RHEOLOGY MODIFYING ADMIXTURES FOR CONCRETE TAKEN FROM NATURE

Wolfram Schmidt¹, Inès L. Tchetgnia Ngassam², Rose Mbugua³, Kolawole A. Olonade⁴

¹ BAM Bundesanstalt für Materialforschung und –prüfung
² University of Cape Town
³ Tshwane University of Technology
⁴ Obafemi Awolowo University
Co-authors

Rose Mbugua
Tshwane University of Technology, ZA

Inès Tchetgïnia Ngassam
University of Cape Town, ZA

Kolawole A. Olonade
Obafemi Awolowo University, NG
Introduction
Introduction
Relevance of rheology modifying admixtures

- Strength evolution
Introduction
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- Strength evolution
- New casting technologies
Introduction

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- Strength evolution
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- New architecture
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- 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

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

![Graph showing required working days to purchase a ton of cement]

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
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
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.
• Africa’s 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.
- Africa's 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

Cement, 20 µm

Ettringite

Amylopectin

GAK, LS

PCE

Cement, 5 µm
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.
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- 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*

<table>
<thead>
<tr>
<th>w/c = 0.3</th>
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<tbody>
<tr>
<td>0.35% PCE</td>
<td>0.35% GA</td>
<td>0.35% GA</td>
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<tr>
<th>w/c = 0.4</th>
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<td>0.35% GA</td>
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</table>
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 Msijnili

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21.02.2017
Lignosulfonate

Potentials

- SCC with lignosulfonate is possible.

<table>
<thead>
<tr>
<th>Compound: Mineral components</th>
<th>[kg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPC</td>
<td>399</td>
</tr>
<tr>
<td>Pozzolan (Uganda)</td>
<td>80</td>
</tr>
<tr>
<td>Fine sand [0 - 2 mm]</td>
<td>972</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Compound: Admixtures</th>
<th>[% of cem.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lignosulfonate SP (Powder)</td>
<td>1.96%</td>
</tr>
<tr>
<td>De-foaming agent (Powder)</td>
<td>0.75%</td>
</tr>
<tr>
<td>Nigerian cassava starch (Powder)</td>
<td>0.004%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Components to be added</th>
<th>[kg/m³]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>238</td>
</tr>
<tr>
<td>Aggregate [2 – 16 mm]</td>
<td>613</td>
</tr>
</tbody>
</table>

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

Food → Waste

Waste → Boiling

Boiling → Admixture

Admixture → Energy

Energy → Usage of ashes

Usage of ashes → SCM

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

Olonade, 2015

Msinjili, 2015

Boiling

Usage of ashes

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

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- In combination with PCE, the performance can be interesting.
Nkui

Effect on superplasticised systems

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- In combination with PCE, the performance can be interesting.

w/c = 0.3
0.35% PCE
0.08% Nkui
Rheometric comparison
Rheometric comparison

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

- Polycarboxylate ether
- Hydroxypropylated potato starch
- Untreated boiled cassava starch
- Karoo gum
- Lignosulphonate

Torque [Nmm]

Polymer addition [% by weight of powder]
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
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 Ljubljana, Slovenia
- **Dr. Dipl.-Ing. Wolfram Schmidt**
  BAM, Germany
Announcement

UNEP report – Eco-efficient cements

Contents

Executive Summary vii
1. Introduction 1
2. Cement and Modern Society 2
4. Our Working Method 7
5. Overview of Cementitious Materials Use 8
6. The Limitations of Earth Chemistry 10
7. Cements Made from “Alternative Clinkers” 11
8. Extending Clinker Substitution with Mineral Additions/Supplementary Cementitious Materials 15
9. Alkali Activated Cements 21
10. CO₂ Mitigation by Increased Cement Use Efficiency 22
11. Soil Concrete 27
12. Structures 29
13. Standardisation 31
14. Estimating the Mitigation Potential 32
15. Research Needs 38
16. Education and Sustainable Construction 40
17. Main Conclusions 42
18. Acknowledgments 44
19. Group Members 45
20. References 47
21. Glossary 50

Thank you very much for your kind attention!

Meu lap‘teu!

Niwega!

E sé ún púpò!

Siyabonga!

Asante sana!

Danke!