Regensburg, 19.3.2012

Rheology of SCC mortar with different superplasticizer

Introduction to polyphosphonic superplasticizer

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Introduction. Purpose of this work

Why SCC?

✓ World consumption of PC is 650.000 t (raw material).

x What is SCC share in all concrete production?

x What is ratio between ready – mix SCC and precast SCC?

Why mortar?

✓ To determine standard mix for SCC mortar to study SP influence.

✓ To reduce influence of large aggregate particles

✓ To reduce work needed for concrete testing

Why superplasticizers (SP)?

✓ TKK is a formulator of chemical admixtures for South Eastern Europe

✓ We know a significance of SP on concrete rheology.
How to measure it in lab?

✓ We know a new group of SP – Polyphosphonic SP (Ph)

Why Rheology?

Introduction. Purpose of this work

Why Rheology?

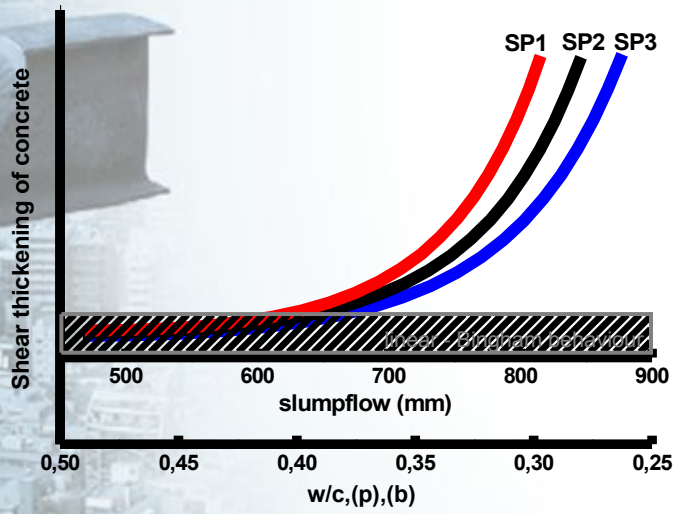


Figure 1. Shemicatic presentation of influence of SP on c/η - shear thickening in modified Bingham model **[Feys et al., CCR, 39, 510]**

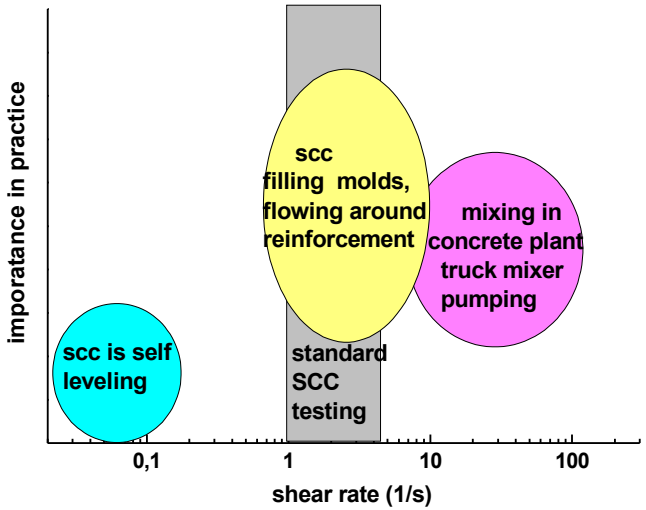
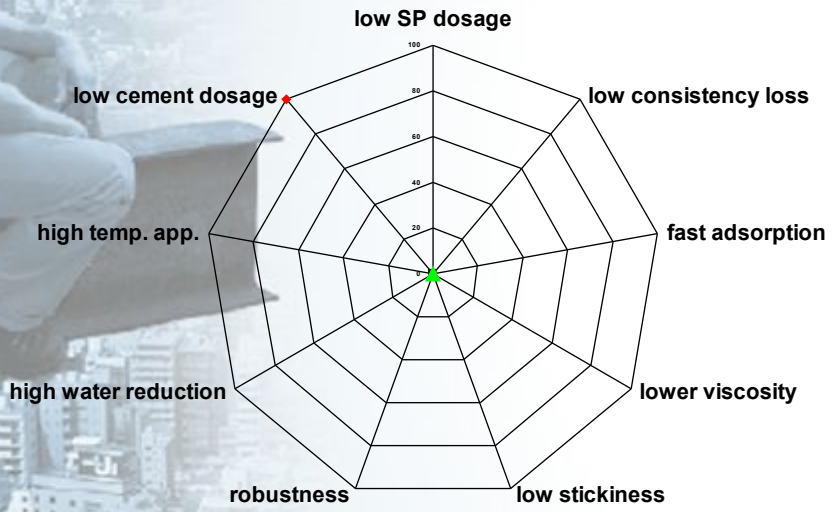


Figure 2. Shemicatic presentation of influence of several processes with concrete on shear rate.

Introduction. Influence of SP on concrete

Fresh concrete



Hardened concrete

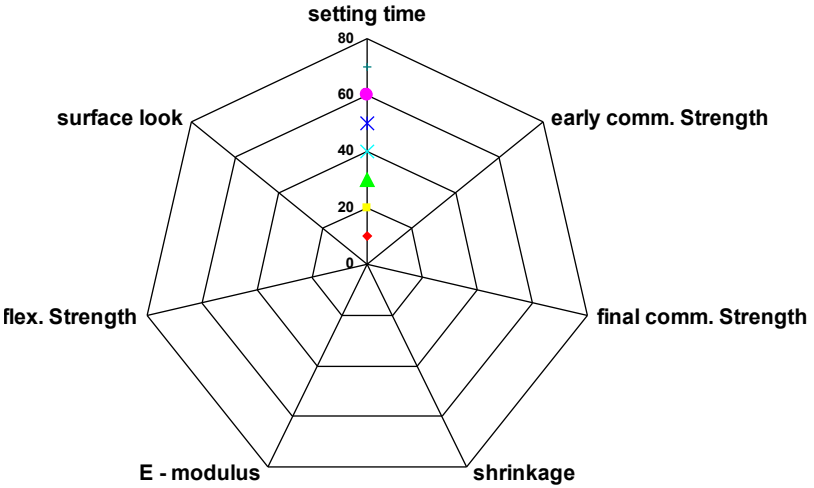


Figure 3. Shematic diagrams for presentation of SP influence on fresh and hardened concrete.

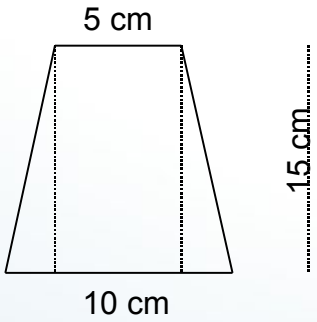
- The higher the flow of concrete, the pronounced SP effect on fresh properties
- Rheology of concrete could also influence some properties of hardened concrete

Experimental. Mortar design

SCC Concrete

SCC (0-16 mm) SF=750 mm

SCC mortar



Experimental. Mortar design

Table 1. Dry material information.

Material	Producer	Type	Dosage kg/m³
Cement	Salonit	CEM I 52,5 R	600
Filler	Primorje	Limestone Laže	177
Sand 0-1 mm	Kema Puconci	Quarz	775
Sand 0,5-2	Kema Puconci	Quarz	376

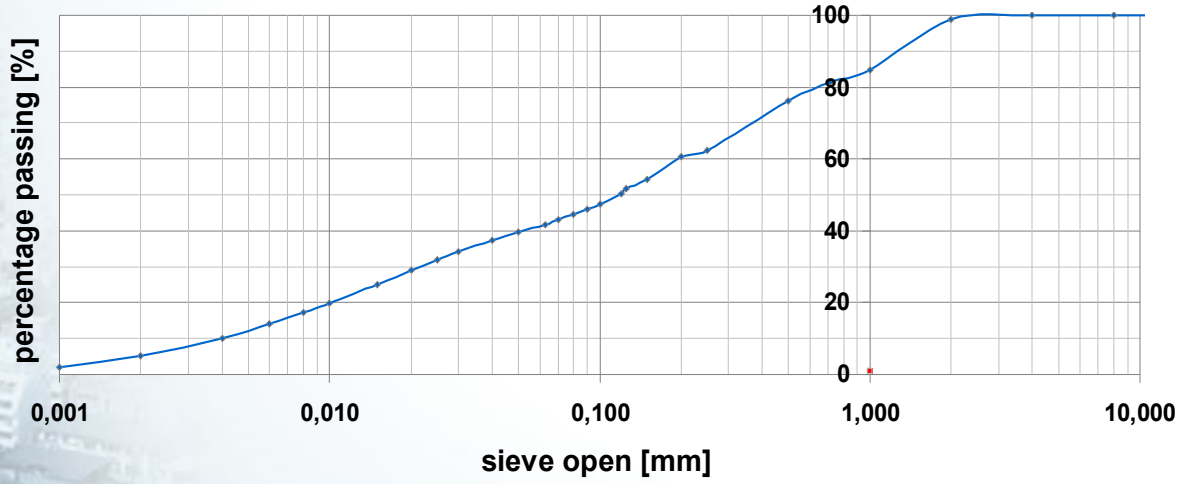


Figure 4. Particle distribution of dry mix.

Experimental. Mortar design – target.

Table 2. Target mortar parameters, which influence the rheology.

time	$SF_{minicone}$ (mm)	w/c	air (%)	Temp. (°C)	Defoamer (%)
15 min	350 ± 15	0,49	2 ± 0,2	22 ± 1	0,1

Table 3. Basic SP information.

	PC 1*	PC 2*	PC 3	Ph 1	Ph 2	Ph 3	PC Sika*	PC BASF*
Commercial name	Cementol Hiperplast 179	Cementol Hiperplast 481	Cementol VF 1/12	Cementol VF 2/12	Cementol VF 3/12	Cementol VF 4/12	Sika Plast 400 Xtend	Glenium Sky 582
Company	TKK	TKK	TKK	TKK	TKK	TKK	Sika	BASF
Proposed application	Ready mix	Ready mix/ Precast	Ready mix	Transport	Transport	Transport	Transport	Transport
Chem. Basis	**PC**	**PC**	**PC**	**Phosphonic**	**Phosphonic**	**Phosphonic /PC**	**PC**	**PC**
SCC	✓	✓	✓	✓	✓	✓	✓	✓

*Data from technical specification available at www

Experimenal. Fresh mortar data.

Table 4. Fresh mortar parameters.

Mix name	SP	SP (%ds)	Slumpflow (cm) at 15`	Air (%)	T (°C)	w/c
1	PC 1	0,325	33,5	2,4	23	0,50
2	PC 2	0,238	37,1	2,0	23	0,50
3	PC 3	0,364	35	2,0	22	0,50
4	Ph 1	0,806	35,1	2,0	22	0,50
5	Ph 2	0,65	35,6	1,4	22	0,50
6	Ph 3	0,378	37	2,0	23	0,50
7	PC Sika	0,623	35	2,5	23	0,50
8	PC Basf	0,554	35,5	3,1	23	0,50

No bleeding, segregation, jamming for all mixes!

Experimental. Rheology testing.

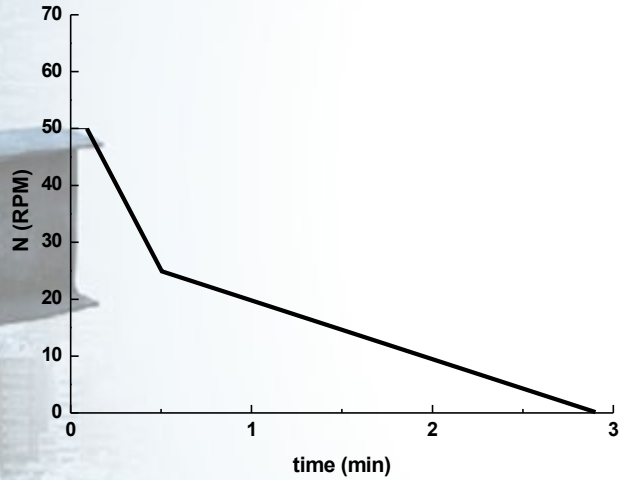


Figure 5. A typical speed profile.

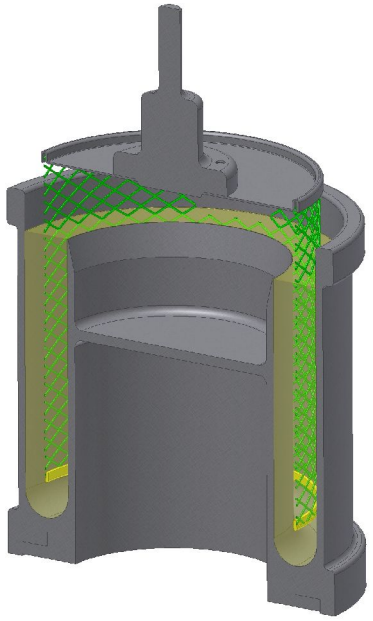


Figure 6. Vogel type measuring body.
Picture from [www.schleibinger.com]

- Rheometer - Viskomat NT
- Vogel type measuring body
- [Ein Messezell fur Specialmortel, www.vogel-labor.de]
- Preshearing with mortar mixer

Calibration data (TKK)

$\forall \dot{\gamma}/N = 0{,}447$ [min]/[s]

$\forall \dot{\gamma}_{crit.}/(\tau_o/\eta_{pl}) = 0{,}321$

- $c_K = 0{,}868$

$\forall \tau/T = 0{,}76$ [Pa]/[mNm]

Experimental. Measurement and definitions.

- Test of slumpflow and rheology was measured for **SF > 30 cm**, at **15`, 60`, 120` and 180`.**
- For extrapolation of flow curve to shear rate = 0 we used Hershley–Bulkly (HB) model, fitting only to shear thinning stress.

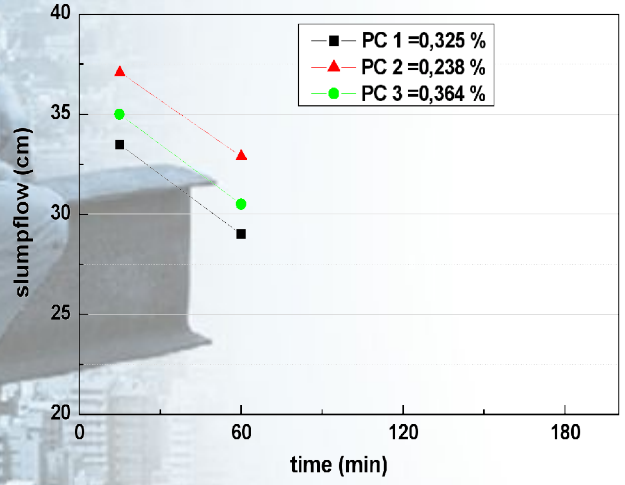
$$\tau = \tau_o + k\gamma^n \quad \text{(HB equation)}$$

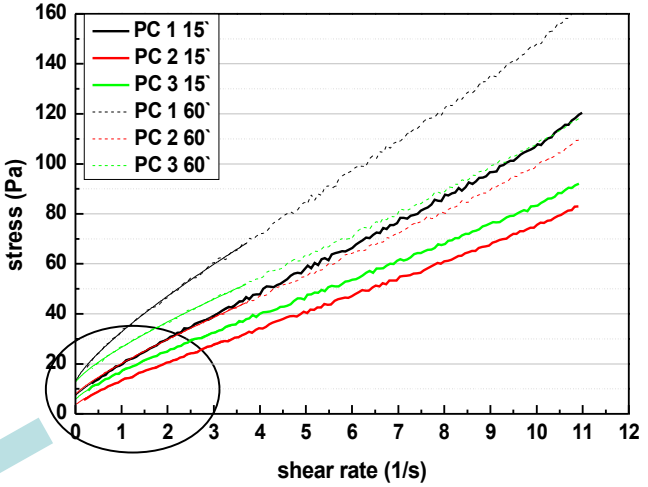
- Results below critical shear rates (artefact because of geometry) acc. to Vogel [www.vogel-labor.de] were omitted
- For calculation of viscosity we used

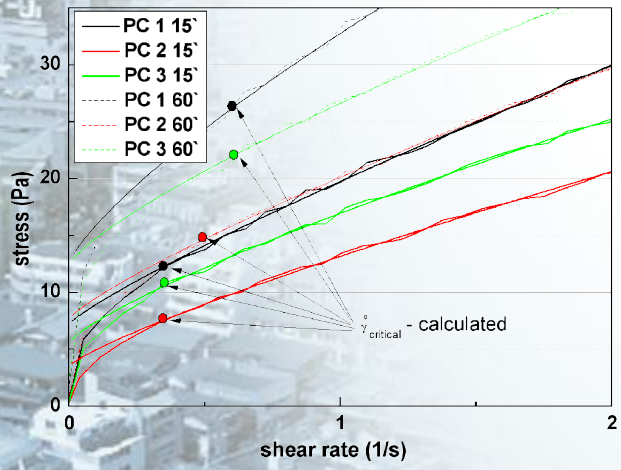
$$(\tau - \tau_o)/\gamma \quad \text{(app. Bing. visco.)}$$

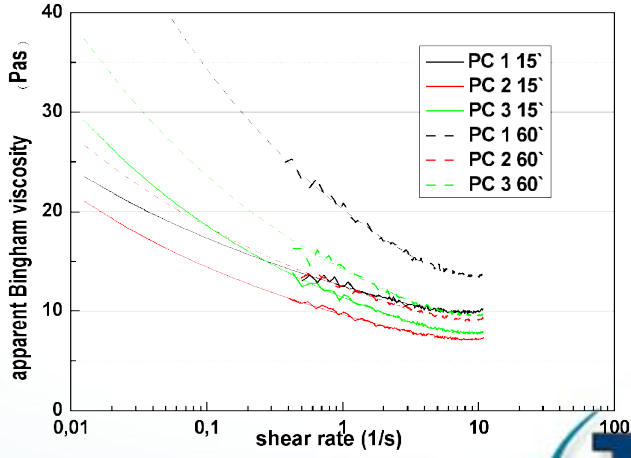
We named it apparent Bingham viscosity.

Results. PC 1, PC 2, PC 3

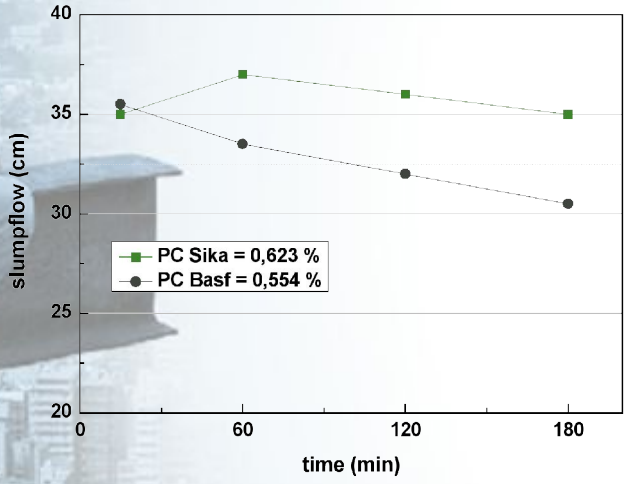


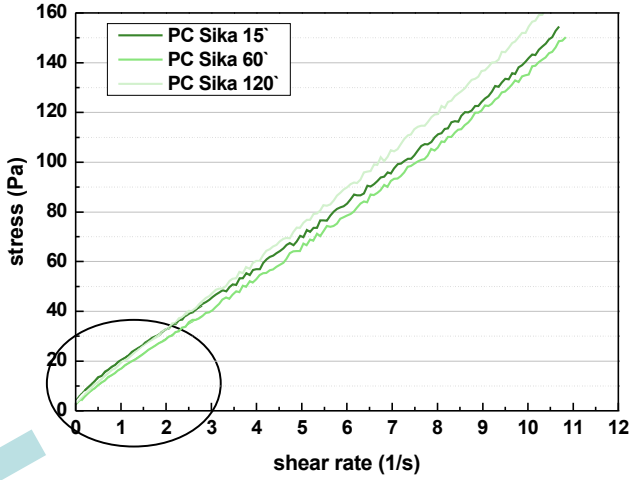


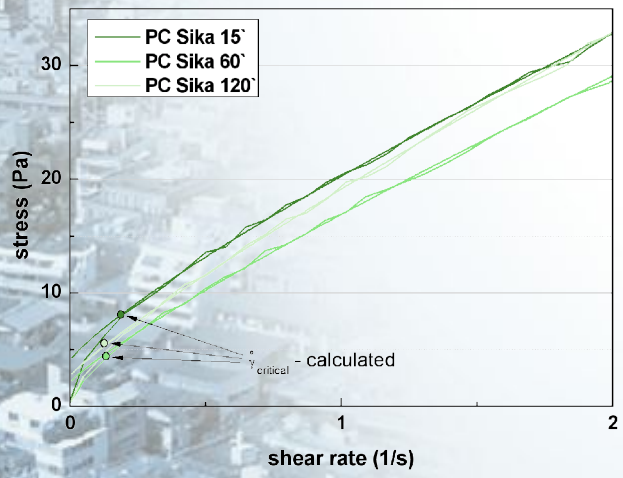


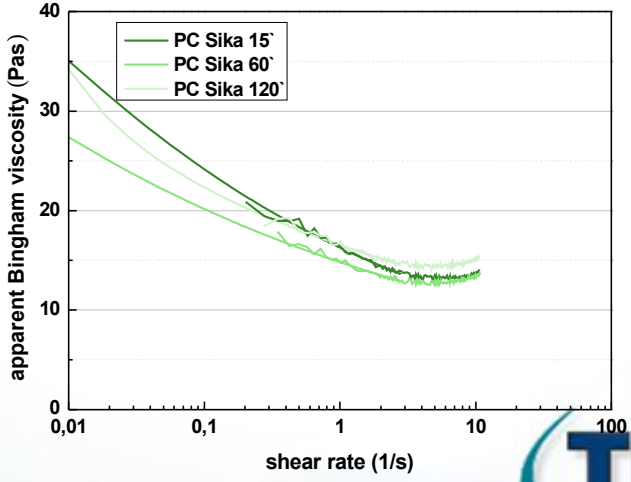


Results. PC Sika, PC Basf

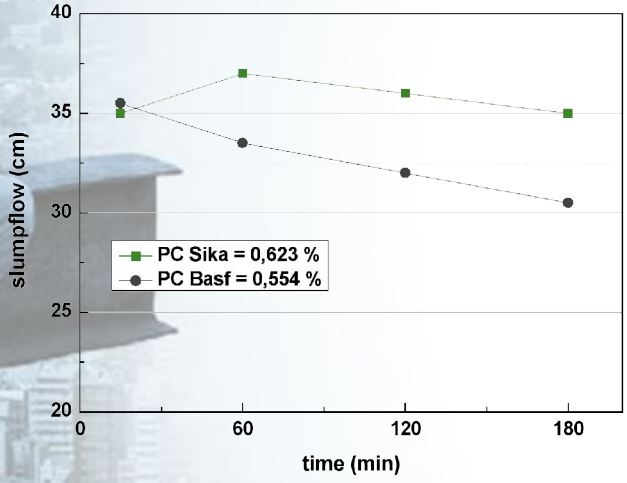


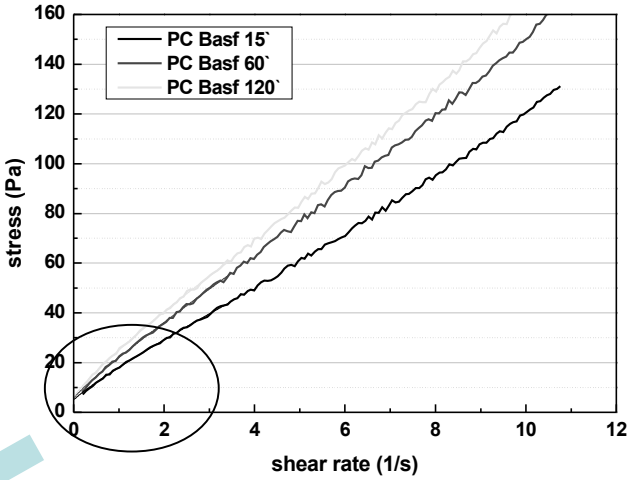


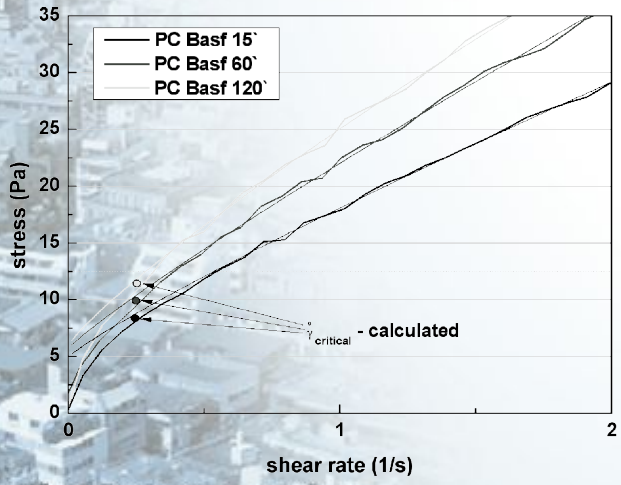


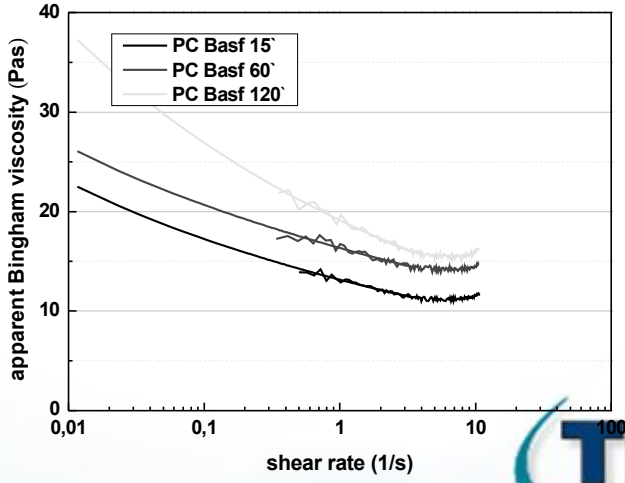


Results. PC Sika, **PC Basf**









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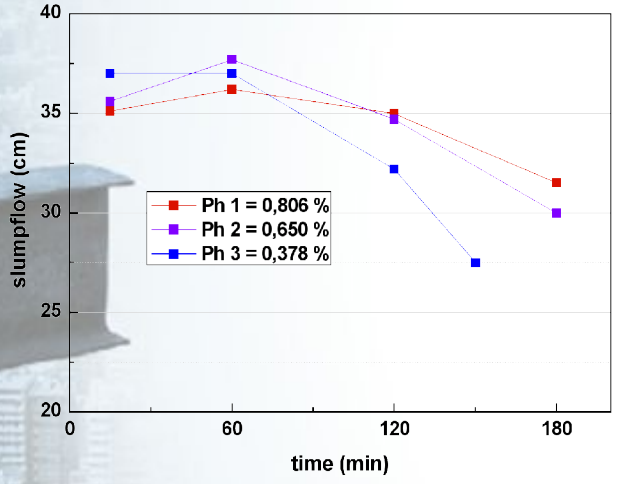
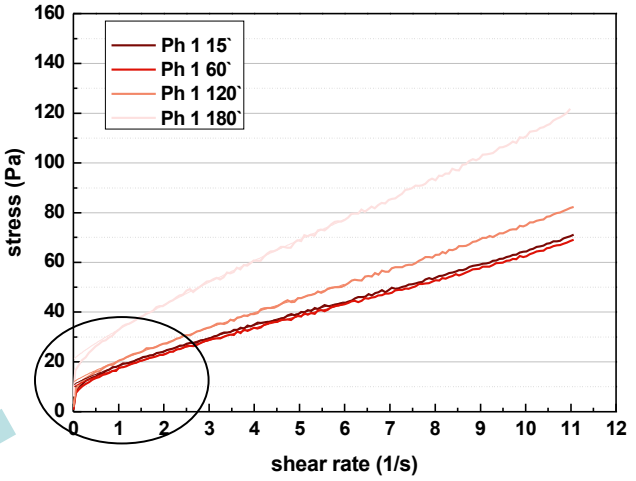
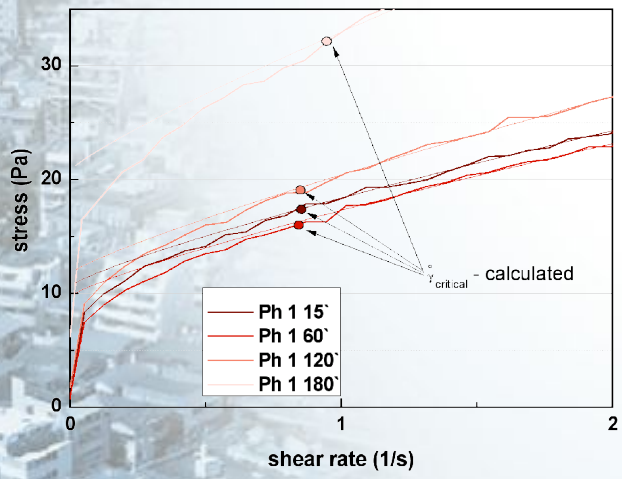
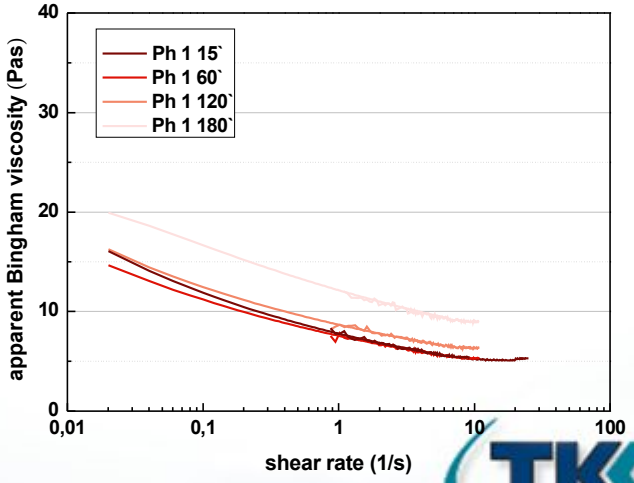
Results. **Ph1,** Ph2, Ph3

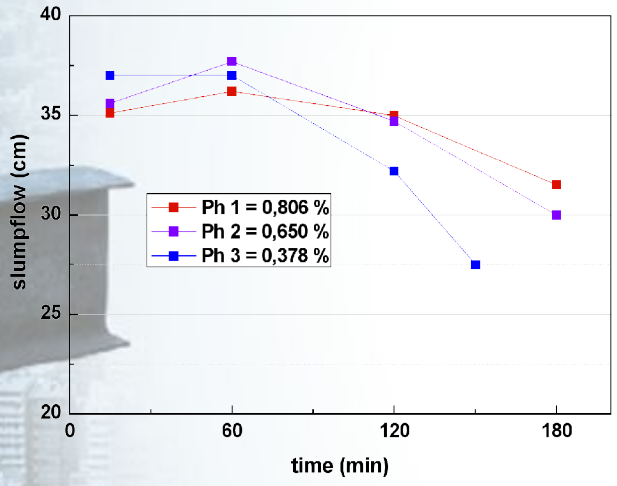


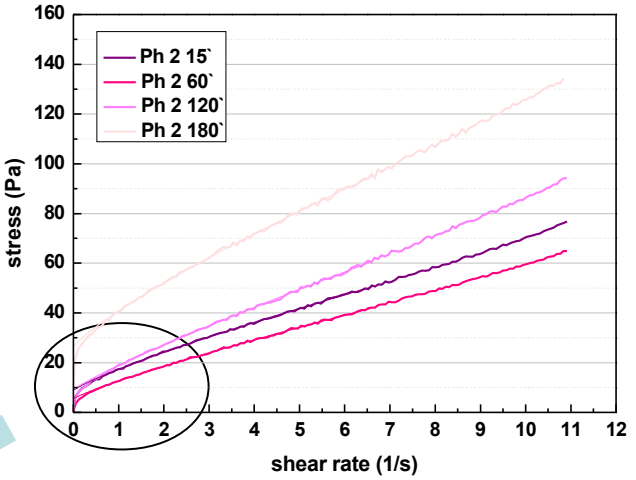


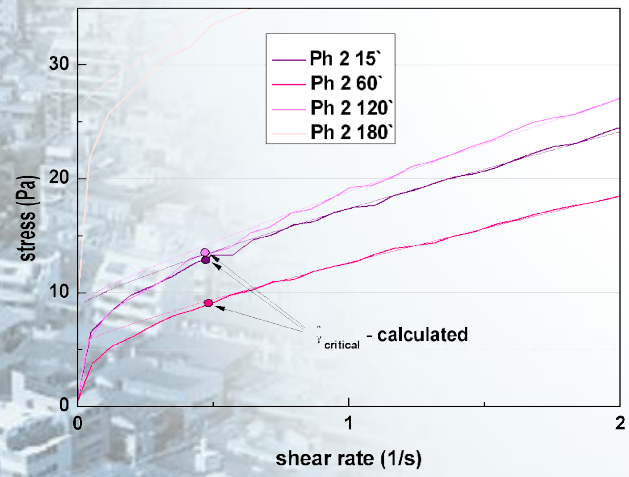


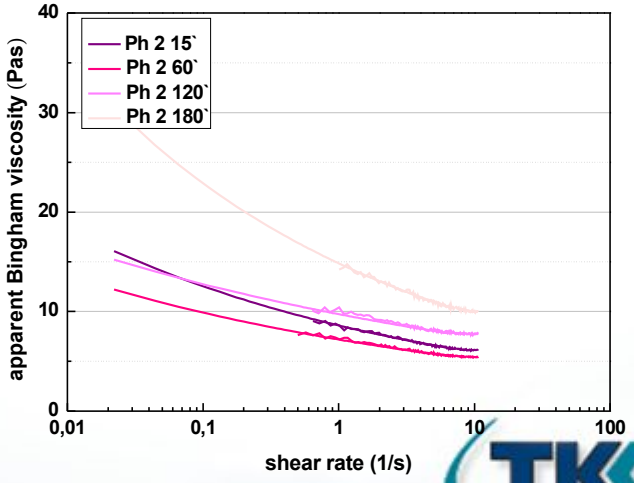


Results. Ph1, **Ph2**, Ph3









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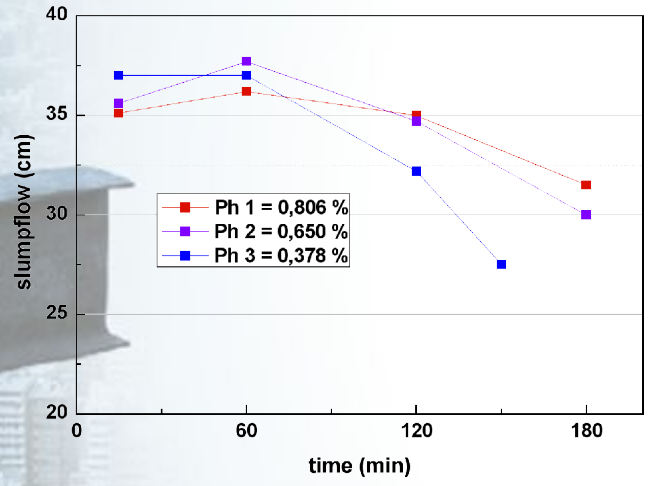
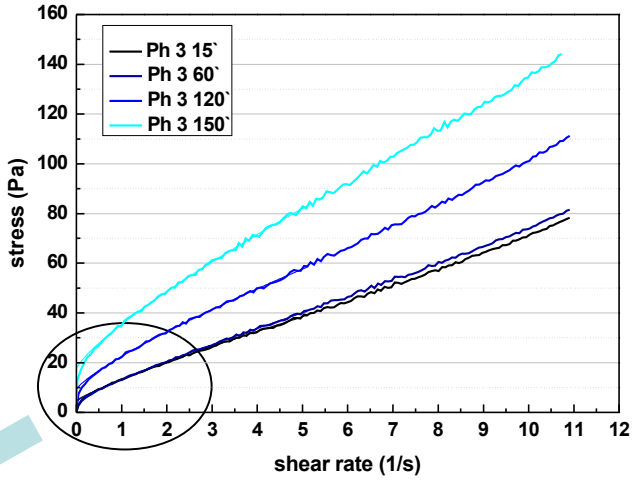
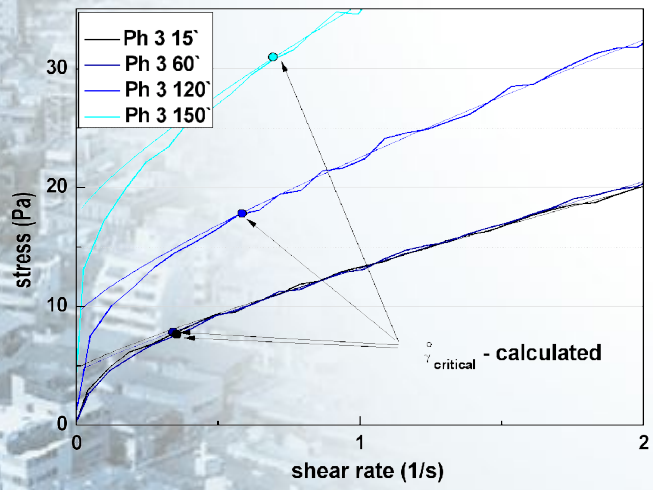
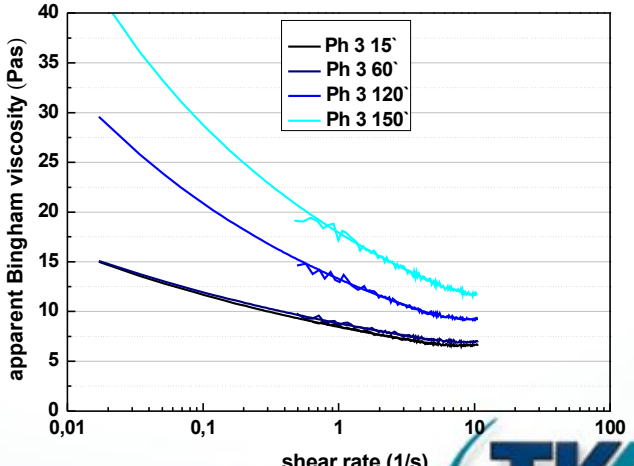
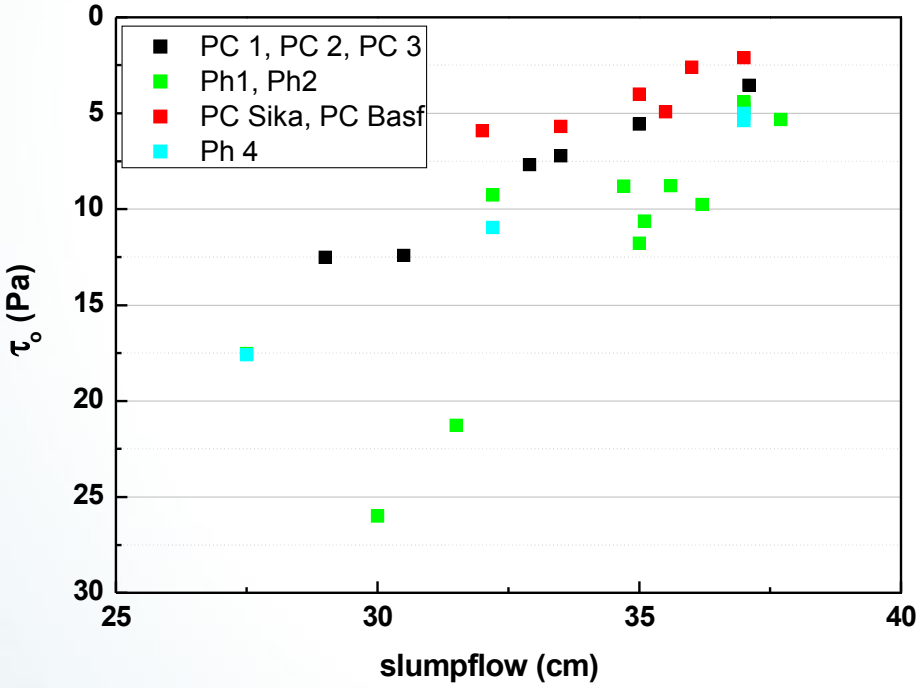






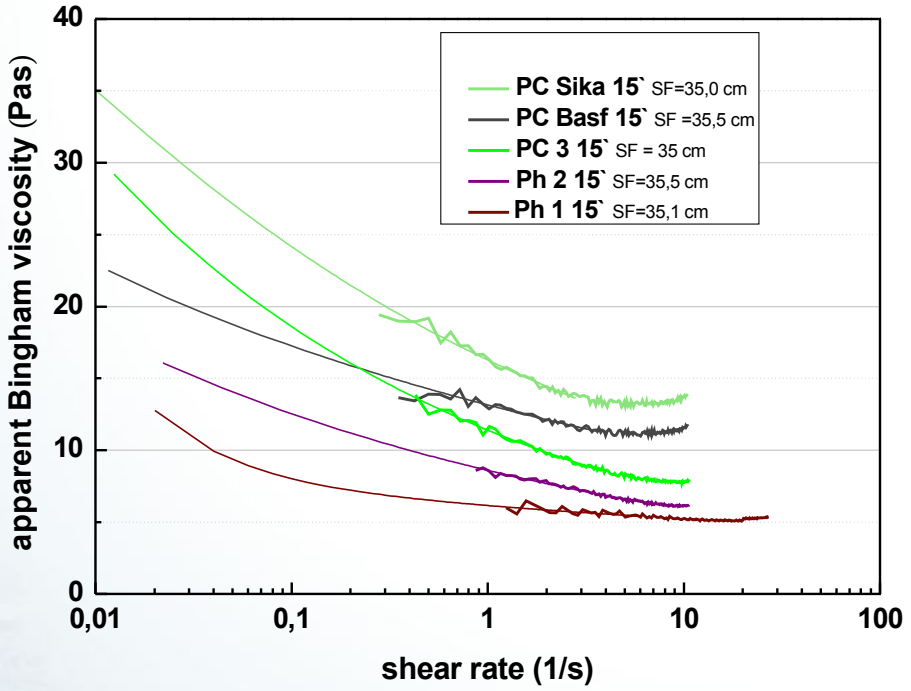


Results. yield stress vs. slumpflow



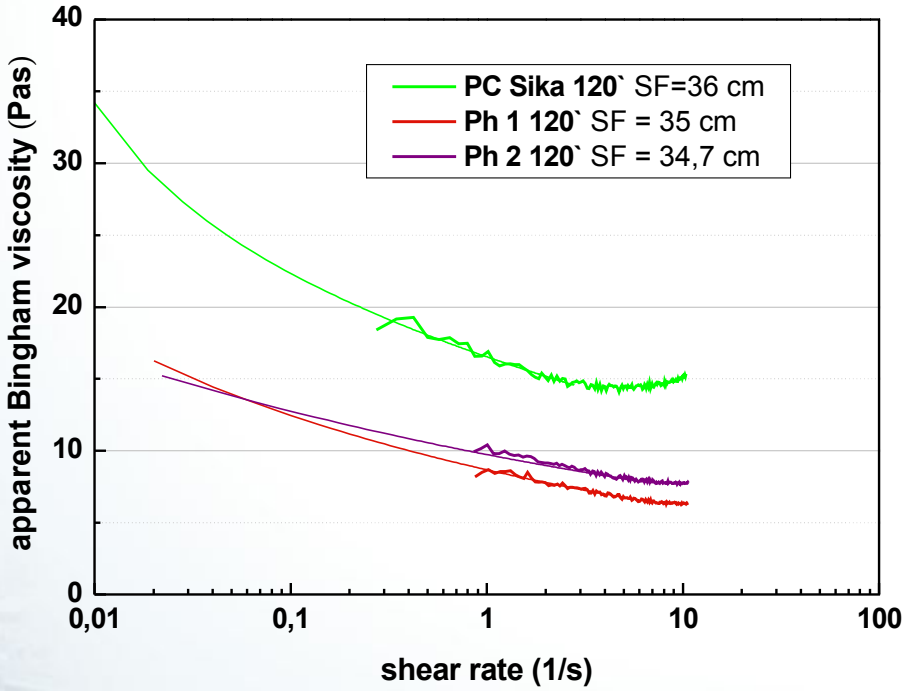
Results.

SP	PC 3	Ph 1	Ph 2	PC Sika	PC Basf
dosage (%ds)	0,364	0,806	0,65	0,623	0,554
SF 15`	35	35,1	35,6	35	35,5



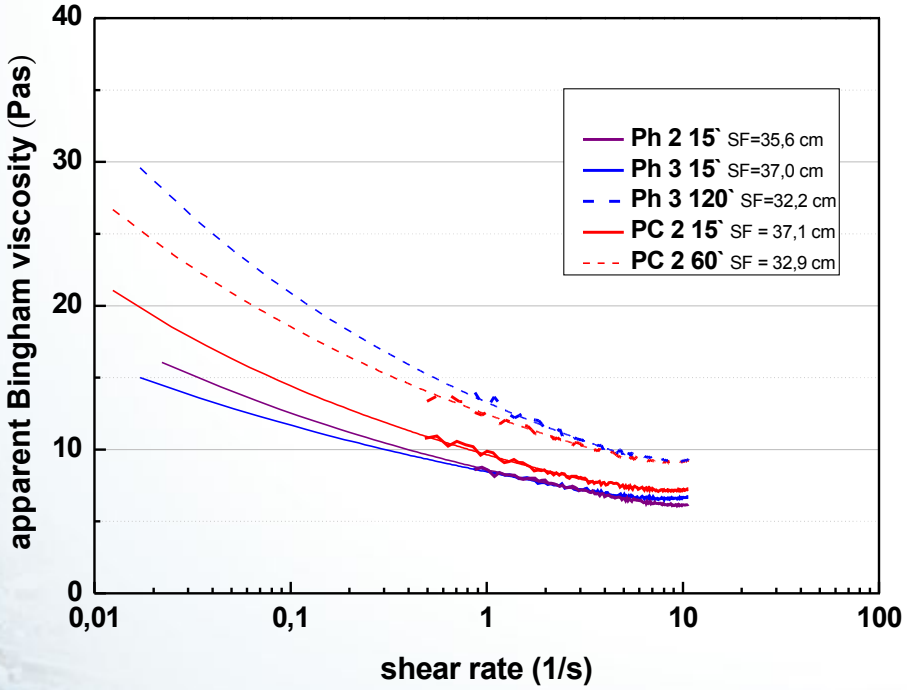
Results.

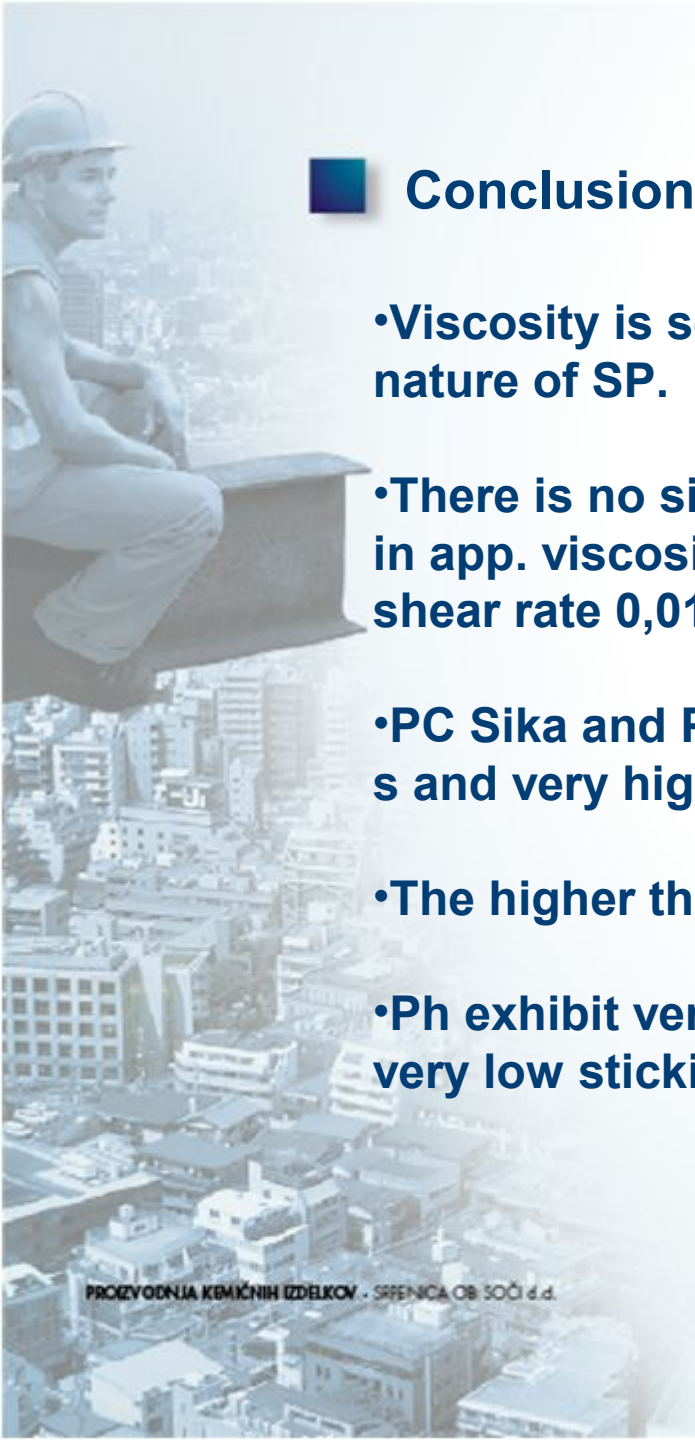
SP	PC Sika	Ph 1	Ph 2
dosage (%ds)	0,623	0,806	0,65
SF 120`	35 cm	35 cm	34,7 cm



Results

SP	SP (%ds)	SF	SF
PC 2	0,238	37,1 (15`)	32,9 (60`)
Ph 2	0,65	35,6 (15`)	
Ph 3	0,378	37 (15`)	32,2 (120`)



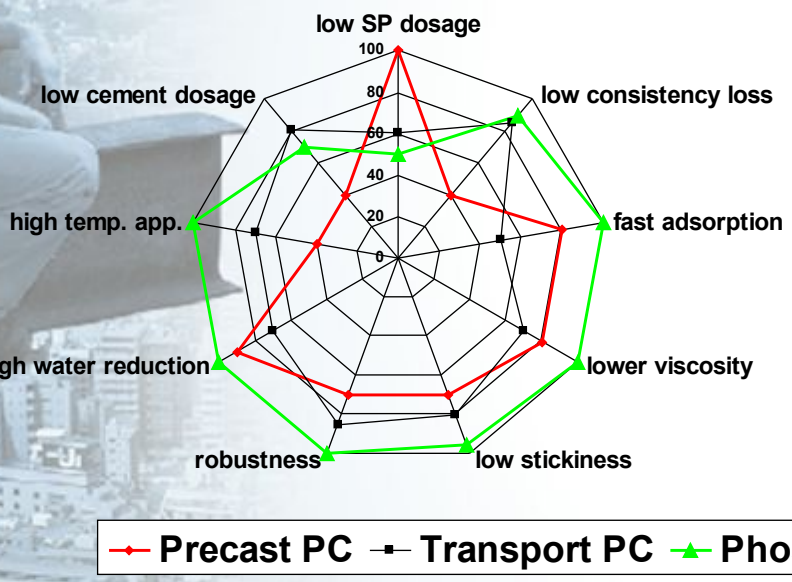


Conclusions

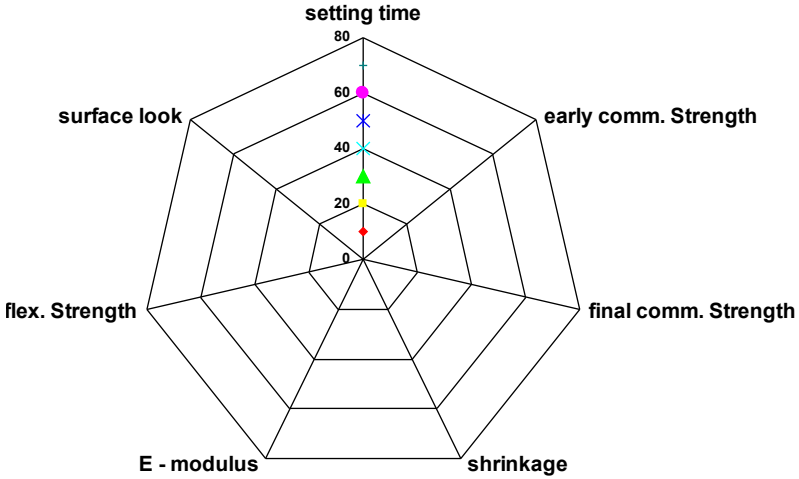
- Viscosity is sensitive to SF. τ vs SF depends on chemical nature of SP.
- There is no significant difference (for PC 1, PC 2 and PC 3) in app. viscosity at same SF for shear rates > 10 1/s. For shear rate 0,01 1/s there is a difference.
- PC Sika and PC Basf exhibit shear thickening from γ > 3 1/ s and very high app. viscosity.
- The higher the dosage of PC, the higher the viscosity
- Ph exhibit very good slump retention and at the same time very low stickiness and viscosity. Ph exhibit shear thinning

Conclusion

Fresh concrete



Hardened concrete



Rheology of concrete could also influence some properties of hardened concrete
The higher the flow of concrete, the pronounced SP effect on fresh properties