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Influence of Plasticizer Introduction Method on the Efficiency of Cement Suspensions

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***Abstract*—The paper studies the influence of composition and technological factors on rheological indicators of concrete mixes modified by various chemical additives. The rheological and water-reducing efficiency of super- and hyper-plasticizers in cement suspensions depending on their addition procedure was studied. The efficiency of a two-stage concrete mixing with the introduction of a plasticizer at the second stage with remaining 1/3 content of mixing water, which improves the efficiency of the additive by almost 20% in comparison with the traditional technology, was experimentally proved.**

***Keywords*—concrete mix, superplasticizer, addition procedure, two-stage mixing, separate mixing, plasticizer efficiency**

I. Introduction

It is known that rheology as a new branch of mechanical engineering studies the behavior of damp systems under external load, which are not related neither to liquids, nor to solid bodies [1, 2]. The concrete mix, which, in fact, is the elastic and viscous environment, [3, 4] belongs to these materials.

It is proved that in such systems it is possible to regulate the rheotechnological properties of a concrete mix and the physicomechanical properties of a concrete composite by using modern modifiers and superplasticizers [5, 6].

Plasticizing, water-reducing and cement-saving effects of various plasticizers can be enhanced by the application of various technological methods of their introduction into the concrete mix: separate mixing, two- and multi-stage mixing, etc., as well as by their complex application with mineral fillers of various origin.

There are various methods of introducing plasticizing additives into concrete mixes, e.g. with mixing water, separately after mixing with water, two- and multi-stage mixing, etc. According to the researchers [7, 8], each method of introduction has a particular effect on rheotechnological properties of the concrete mix.

II. Methods and Materials

The mixing to obtain control samples was carried out in the RM-1A mixer.

The rheology of concrete mixes was studied according to GOST 10181-2014, GOST 7473-2010.

During the experiment, the composition of the concrete mix in all test series remained invariable, only the method of introduction of an additive into the concrete mix was changed.

Superplasticizer Linamiks PK based on polyoxyethylene derivatives of polymethacrylic acid by the Polyplast company was used as a chemical additive according to GOST 24211-2008. Dispensing of superplasticizer Linamiks PK was carried out within 0.8-1.2% of the cement mass.

III. Results

To determine the most effective way of additive introduction into the concrete mix according to GOST 10181-

2014, we have carried out a number of tests to obtain the following compositions:

1. Composition 1 – control sample, with the introduction of additive (A) into the concrete mix with mixing water (W) (i.e., W + A);

2. Composition 2 – introduction of a plasticizer into a water concrete mix at the end of its preparation (W, then A);

3. Composition 3 – two-stage concrete mixing, where at the 1st stage 2/3 of the mixing water is introduced and mixed for 30-40 seconds, at the 2nd stage – remained 1/3 of water with the additive of plasticizer diluted in it is added and again mixed until the homogeneous mass is obtained (2/3 W, then 1/3 W + A).

According to GOST 7473-2010, the concrete mix was designed as the BST V25 P4 brand (cone slump CS = 16-20 cm).

Table 1 and Figure 1 show test results.

TABLE I. INFLUENCE OF A PLASTICIZER ADDED INTO A CONCRETE MIX ON ITS TECHNOLOGICAL PROPERTIES

No.	Composition	Addition procedure	Placeability of concrete mix	
			Cone slump (CS), cm	CS brand
1	Control sample	Traditional method: with mixing water	17	P4
2	Test sample 1	Separate method: introduction into the concrete mix with mixing water at the end of its preparation	19	P4
3	Test sample 2	Two-stage: 1st stage – 2/3 of water, 2nd stage – remained 1/3 of water with additive diluted in it	20	P4-P5

They showed the difference in the introduction of a plasticizer into a concrete mix. The best results in terms of technological efficiency of the mix are received at two-stage additive introduction.

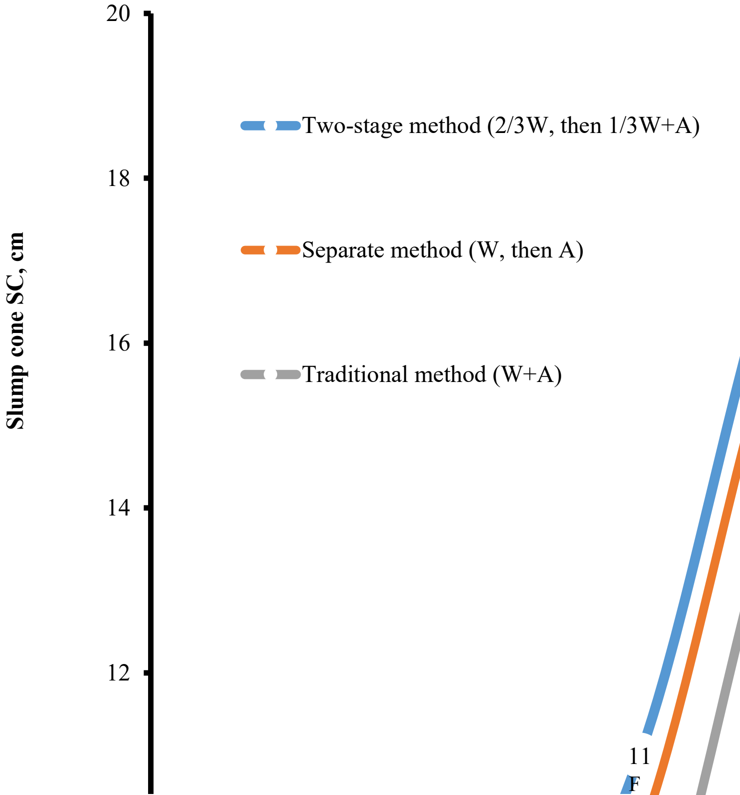

Fig. 1. Influence of a plasticizer added into a concrete mix on its technological properties

The efficiency of the two-stage concrete mixing with water and a plasticizing additive is explained by the fact that the potential of the plasticizer is used more at its separate introduction at the end of preparation, rather than with the traditional method. This happens since, according to the traditional method, part of the plasticizer with the mixing water is absorbed into the pores and voids of the filler, which is just held in a “blocked” form due to molecular and adsorption forces (Figure 2).

The two-stage mixing with water contributes to the fact that the above mentioned pores and voids are filled with some water that is introduced into the mix at the first stage (i.e. with the first 2/3 of water), and the plasticizer is added with the remaining (1/3) of the mixing water, being in the adsorbed state on cement grains thus creating a “steric” repulsion effect, which leads to long-term viability of concrete and mortar mixes. Such technological methods, triggering the mechanical action of superplasticizers, increase the mobility of the concrete mix by 3-5 times in comparison with additive-free compositions.

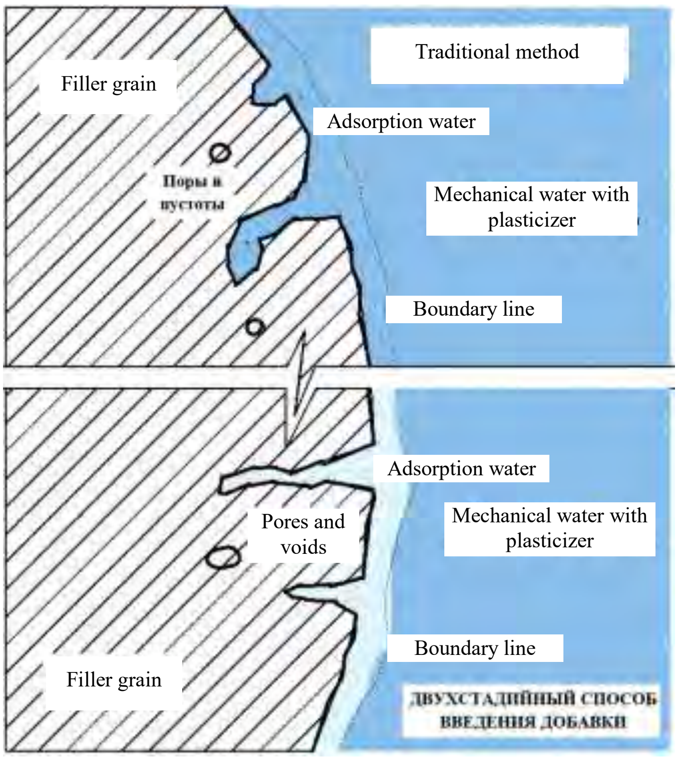

Fig. 2. Comparison of the introduction methods of a plasticizing additive into a concrete mix

The separate method of introduction (W, then A) also proved to be efficient in the preparation of high-mobile concrete mixes, however, this method stands down the two-stage mixing (2/3 W, then 1/3 W + A) in terms of the quality of the mix homogeneity. It is explained by the fact that the homogeneity of a mix at its repeated mixing (at the second stage) is better reached when the additive is mixed with a certain amount of water, for example, with 1/3 of the mixing water at two-stage concrete mixing than introduced separately.

Besides, Figure 1 shows that when switching from the traditional method (W + A) to the two-stage mixing (2/3 W, then 1/3 W + A), it is possible to obtain equally moving mixes with lower consumption (up to 20%) of a superplasticizer.

The plasticizing additive is saved at two-stage method is reached since it is fully dissolved in “mechanical” water, but it is spent for chemical, physico-chemical (adsorption) and mechanical (structural) water during traditional method (Figure 3).

A small part of the liquid phase that reacts at the chemical level with the cement clinker is usually in a chemically bound state, which relative amount increases with time, i.e. it is more involved in the chemical process, but by the end of the setting it does not exceed 5%. Due to adsorption in the zone of solid molecular force fields action, the remaining water is physically and chemically bound on its surface [9-12].

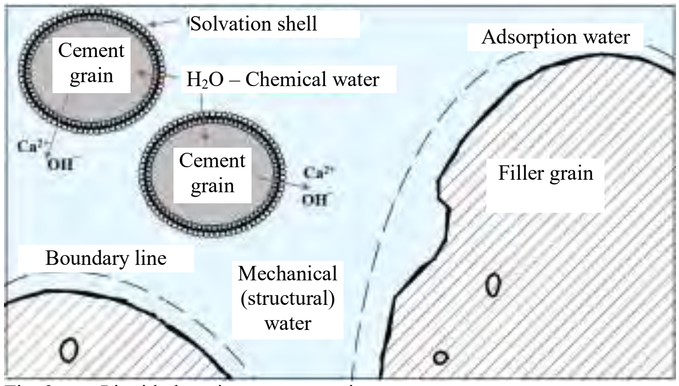

Fig. 3. Liquid phase in a concrete mix

The volume of physico-chemical (adsorption) bound water in a concrete mix also changes with time. By the beginning of the mixing, the volume of adsorption water does not exceed 4-6%, which can reach 20-25% of the total volume of the mixing water by the end.

The main amount of water in the cement mix being in the intergranular space is mechanical (or structural) water. It is free water that is not chemically bound and not influenced by molecular forces of the solid phase.

In fresh concrete mix the relative amount of mechanical water makes about 90% of the mixing water, which is reduced to 65-70% already in the last stages of hardening. Placeability of concrete mixes is ensured due to mechanical water.

IV. Conclusions

Thus, the method of introduction of a plasticizer into concrete mixes significantly affects the water-reducing activity of the additive. The two-stage concrete mixing with the introduction of a plasticizing additive with the remaining 1/3 of the mixing water at the second stage contributes to the increase of water-reducing and plasticizing efficiency of chemical modifiers by up to 20% in comparison with traditional technology.

References

[1] Yu.M. Bazhenov, V.S. Demyanova, V.I. Kalashnikov, Modified high-quality concrete: scientific publication, Moscow: Publishing House of Association of Construction Institutions, 2006, pp. 368.

[2] Yu.M. Bazhenov, S-A.Yu. Murtazaev, M.S. Saidumov, Construction composites based on concrete scrap and stone-breaking waste: scientific publication, Grozny: Grozny Worker Publishing and Printing Complex, 2014, pp. 334.

[3] V.S. Lesovic, A.D. Tolstoy, A.S. Milkina, “Features of the structure of new generation concrete with the use of artificially-produced materials,” Russian Automobile and Highway Industry Journal, Vol. 15, No. 4 (62), pp. 588-595, 2018.

[4] V.V. Strokova, L.N. Botsman, A.V. Ishenko, A.N. Botsman, “Improving the efficiency of concrete through the application of additives of various nature,” Bulletin of Belgorod State Technological University named after V.G. Shukhov, No. 6, pp. 90-94, 2016.

[5] V.S. Demyanova, A.D. Gusev, Efficient building materials using technogenic waste, Penza: PSUAC, 2013, pp. 127.

[6] V.S. Ramachandran, Additives in concrete, M.: Stroyizdat, 1988, pp. 575.

[7] S.A. Udodov, “Re-introduction of a plasticizer as a tool for controlling the mobility of a concrete mix,” Collection of scientific papers of the Kuban State Technological University, No. 9, pp. 175-185, 2015.

[8] L.D. Chumakov, Technology of concrete aggregates, M.: Publishing House DIA, 2011, pp. 264.
[9] Yu.M. Bazhenov, Concrete Technology, Moscow: Publishing Press Association, 2002, pp. 500.
[10] Yu.M. Bazhenov, V.R. Falikman, "New century: new efficient concretes and technologies," Stroy-Info, No. 1-2, pp. 289-290, 2007.
[11] Yu.I. Koryanova, N.E. Rezantcev, A.S. Shumilova, "Materials and structures used in the construction of high-rise buildings – from tradition to innovation, Alley of Science, Vol. 6, No. 4 (20), pp. 95-99. , 2018
[12] S-A.Yu. Murtazaev, M.Sh. Salamanova, R.G. Bisultanov, "High-quality modified concretes using a binder based on a reactive active mineral component," Construction materials, No. 8, pp. 74-80, 2016.