Impact of some parameters in cement production on rheological properties of cement paste

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Rheological Investigations

Definition:

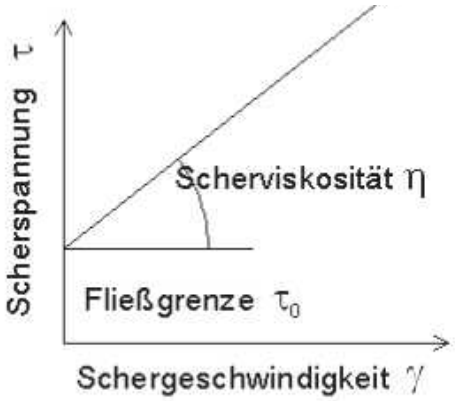
- is the science of deformation and flow character of matter.

Rheology in cement based systems is determined by:

- Plastic viscosity
  - A property of fluids in movement
  - Is mainly determined by dynamic friction between moving elements
- Yield stress
  - A property of the fluid at shear rate zero, mainly influenced by attractions and physical networking of two or more component
  - Variations of the first hydration products of cement affect these forces

Bingham

$$\tau = \eta \times \gamma + \tau_0$$



State of the art relating to cement paste and rheological investigations

- Depending on the clinker and sulphate retarding the composition of the pore solution changes → change of rheological behavior (the dispersing force of super plastizier degrade by the sulfate ion)
- Structure of plasticizer → change the rheological performance
- Cement types with blast furnace slag or limestone shows in general better workability → need lower concentration of plasticizer
- The choice of the plasticizer for the best performance (fluidity and stability) is essential

Instrument for Investigations on cement

Rheometer is an appropriate instrument (tool) for

- Characterization or description of the flowability,
- Determining the yield stress values
- Viscosity of the cement pastes

Viskomat NT

useful for

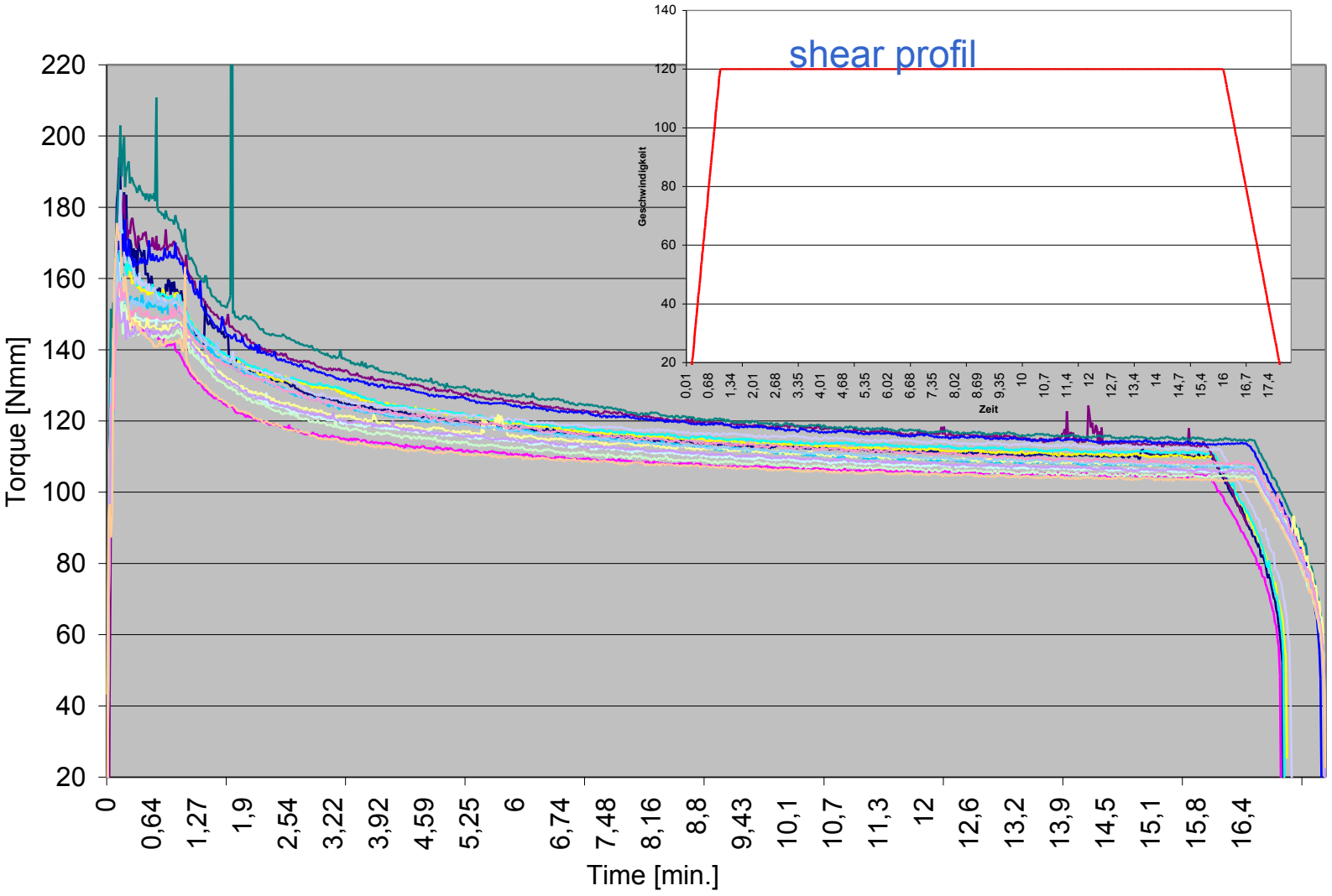
- Comparison of the effect of different plasticizers such as Polycarboxylate ether-based (PCE) superplasticizer with different structures
- Determination of the most effective concentration of superplasticizer
- Determination of the influence of various factors on the rheological characteristics such as temperature (winter/summer) or variation in cement production

Pilot tests

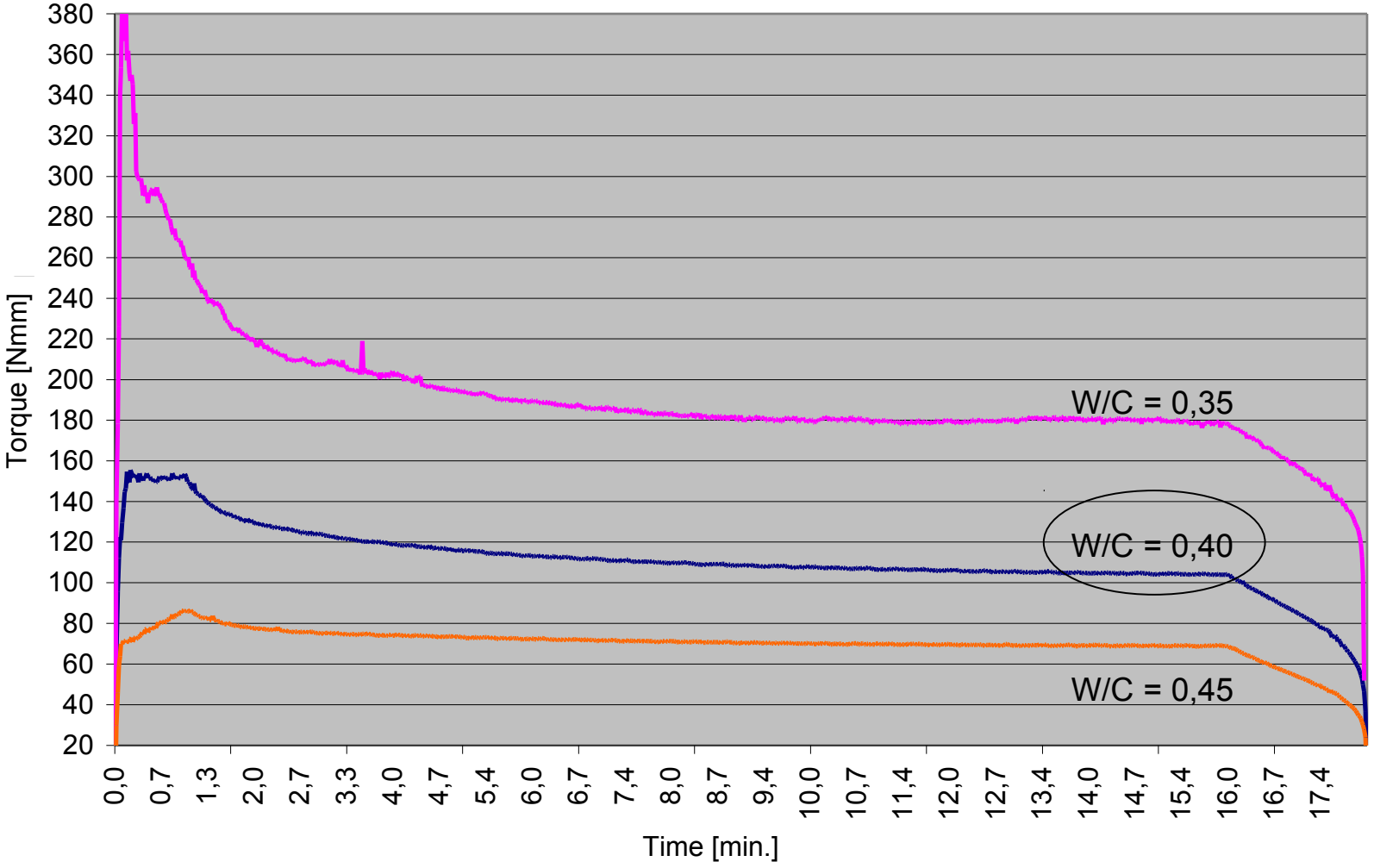
Objectives of the pilot tests:

- Which factors are critical for measurements with Viskomat NT?
- How is the repeatability of measurements?
- What is the appropriate measuring profile → constant shear stress, step load
- Sample preparation
  - Mixing tool
  - Mixing time
  - W/C ratio
- Storage of materials → in a room with constant temperature and air humidity

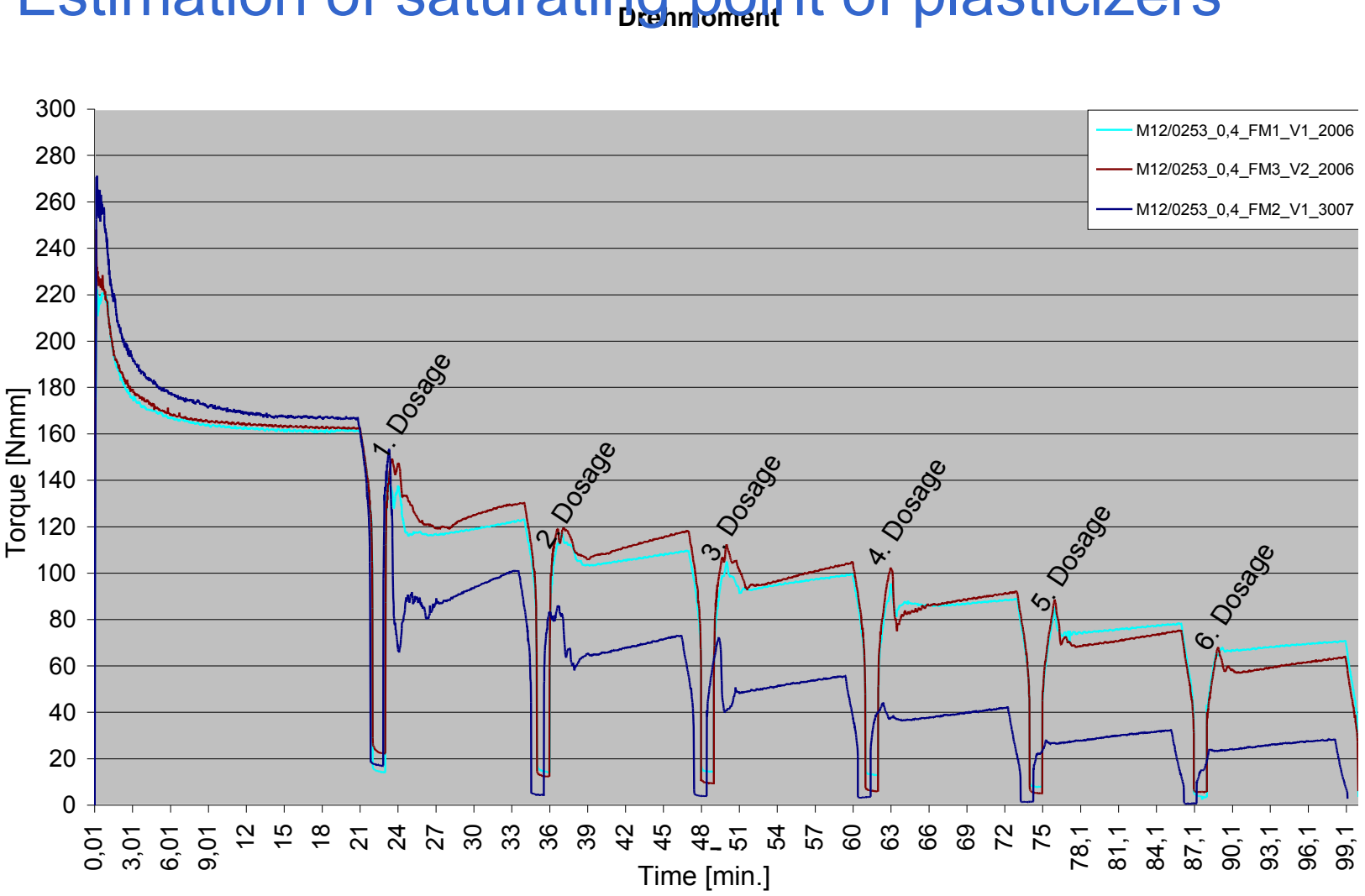
Flow diagrams of pilot tests



Variation in W/C ratio



Estimation of saturating point of plasticizers



Summary of results of pilot tests

Variation of parameter				
Type of blender	**Mortar blender**	Household blender		
Mixing time	**90 s**	120 s	150 s	180 s
W/C ratio	0,35	**0,4**	0,45	
Measuring time	**20 min**	45 min	60 min	
Shear profile		Ramp		
Repeatability		**± 3,2%**		

Setting the parameters of the experiments and estimating the repeatability before starting the comparative investigations on Viskomat NT

Investigated parameters of cement paste – comperative experiments

All investigations run with cement type CEM I 42,5 R

- Influence of fineness → in cement production
- Influence of sulfate retarding agent → in cement production
  - dihydrate / hemihydrates / anhydrite
- Influence of temperature (winter - summer) → construction praxis
- Influence of chemical structure of the plasticizer → in the market available PCE variations e.g. total chain length, side-chain length, charge density

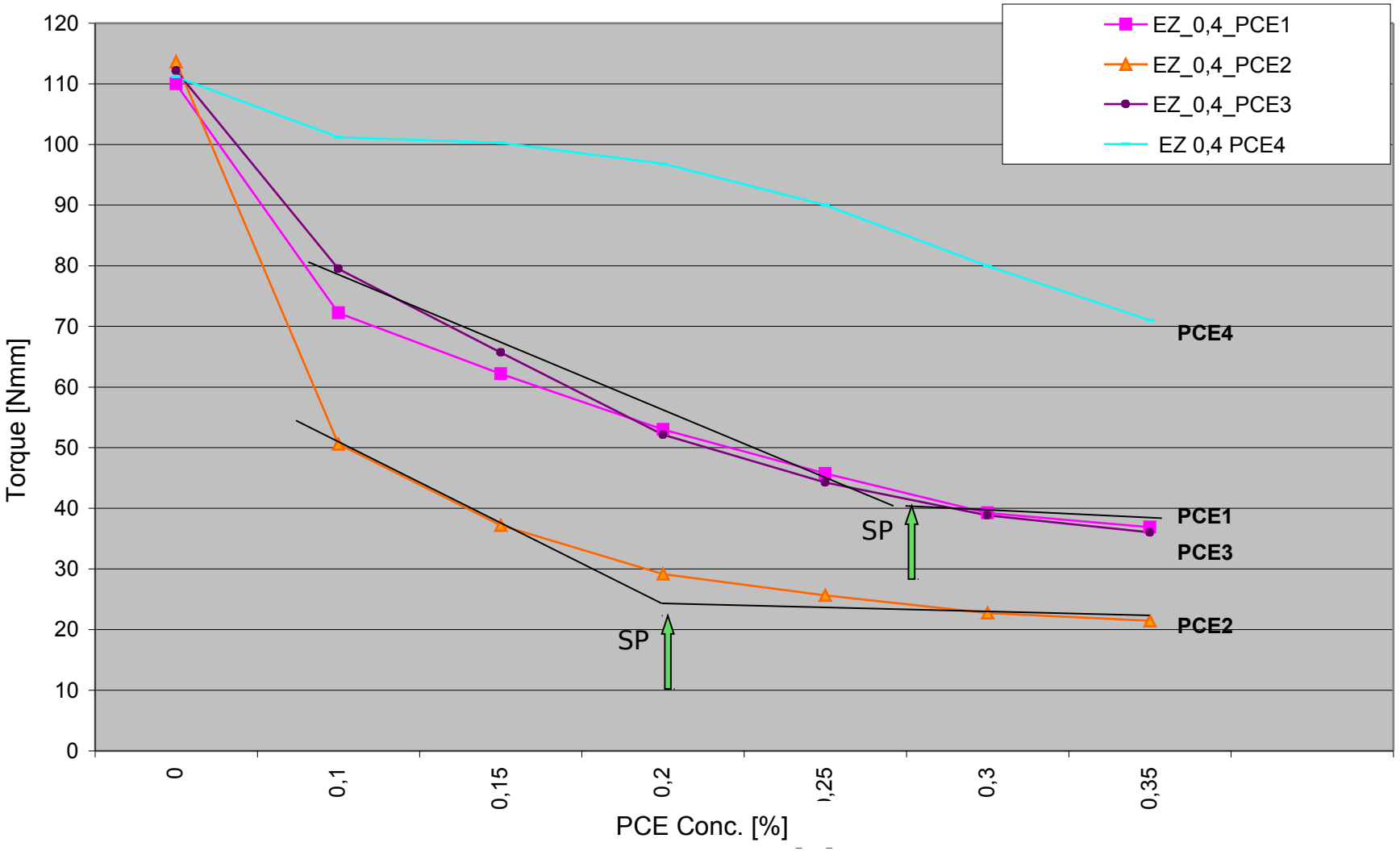
Different PCE-Molecule structures

Following structures from one producer were chosen for these investigations:

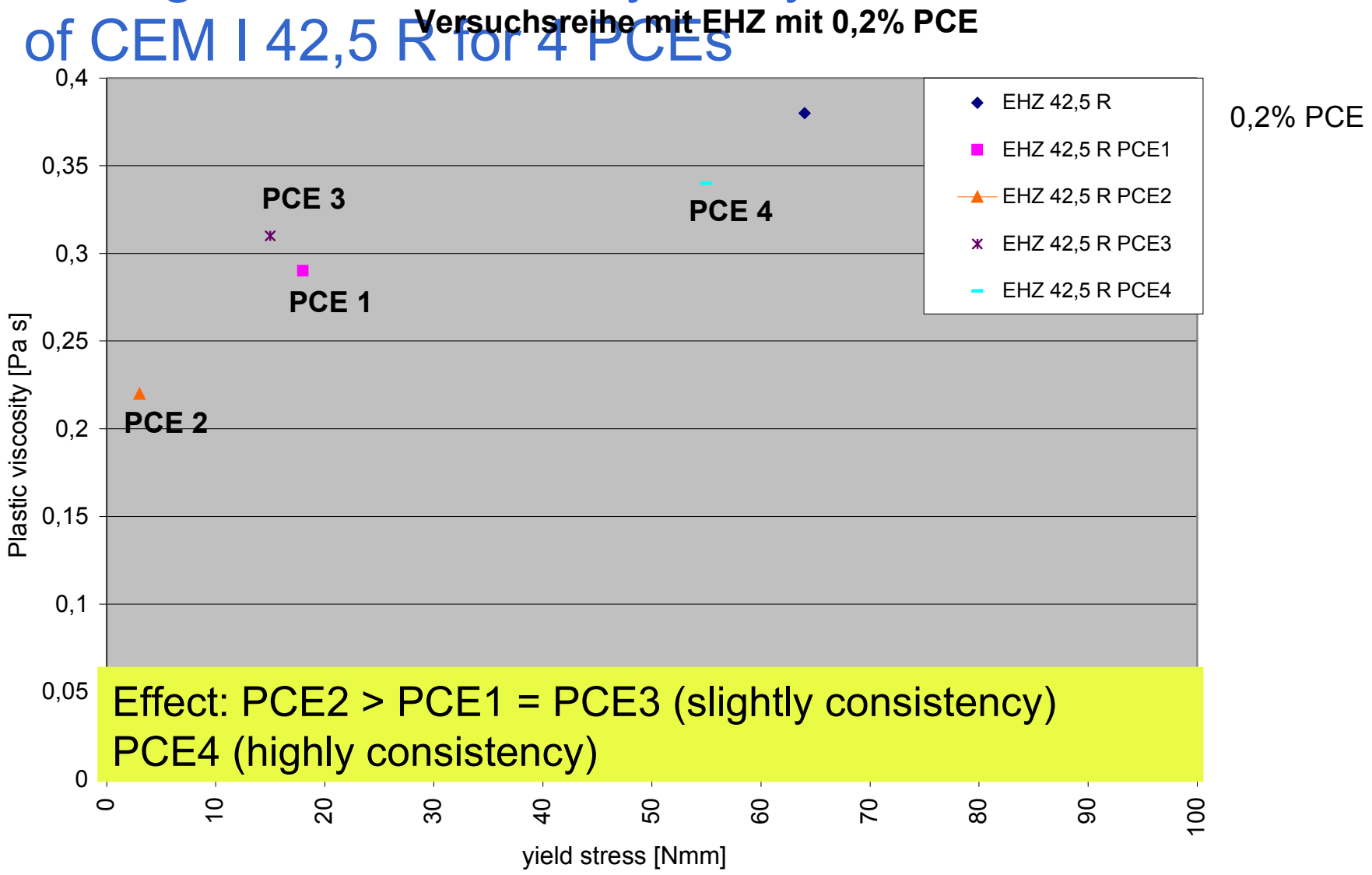
- PCE-1: short side chain, high charge density
- PCE-2: short side chain, low charge density
- PCE-3: long side chain, low charge density
- PCE-4: long side chain, active functional group

Concentration of all sample solutions was 30 %

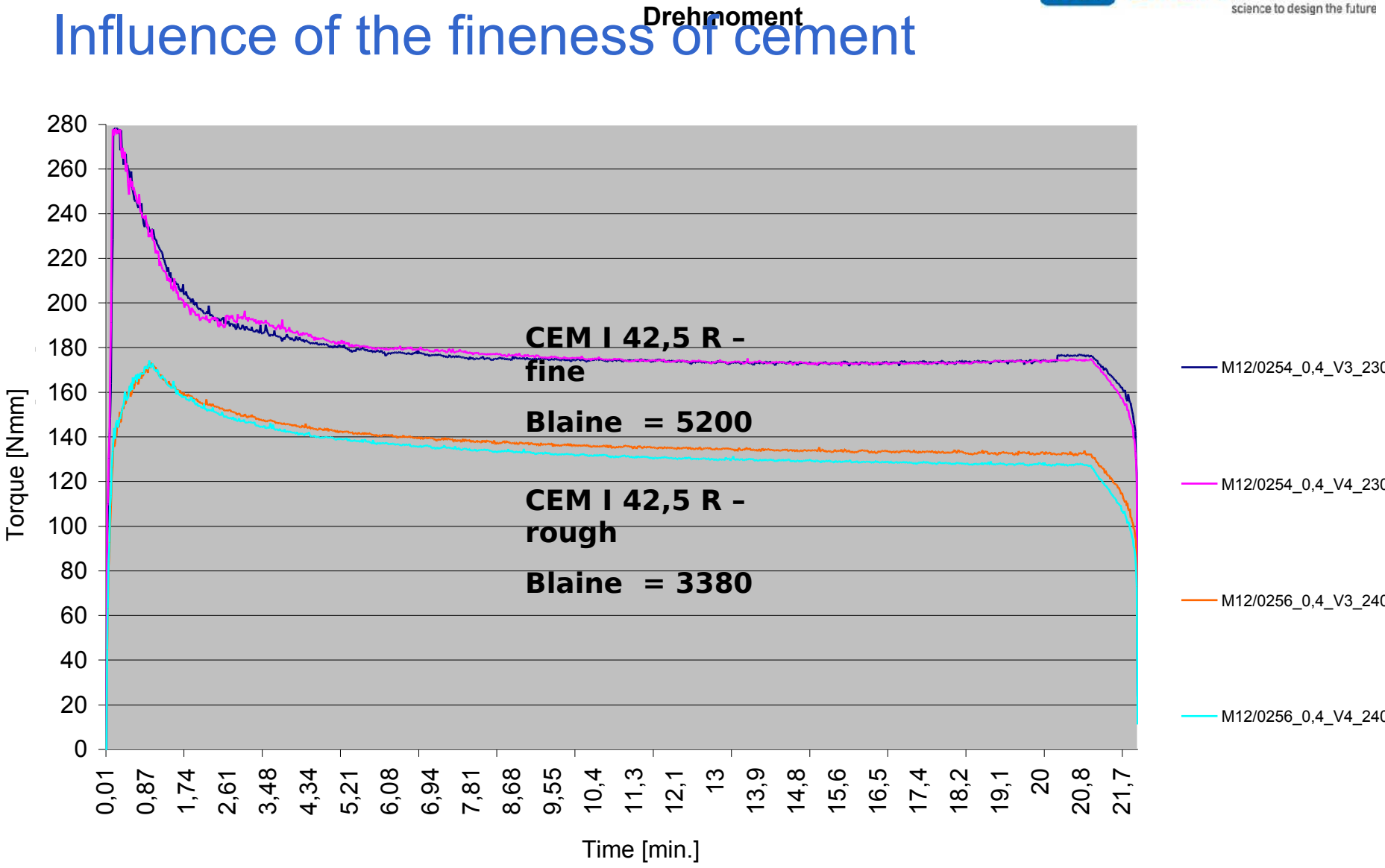
Saturating point of 4 PCEs for CEM I 42.5 R



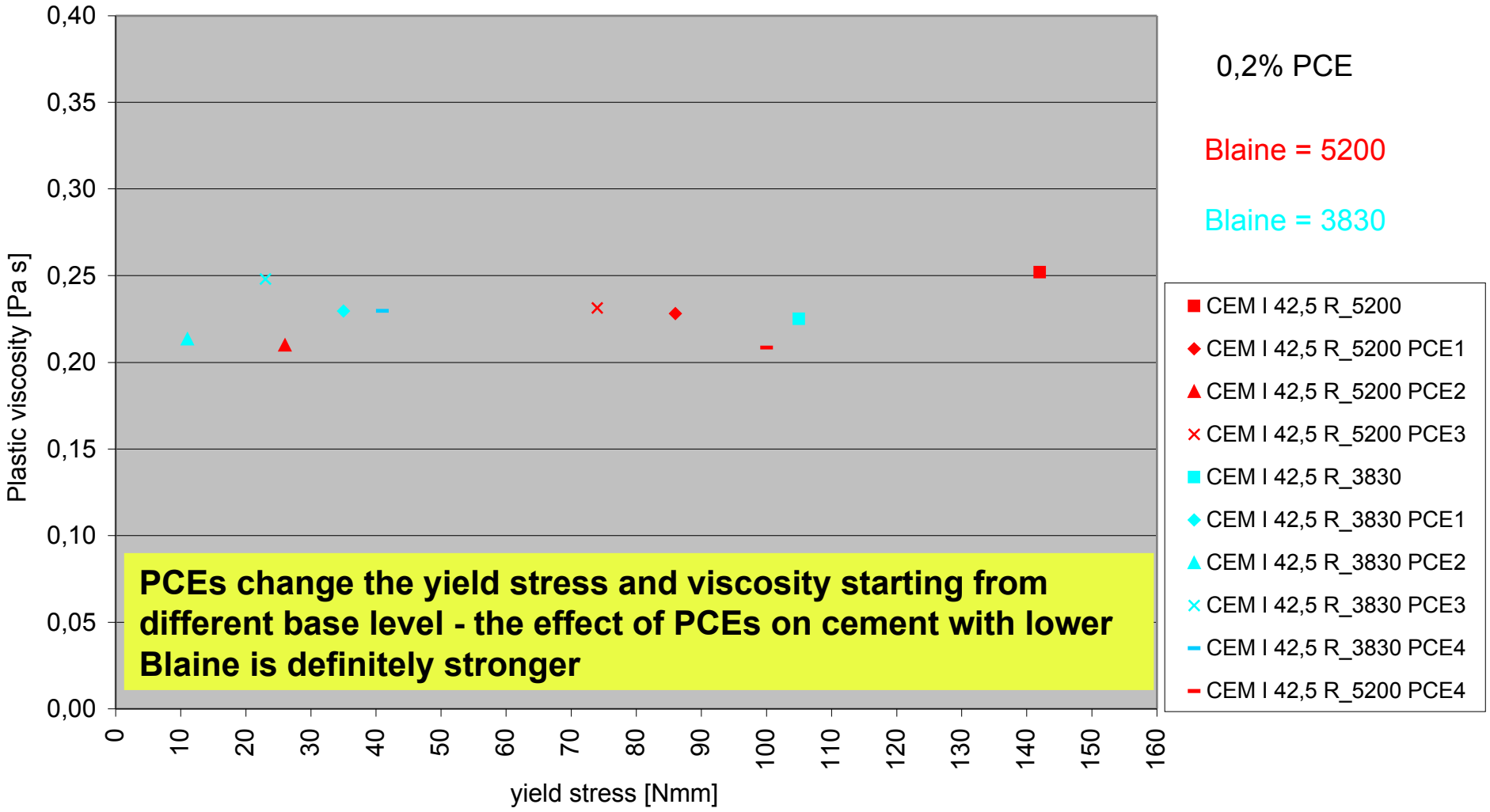
Changes of the viscosity and yield stress of CEM I 42,5 R for 4 PCEs



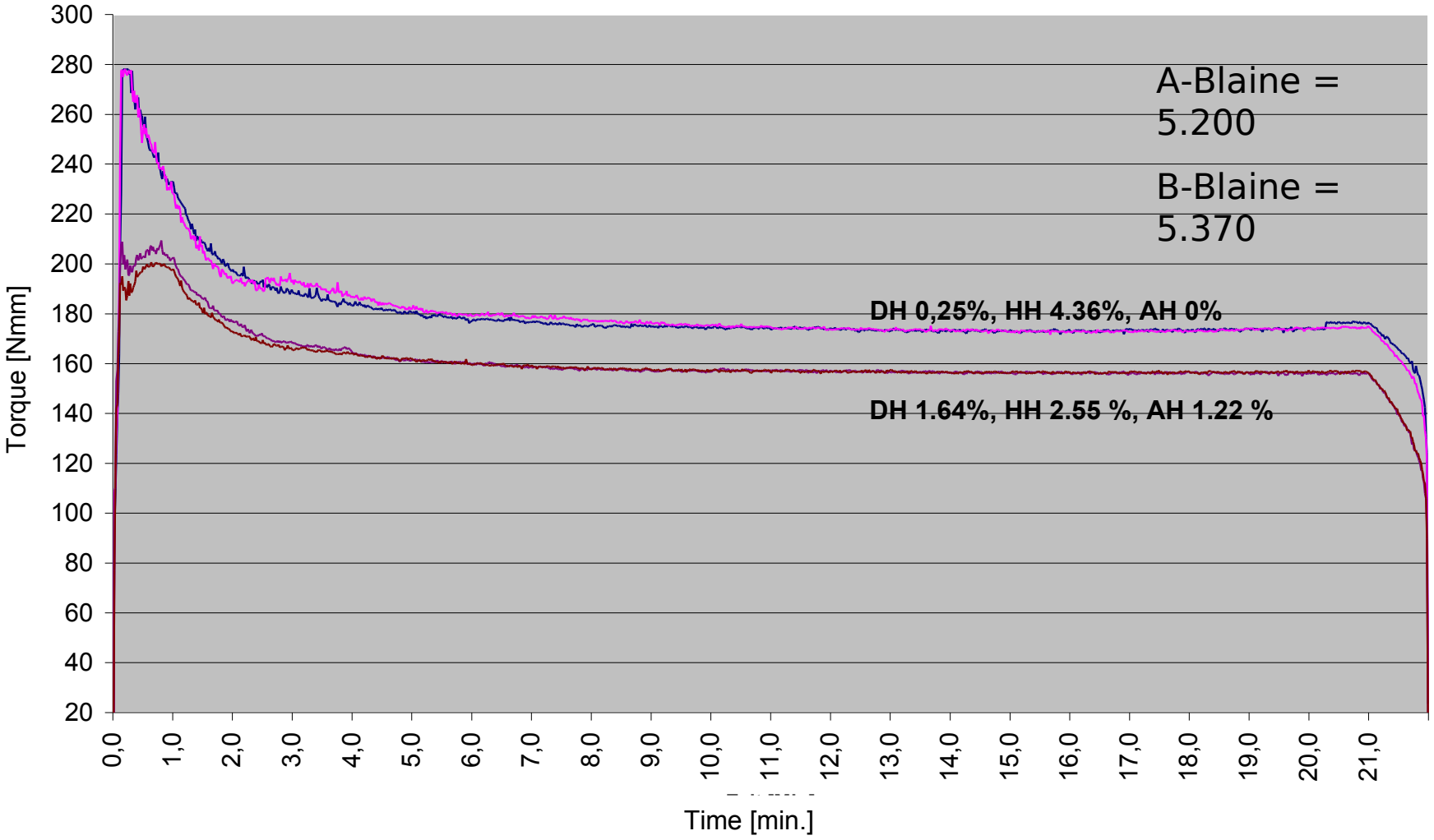
Influence of the fineness of cement



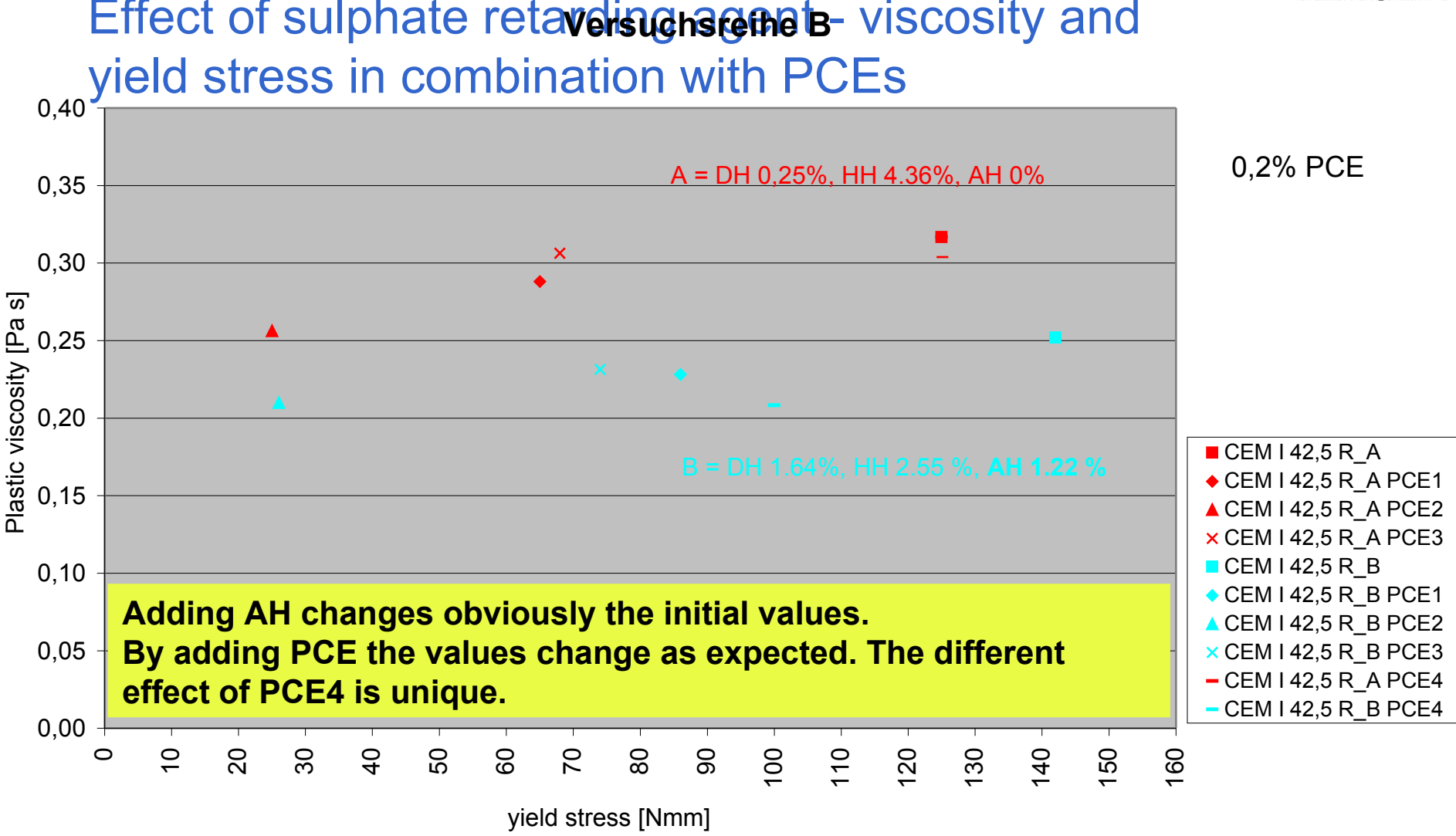
Influence of the fineness of cement – Viscosity and yield stress in combination with 4 different PCE



Effect of sulphate retarding agent

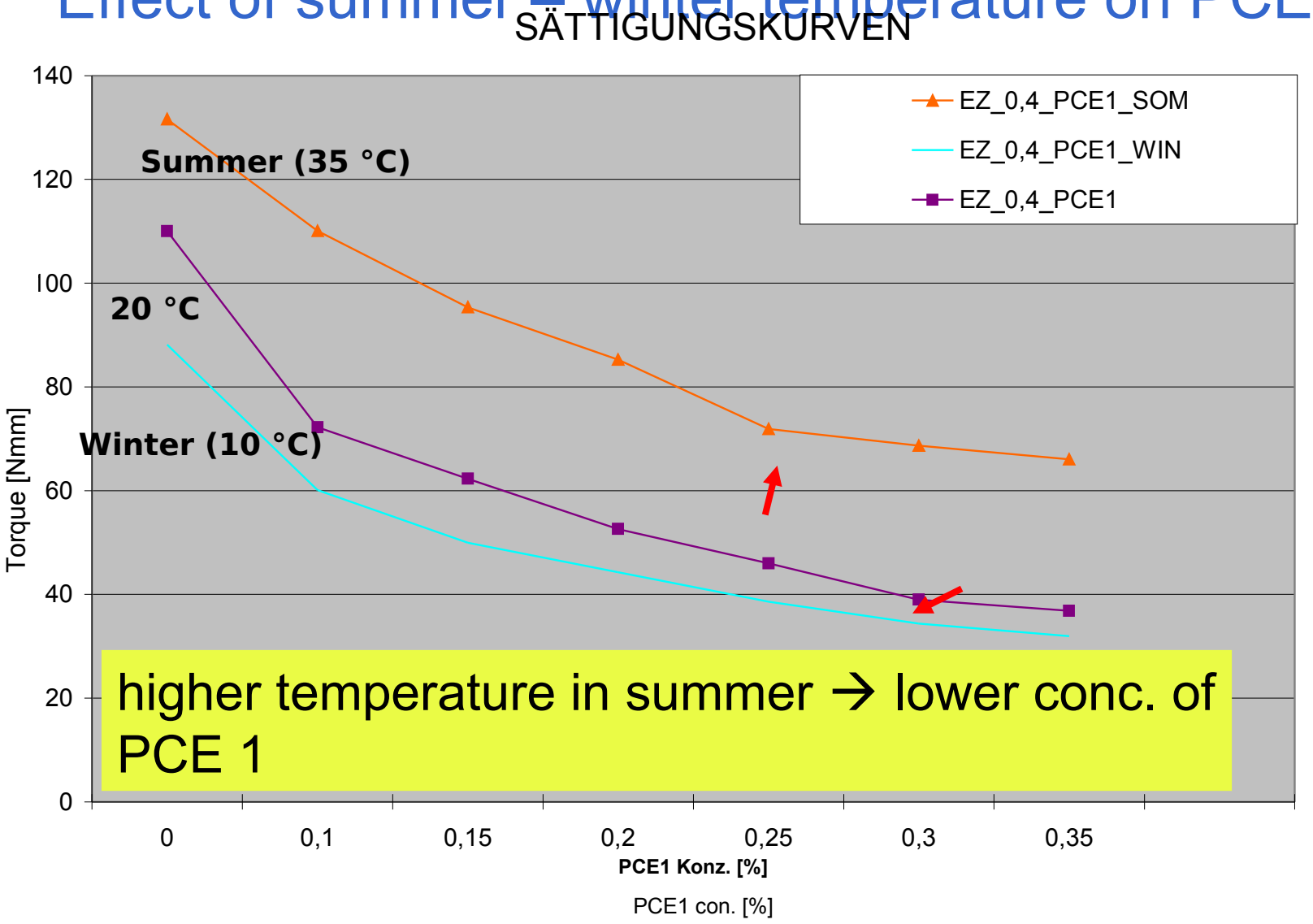


Effect of sulphate retarding agent - viscosity and yield stress in combination with PCEs



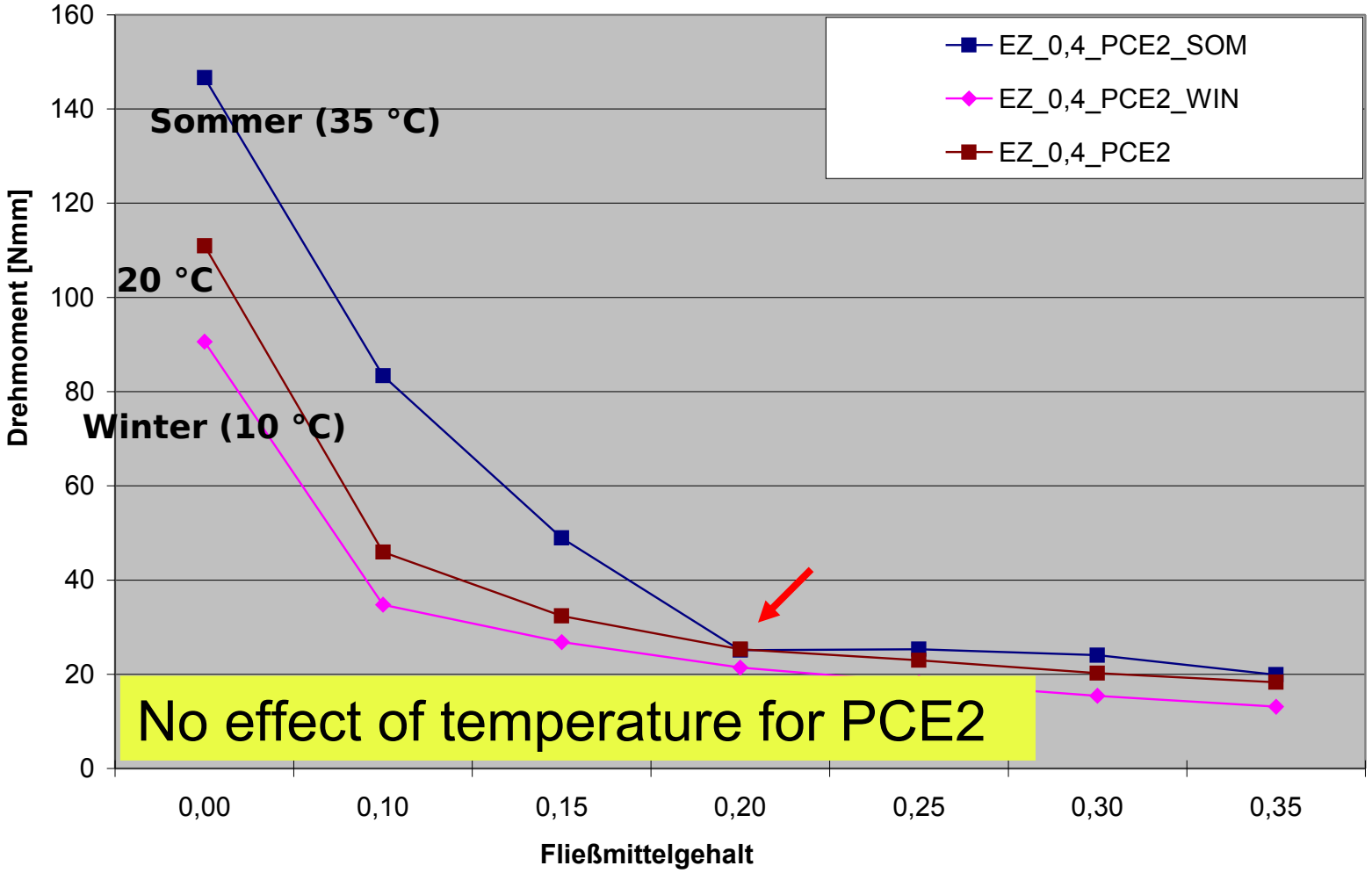
Adding AH changes obviously the initial values.
By adding PCE the values change as expected. The different effect of PCE4 is unique.

Effect of summer – winter temperature on PCE1



higher temperature in summer → lower conc. of PCE 1

Effect of summer – winter temperature on PCE2



Conclusions

Manufacturer's expectations to current test results:

- PCE-1: short side chain, high charge density. In the mortar/concrete: moderate (good) fluidizer, good consistency, slightly retardant → could be confirmed
- PCE-2: short side chain, low charge density. In the mortar/concrete: good (very good) fluidizer, moderate (lightly) consistency, slightly retardant → could be confirmed to some extent
- PCE-3: long side chain, low charge density. In the mortar/concrete: very good fluidizer (good) , slightly consistency, no retardant → could be confirmed to some extent (similar to PCE1)
- PCE-4: long side chain, active functional group. In the mortar/concrete: slight fluidizer, very good consistency → could be confirmed

Summary of Rheological investigations on cement paste

In addition to the well known factors such as limestone and blastfurnance slags content, fineness, sulphate retarding agent and temperature affect the efficiencies of the PCE-Superplasticizers.

Rheological investigations are necessary for selection of plasticizer for the best performance (fluidity and stability)

In principle the effect of two or more factors of cement paste can be estimated by these investigations → the combined effect

Prospects: → transfer of the results on cement paste to mortar and concrete

Thank you for your kind attention!

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