

Technologische und wirtschaftliche Lösungsansätze für rheologisch optimierte Betone für subsaharische afrikanische Länder

Technological and Economic Solutions for Rheologically Optimised Concrete
for Sub-Saharan Africa

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Concrete technological boundary parameters in Africa and Europe

History of Concrete in Europe and Africa

Europe has a 150 years lasting history of cement and concrete technology

Status Quo

- Safety in use
- Predictable performance
- High level of education and technology
- Well established standards
- Good involvement of all actors

LIMITATION →

State of possibilities

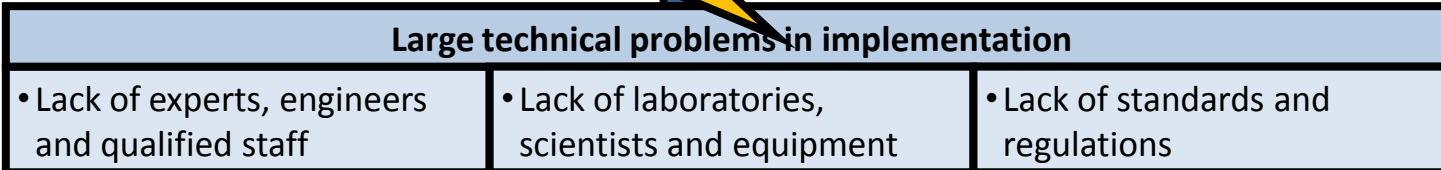
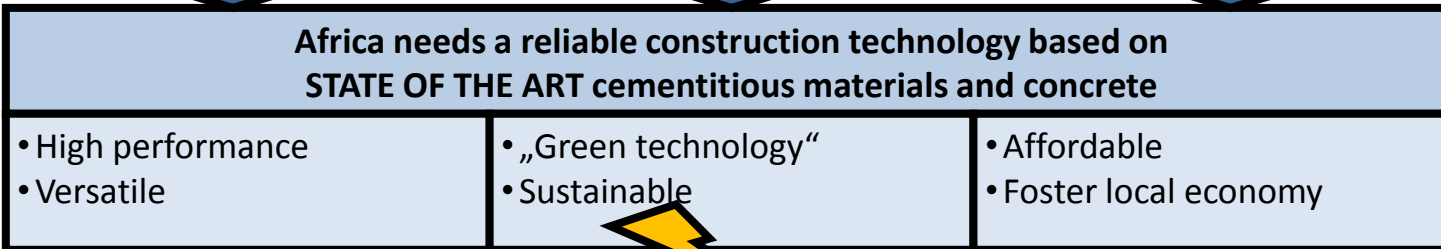
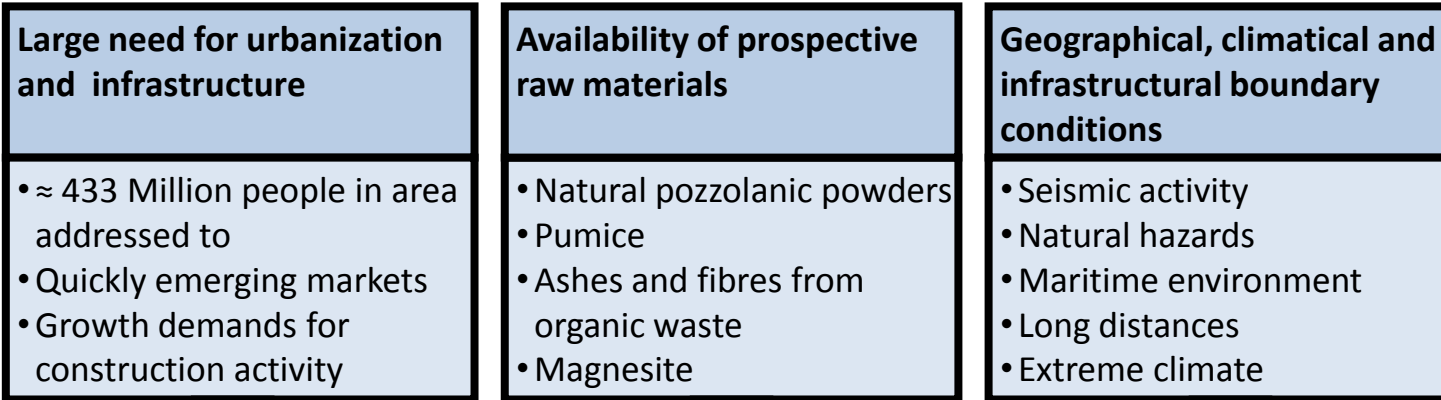
- Technology boost during the last 20 years
- High-Performance Concrete
- Eco-Concrete
- Taylor-made performance

Cement and concrete are rather new materials for Africa

- Implementing best available knowledge without repeating mistakes of the past
- No technological limitations due to established standards and political structures

**Possible technology is not the best available technology.
African technology needs to consider African boundary conditions.**

Problems, Opportunities, and Challenges for Africa



Educated experts that stay on the ground are the major deficit.



“Spearhead Network for Innovative, Clean and Safe Cement and Concrete Technologies”



Funding Scheme: ACP-ST Science and Technology Programme

Total Budget: approx. 1,250,000.00 €

Funding: approx. 1,000,000.00 €

Project Partners:

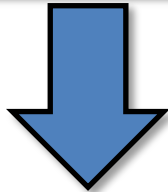
- Democratic Republic of Congo: University of Lubumbashi
- Uganda: Department of Geological Survey and Mines
- Burundi: Université de Burundi
- Rwanda: Kigali Institute of Science and Technology
- Tanzania: University of Dar es Salaam
- Mozambique: Eduardo Mondlane University,
- South Africa: University of the Witwatersrand
- South Africa: Advanced Cement Training & Projects CC
- Netherlands: Eindhoven Technical University
- Croatia: Institut IGH d.d.
- Germany: BAM Federal Institute for Materials Research and Testing

Why does Africa need a new approach to concrete technology?

Because they can!

Europe

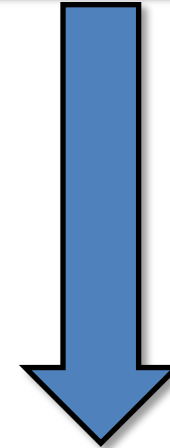
- Concrete technology has evolved rapidly during the last three decades.
- Numerous innovations have been developed, e.g. SCC, UHP(FR)C, ECC, "Green"-Concrete, ...



- Traditional methods are well established.
- No urgent need to apply innovations.

South, Central, and East Africa

- Africa does not have established solutions

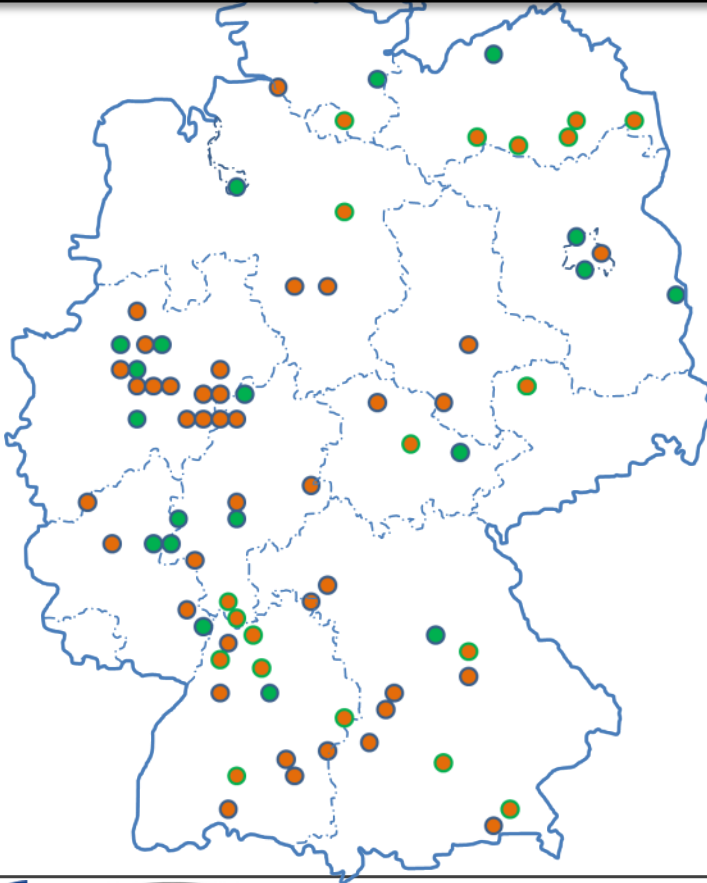


Not making use of newest technologies in establishing concrete practice would be a fatal mistake!!!

Cement Infrastructure

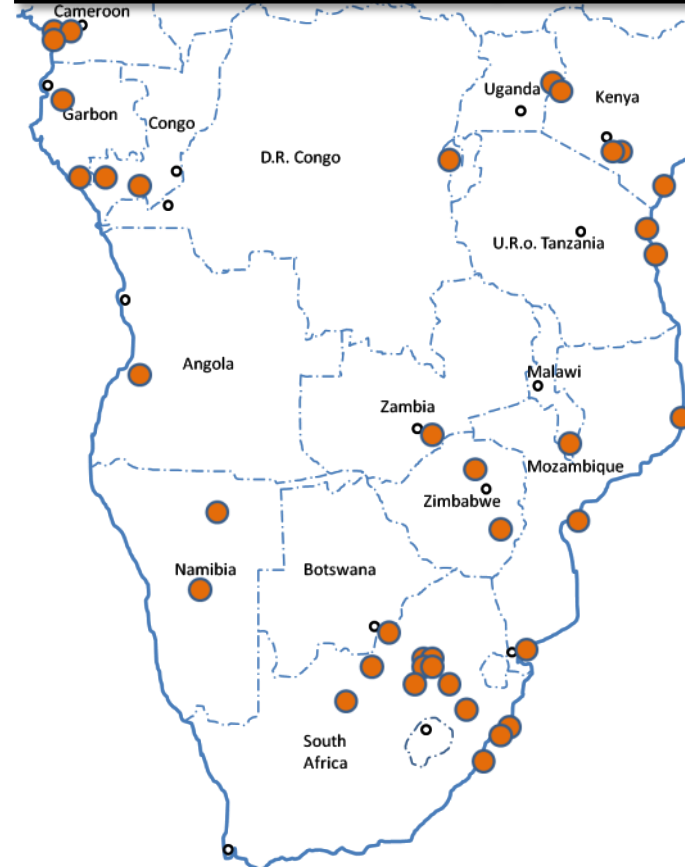
Germany

77 cement plants

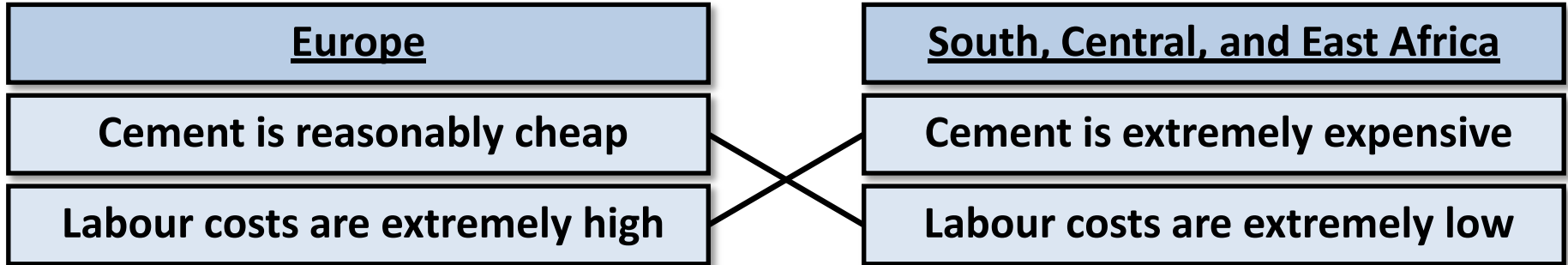


South, Central, and East Africa

37 cement plants

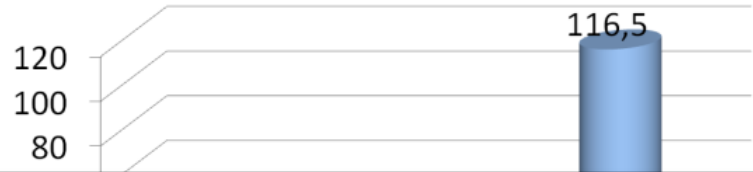
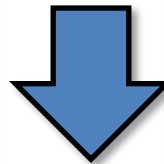


Cost factor: Cement price vs. labour cost



The cost situation between Europe and sub-Saharan Africa is completely inverted!!!

Established methods from Europe cannot be economically reasonable!



African concrete needs:

- low cement content
- high amount of SCMs

But it can be work-intensively treated on the construction site

Concrete philosophy/infrastructure:

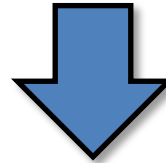
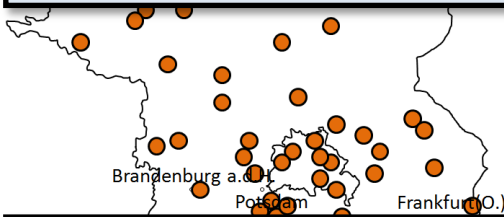
Europe

Ready mix concrete is extremely well established

South, Central, and East Africa

Virtually no ready mix industry

Job site mixing will predominate the concrete landscape for the next decades



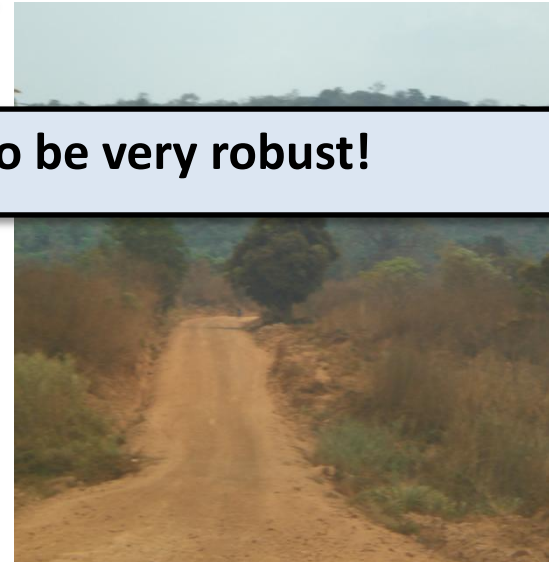
areas, e.g. Johannesburg, Nairobi, Dar es Salaam

African concrete needs to be very robust!



1955 ready-mix plants all over Germany in 2010 *

* Bundesverband der Deutschen Transportbetonindustrie e. V. Jahresbericht 2010/2011

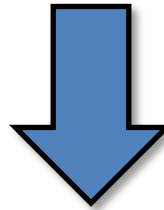
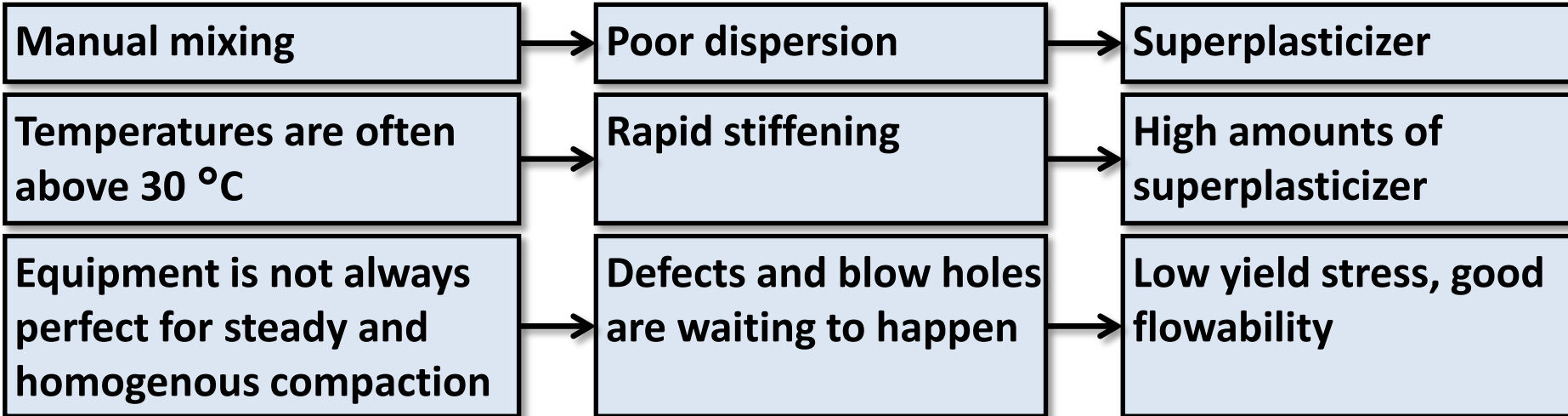


Job site conditions:



Picture: Nsesheye Susan Msinjili

Job site conditions:

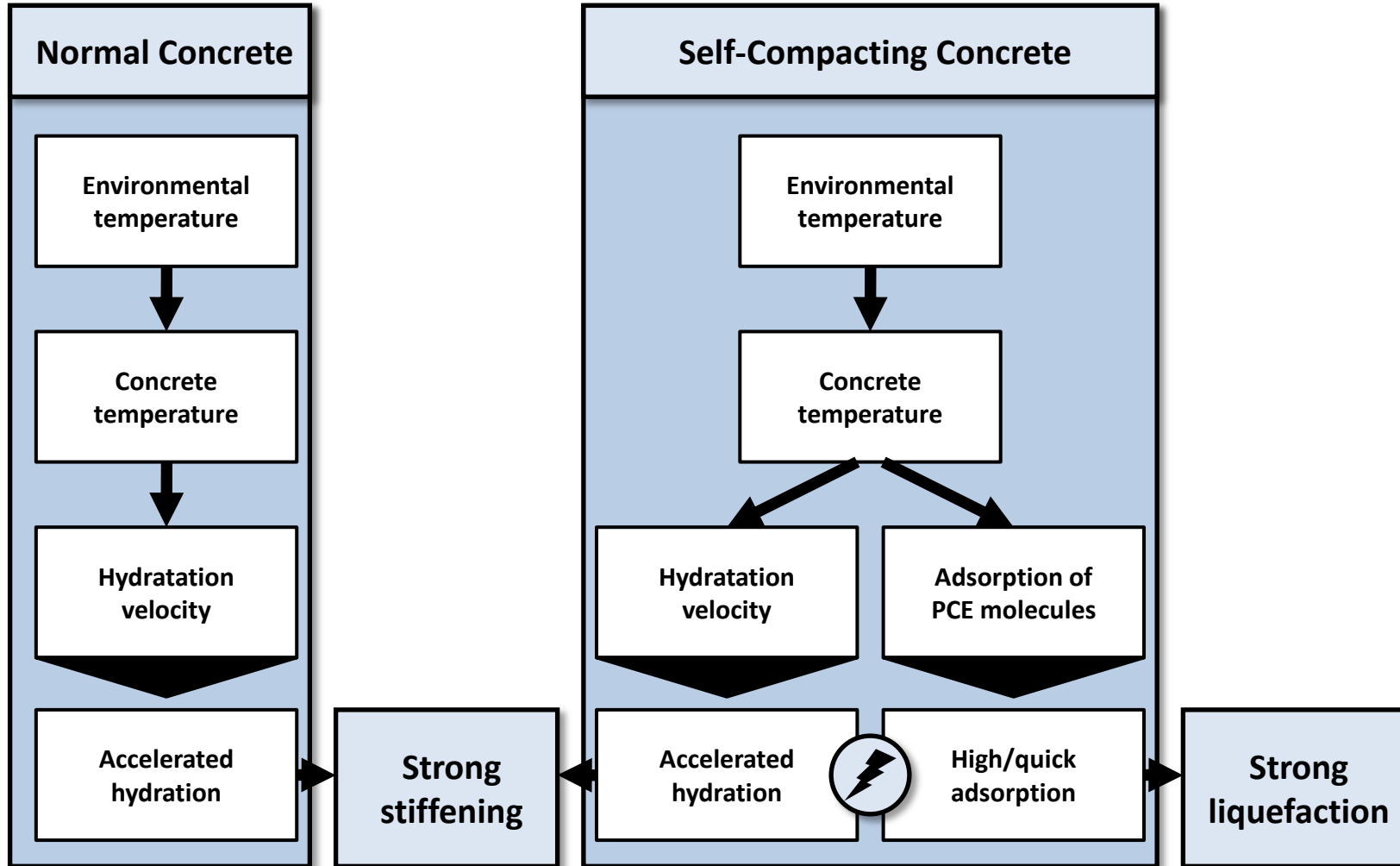


Self-compacting concrete is the right way to bring robustness on the job site!!!



How should African SCC be composed?

Behaviour of SCC at high temperatures:



Behaviour of SCC at high temperatures:

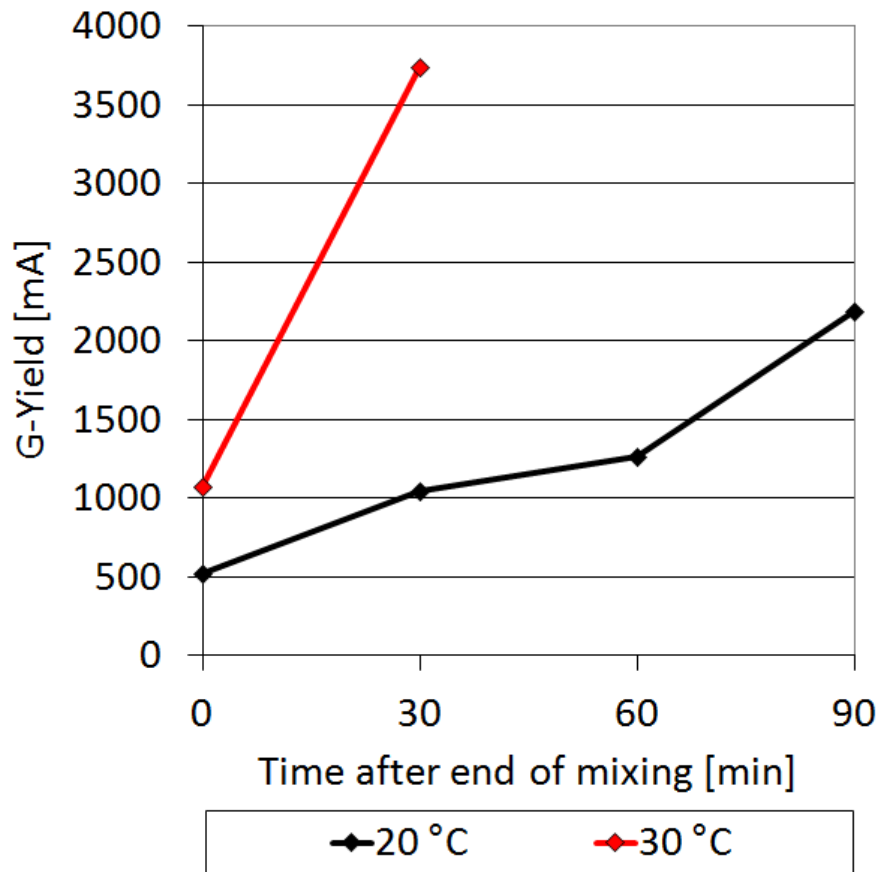
Two driving factors determine the rheology of SCC at high temperature

Water/powder-ratio

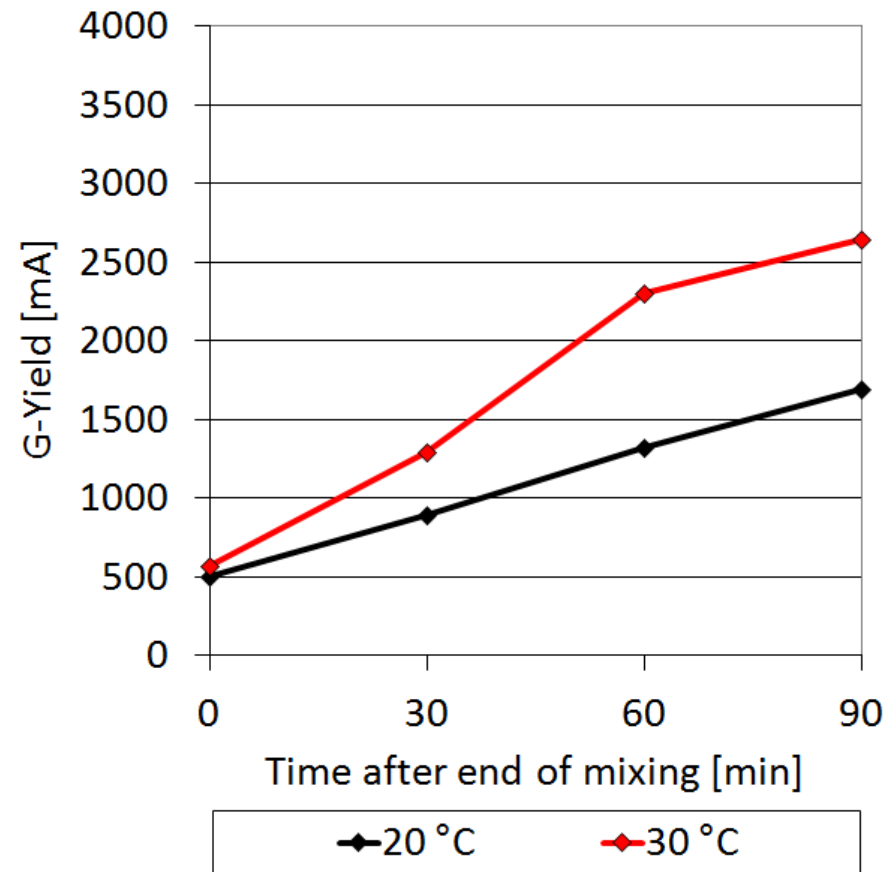
Charge density of the superplasticizer

SCC mixture composition for high temperatures: w/p-ratio

SCC with high powder content

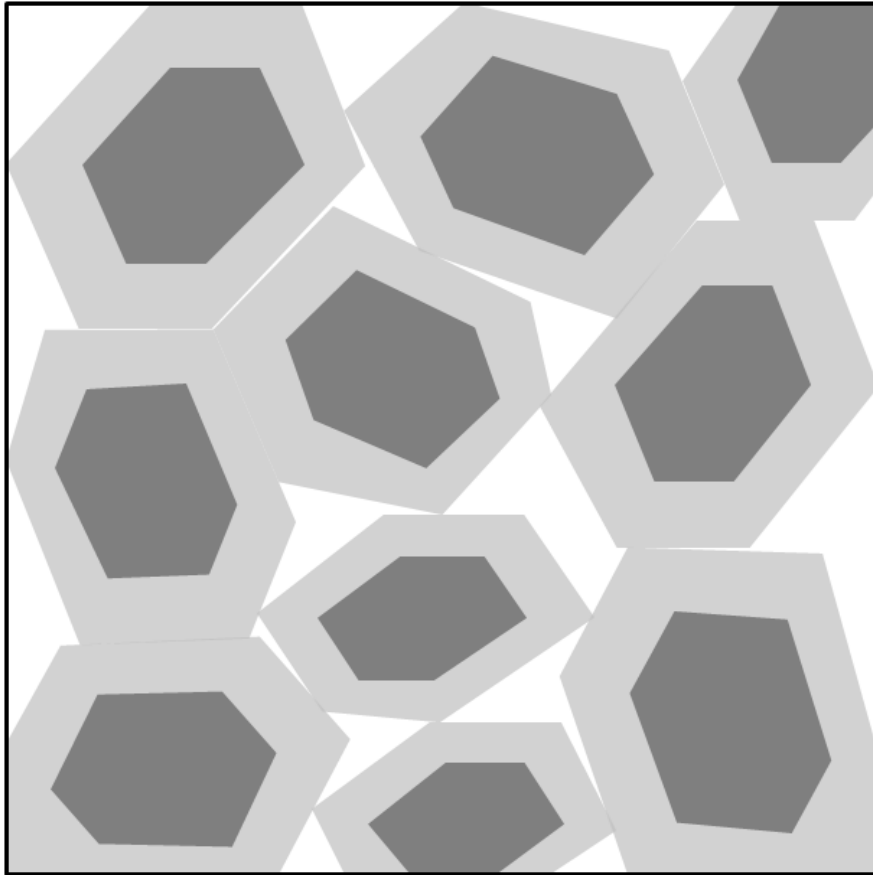


SCC with low powder content

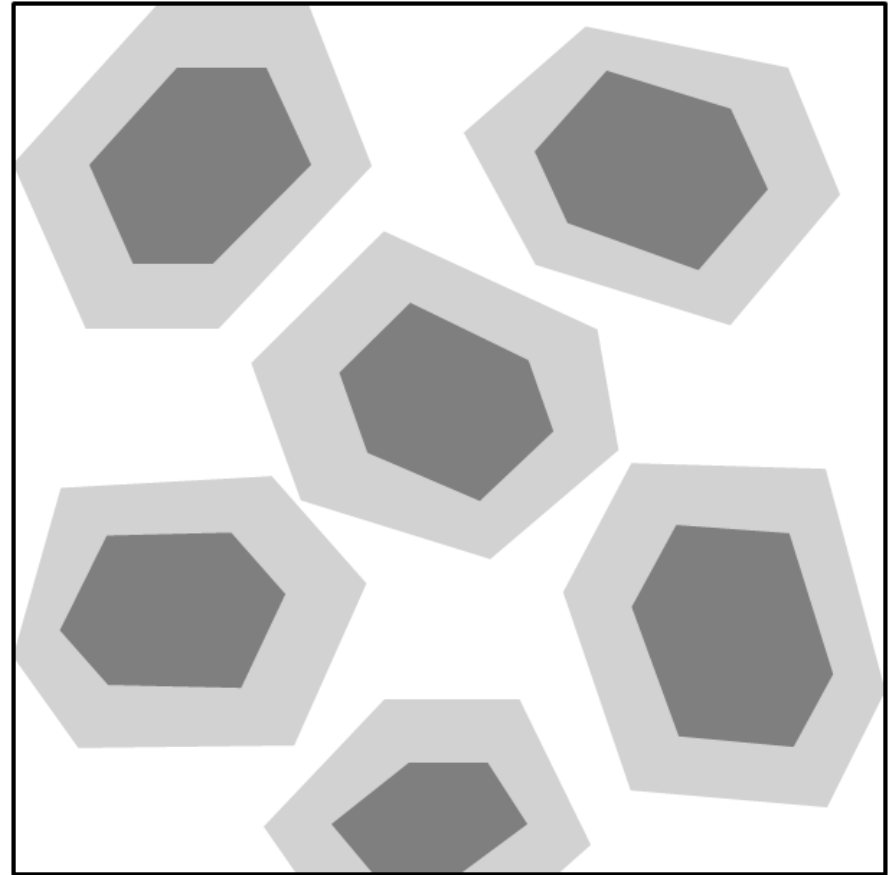


SCC mixture composition for high temperatures: w/p-ratio

SCC with high powder content

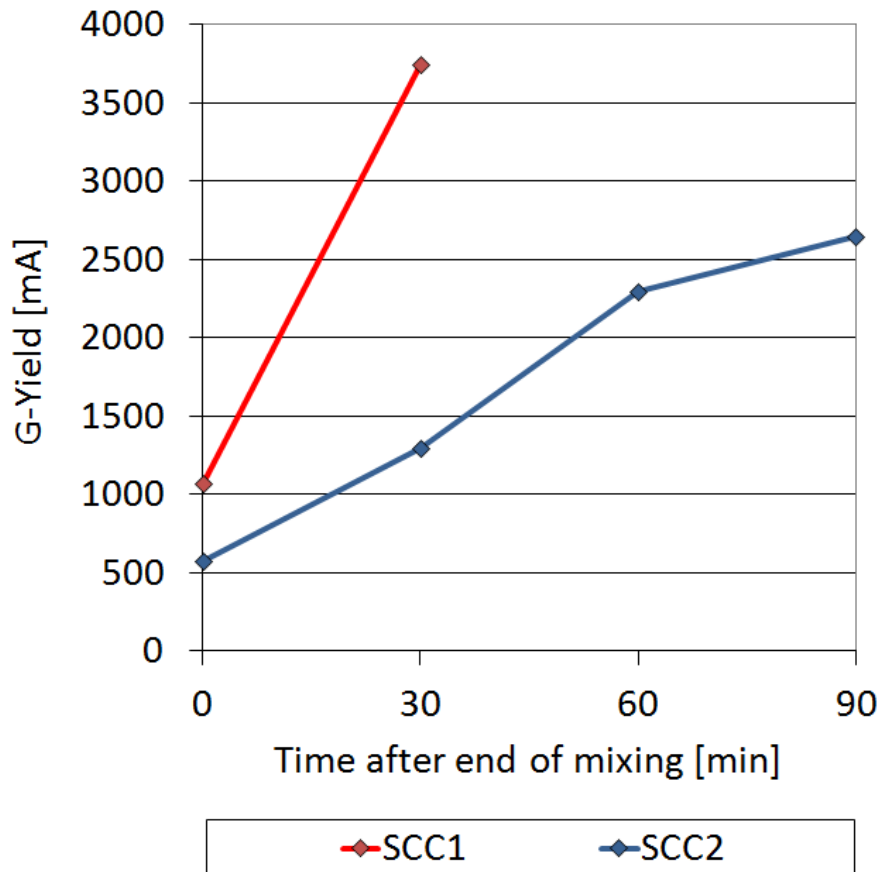


SCC with low powder content

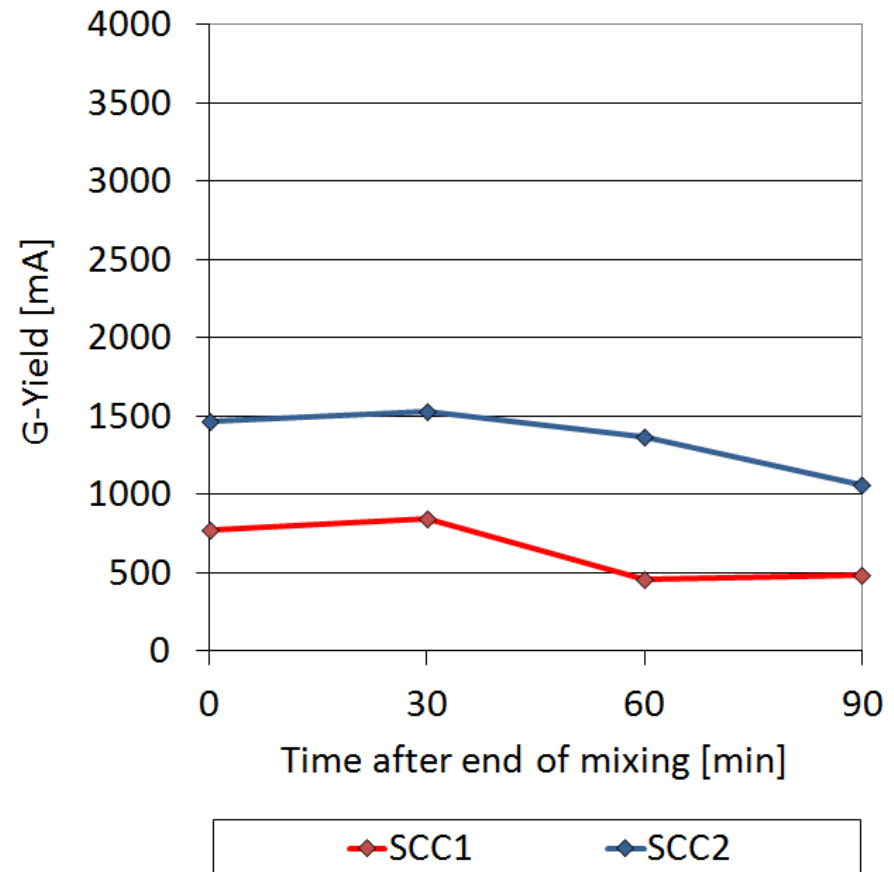


SCC mixture composition for high temperatures: SP charge density

SCC with high charge density PCE

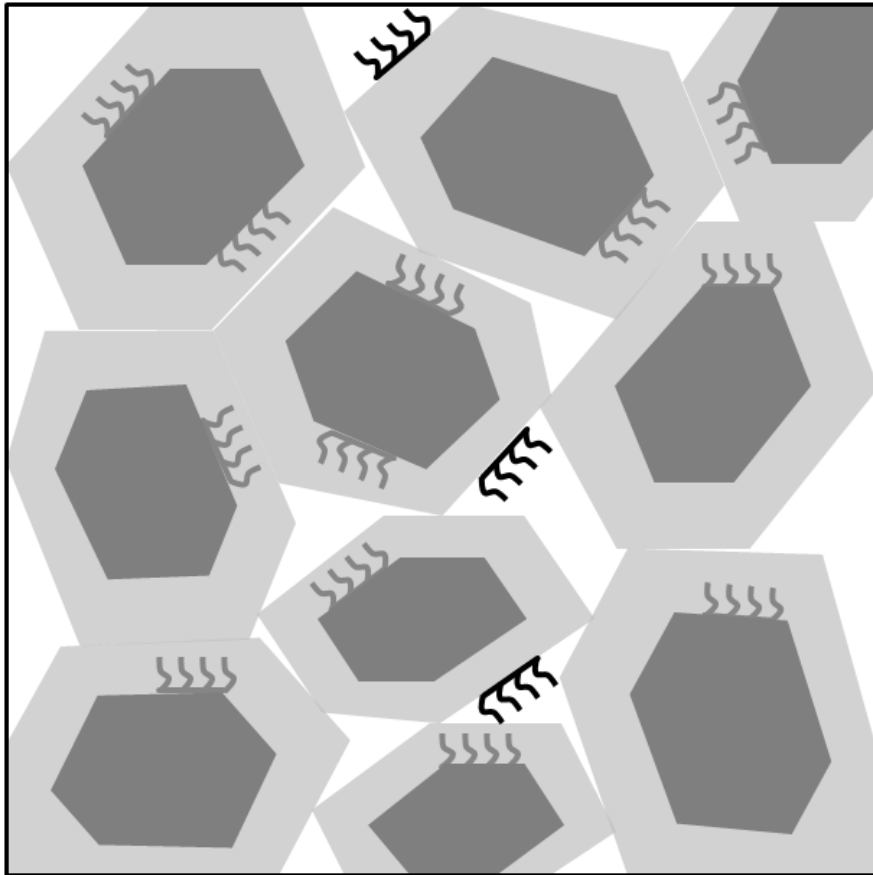


SCC with low charge density PCE

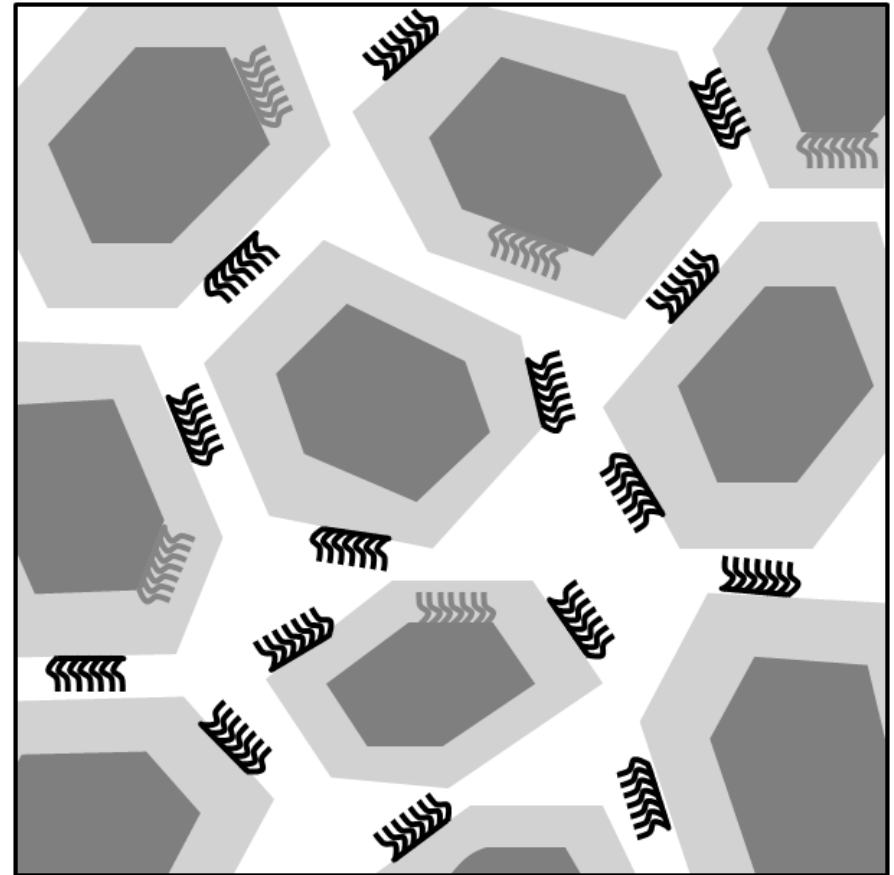


SCC mixture composition for high temperatures: SP charge density

SCC with high charge density PCE



SCC with low charge density PCE



Behaviour of SCC at high temperatures:

Two driving factors determine the rheology of SCC at high temperature

Water/powder-ratio

- The lower the w/p-ratio, the more the effects of rapid hydration dominate the rheology

Charge density of the superplasticizer

- The higher the charge density, the quicker the superplasticizer is consumed



High temperature SCC requires low charge density PCE superplasticizer and high water/powder ratio.



In order to avoid segregation, stabilising agent might be unavoidable

Optimised high temperature SCC:

Low cement content

Low charge density PCE

High water/powder-ratio

Stabilising agent



Sophisticated, engineered mixture composition!



Is this affordable???

How to bring into practice???

**Is a sophisticated, engineered
mixture composition affordable?**

Is a sophisticated mixture composition affordable?

Cement can be saved by an elaborate mixture composition!

- Optimised grading of fines, sand, and aggregates
- Replacement of OPC by fillers and SCMs

Is a sophisticated mixture composition affordable?

Cement can be saved by an elaborate mixture composition!

Lignosulphonate can be used as superplasticizer!

- Less expensive than polycarboxylate ethers
- Easily available as waste from paper industry
- Replacement of OPC by fillers and SCMs
- Disadvantage: High charge density → short retention and risk of intercalation
- In order to avoid problems:
 - Addition as late as possible
 - High water/powder-ratio

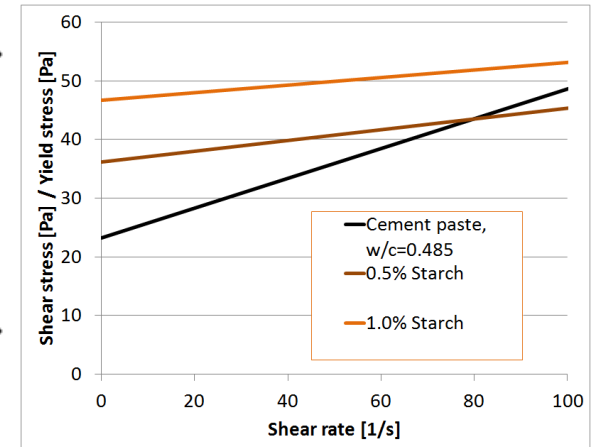
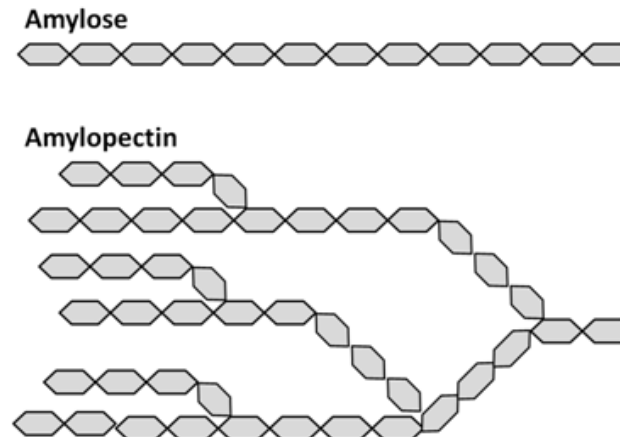
Is a sophisticated mixture composition affordable?

Cement can be saved by an elaborate mixture composition!

Lignosulphonate can be used as superplasticizer!

High water content and starch as stabilising agent!

- E.g. Cassava is well established all over Africa
- It contains $\approx 17\%$ Amylose
- Numerous options to modify (e.g. see Schmidt, Regensburg 2011)



Is a sophisticated mixture composition affordable?

Cement can be saved by an elaborate mixture composition!

Lignosulphonate can be used as superplasticizer!

High water content and starch as stabilising agent!

Not yet well established promising materials (e.g. bagasse ash, rice husk ash)!

- E.g. bagasse ash and rice husk ashes show pozzolanic properties
- East African Rift provides high contents of natural pozzolans



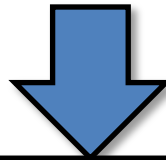
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Lignosulphonate can be used as superplasticizer!

High water content and starch as stabilising agent!

Not yet well established promising materials (e.g. bagasse ash, rice husk ash)!



Sophisticated concrete mixture compositions can be affordable!

How can a sophisticated mixture composition be brought into practice?

How to put rheologically optimised SCC into practice?

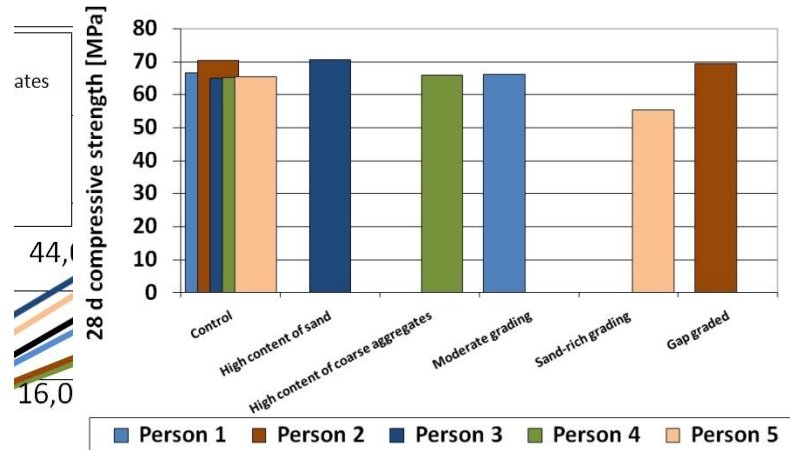
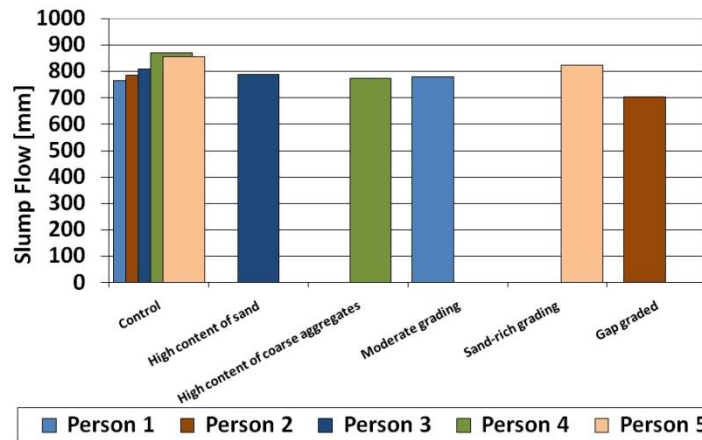
- Problem: Sophisticated mixtures need stable and automated conditions.
- Typical way of casting concrete in Africa is on-site mixing
 - Typically no equipment to precisely proportion materials
 - Dispersion and homogenisation depending upon equipment

→ Pre-mixed dry binder compound in bags, including:

- Cement
- Filler
- Superplasticizer (powder type)
- Stabilising agent (powder type)
- Fine sand

Only addition of water and coarse aggregate is required.

Experiences with dry pre-mixed binder compound for SCC



It works!!!

Conclusions

Conclusions

- **Africa needs new and alternative approaches to concrete technology.**
- **For African boundary conditions, flowable concrete or SCC might be the most robust solution.**
- **Flowable concrete at high temperatures should be composed of:**
 - Low charge density superplasticizer
 - High water/powder-ratio
 - Stabilising admixtures
- **Sophisticated mixture compositions are possible with locally available materials, some of which are:**
 - Cassava, Lignosulphonate
 - Rice husk ashes, bagasse ashes
 - Natural pozzolans
 - Pumice
- **Considering the job-site possibilities, the best way to bring rheologically optimised concrete into practice is using pre-mixed dry compounds.**

Announcement

International Conference *Advances in Cement and Concrete Technology in Africa (ACCTA) 2013*

Date: 28th – 30th January 2013

Venue: Emperor's Palace, Johannesburg, South Africa

Themes:

- State-of-the-art of concrete Technology in developing countries
- Case studies and concepts
- Characteristics of cementitious materials
- Mixture Composition, additives and chemical admixtures
- Innovative use of concrete and high performance concrete
- Natural materials and innovative technologies for construction
- Design and evaluation of struct. durability behaviour of conc. elements
- Durability and structural evaluation of concrete structures
- Concrete technology for sustainability and energy efficiency
- Rehabilitation and maintenance
- Education, standardisation, future research and visions
- Social, econ. and envir. aspects of cement, conc. and conc. Construction

Announcement

Important Dates:

Abstract submission:	31st March 2012
Abstract acceptance:	15th May 2012
Paper submission:	15th August 2012
Advanced Registration:	Bef. 15th Dec 2012

Conference Fees:

Students:	\$180
Early bird (bef. 30th Sept. 2012):	\$450
Normal Registration:	\$550

Please visit:

www.accta2013.com



Thank you very much for your kind attention!

Acknowledgements:

