COMPARISSON OF TWO RHEOMETERS USED FOR MEASURING RHEOLOGICAL PROPERTIES OF SCCs

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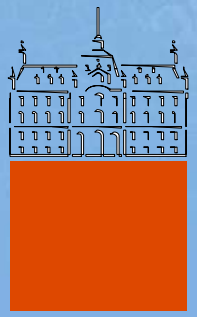

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OUTLINE

- Introduction
- Rheometers
- Test program
- Results
- Conclusions
- Acknowledgment

INTRODUCTION

- Aim of the study was to compare rheometers
- “Mix by mix” comparison
- Evaluation of number of repetitions
- Comparison of time dependent behavior
- Comparison with workability method

RHEOMETERS

- ConTec Viscometer 5
- Outer cylinder radius, R_o = 145 mm
- Inner cylinder radius, R_i = 100 mm
- Height of the cylinder, h = 100 mm

RS

- ConTec Visc
- Outer cylind mm
- Inner cylinde mm
- Height of the mm

RHEOMETERS

- ICAR Rheometer
- Outer cylinder radius, R_o = 143 mm
- Inner cylinder radius, R_i = 63.5 mm
- Height of the cylinder, h = 127 mm

RHEOMETERS

- ICA
- Out
- Inne
- Hei

TEST PROGRAM

- 12 different SCC mixtures (40 liters)
- Rheology and slump flow at times 0 min, 20 min, 40 min and 60 min after end of mixing
- Mixing procedure (5 min):
  - Dry constituents - 1 min
  - Half of the water, 0.3 l of water with diluted liquid admixtures, rest of the water - 1 min (while mixing)
  - Mixing for another - 3 min

TEST PROGRAM - mixtures

	SCCR1	SCCR2	SCCR3	SCCM1	SCCM2	SCCM3	SCCM3
CEM I 42,5 R (kg)	400	400	400	400	400	400	400
V/C	0.46	0.52	0.58	0.58	0.58	0.58	0.58
WATER (kg)	184	208	232	232	232	232	232
COARSE AGG. (kg)	688	659	630	652	674	696	726
FINE AGG. (kg)	875	839	802	830	858	886	924
LIMESTONE FILLER (kg)	216.5	216.5	216.5	166.5	116.5	66.5	-
SP1 (%) *	0.70	0.70	0.70	0.70	0.70	0.70	0.70
VA (%) *	-	-	0.10	0.20	0.25	0.30	0.35

* Percentage of binder (cement+limestone filler)

TEST PROGRAM - mixtures

	SCCR4	SCCR4A	SCCR4B	SCC4C	SCC4D
CEM I 42,5 R (kg)	400	400	400	400	400
V/C	0.52	**	**	**	**
WATER (kg)	208	213	203	198	218
COARSE AGG. (kg)	656	656	656	656	656
FINE AGG. (kg)	835	835	835	835	835
LIMESTONE FILLER (kg)	216.5	216.5	216.5	216.5	216.5
SP2 (%) *	1.15	1.15	1.15	1.15	1.15

* Percentage of binder (cement+limestone filler)
** Volume for the composition of the concrete is different than 1 m^3

TEST PROGRAM

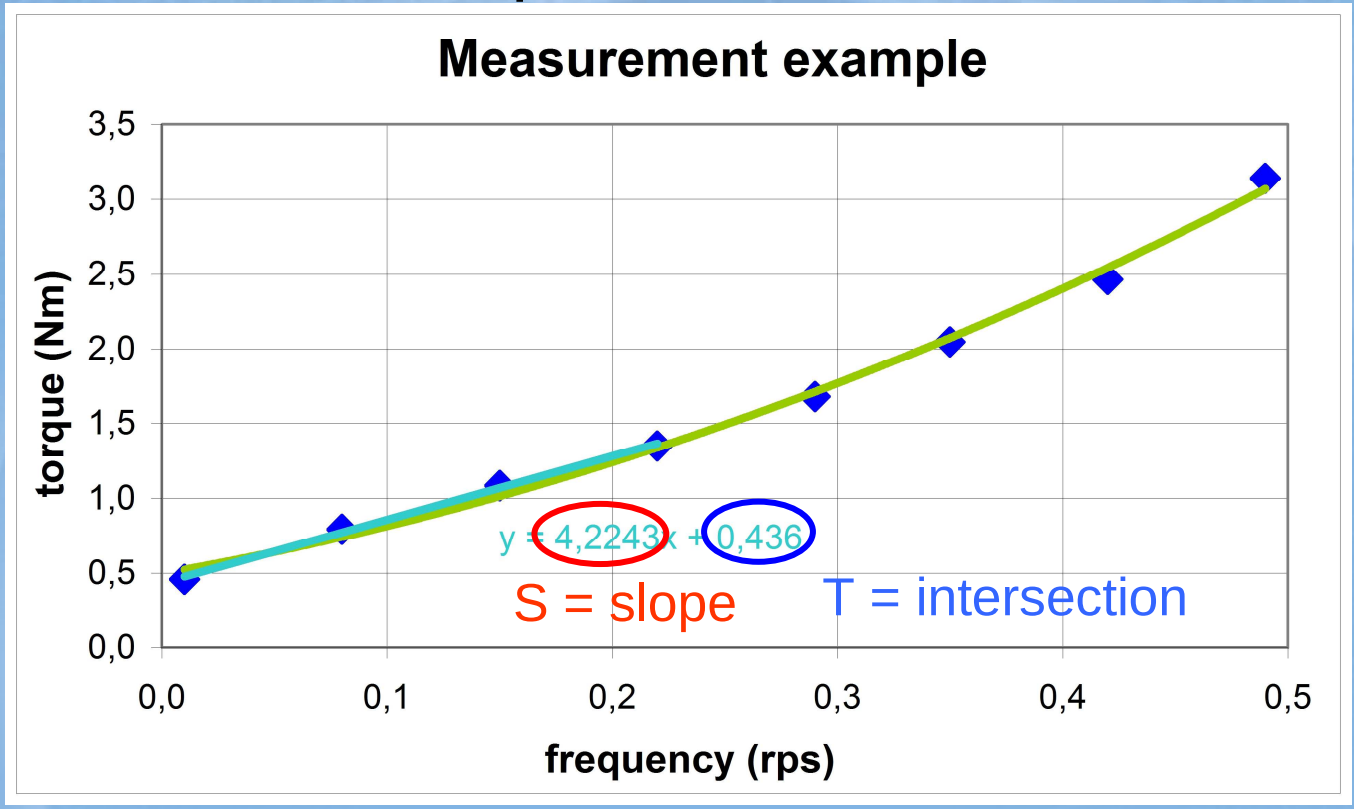
- Measuring procedure:
  - Containers filled at the mixer
  - Moved to rheometers positions
  - Remixed with flat rod before each measurement
  - 3 repetitions at every time interval
  - Return to mixer till next time interval, remix

TEST PROGRAM

- Calculation of fundamental results
- Shear thickening behavior observed
- Bingham model on bottom 4 points

$$\tau_0 = \frac{T\left(\frac{1}{R_i^2} - \frac{1}{R_o^2}\right)}{4\pi h \ln\left(\frac{R_o}{R_i}\right)}$$

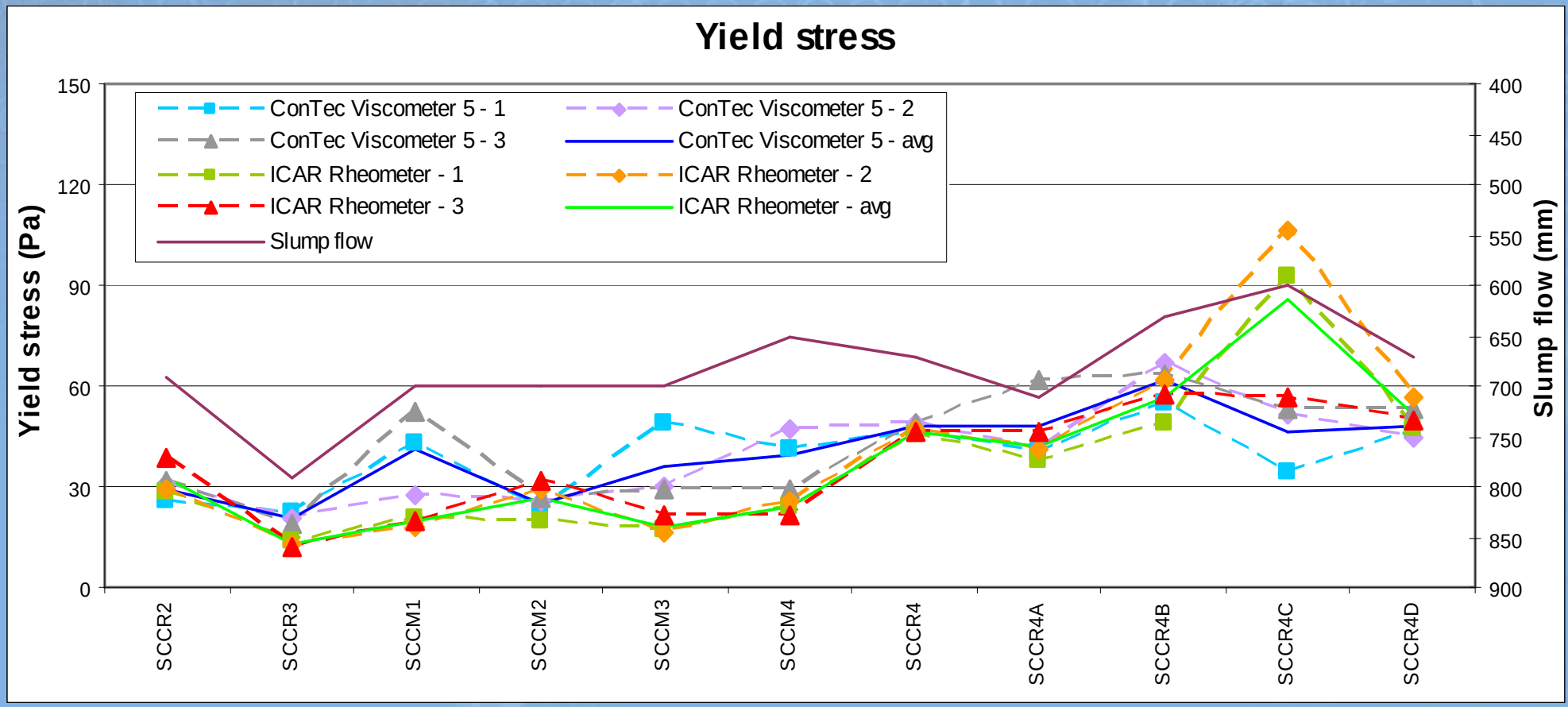
$$\mu = \frac{1}{8\pi^2 h}\left(\frac{1}{R_i^2} - \frac{1}{R_o^2}\right)\frac{1}{S}$$



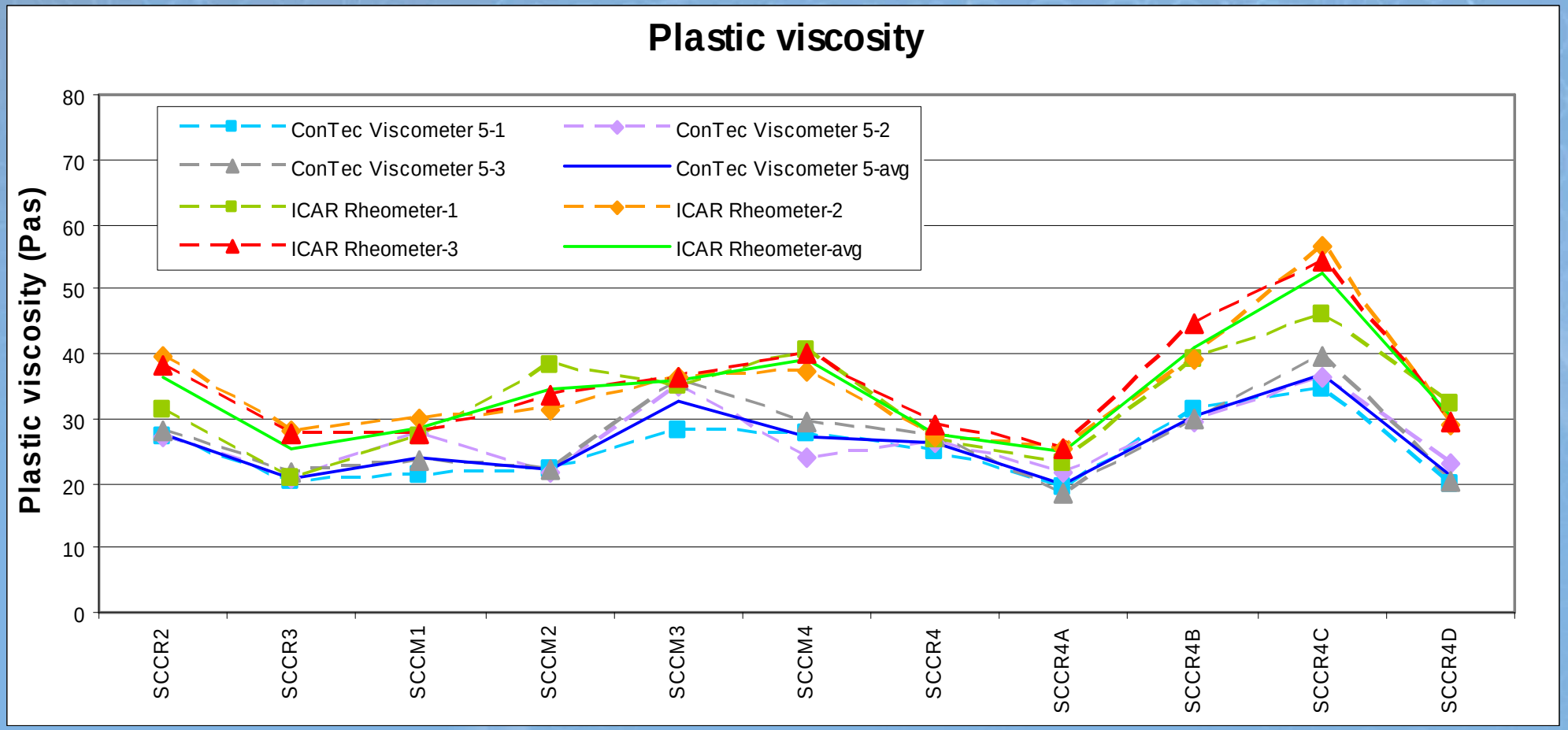
RESULTS – mix by mix

- Mixture SCCR1 had a slump flow of 370 mm
- Not really a SCC
- Excluded from analysis

RESULTS – mix by mix



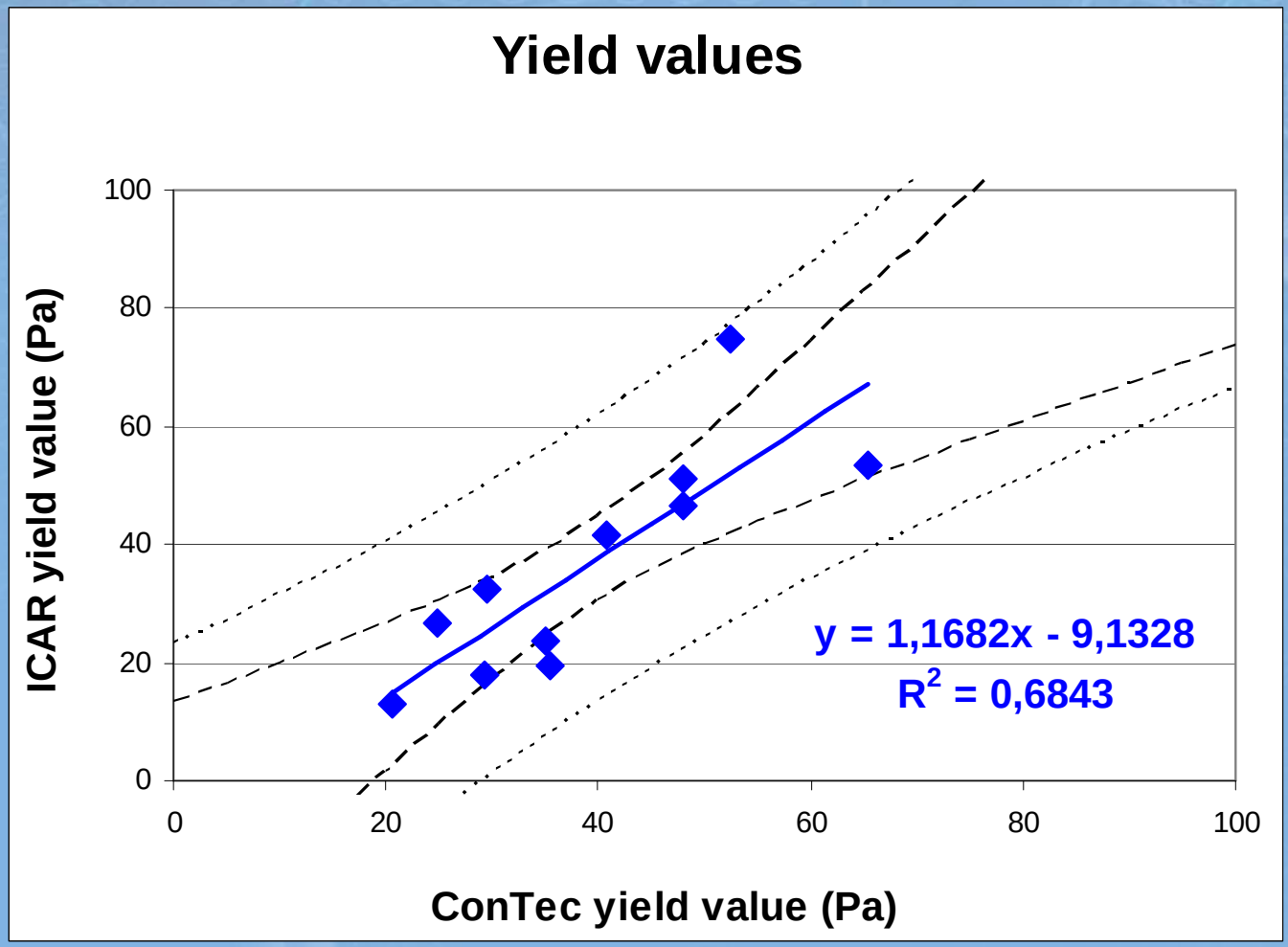
RESULTS – mix by mix



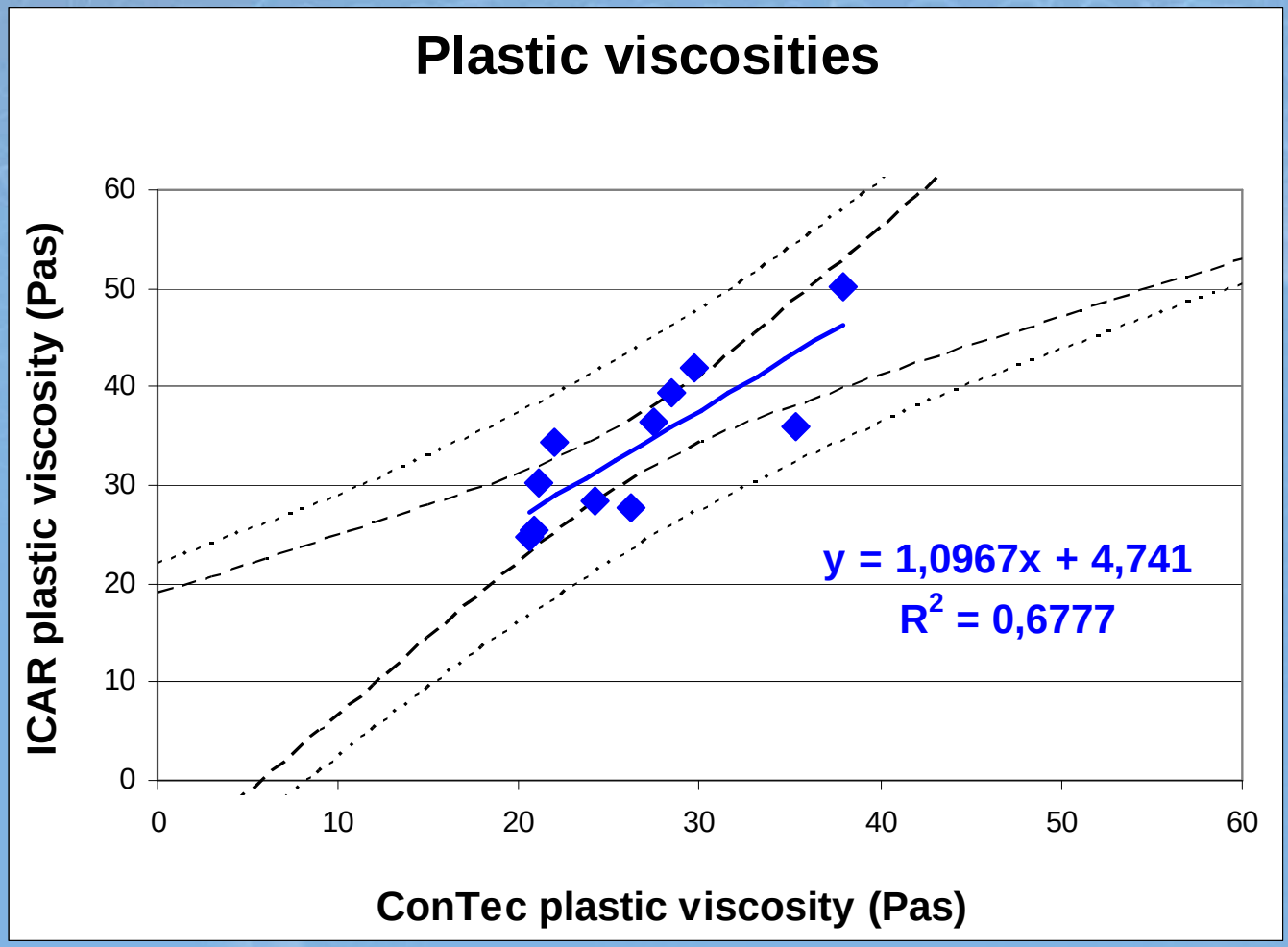
RESULTS – number of repetitions

Number of repetitions	R^2	
	τ_0	μ
1	0.048	0.614
2	0.283	0.703
3	0.436	0.726
At least 2, remove bad measurements	0.684	0.678

RESULTS – number of repetitions

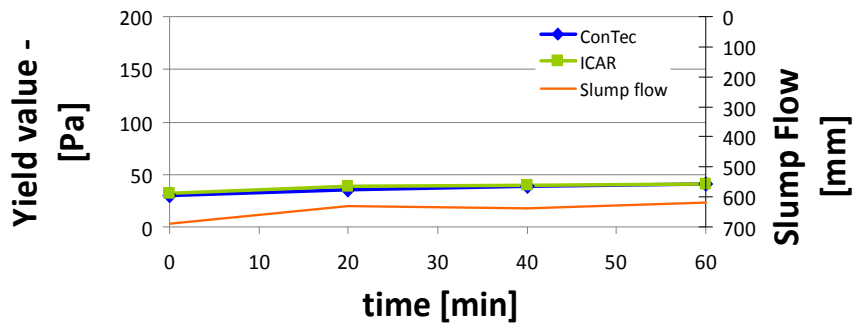


RESULTS – number of repetitions

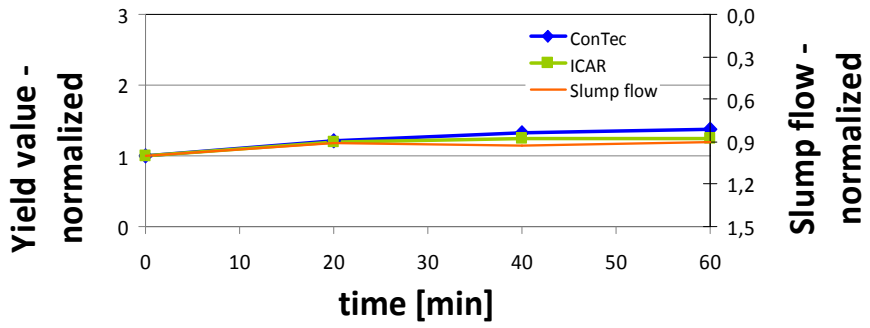


RESULTS – time (SCCR2)

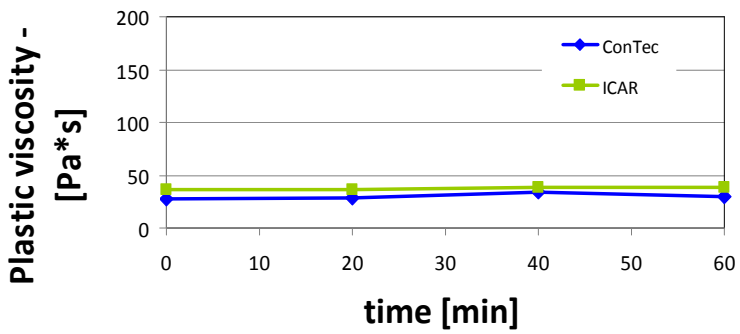
Yield value



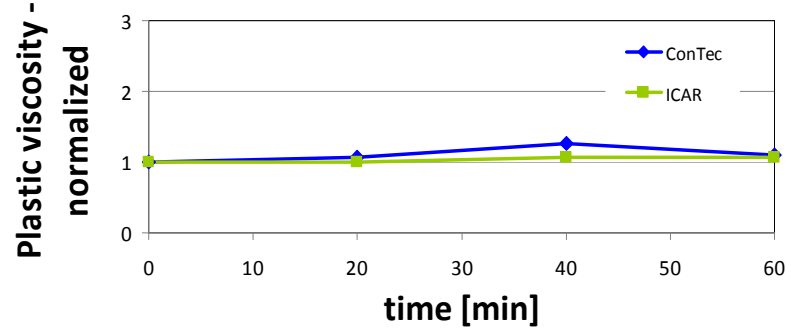
Yield value - normalized



Plastic viscosity

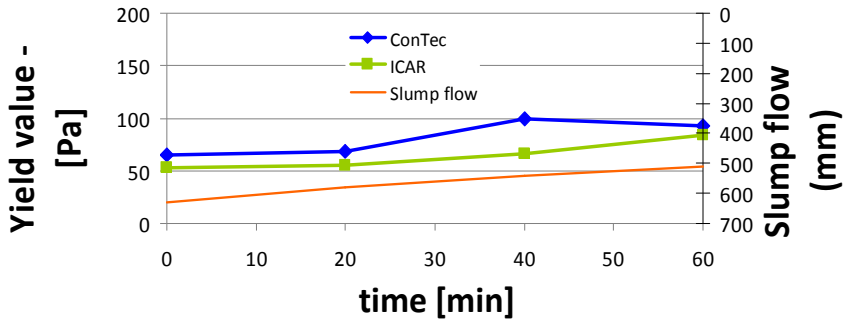


Plastic viscosity - normalized

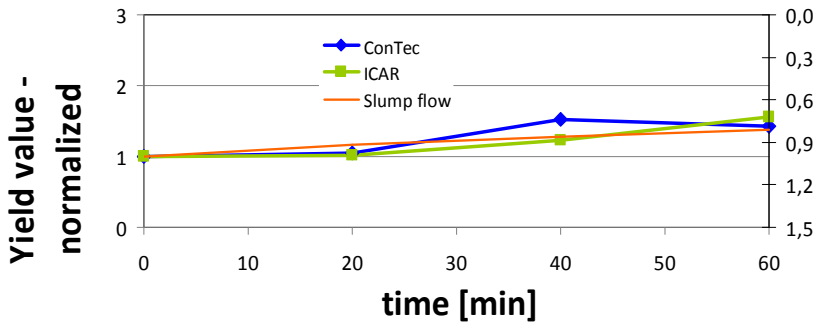


RESULTS – time (SCCR4B)

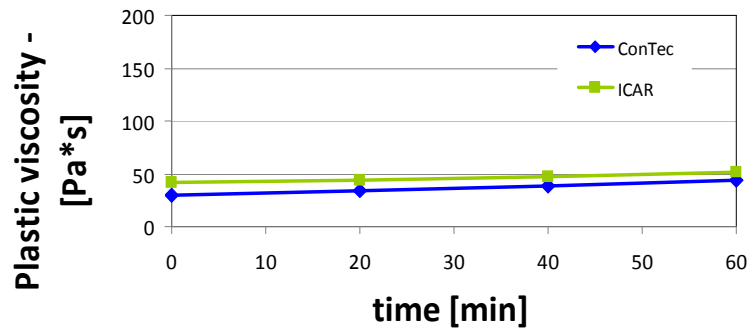
Yield value



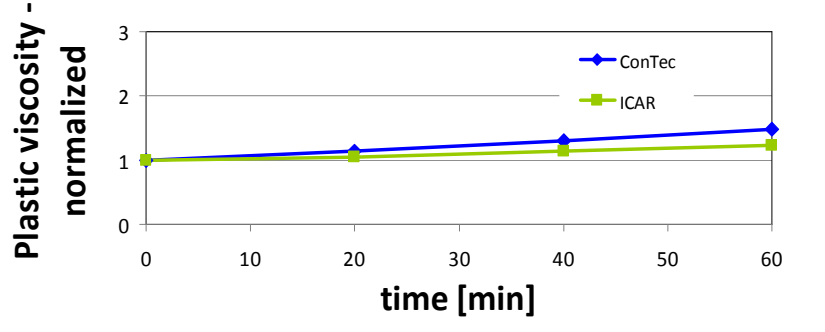
Yield value - normalized



Plastic viscosity

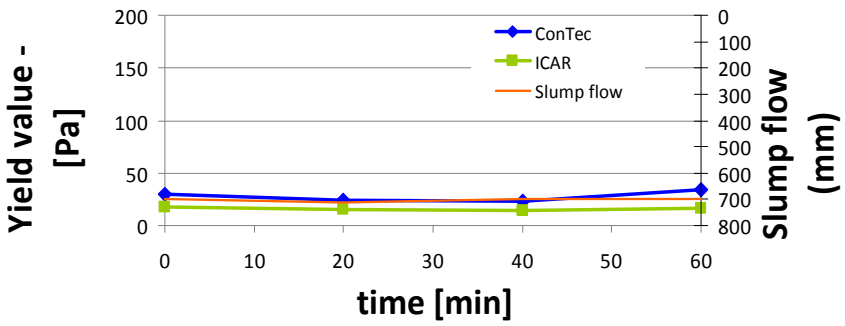


Plastic viscosity - normalized

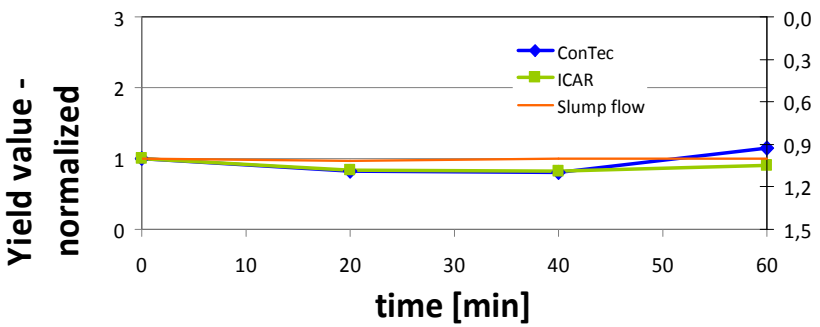


RESULTS – time (SCCM3)

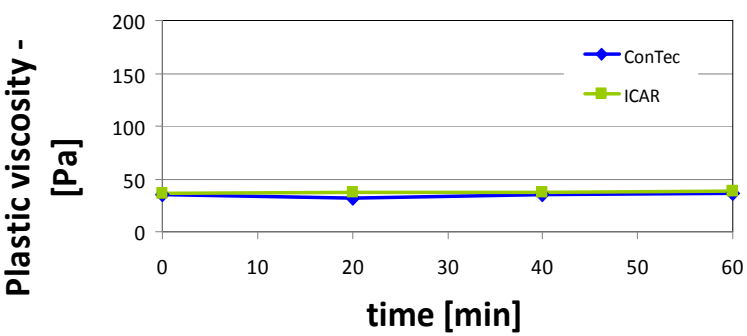
Yield value



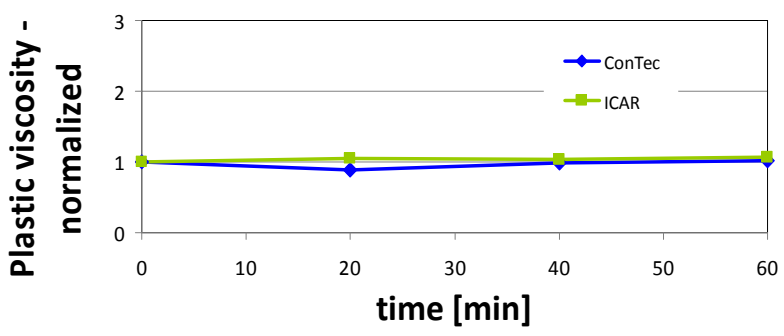
Yield value - normalized



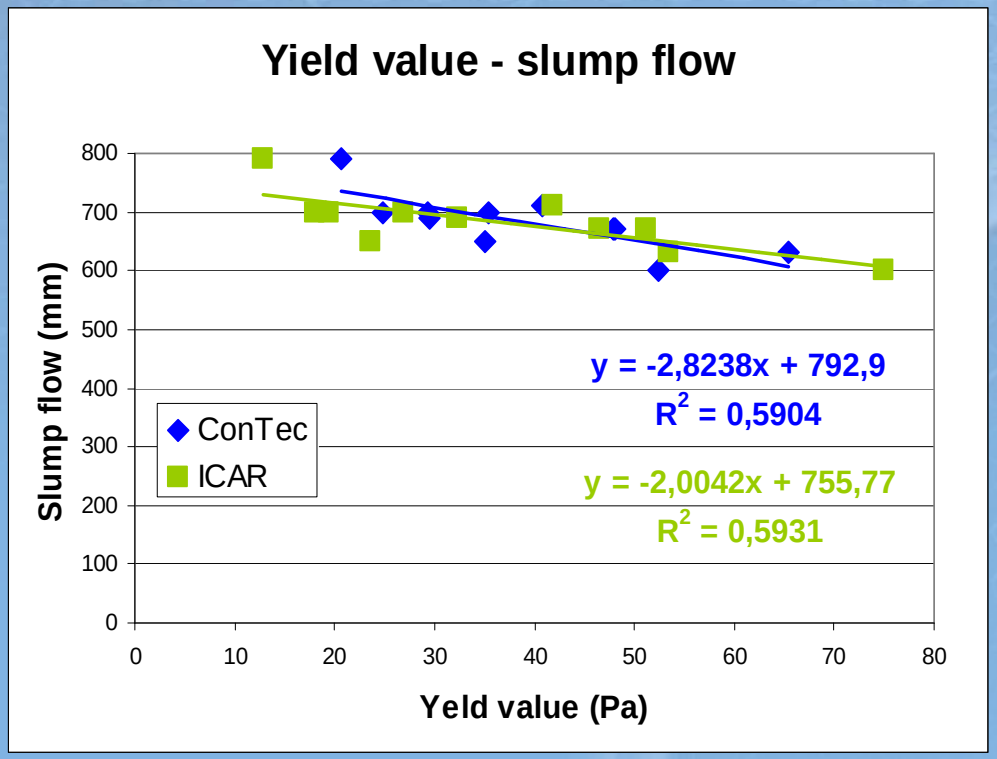
Plastic viscosity

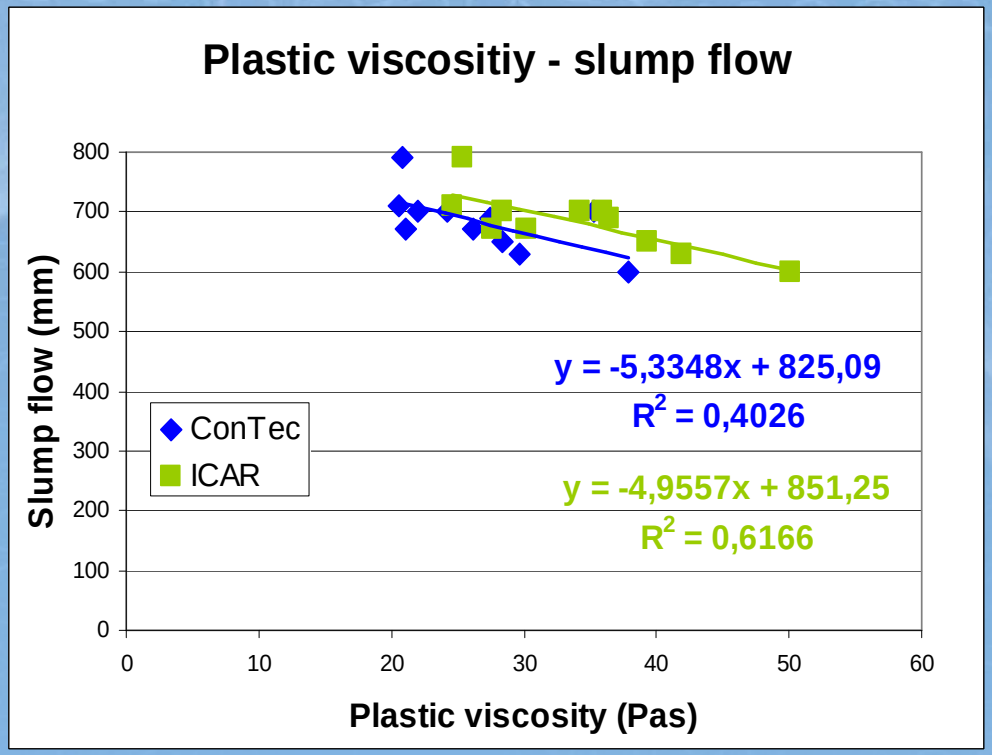


Plastic viscosity - normalized



RHEOLOGY - WORKABILITY





CONCLUSIONS

- In “mix by mix” analysis we observe similar trends for both rheometers with a few points visually standing out
- We recommend measuring at least 3 times so we can eliminate possible bad results
- We observe similar time behavior of SCC with both rheometers
- We must be careful at measurements at time 0 min, normalizing is very sensitive to this point
- Correlation between rheology and workability is similar for both rheometers

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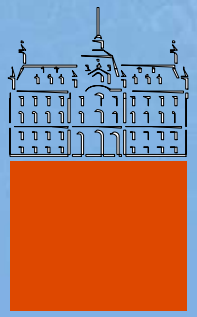

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