



## **25. Tagung "Rheologische Messungen an Baustoffen"**

**02. März 2016, OTH Regensburg, Germany**

***Admixtures in Self-Compacting Concrete***

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# SELF-COMPACTING CONCRETE

***Self-compacting concrete (SCC) is a concrete which in the fresh state is able to flow and to consolidate under its own weight***



***Flowability***

***Ability to consolidate  
(self-air release)***

***Mixture stability***

***Yield value***

***Viscosity***





# ADMIXTURES FOR CONCRETE

**Admixtures are used to create and modify properties of fresh and hardened concrete, their usage is more complicated in SCC.**

- **rheological admixtures:** high range water reducing/superplasticizing admixtures, water reducing/plasticizing admixtures, viscosity modifying admixture, water retaining admixture
- **other admixtures:** air entraining, set retarding and accelerating, hardening accelerating, water resisting admixture, antifreezing, shrinkage reducing, expansion producing, ASR inhibiting, corrosion inhibiting, waterproofing, pigments, etc.

**Rheological effects of use admixtures in SCC under influence of various technological factors and how to control them.**



# **SUPERPLASTICIZERS**

***Superplasticizer should enable the required reduction of the amount of water in concrete and achieving and maintaining the required rheological properties of the mixture during the concreting process***

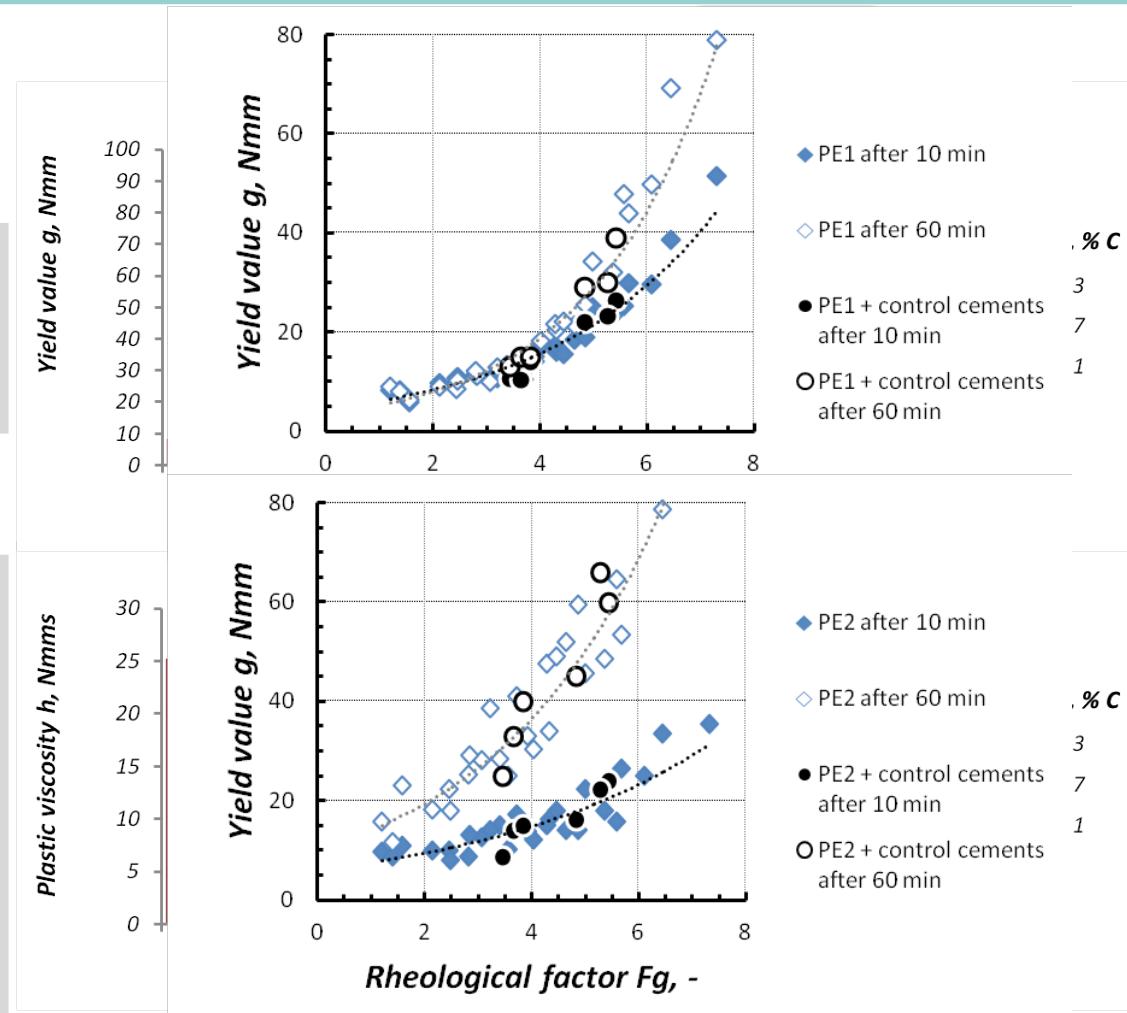
***Factors influencing effectiveness of superplasticizers:***

- *superplasticizer properties - chemical composition and polymer nature,*
- *type, chemical and mineral composition and specific surface area of cement;*
- *amount of superplasticizer added,*
- *time of adding the superplasticizer in relation to the time of mixing of cement and water;*
- *type and properties of mineral additives, in particular chemically active additives;*
- *mixture temperature;*
- *presence of other chemical admixtures.*

# EFFECTIVENESS OF SP - Sp and cement properties

Polycarboxylate ether-based SP are used for SCC

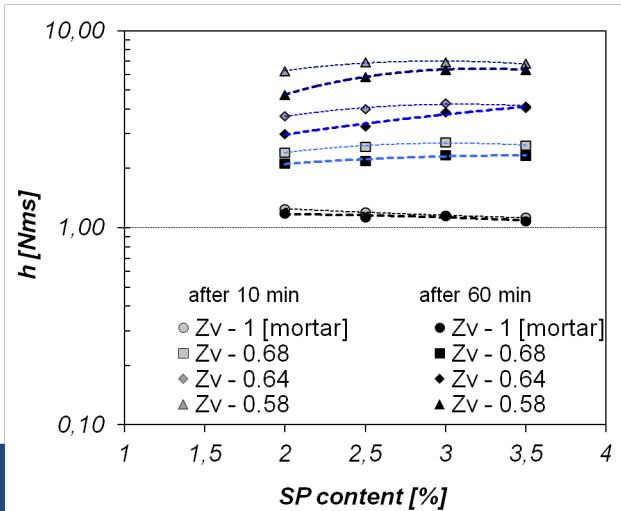
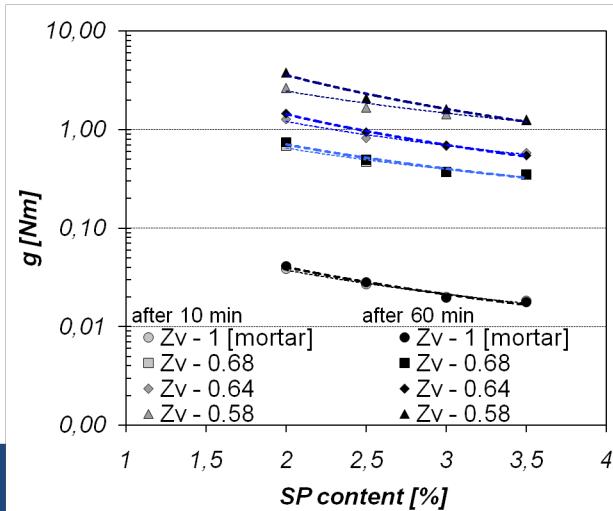
Increased content of  $C_3A$  and / or  $Na_2O_e$  in cement and increased surface area of the cement lowers the effectiveness of PC and PE superplasticizers



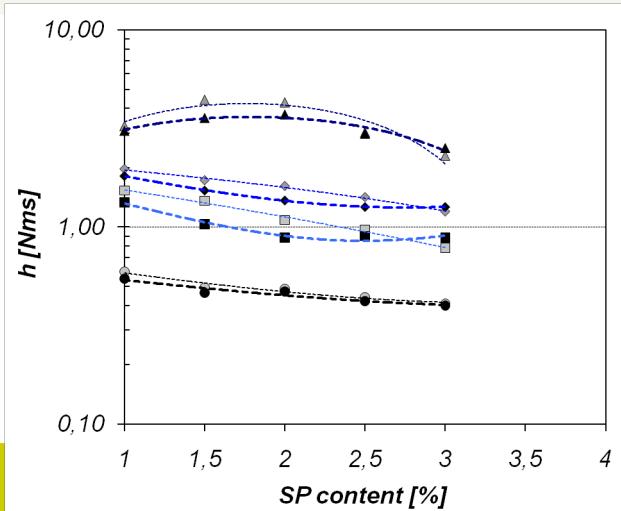
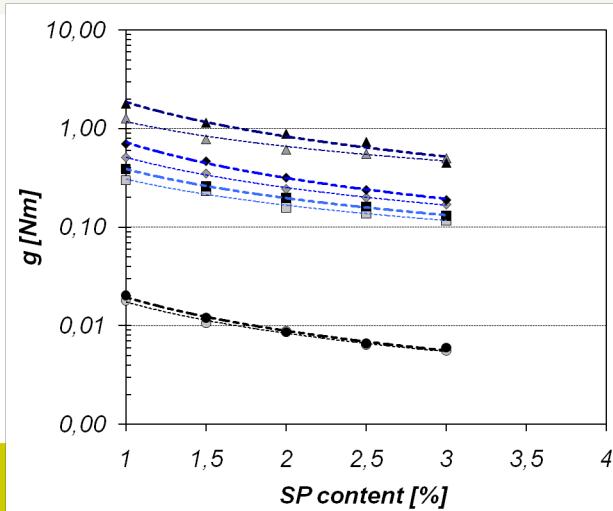
$$F_g = 3,13 \cdot 10^{-3} \cdot S_{wc} \cdot (0,25 \cdot C_3A + 2,33 \cdot Na_2O_e) \cdot \frac{g_{after\ 10\ min}}{g_{after\ 60\ min}}$$

# EFFECTIVENESS OF SP - Sp content and mortar volume

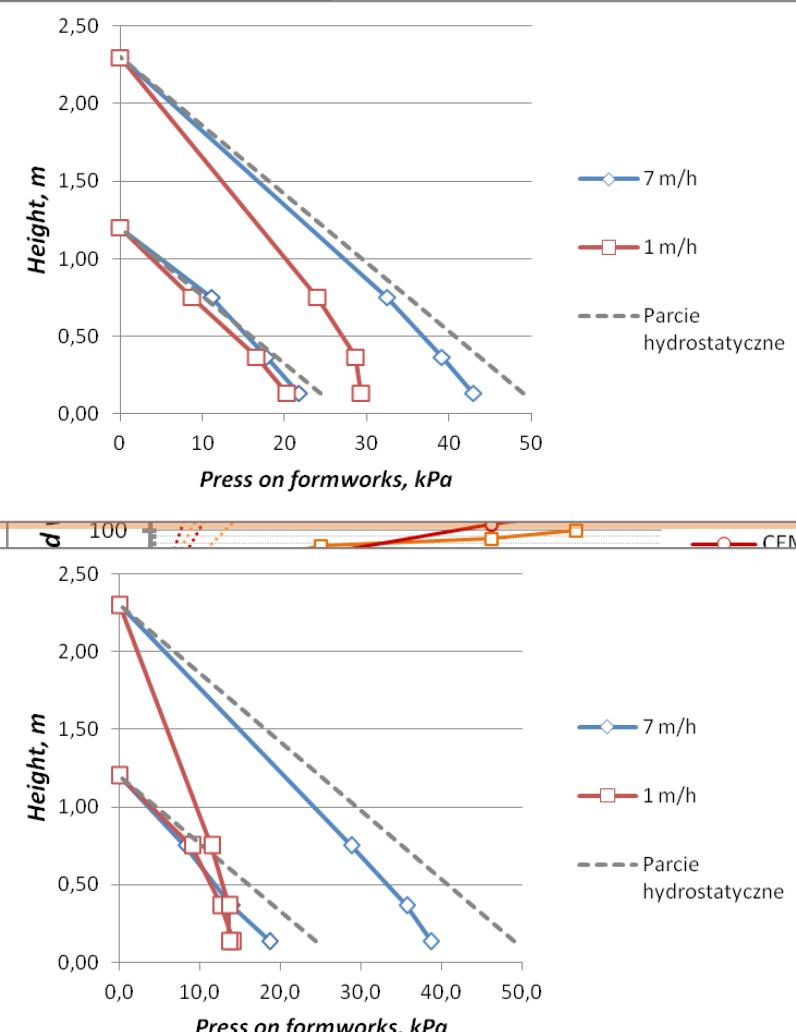
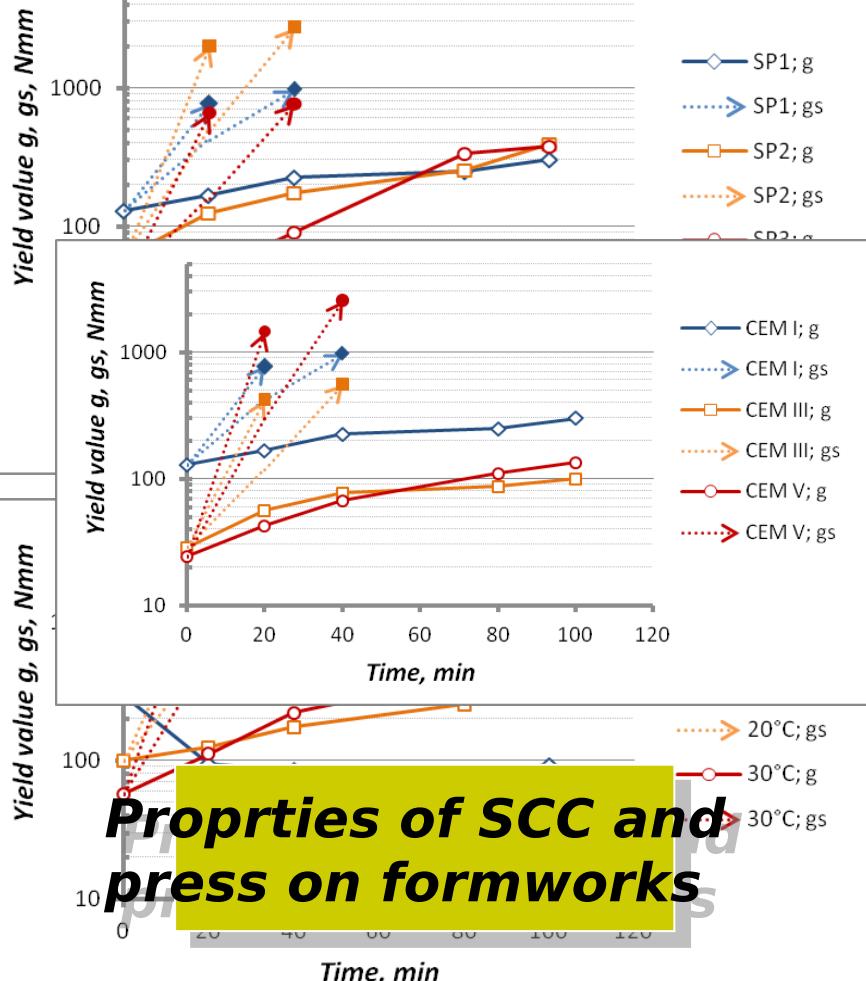
**w/c = 0,30**



**w/c = 0,35**

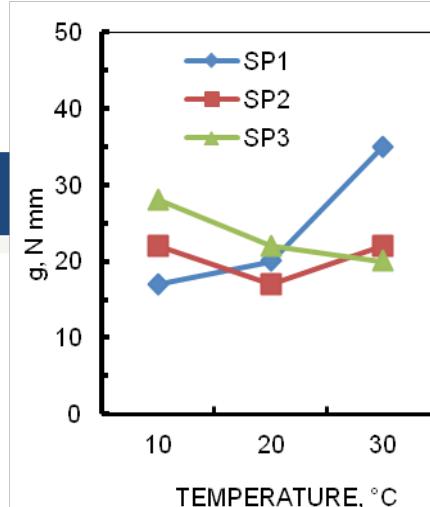


# EFFECTIVENESS OF SP - time effects

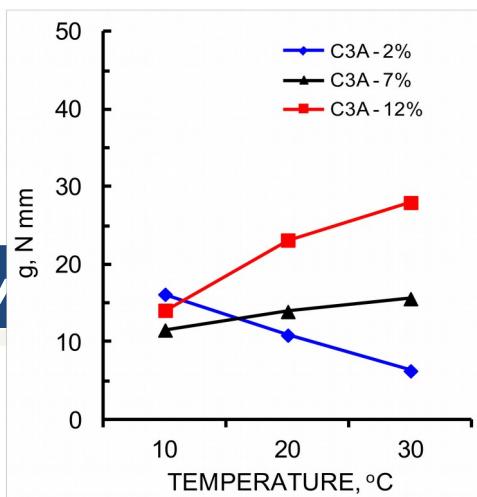


# EFFECTIVENESS OF SP - temperature

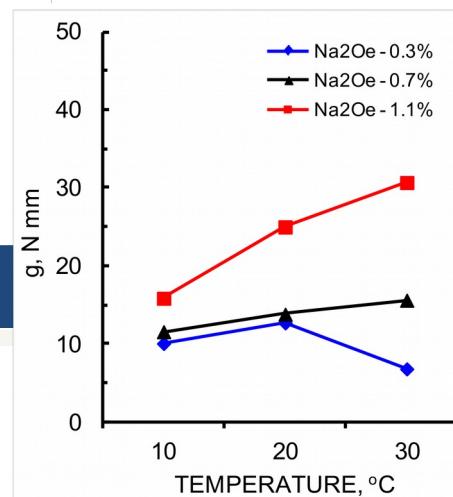
## SP type



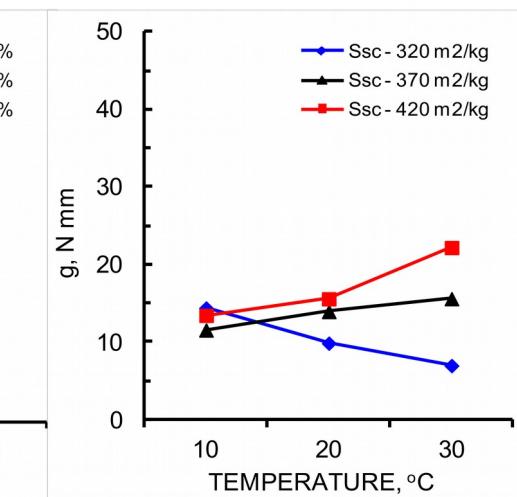
## Cement type



$C_3A$



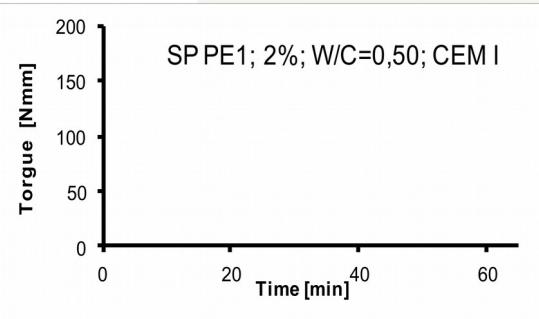
$Na_2Oeq$



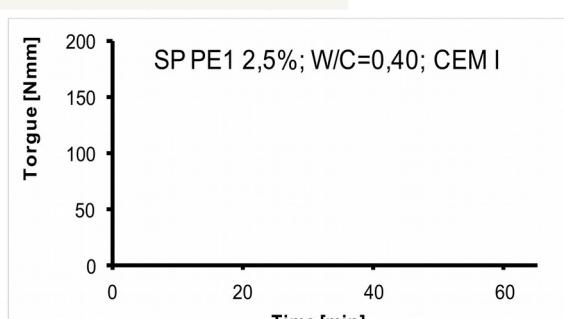
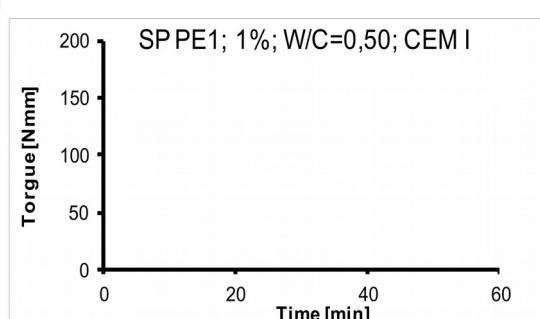
$Cement \text{ specific } surface$

# EFFECTIVENESS OF SP - temperature

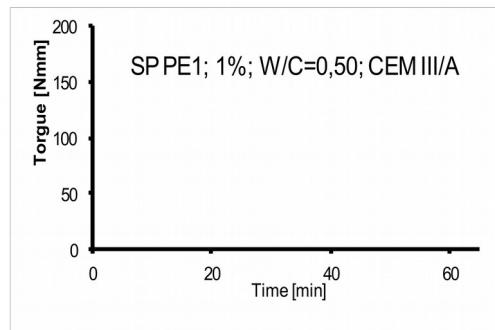
**SP type =**



**w/c ratio ↴**

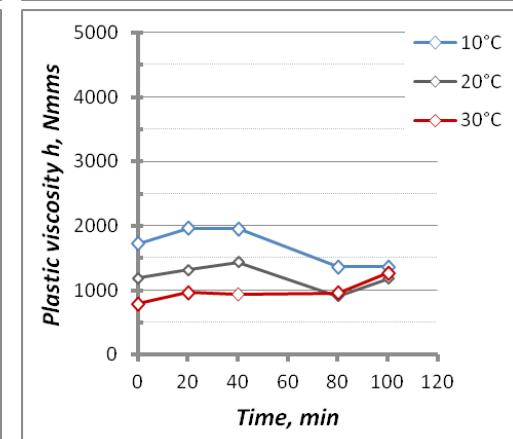
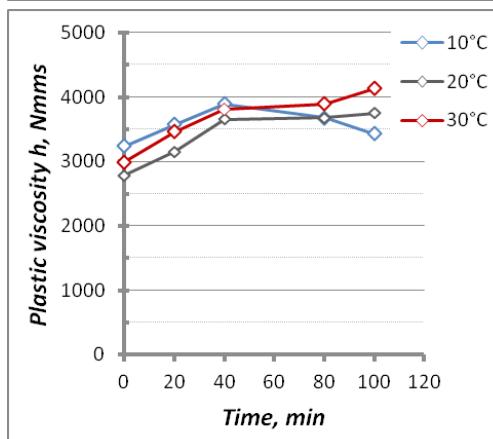
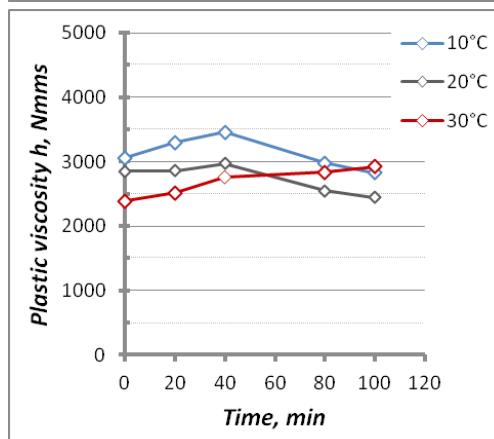
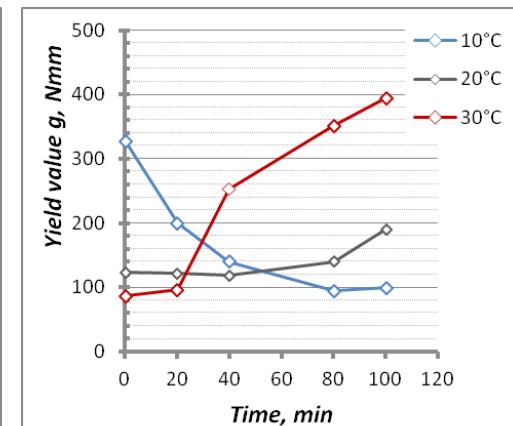
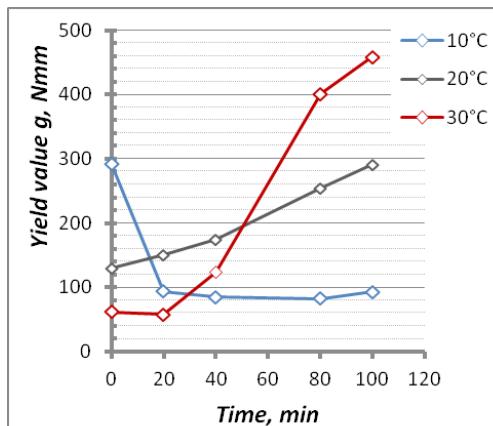
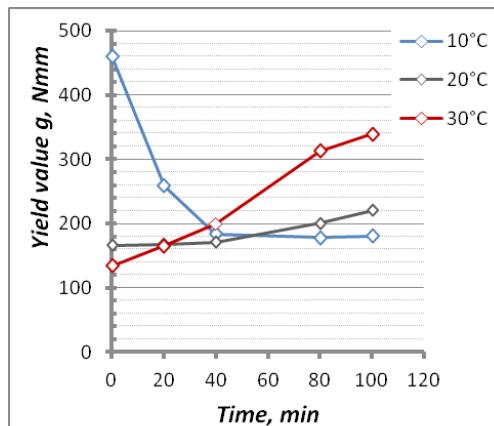


**SP content ↴**



**Cement type ↴**

# **EFFECTIVENESS OF SP - temperature**



**SP 1, w/c = 0,3**

**SP 2, w/c = 0,3**

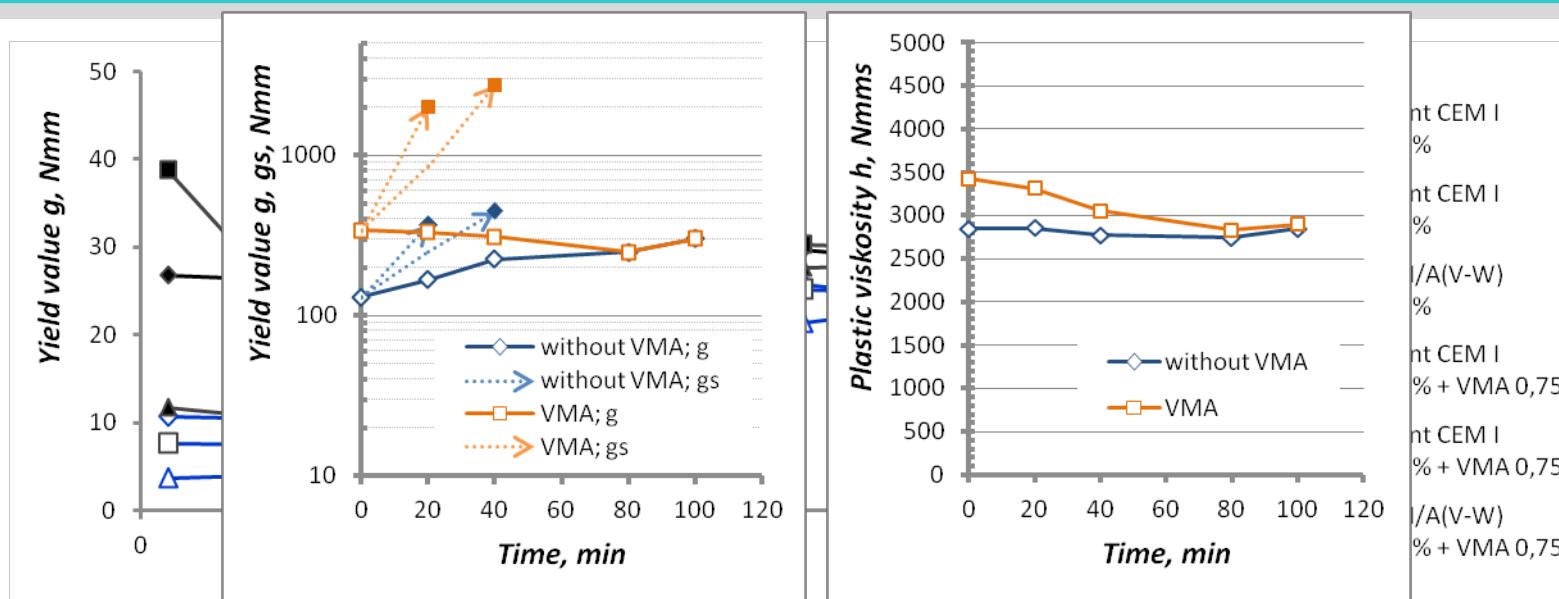
**SP 2, w/c = 0,4**

**SP type**

**w/c ratio**

# VISCOSITY MODIFYING ADMIXTURE

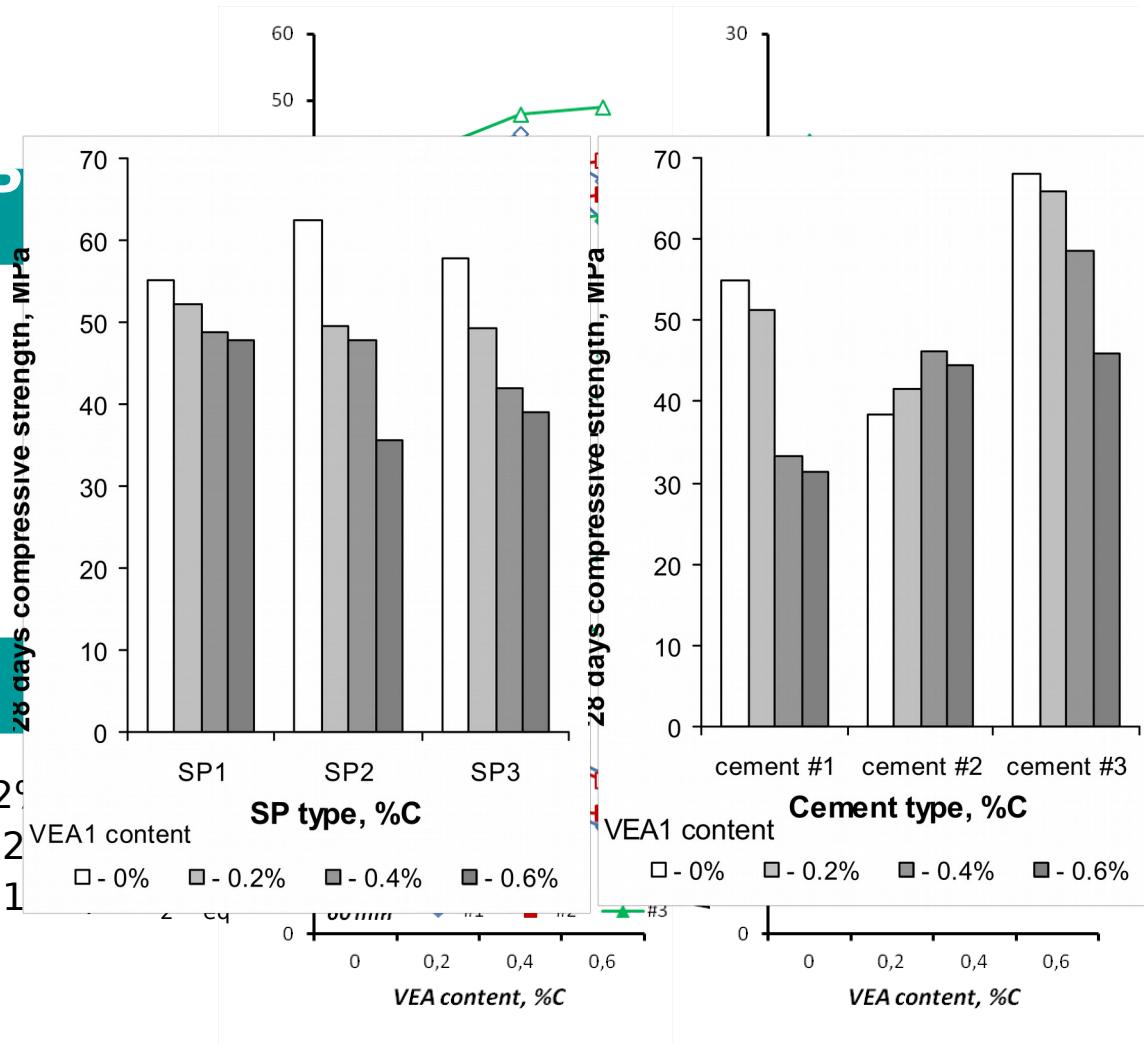
**Viscosity Modyfing Admixturures (VMA) are used to eliminate or reduce segregation and bleeding of SCC, as well as to reduce the sensitivity of the self-compacting concrete mix to the changes in the amount of water and to reduce its pressure on the formworks.**



**Influence of VEA on SCC properties with time**

# VISCOSITY MODIFYING ADMIXTURE

## Effect of SP type



## Cement type

cement #1( $C_3A = 29\%$ )  
 cement #2 ( $C_3A = 22\%$ )  
 cement #3 ( $C_3A = 11\%$ )



## AIR ENTRAINING ADMIXTURE

***Air-entraining admixtures are used to improve the freeze-thaw resistance of concrete.***

SCC must comply with strict requirements of workability and the introduction of AEA significantly affects the rheological properties of the mixture.

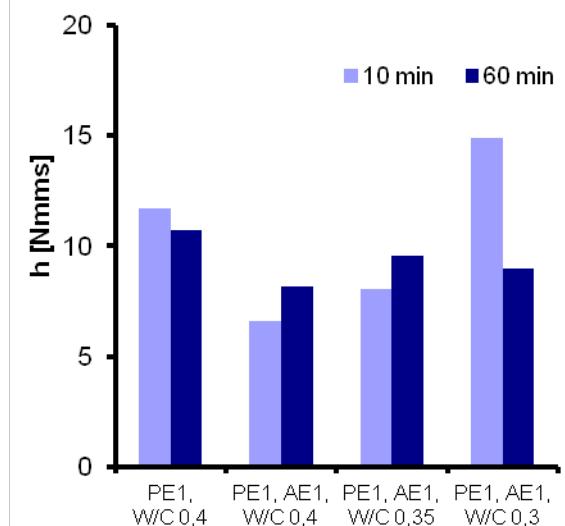
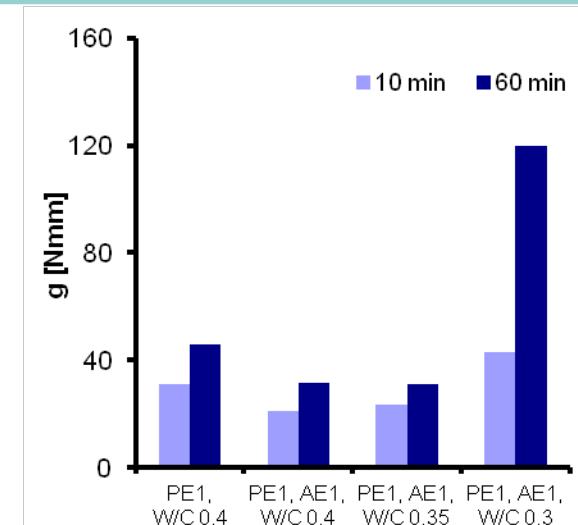
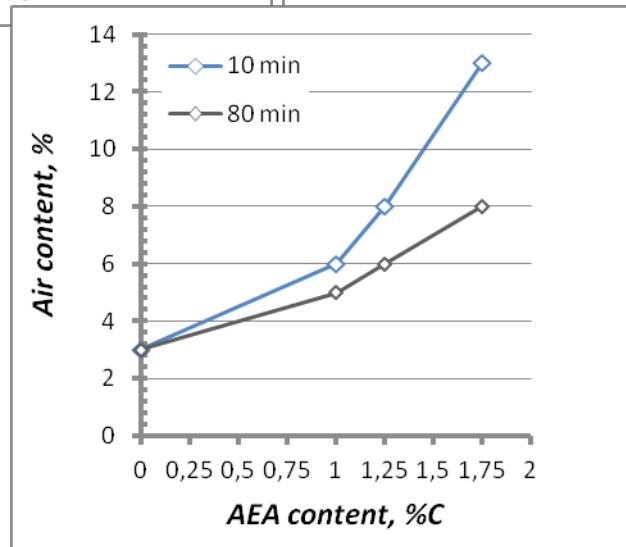
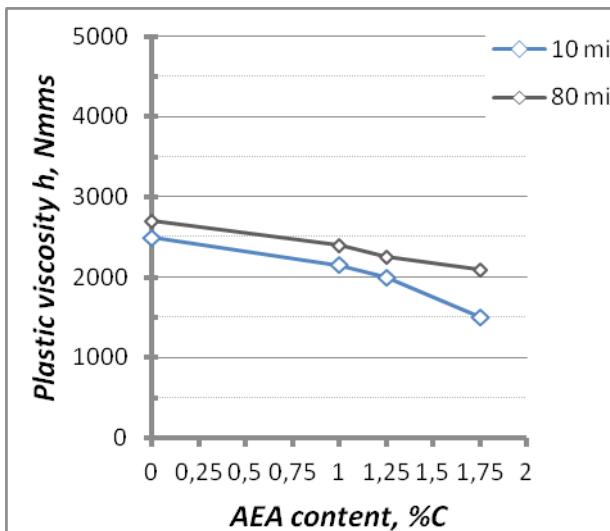
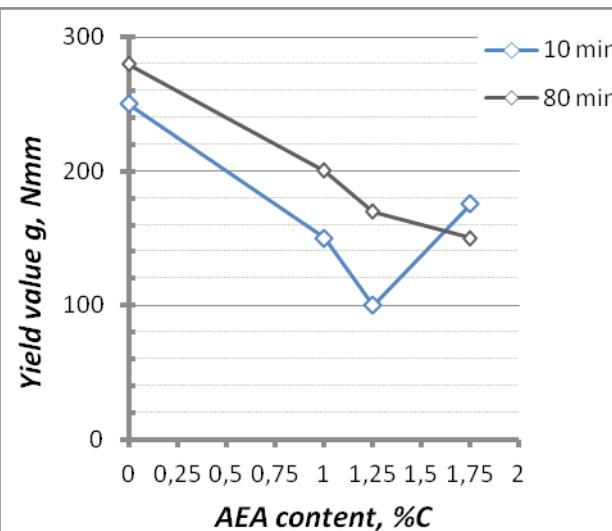
Presence of AEA can influence the reduction in effectiveness of the superplasticizer.

Extensive usage of some superplasticizers may cause uncontrolled aeration of concrete and affect structure of air-entrainment.

Effectiveness of AEA action is influenced by many material and technological factors. Strict procedure of SCC production, transport and placing is necessary.

***Optimization of superplasticizer and AEA is necessary .***

# AIR ENTRAINING ADMIXTURE





## **OTHER ADMIXTURES**

**Water retaining admixtures** - in typical dose necessary to achieve the desired effect worsens workability.

**Water resisting admixtures** - that display hydrophobic abilities, in particular admixtures based on soap and fats, aerate the mixture and improve workability, in combination with SP aeration may be high

**Shrinkage-reducing admixtures** - most of the shrinkage-reducing admixtures are surface-active substances and improve workability .

**Set retarding admixtures** - reduces the scope of changes of rheological parameters of the concrete mix in time.

**Set accelerating admixtures** - improving initial workability, may have negative impact on workability loss .



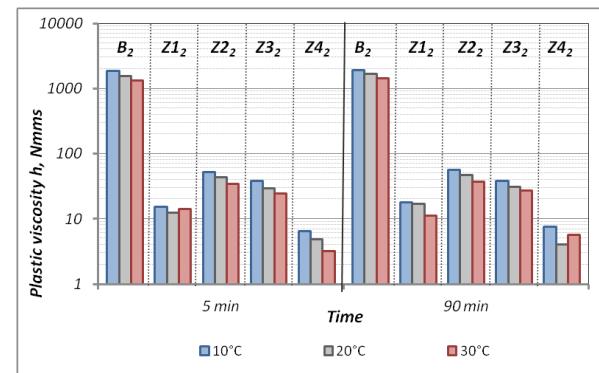
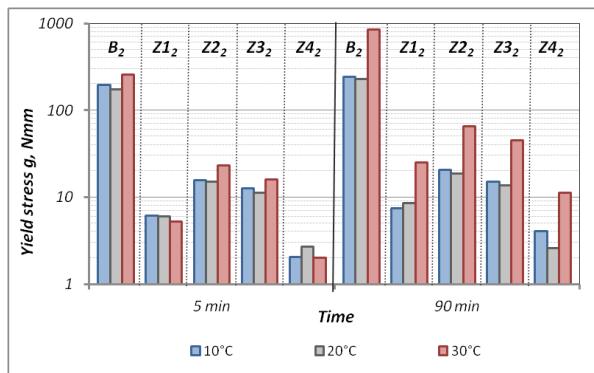
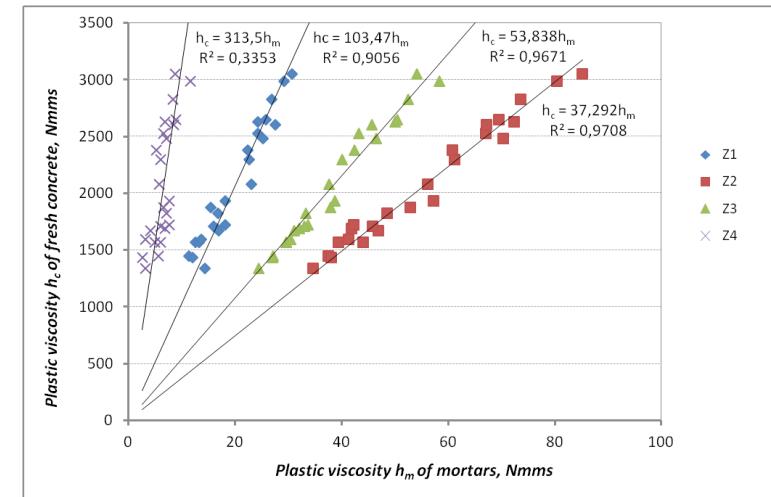
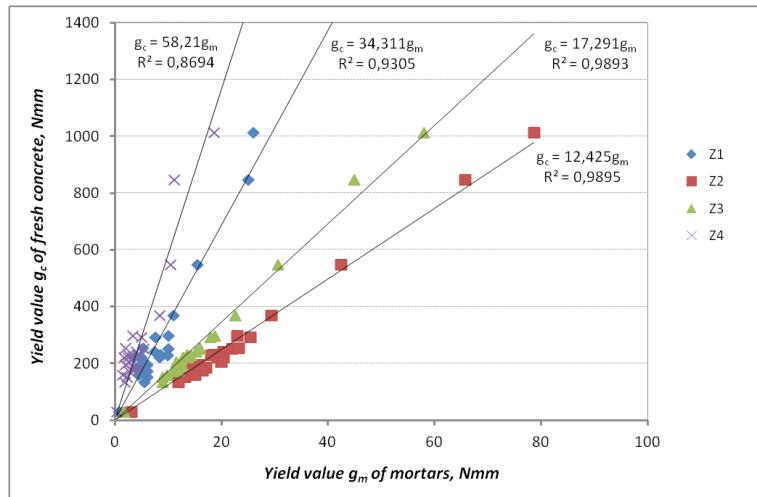
## SUMMARY

***Proper selection of admixtures, especially superplasticizer is crucial for the proper implementation of SCC. Presented relationships show the general information on influence of admixtures on SCC rheological properties.***

***Prediction of effectiveness of admixtures is difficult. It is always necessary to verify admixtures action by experimental research which takes into account all material and technological factors and conditions occurring during the concrete processing.***

***Choosing the admixtures to the SCC is best made on the basis of the tests performed on mortars.***

# HEOLOGICAL PROPERTIES OF MORTARS AND CONCRETE





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## SELECTED RESEARCH OUTCOMES

Influence of cement properties on new generation superplasticizers performance.

[Aut.]: Jacek Gołaszewski.

-**Constr. Build. Mater.** 2012 vol. 35, s. 586-596, bibliogr. 53 poz..

Cement paste properties and paste-aggregate void saturation ratio as the factors governing the selfcompactness and compressive strength of concrete

[Aut.]: Janusz Sztabowski, Jacek Gołaszewski.

-**Cem. Wap. Beton** 2010 R. 15 nr 2, s. 97-107, bibliogr. 11 poz.

Influence of superplasticizers on rheological behaviour of fresh cement mortars.

[Aut.]: Jacek Gołaszewski, Janusz Sztabowski.

-**Cem. Concr. Res.** 2004 vol. 34 iss. 2, s. 235-248. Impact Factor 0.834

Influence of antifoaming admixture type on several properties of high-performance self-compacting concrete.

[Aut.]: Beata Łażewska-Piekarczyk.

-**J. Mater. Civ. Eng.** 2014,

The influence of selected new generation admixtures on the workability, air-voids parameters and frost-resistance of self compacting concrete.

[Aut.]: Beata Łażewska-Piekarczyk.

-**Constr. Build. Mater.** 2012 vol. 31, s. 310-319, bibliogr. 31 poz.

Correlation between rheology of superplasticized fresh mortars and fresh concretes.

[Aut.]: Jacek Gołaszewski.

W: **Ninth ACI International Conference on Superplasticizers and Other Chemical Admixtures, Seville, Spain, October 2009. Ed. T. C. Holland. Farmington Hills : American Concrete Institute, 2009**, s. 215-235 (ACI Special Publication ; American Concrete Institute vol. 262 0193-2527)

The effect of temperature on the rheological properties of self-compacting concrete.

[Aut.]: Jacek Gołaszewski, Grzegorz Cygan.

W: **Brittle matrix composites 9. Proceedings of the Ninth International Symposium on Brittle Matrix Composites, BMC9, Warsaw, Poland, 25 - 28 October 2009. Ed. by A. M. Brandt, J. Olek, I. H. Marshall. Institute of Fundamental Technological Research. Polish Academy of Sciences. Cambridge : Woodhead Publishing, 2009**, s. 359-368, bibliogr. 10 poz.