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ADJUSTING THE CONCRETE CONSISTANCY BY USING SUPERPLASTICIZERS

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Abstract: The workability and open time of fresh concrete is a very important issue when placing structural concrete. The workability of fresh concrete is influenced by the used cement and aggregates, the amount of fines and the paste volume. Concrete admixtures are used to modify the flowability of the paste, while changes of the paste characteristics will have a direct influence of the concrete workability. The current paper presents the effects and benefits when using superplasticizing admixtures, to adjust and keep the workability of a concrete mix.

Key words: Concrete Admixtures, Superplasticizers

1. SUPERPLASTICIZERS

1.1 GENERAL INFORMATIONS

Superplasticizing admixtures are a special category of water-reducing agents which allow a great water reduction, or alternatively extreme workability of concrete in which they are incorporated. This is achieved without undesirable side effect such as excessive air entrainment or set retardation.

Sulfonated naphthalene formaldehyde and sulfonated melamine formaldehyde were the materials originally developed as a basis for superplasticizing admixtures. Initially they were used in Japan and Germany, finding afterwards a world-wide applicability. In the early 1980s, work began on designing polyacrylate-based polymers for superplasticizers formulations and after some difficulties with severe retardation, and in some cases excessive air entrainment, products began to appear in the marketplace, initially in Germany, and then in Japan and the United States.

Nowadays superplastcizers are based on Polycarboxilat-Ether (PCE), which allows them to be very flexible and robust. The polymers consist of backbones with carboxyl groups and side chains.

The backbones are responsible for the total water reduction, the initial slump and the needed mixing time, while the side chains determines the slump keeping capability of the superplasticizers. Based on this technology, the polymers used to produce superplasticizers, can be adjusted for the specific needs. Three types of superplasticizers can be defined: water reducing, slump controlling and retention polymers.

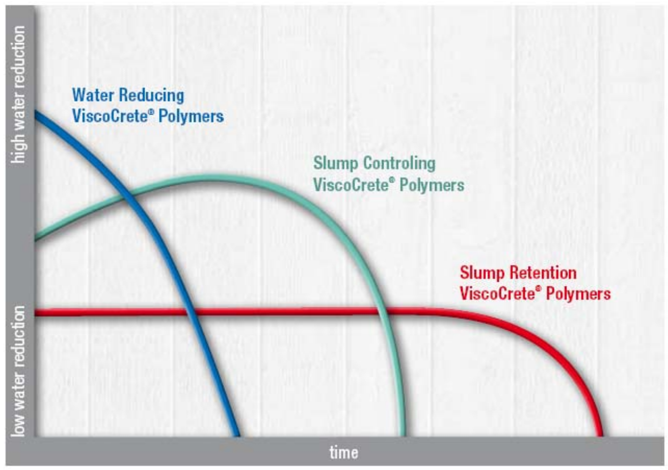

Fig. 1 Types of superplasticizers

A normal water reducer is capable to reduce the amount of needed water by 10-15 %. Further reductions can be obtained at higher dosages but this may result in undesirable effects on setting, air content, bleeding, segregation and hardening characteristics of concrete. Due to their special structure, superplaticizers can be used to reduce the water amount by about 30 %.

The advantages derived by the use of superplasticizers can be summarized in three ways:

- by adding a water-reducing admixture and consequentially reducing the water amount, a concrete having the same workability as the control concrete can be obtained, while the compressive strengths will exceed those of the control mix at all ages
- if the admixture is added directly to a concrete as part of the gauging water with no other changes to the mix proportions, a concrete with similar strength development characteristics is obtained, while having a greater workability than the control concrete
- a concrete with similar workability and strength development characteristics can be obtained at lower cement contents than a control concrete, without affecting the durability or engineering properties of the concrete

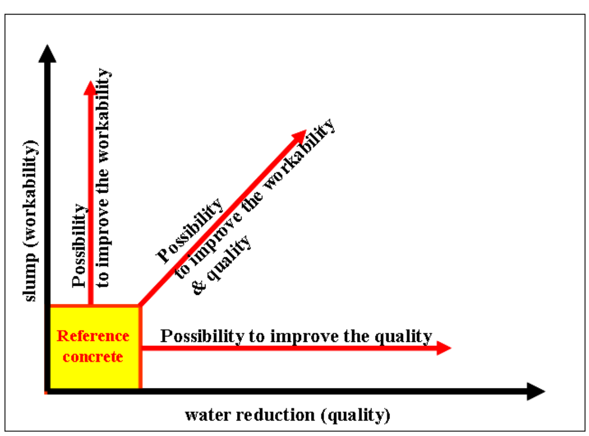

Fig. 2 Advantages of superplasticizers

1.2 APPLICATIONS

The main characteristic of superplasticizing admixtures is their capability to reduce the water content of a mix design. An enhanced durability is one of the consequences of the water reduction, induced by a low concrete permeability. Superplasticizers respond mainly to the current trend to use flowable concrete types. Therefore superplasticized concrete is suitable to be placed in congested reinforcement and in hard accessible areas. Concrete with a fluid consistency can be used to cast any type of structural element. Superplasticizers have also been used for tunnel linings and spray applications.

One of the industries where superplasticizers are indispensable is the wet heavy precast industries, where initial compressive strengths of 40 MPa are needed after 12-18 hrs.

Self Compacting Concrete and high strength concrete (> 100MPa) are impossible to produce without the latest superplasticizing admixtures.

2. PERFORMED TESTS

Several tests were done in the concrete laboratory of Sika Romania using SikaViscoCrete and SikaPlast superplasticizers. During this tests the performance of different admixtures were analyzed, by measuring the initial workability, the workability loss and the compressive strength.

All mix designs were done using the same cement and aggregates from the same source. The cement was supplied from Holcim beeing a CEM II AM(S-LL) 32,5 R and the aggregates were supplied from a local source.

The produced concrete batches were analyzed in fresh and hardened state, measuring slump, slump loss and density in the fresh state and compressive strength on the hardened concrete cubes.

Table 1 Mixes tested

Mix		1	2	3	4
CEM II AM(S-LL) 32,5 R		335 kg	335 kg	335 kg	335 kg
Water		251 kg	164 kg	171 kg	178 kg
water/cement		0,75 kg	0,49 kg	0,51 kg	0,53 kg
Total Aggregates		1734 kg	1886 kg	1866 kg	1830 kg
Admixture	Dosage	0,00 kg	2,01 kg	3,35 kg	2,68 kg
	%	0,00 %	0,60 %	1,00 %	0,80 %
	Name	-	SikaPlast 305	Sika ViscoCrete 2320	Sika ViscoCrete 1040
Density		2320 kg/m^3	2387 kg/m^3	2375 kg/m^3	2345 kg/m^3
Slump	T0	205 mm	210 mm	215 mm	205 mm
	T15	mm	210 mm	225 mm	195 mm
	T30	mm	200 mm	215 mm	175 mm
	T45	mm	185 mm	215 mm	145 mm
	T60	mm	160 mm	210 mm	85 mm
	T75	mm	115 mm	190 mm	mm
	T90	mm	mm	140 mm	mm
	T105	mm	mm	120 mm	mm
Compressive Strength	24 h	2,08 N/mm^2	7,2 N/mm^2	5,73 N/mm^2	9,72 N/mm^2
	48 h	5,95 N/mm^2	12,9 N/mm^2	11,21 N/mm^2	14,98 N/mm^2
	7 days	13,4 N/mm^2	25,9 N/mm^2	22,71 N/mm^2	26,81 N/mm^2
	28 days	19,3 N/mm^2	36,37 N/mm^2	31,49 N/mm^2	35,15 N/mm^2

Four mixes were selected to compare the performances of three superplasticizing admixtures to a reference concrete:

- Mix 1 Reference concrete
- Mix 2 + SikaPlast 305
- Mix 3 + Sika ViscoCrete 2320
- Mix 4 + Sika ViscoCrete 1040

To compare their water reducing capabilities and slump keeping performance the water amount and admixture dosage were adjusted, so that the initial slump was for all four mixes approximately the same, without bleeding.

Analyzing the above mentioned mix designs it can be observed that the water amount varies from mix to mix, from 251 kg/m^3 for the reference concrete to a minimum of 164 kg/m^3, when using the admixture SikaPlast 305.

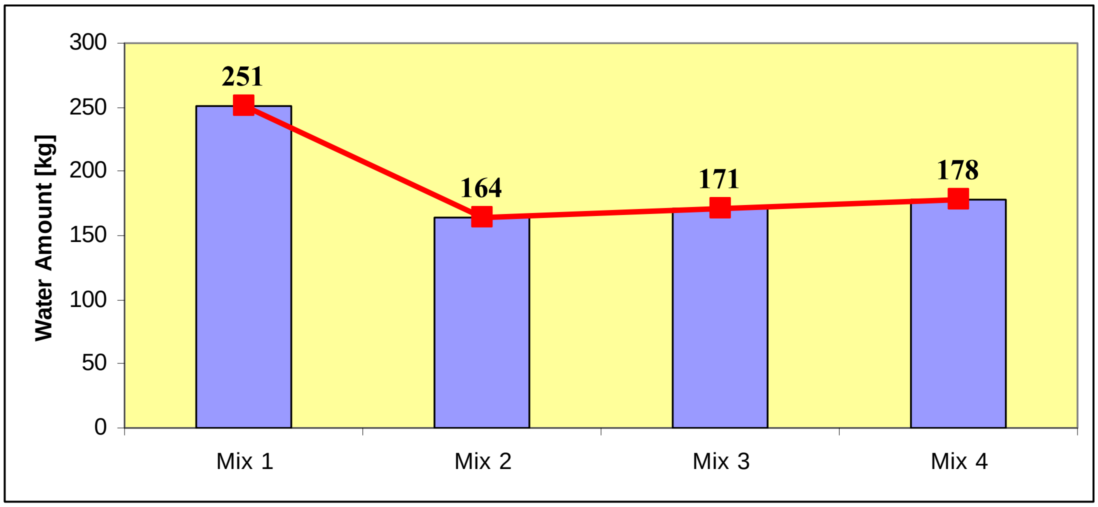

Fig. 3 Water amount for mixes tested

As expected the water reduction obtained by using superplasticizing admixtures is between 30-35%.

Another important issue when using concrete for structural purposes is the workability of the concrete before casting. This means that a concrete should keep its characteristic for a certain period, long enough to produce and to deliver it. The workability measured by the slump test should be at least 120 mm before casting, to assure a proper placement, especially when a pump is used to place the concrete into the formwork.

The open time for the evaluated mixes is different and dependent to the type of admixture that is used. Sika ViscoCrete 2320 offers the best open time. The open time of the reference concrete was not measured, because the needed water amount was too high to fit the recommendations of the norm (EN 206-1).

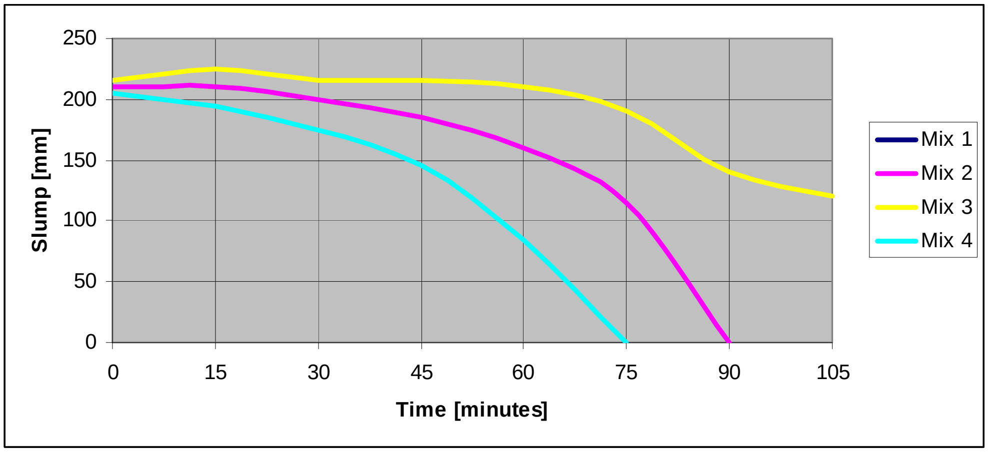

Fig. 4 Slump vs. time for mixes tested

Finally the strength development of the four mixes was evaluated. The compressive strength was measured on standard cubes (EN 206-1), at following ages: 24 and 48 hours, 7 and 28 days.

Table 2 Compresive strength for mixes tested

	Age	Mix 1	Mix 2	Mix 3	Mix 4
Compressive Strength	24 h	2,08 N/mm^2	7,2 N/mm^2	5,73 N/mm^2	9,72 N/mm^2
	48 h	5,95 N/mm^2	12,9 N/mm^2	11,21 N/mm^2	14,98 N/mm^2
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The compressive strengths vary due to different water dosages used to obtain the same initial slump. Using superplasticizing admixtures an initial 24 hrs strength increase of min. 275% was reached and min. 163% increase of the 28 days compressive strength.

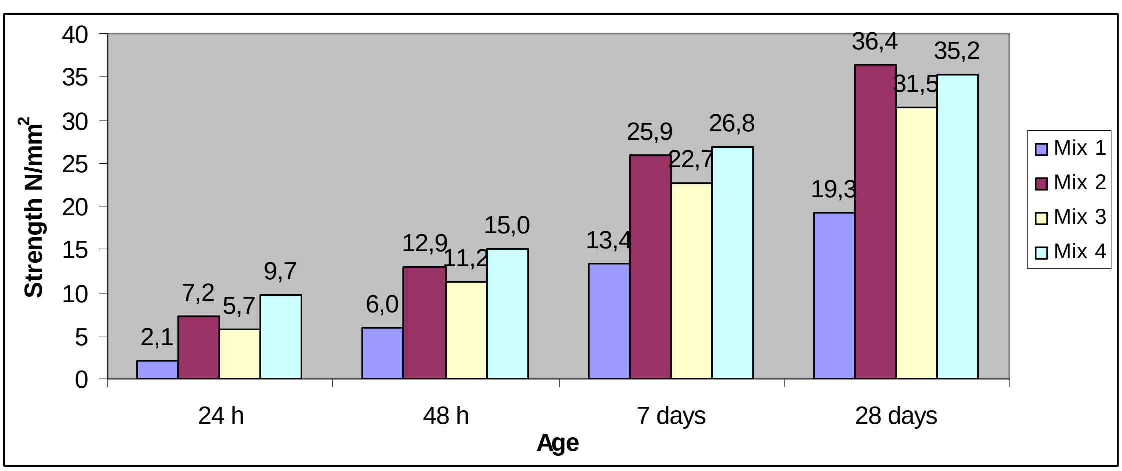

Fig. 5 Compresive strength vs. age for mixes tested

3. CONCLUSIONS

Superlasticizers have generally very good dispersing effect in any type of cement. As described above superplasticizing admixtures are one important element of a concrete mix. The concrete developed from a 3 component system, containing cement, aggregates and water to a five component system including additives and admixtures, where superplasticizing admixtures play a major role as a water reducing agent, and nevertheless as a slump controlling tool.

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