

# Regulation of Persistence (Viability) of Concrete Mixtures Using Modern Plasticizing Agents

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**Abstract** – The paper presents the results of studies the role of modern chemical, mineral and micro-reinforcing additives in the process of structure formation of high-strength concrete. The paper reveals the features of the structure formation of cement stone in the presence of a superplasticizer. The paper experimentally proves that, according to the test results, the best performance on the persistence of concrete mixtures has a superplasticizer «Linamix PC» while this additive has the lowest consumption (1.1% by weight of cement). The specified grade for workability on this type of additive is maintaining for 4-5 hours, and the mixture becomes stiff after 7 hours of mixing, while the concrete grade (P5) is lost after 3 hours. It has been established that the persistence of concrete mixtures can be increased up to 8-10 hours by using the “Linamix RS” additive jointly with the “Linamix PC” superplasticizer slowing down the mixture hardening rate by 2 times or more, which is very important in continuous monolithic concreting at various construction sites.

**Keywords** – concrete mix; additives to concrete; plasticizer; plasticizing effect; high mobility; hardening inhibitor; viability of concrete mixes; persistence.

## I. INTRODUCTION

The proportion of the liquid phase in concrete mixtures can be reduced to the level of the normal density of the used binders using special additives dewatering – liquefier [1-6]. First, such superplasticizer additives (SP) are used in high-strength concrete technology [7, 8]. From various sources, we know [13–18] that in the 1990s in the USA almost all prestressed structures were made using SP, when in 1983 it was only 65%.

SPs abroad are subject to strict requirements not only for the rheological parameters of the additive but also for the minimal impact on cement hydration processes in the early stages of its hardening, i.e. without slowing down the process of concrete strength development [19, 29]. This is very important with the technology of monolithic construction using sliding formwork. We know that modern plasticizers can produce concrete with strength at the age of 1 day up to 50-60% of the normative [20, 21]. We hope that in our country the technology of superplasticizers will develop in this direction.

Plasticizers used in various countries include various compounds of lignosulfonates, sulfonated melamine formaldehyde resins, naphthalene sulfonic acid and formaldehyde [9-12, 22-25]. However, in the Russian market very few plasticizers meet European requirements. S-3, 10-03, 40-03, SMF, SMD and their varieties are distinguished from the widely used domestic plasticizers. Domestic plasticizers are inferior to European additives in terms of the strength of concrete on the first day after preparation, more than providing the required concrete rheology. In this regard, it is uncommon to additionally use various polyfunctional additives in the form of surfactants (SAS), accelerator additives, corrosion inhibitors, etc., which significantly complicates the technology of monolithic concrete and increases its cost price [26, 27]. In addition, many additives require special conditions of storage, transportation and dispensing, require special conditions of storage, transportation and dispensing.

When producing concrete with a high early daily strength, it is important to use plasticizers not based on air-entraining, water-repellent components, but additives with an accelerator effect. Such plasticizers preserve the mobility of the concrete mix for the period of concreting (4-6 hours), and then contribute to an intensive set of concrete strength [29, 30].

Plasticizing, water-reducing and cement-saving effects of superplasticizers, as it is known, can be enhanced by applying various technological methods of their introduction into the concrete mix: separate mixing, two- and multi-stage mixing, etc., as well as through their combined use with mineral fillers of different origin. Such micro fillers, as a rule, are obtained from various rocks, as well as from manufactured raw materials in the form of concrete scrap, brick fights, ash and slag mixtures, etc.

However, not all rocks are suitable for the production of fillers for high-strength concrete. So, the mineral fillers from the flask, tripoli, and diatomite cannot be used in HSC due to their increased water demand, high porosity and poor liquefaction in the presence of superplasticizer.

Therefore, it is important to choose the right raw materials for the production of finely ground filler for HSC [30, 32].

The production of finely ground filler suitable for the production of HSC is of great interest from manufactured waste, the issue of disposal of which is very important throughout the world. Since manufactured waste (or manufactured raw materials, secondary raw materials) are formed all over the world so much that in some sources of literature they are designated as new fields. In the Chechen Republic, concrete broken materials and crushed bricks, demolition of buildings and structures, ash and slag mixtures, sawmill waste and stone processing, substandard raw materials, etc., have been accumulated in the form of man-made raw materials.

Non-conforming raw materials at reinforced concrete plants in the form of defective products, as well as waste from dismantling buildings and structures, predetermines their use in the technology of concrete and reinforced concrete in the form of fine aggregate compacting cement stone, since such raw materials as polymineral compositions contain particles of granite, limestone, hydrates clinker minerals (non-hydrated clinker), etc. Thus, in Germany, more than 350 organizations are engaged in the processing and recycling of solid waste with a total volume of more than 50 million tons. Up to 50% of this processed raw material is waste, road reconstruction; about 25% is construction waste and building reconstruction. In general, 94-97% of all waste is disposed of with the production of secondary break-stone of various fractions.

A similar technology was introduced in the UK, where the volume of construction waste recycled at hundreds of enterprises exceeds 30 million tons.

## 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.

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/m<sup>3</sup>; density pnas. = 1512 kg/m<sup>3</sup>.

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-diabase 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 sm<sup>2</sup>/g, water segregation ≤ 18 % and setting up time 2 h 15 min (beginning) и 3 h 40 min (ending), mineralogical composition: C<sub>3</sub>S = 59 %; C<sub>2</sub>S = 16 %; C<sub>3</sub>A = 8 %; C<sub>4</sub>AF = 13 %;

All the MMFs were ground for 5 minutes in the «MV-20-EKS» laboratory vibratory ball mill with a loading volume of 5-6 liters to obtain a specific surface of 450-600 m<sup>2</sup>/kg.

The chemical composition of the feedstock, as well as the macro- and microstructure of the concrete samples was using the dispersion-energy spectrometer (DES) of a Quanta 3D 200i scanning electron microscope with the integrated Genesis Apex 2 EDS microanalysis system from EDAX.

## III. RESULTS

The viability of concrete mixes as an important technological parameter imposed on modern high-quality concrete mixes, is characterized by the preservation of the specified rheological and technological indicators of concrete mixes for a long (specified) time.

So, for example, high rates of workability of concrete mixtures are laid in the technology of monolithic concreting the foundation slab of the 435-meter skyscraper of the MFC «Akhmat-Tauer», (Grozny, the Chechen Republic), where a continuous installation of more than 16,000 m<sup>3</sup> of concrete mix during 3- x days at a speed of about 250 m<sup>3</sup>/h [31].

As shown by the test results (Fig. 1), the best performance on the persistence of concrete mixtures has a superplasticizer «Linamix PC», while this additive has the lowest consumption (1.1% by weight of cement). The specified grade for workability on this additive lasts up to 4-5 hours, and the mixture becomes quite tough after 7 hours of mixing, while the concrete mark (P5) is lost in concrete mixes after 3 hours.

In addition, it was found that the persistence of concrete mixtures can be increased up to 8-10 hours by using the additive «Linamix RS» jointly with superplasticizer

«Linamix RS» which slows down the rate of mixture hardening by 2 times or more, which is very important for continuous monolithic concreting on various objects construction.

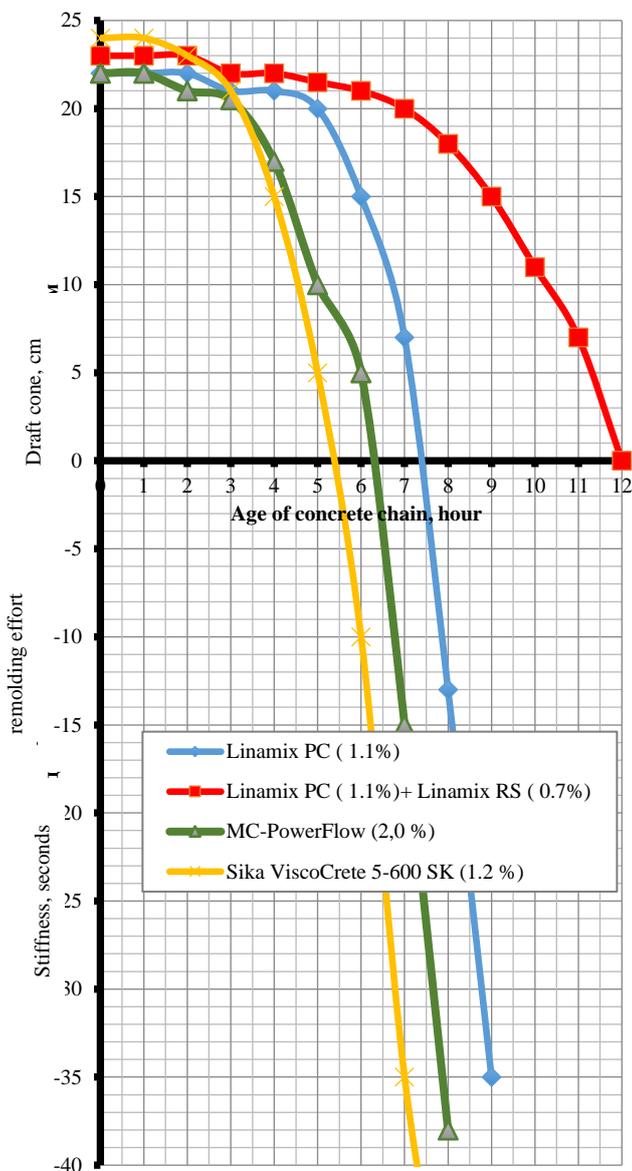


Fig. 1. The dependence of the workability parameters of the concrete mix on various plasticizers on its age.

Such an effect of superplasticizers is that colloidal-sized anionic organic substances with a large number of polar groups in the chain create a «steric» repulsion effect adsorbed on cement grains and neoplasms due to the nature of the charges on the surface of the grains of cement and hydrates and the forms of their chains which is the cause of long-term viability of concrete and mortar mixes.

It turns out that the influence of the spatial volume of the plasticizer molecule on the course of a chemical reaction in a concrete mixture can prevent the dispersing of the binder particles from coming together and slow down the cement hydration reaction, making it temporarily «impossible». This mechanical effect of superplasticizers significantly increases the workability of concrete or mortar mixes.

However, the «steric» repulsion effect in concrete mixtures, as shown by tests, persists only for 3-4 hours after the introduction of superplasticizer. After the phenomenon of the «steric» effect of repulsion of particles of the additive dies out, in the resulting coagulation structure of the concrete mix, the structure formation and hardening of the concrete accelerates. This fact explains that the adsorption layer of the plasticizer on the surface of the cement grains is permeable to water, and the defloculatory effect of surfactants (SAS) promotes the formation of open zones for the contact of cement and water, which leads to an increase in the number of hydrate tumors in the mixture (Figure 2)

The use of superplasticizers in concrete and mortar mixes, the basis of which are expensive synthetic polymeric substances should be both technically and economically beneficial.

#### IV. CONCLUSION

Thus, the above-mentioned fillers differ in structure, chemical activity and composition from silica fume and require further study of their reactivity and study of their role in the formation of early and standard (final) strength of concrete and mineral fillers of manufactured origin. They form during the utilization concrete broken materials and crushed bricks, brick manufacturing and they have not been practically studied.

It is important to investigate these mineral powders for their use in high-quality concrete, to study their water-holding capacity, hydraulic activity, the effect on the basic properties of both concrete mixes and concrete because of the Chechen Republic. There where hundreds of thousands tons of waste dismantling of buildings and structures in the form of concrete broken material and crushed brick, the rational use of which will give a significant socio-technical, ecological and economical effect.

However, despite the high cost, concretes modified with such surfactants (SAS) are quite effective, since the savings of the binder in them can reach over 40-60 kg/m<sup>3</sup> of concrete. At the same time, the use of plasticizing additives allows the use of highly mobile (cast, self-compacting, etc.) concrete mixes, which leads to a noticeable reduction in labor costs and, as a consequence, to an improvement in working conditions of production.

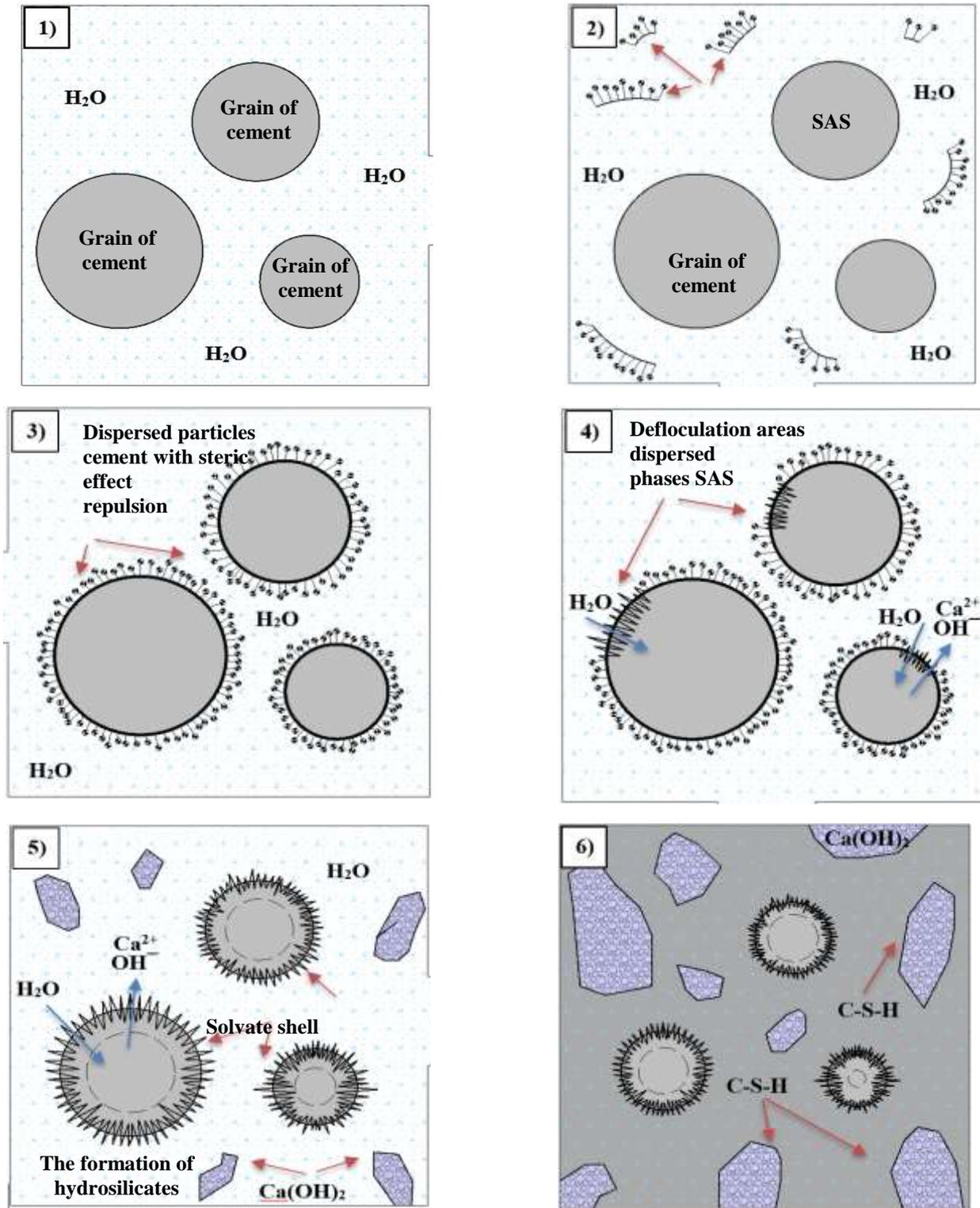


Fig. 2. The mechanism of action of superplasticizers: C-S-H - new growths in the concrete mix - hydrosilicates  $3CaO \cdot 2SiO_2 \cdot 3H_2O$  and other minerals ; 1 – grains of cement in the liquid phase (the first minutes after mixing the mixture with water); 2 - the beginning of the process of dispersion of cement grains with fine particles of the dispersed phase of surfactant; 3 - the period of «steric» repulsion effect of completely dispersed particles of cement (within 2-4 hours after mixing the mixture with water); 4 - deflocculatory action of surfactants (SAS), contributing to the formation of open zones on the surfaces of grains of cement for contacting the binder and water — the beginning of the hydration of cement with the formation of a gel coat on the cement grains; 5 - layer-by-layer hydration of cement with the formation of all-new gel (solvation) layers on the surface of its grains after osmotic destruction of the initial shell, the formation of wavy and columnar structures on the surface of the grains and in the pores of the cement stone; 6 - growth of hydrosilicates  $3CaO \cdot 2SiO_2 \cdot 3H_2O$  consolidation of the structure of cement stone during the subsequent hydration of cement.

## References

- [1] Yu.M. Bazhenov, B.C. Demianova, Modified high-quality concretes. Moscow: Publishing Association of the building universities, 2006, 368 p.
- [2] S.A. Udodov, "Re-introduction of plasticizer as a tool for controlling the mobility of a concrete mix", Scientific works of the Kuban State Technological University, no. 9, pp. 175–185, 2015.
- [3] Yu.M. Bazhenov, S-A.Yu. Murtazaev, M.S. Saidumov, Construction composites based on concrete broken materials and crushed bricks. Grozny: Publishing and printing complex "Grozny worker", 2014, 334 p.
- [4] V.S. Lesovik, D.Iu. Popov, E.S. Glagolev, "Textile-concrete – an effective reinforced composite of the future", Construction materials, no. 3, pp. 81–84, 2017.
- [5] S-A.Yu. Murtazaev, D.K-S. Bataev, Z.Kh. Ismailova, Fine-grained concretes based on recycled fillers. Moscow: Comtechprint, 2009, 142 p.
- [6] Iu.M. Bazhenov, L.A. Alimov, V.V. Voronin, Concrete technology, building products and structures. Moscow: Publishing house ACB, 2008, 350 p.
- [7] Iu.M. Bazhenov, D.K-S. Bataev, Kh.N. Mazhiev, "Fine-grained concretes from recycled materials for the repair and restoration of damaged buildings and structures. Grozny: IE "Sultanbegova Kh.S.", 2011, 342 p.
- [8] D.K-S. Bataev, M.S. Saidumov, T.S-A. Murtazaeva, "Formulations of high-strength concrete on technogenic and natural raw materials", Actual problems of modern construction science and education, pp.109–117, October 2017 [All-Russian scientific-practical conference dedicated to the 60th anniversary of the Faculty of Civil Engineering FSBEU "GSNTU named after Academician M.D. Millionshtchikov", 460 p., 2017].
- [9] S.S. Kapriolov, N.G. Bulgakova, "High-strength pneumo-concrete with the addition of microsilica for protective coatings", Concrete and reinforced concrete, no. 5, pp. 7–8, 1993.
- [10] B.C. Lesovik, S-A.Yu. Murtazaev, M.S. Saidumov, Construction composites on the basis of screenings of concrete broken materials and rocks. Grozny: Typography, 2012, 192 p.
- [11] M.I. Afonina, E.V. Kozyreva, "Features of the construction of sports facilities in the territories of the former industrial area", Days of student science, pp. 390–392, 2017 [Scientific and Technical Conference on the results of research works of students of the Institute of Construction and Architecture 488 p., 2017].
- [12] E.M. Shcherban, S.A. Stelmakh, A.K. Khaliushev, "Development of pozzolan cement composition on volcanic tuff", Building. Architecture. Economy, pp. 110–113, 2018 [International Forum "Victorious May", 258 p., 2018].
- [13] V.S. Demianova, A.D. Gusev, Effective use of construction materials with man-made waste. Pensa: PSGAC, 2013, 127 p.
- [14] R. Lermitt, Concrete Technology Problems. Moscow: Publishing house LKI, 2007, 296 p.
- [15] Iu.M. Bazhenov, Concrete technology. Moscow: ACB, 2011, 500 p.
- [16] S.A. Stelmakh, E.M. Shcherban, K.V. Serdiukov, "The influence of some characteristics of coarse aggregate used on the properties of heavy concrete, intended for the manufacture of centrifuged products and structures", Bulletin of Belgorod State Technological University, no. 10, pp. 15–20, 2017.
- [17] I. Korianova, N.E. Reztantsev, 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.
- [18] A.A. Soldatov, A.V. Galych, I.V. Sariev, "Experience of using sodium silicate as a binder in the production of building material", Actual problems of construction, transport, engineering technosphere safety, pp. 186–188, 2016 [the IVth annual scientific-practical conference of the North Caucasus Federal University, 254 p., 2016].
- [19] B.A. Usov, Physical and chemical processes of building materials science in concrete and reinforced concrete technology. Moscow: Publishing MGOU, 2009, 326 p.
- [20] S.A.Yu. Murtazaev, M.Sh. Salamanova "Clinker-free binders based on finely dispersed mineral components", Ibausil conference proceedings, vol. 2, pp. 707–714, 2018 [Ibausil conference, 997 p., 2018].
- [21] M. Salamanova, M. Khubaev, M. Saidumov, T. Murtazayeva, "Self-Consolidating Concretes with Materials of the Chechen Republic and Neighboring Regions", International journal of environmental & science education, vol. 11, no. 18, pp. 12719–12724, 2017.
- [22] V.S. Lesovik, N.I. Alfimova, P.V. Trunov, "Reduction of energy consumption in manufacturing the fine ground cement", Research Journal of Applied Sciences, vol. 9, iss. 11, pp. 745–748, 2014.
- [23] S-A.Y. Murtazaev, Sh.Sh. Zaurbekov, A.Kh. Alaskhanov, M.S. Saydumov, T.S-A. Murtazaeva, M.R. Khadzhev, "Impact of Technogenic Raw Materials on the Properties of High-Quality Concrete Composites", International Symposium "Engineering and Earth Sciences: Applied and Fundamental Research" (ISEES 2018). Advances in Engineering Research, vol. 177, pp. 275–279, 2018.
- [24] V.S. Lesovik, L.K. Zagorodnyuk, A.E. Mestnikov, A.I. Kudinova, D.A. Sumskoj, "Designing of mortar compositions on the basis of dry mixes", International Journal of Applied Engineering Research, vol. 10, iss. 5, pp.12383–12390, 2015.
- [25] S-A.Y. Murtazaev, M.Sh. Mintsaeve, S.A. Aliev, M.S. Saydumov, "Strength and Strain Properties of Concrete, Comprising Filler, Produced by Screening of Waste Crushed Concrete", Published by Canadian Center of Science and Education. Received, vol. 9, no 4, pp. 32–44, 2015.
- [26] D.K-S. Bataev, A.A. Uzaeva, S.A. Uzaeva, M.A. Uzaev, T.A. Tuzurkaeva, "The Study of Shrinking Deformations of Repair Compositions on Barkhan Sands", International Symposium on Engineering and Earth Sciences (ISEES 2018) Advances in Engineering Research, vol. 177, pp. 254–257, 2018.
- [27] S-A.Yu. Murtazaev, D.K-S. Bataev, Z.Kh. Ismailova, Fine-grained concretes based on secondary raw materials. Moscow: Comtechprint, 2009, 142 p.
- [28] S-A.Yu. Murtazaev, D.K-S. Bataev, M.Sh. Salamanova, Extruded fine-grained cement concrete on a modified aggregate: a scientific publication. Grozny: Publishing and Printing Complex "Grozny Worker", 2014, 160 p.
- [29] Iu.M. Bazhenov, Concrete technology. Moscow: ACB, 2011, 500 p.
- [30] S.A. Aliev, S-A.Yu. Murtazaev, M.Sh. Salamanova, "The use of waste from the development of volcanic tuff to produce modern concrete composite", Ecology and Industry of Russia, vol. 21, no. 4, pp. 32–35, 2017.
- [31] G.V. Nesvetaev, A.V. Nalimova, G.V. Chmel, "Evaluation of the effectiveness of superplasticizers for high-strength and high-quality concretes", Izvestia of HEE.Construction, no. 9, pp. 38–41, 2003.
- [32] S.S. Kapriolov, A.V. Sheinfeld, I.A. Arzumanov, Technological regulations for the production of concrete work during the construction of the foundation slab of the high-altitude part of the multifunctional complex "Akhmat Tower". Moscow, 2016. 60 p.
- [33] T.A. Khezhev, A.R. Kazharov, A.V. ZHurtov, "Self-compacting fine-grained fiber concretes with the use of waste stone crushing", Don Engineering Bulletin, no. 1, 2017. Retrieved from: [ivdon.ru/magazine/archive/n1y2017/4018/](http://ivdon.ru/magazine/archive/n1y2017/4018/)