

Influence of Different Storage Conditions on the Rheological Properties of Cement Based Systems

Der Einfluss unterschiedlicher Vorlagerungsbedingungen auf die rheologischen Eigenschaften zementgebundener Systeme

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1. Introduction
2. Experiments
3. Results
4. Conclusions / Outlook

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Relevance

Historical excursion:

1890: 20000 t of Cement from Amöneburg used for the base of the Statue of Liberty, delivery by ship!

today:

Industrial use: Less important but present

Scientific research: Very important! Crucial for long term research programmes...

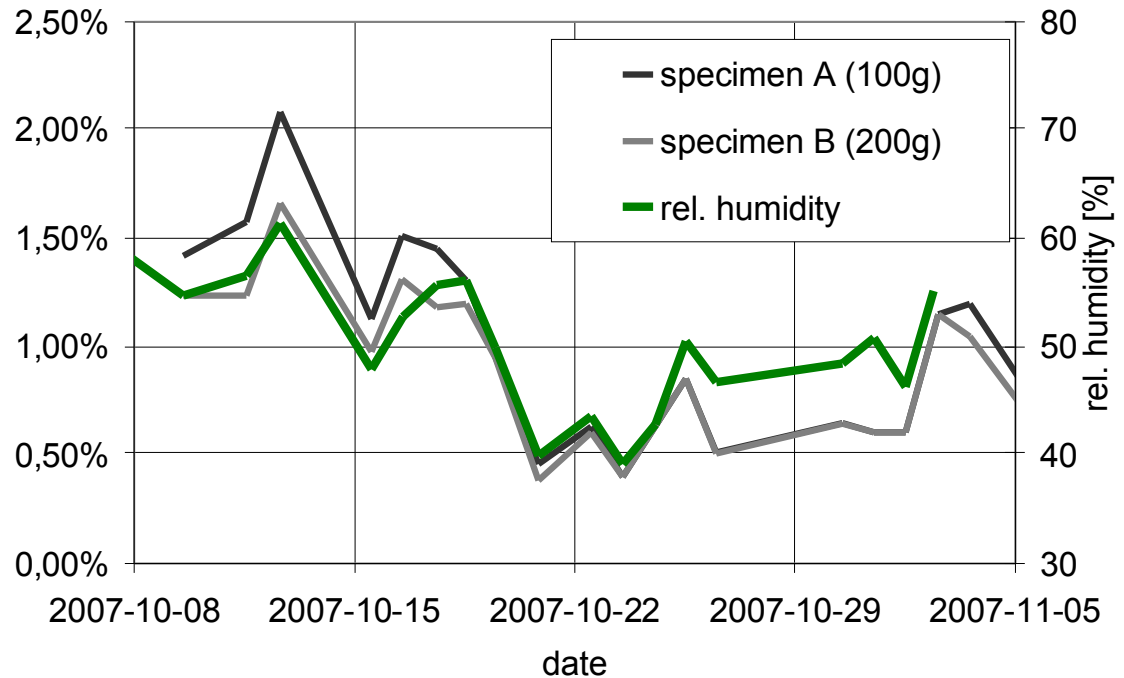
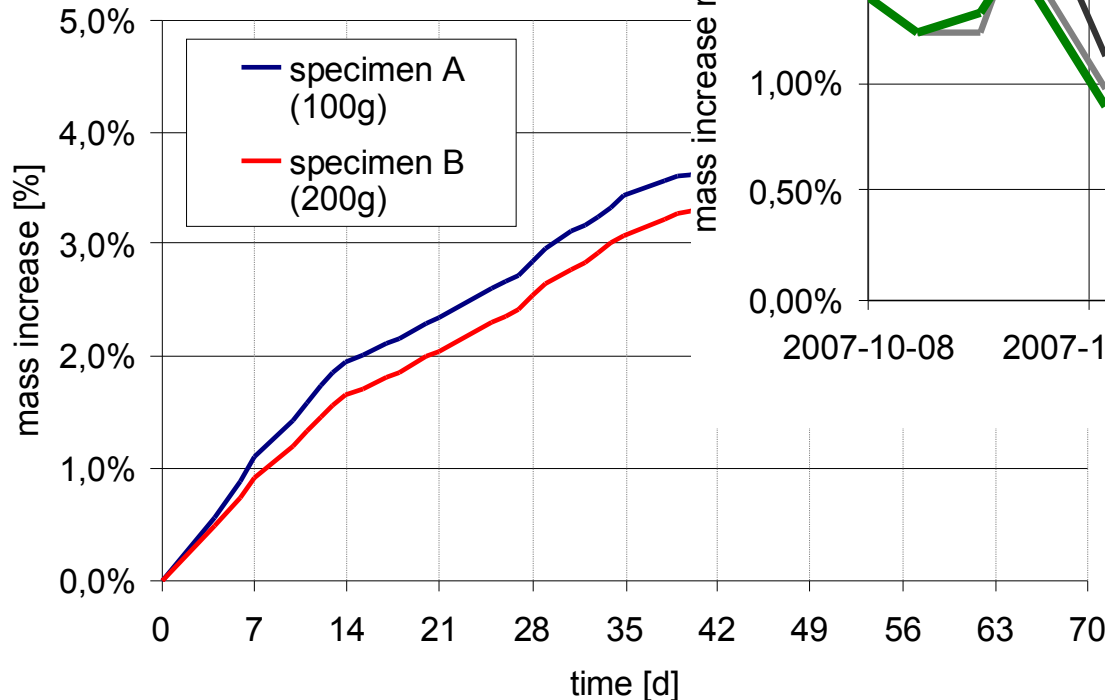
future:

Industrial use: Increasing relevance! global cement import and export (e.g. China)



Pre-examinations

Water adsorption of cement:
Specimens stored in
laboratory climate



Water adsorption of cement:
Adsorption rate correlates with
relative humidity

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Four different concrete applications:

ordinary concrete (OC): standard mortar according to EN 196-1

SCC: combination type

UHPC: “moderate” mixture, $w/b = 0,26$ $f_{c,28d} = 106 - 119 \text{ N/mm}^2$

PCC : special mixture with low polymer content

Different storage conditions and storage duration of the cement:

23°C / 50% RH: 14d, 28d, 56d

23°C / 35% RH: 14d

20°C / 65% RH: 14d

8°C : 14d

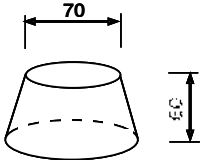

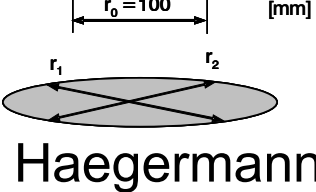




40°C : 14d

“Control”: specimens sealed air and vapour tight on day “zero”

Matrix of experiments

	Blaine	Punkte	SEM pictures	strength	fresh concrete	rheology	Vicat	early shrinkage	shrinkage
cement	X	X	X						
OC				X	X	X	X	X	
SCC				X	X	X	X	X	
UHPC				X	X	X	X		
PCC				X	X	X	X		X

Rheological investigations

OC			max. 80 rpm
PCC	 <p>Haegemann</p>		max. 1 rotation in total (slow speed)
SCC			max. 60 rpm
UHPC	<p>slump flow</p>		max. 80 rpm



manual tests and
measurements with
Viskomat NT

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Results

Properties of the Cement

Specific surface according to Blaine:

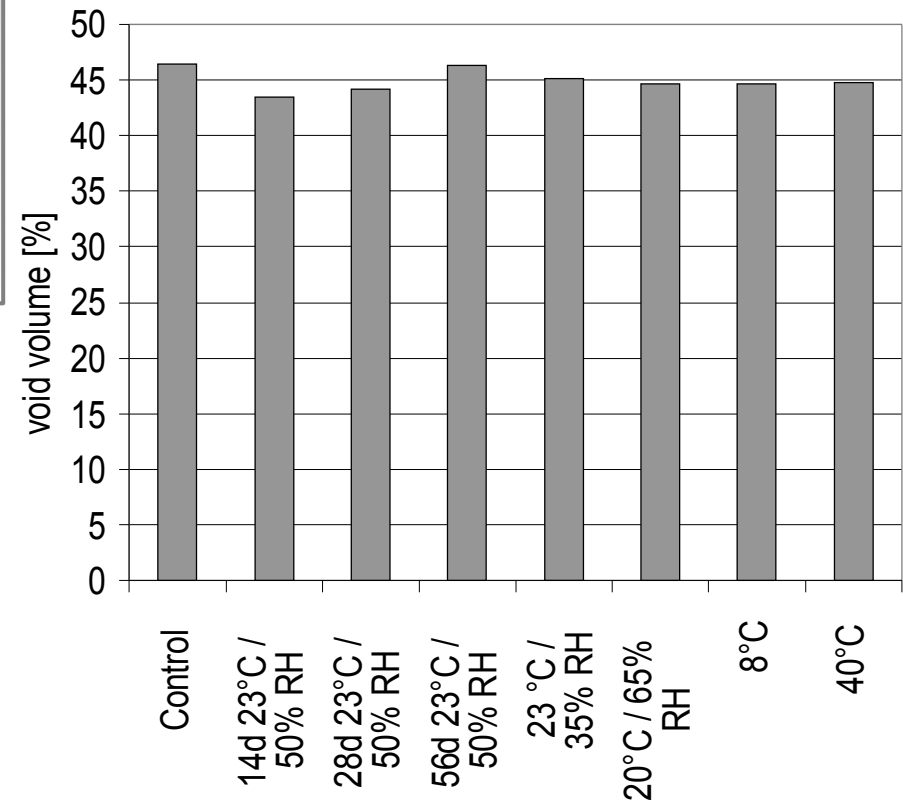
Values differ between 4110 and 4380 cm²/g

But no correlation between the storage conditions and the measured values

Water demand according to Puntke:

Void values differ between 43,4% and 46,3%

The observable dependency on the storage duration (in humid condition) does not correlate systematically



Resume:

Blaine and Puntke are not influenced significantly

Results

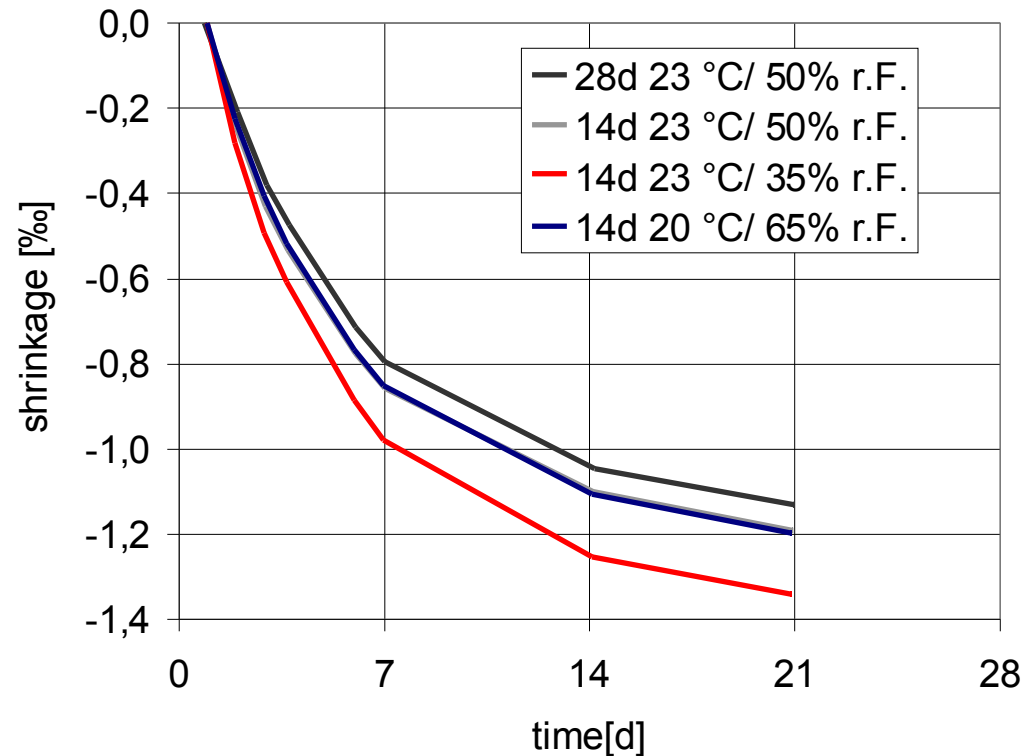
Hardened Concrete Properties

Compressive and flexural strength:

Strength values vary in the range of a normal expected variation, no systematic correlation to the storage conditions obtainable.

Shrinkage (for PCC only):

“pre-stressed” cement seems to reduce the shrinkage value

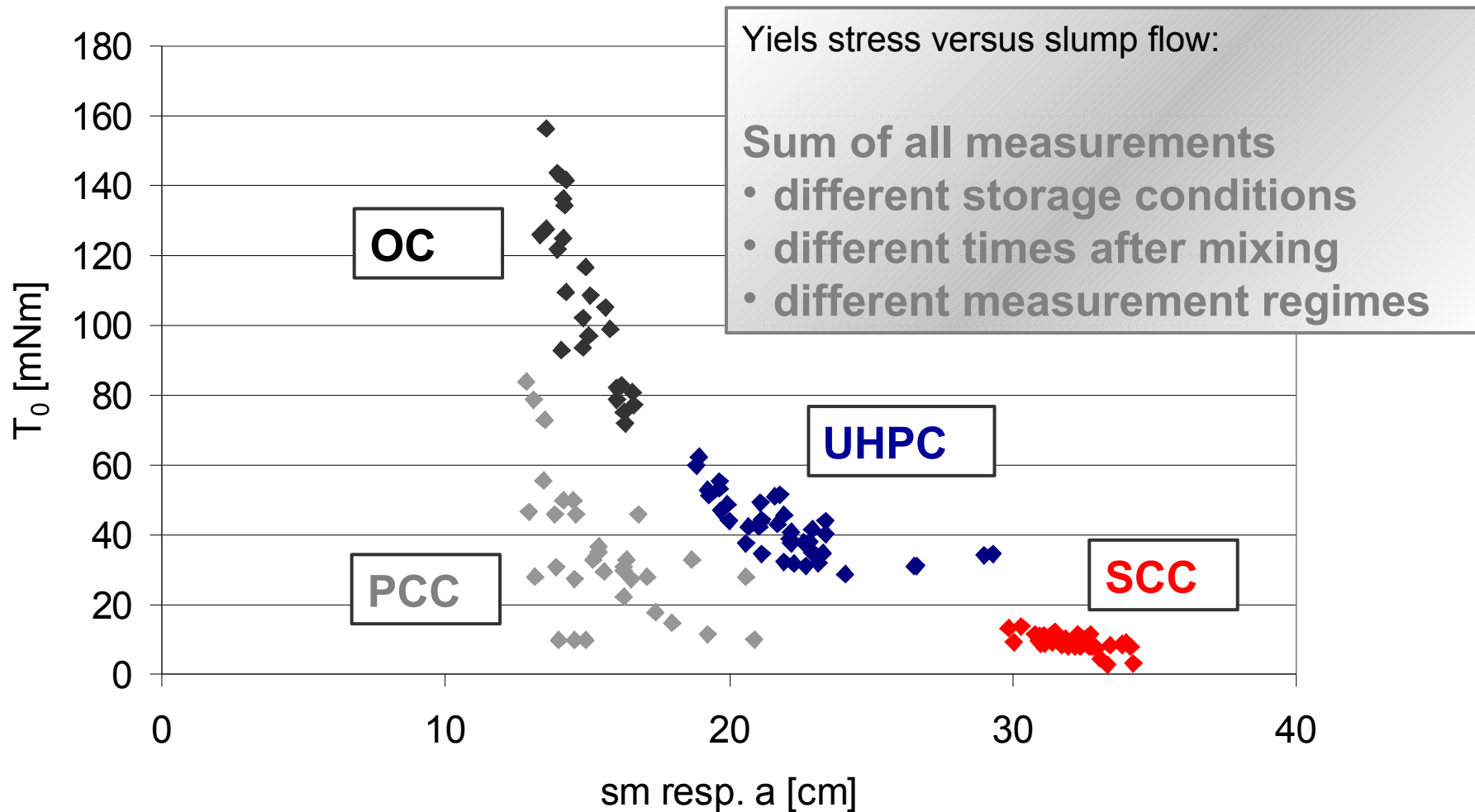


Resume:

Hardened concrete properties are not influenced significantly

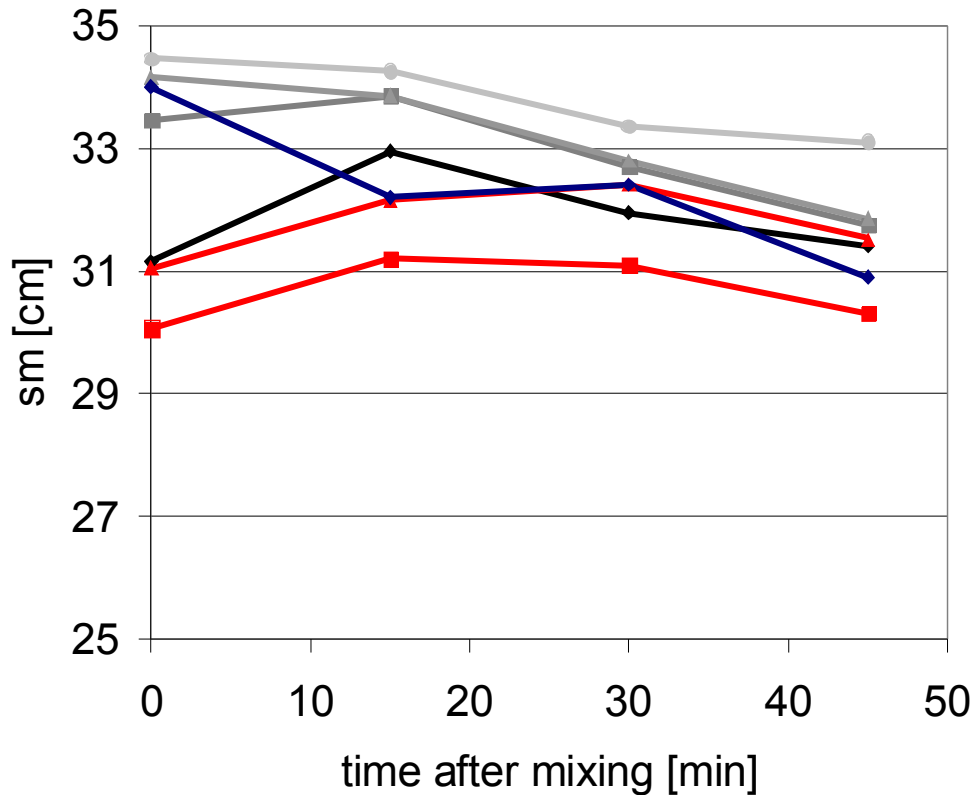
Results

Fresh Concrete Properties

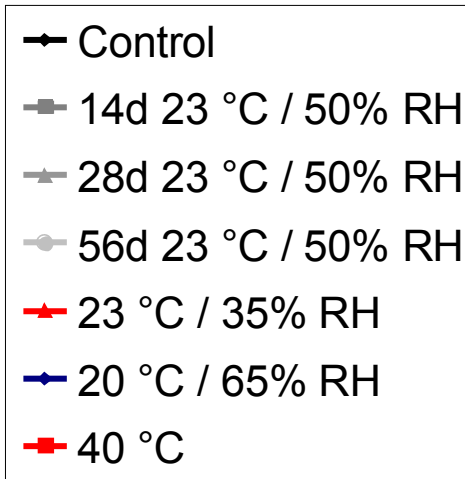


Results

Fresh Concrete Properties



SCC

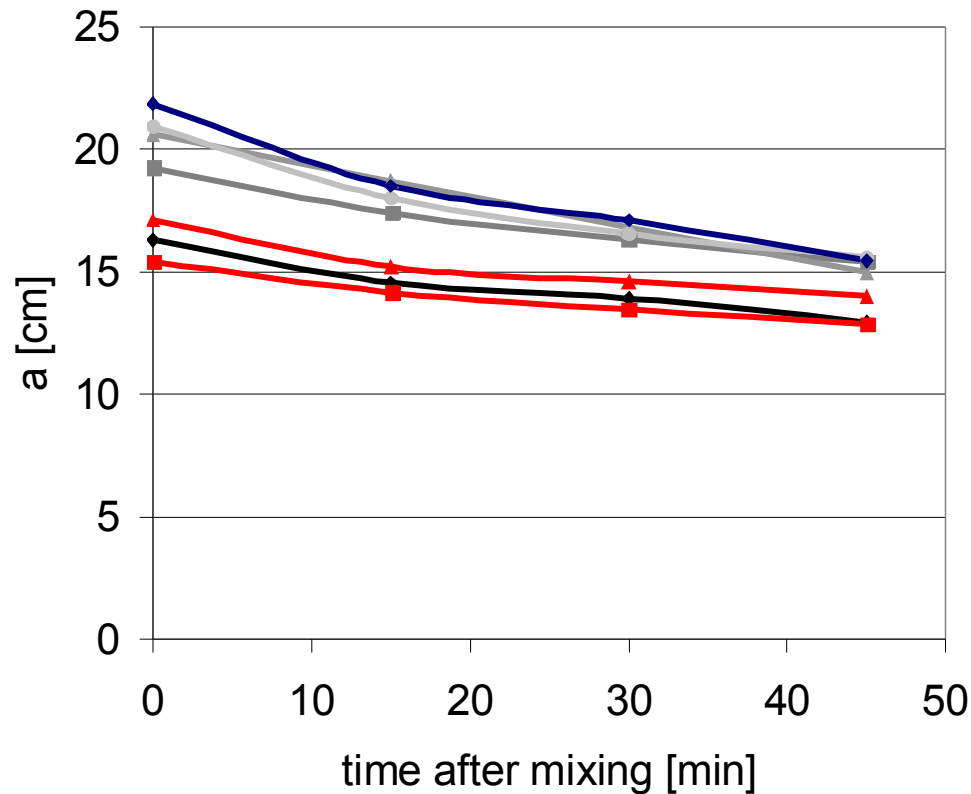


Slump flow versus time:

Humid storage conditions seem to increase the initial values

Results

Fresh Concrete Properties



PCC

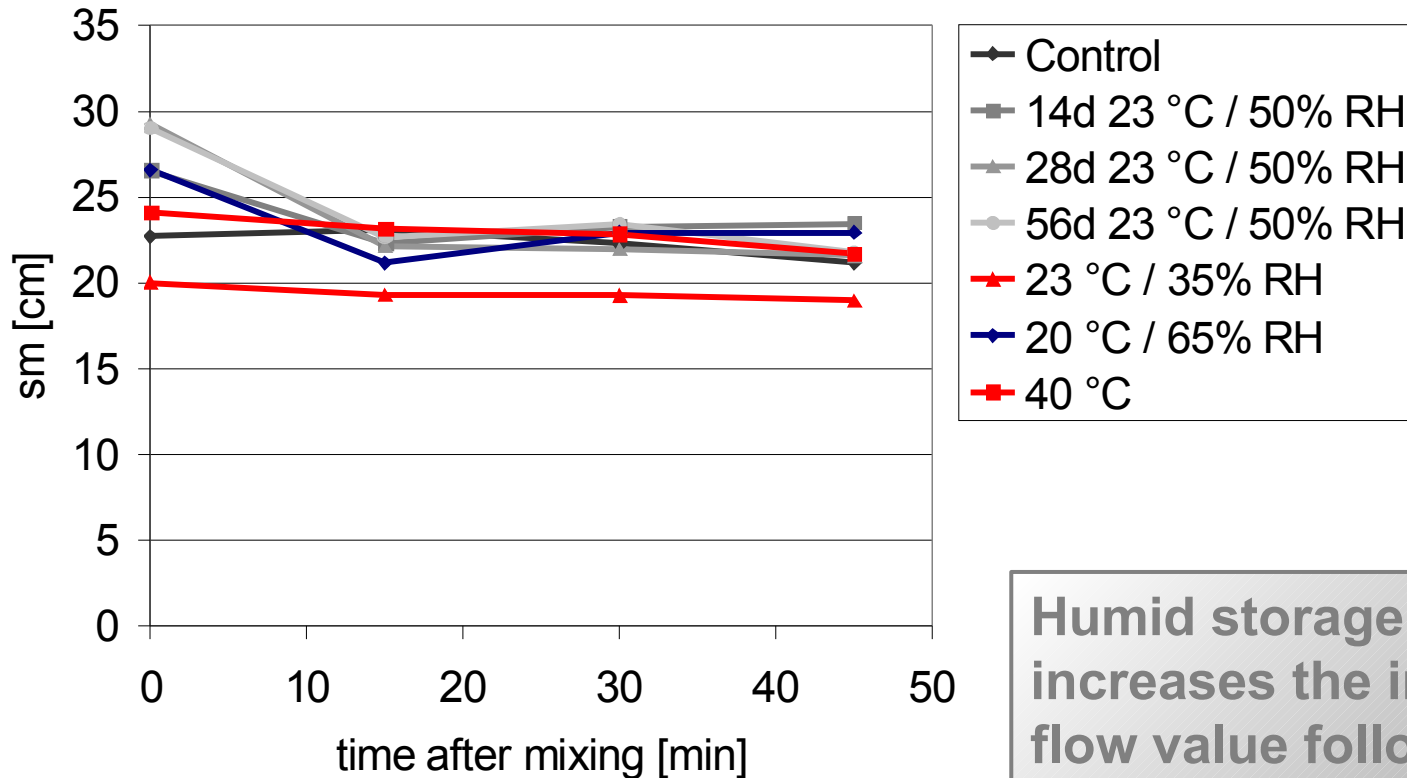
- Control
- 14d 23 °C / 50% RH
- 28d 23 °C / 50% RH
- 56d 23 °C / 50% RH
- 23 °C / 35% RH
- 20 °C / 65% RH
- 40 °C

**Humid storage conditions
decrease the yield stress of
PCC**

This is often not beneficial!

Results

Fresh Concrete Properties



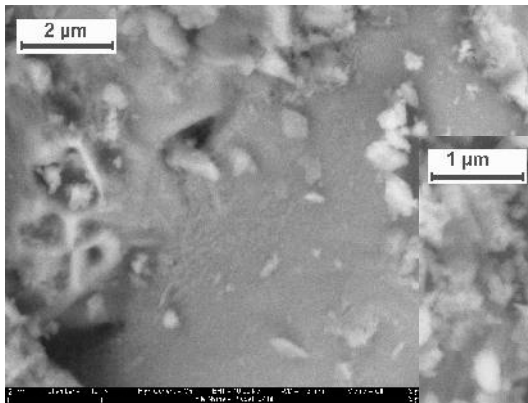
UHPC

Humid storage drastically increases the initial slump flow value followed by a significant loss of workability

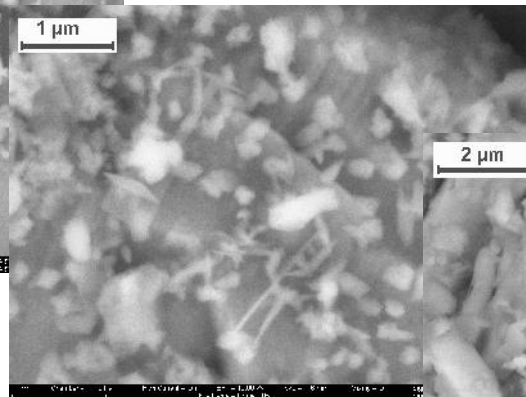
This is not favourable!

Results

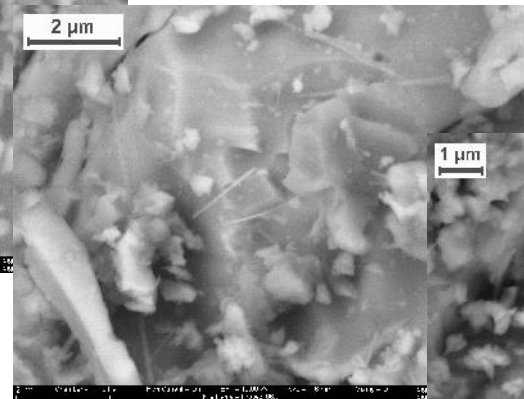
SEM pictures



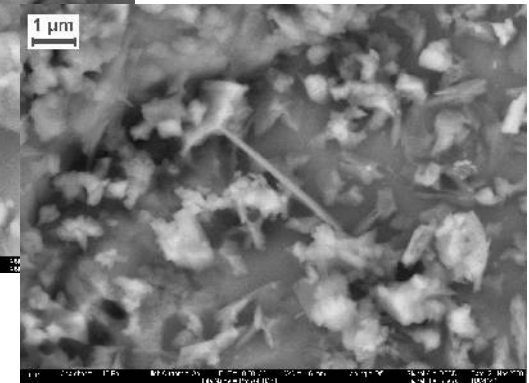
Storage conditions: 23°C / 50 % RH



28 d



56 d



Resume:

Humid storage conditions cause hydration products to grow on the cement grains. The longer and the more humid the exposition is, the more hydration products do form.

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Appliance in industrial use:

- If fresh concrete properties are crucial: **use “fresh” material of good quality**
- If fresh concrete properties are of low importance: **no special action needed**

Appliance in laboratory use:

“Trust in God and keep your Powder dry!”

(Oliver Cromwell, 1649)

Further research needed:

- **Test series on concrete scale**
- **Specific investigation in hot climate with high humidity**
- **Research on the mineralogy of the hydration products**

Rheologische Messungen an Baustoffen

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**Thanks for your
Attention...**

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