

Water-Reducing and Plasticizing Additives for Highly Mobile Concrete Mixtures

Saidumov M.S.

Faculty of Civil Engineering
Grozny State Oil Technical University named after
Academician M.D. Millionshtchikov
Grozny, Russia
saidumov_m@mail.ru

Murtazaeva T.S-A.

Faculty of Civil Engineering
Grozny State Oil Technical University named after
Academician M.D. Millionshtchikov
Grozny, Russia
tomamurtazaeva@mail.ru

Salamanova M.Sh.

Division for Materials Science.
Kh. Ibragimov Complex Institute of the Russian Academy
of Sciences
Faculty of Civil Engineering
Grozny State Oil Technical University named after
Academician M.D. Millionshtchikov
Grozny, Russia
madina_salamanova@mail.ru

Alaskhanov A.Kh.

Faculty of Civil Engineering
Grozny State Oil Technical University named after
Academician M.D. Millionshtchikov
Grozny, Russia
uspek@ro.ru

Ismailova Z.Kh.

Faculty of Civil Engineering
Grozny State Oil Technical University named after Academician M.D. Millionshtchikov
Grozny, Russia
Ismailova-Z-H@mail.ru

Abstract – The paper presents the results proving the possibility of using the super-plasticizer of the type «Linamix PC» in highly mobile and cast concrete mixes for the production of high-strength concrete. The paper gives results of raw materials tests for the preparation of monolithic compositions of high-strength concrete and a comparative assessment of the quality indicators of chemical additives-water additives for concrete mixes and concrete. The water-reducing and plasticizing effect from the use of chemical additives from various manufacturers was of great attention. The paper proves that the additive «Linamix PC» has a high stability of the « water-binder-plasticizer» system, good mixture viscosity and persistence; it has a significant retarder effect, which explains the good persistence of concrete mixtures obtained on its basis. Experimental work was carried out in testing laboratories of the Scientific and Technical Center « Modern building materials and technologies» of the GSOTU named after Acad. M.D. Millionshtchikov.

Keywords – concrete mix; concrete admixtures; superplasticizer; water-reducing effect; plasticizing effect; high mobility; sludge cone; cement savings.

I. INTRODUCTION

To the issues of rational use of raw components of concrete, in particular, to save the most expensive component of it - a binder, concrete technology pays great attention [1-3, 5, 8]. Such solutions in most cases are associated with the use of

modern chemical additives with plasticizing, water reducing and cement saving effects [4, 6, 7–10].

Water-reducing effect obtained by the use of concrete mixtures in special dewatering additive mixture allows obtain the desired remolding effort with reduced water consumption.

In accordance with the literature data [4–9, 11–15], the highest rheological and water reducing activity of plasticizing agents is shown in low water consumption binders (LWCB), i.e. when grinding dry plasticizer in high dosages together with cement clinker (cement). In this case, the water-reducing capacity of the additive in the composition of the LWCB may be increased using ultra-fine mineral powders (fillers) [16-20].

II. METHODS AND MATERIALS

In accordance with SCS 24211-2008, the superplasticizer « Linamix PC» and the hardening retarder « Linamix RS », the hyperplasticizer «MC-PowerFlow» and the superplasticizer «Sika ViscoCrete 5-600 SK » were used in the work (Tables 1–3).

TABLE I. TECHNICAL DESCRIPTION OF THE «LINAMIX PC» ADDITIVE

Indicator	Value of the indicator
The name of the additive	Linamix PC
Type of additive	retarder superplasticizer
Raw material basis	polyoxyethylene polymethacrylic acid derivatives
Delivery form	liquid
Colour	brown
Density, g/sm ³	1,03-1,08
pH – indicator, units not less	8,0±1
Storage temperature	from +5°C to + 35 °C
Dosage,% by weight of cement	0.3-2.5

TABLE II. TECHNICAL DESCRIPTION OF THE «MC-POWERFLOW» ADDITIVE.

Indicator	Value of the indicator
Base additive	Polycarboxylate
Colour additive	Brown liquid
Density, g/sm ³	1,3-1,09
pH – indicator, units not less	6,5
Storage temperature	from +5°C to + 35 °C
Dosage,% by weight of cement	0.2-5.0

TABLE III. TECHNICAL DESCRIPTION OF THE «SIKA VISCOCRETE 5-600 SK» ADDITIVE.

Indicator	Value of the indicator
Base additive	Aqueous compositions modified polycarboxylate
Colour additive	Turbid liquid with a shade of yellow
Density, g/sm ³	1,055-1,085
pH – indicator, units not less	4-6
Storage temperature	from +5°C to + 35 °C
Dosage,% by weight of cement	0.4-1.8

According to the test results of the above plasticizers, we have the following dependencies (Figure 1).

The test results showed that the most effective plasticizer is the «MC-PowerFlow» superplasticizer, which allows you to increase the mark on the remolding effort of the concrete mix from P1 to P5. The recommended dose for this type of additive is set to 2.0-2.5% by weight of cement, since a further increase in the additive does not lead to a strong increase in the mobility of the mixture. In addition, an increase in the consumption of additives more than 2.5% by weight of cement leads to the formation of small bubbles in the concrete mix, however, this effect fades within 30 minutes. since the preparation of the mixture.

Other additives have also proven effective -« Linamix PC» and «Sika ViscoCrete 5-600 SK». However, the effect of the formation of bubbles with an increase in the proportion of the additive in «Sika ViscoCrete 5-600 SK» was longer than that of the super-plasticizer «MC-PowerFlow». In addition, the additives of « Linamix PC» and «Sika ViscoCrete 5-600 SK» have a very strong dependence of the mobility of the mixture on the amount of water in it.

Despite the fact that the addition of «Linamix PC» is inferior in terms of the plasticizing effect to the additives« Sika

ViscoCrete 5-600 SK» and «MC-PowerFlow», it is distinguished from the latter by the high stability of the water-binder-plasticizer system, good viscosity of the mixture and persistence. The additive « Linamix PC» has the effect of a moderator, which explains the good persistence of the concrete mixtures obtained on its basis.

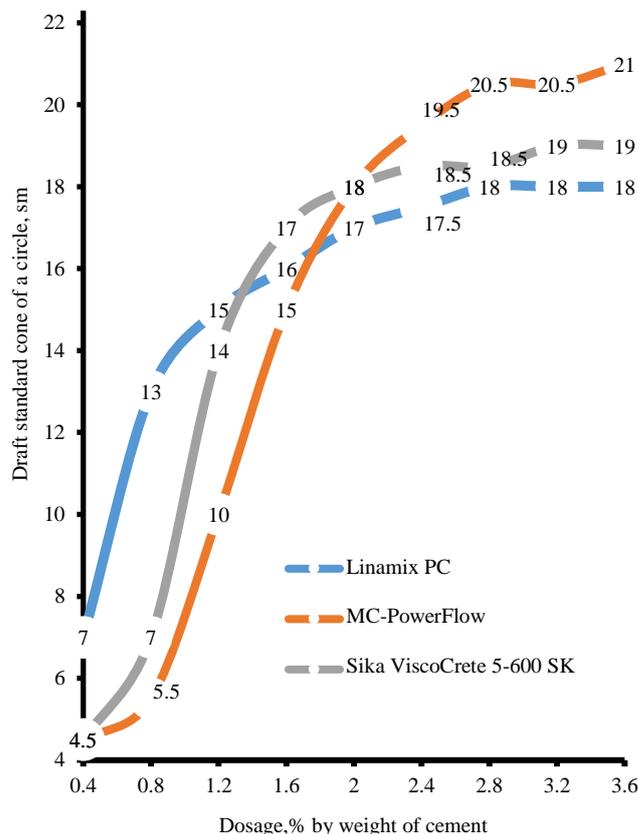


Fig. 1. The plasticizing effect of the use of chemical additives from various manufacturers.

Since comparative studies of additives, the results of which are presented in the preceding paragraphs, showed the effectiveness of the plasticizer «Linamix PC» in comparison with the additives of other manufacturers, in further tests we used this additive with an average consumption per one m3 of concrete mix for 1.1% of masses of cement.

To achieve the goal and solve the problems of integrated use of local natural and manufactured raw materials, we carried out research in testing laboratories of the Scientific and Technical Center of State Enterprise «Modern building materials and technologies » of GSOTU.

We use mainly local raw materials in the work:

- The natural sand of the Chervlensky field of the Chechen Republic with the following characteristic used as fine aggregate: gradation factor M_{cr} = 1.8-1.9; porosity - 40.8%; the content of dust and clay particles

- 1.7-1.9%; density pist. = 2617 kg/m³; density pnas. = 1512 kg/m³;

- Local crushed gravel of 5-20 mm from the Argunsky and Sernovodsky fields of the Chechen Republic and imported crushed gravel of the 5-20 mm fraction from granite-dabase rocks of the Alagirsky field of the RNO-Alania used as coarse aggregate;
- As a binder in experimental studies we used additive-free portland cement brand PC 500 D0 of «Chehencement» production (Chechen Republic, v. Chiri-Yurt) with NG = 25,5 %, specific surface 3252 sm²/g, water segregation ≤ 18 % and setting up time 2 h 15 min (beginning) и 3 h 40 min (ending), mineralogical composition: C₃S = 59 %; C₂S = 16 %; C₃A = 8 %; C₄AF = 13 %.

III. RESULTS

The basic additive-free concrete composition, relative to which the experimental compositions with the addition of «Linamix PC» were designed, was as follows: cement – 520 kg, break stone - 1200 kg, sand - 600 kg, W/C = 0.55.

The test results showed that the use of the super-plasticizer «Linamix PC» allows obtain a significant water-reducing effect (Figure 2), which allows reducing the consumption of mixing water to 25-30%. At the same time, the W/C of concrete mixes can be reduced to values of 0.33–0.35, which is very important for high-quality and high-strength concretes requiring low W/C-ratios.

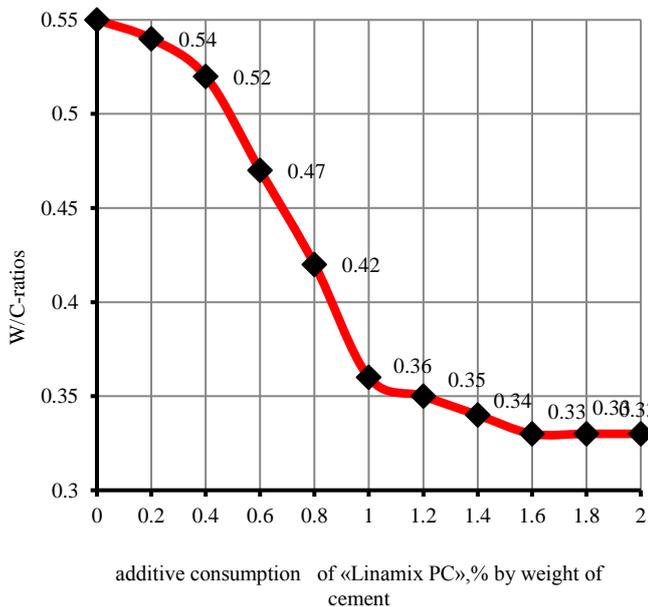


Fig. 2. Water-reducing effect from the use of the super-plasticizer «Linamix PC» in the concrete mix of the grade on the draft of the cone P3 (CC = 10-15 sm).

The plasticizing effect of the «Linamix PC» superplasticizer, which allows obtaining highly mobile mixtures at low W/C values, is presented in Figure 3 as a graph.

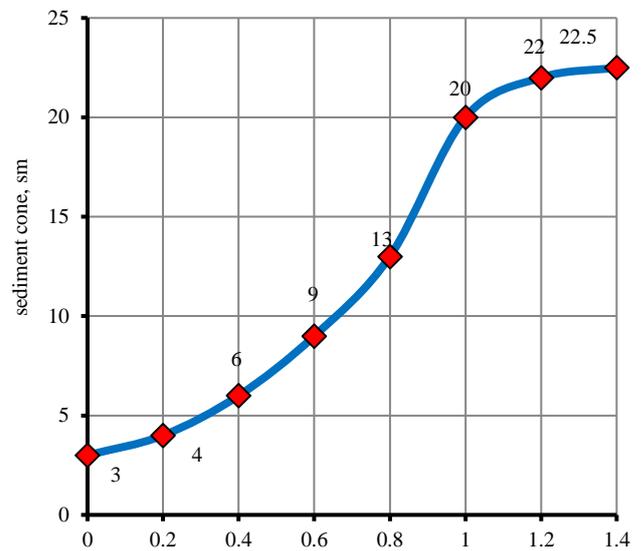


Fig. 3. The plasticizing effect of the application of the use of super-plasticizer «Linamix PC» in the concrete mix.

The optimal dosage of the plasticizer «Linamix PC» set its flow rate in the range of 1.0-1.2% by weight of cement. A further increase in the consumption of the additive did not lead to a noticeable improvement in the workability of the concrete mix and, thus, it was not economically feasible.

Table 4 shows the cement-saving effect of the «Linamix PC» additive we obtained in concrete of various classes.

TABLE IV. INDICATIVE CEMENT-SAVING EFFICIENCY OF ADDITION «LINAMIX PC» IN EQUAL-MOBILE CONCRETE OF VARIOUS CLASSES

№	Class (grade) of concrete	Mark concrete mix CC	The dosage of the additive «Linamix PC», % by weight of cement	Cement-saving effect from the use of additives, %
1	C40 (M500)	P1	1,0-1,1	16-18
		P2		14-16
		P3		12-15
		P4		9-12
		P5		5-10
2	C45 (M600)	P1	1,0-1,2	18-21
		P2		17-18
		P3		13-17
		P4		10-14
		P5		8-11
3	C50 (M700)	P1	1,1-1,4	23-26
		P2		20-23
		P3		17-20
		P4		15-17
		P5		10-15

As can be seen from the calculations (Table 4), the total cement-saving effect from the use of the additive «Linamix PC» is 20% or more. Moreover, this effect increases with the transition to concrete of higher classes. Naturally, with the transition to higher classes of concrete, the proportion of the

additive «Linamix PC» increases relative to the consumption of cement, which contributes to a greater effect.

In addition, we investigated the dynamics of the strength of concrete, obtained using the super-plasticizer «Linamix PC». We know [13–15, 21–25] that this indicator of concrete plays an important role in monolithic construction, where the rates of removal of structures and their subsequent concreting depend on the dynamics of strength set. Thus, according to the regulatory documentation, it is necessary to provide a set of stripping strength of concrete, including during winter concreting for floors 80% of the required for the project, for columns - 50-60%. Modern chemical additives can provide a sufficiently high strength at an early age (1–3 days) without a significant increase in the cost of concrete itself [26–32].

Curves of the dynamics of strength set-up of control concrete and concrete without superplasticizer «Linamix PC» are in Figure 4.

The strength class of the designed concretes was C45 (M600) with the required minimum strength of 58.9 MPa.

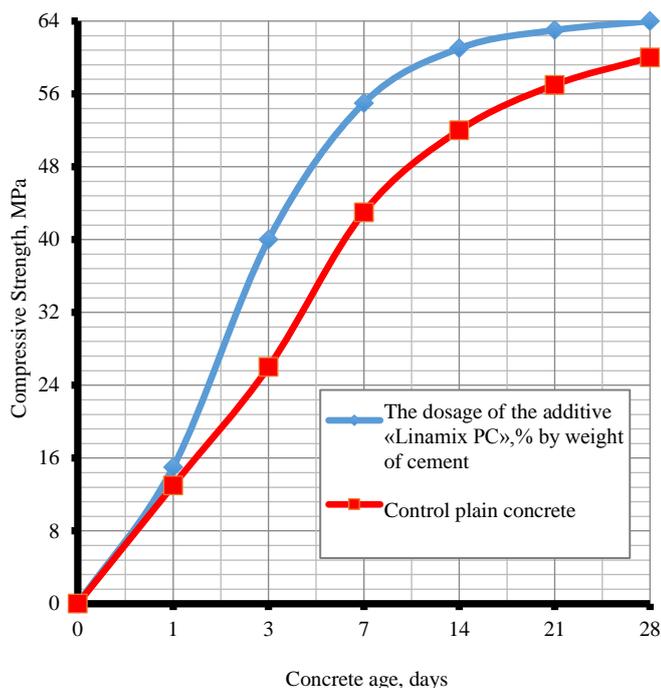


Fig. 4. The dynamics of the strength of concrete with a superplasticizer «Linamix PC».

As we can see on the graph, the strength of concrete with the addition of «Linamix PC» at the age of 3 days gains already about 65% of the design strength, when this indicator for the control composition is slightly over 40%. At the age of 7 days, the additive «Linamix PC» provides strength over 90% of the design, which is 1.4 times the strength of the control composition.

IV. CONCLUSION

Thus, we can conclude that when using the «Linamix PC» superplasticizer is possible to obtain highly mobile and cast concrete mixes for high-strength concrete.

The results of tests of raw materials for the preparation of monolithic compositions of HSC are presented. A comparative assessment of the quality indicators of chemical additives-water additives for concrete mixes and concrete. The water-reducing and plasticizing effect from the use of chemical additives from various manufacturers was investigated.

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