BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul **LIV (LVIII)**, Fasc. 4, 2008
Sectia
CONSTRUCŢII. ARHITECTURĂ

CHARACTERISTICS OF CONCRETE WITH ADMIXTURES

BY

P. MIHAI and BOGDAN ROŞCA

Abstract. In recent decades, tremendous success has been achieved in the advancement of chemical admixtures for Portland cement concrete. Most efforts have centered on improving the properties of concrete with minimal investments by ready-mix suppliers and contractors in the way of specialized equipment or special skills and education of their labor forces. This approach has resulted in construction cost reductions and universally accepted ready-made remedies for unexpected problems during construction. The behavior of concrete improved with superplasticizers additives is studied.

Key Words: Concrete; Admixtures; Superplasticizers; Strength; Durability.

1. Introduction

Materials scientists, chemists, engineers, and manufacturers' technical representatives have helped the concrete industry to improve our ability to control work times, workability, strength, and durability of Portland cement concrete by adding some supplementary substances named *admixtures*.

The function of each admixture focuses on a specific need, and each has been developed independently of the others. Some admixtures already have chemistry that affects more than one property of concrete, and some have simply been combined for ease of addition during the batching process.

All of these admixtures have been refined to provide concrete designers and builders with increasing options and greater adaptability to an expanding variety of applications and ambient conditions. It is estimated that one or more chemical admixtures, not including air-entraining agents, are present in 80% of the concrete placed today, and the figure rises to almost 100% when air-entraining agents are included. To better understand recommended usage for various applications of these chemical admixtures in concrete, a short review of each functional category is presented.

a) Retarding admixtures are used to slow down the initial set of the concrete whenever elevated ambient temperatures shorten working times beyond the practical limitations of normal placement and finishing operations. Retarders are used in varying proportions, often in combination with other admixtures, so that, as working temperatures increase, higher doses of the admixture may be used to obtain a uniform setting time. Simple retarders typically consist of one of four relatively inexpensive materials: lignin, borax, sugars, or tartaric acids or salts. Retarders serve best to compensate for unwanted accelerations of working times due to changes in temperature or cement or due to other admixture side effects. They also are used to extend the working time required for complicated or high-volume placements and for retarding the set of concrete at a surface where an exposed aggregate finish is desired.

b) Accelerators are commonly used to offset retardation effects from other admixtures, although overcoming weather-induced retardation due to colder temperatures at the job site is probably their primary application.

Through the use of accelerators contractors can be placed concrete at much lower temperatures than would be practical without their use. Accelerating admixtures are also commonly used to speed up normal set and cure times for purposes of earlier service than would be possible with an unaccelerated mix design. Such an application is most often the case for concrete repair mix designs and in prestressed or precast applications, where time delays cost customers or precasters significant amounts of money and inconvenience.

c) Air-entrained concrete was developed in the 1930s, and it is still recommended today for nearly every commercial application. Air-entraining agents are provided already ground into the cement (air-entrained cement) or as an admixture whose addition can be adjusted for individual batch design needs. Because air-entraining agents provide extremely small and well-dispersed air bubbles in the paste, they act as localized stress reducers in the cured matrix. This is advantageous in concrete exposed to moisture and especially to wet deicing chemicals during freezing and thawing conditions. Because the bubble voids provide room for microscopically localized expansions, resistance to damage from alkali-silica reactions and sulfate attack is enhanced as well.

d) Antifreezing admixtures are employed to allow most types of concrete construction work and precasting to take place at freezing and well below freezing temperatures. These admixtures are sometimes used in conjunction with external energy and heat sources, but they are often used without them, even under bitterly cold environmental conditions. Antifreezing admixtures work by lowering the freezing point of the water in fresh concrete. This is accomplished by dissolving salts and mixing in higher-molecular-weight alcohols, ammonia, or carbamide into the mix water. For this reason the admixture dosage rates are based on the amount of mixing water in the given batch design. These antifreezing admixtures tend to seriously retard the set and cure properties of the matrix, as do freezing temperatures. It is obvious, then, that at the same time the water is being kept unfrozen and thus available for hydration acceleration of the hydration process is also important and must be designed to work with the antifreezing component. Thus, these two admixtures – antifreeze and accelerator – are often combined into one complex multicomponent additive.

e) Antiwashout admixture was developed as a viscosity-modifying admixture that could improve the rheological properties of the cement paste. It has proved itself in the field by significantly improving the cohesiveness of concrete being placed underwater, where the exposed matrix is in jeopardy of being diluted and segregated or washed away by the surrounding water. It is most commonly used underwater in large placements and in repairs. These admixtures are also known as viscosity-enhancing admixtures and are sometimes used to produce self-leveling concrete or self-consolidating concrete, which is used wherever extreme congestion due to reinforcement configurations or unusual geometry of the forms requires a very fluid, cohesive concrete that resists bleeding and segregation. Disadvantages of antiwashout or viscosity-enhancing admixtures include the typical reductions in strength and modulus of elasticity. Depending on the base concrete batch design, water/cement ratio, and the type and dosage rate of antiwash admixture (AWA), compressive strength has been determined to be 75% to 100% of the same control mix without this admixture. Flexural strengths have been reported at 84% to 100%, and modulus of elasticity measurements are 80% to 100% of the control batch.

f) Shrinkage-reducing or **shrinkage-compensating admixtures** promote expansion of the concrete at about the same volume that normal drying shrinkage is contracting it. The net change in length of the hardened concrete should be small enough to prevent shrinkage cracks. The typical materials used for shrinkage compensation in concrete are based on calcium sulfoaluminate or calcium aluminate and calcium oxide.

Some losses in properties are typical with the introduction of these anti-shrinkage agents. Any ill effects on strength are minimized by the use of high-range water reducer admixtures, which provide good workability while allowing reduction of the water content. These admixtures can be used to great advantage in slabs, bridge decks, structures, and repair work where cracking can lead to steel reinforcement corrosion problems, but maintaining effective air entrainment for resistance to freezing and thawing damage can be difficult with shrinkage-reducing admixtures.

g) High-range water reducers are also known as **superplasticizers**, super fluidizers, and super water reducers due to their higher efficiency than conventional water reducer admixtures in improving workability and flow of concrete mixes. They were developed for use where the amount of water reducer admixtures required to reach a desired slump or flow resulted in unacceptable reductions of other critical properties. Different chemistry enabled developers to produce an admixture that allowed contractors to place highly workable, pumpable, or even flowing concrete with higher strengths and greater durability and less shrinkage when the concrete mix was properly designed.

High-range water reducers are typically one of four chemical groups: sulfonated melamine-formaldehyde condensate, sulfonated naphthalene-formaldehyde condensate, modified lignosulfonate, and others that may include sulfonic acid esters or carbohydrate esters (carboxylates). High-range water reducers deflocculate and disperse the cement particles in a similar manner but much more efficiently than conventional water reducer admixtures. Superplasticizers can reduce water demand in the matrix by as much as 30%, and, because they can be added into the transit mixer at the plant and again at the jobsite, workability can continue to be customized at the site for specific application needs regardless of transit-time slump.

2. Behavior of Concrete with Superplasticizers

To establish the influence of superplasticizers was made an experimental study on cubic concrete samples. All samples was made with C12/15 concrete grade with CEM II AS 32,5R cement.

To establish the influence of admixture are made four types of probes. Admixture was studied in the following quantities: 0.5% 0.8% and 1.1% of superplasticizer. All results were compared with a base probe, without admixture.

Because the most important property is strength of concrete in compression, all studies are based on this parameter.

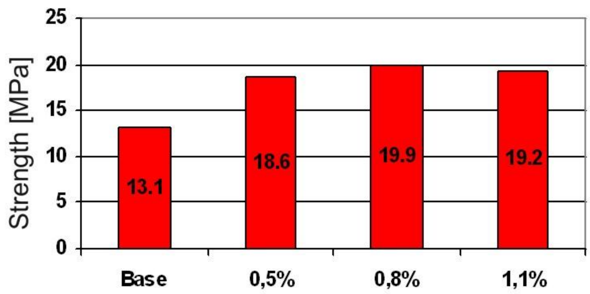

Fig. 1. – Strength results at seven days.

The strength of concrete at seven days is important because the removing of formwork depend directly from strength value. The result of the study at seven days is presented in Fig. 1. The strength increase up to 47% if admixture is used and the result is spectacular. The optimum quantity of admixture is situated around 1.1%.

On 28 days the increase of strength is smaller compared with the partial results on 7 days. In this later case the strength of concrete in compression is up to 30% and the optimum quantity of admixture is situated around 0.8% (Fig. 2).

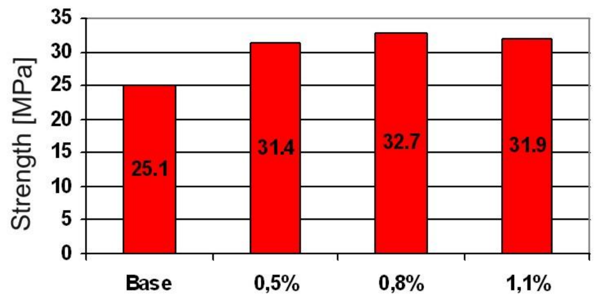

Fig. 2. – Strength results at 28 days.

3. Conclusions

The superplasticizers are recommended in all situations because they increase the strength of concrete. If the most important parameter is final strength in compression, the optimum amount of admixture must be 0.8%. If it is necessary to remove the formwork very quick, the optimum percentage of admixture must be 1.1%.

Received, November, 27, 2008

„Gheorghe Asachi" Technical University, Jassy,
Department of Concrete, Materials, Technology and Management.
e-mail: petrumihai@yahoo.com

REFERENCES

1. Nawy E.G., *Concrete Construction Engineering Handbook*. CRC Press, New York, 2008.
2. * * *, *Chemical Admixtures for Concrete,* ACI 212.3R-04. American Concrete Institute, Farmington Hills, MI.

CARACTERISTICILE BETOANELOR ADITIVATE

(Rezumat)

Îmbunătăţirea caracteristicilor fizico-mecanice ale betonului prin utilizarea aditivilor reprezintă o preocupare din ce în ce mai importantă pentru obţinerea unor betoane cu performanţe ridicate dar cu costuri reduse. Se prezintă caracteristicile principale ale aditivilor utilizaţi la prepararea betonului precum şi rezulatele unui studiu efectuat pe aditivii superplastifianţi privind influenţa acestora asupra rezistenţei mecanice a betonului.