

MUHANDISLIK

& IQTISODIYOT

№3

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

2026
MART



Milliy nashrlar

OAK: <https://oak.uz/pages/4802>

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08.00.00 - Iqtisodiyot fanlar



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ISSN: 3060-463X

РЭУ.РФ
РОССИЙСКИЙ ЭКОНОМИЧЕСКИЙ УНИВЕРСИТЕТ
ИМЕНИ Г.В. ПЛЕХАНОВА
ТАШКЕНТСКИЙ ФИЛИАЛ



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ijtimoiy-iqtisodiy, innovatsion texnik,
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Elektron nashr, 2026-yil, mart.

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- 05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
- 05.01.03 – Informatikaning nazariy asoslari
- 05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
- 05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
- 05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
- 05.01.07 – Matematik modellashtirish
- 05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
- 05.02.00 – Mashinasozlik va mashinashunoslik
- 05.02.08 – Yer usti majmualari va uchish apparatlari
- 05.03.02 – Metrologiya va metrologiya ta'minoti
- 05.04.01 – Telekommunikatsiya va kompyuter tizimlari, telekommunikatsiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
- 05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
- 05.05.05 – Issiqlik texnikasining nazariy asoslari
- 05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
- 05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
- 05.08.03 – Temir yo'l transportini ishlatish
- 05.08.06 – "G'ildirakli va gusenisali mashinalar va ularni ishlatish" (texnika fanlari)
- 05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
- 05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
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- 08.00.13 – Menejment
- 08.00.14 – Iqtisodiyotda axborot tizimlari va texnologiyalari
- 08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
- 08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
- 08.00.17 – Turizm va mehmonxona faoliyati

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THE ROLE OF SUPERPLASTICIZERS IN REDUCING WATER DEMAND AND ELIMINATING EXTERNAL CURING IN CONCRETE

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Abstract. This paper presents a comprehensive study on the influence of the latest-generation superplasticizers and hyperplasticizers on the physical, mechanical, and operational characteristics of concrete mixes. Special attention is paid to the comparative analysis of dispersion mechanisms: from the electrostatic repulsion of lignosulfonates and naphthalene sulfonates to the steric stabilization effect of polycarboxylate-based admixtures. The research demonstrates that optimizing particle distribution allows for a radical reduction in the water-cement ratio while maintaining high workability and pumpability. A key aspect of the study is the evaluation of internal self-curing technologies. By forming a highly dense microstructure and utilizing specialized organomineral components, the necessity for traditional external moisture curing is minimized. The results confirm that the integrated use of chemical admixtures significantly improves the durability of monolithic structures, reduces plastic and drying shrinkage, and increases resistance to aggressive environmental factors.

Keywords: monolithic concrete, lignosulfonates, naphthalene sulfonates, polycarboxylates, hyperplasticizers, superplasticizers, organomineral materials.

Annotatsiya. Ushbu maqolada so'nggi avlod superplastifikatorlari va giperplastifikatorlarining beton aralashmalarining fizik-mexanik hamda foydalanish xususiyatlariga ta'siri bo'yicha keng ko'lamlı tadqiqot natijalari keltirilgan. Asosiy e'tibor dispersiyalanish mexanizmlarining qiyosiy tahliliga qaratilgan: lignosulfonatlar va naftalinsulfonatlarining elektrostatik itarilishidan tortib, polikarboksilat asosidagi qo'shimchalarning sterik barqarorlashuv effektigacha. Tadqiqot shuni ko'rsatadiki, zarralar taqsimotini optimallashtirish aralashmaning yuqori ishlov beruvchanligini saqlab qolgan holda suv-sement nisbatini keskin kamaytirish imkonini beradi. Ishning muhim jihati ichki o'z-o'zini namlash (parvarishlash) texnologiyalarini baholashdan iborat. Beton strukturasi o'ta zichligini shakllantirish va maxsus organomineral komponentlarni qo'llash orqali an'anaviy tashqi namlashga bo'lgan ehtiyoj minimallashtiriladi. Olingan ma'lumotlar kimyoviy qo'shimchalardan kompleks foydalanish monolit konstruksiyalarning chidamliligini sezilarli darajada oshirishini, plastik va gidravlik qisqarishni kamaytirishini hamda agressiv muhit ta'sirlariga chidamliligini oshirishini tasdiqlaydi.

Kalit so'zlar: monolit beton, superplastifikatorlar, giperplastifikatorlar, polikarboksilatlar, lignosulfonatlar, naftalinsulfonatlar, ishlov beruvchanlik, o'z-o'zini parvarishlash, qisqarish deformatsiyalari, organomineral materiallar.

Аннотация. В данной статье представлено комплексное исследование влияния суперпластификаторов и гиперпластификаторов последнего поколения на физико-механические и эксплуатационные характеристики бетонных смесей. Особое внимание уделено сравнительному анализу механизмов диспергации: от электростатического отталкивания лигносульфонатов и нафталинсульфонатов до эффекта стерической стабилизации добавок на основе поликарбоксилатов. Исследование доказывает, что оптимизация распределения частиц позволяет радикально снизить водоцементное отношение при сохранении высокой удобоукладываемости и прокачиваемости смеси. Ключевым аспектом работы является оценка технологий внутреннего самовысыхания (самоухода). За счёт формирования сверхплотной микроструктуры камня и применения специальных органоминеральных компонентов минимизируется необходимость традиционного внешнего увлажнения бетона. Полученные данные подтверждают, что комплексное использование химических добавок существенно повышает долговечность монолитных конструкций, снижает пластическую и гидравлическую усадку, а также увеличивает стойкость к агрессивным воздействиям среды.

Ключевые слова: монолитный бетон, суперпластификаторы, гиперпластификаторы, поликарбоксилаты, лигносульфонаты, нафталинсульфонаты, удобоукладываемость, самоход, усадочные деформации, органоминеральные материалы.

INTRODUCTION

Concrete is one of the most essential construction materials in modern engineering. However, its production is characterized by significant water consumption. Globally, millions of liters of water are used annually in concrete manufacturing, which represents a serious challenge in a world where water conservation is becoming increasingly important.

Modern innovative solutions, particularly chemical admixtures for concrete produced by companies such as Sika, make it possible to significantly reduce water consumption by improving the workability of concrete mixtures without increasing the water content. The use of superplasticizers and hyperplasticizers based on polycarboxylates enhances the rheological properties of the mixture, lowers the water–cement ratio, and improves the overall performance characteristics of concrete.

Modern concrete admixtures improve the workability of the mixture and reduce the water–cement ratio. This means that less water is required to achieve the same consistency and performance characteristics. For example, certain superplasticizers increase the fluidity of concrete while maintaining its strength and durability, thereby reducing the overall water demand during mixing. It has been reported that the number of pores in cement paste can be reduced by up to 75% through the addition of a superplasticizer or a water-reducing admixture.

By decreasing the required amount of water without compromising the quality of the final product, these admixtures are revolutionizing concrete production.

Reducing the water content in concrete also directly affects its durability. A lower water content in the mixture results in fewer pores in the hardened concrete, making the material denser and more resistant to environmental factors such as chemical attack and freeze–thaw cycles. This not only extends the service life of concrete structures but also reduces environmental impact by conserving water and decreasing the need for repair or replacement over time.

In addition, the incorporation of superplasticizers (SP) significantly increases the compressive strength of foamed concrete. This improvement varies depending on the type and dosage of SP, which is consistent with earlier studies conducted by Manghein [1], who demonstrated an increase in compressive strength for different types of SP at the same water–cement ratio after 28 days. Furthermore, compressive strength improved at the same SP content.

This behavior is attributed to the influence of SP on enhancing the ability of the slurry to optimize and redistribute its larger pores, making them more uniform than before. These findings are consistent with the results reported by Wu [2], who noted that compressive strength increased significantly over time when the SP concentration was raised from 1.0% to 2.0%. Figure 6 illustrates the effect of superplasticizers on compressive strength.

This improvement varies depending on the type and dosage of the superplasticizer (SP), which is consistent with earlier research conducted by Manghein [3], who demonstrated an increase in compressive strength for various types of SP at the same water–cement ratio after 28 days. Furthermore, compressive strength improved for SP of the same type.

This behavior is attributed to the effect of SP on enhancing the paste's capacity, enabling the optimization and redistribution of larger pores, making them more uniform than before. These findings are consistent with



the results reported by Wu [4], who stated that compressive strength increased significantly over time as the SP concentration was raised from 1.0% to 2.0%, illustrating the influence of superplasticizers on compressive strength.

At present, with the continuous acceleration of urbanization, the use of commercial concrete in construction is steadily increasing, and performance requirements for concrete are becoming more demanding. The quality of raw materials used in concrete production has a significant impact on its overall performance. As an important component in the preparation of high-quality concrete, the effective use of water-reducing admixtures can substantially enhance the overall performance characteristics of concrete.

The type of cement, the dosage of water-reducing admixture, water consumption, admixture content, aggregate dosage, and other factors directly or indirectly affect the quality of the finished concrete. Regarding cement types, even cement with the same formulation and grade may exhibit slight differences due to regional variations and manufacturers, which significantly affect the compatibility of water-reducing admixtures and indirectly influence the overall quality of concrete.

When using water-reducing admixtures in high-viscosity concrete, differences in chemical composition among various admixtures result in different performance effects during practical application. Therefore, multiple experimental trials are required to determine the optimal dosage for achieving maximum performance. At the same time, since high-viscosity concrete often contains slag and fly ash, controlling the proportion of raw materials can effectively reduce the problem of bleeding. Thus, in preparing high-viscosity concrete, it is necessary not only to control the amount of fly ash and slag but also to consider the water condition and implement appropriate control measures to improve concrete quality effectively.

Furthermore, concrete possesses a relatively complex structure, which is primarily determined by aggregate shape, mud content, the presence of potentially harmful substances, and particle size distribution. These parameters influence the efficiency of water-reducing admixtures to varying degrees, with mud content being one of the most influential factors. In practical engineering applications, controlling the mud content in aggregates is essential, as it plays a key role in ensuring the effective performance of water-reducing admixtures.

An experimental study was conducted to evaluate the water-reducing performance of a polycarboxylate-based superplasticizer in high-performance concrete. The bridge under investigation has a total length of 500 meters, with the main box girder concrete designed at a strength grade of C50 and a total concreting volume of approximately 15,000 m³. In order to ensure timely project completion, the construction process was carried out under an accelerated schedule. During construction, concrete incorporating polycarboxylate superplasticizers was extensively applied, with the requirement that the compressive strength of prestressed concrete in the main box girder exceed 90% of the design strength. Notably, the construction process took place during winter conditions, which required the implementation of appropriate technological solutions to ensure quality and performance.

Regarding raw materials, cement from different sources may vary in mineral composition, and supplementary materials introduced during production can influence the performance and workability of polycarboxylate-based water-reducing admixtures. Moreover, compliance of cement particles with standard specifications, as well as the controlled content of primary sulfates, plays an important role in ensuring compatibility between cement and admixtures. Enhancing this compatibility represents a promising and important direction for future research.

LITERATURE REVIEW

At the current stage of construction development, where concrete is extensively utilized, conducting high-quality research on polycarboxylate-based water-reducing agents is of particular importance. In this study, ordinary Portland cement (grade 52.5) was selected and tested prior to its application. In addition, fly ash and ground granulated blast furnace slag are commonly used as mineral admixtures in concrete. Fly ash should comply with the requirements of GB/T 1596–2017 “Fly Ash Used for Cement and Concrete.” Since the CaO content in fly ash directly affects the volumetric stability of concrete, the use of high-calcium fly ash is carefully controlled. Slag powder should comply with GB/T 18046–2017 “Ground Granulated Blast Furnace Slag Used for Cement, Mortar and Concrete.” [5]

Based on the above analysis, it can be concluded that, under existing conditions, the performance of concrete containing polycarboxylate-based superplasticizers (water-reducing agents) has significantly improved compared with traditional concrete incorporating conventional admixtures. This advancement has greatly contributed to the successful implementation of large-scale construction projects, including offshore drilling platforms, tunnel construction, and high-rise buildings. [6]

At the same time, further improvements and optimizations remain important to meet the evolving quality requirements of modern engineering practice. Since the beginning of the 21st century, polycarboxylate

superplasticizers have been widely applied in concrete technology and have attracted considerable attention from researchers worldwide. Through extensive experimental studies, researchers have focused on enhancing performance characteristics and improving the synthesis processes of polycarboxylate-based water-reducing admixtures based on fundamental scientific principles. Consequently, research on polycarboxylate superplasticizers has gradually become a key direction in the development of chemical admixtures for concrete. [7]

The compressive strength of concrete in each series of specimens is determined as the arithmetic mean of the strengths obtained from the tested samples within that series. For each strength value, three specimens of each concrete composition were tested to ensure reliability and accuracy of the results.

RESEARCH METHODOLOGY

In this study, an experimental approach was employed to evaluate the effect of polycarboxylate-based superplasticizers on the performance of high-strength concrete. Concrete mixtures were prepared using ordinary Portland cement (grade 52.5), crushed stone, sand, screenings, and chemical admixtures. For each composition, three specimens were tested to determine compressive strength at 7 and 28 days, and average values were calculated. Additionally, key parameters such as density, slump, and water-cement ratio were analyzed to identify optimal mixture proportions and assess the efficiency of the applied admixtures.

ANALYSIS AND RESULTS

As a result of a series of experiments, the optimal proportions of the concrete mixture components were determined (Table 1).

Table 1. Proportions of components per 1 m³ of concrete mix

Cement (kg)	Crushed Stone (kg)	Screenings (Klinets) (kg)	Sand (kg)	BAAS MIX-PLAST 100 (kg)	BAAS RESET-PLAST 5000 (kg)	Water (kg)
390	725	825	280	3.32	1.09	175

As can be seen from Table 1, the reduced sand content is compensated by the use of crushed stone screenings, which contain a certain proportion of fine sand fractions. The screenings also include particles larger than 5 mm, which help fill the gap between the sand and coarse aggregate fractions. As a result, a denser packing of aggregate grains is achieved, with minimal intergranular voids.

Another important factor is that, since 01-05-2024, a moratorium has been introduced on river sand extraction in several rivers of the Republic of Uzbekistan [8]. In this context, the production of fine aggregates from hard rock, as well as the partial or complete replacement of river sand in concrete, has become increasingly relevant and promising.

The physical and mechanical properties of the freshly prepared concrete mix and the hardened concrete are presented in Table 2.

Table 2. Physico-mechanical properties of concrete

Concrete Class/Grade	Slump (cm)	Average Density (kg/m ³)	Compressive Strength at 7 days (MPa)	Compressive Strength at 28 days (MPa)	Achievement of Design Strength at 7 days (%)	Achievement of Design Strength at 28 days (%)
B40 / M500	25	2380–2397	51.70	58.80	101.0	115.0

The results show that the concrete achieved the required design compressive strength already after 7 days of curing. This indicates an intensification of the hardening (hydration) processes, an increase in the packing density of the concrete mixture components, and a reduction in the proportion of macropores in the concrete structure, with a shift toward micropores.

CONCLUSION AND RECOMMENDATIONS

Thus, class B40 concrete was obtained using conventional components in combination with two chemical admixtures. The design strength was achieved after 7 days, which indicates the positive effect of chemical admixtures on cement hydration processes, the appropriate selection of component proportions, and the formation of a denser packing of the solid constituents of the concrete mixture.

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muhandislik **& iqtisodiyot**

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

Ingliz tili muharriri: Feruz Hakimov

Musahhih: Zokir Alibekov

Sahifalovchi va dizayner: Abdurahmon Qurbonov

2026. № 3

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"Muhandislik va iqtisodiyot" jurnali 26.06.2023-yildan
O'zbekiston Respublikasi Prezidenti Adminstratsiyasi huzuridagi
Axborot va ommaviy kommunikatsiyalar agentligi tomonidan
№S-5669245 reyestr raqami tartibi bo'yicha ro'yxatdan o'tkazilgan.

Litsenziya raqami: №095310.

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