

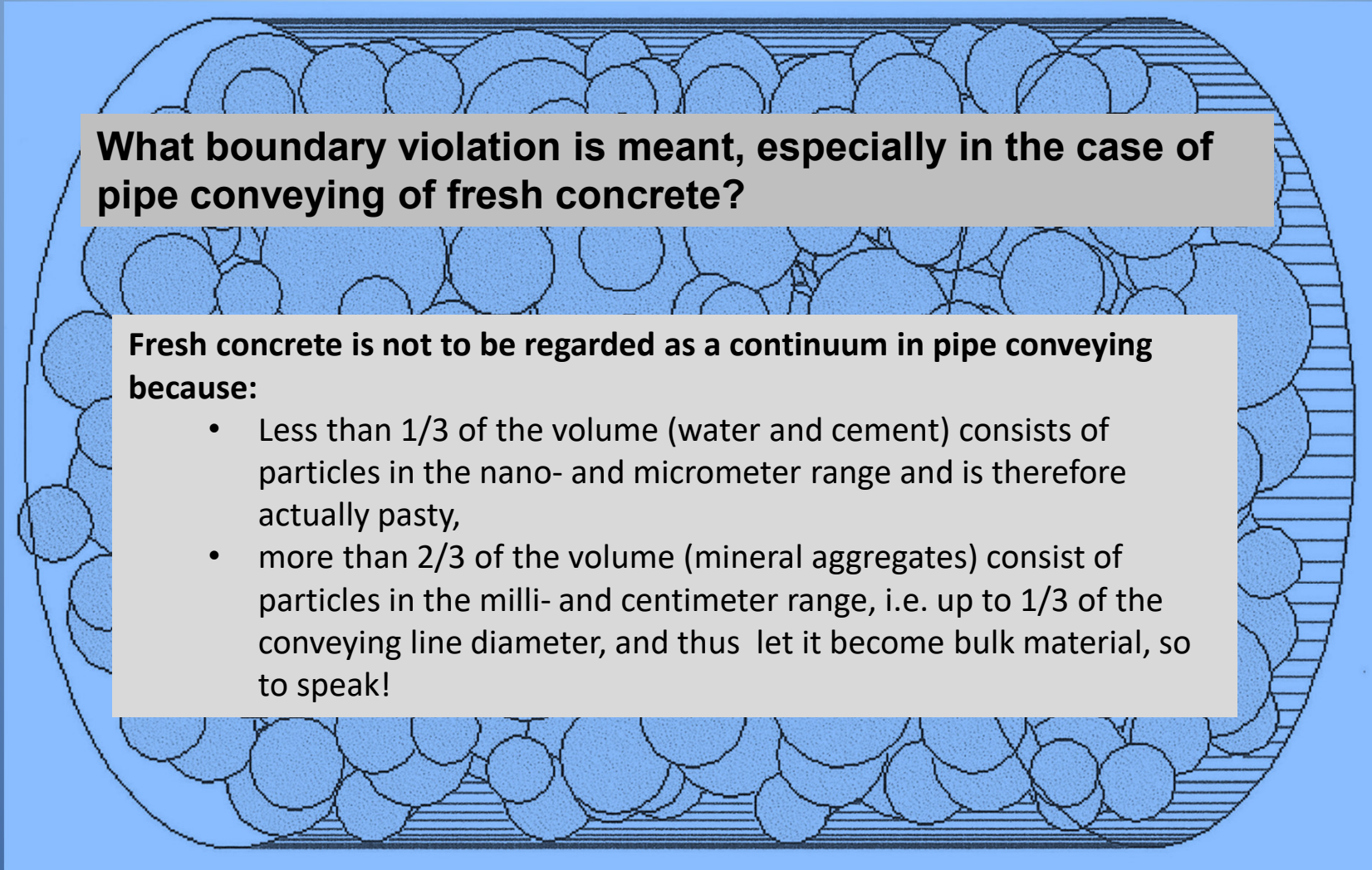
Limit violation in rheological investigations of coarsely dispersed mineral building materials and solutions for the extension of the application limits

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What boundary violation is meant, especially in the case of pipe conveying of fresh concrete?

Fresh concrete is not to be regarded as a continuum in pipe conveying because:

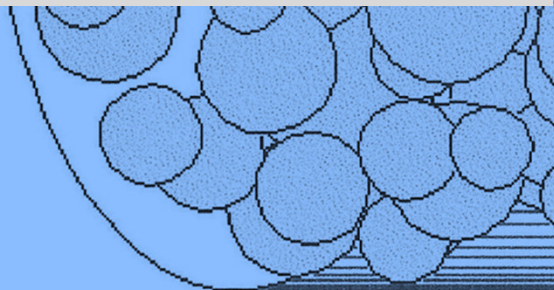
- Less than 1/3 of the volume (water and cement) consists of particles in the nano- and micrometer range and is therefore actually pasty,
- more than 2/3 of the volume (mineral aggregates) consist of particles in the milli- and centimeter range, i.e. up to 1/3 of the conveying line diameter, and thus let it become bulk material, so to speak!

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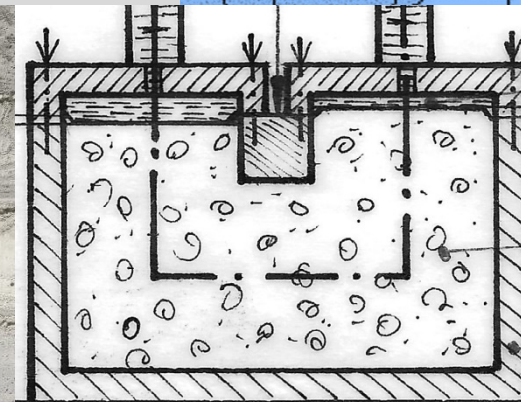
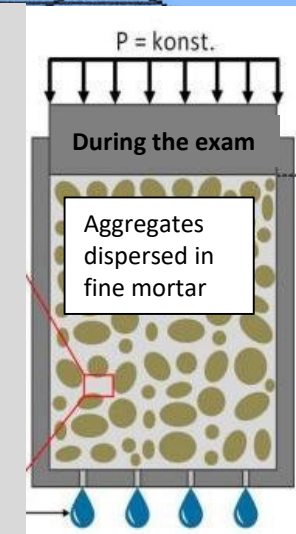
Even cement glue changes its rheological properties in fresh concrete:

- The cement glue (cement and chemically bound water) becomes part of the grain structure, while only the free pore water can flow within the grain structure at appropriate external pressure.
- The internal flow resistance is proportional to the specific surface area of all grains.



for example:

- **Bleeding test with filter press**
Filter pores > cement particles
- **Hydrodynamic pressing**
Bores $\varnothing$ 5 mm for venting and drainage
- **Tests with concrete pressure scale**
pure water separation
- **Wooden board formwork**
Joint width > 1mm



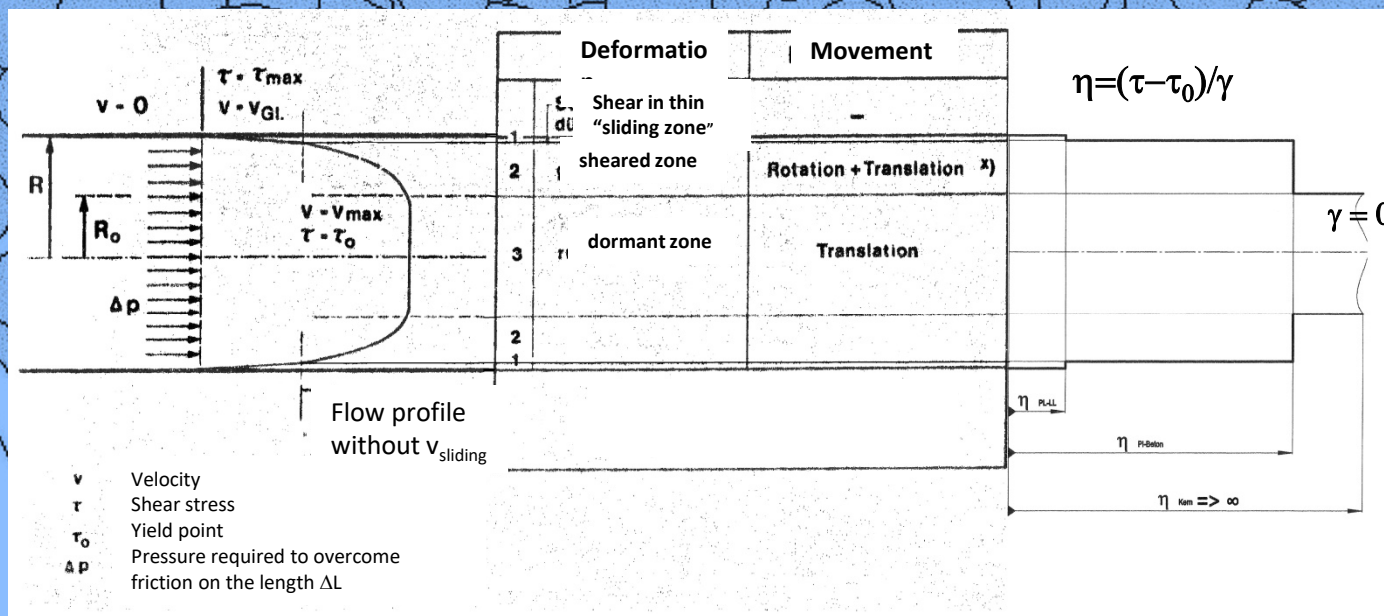
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When describing fresh concrete in formwork, it is quite common to apply the principles of soil mechanics and less rheology!

In the case of pipe conveying of fresh concrete, on the other hand, rheology is usually used, **BUT**: The usual description and derivation of the material model must be critically questioned!

Bingham medium with boundary sliding layer (e.g. to FLATTEN in beton 8-74):



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Numerical simulation for SLIPER (to SECRIERU, Diss. 2018, Abb. 35):

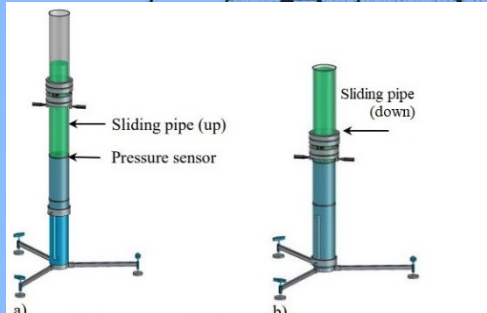


Figure 34. Sliper set-up a) before and b) after downwards movement.

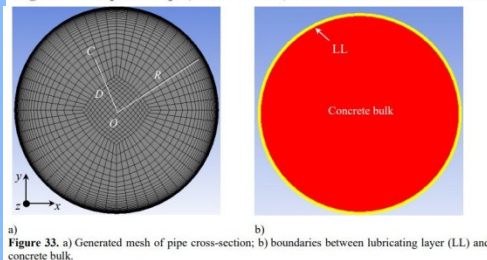
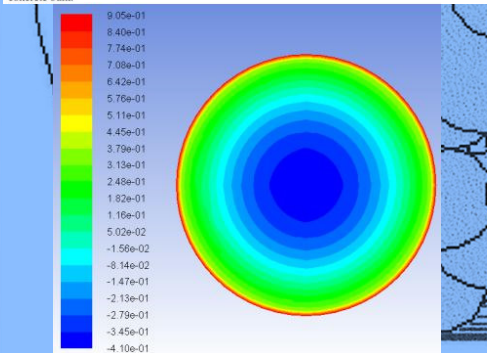


Figure 33. a) Generated mesh of pipe cross-section; b) boundaries between lubricating layer (LL) and concrete bulk.

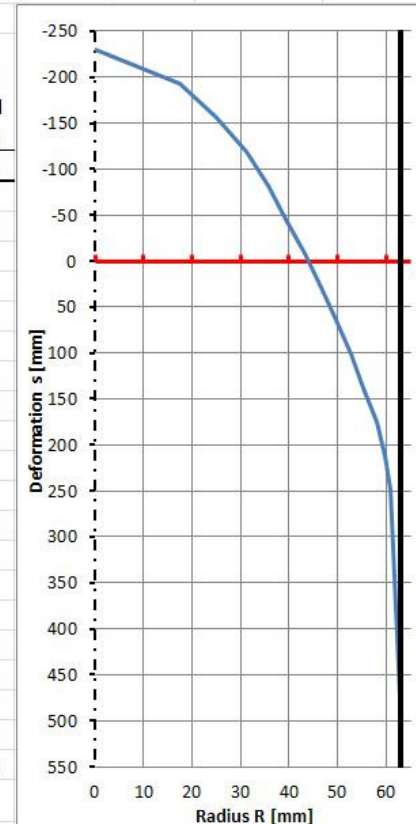


Integration of num. Simulation for Sliper to SECRIERU:

$Q=40\text{m}^3/\text{h}$ means $v_m=0,891\text{ m/s}$ or $t_F=0,56\text{ s}$ for $0,5\text{ m}$

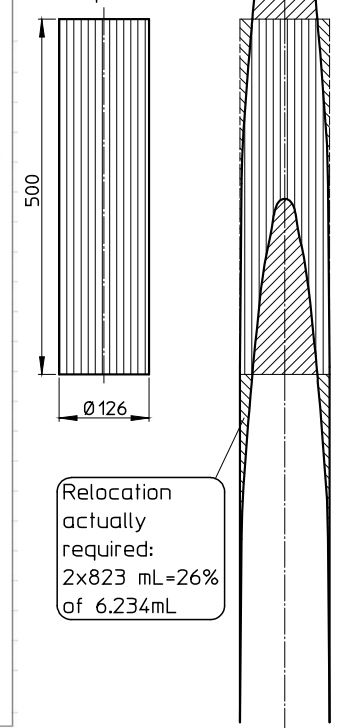
$M=1,112:1$ (Bild 35b)

i	$R_i \cdot M$	R_i	v_i	s_i	rel. dwell time
[-]	[mm]	[mm]	[m/s]	[mm]	[%]
0	0	0	-0,41	-230	68
1	19,5	17,4	-0,35	-193	71
2	28	25,0	-0,28	-156	75
3	34,8	31,1	-0,21	-119	80
4	40	35,7	-0,15	-82	85
5	44	39,3	-0,08	-46	90
6	48,5	43,3	-0,02	-9	97
7	52	46,5	0,05	28	104
8	55,5	49,6	0,12	65	113
9	59	52,7	0,18	102	123
10	62	55,4	0,25	139	135
11	65	58,1	0,31	175	150
12	67	59,9	0,38	212	169
13	68	60,8	0,45	249	193
14			0,51	286	226
15			0,58	323	271
16	not measurable		0,64	360	338
17			0,71	396	452
18			0,77	433	679
19			0,84	470	1369
20	70,5	63,0	0,91	507	∞



Deformation according to numerical Simulation

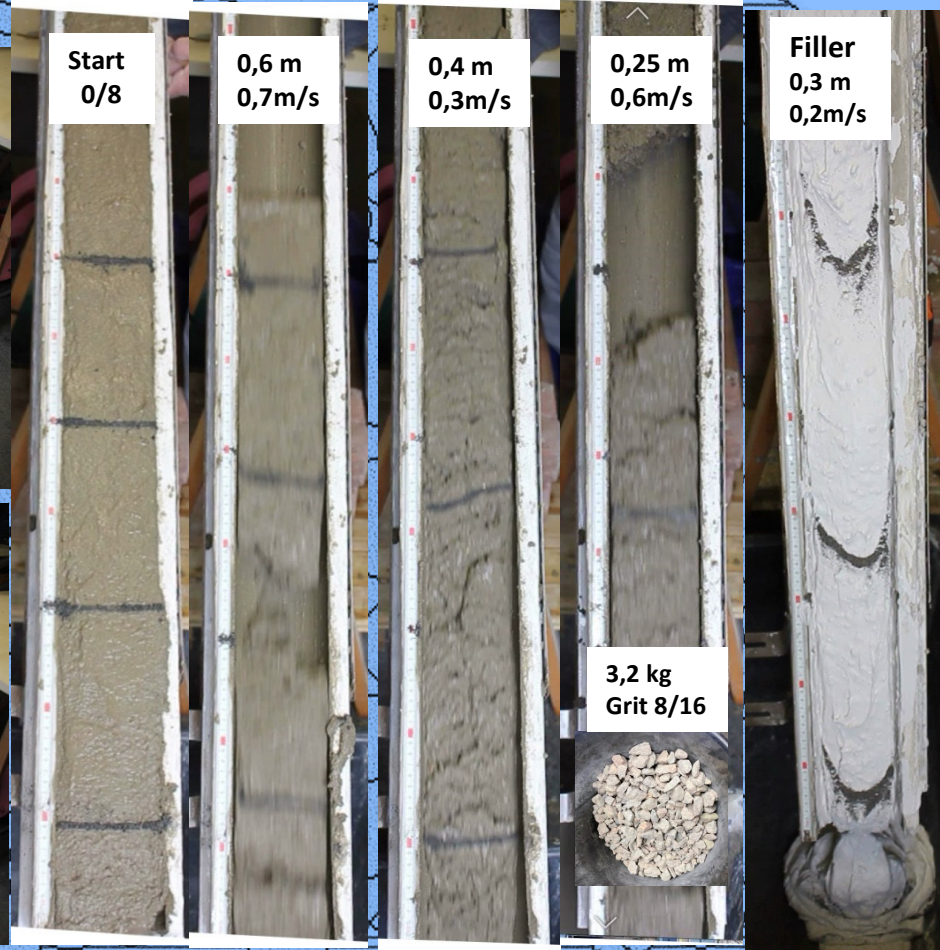
Starting in Sliper



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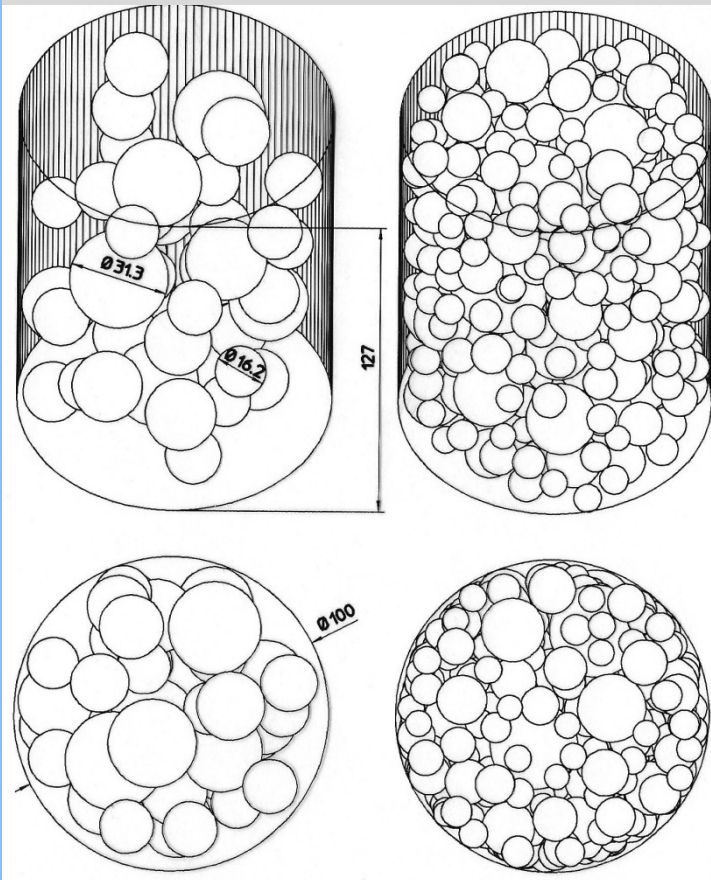
Tests with halfpipe:



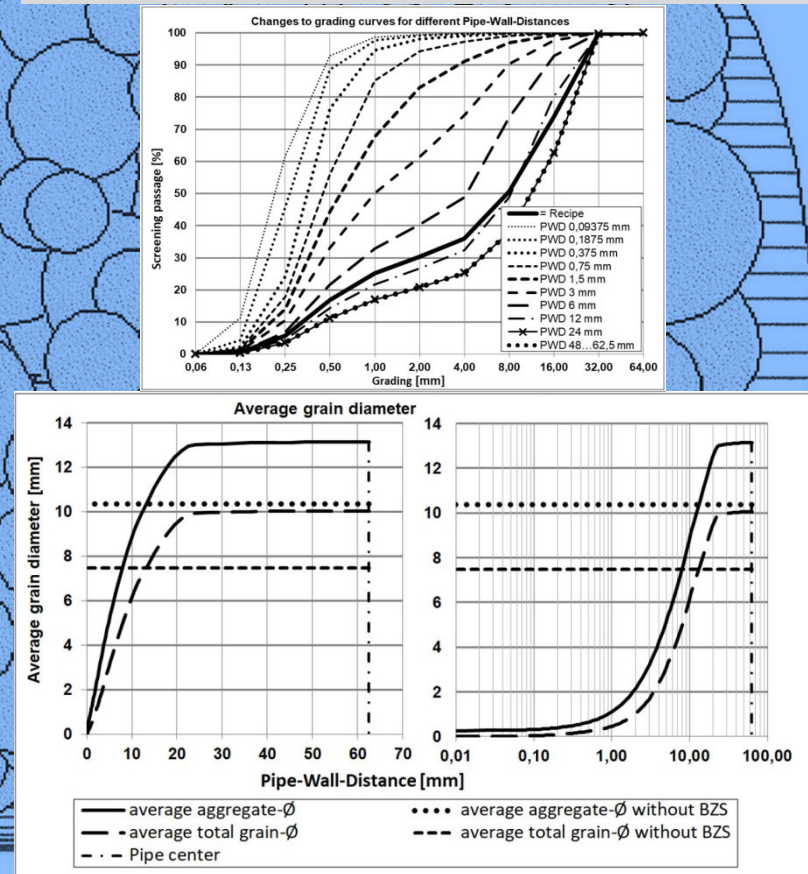
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Grain distribution 16/32 and 8/16 in pipe DN 100 (1 Litre) (to BERGEMANN 1995/2011, Putzmeister, Betontechnologie für Betonpumpen):



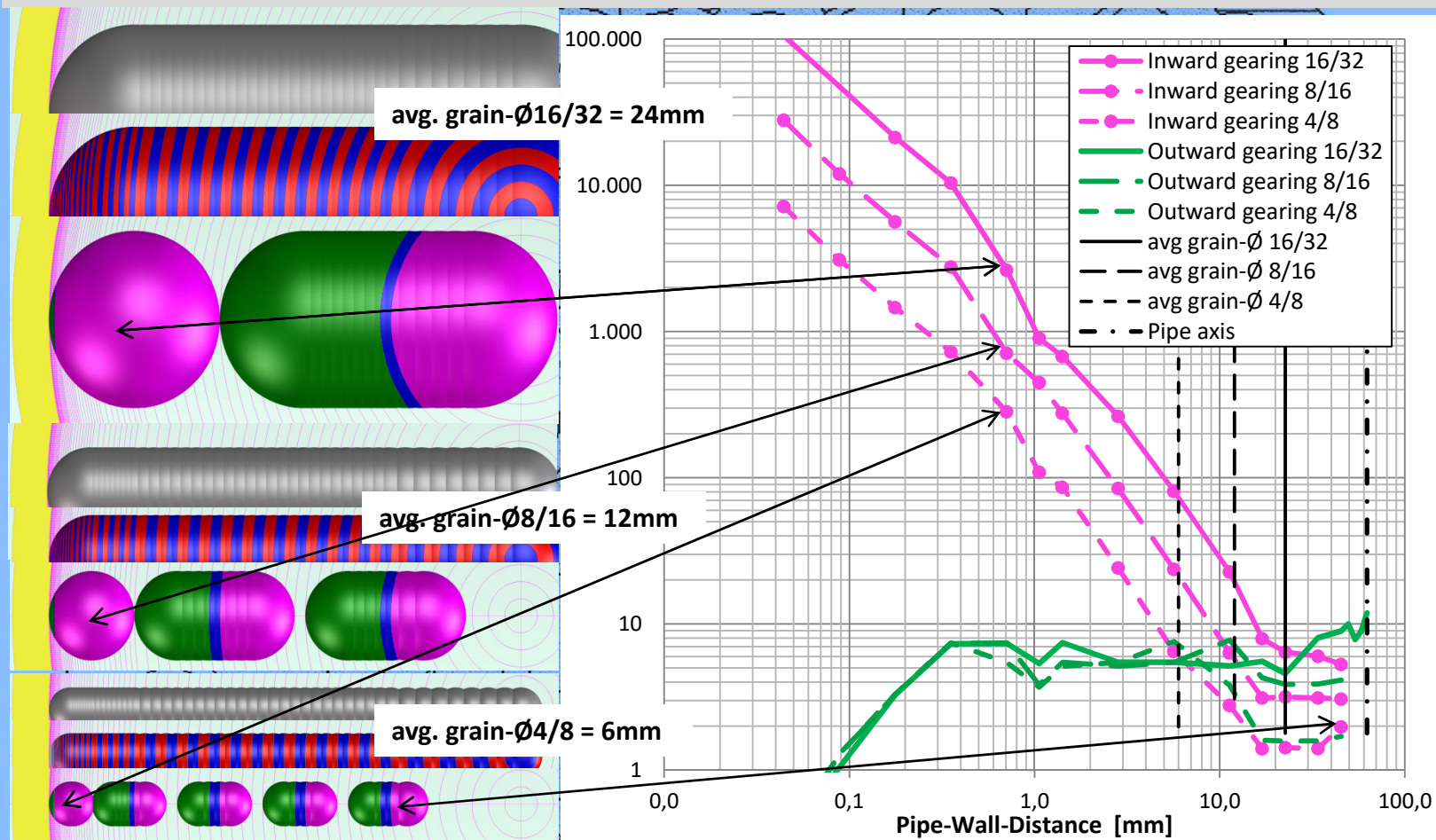
Calculation of Boundary zone Segregation depending on the pipe wall distance
(Conference Lecture 2022):



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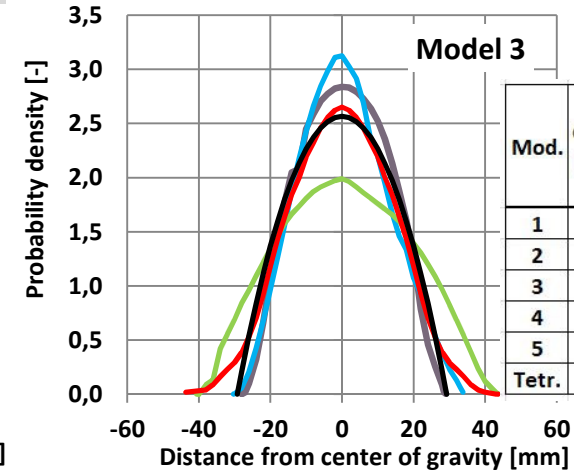
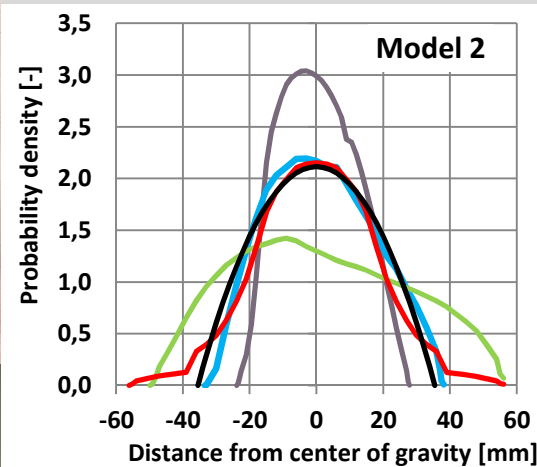
3D CAD models 16/32, 8/16, 4/8 for determination of the "layer gearing" in pipe DN125



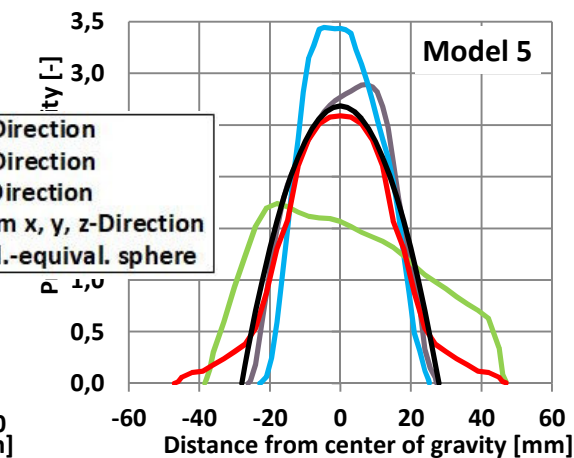
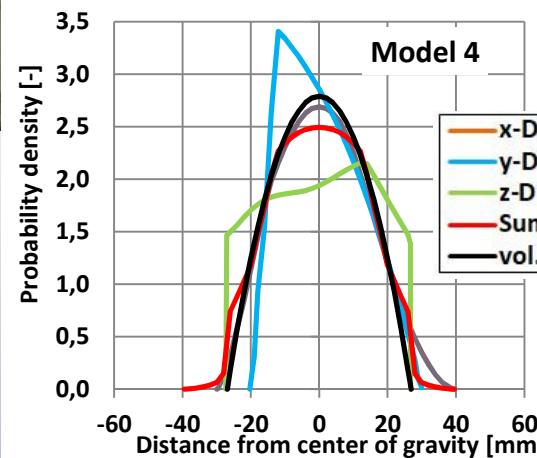
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The irregular shapes of the individual grains can be statistically regarded as spherical probability clouds!



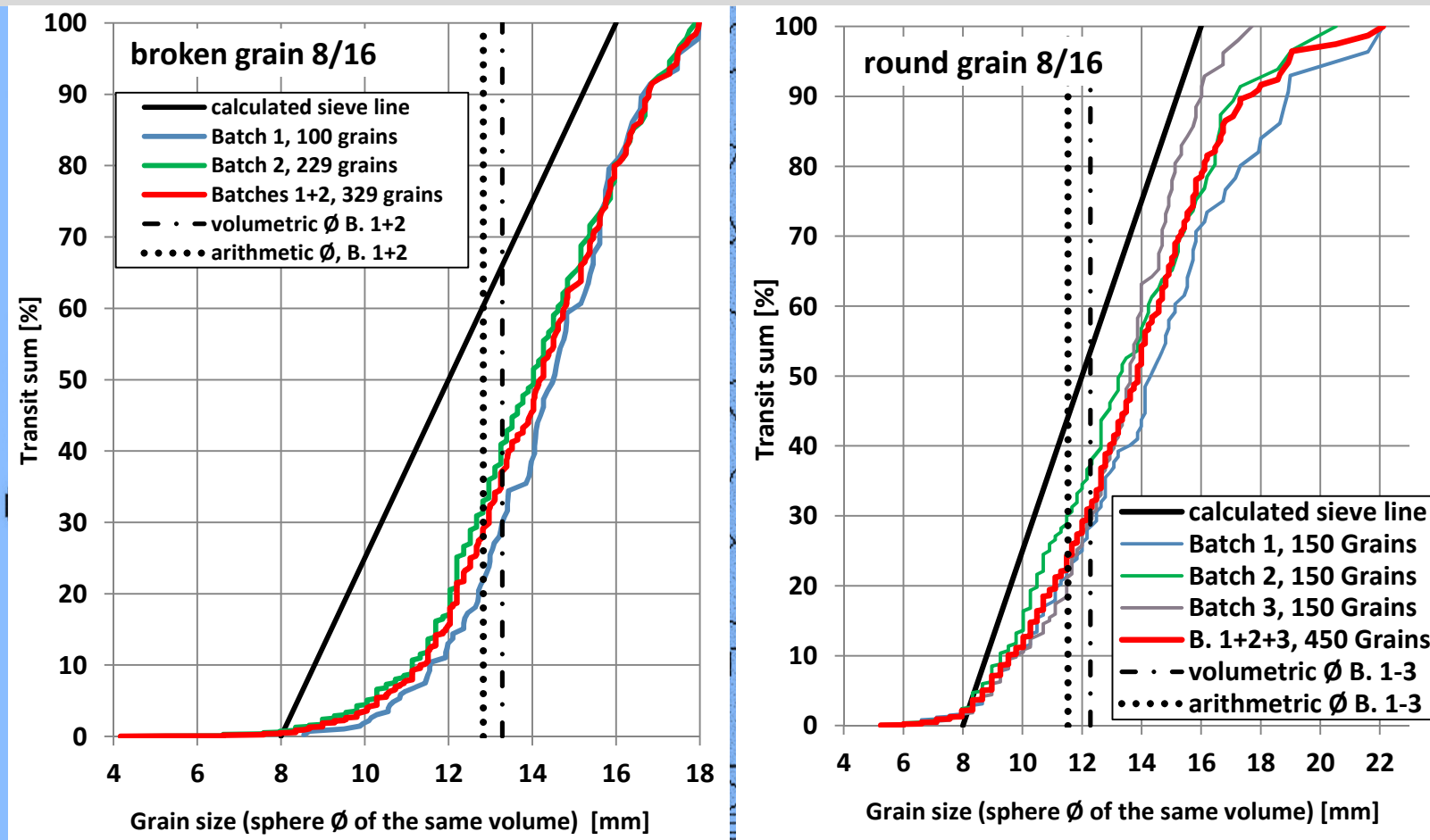
Mod.	d_{km_vol} [mm]	Screen mesh size [mm]
1	72	63
2	71	62
3	55	58
4	54	50
5	56	44
Tetr.	30	36



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Comparison of sieve curve and actual grain size distribution within a fraction:



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Misinterpretations of dynamic forces and effects in concrete pipe conveying :

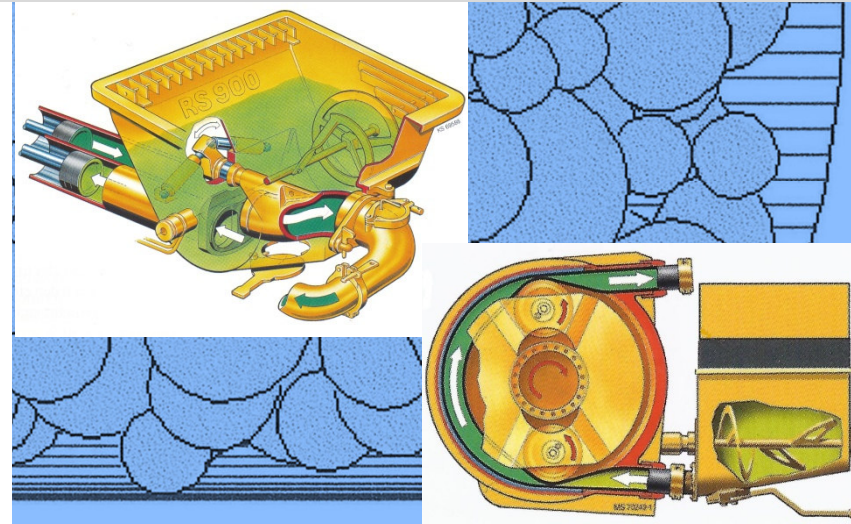
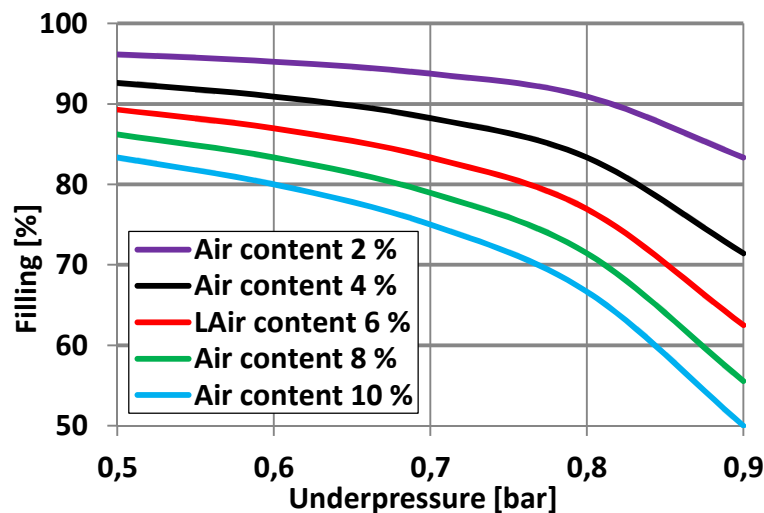
Elbow: For 1g centrifugal acceleration

DN	R _{Elbow}	v	Q
[mm]	[mm]	[m/s]	[m³/h]
100	142,5	1,2	33
	181	1,3	38
	252,4	1,6	44
125	181	1,3	59
	312,5	1,8	77

According to KAPLAN, de LARRARD and SEDRAN (2005), coarse aggregate grains move through the pump mortar when stopping the concrete flow after each pump stroke because of their inertia and thus possibly cause blockage!

This is wrong, because the pump mortar has the same density and thus the same inertia as the aggregate grains!

Influence of air inclusions when suction of concrete in the concrete pump :



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Offer for advice on further investigations :

- Transfer of all results for the calculation of the “Boundary Zone Segregation” of fresh concrete
- Transfer of all results of the preliminary investigations with the halfpipe demonstrator and, if necessary, construction of a "correct" test facility, e.g. for measuring the actual speed profiles and creating test programs
- Extension of investigations to elbows
- Studies on statistical grain geometry:
 - Definition of the most suitable average grain $\emptyset$,
 - Measurement of irregular grain shapes

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dispersed mineral building materials and solutions for the
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Thank you for your attention.