Schleibinger Geräte

Teubert u. Greim GmbH

Testing Systems

Schleibinger Geräte

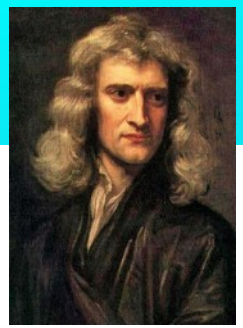
Teubert u. Greim GmbH

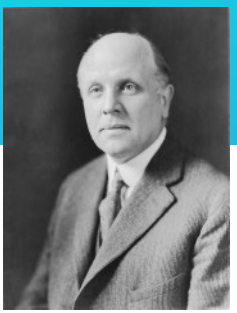
19. Conference
“Rheology of Building Materials”
Workshop 12.mar.2020

M. Greim / J. Flotzinger

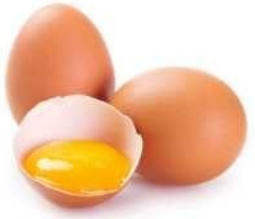
Schleibinger Geräte Teubert u. Greim GmbH
Buchbach / Germany

Newton or Bingham?

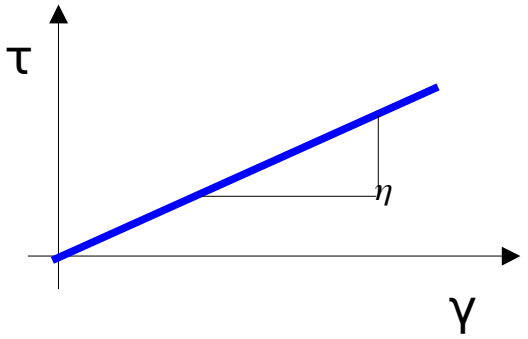




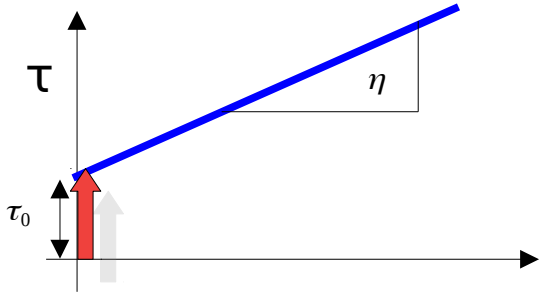
Lid on the top



Lid on the bottom!



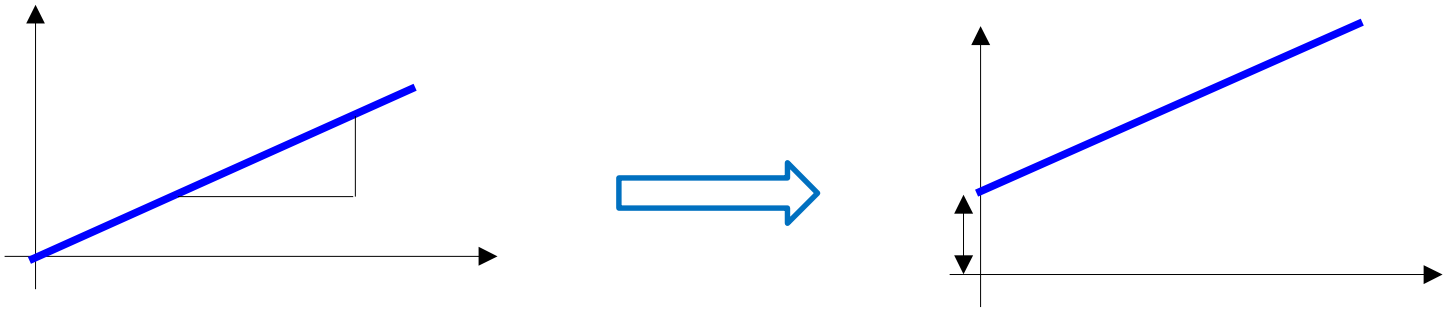
Oil + Water + Lecithin



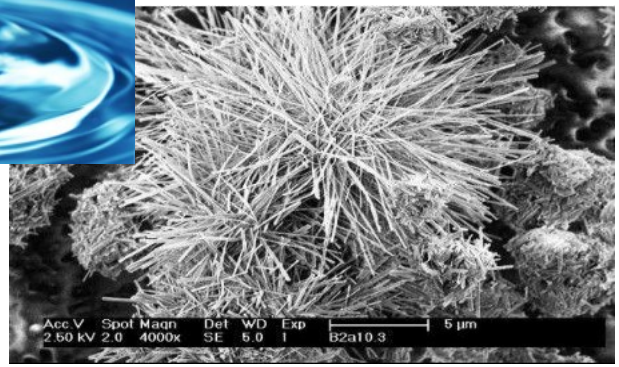
= Mayonnaise

rheology

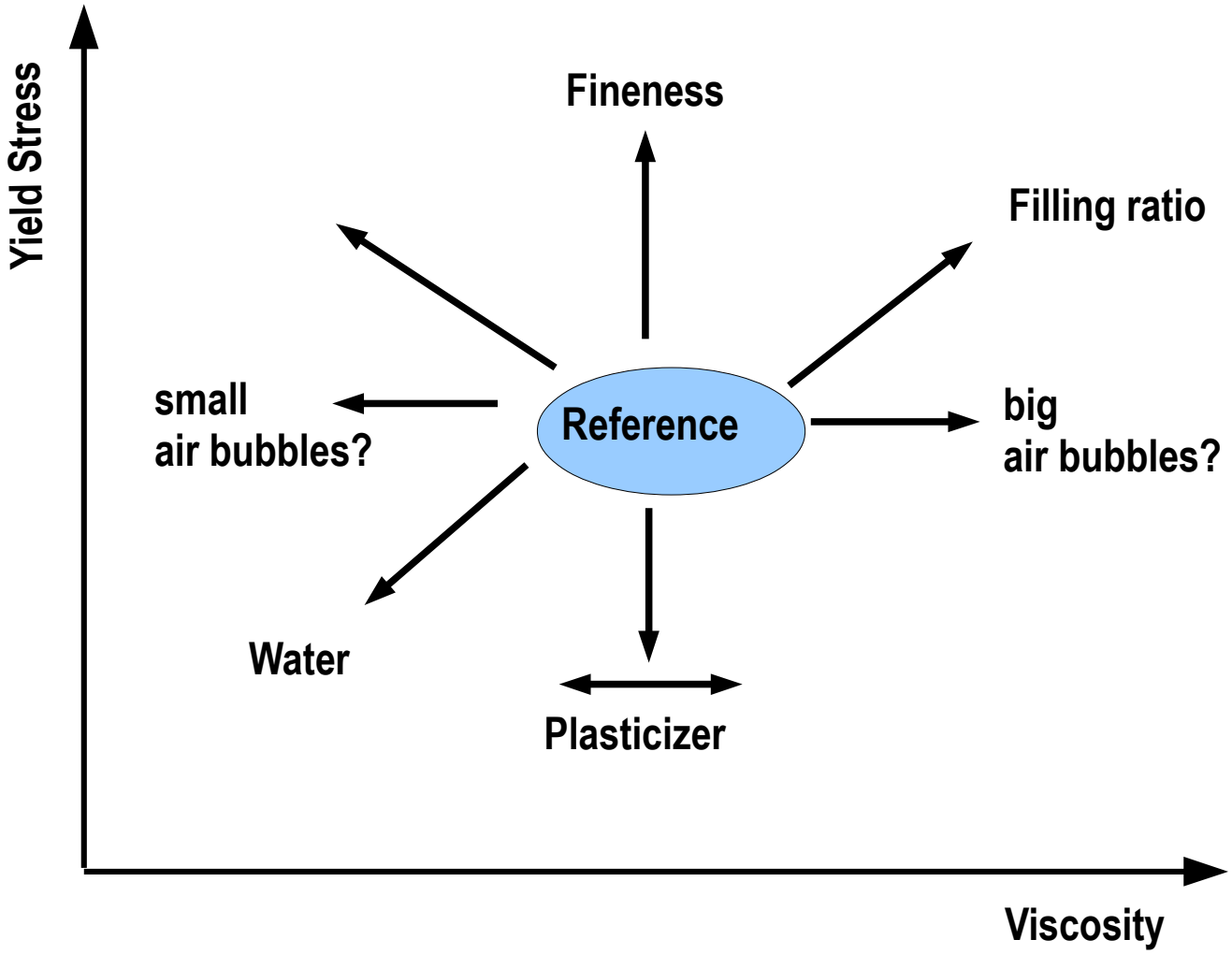
→ **non-Newtonian fluid or Bingham fluid** – fluid that does not follow Newton´s law of viscosity. Viscosity is dependent on shear rate or shear rate history.



water **+ cement** **= paste**
+ additives **= mortar / concrete**



rheology


Yield Stress
Fineness
Filling ratio
small
air bubbles?
Reference
big
air bubbles?
Water
Plasticizer
Viscosity

measuring technology – 1911...now

1918 – Duff Abrams, Concrete Slump Test

“I belive that the big thing [the slump] test can do is to bring home the importance of water control in building construction” (Abrams D.A. “Proportioning Concrete Mixtures”, Proceedings of the American Concrete Institute, Detroit, MI, 1922)

sein. Die beim Versuch bewegte obere Tischplatte soll rd. 16 kg wiegen.

Der kegelige, 20 cm hohe Trichter aus 2 mm dickem Blech (Bild 2) hat oben 13 cm, unten 20 cm lichten Durchmesser[2]).

3. Ausführung des Versuchs. Beim Versuch muß der Ausbreittisch waagerecht und unverrückbar gelagert sein. Vor dem Versuch sind Tischplatte und Innenfläche des Trichters mit einem feuchten Tuch abzureiben.

Bild 2.

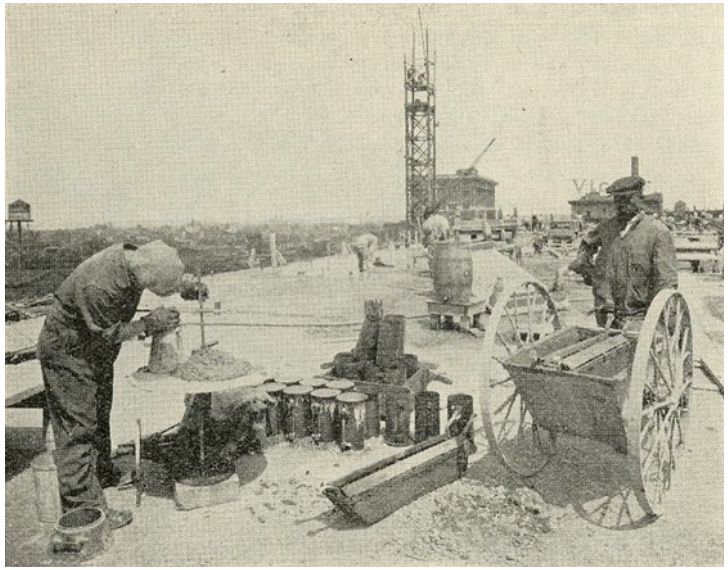
Der Beton wird in 2 etwa gleich hohen Schichten in den mitten auf den Ausbreittisch gestellten Trichter gefüllt und jede Schicht mit einem Holzstampfer von quadratischem Querschnitt (4 cm Seitenlänge) 10mal leicht bearbeitet. Beim Füllen muß sich der Arbeiter auf die unten am Trichter angebrachten beiden Fußeisen stellen. Nach dem Füllen ist die Form oben mit der Kelle eben abzuziehen und die freie Fläche der Tischplatte zu reinigen.

Eine halbe Minute nach dem Füllen wird der Trichter an den Griffen langsam lotrecht hochgezogen, wobei sich der Beton je nach seiner Steife schon mehr oder weniger setzt. Hierauf hebt man den Ausbreittisch am Handgriff 15mal[3]) langsam um $e = 4$ cm (Bild 1) an und läßt ihn wieder fallen. Dabei breitet sich der Beton aus.

Dann werden die zu den beiden Tischkanten gleichlaufenden Durchmesser g_1 und g_2 des ausgebreiteten Betons gemessen (Bild 1). Das Ausbreitmaß g ist das Mittel beider Durchmesser, es wird in ganzen cm angegeben.

1924 – Ahlers J.G., Walker S., Slump Flow

“Field tests of Concrete”, Proceedings of the Twentieth Annual Convention of the American Concrete Institute, 20, 1924.



Concrete as Multi - Phase System – 1981 / 1994

Die Messung der Konsistenz von Betonmörtel und ihre Bedeutung für die Verarbeitungseigenschaften des Frischbetons

Measuring the consistency of concrete mortar and its importance to the workability of fresh concrete

Von Dipl.-Geol. Jürgen Teubert, Obertaufkirchen

BETONWERK + FERTIGTEIL-TECHNIK, HEFT 4/81

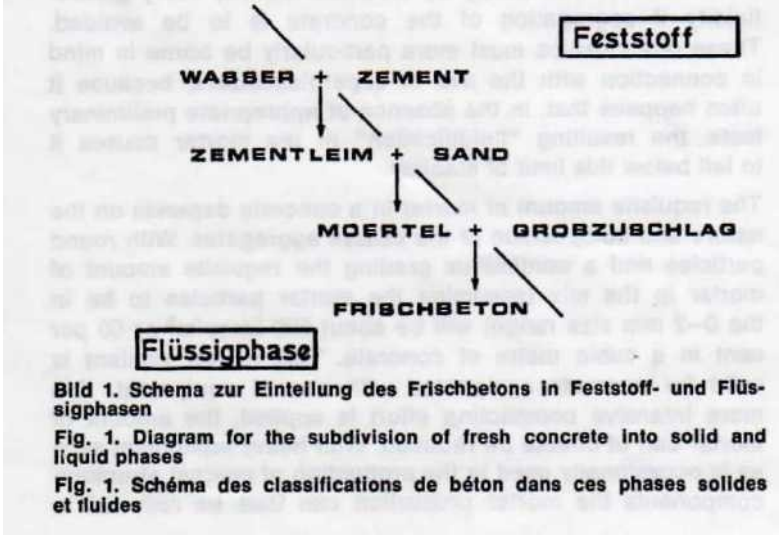


Bild 1. Schema zur Einteilung des Frischbetons in Feststoff- und Flüssigphasen

Fig. 1. Diagram for the subdivision of fresh concrete into solid and liquid phases

Fig. 1. Schéma des classifications de béton dans ces phases solides et fluides

CONCRETE LIBRARY OF JSCE NO. 25, JUNE 1995

MIX DESIGN FOR SELF-COMPACTING CONCRETE

(Translation from Proc. of JSCE, No.496/V-24, 1994.8)

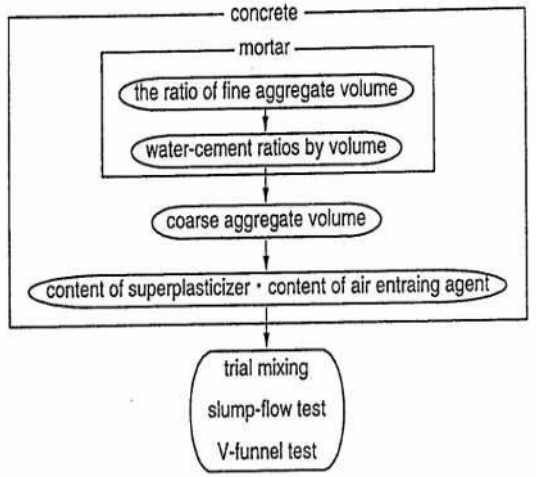


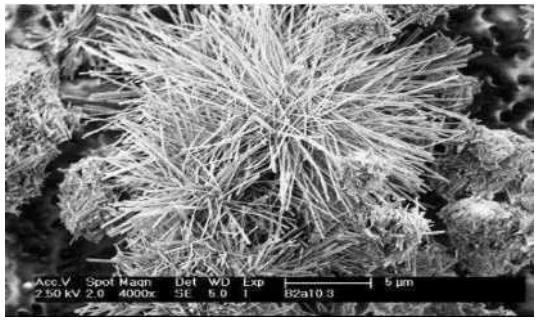
Fig.17 Mix design system for self-compacting general-purpose high-performance concrete

J. Teubert
Germany,1981

H. Okamura
Japan, 1994

Paste vs. Mortar- vs. Concrete Rheology

Cement + Water = Paste



The flow properties of paste are influenced by the ratio of total particle surface to water (true?)

Paste + Sand = Mortar

If he paste volume is higher then a certain amount X the flow properties of the mortar are dominated by the flow properties of the paste.

Mortar + Aggregates = Fresh Concrete

If the volume of mortar is higher then 52% (?) the flow properties of concrete are dominated by he flow properties of the mortar.

Paste → Mortar → Concrete

Mix Design

Label: Rheometer		Original Mix	Concrete Rheo CT	Concrete Viskomat XL	Mortar (d<2mm) Viskomat NT	Paste Viskomat NT
Volumen in l:	Density	1000	40	4	0,5	0,4
	[kg/dm³]	[kg]	[kg]	[kg]	[g]	[g]
Sand 0/3	2,79	867,5	34,7	3,47	634,604	
Aggregates (crushed) 1/3	2,68	166,75	6,67	0,667		
Aggregates (crushed) 9/16	2,68	666,5	26,66	2,666		
Cement (CEM II/A-LL 42,5 R)	3,00	410	16,4	1,64	299,93	445,86
Limestone	2,60	120	4,8	0,48	87,78	130,50
Water	1,00	166,75	6,67	0,667	121,98	181,33
PCE	1,08	7,375	0,295	0,0295	5,40	8,02
Defoamer	1,04	6,15	0,246	0,0246	4,50	6,69

				Mortar (d<2mm) Viskomat NT				Cement Paste Viskomat NT		
	[kg/dm³]	[kg]	[l]	[kg]	[l]	[l]	[kg]	[l]	[l]	[kg]
Sand 0/3	2,79	867,50	310,93	867,5	310,93	454,91	1269,21			
Aggregates (crushed) 1/3	2,68	166,75	62,22							
Aggregates (crushed) 9/16	2,68	666,50	248,69							
Cement (CEM II/A-LL 42,5 R)	3	410,00	136,67	410	136,67	199,95	599,86	136,67	371,55	1114,64
Limestone	2,6	120,00	46,15	120	46,15	67,53	175,57	46,15	125,48	326,24
Water	1	166,75	166,75	166,75	166,75	243,97	243,97	166,75	453,33	453,33
PCE	1,08	7,38	6,83	7,375	6,83	9,99	10,79	6,83	18,56	20,05
Defoamer	1,04	6,15	5,91	6,15	5,91	8,65	9,00	5,91	16,08	16,72
Air pores 1,5%			15,00		15,00	15,00		15,00	15,00	
SUM:			999,1587568087		688,24	1000		377,31	1000,00	
Difference:					311,76			622,69		

measuring technology - 1969

1

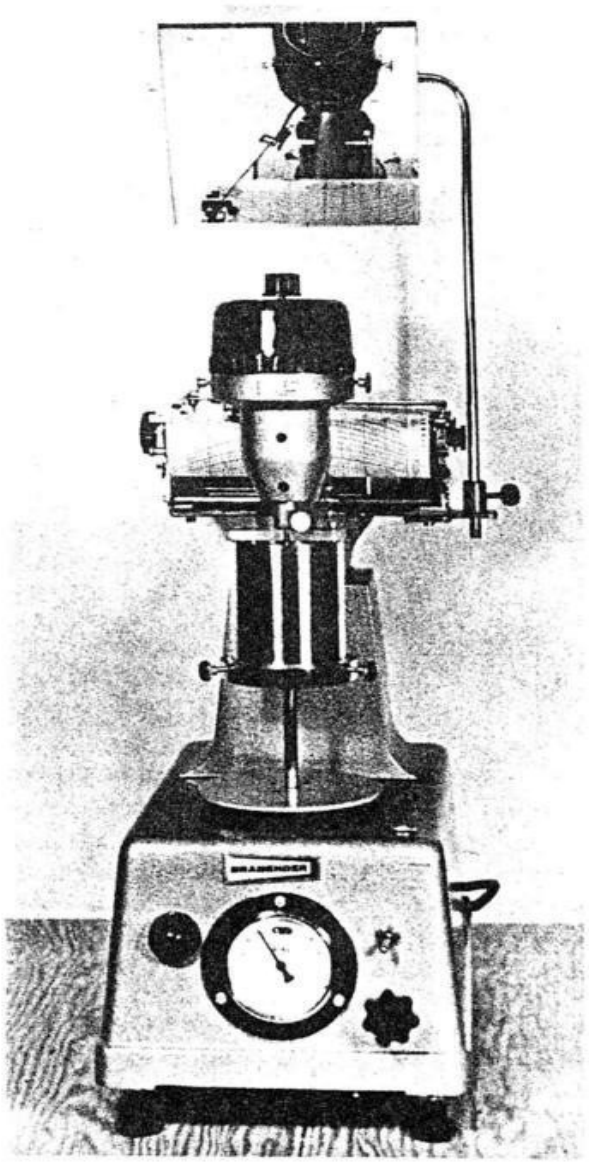
Ermittlung eines zementabhängigen Grenzwasserzementwertes a
Kenngröße für Sichtbeton

Determination of water/cement ratio as a function of cement, as an index for exposed concrete
Détermination d'un rapport limite eau/ciment, en fonction du ciment, comme indice pour béton exposé

VON DIPL.-GEOL. JÜRGEN TEUBERT, POING

"Determination of water/cement ratio as a function of cement, as an index for exposed concrete"
Betonstein-Ztg. 35 (1969), H. 11

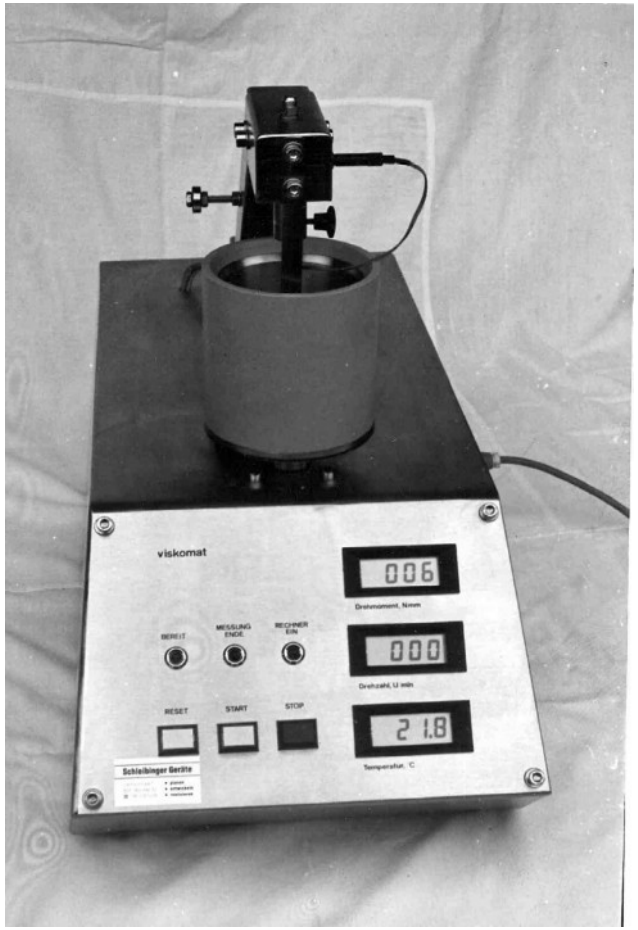
Prof. Dr. Jürgen Teubert,
Obertaufkirchen, Germany

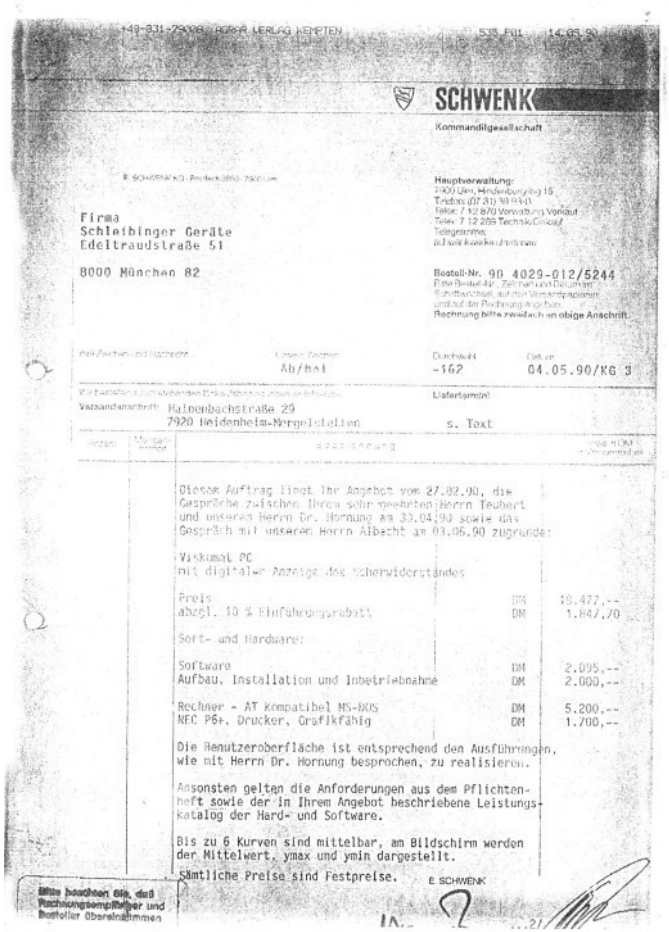


Viscocorder®
Fa. Brabender
Duisburg, 1969

measuring technology – Viskomat PC 1990

1. order
Mai, 4th, 1990, Schwenk Zement KG, Ulm / Mergelstetten





SCHWENK
Kommanditgesellschaft

Hauptverwaltung:

Firma
Schleibinger Geräte
Edeltraudstraße 51

8000 München 82

Bestell-Nr. 90 4029-012/5244
Rechnung bitte zweifach an obige Anschrift

Ab/hei -162 04.05.90/KG 3

Versandanschrift: Hainenbachstraße 29
7920 Heidenheim-Mergelstetten
Lieferzeit: s. Text

Diesen Auftrag liegt Ihr Angebot vom 27.02.90, die Gespräche zwischen Ihrem sehr geehrten Herrn Teubert und unserem Herrn Dr. Hornung am 03.04.90 sowie das Gespräch mit unserem Herrn Albrecht am 03.05.90 zugrunde:

Viskomat PC
mit digitaler Anzeige des Scherwiderstandes

Preis	DM	19.477,--
abzgl. 10 % Einführungsrabatt	DM	1.947,70
Soft- und Hardware:		
Software	DM	2.095,--
Aufbau, Installation und Inbetriebnahme	DM	2.000,--
Rechner - AT Kompatibel MS-DOS	DM	5.200,--
NEC P6+, Drucker, Grafikfähig	DM	1.700,--

Die Benutzeroberfläche ist entsprechend den Ausführungen, wie mit Herrn Dr. Hornung besprochen, zu realisieren.

Ansonsten gelten die Anforderungen aus dem Pflichtenheft sowie der in Ihrem Angebot beschriebene Leistungskatalog der Hard- und Software.

Bis zu 6 Kurven sind mittelbar, am Bildschirm werden der Mittelwert, ymax und ymin dargestellt.

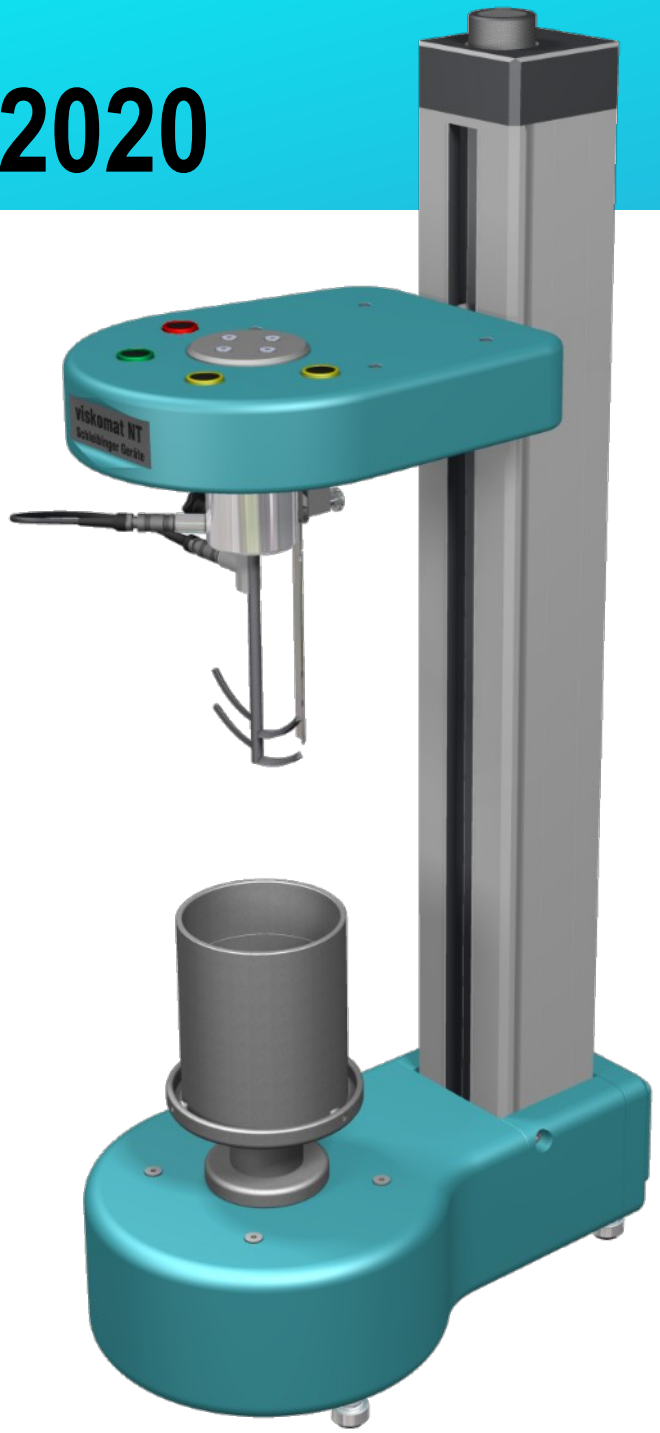
Sämtliche Preise sind Festpreise.

E. SCHWENK

Bitte beachten Sie, daß Rechnungsempfänger und Besteller übereinstimmen

Viskomat NT 2020

- Vessel with 360 ml
- Speed 0,001.. 400 rpm.
- Torque 0..500 Nmm on the probe
- Scraper is removing gluing material from the wall of the vessel.
- Temperature control.
- Shear stress controlled drive
- Shear rate control drive
- Oscillation
- etc.



Different Probes
Absolute vs. Relative

Coaxial Cylinder

Plate Cone

Double Gap
(Basket Probe)

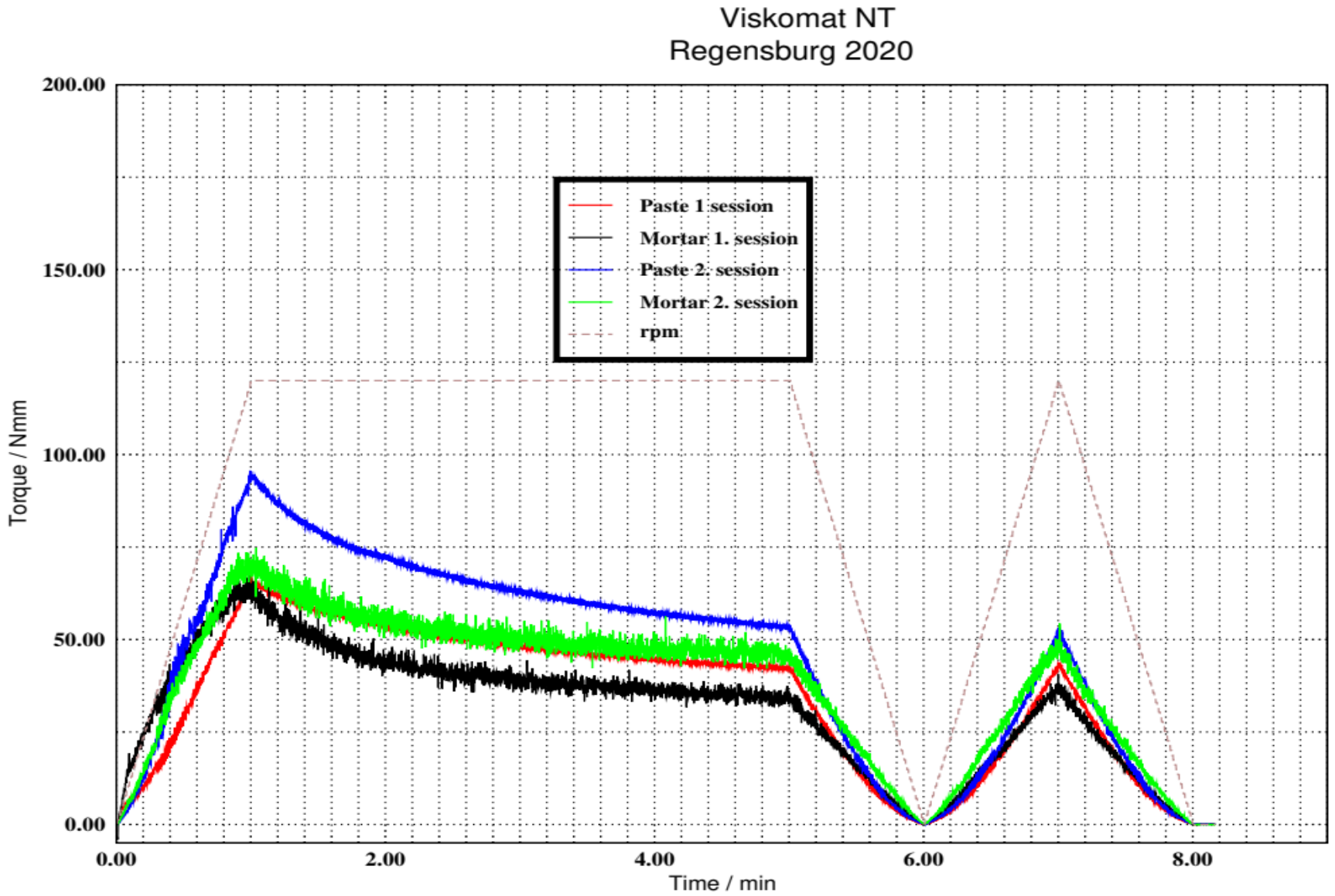
Vane Probe

Plate-Plate

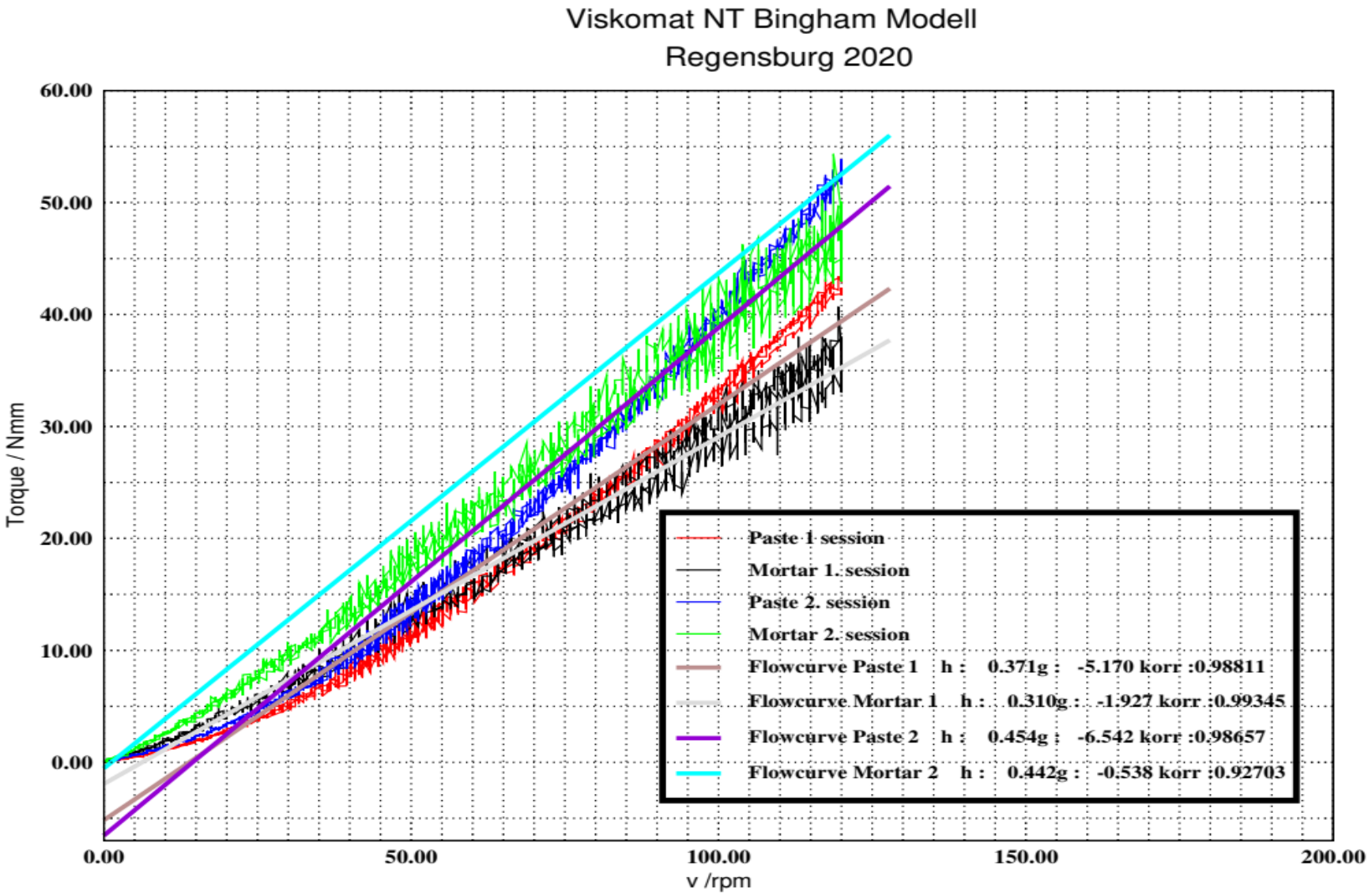
Mixer Formed Probes

Sphere Probe

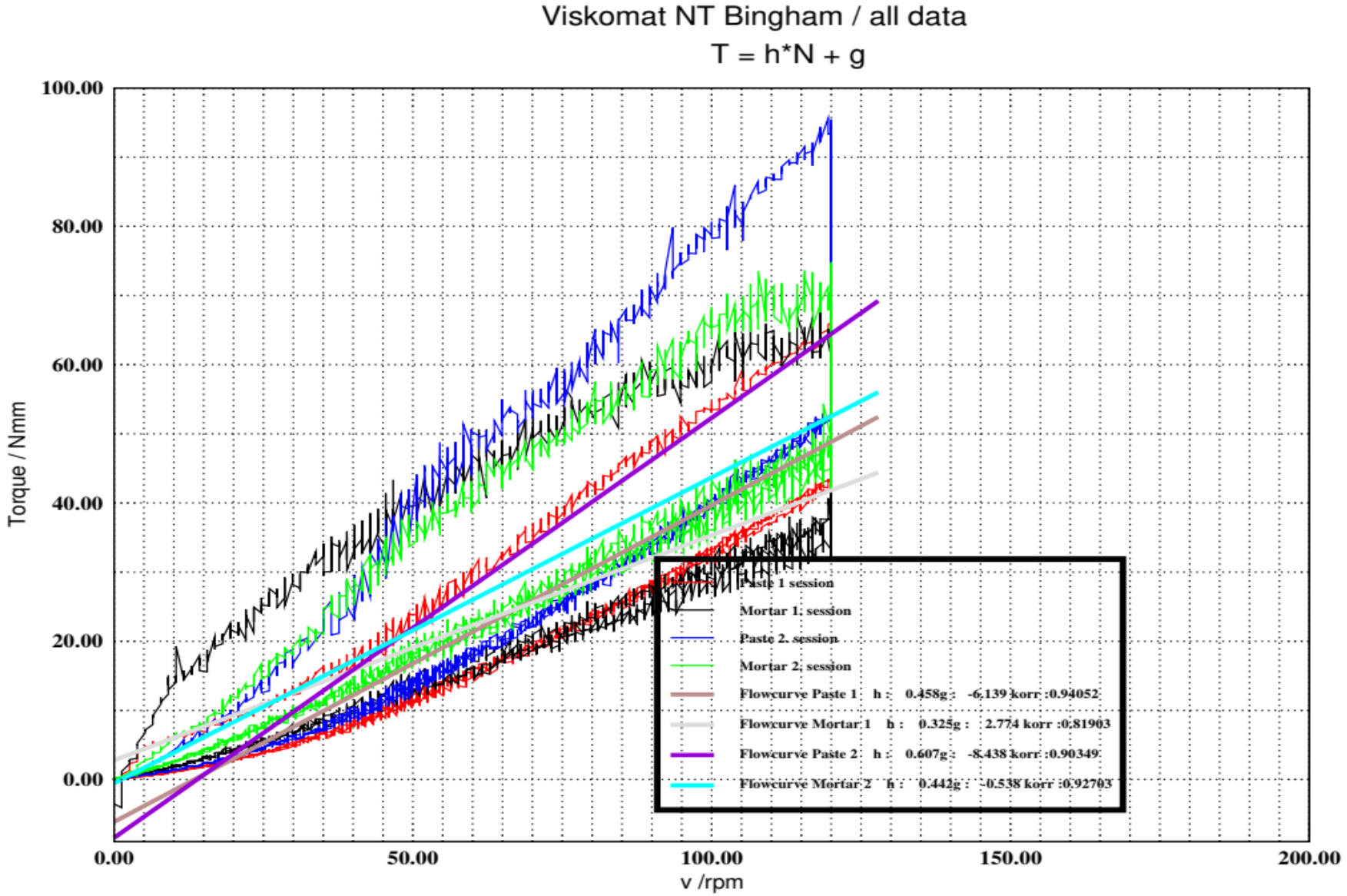
Viskomat NT
Torque and speed over time



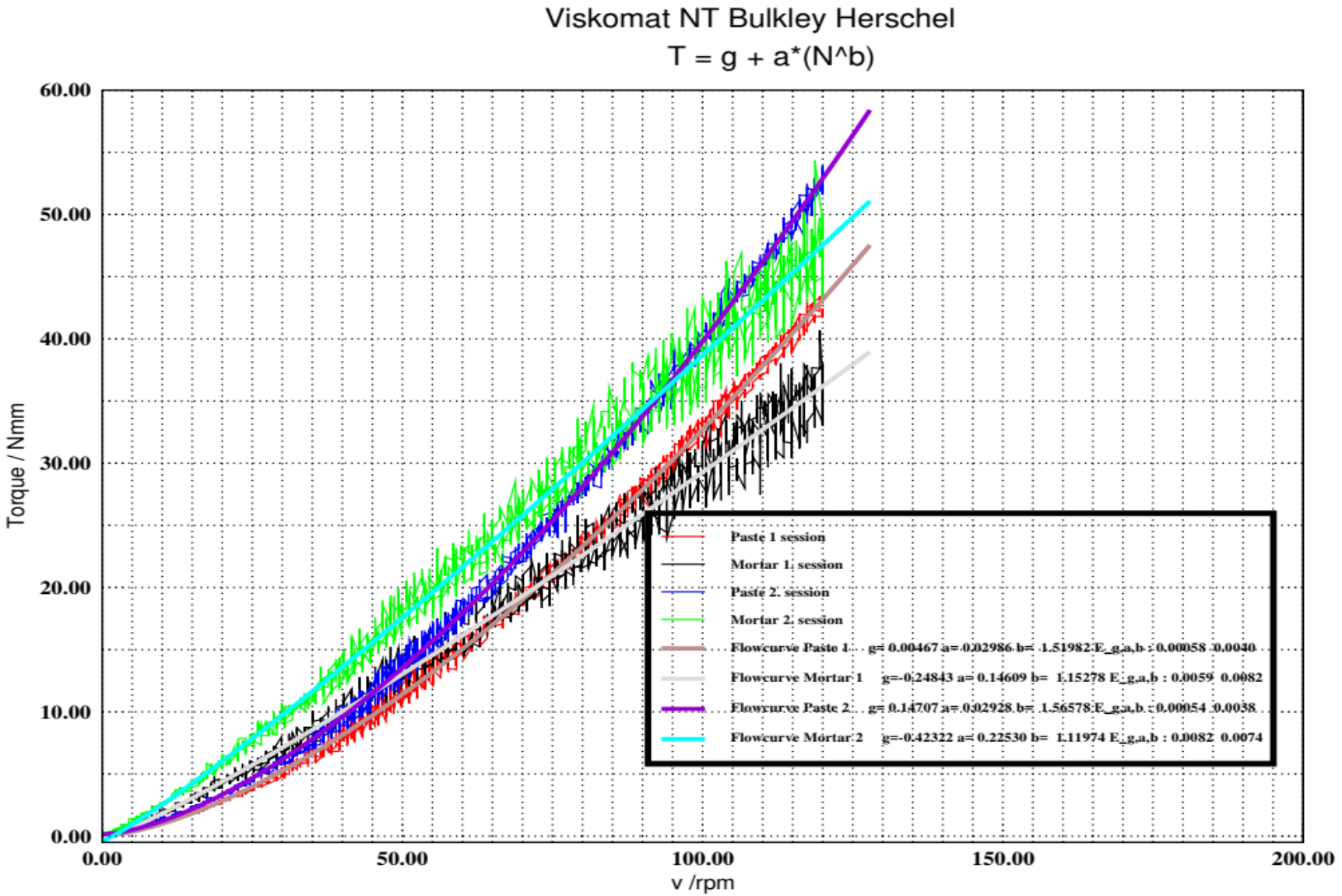
Flowcurve Bingham
T = h*v + g / time: 5’ .. 8’



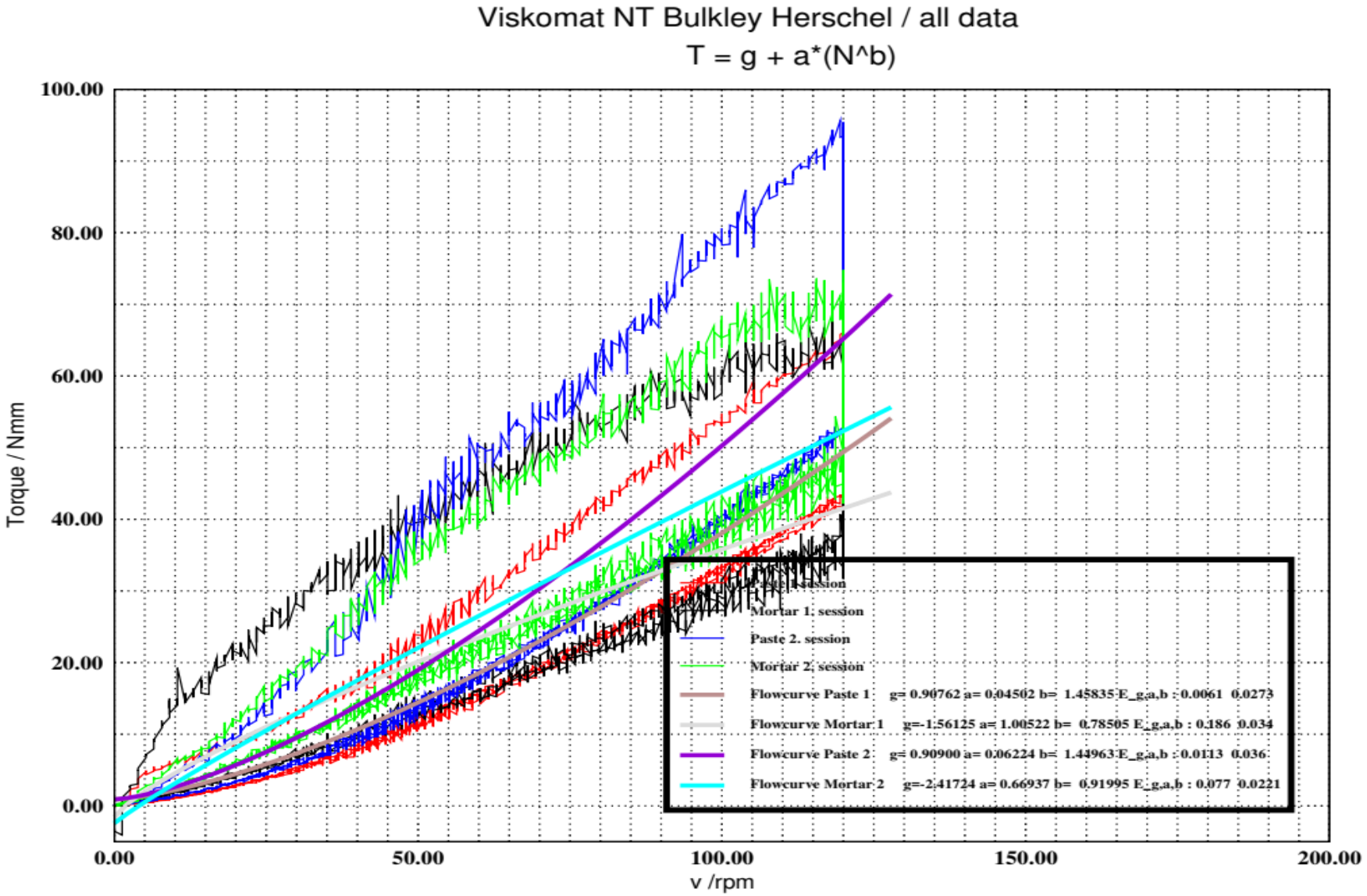
Flowcurve Bingham
T = h*v + g / whole time



Bulkley Herschel
$T = a*v^b + g$ / time: 5’ .. 8’



Bulkley Herschel
$T = a*v^b + g$ / whole time



Different types of rheometers for different kinds of materials and applications:

Viskomat XL:
0...10,000 Nmm
0...8 mm
3,000 ml
0.001...80 rpm

SLIPER:
1...1000 mbar
0...4 m/s
6,000 ml

Viskomat NT:
0...500 Nmm
0...2 mm
360 ml
0.001...400 rpm

eBT-V:
0...10,000 Nmm
0...20 mm
15,000 ml
0.1...30 rpm

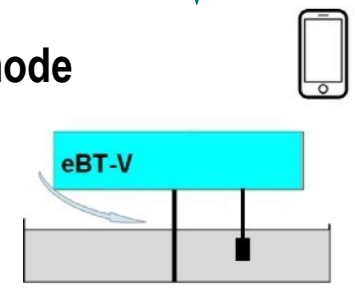
rheometer - eBT-V

eBT-V:

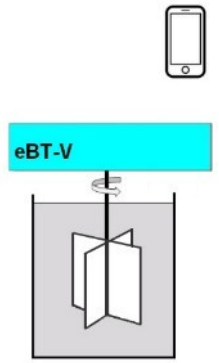
mobile rheometer for stiff and self-compacting (self-consolidating), SCC, concretes up to 32 mm grain size

eBT-V:
0...10,000 Nmm
0...32 mm
15,000 ml
0.1...40 rpm or
0.1 ...40 °/sec

P-mode



V-mode:
Vane probe



P-mode: for fluid to no-slump concrete: evaluation of relative rheological parameters
V-mode: Vane-probe-mode for fluid concrete and SCC.

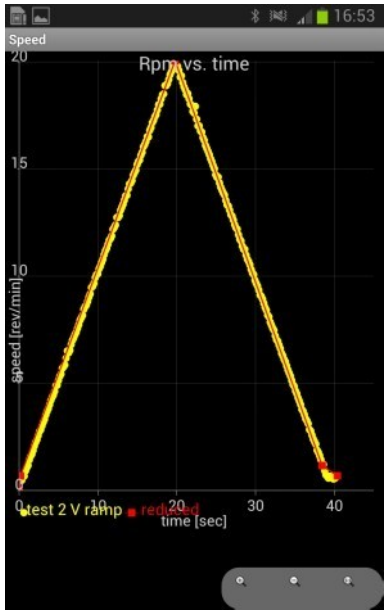
Measuring technology – eBT-V

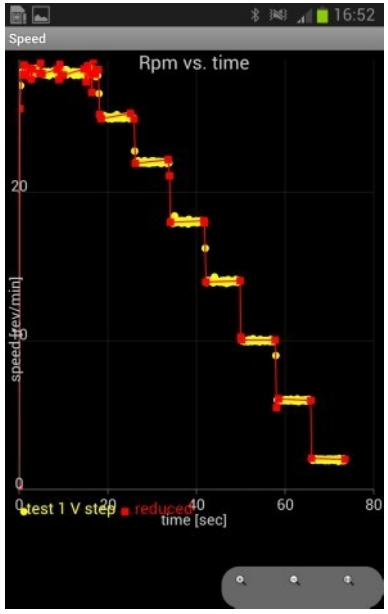
Smartphone-App:

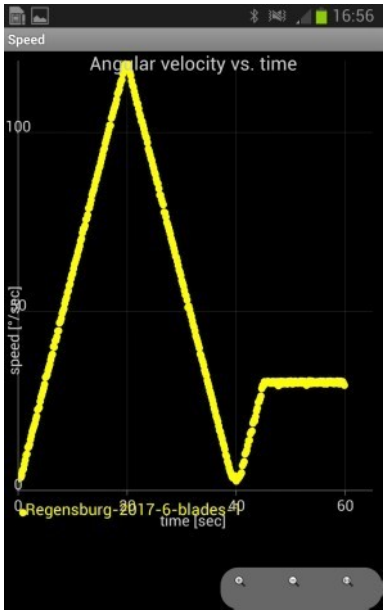
Profiles: different measuring profiles are possible

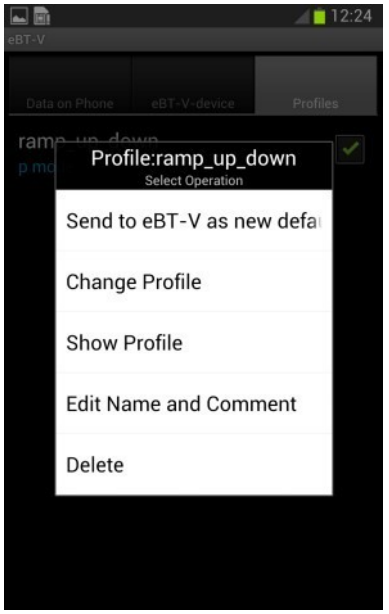
- ramp profile
- step profile
- combinated ramp and step profile.

Examples:

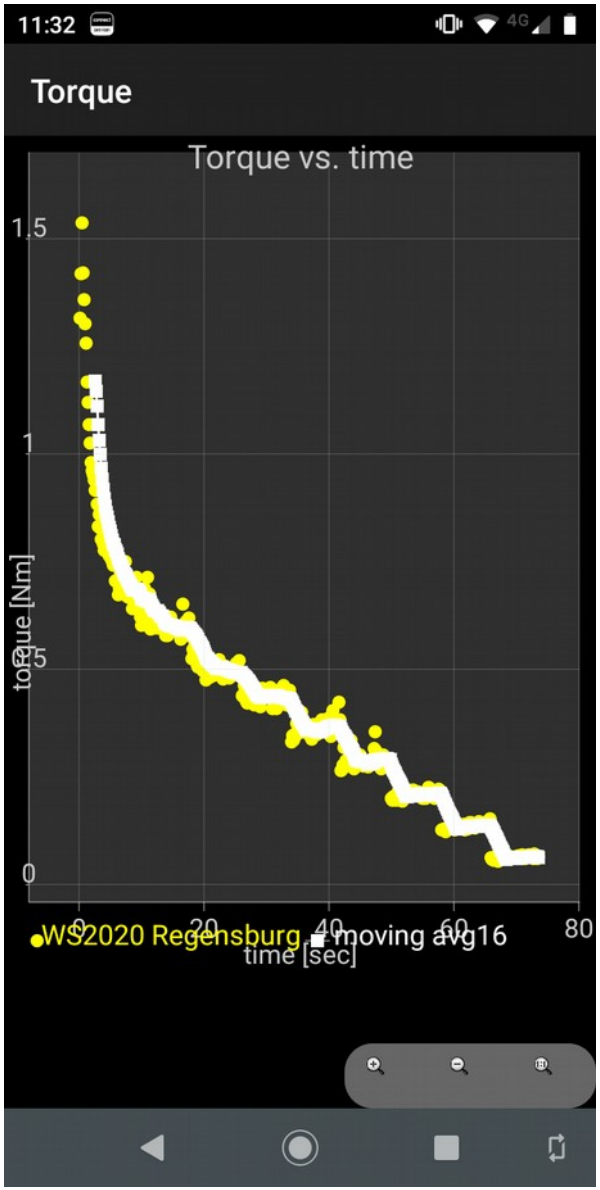


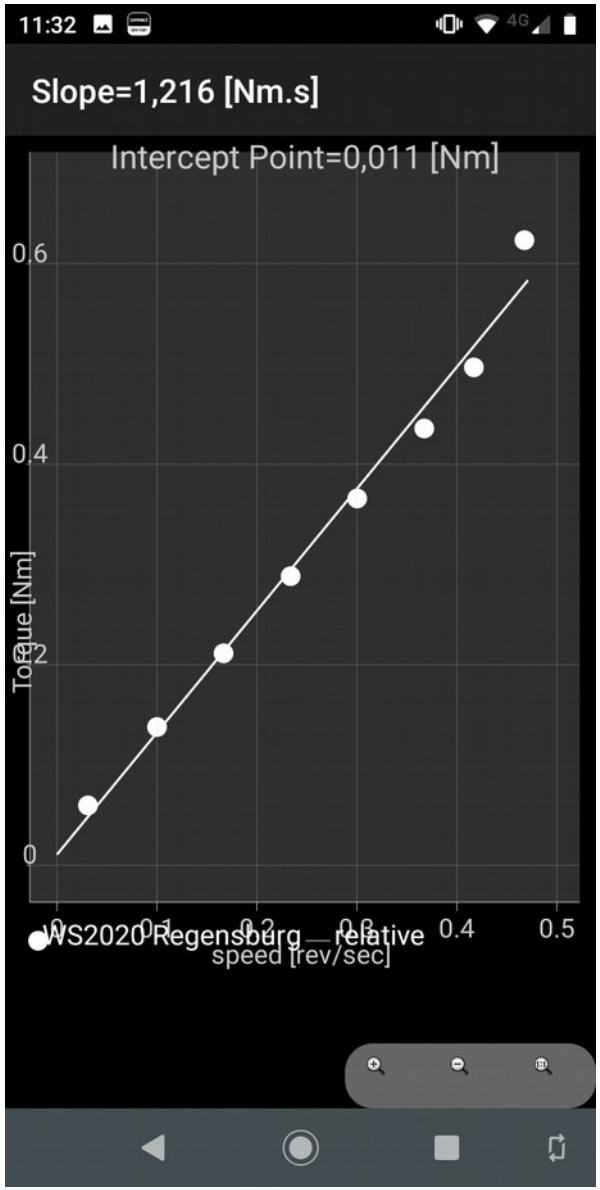


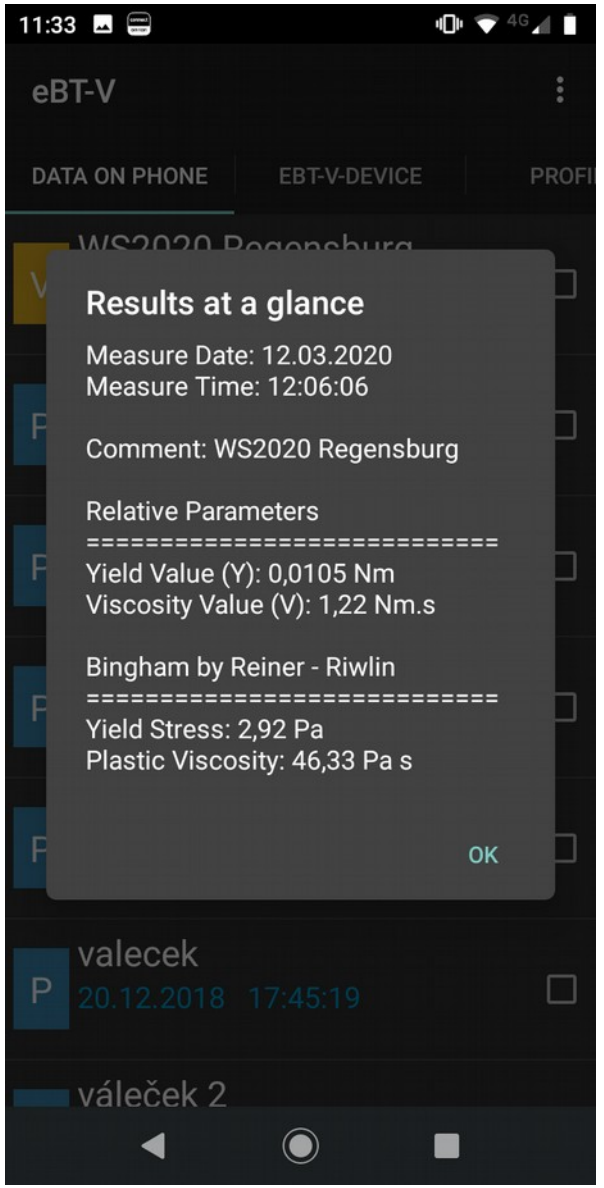




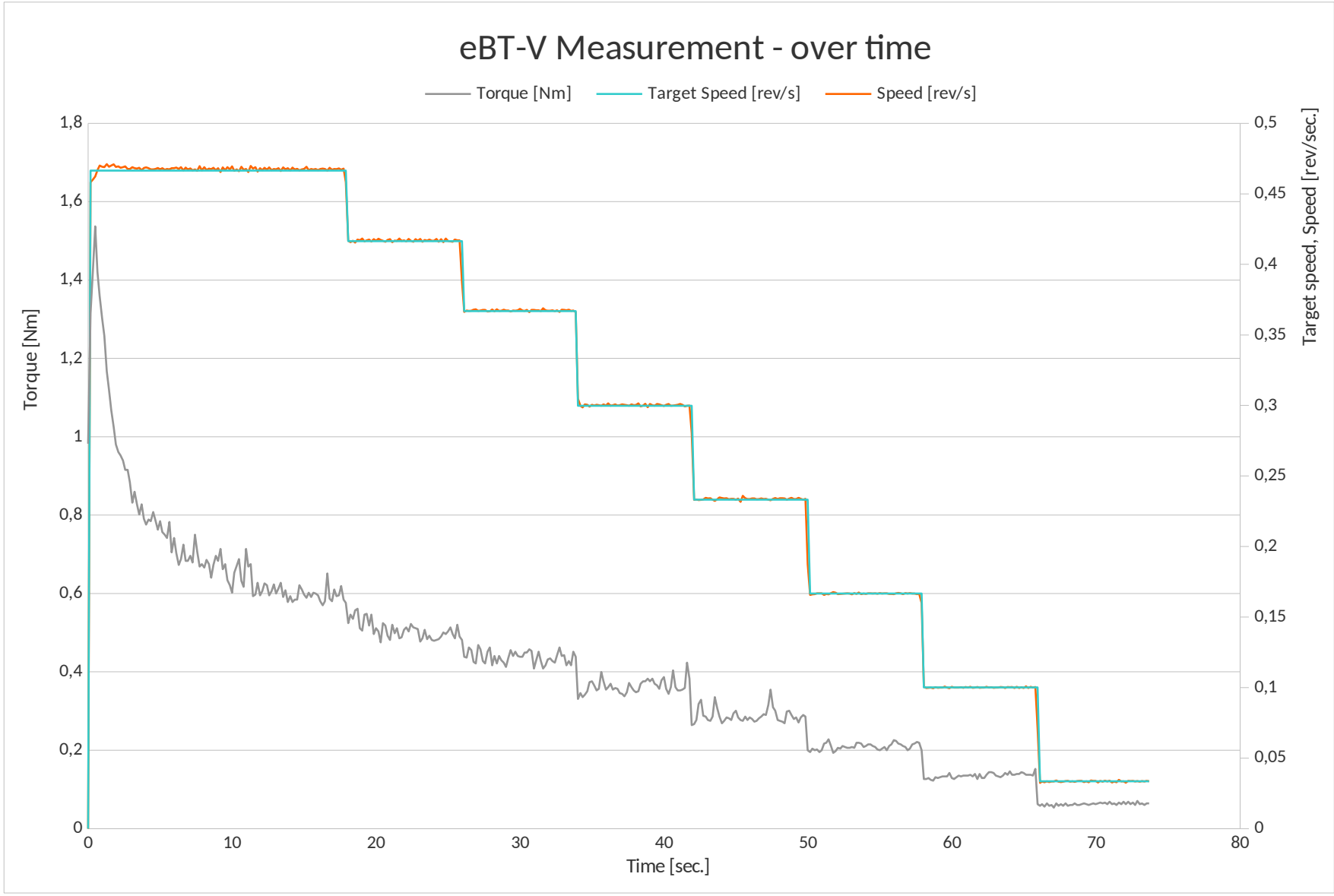
SCC: Results eBT-V measurement
V-mode (Vane probe)



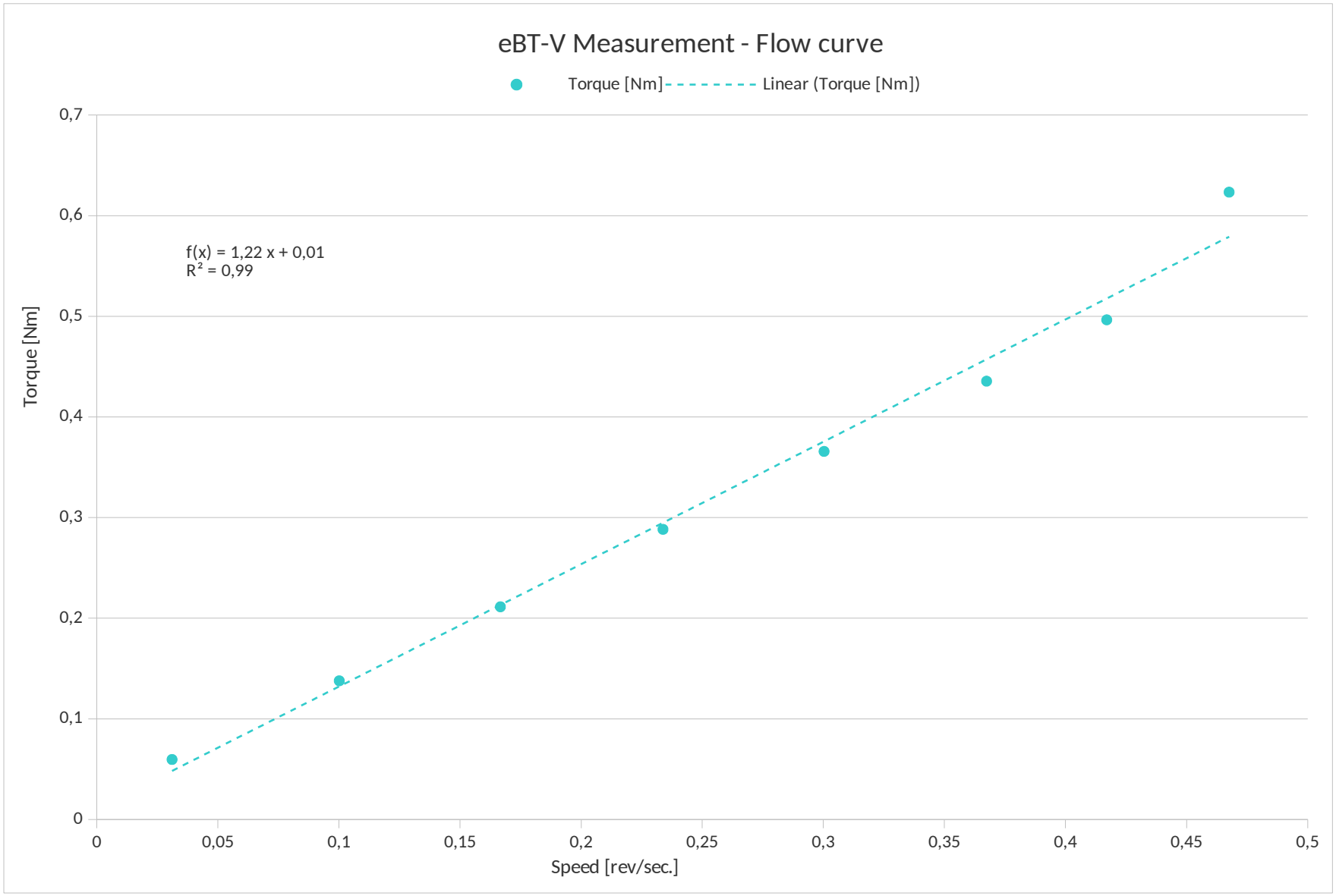




eBT-V: torque and speed over time

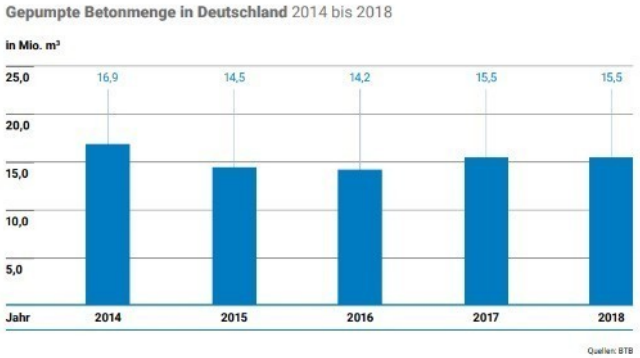


eBT-V – flow curve

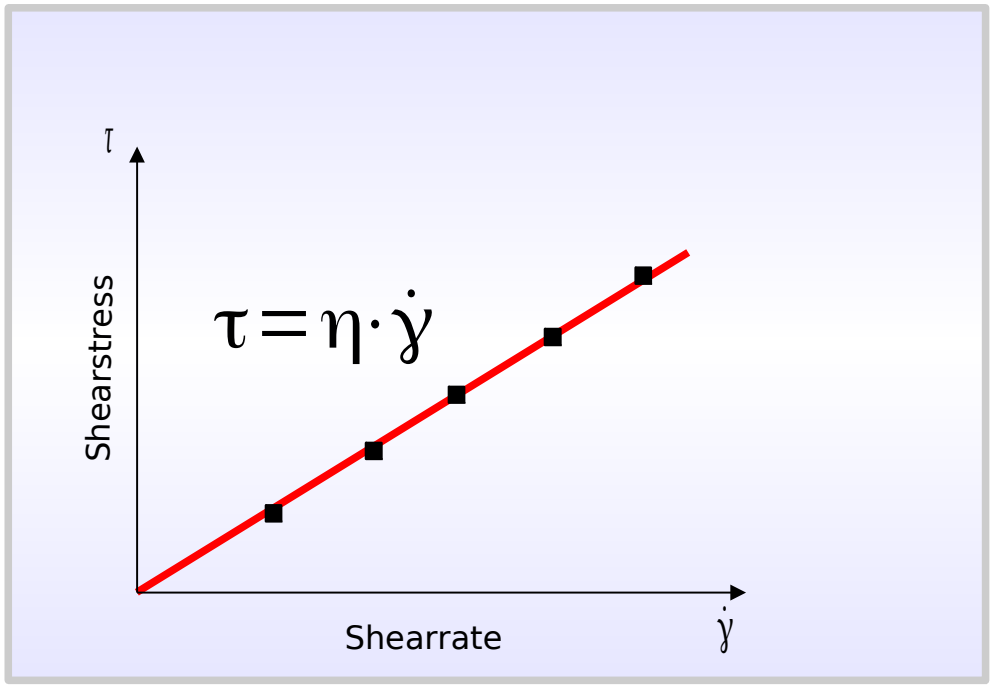


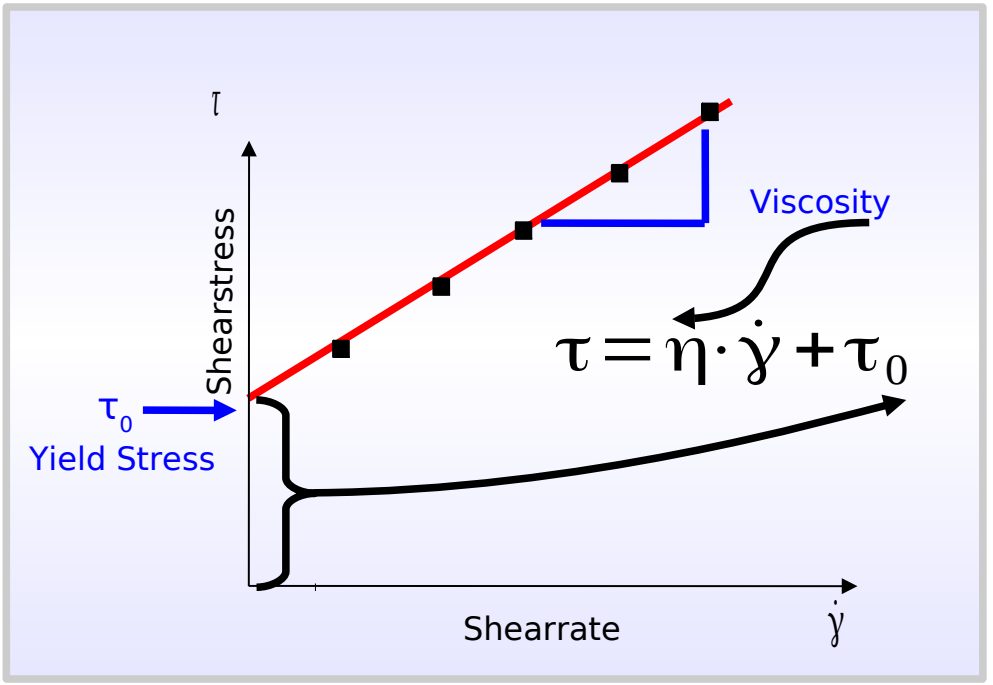
Rheology ↔ Pumpability I

"Concrete Pump RB". Licensed under CC BY-SA 3.0 via Commons
- https://commons.wikimedia.org/wiki/File:Concrete_Pump_RB.JPG#/media/File:Concrete_Pump_RB.JPG

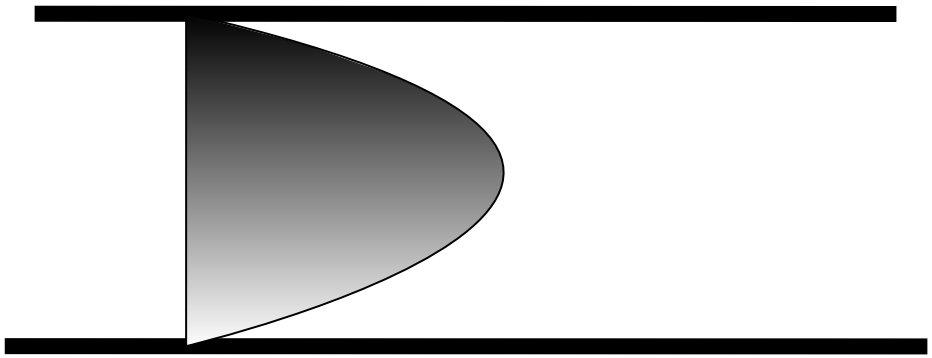


Rheologie ↔ Pumpability II

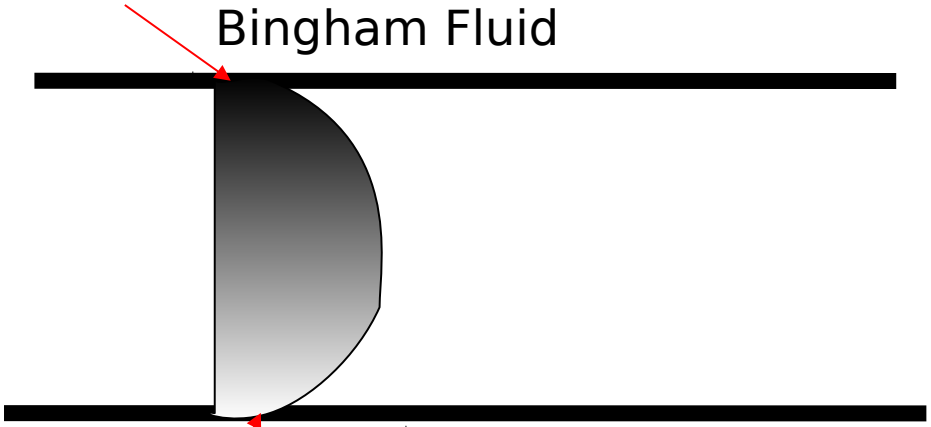




Newton Fluid

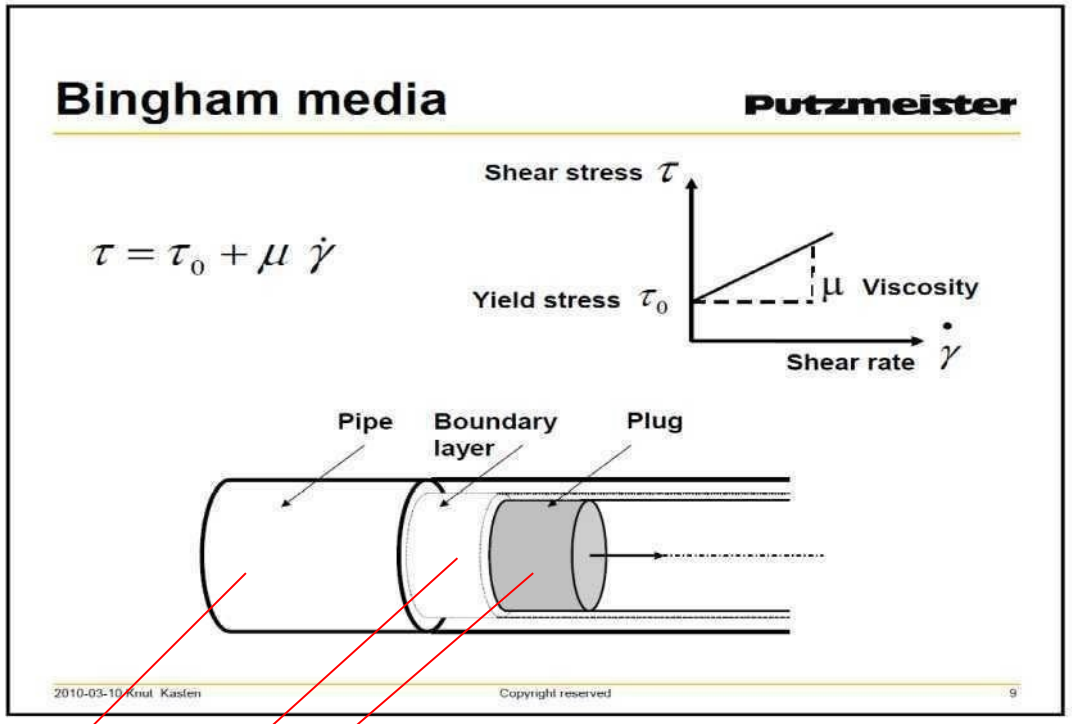


Bingham Fluid



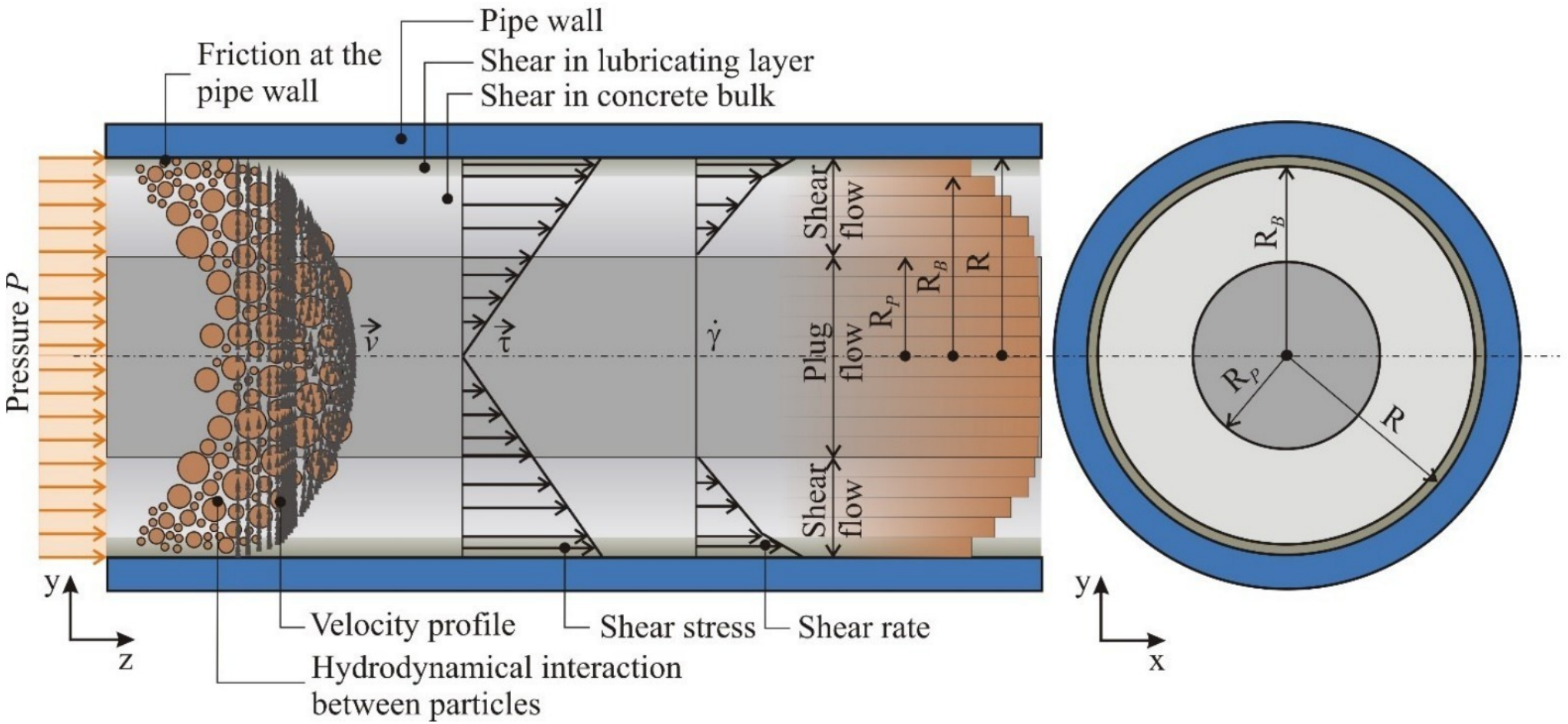
Profile of the Shearrate

Rheologie + Grenzschicht = Pumpbarkeit I



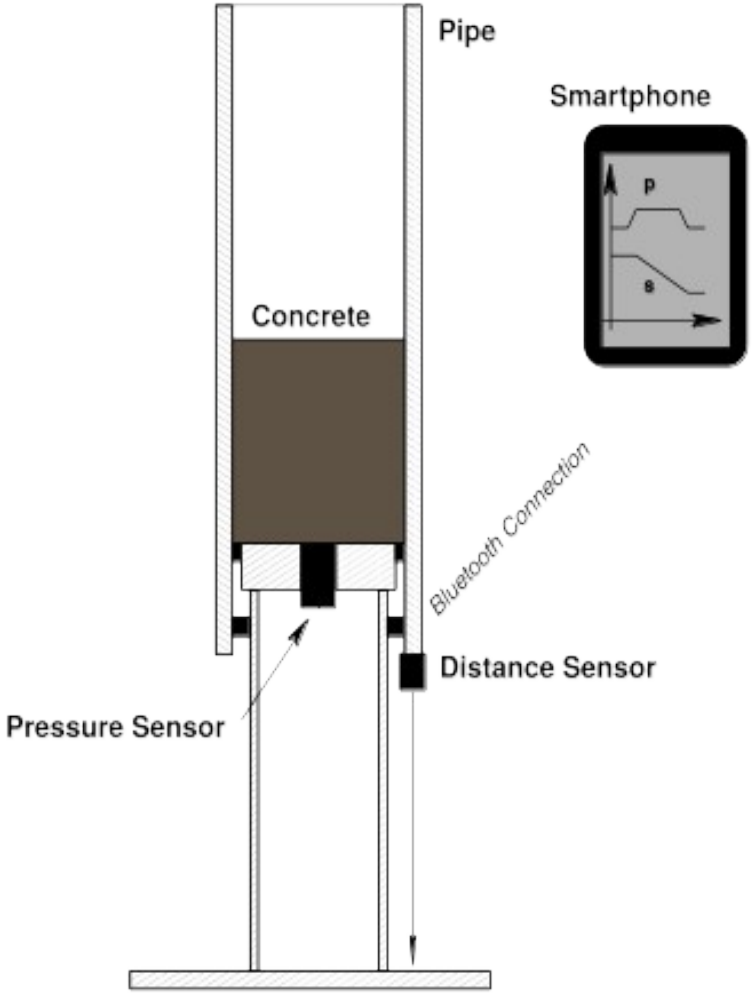
Secrieru, Butler, Mechtcherine, *Bautechnik, Heft* 11 (2014) 797-811.

Rheology + Interfacelayer = Pumpbability II



Source: Dissertation E. Secrieru / AiF Abschlussbericht

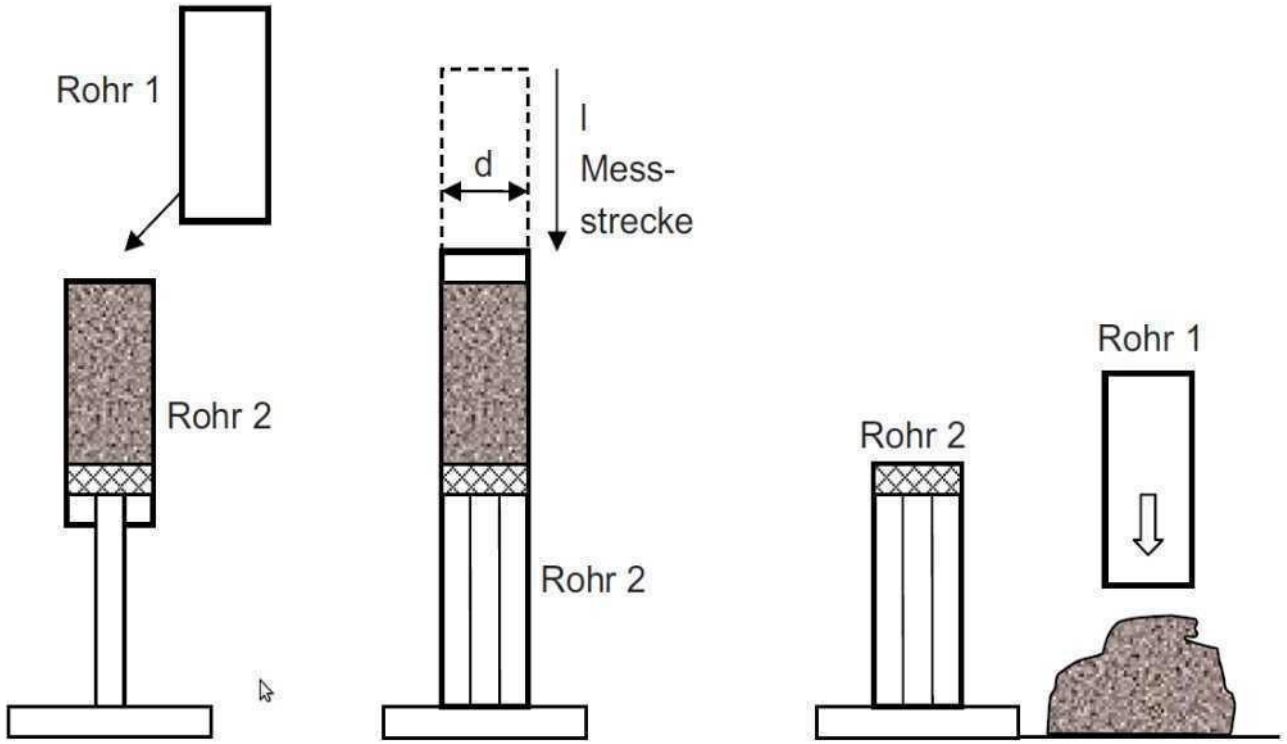
SLIPER - Sliding Pipe Rheometer I



Gleitrohr Rheometer
Ein Verfahren zur Bestimmung der Fließeigenschaften von Dickstoffen in Rohrleitungen.
Dissertation, Kasten 2009

PM Putzmeister inside

SLIPER - Sliding Pipe Rheometer II



a) Befüllen und Verlängerungsrohr aufsetzen

b) Messvorgang - Rohr gleitet nach unten

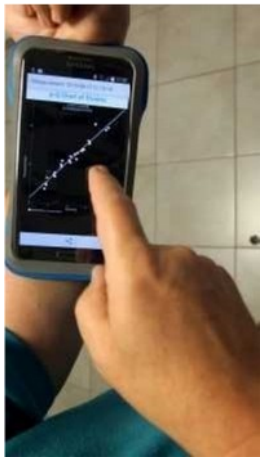
c) Verlängerungsrohr abnehmen und entleeren

SLIPER Measuring Procedure



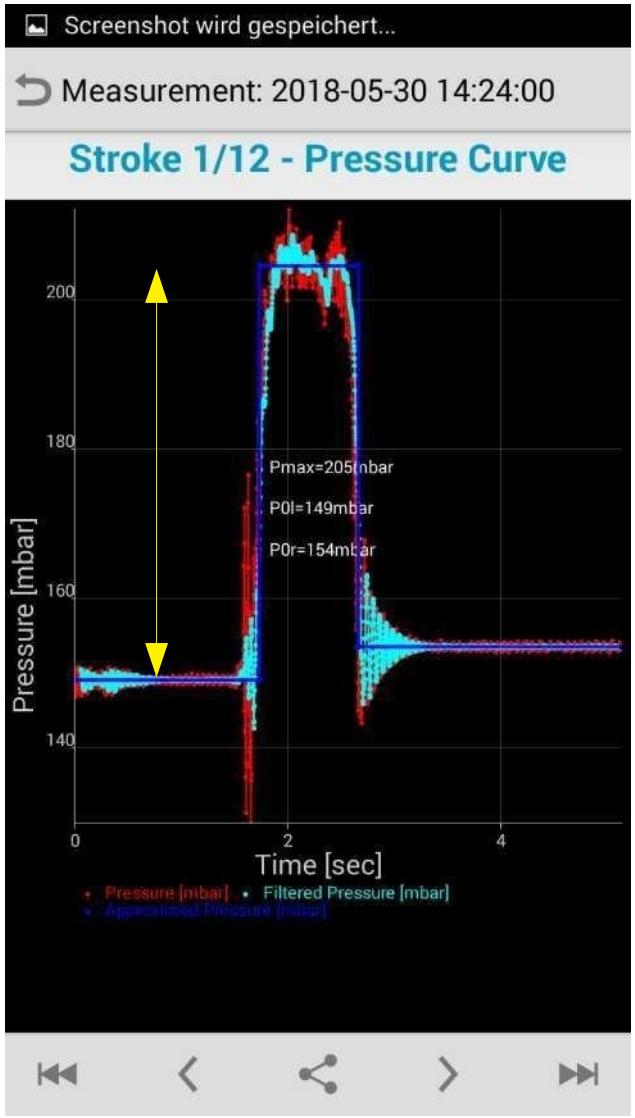

Lift the pipe Pipe is sliding down by gravity

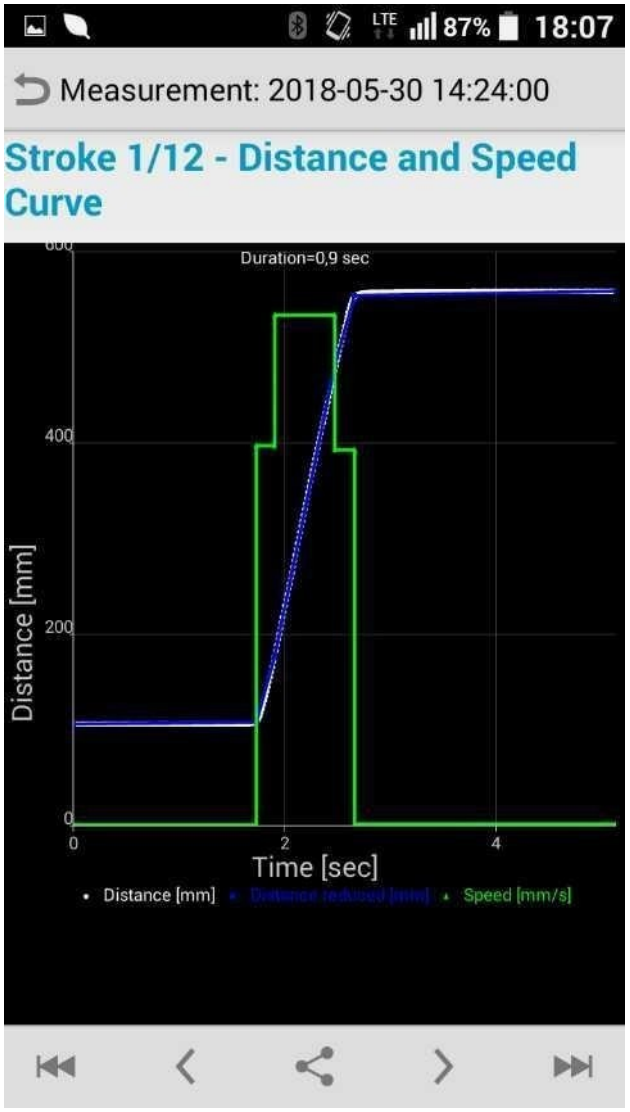


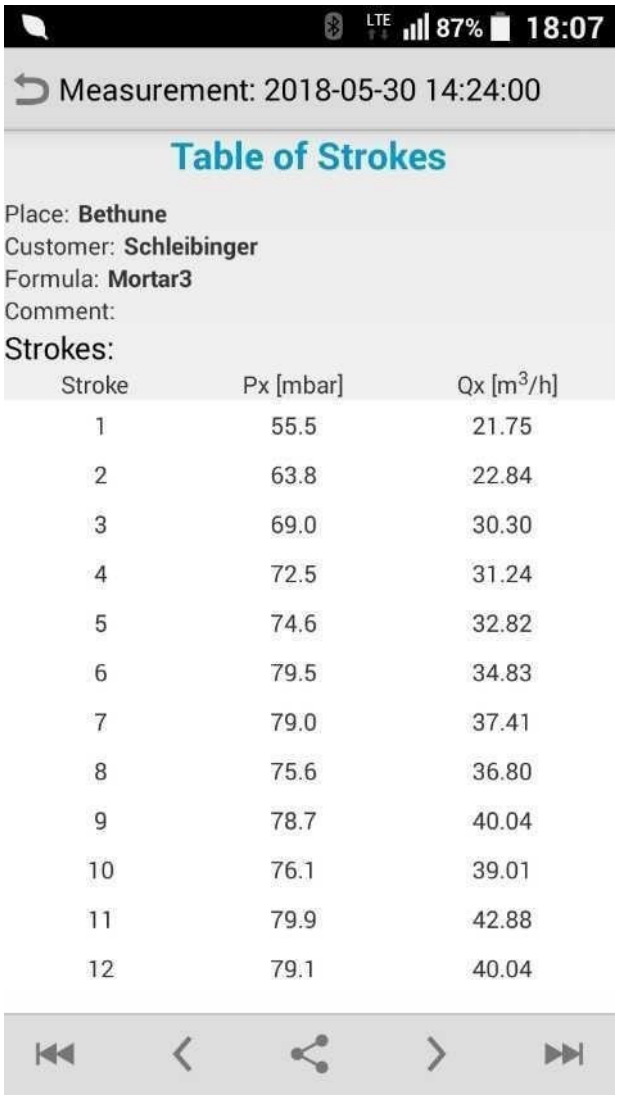



Add a load and repeat the procedure → data evaluation

Forecast of Max. Pressure and Flow Rate

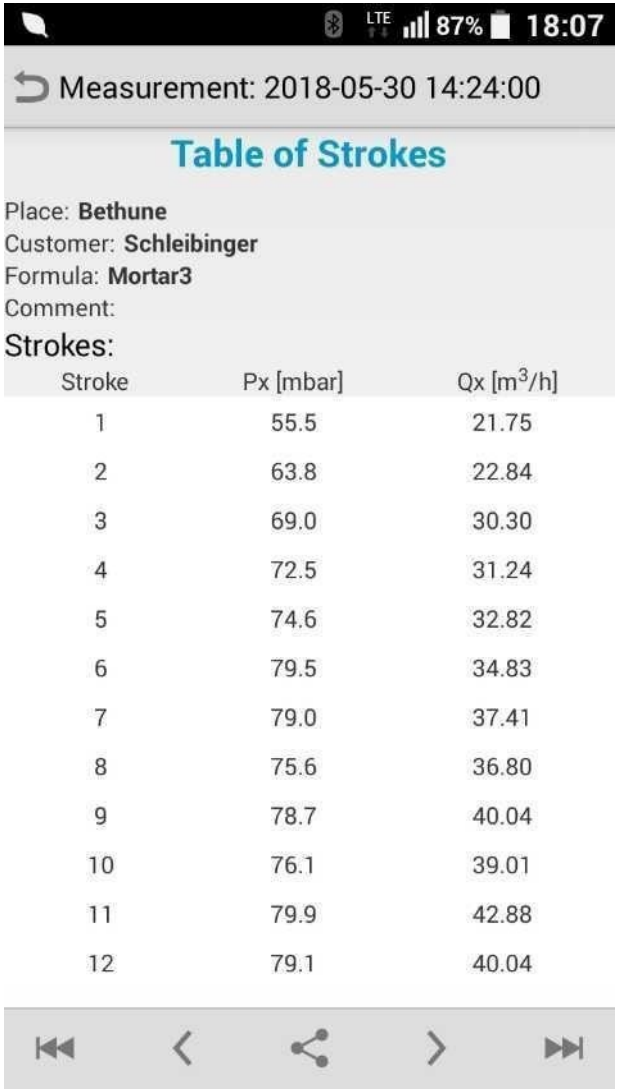


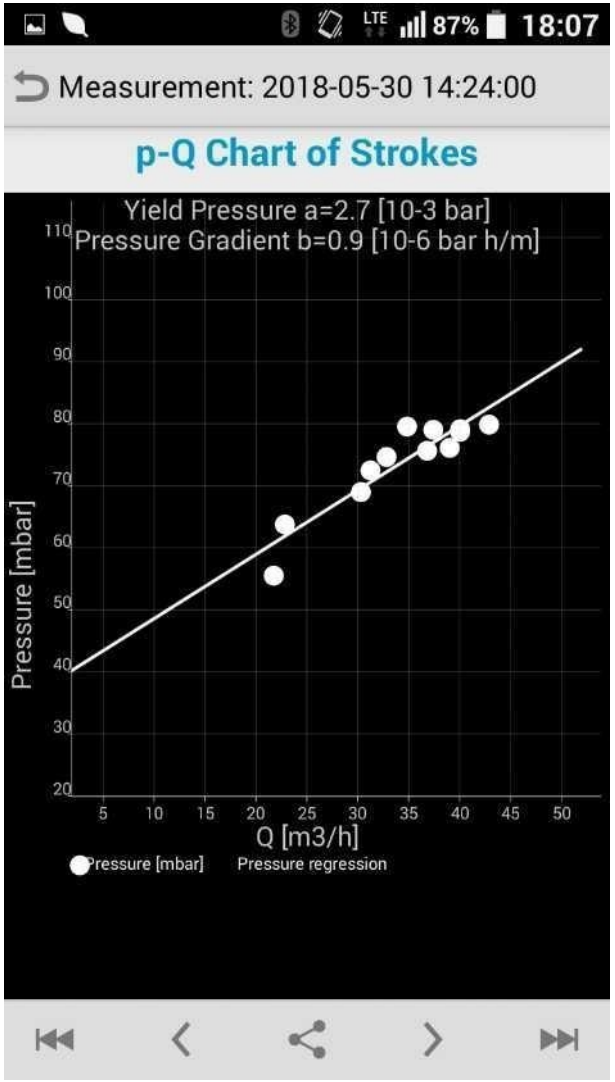


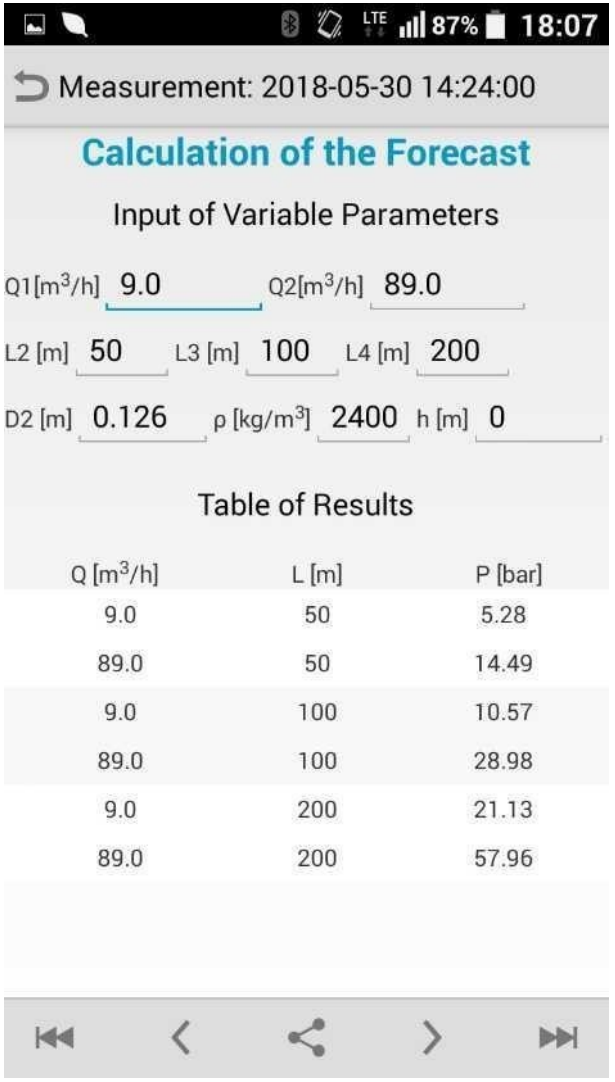


Stroke	Px [mbar]	Qx [m³/h]
1	55.5	21.75
2	63.8	22.84
3	69.0	30.30
4	72.5	31.24
5	74.6	32.82
6	79.5	34.83
7	79.0	37.41
8	75.6	36.80
9	78.7	40.04
10	76.1	39.01
11	79.9	42.88
12	79.1	40.04

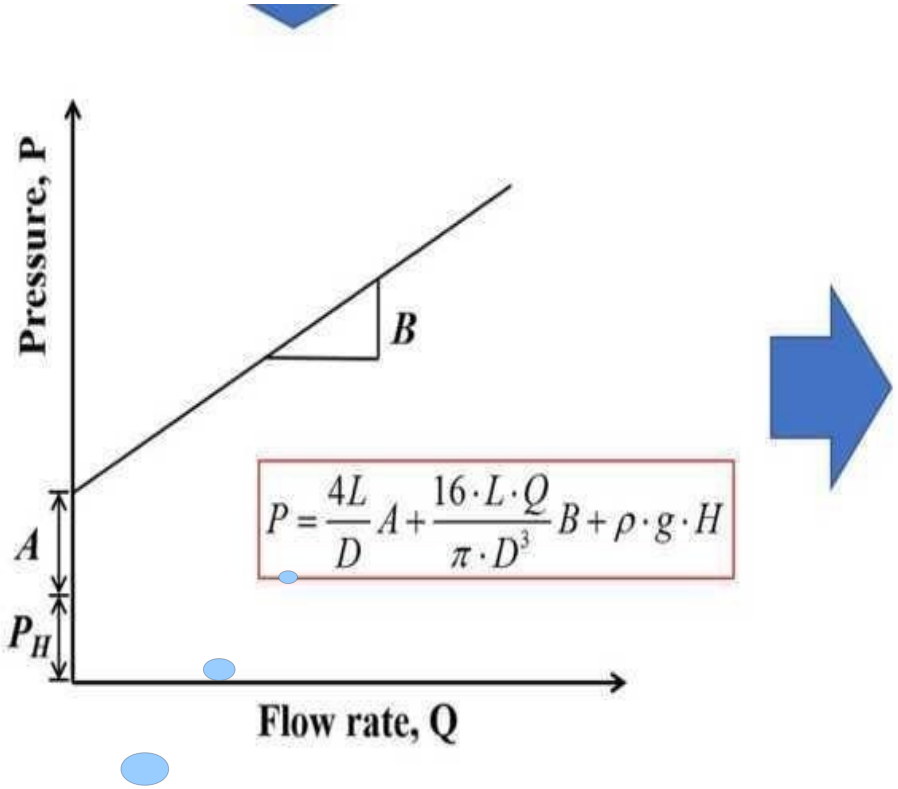
Forecast of Max. Pressure and Flow Rate II

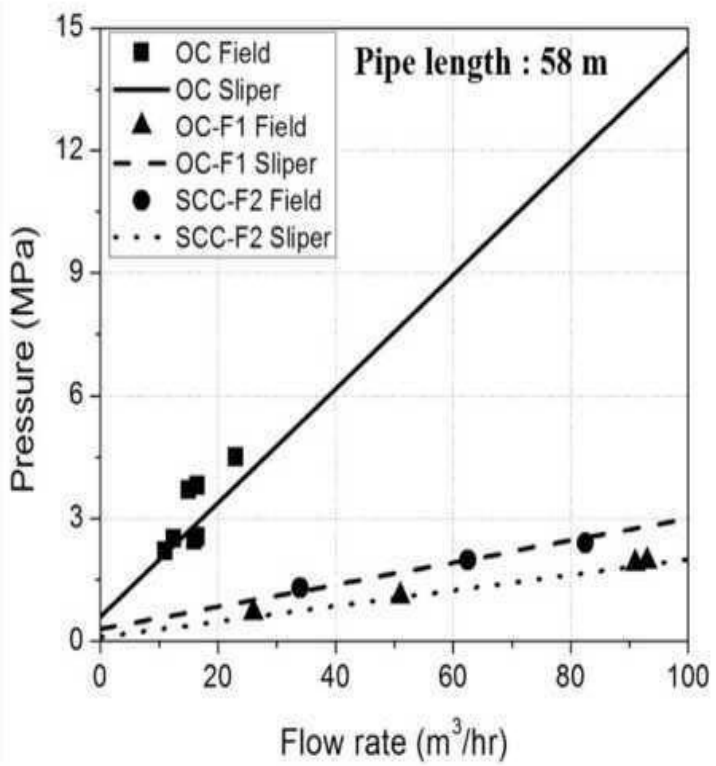






•Forecast of Max. Pressure and Flow Rate III



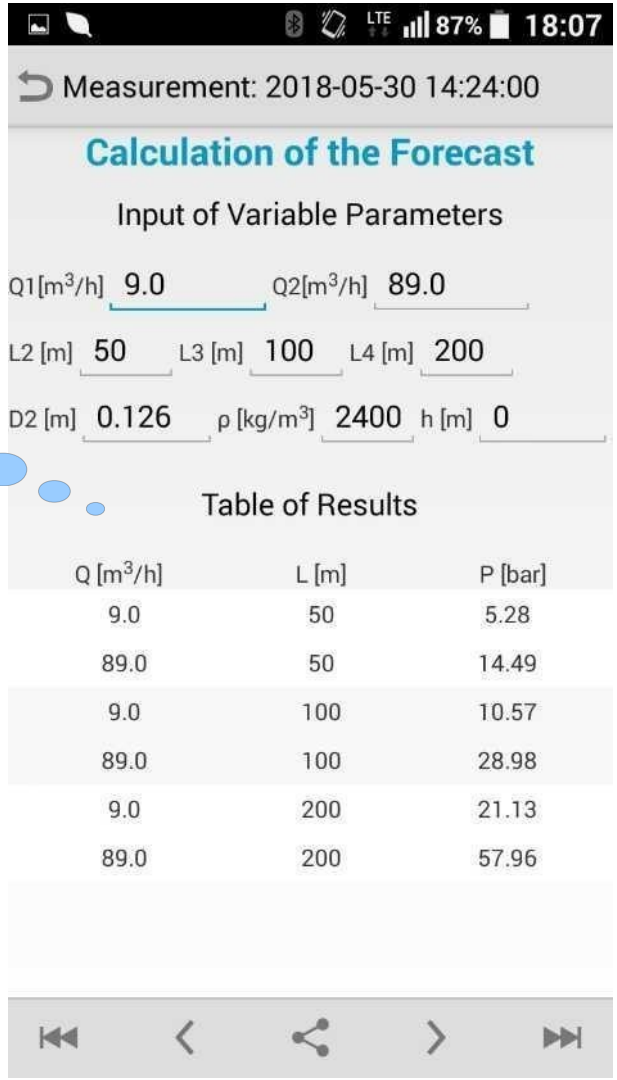


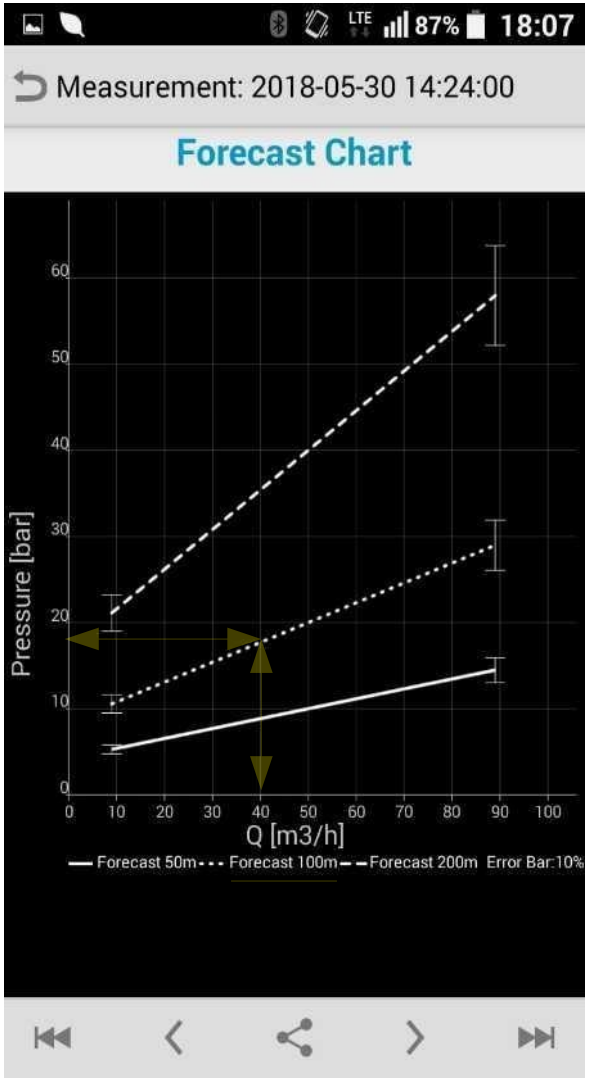
Formula of Kaplan u. Kasten

Quelle: Mechtcherine, V., Nerella, V. N., & Kasten, K. (2014). Testing pumpability of concrete using sliding pipe rheometer. Construction and Building Materials, 53, 312–323.

Forecast of Max. Pressure and Flow Rate IV

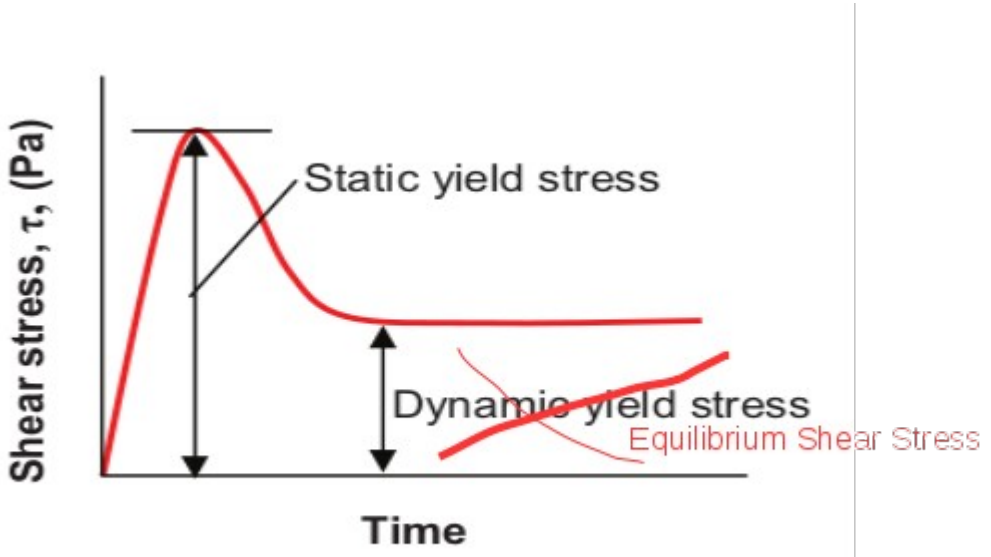
Formula of Kaplan & Kasten





40 m³/h → 18 bar

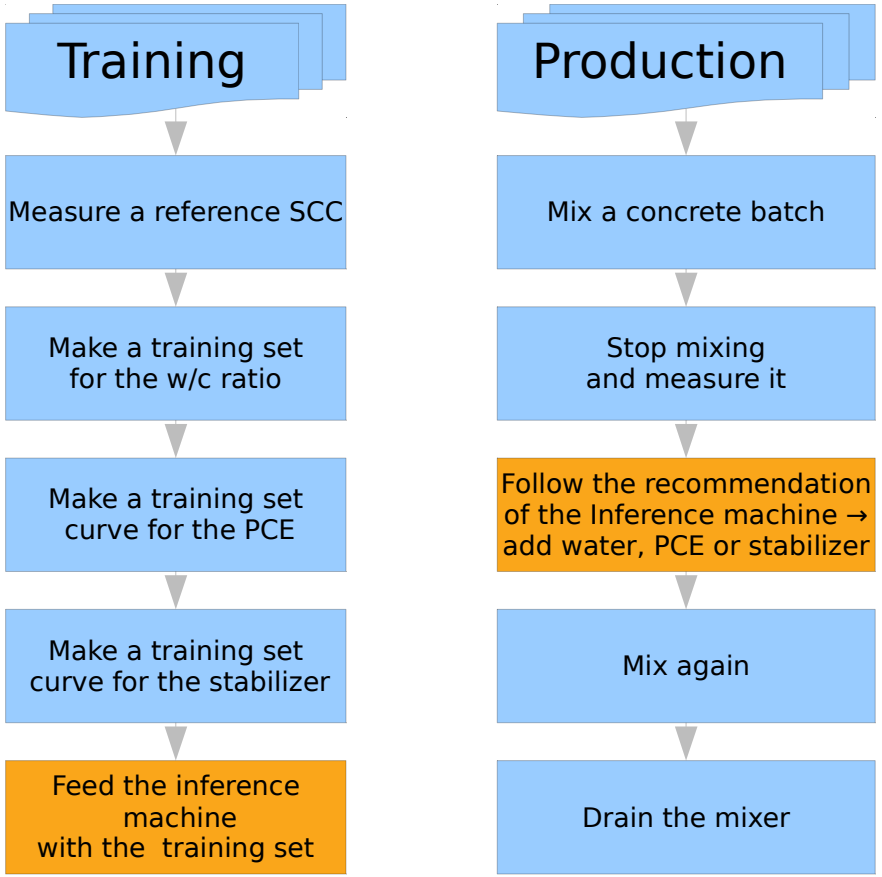
Equilibrium Shear Stress



Das Rilem Komitee 266-MRP : Measuring Rheological Properties of Cement-based Materials
hat am 08.09.2019 in seiner Sitzung in Radebeul bei Dresden beschlossen, dass
statt des Begriffes *Dynamic Yield Stress* der Begriff
Equilibrium Shear Stress verwendet wird.
Von 23 Anwesenden stimmten 15 dem Vorschlag zu.
Darunter: Prof. Lowke, Prof. Haist, Prof. Feys, Prof. de Schutter, Prof. Sonebi, Dr. W. Schmidt,
Prof. Mechtcherine, M. Greim, et.al.
Auf Deutsch: **Gleichgewichts-Scherrate.**

RheoCT – Rheometer for the Concrete Mixer

Designed for quality control during the SCC production in the concrete plant. Viscosity and the drag force on the sphere probe is measured and gives the value for the equilibrium shear stress.



Schleibinger Geräte

Teubert u. Greim GmbH

Thank you for your attention!