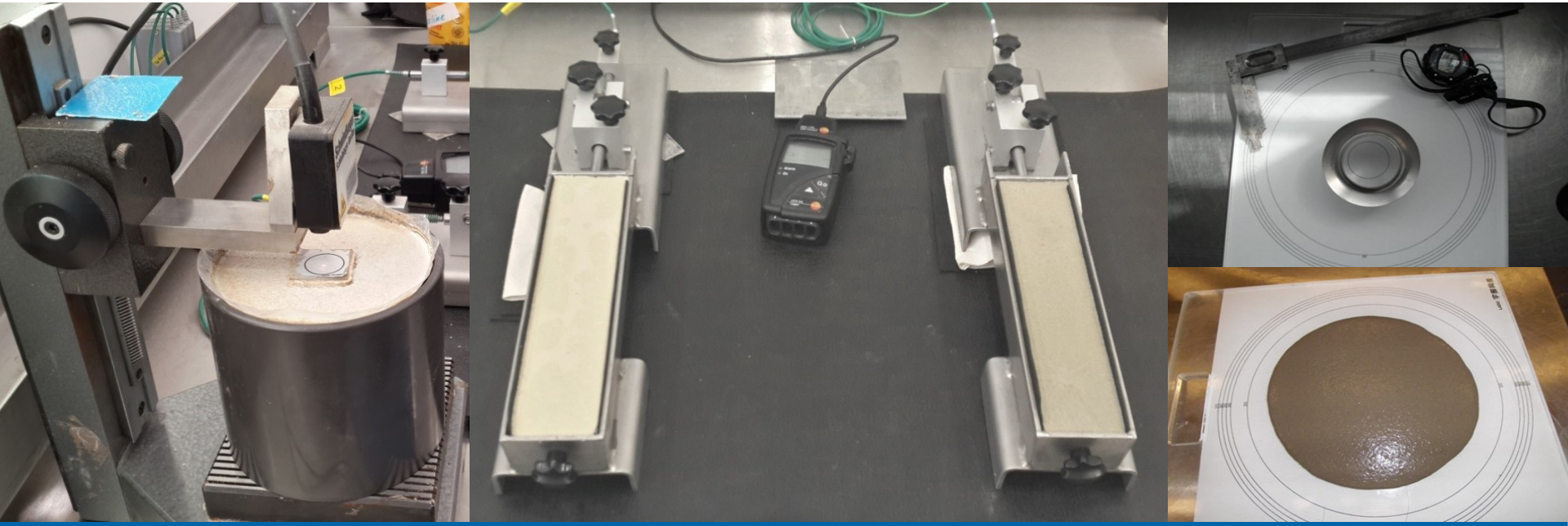
TECHNISCHE UNIVERSITÄT
BERGAKADEMIE FREIBERG
The University of Resources. Since 1765.

Professorship of construction materials
Institute of Ceramic, Glass and Construction Materials
Faculty of Mechanical, Process and Energy Engineering

Influence of Flow Ability on Early Vertical & Horizontal Length Changes in Cementitious Materials



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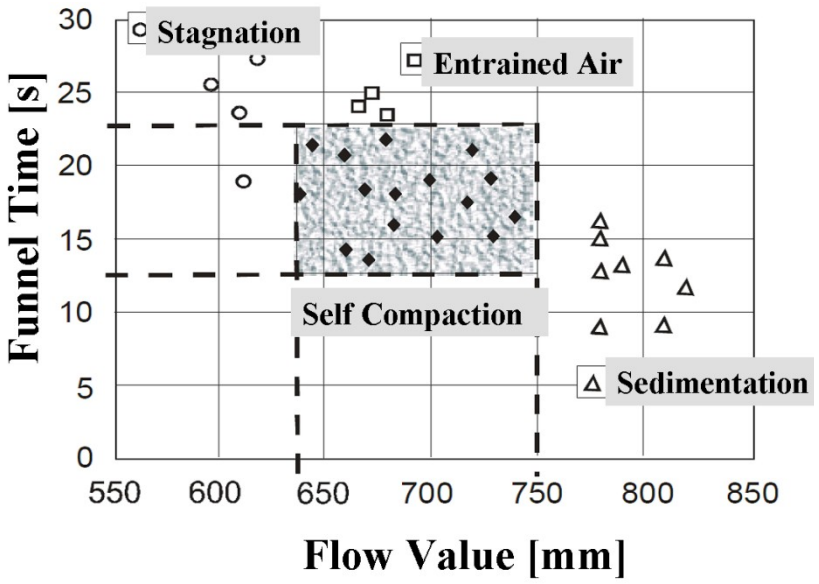
Outline

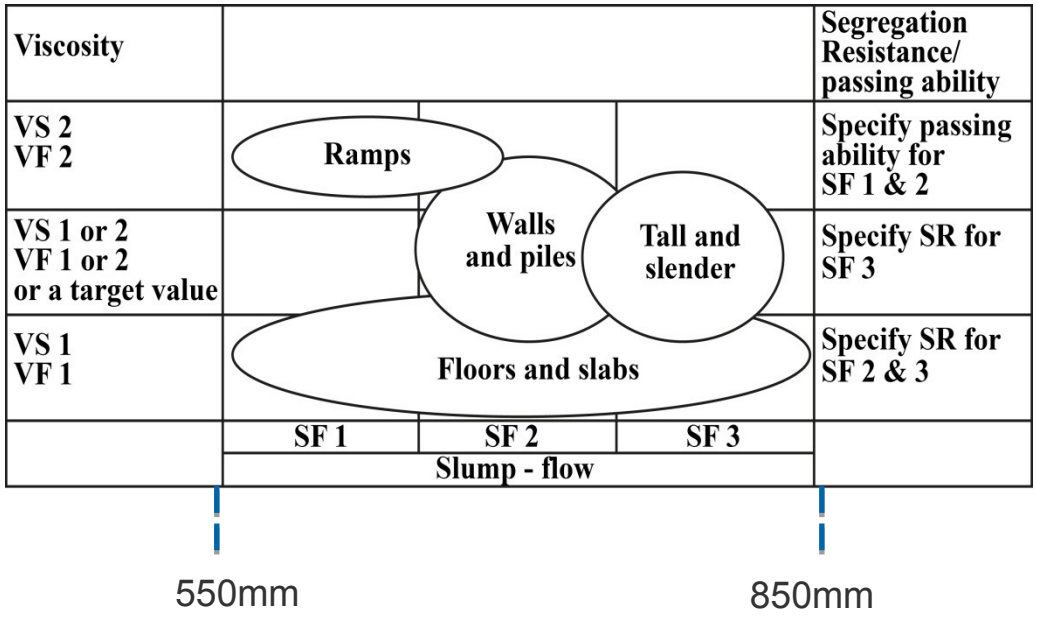
1. Motivation
2. Introduction
3. Experimental
4. Results & Discussion
5. Conclusion

Self Leveling Underlayment Mortars (SLU) & Self Compacting Mortars (SCM) Requirements

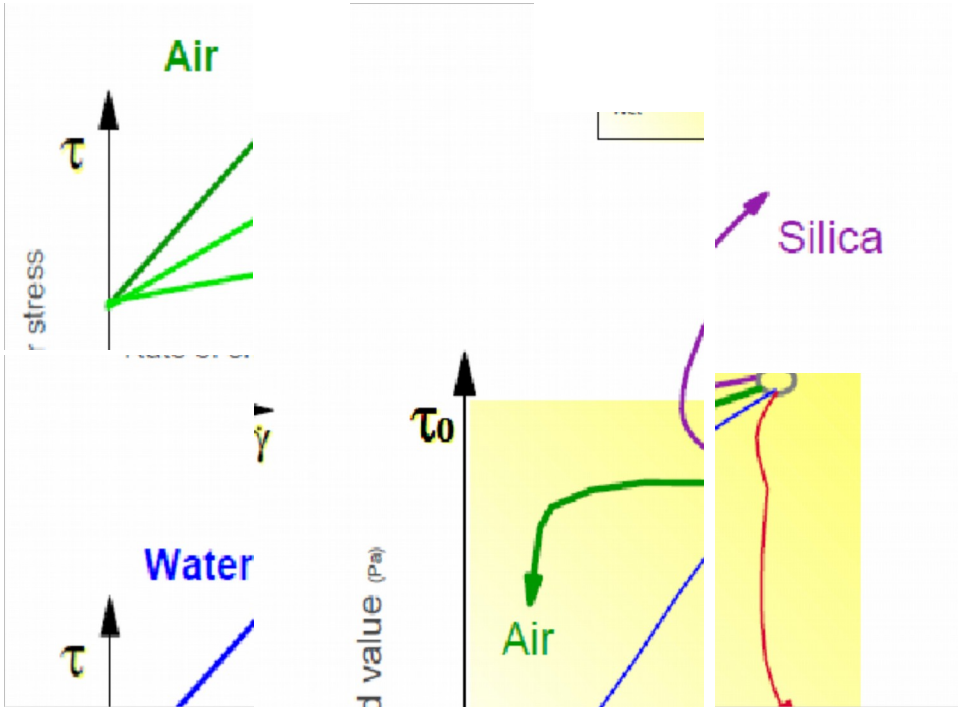
- High flow/self flow
- Workability
- No vibration for construction
- Fast setting
- Low heat of hydration
- Dimensional stability
- Chemical admixture
- Early Strength

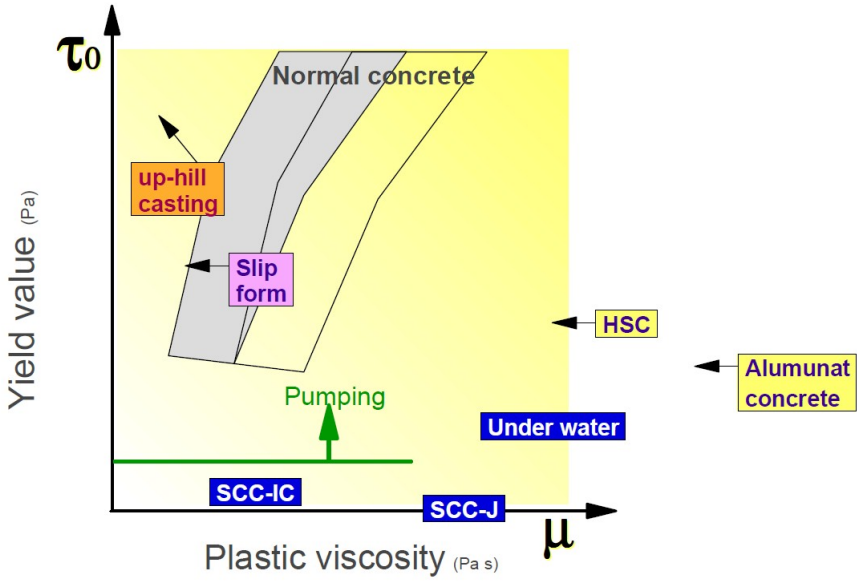
Workability

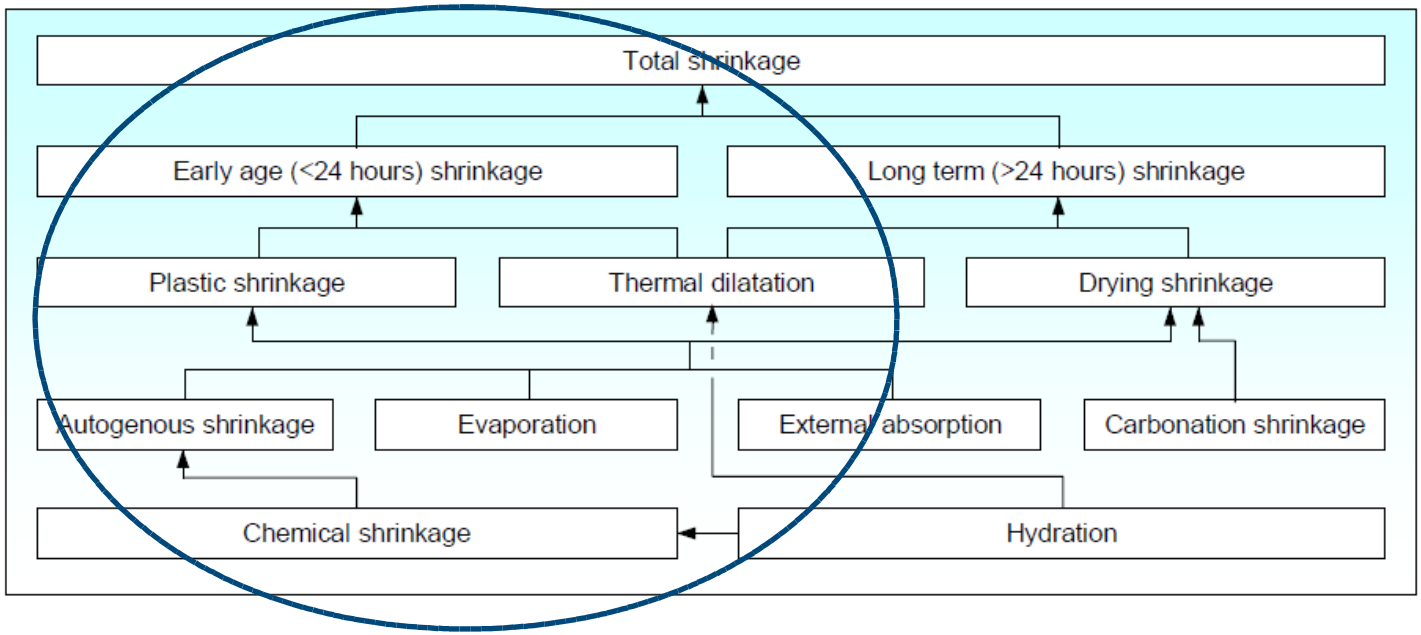


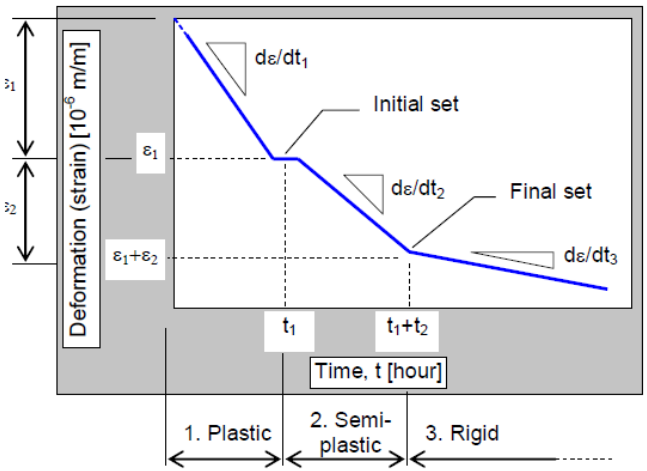


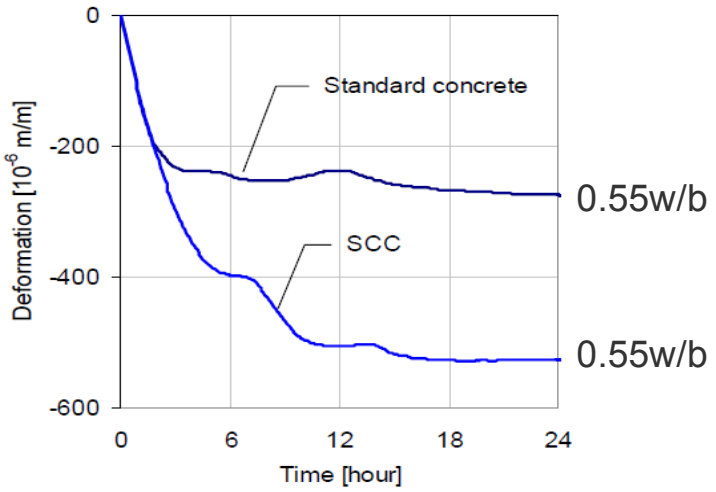
Rheology


Air
τ
stress
Water
τ
Silica
τ0
Air
value (Pa)


τ0
Normal concrete
up-hill casting
Slip form
HSC
Alumunat concrete
Pumping
Under water
SCC-IC
SCC-J
μ
Yield value (Pa)
Plastic viscosity (Pa s)


Total shrinkage
Early age (<24 hours) shrinkage
Long term (>24 hours) shrinkage
Plastic shrinkage
Thermal dilatation
Drying shrinkage
Autogenous shrinkage
Evaporation
External absorption
Carbonation shrinkage
Chemical shrinkage
Hydration


dε/dt1
Initial set
ε1
dε/dt2
Final set
ε1+ε2
dε/dt3
Deformation (strain) [10-6 m/m]
t1
t1+t2
Time, t [hour]
1. Plastic
2. Semi-plastic
3. Rigid


0
-200
-400
-600
Deformation [10-6 m/m]
Standard concrete
SCC
0.55w/b
0.55w/b
0
6
12
18
24
Time [hour]

Experimental

- **Materials & Composition**
- **Methods**
  - ✓ **Flow value**
  - ✓ **Setting time**
  - ✓ **Rheology**
  - ✓ **Length changes (horizontal & vertical)**

Materials & Composition

OPC – CEM I 42.5 R (Lafarge)

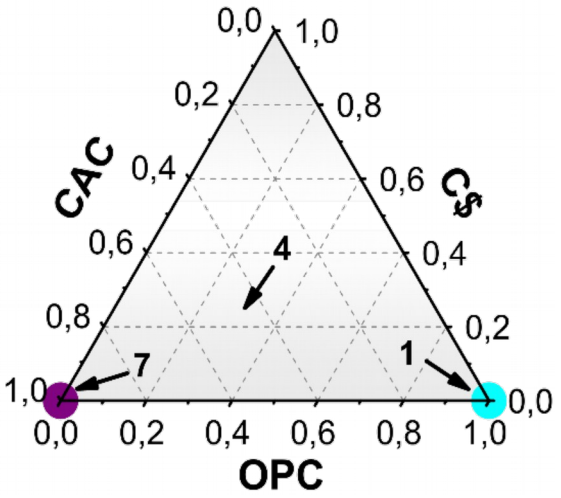
CAC – Fondu

$C\bar{S}$ – α-Hemihydrate (Casea)

Sand – siliceous sand (1mm max grain size)

LSP – limestone powder (Lafarge)

SP – MF 4930 F (Polycarboxylate Base)

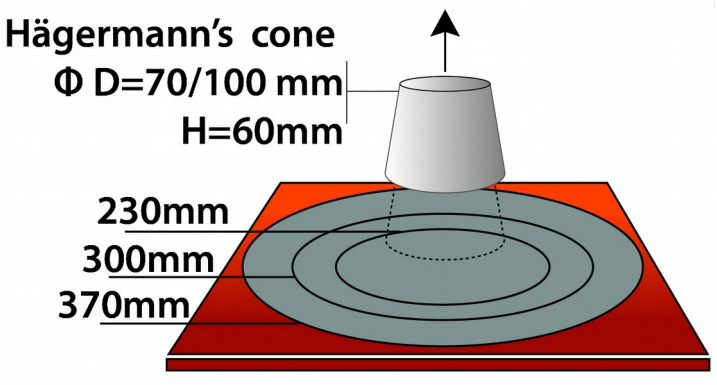


ole	OPC	CAC	$C\bar{S}$	LSP	Sand	SP (gr) for specific flow			W/B
	Mass in (gr)					230mm	300mm	370mm	
1	350	0	0	270	380	1.68	1.79	1.97	0.55
4	108.5	171.5	70	270	380	1.6	1.83	2.1	0.55
7	0	350	0	270	380	0.71	0.8	0.92	0.55

Methods

✓ Flow value

- Hägermann's mini slump cone.
- measurement started approximately 1 minute after mix end.
- Video recorded



✓ Setting time

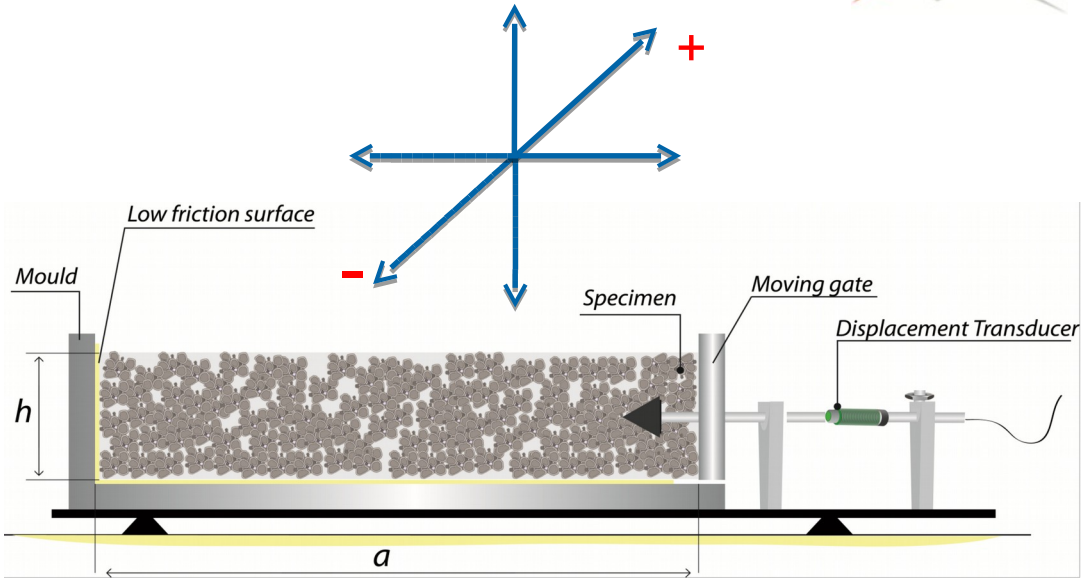
- Mortars initial & final setting time with an automatic Vicat apparatus
- according to DIN EN 196-3.
- Measurement was started 5 minutes after mixing water was added

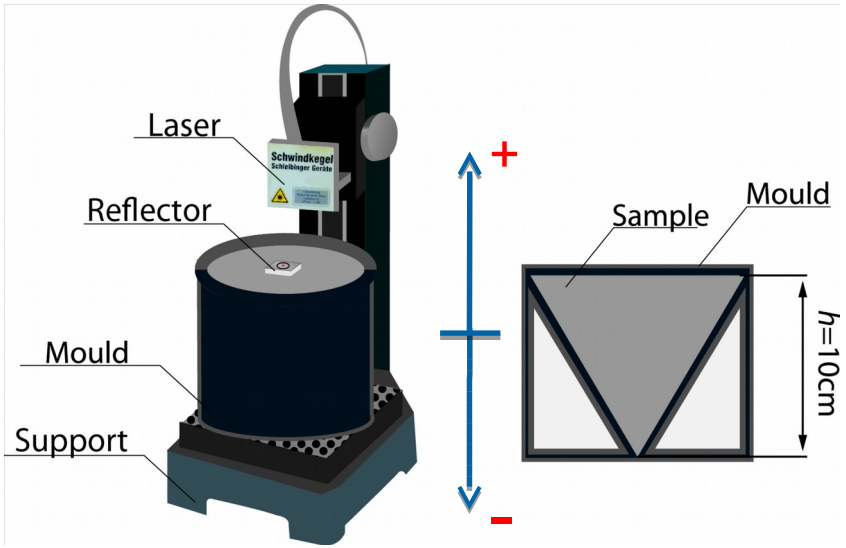
✓ Rheology

- Haake RheoStress RS 150 and Haake F6 - C25 for temp. control
- Temperature was set to 20.5 ± 0.5 ºC .
- cylinder Ø 38mm-DIN 53018 – Z38
- Sh. stress & viscosity were measured as a function of time at a constant shear rate ($\dot{\gamma}$) of 1/sec
- Measurements started 2 minutes and 30 second after end of mixing

✓ Shrinkage

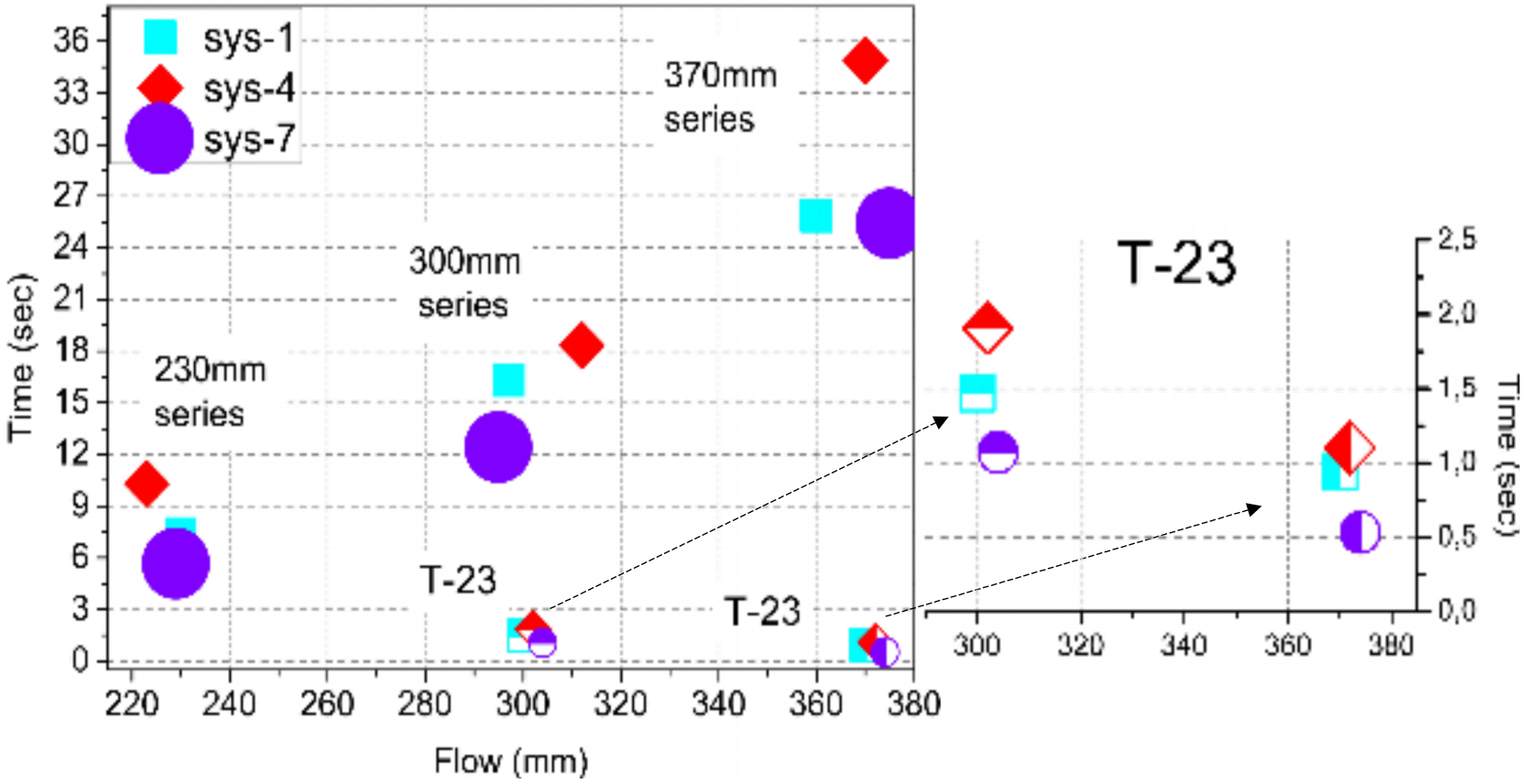
- Schwindrinne / shrinkage drain apparatus of 40mm (h) x 60mm (b) x 250mm (a)
- Schwindkegel - cone shaped mould of 100 mm height
- Measurements started between 6-7 min. after mixing water addition and 3-4 minutes after placement



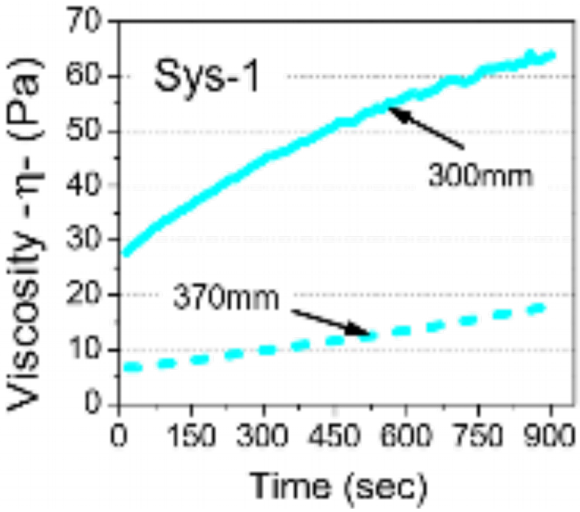


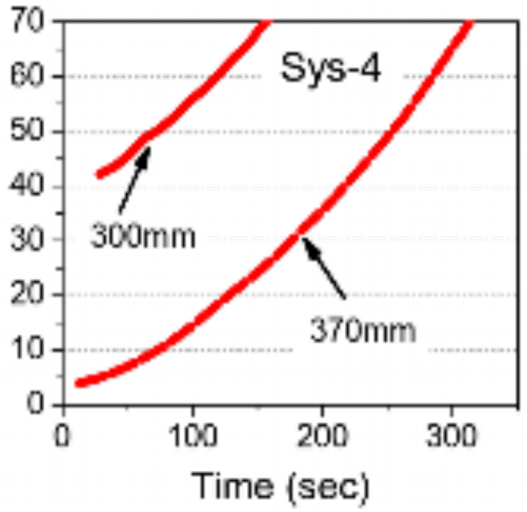
Results & Discussion

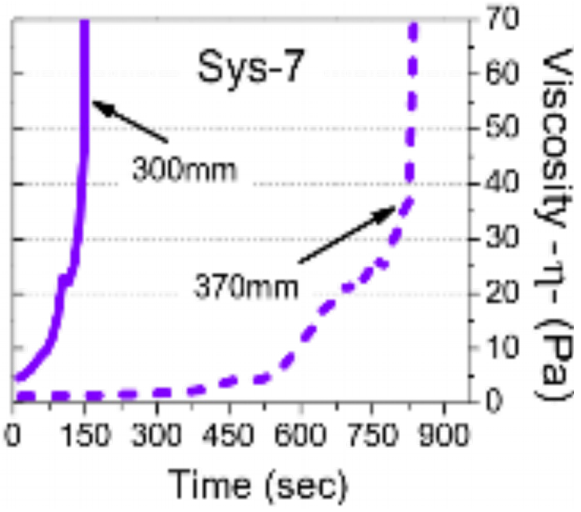
Flow behavior

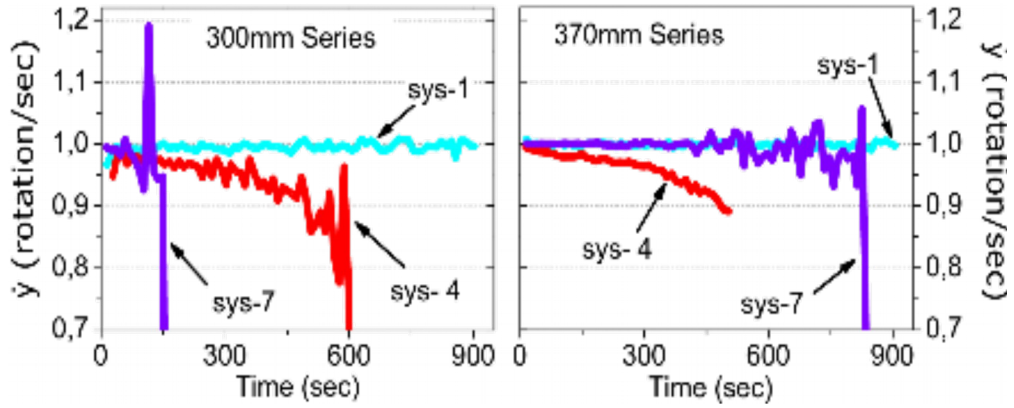


Rheology


Sys-1
300mm
370mm
Viscosity -η- (Pa)
Time (sec)
0
10
20
30
40
50
60
70
0
150
300
450
600
750
900

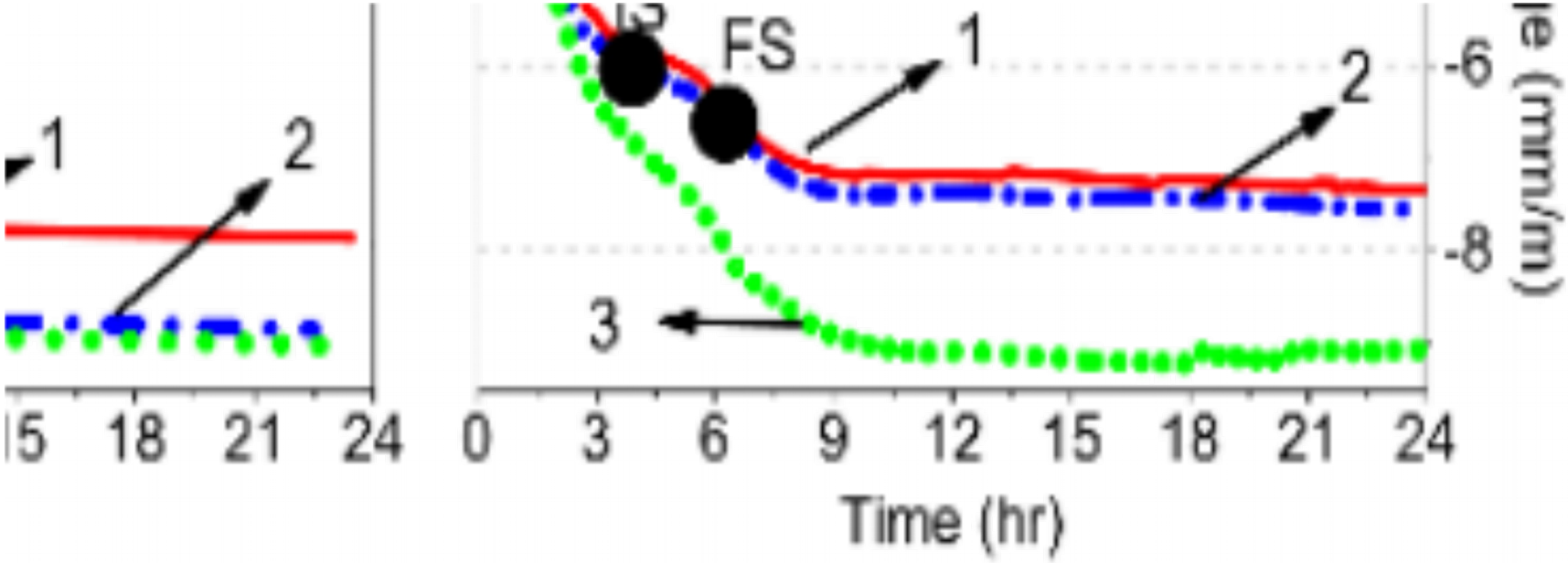

Sys-4
300mm
370mm
Time (sec)
0
10
20
30
40
50
60
70
0
100
200
300


Sys-7
300mm
370mm
Viscosity -η- (Pa)
Time (sec)
0
10
20
30
40
50
60
70
0
150
300
450
600
750
900


300mm Series
370mm Series
sys-1
sys-7
sys- 4
ẏ (rotation/sec)
Time (sec)
0,7
0,8
0,9
1,0
1,1
1,2
0
300
600
900

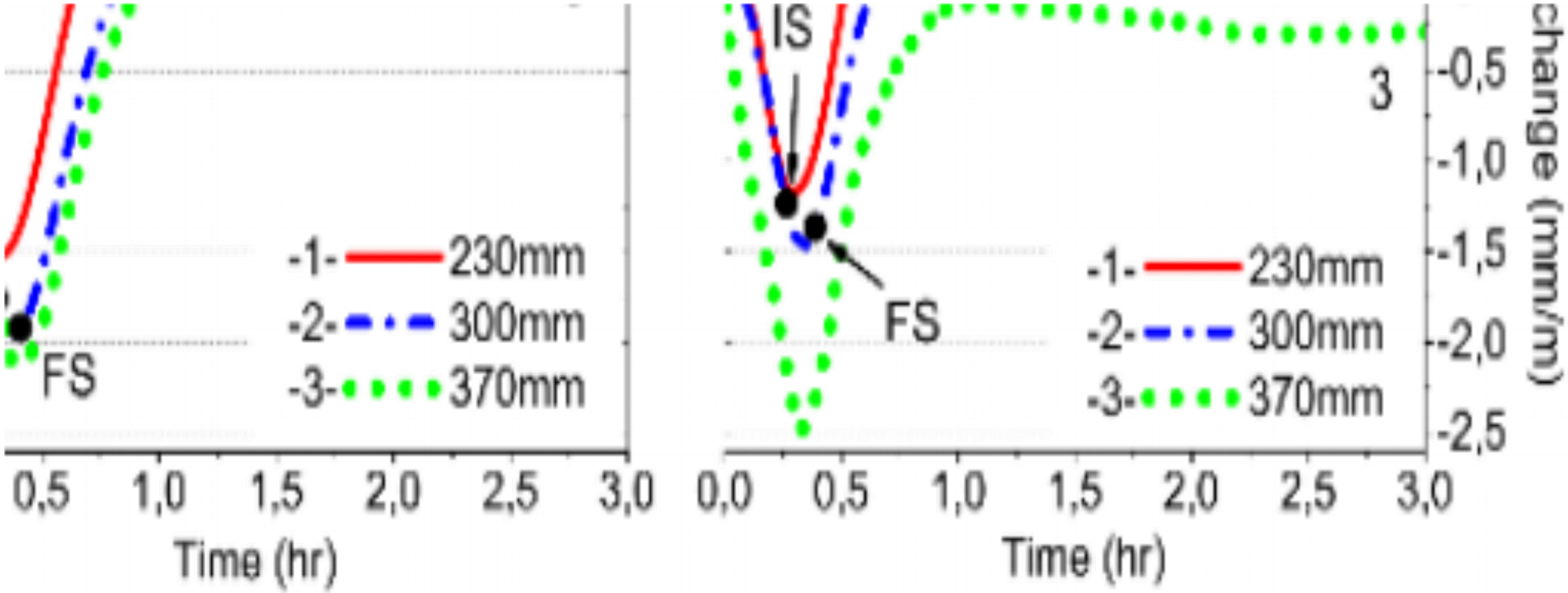
Length change

System - 1



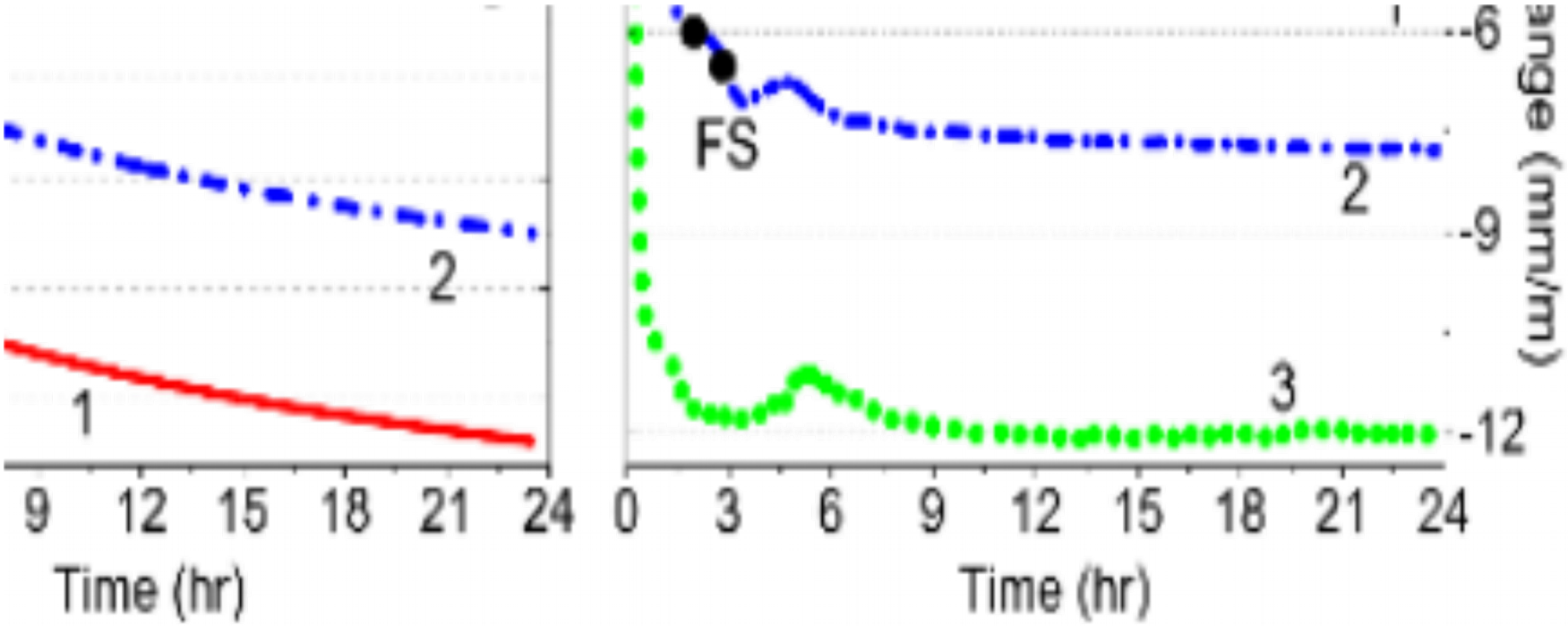
	OPC	CAC	CS	LSP	Sand	SP (gr) for specific flow			W/B
ole	Mass in (gr)					230mm	300mm	370mm	
1	350	0	0	270	380	1.68	1.79	1.97	0.55

System - 4



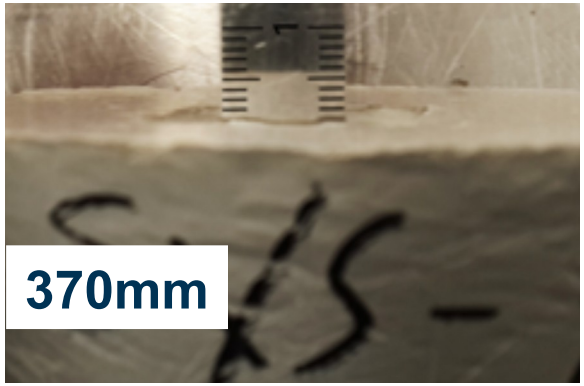
	OPC	CAC	CS	LSP	Sand	SP (gr) for specific flow			W/B
ble	Mass in (gr)					230mm	300mm	370mm	
4	108.5	171.5	70	270	380	1.6	1.83	2.1	0.55

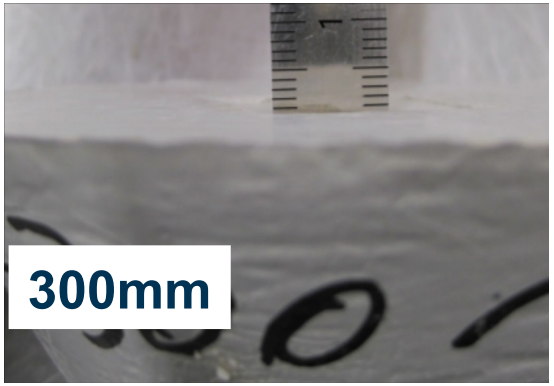
System - 7

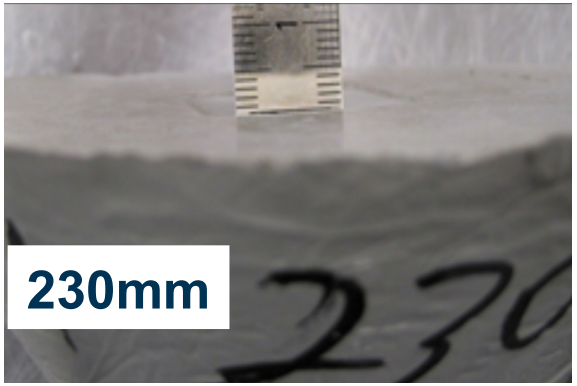


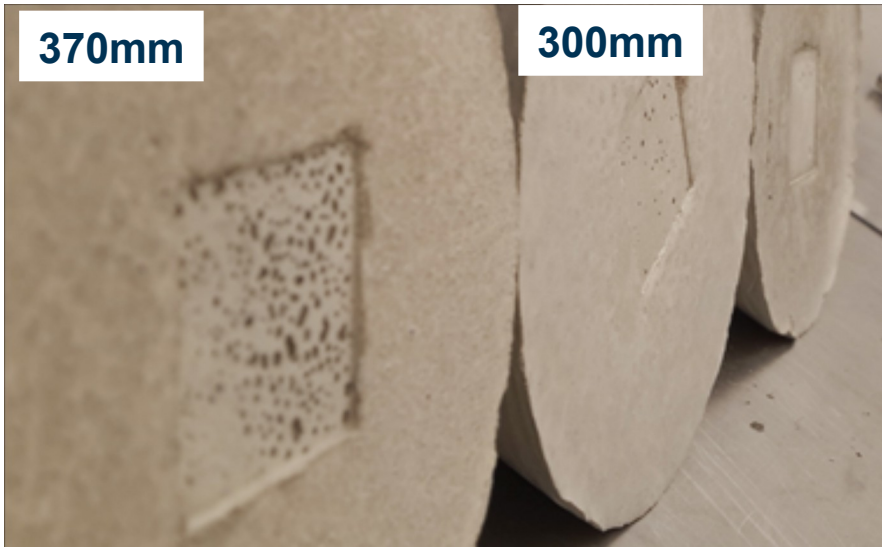
	OPC	CAC	CS	LSP	Sand	SP (gr) for specific flow			W/B
ble	Mass in (gr)					230mm	300mm	370mm	
7	0	350	0	270	380	0.71	0.8	0.92	0.55

System - 1









CONCLUSIONS AND OUTLOOK

- As the flow value changes, it strongly influences/changes apparent viscosity which influences directly the ability of the material to settle, de-air, self –compact and/or self-level and bleed. These mechanisms - on the other hand - substantially influence early dimensional stability behavior.
- Length change measurement performed in cone show to be more effected by high flow values in comparison with those performed in horizontal drain. The reason behind this is the measurement principle used in cone where all material behavior is expressed in only one vertical axis.
- The reflector used in cone measurement has an influence on measurement especially in high flow value series. As the flow increases the viscosity drops and the reflector begins to immerse into the material directly after placement which is than shown as an immediate and strong shrinkage curve. In relatively low flow series the influence of reflector trend to minimize and length change results measured in both devices are becoming comparable.
- Towards the end of the plastic shrinkage phase autogenous shrinkage becomes predominant. This leads to e reduction in total shrinkage measured. As a function of the phases formed during hydration and the visco-elastic properties of the material at that point in time, even expansion can be observed.

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THANK YOU FOR YOUR ATTENTION

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