WWF, 2008

Relevance of rheology modifying admixtures in Africa

Relevance for Africa

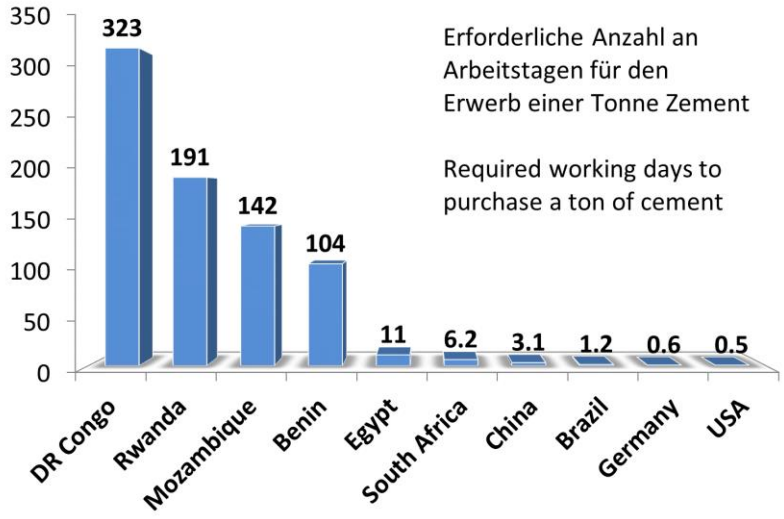
Economy and society

- Africa‘s economies grow at rapid pace.
- Investment in construction ensures ongoing growth and triggers new developments.
- The most crucial challenges are:
  - Infrastructure
  - Housing
- Construction business allows the population to participate in economic growth, and thus ensures social stability.
- Admixtures support efficient and sustainable construction.

Relevance for Africa

Affordable construction

- Cement is extremely expensive.
- Alternatives do exist, e.g.:
  - Rice husk ashes
  - Cassava peel ashes
  - Bagasse ashes
- But pozzolanic materials typically require admixtures to compensate for the higher water demand.



Msinjili, 2015

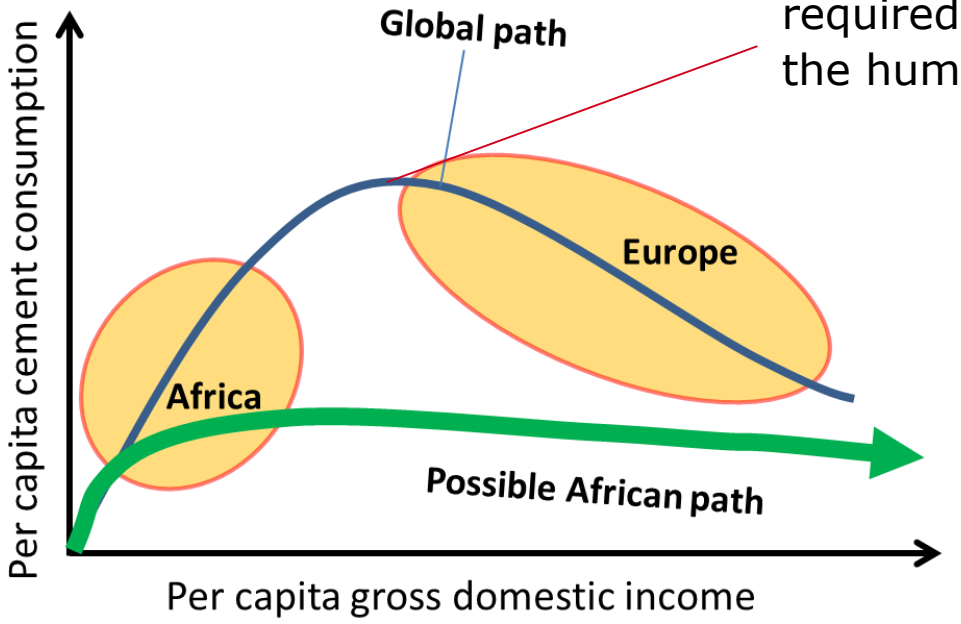
Olonade, 2015

Wikipedia

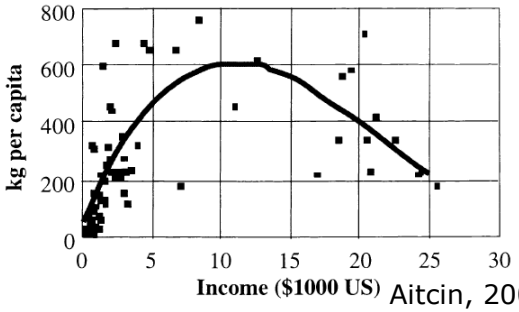
Relevance for Africa

Sustainability

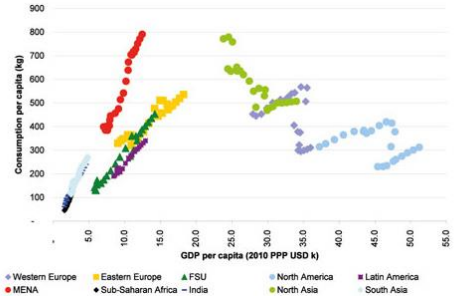
- Admixtures help to minimise the cement content as well as the w/c.
- Therefore today, the correlation between high cement content and good concrete does not hold true anymore.



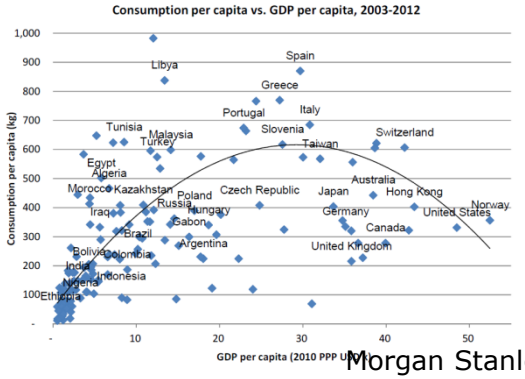
Admixtures required to avoid the hump



Aitcin, 2000



CEMNET, 2013

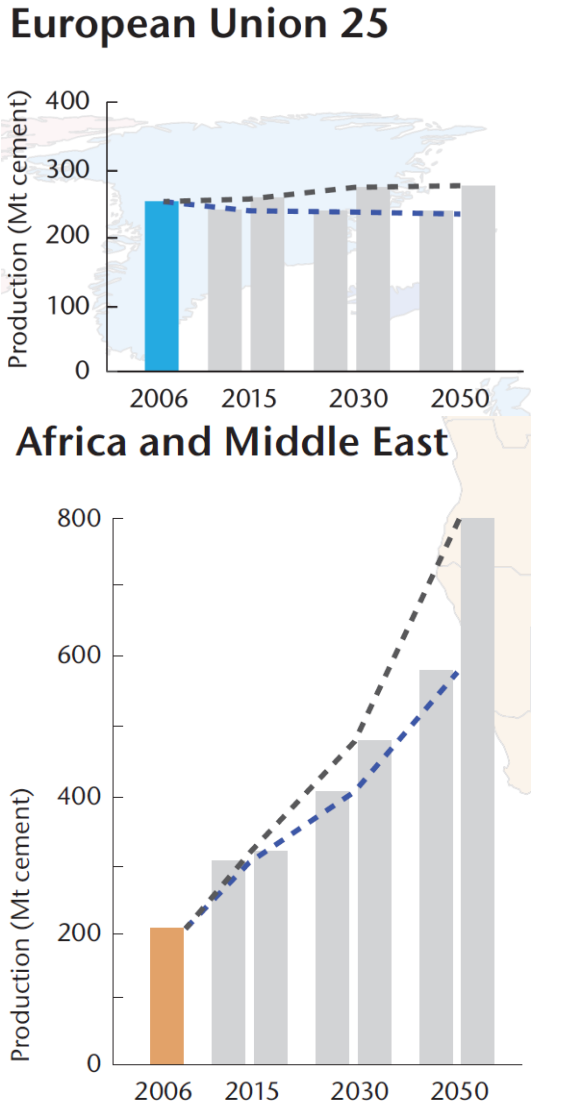


Morgan Stanley Research, 2015

Relevance for Africa

Global effects

- Hence, admixtures are of enormous relevance for the African continent.
- However, they are also extremely important for the global environment, since reasonable concrete technology will achieve the greatest momentum today in Africa.
- Sustainable concrete technology pays back a multiple due to the rapid cement market growth, to the benefit of:
  - The environment
  - Local markets
  - Global markets



International Energy Agency

Relevance for Africa

Admixture shipments to Africa

- Admixture supply from outside, and mainly coastal regions.

www.maps.google.de

Relevance for Africa

Admixture shipments to Africa

- Admixture supply from outside, and mainly coastal regions.
- Alternatives are required.
- Africas strength is agriculture.
- 600 Million ha of unused agricultural areas (Perry 2016).

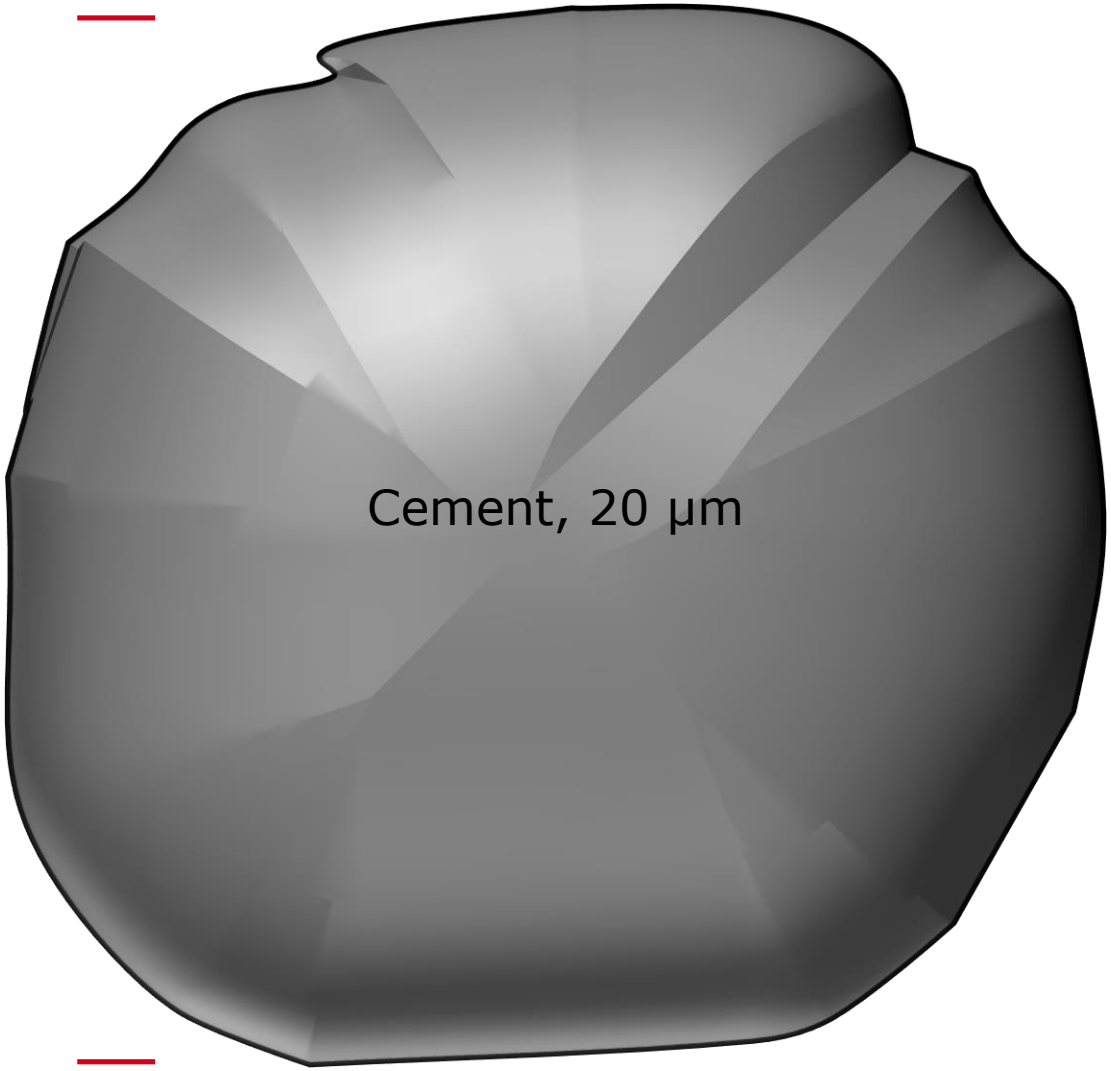
Relevance for Africa

Admixture shipments to Africa

- Admixture supply from outside, and mainly coastal regions.
- Alternatives are required.
- Africas strength is agriculture.
- 600 Million ha of unused agricultural areas (Perry 2016).
- Local plants and local agricultural wastes can be used, like
  - Acacia gum
  - Lignosulfonate
  - Starch
  - Nkui

Relevance for Africa

Comparison



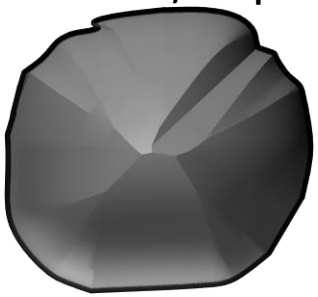
Ettringite

Nkui

Amylopectin

GAK, LS

Cement, 5 µm



PCE

Acacia gum as superplasticizer

Acacia gum

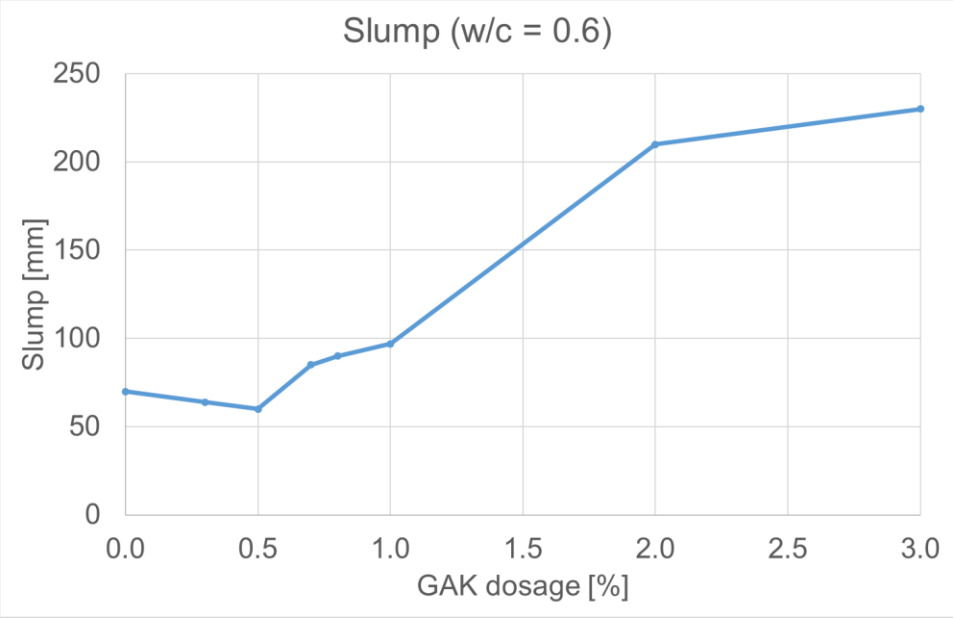
Origin

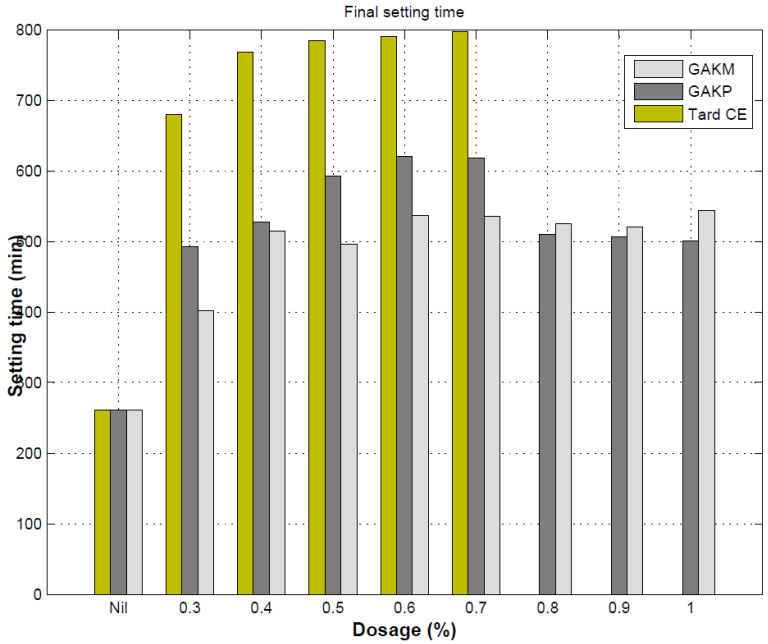
- Acacia gum can be obtained from the stem, e.g. from Acacia Karoo Hynes
- One tree can be harvested for 15 years

Acacia gum

Influence on rheology

- An increasing dosage of GAK (Acacia gum from the Karoo) can significantly enhance the slump of concrete.
- Set retardation could be observed, but it was not dramatic and can even be positive high temperature conditions.





Acacia gum

Influence on rheology

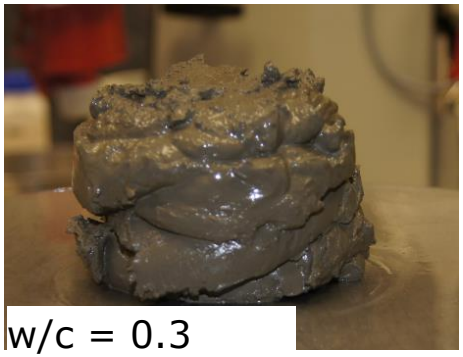
- An increasing dosage of GAK (Acacia gum from the Karoo) can significantly enhance the slump of concrete.
- Set retardation could be observed, but it was not dramatic and can even be positive high temperature conditions.

- In future research the use of GAK as admixture for SCC in East Africa is observed in cooperation between Tshwane University of Technology, the Pan-African University at Kenyatta University and BAM.

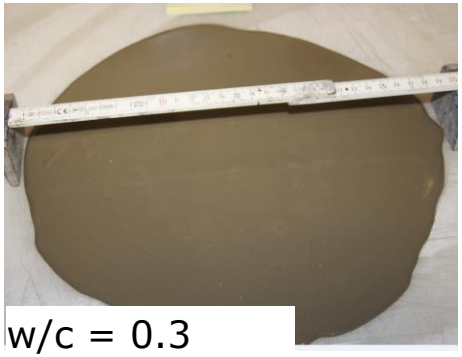
see MSc thesis Caroline Mwende

Acacia gum

Influence of solid volume fraction on GA

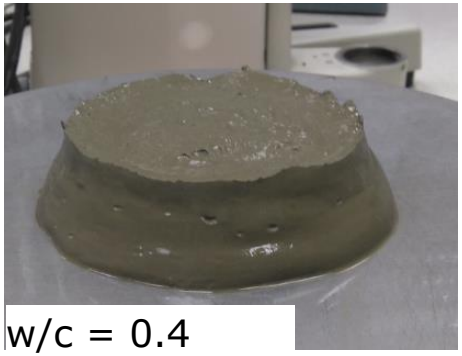


w/c = 0.3

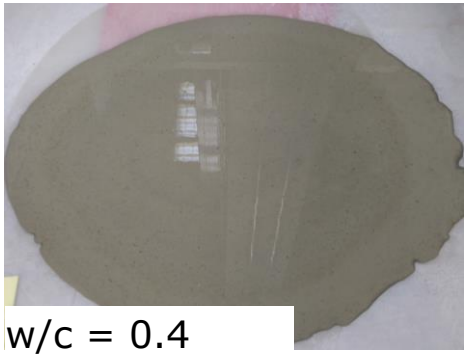


w/c = 0.3
0.35% PCE

w/c = 0.3
0.35% GA



w/c = 0.4



w/c = 0.4
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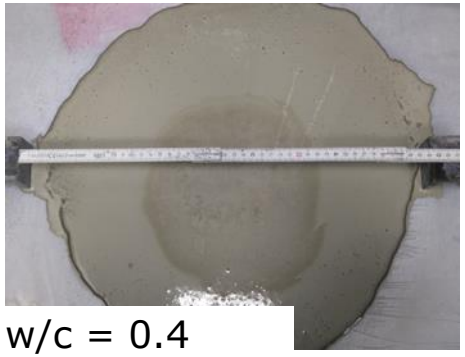


w/c = 0.4
0.35% GA

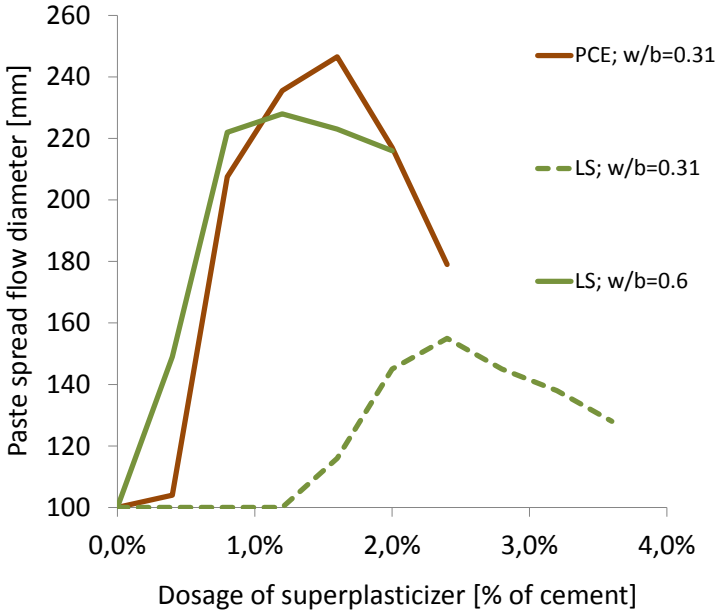
Lignosulfonate

Lignosulfonate

Peculiarities of lignosulfonate

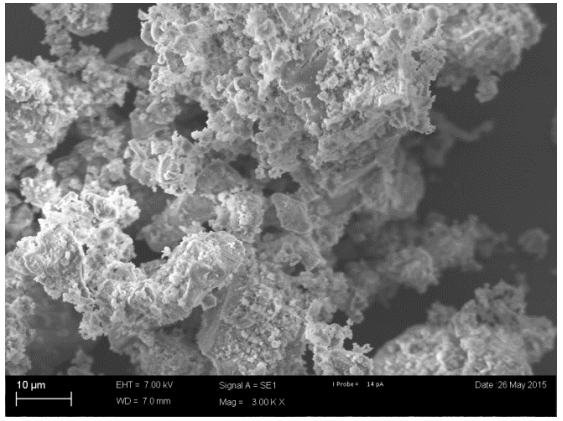
Lignosulphonates are typically considered as plasticizer.

- Waste product of cellulose industry
- More water required than with PCE
- More complex adjustment.



Lignosulfonates pointed out to perform very well in conjunction with porous surfaces such as rice husk ashes.

- For further information, please see Nsesheye Susan Msinjili →



Lignosulfonate

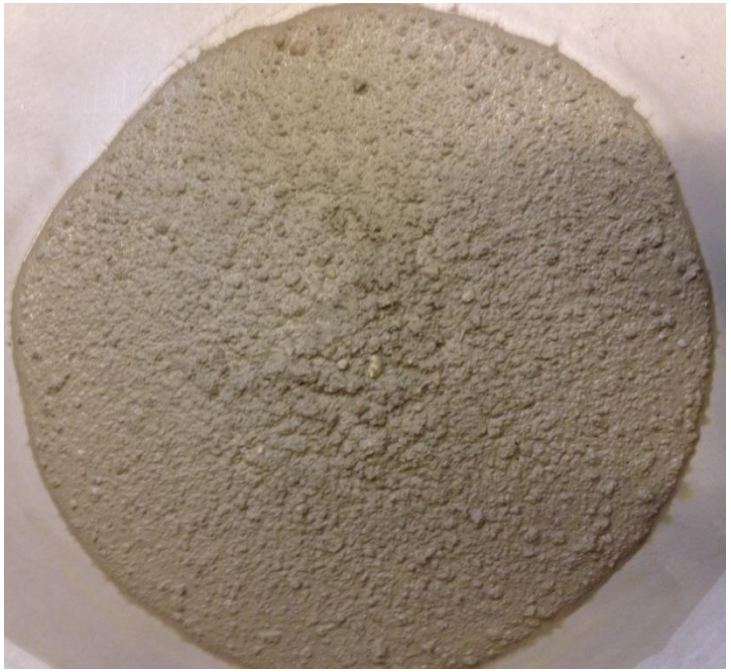
Potentials

- SCC with lignosulfonate is possible.

Compound: Mineral components	[kg/m³]
OPC	399
Pozzolan (Uganda)	80
Fine sand [0 - 2 mm]	972

Compound: Admixtures	[% of cem.]
Lignosulfonate SP (Powder)	1.96%
De-foaming agent (Powder)	0.75%
Nigerian cassava starch (Powder)	0.004%

Components to be added	[kg/m³]
Water	238
Aggregate [2 – 16 mm]	613



Slump flow ~ 30 min: 635 mm

28d compr. strength: 56.2 MPa
90d compr. strength: 68.4 MPa

Cassava starch/starch

Cassava starch

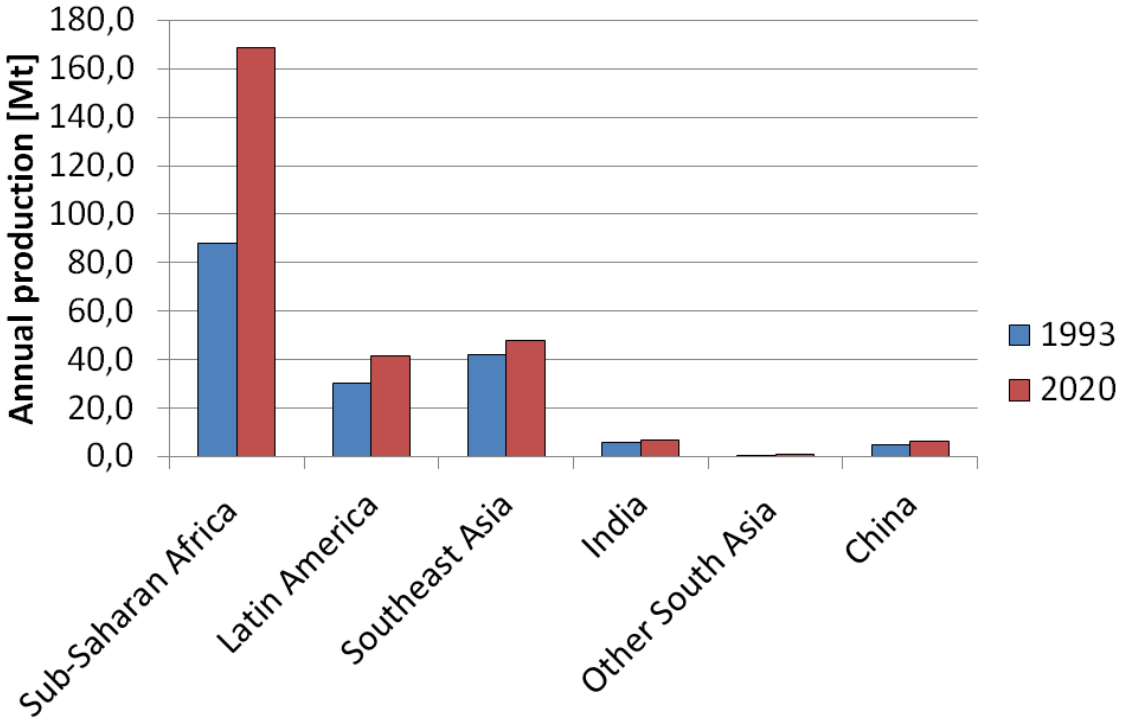
Origin

- Cassava, manioc, tapioca or yuca.
- Food: Staple crop of over 200 million people in Africa alone
- Animal Feed
- Industrial usage

Cassava starch

Projection

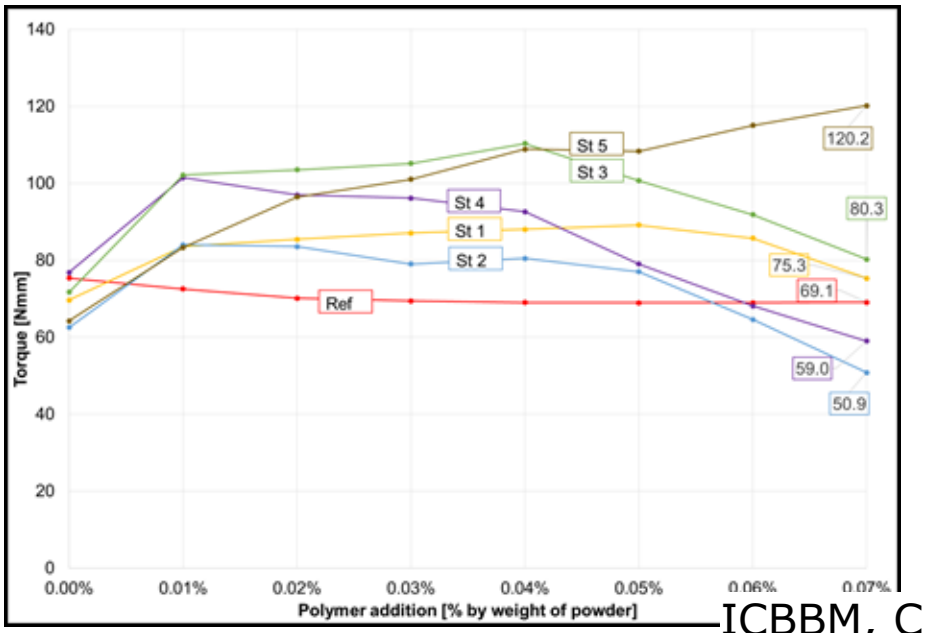
- Cassava is an important resource in Africa.



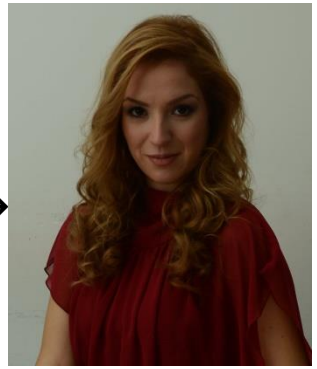
Cassava starch

Versatility

- Cassava is an important resource in Africa.
- Chemically it is similar to potato.
  - 80% by mass Amylopectin
  - 20% by mass Amylose
- After modification it can be extremely versatile.



For more information, see: Eleni Vasiliou →



ICBBM, Clermont Ferrand, 2017

Cassava

Sustainability

Peeling

Food

Waste

Boiling

Admixture

Fuelling

Energy

Usage of ashes

SCM

http://www.arte.tv/guide/de/063945-041-A/xenius

Cassava

Potentials for sustainability

- Cassava starch is also a waste from Gari production.

https://www.youtube.com/watch?v=kDkxk64dRHA

Nkui

Nkui

Origin

- Nkui is a traditional dish of the Bamileke in Cameroon.
- A gum inside the barks of Triumfetta pendrata A. Rich is responsible for the very peculiar consistency.

Nkui

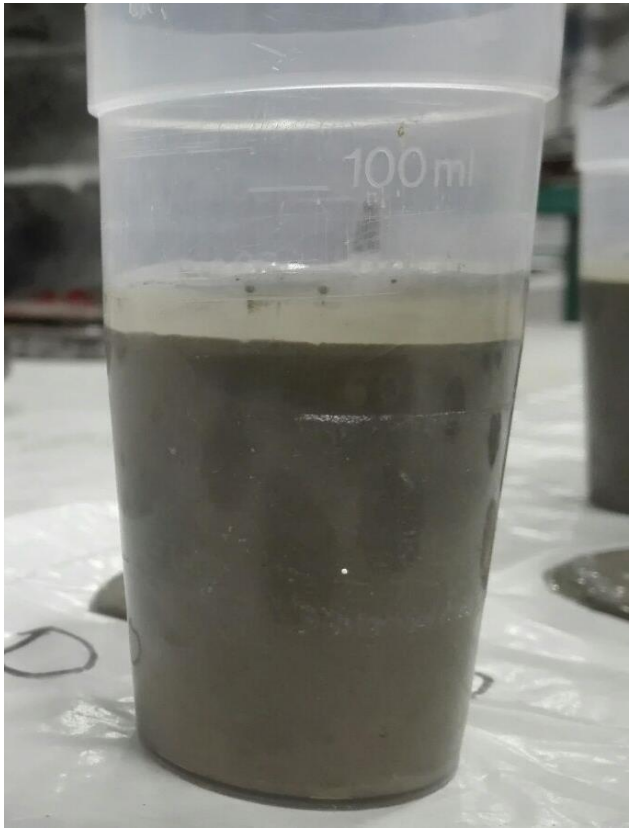
Consistency

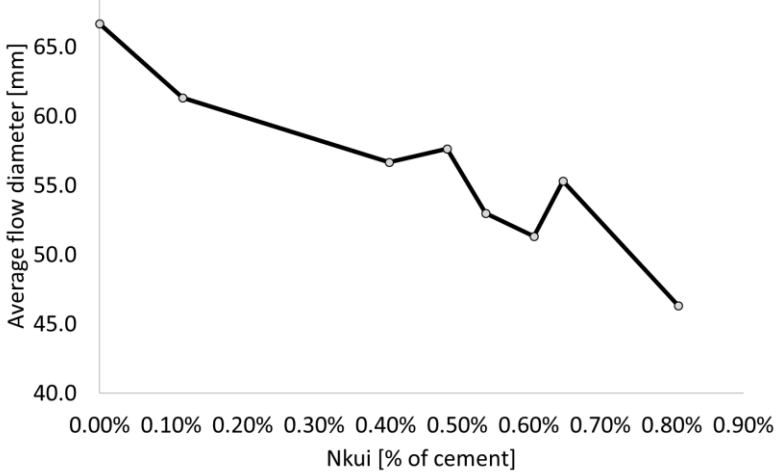
- The sticky consistency can possibly be used to stabilise cementitious systems effectively and provide for special consistency.

Nkui

Effect on instable cementitious systems

- The sticky consistency can possibly be used to stabilise cementitious systems effectively and provide for special consistency.





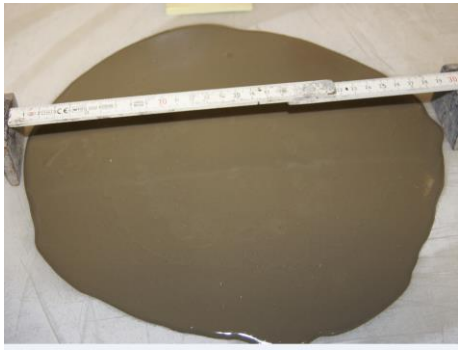
Nkui

Effect on superplasticised systems

- The sticky consistency can possibly be used to stabilise cementitious systems effectively and provide for special consistency.
- In combination with PCE, the performance can be interesting.

w/c = 0.3

w/c = 0.3
0.08% Nkui



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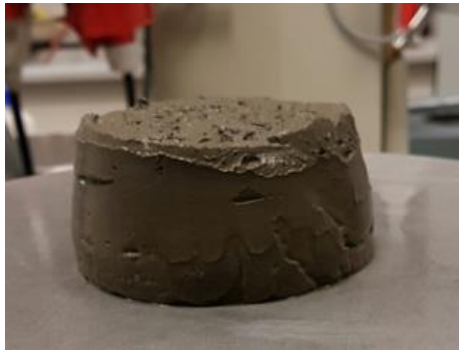

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Rheometric comparison

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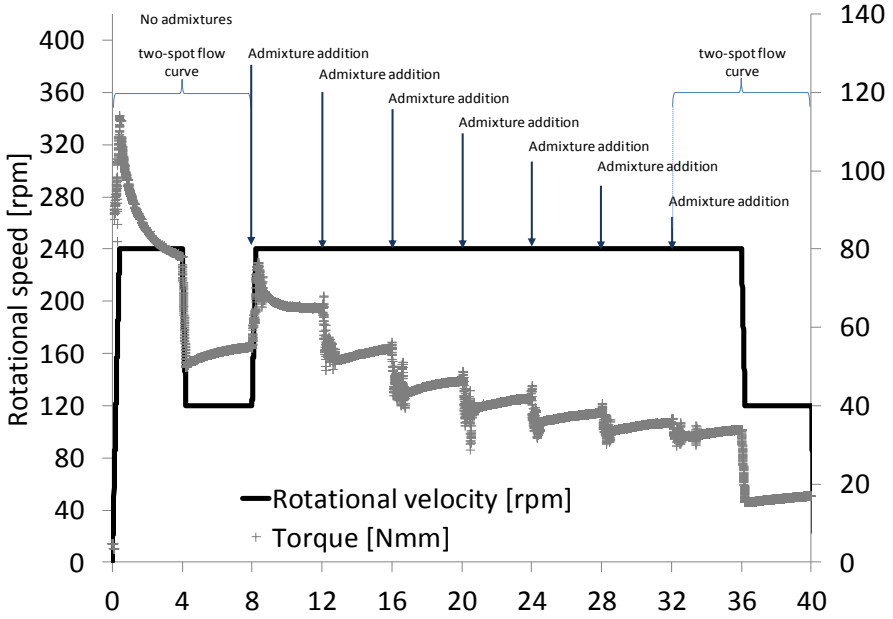
Experimental setup

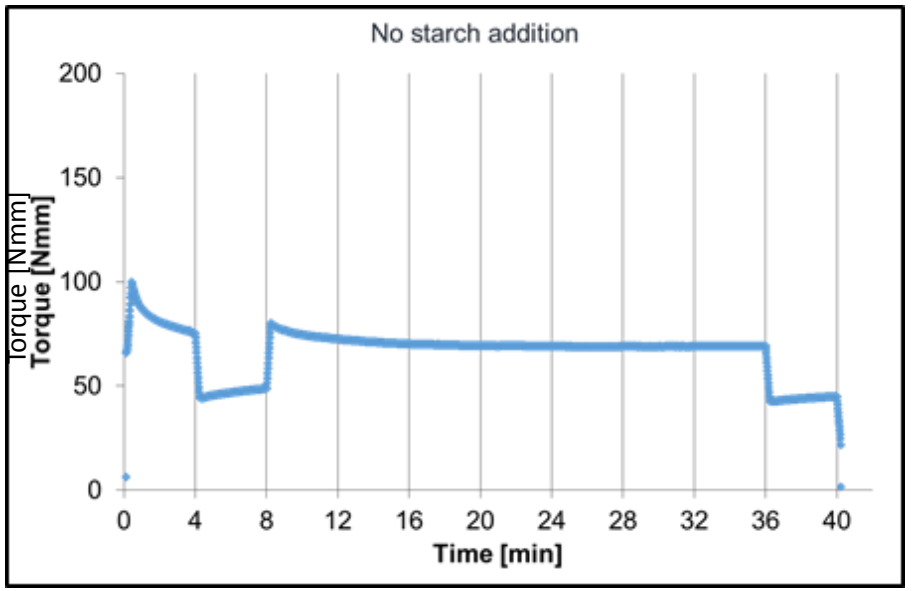
- Water cement system
- Solid volume fraction = 0.48
- Viskomat NT
- Cement paste stirrer

Rheometric comparison

Experimental setup

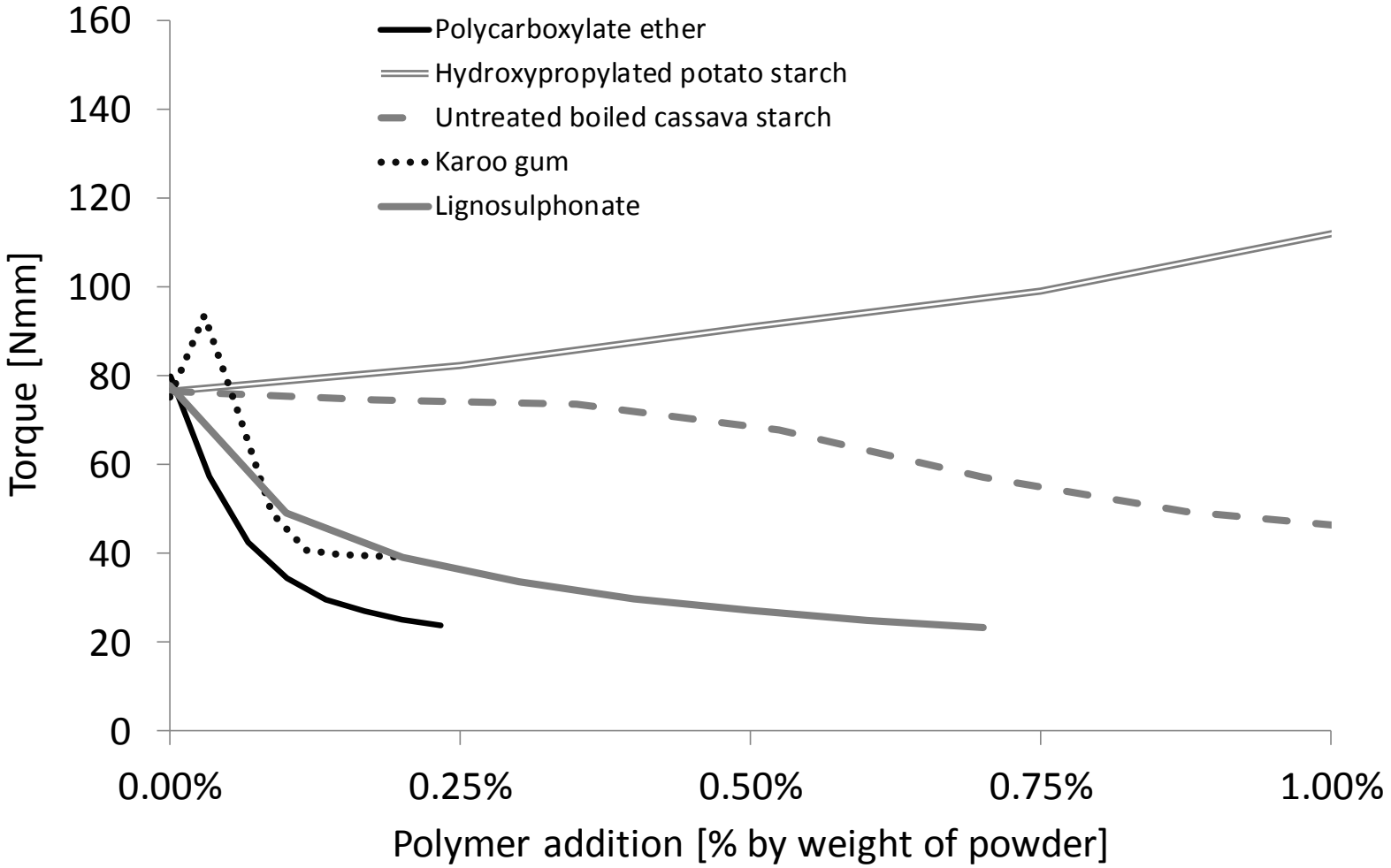
- Water cement system
- Solid volume fraction = 0.48
- Viskomat NT
- Cement paste stirrer
- Measurement regime allows saving materials





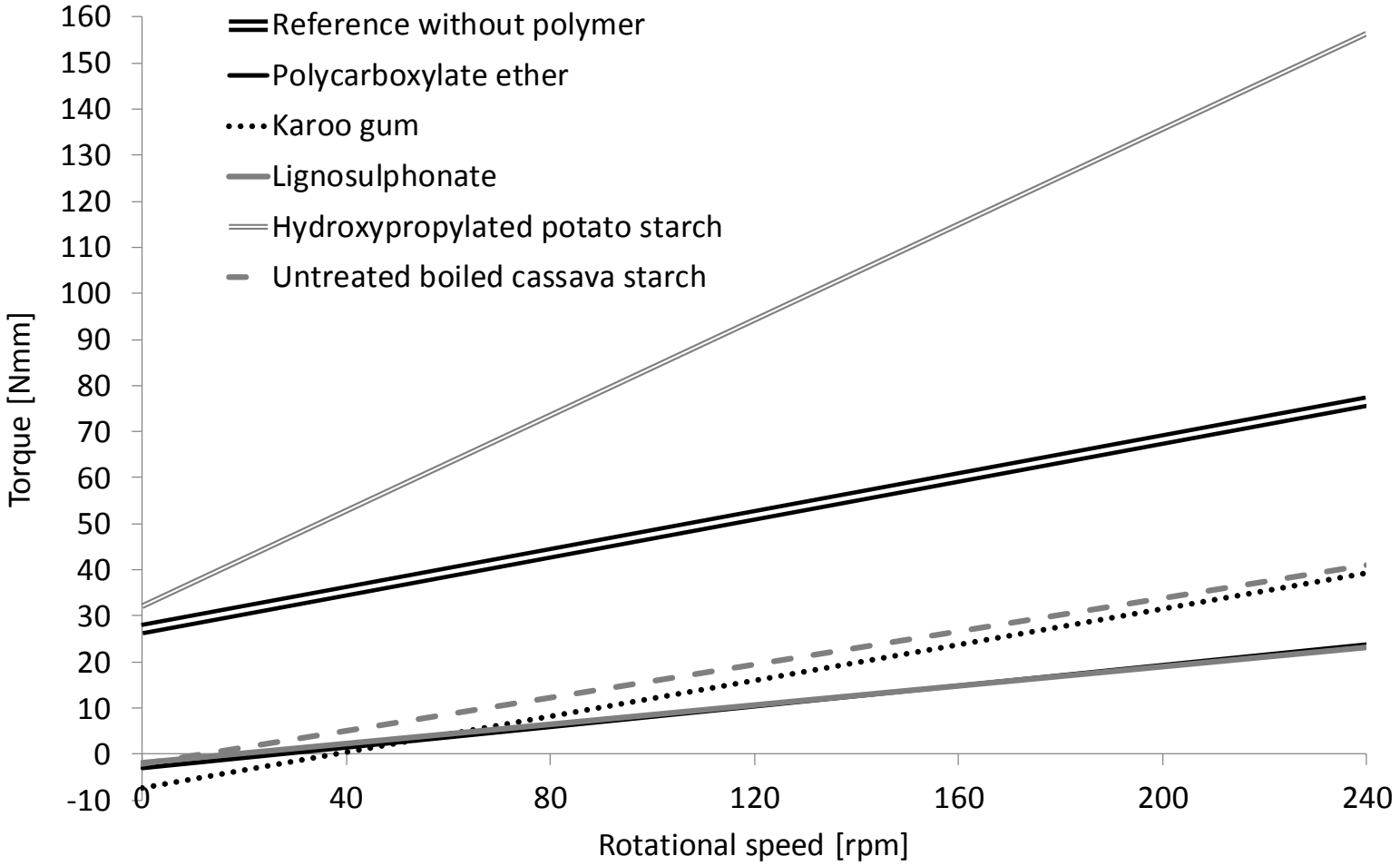
Rheometric comparison

Results at constant rotational speed 240 rpm



Rheometric comparison

Results at 240 rpm and 120 rpm



Summary

Summary

Nkui

- Cement and concrete construction are of enormous importance for SSA.
- All over the world we need more sustainable concrete technologies.
- Admixtures are the key.
- In Africa the supply chains for chemical admixtures are not well developed.
- Nature based chemical components can be used effectively to fill the gap.
- Some potentially promising materials were presented, but further research is required.

If natural polymers point out to be promising, this can trigger more sustainable admixtures all over the world.

Announcement

KEYS – Knowledge exchange for young scientists

Next symposium: Johannesburg, SA

Deadline for abstract: 28. Feb. 2017

Selected authors attend for free

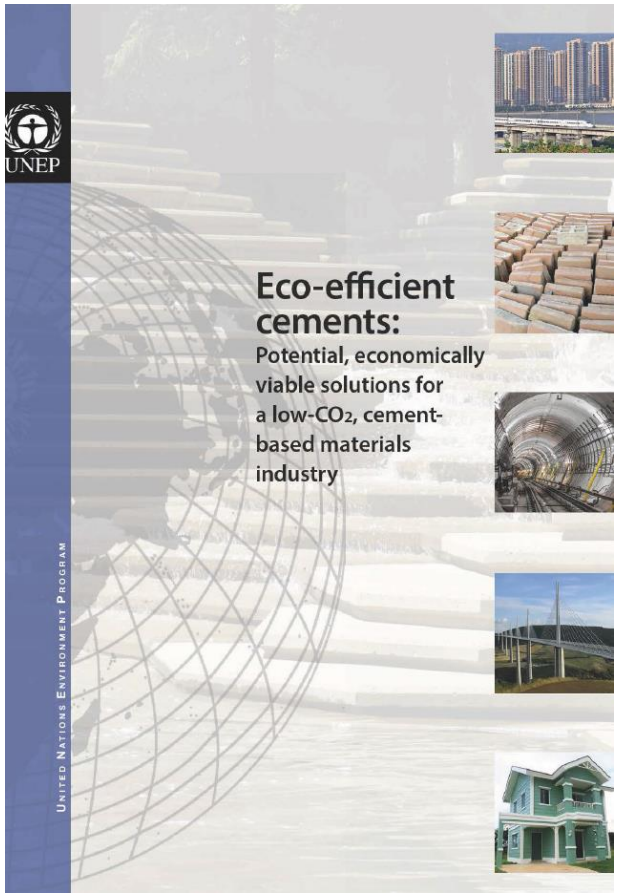
Speakers:

- **Prof. Billy Boshoff**
  University of Stellenbosch, South Africa
- **Prof. Elsabe Kearsley**
  University of Pretoria, South Africa
- **Prof. Ephraim Senbetta**
  Addis Ababa University, Ethiopia
- **Dr. Soumen Maity**
  Development Alternatives, New Delhi, India
- **Prof. Marco Menegotto**
  Sapienza University of Rome, Italy
- **Dr. Mike Otieno**
  University of the Witwatersrand, South Africa
- **Prof. Mitchell Gohnert**
  University of the Witwatersrand, South Africa
- **Prof. Viktor Mechtcherine**
  Technical University of Dresden, Germany
- **Prof. Violeta Bokan Bosiljkov**
  University of Ljubliana, Slovenia
- **Dr. Dipl.-Ing. Wolfram Schmidt**
  BAM, Germany

Announcement

UNEP report – Eco-efficient cements

Contents



http://lmc.epfl.ch/files/content/users/184559/files/2016-UNEPReport-Complete4.pdf

Thank you very much for your kind attention!

Meu lap'teu!

Niwega!

E sé ún púpò!

Siyabonga!

Asante sana!

Danke!