ENGINEER

international scientific journal

ISSUE
1, 2024 Vol. 2
ISSN
3030-3893

A bridge between science and innovation

TOSHKENT DAVLAT TRANSPORT UNIVERSITETI
Tashkent state transport university

ENGINEER

A bridge between science and innovation

ISSN 3030-3893

VOLUME 2, ISSUE 1

APRIL, 2024

engineer.tstu.uz

TASHKENT STATE TRANSPORT UNIVERSITY
ENGINEER
INTERNATIONAL SCIENTIFIC JOURNAL
VOLUME 2, ISSUE 1 APRIL, 2024

Founder of the international scientific journal "Engineer" – Tashkent State Transport University, 100167, Republic of Uzbekistan, Tashkent, Temiryo'lchilar str., 1, office: 465, e-mail: publication@tstu.uz.

The "Engineer" publishes the most significant results of scientific and applied research carried out in universities of transport profile, as well as other higher educational institutions, research institutes, and centers of the Republic of Uzbekistan and foreign countries.

The journal is published 4 times a year and contains publications in the following main areas:

- Engineering;
- General Engineering;
- Aerospace Engineering;
- Automotive Engineering;
- Civil and Structural Engineering;
- Computational Mechanics;
- Control and Systems Engineering;
- Electrical and Electronic Engineering;
- Industrial and Manufacturing Engineering;
- Mechanical Engineering;
- Mechanics of Materials;
- Safety, Risk, Reliability and Quality;
- Media Technology;
- Building and Construction;
- Architecture.

Tashkent State Transport University had the opportunity to publish the international scientific journal "Engineer" based on the **Certificate No. 1183** of the Information and Mass Communications Agency under the Administration of the President of the Republic of Uzbekistan. **ISSN 3030-3893.** Articles in the journal are published in English language.

CONTEXT / MUNDARJA

Effect of microsilica supplement on workability and density of equally moveable flow concrete and concrete strength

S.A. Ahmadov[1] [a], D. V. Khaydarova[1] [b], G.A. Suleymanova[1] [c]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: The article examines the possibility of improving the concrete composition, by introducing the component of microsilica, in order to reduce the consumption of cement in concrete and, consequently, its cost. The result of using a mixture based on Portland slag cement (M 400) of Magnitogorsk Cement and Refractory Plant is described. The composition of concrete also included the following: porphyritic gravel GOP MMK fraction 10 - 20 mm; sand river fraction 0,16 - 5 mm; mixing water from the municipal water supply system and microsilica of the Chelyabinsk electrometallurgical plant with SiO2 content of 65- 83.38%. The authors reviewed the effect of microsilica on the strength of equally moveable concrete and the effect of microsilica on the properties of equally moveable mixtures and concrete. It was found that the addition of microsilica in an amount of 5 ... 15% of the weight of cement density of equally mobile, including concrete decreases by 80 ... 85 kg/m3; mix workability decreases from 5 to 0 cm; the strength of the concrete increases by 45 ... 90% – for steamed concrete; and by 19 ... 40% – for concrete hardening in normal conditions.

According to the work results, saving of cement in concrete of B15...B25 class due to the introduction of microsilica may amount to 41 to 183 kg/m3, depending on curing conditions and the properties of concrete mixtures. The authors conclude that there are real prerequisites for the systematic organization of industrial production of new thermal insulation materials on an industrial scale using regional resources.

Keywords: microsilica, concrete mixes, cement, strength, mobility

1. Introduction

Many foreign researchers are engaged in the search for new materials and concreting technologies [1], [2], [3]. A number of foreign researchers, guided by the idea of recycling raw materials, are looking for ways to use unusual materials as additives. It is proposed, for example, to introduce the ash of Khyber-Pakhtunkhwa rice husk (RHA) into the mixture to improve the mechanical properties of cement [4], use rubber fillers [5] and so on. The direction of promising research is the use of new powder-type composite materials in the process of additive construction of residential and public buildings [6]. The strength properties of materials are one of the main indicators of quality and reliability, and calculating the risk of accidents and failure of structural parts in production helps to anticipate and avoid negative consequences [7]. The relevance of the study is due to the development of construction technologies, the search for optimal economic investments and the need to improve them in accordance with the condition of using available regional materials.

2. The main part

The mineral resource base for the production of modern refractories in the region is represented by such raw materials as graphite, magnesite, high-alumina raw materials (in particular, based on minerals of the sillimanite group containing 62.9% Al_2O_3 and 37.1% SiO_2), high-quality natural magnesia silicate raw materials (for example, serpentinites), dolomite (more than 15 deposits), chromites, zircon (more than 10 deposits and ore occurrences containing zircon as the main useful mineral or as a satellite mineral in complex ores), pyrophylite, alumothermal slags [8], [9]. There are real prerequisites for the systematic organization of industrial production of new thermal insulation materials on an industrial scale using regional resources.

Recently, there has been increasing interest in the problem of reducing cement consumption in concrete and, consequently, its cost. One of the ways to reduce the consumption of cement in concrete is to modify it with silica. Russian researchers have established the positive effect of microsilicon on the formation of the structure of expanded clay concrete [10], the use of microsilicon makes it possible to obtain concrete with high performance characteristics and unique structural capabilities from ordinary materials [11]. For example, the use of microsilicon provides the possibility of creating highly efficient thermal insulation using, among other things, shotcrete technology, which has a positive effect on reducing economic costs [12], [13].

Previously, the effectiveness of the addition of silica in concretes of classes B15...B25 with a mark for workable P1 obtained on the basis of slag-portland cement (SHPTS) [14], [15], [16].

The following materials were used in the work:
Slag Portland cement CEM III/A-Sh 32.55 (M 400, SHP 400) Magnitogorsk Cement and Refractory Plant, characterized by the content of C_3S, C_2S, C_3A and C_4AF in clinker – 62.5, 9.4, 8.2 and 13.2%, meeting the requirements

[a] https://orcid.org/0009-0007-0925-0101
[b] https://orcid.org/0009-0000-9528-842X
[c] https://orcid.org/0009-0000-0992-9404

of GOST 31108-2020. The building properties of SHPTS 400 are shown in the table (Table 1).

Table 1

Building properties of SHPTS 400

Residue on the sieve No. 008, %	Normal dough density, %	Setting time, 2 - minutes		Ultimate strength, MPa, atthe age of 28 days.	
		start	end	when bending	in compression
6,6	26,5	3-50	4-30	6,0	398

Porphyritic crushed stone of MMK PJSC of a fraction of 10 - 20 mm.
Sand of the river fraction of 0.16 – 5 mm. The physical and mechanical characteristics of the fillers are presented in the tables (Table 2.3). The properties of crushed stone were determined according to GOST 8269.0-97, sand – according to GOST 8735-88.

Table 2

Physical and mechanical properties of fillers

Aggregate typei	Average density, kg/m3	Bulk density, kg/m3	Voidness b, %	Water content, %	Content% of leshchadny grain content, %	Strength grade
Crushed	stone 2190	1440	50,5	-	30	1000
Sand	2630	1535	41.7	12.1	--	-

The shut-off water from the municipal water supply system meets the requirements of GOST 23732-2011.
Silica from the Chelyabinsk Electrometallurgical Combine with a SiO2 content of 65-83.38%.
The research used concrete compositions with the initial compositions shown in the table (Table 2).

Table 3

Initial compositions of concrete mixtures

Concrete class by strength and compressive	Workability, cm	Material consumption per 1 м^{m3} m3 of mix, kg				C /	Density Concrete mix density, kg / m^3
		C	In	P	/ H		
B15	3-5	286	209	848	1207	1.37	2550
B25	3-5	407	209	734	1200	1.95	2550

Studies of the effect of microsilicon on workability, density of concrete mixtures and strength of concrete were carried out according to two schemes:

microsilicon was introduced into the initial compositions of concrete mixtures in the amount of 0; 5; 10 and 15% by weight of cement;

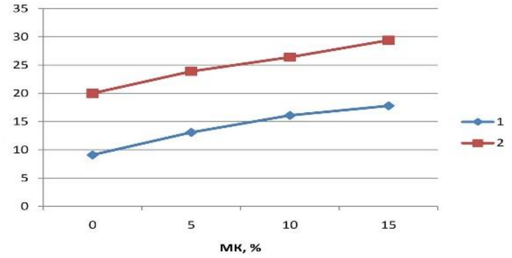

Figure 2. Effect of microsilica on the strength of concrete of class B15:
1 – strength of steamed concrete; 2 – strength of concrete hardening under normal conditions.

Microsilicon was introduced into the initial compositions of concrete mixtures, as well as water and cement were added (while maintaining the water-cement ratio at constant levels) for maintaining workability at a given level (cone draft 3-5 cm).

The concrete mix was prepared by hand. Silica and cement were pre-mixed in a round-bottomed bowl until visible uniformity. The mixing time of the concrete mix components was at least 5 minutes.
The workability and density of the concrete mix were determined according to GOST 10181-2014.

Six cube samples with an edge of 10 cm were formed from each composition of the concrete mixture. The sealing was performed on a standard vibration platform according to the standard mode for 15...20 seconds (in depending on the workability of the concrete mix). The compressive strength was determined according to GOST 10180-2012 on the PGM-500 test press.

To maintain the set parameters of workability and water-cement ratio, with an increase in the addition of silica, the consumption of mixing water and cement was increased. The actual compositions of concrete mixtures with different silica content and their properties are shown in the table (Table 3).

Table 4

The effect of microsilicon on the properties of equally mobile mixtures and concrete

Class concretea		Material consumption per 1 m^3 of mix, kg					Sedimenta conea, cm	Density, kg/m3 Density, kg/m3	Strength, MPa	
		C	MK	V	P	Sch			proparivanie	norm. condition
B15	0	286-209	-	209	848	1207	5	2550	9,1	20,0
	5	290	14,5	212	822	1182	4	2520	13,1	23,9
	10	296	29,6	216	786	1162	4	2490	16,1	26,4
	15	304	45,5	222	750	1153	3,5	2475	17,8	29,4
B25	0	407-209	-	209	734	1200	4	2550	16,5	32,8
	5	419	21,0	215	686	1168	4	2510	24,0	37,5
	10	427	42,7	219	657	1134	4	2480	28,0	40,6
	15	433	65,0	222	630	1120	4	2470	32,0	45,0

Graphical dependences of the density and workability of the concrete mix, as well as the strength of concrete on the content of silica are shown in the figures (Fig. 1,2,3).

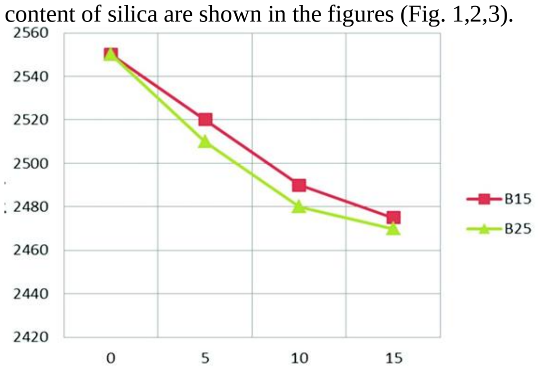

Figure 1. The effect of microsilicon on the density of equally mobile concrete mixtures:
- concrete of class B15; - concrete of class B25

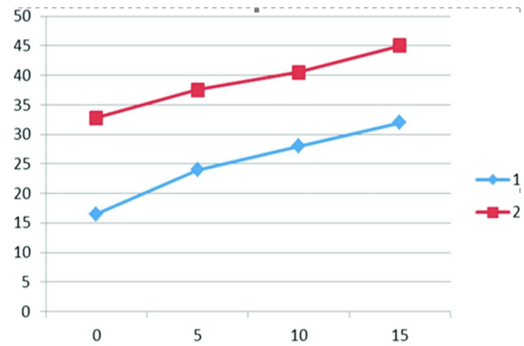

Figure 3. The effect of microsilicon on the strength of equally mobile concrete of class B25:
1 – the strength of steamed concrete; 2 – the strength of concrete hardening under normal conditions

The projected cement savings in equally mobile and equally strong concretes are shown in the table (Table. 5) and in the figure (fig. 4).

Table 5

Projected costs and savings of cement in equally mobile and equally strong concretes

Concrete class (hardening conditions)	Microsilicon additive микрокрем , % of C	Cement consumption, kg/m3³	Actual concrete strength, MPa	CF/RF, kg/MPa	Projected cement consumption ,* kg/m³	Projected cement Projected cement savings , kg/m³
B15 (steaming)	0	286	9,1	31,4	286	-
	5	290	13,1	22,1	201	85
	10	296	16,1	18,4	168	118
	15	304	17,8	17,1	156	130
B15 (normal 43.3 conditions)	0	286	20,0	14,3	286	-
	5	290	23.9	12.1	243	43
	10	296	26.4	11.2	224	62
	15	304	29.4	10.3	207	79
B25 (steaming)	0	407	16,5	24,6	407	-
	5	419	24,0	17,5	288	119
	10	427	28,0	15,2	251	156
	15	433	32,0	13,6	224	183
B25 (normal 41.5 conditions)	0	407	32,8	12,4	407	-
	5	419	37.5	11.2	366	41
	10	427	40.6	10.5	345	62
	15	433	45.0	9.6	316	91

*Note: * - according to GOST 26633-2015, the consumption of slag–portland cement in structures made of heavy non-reinforced concrete operating under atmospheric conditions should not be lower than 170 kg/m3, and in conventional reinforced ones - not lower than 240 kg/m3*

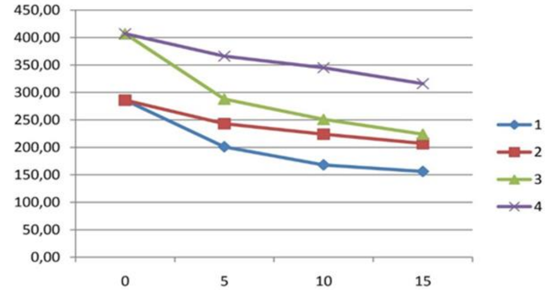

Figure 4. Projected cement costs in equally mobile and equally strong concretes with different silica content: 1, 2 – class B15 concretes; 3, 4 – class B25 concretes; 1, 3 – cement costs in steamed concretes; 2, 4 – cement costs in concretes hardening under normal conditions

From the above data it can be seen:

- the introduction of silica into the concrete mixture is accompanied by a decrease in its density by 80-85 kg/m3. The higher the absolute content of silica in the concrete mixture, the lower its density. This is due to the air entrainment and low silica grains;

- the introduction of silica into the concrete mixture is associated with some loss of workability. Thus, for concretes of class B15...B25 with a cone draft of 5 cm with the introduction of 40 kg/ m3 of silica, the mobility decreases to 0 cm. This is due to an increase in the water demand of concrete mixtures due to an increase in the content of superfine particles in the mixture;

- the introduction of silica into the concrete mixture causes an increase in the strength of concrete. The strength of steamed concrete with a silica content of 5...15% by weight of cement increases by 45... 90%, and the strength of concrete hardening under normal conditions increases by 19...40%. A more intensive increase in strength during steaming is associated with a higher hardening temperature (with a greater reactivity of silica at elevated temperatures).

- the projected cement costs in equally mobile and equally strong concretes are reduced by 85...183 kg/m3 – for steamed concretes and by 41...91 kg/m3 – for concretes hardening in

- normal conditions. Due to the reduction in cement consumption in class B15 concretes below acceptable values, the introduction of silica into steamed concretes of low classes is not advisable.

3. Conclusion

It is established that with the addition of silica in the amount of 5 ...15% by weight of cement, the density of equally mobile, including concrete, decreases by 80 ... 85 kg / m3; the workability of the mixture decreases from 5 to 0 cm; the strength of concrete increases by 45 ... 90% – for steamed concrete; and by 19... 40% – for concrete, hardening under normal conditions.

According to the results of the work, the savings of cement in concretes of class B15...B25 due to the introduction of silica may range from 41 to 183 kg/m3, depending on the hardening conditions and properties of concrete mixtures.

There are real prerequisites for the systematic organization of industrial production of new thermal insulation materials on an industrial scale using regional resources.

References

[1] Kim D.J. Characteristics of Limited Shrinkage During Drying of Arched Steel Fiber Concrete / D.J. Kim, S.X. Kim, V.K. Choi // Applied Sciences. — 2021. — 11(16). — p. 7537. — DOI: 10.3390/app11167537.

[2] Yun H.D. The Effect of the Strength of the Reinforcing Fiber on the Mechanical Properties of High-Strength Concrete. Fibers / H.D. Yun, S.H. Lim, V.K. Choi. — 2019. — 7(10). — p. 93. — DOI: 10.3390/fib7100093.

[3] Yun H.D. Microstructure and Mechanical Properties of Cement Mortar Containing Phase Transition Materials / H.D. Yun, J.V. Lee, Y.Y. Jang [et al.] // Applied Sciences. — 2019. — 9(5). — p. 943. — DOI: 10.3390/app9050943.

[4] Khan U. Evaluation of the Effectiveness of Khyber-Pakhtunkhwa Rice Husk Ash (RHA) in Improving the Mechanical Properties of Cement / U. Khan, K. Shehzada, T. Bibi [et al.] // Building and Construction Materials. — 2018. — Vol. 176. — p. 89-102.

[5] Barichevich A. The Effect of Polymer Fibers Recycled from Used Tires on the Properties of Wet-Coated Concrete / A. Barichevich, M. Pezer, M.J. Rukavina [et al.] // Building Materials. — 2018. — Vol. 176. — p. 135-144. — DOI: 10.1016/j.conbuildmat.2018.04.229.

[6] Permyakov M.B. Creating a Comfortable Environment in Small-Sized Housing / M.B. Permyakov, T.V. Krasnova // International Research Journal. — 2021. — 1(103). — Pt 1. — p. 165-169. — DOI: 10.23670/IRJ.2021.103.1.025.

[7] Udodov S. Mechanical and Physical Properties of Fine-Grained Concrete for Concrete Additive Manufacturing / S. Udodov, Y. Galkin, P. Belov // E3S Web of Conferences. — 2019. — 02041(2019). — DOI: 10.1051/e3sconf/20199102041

[8] Permyakov M.B. Assessment of Reliability and Accident Risk for Industrial Buildings / M.B. Permyakov, A.N. Ilyin, V.M. Andreev [et al.] // MATEC Web of

Conferences. — 2018. — p. 02007. — DOI: 10.1051/matecconf/201825102007

[9] Perepelicyn V.A. Vysokokachestvennoe prirodnoe ogneupornoe syr'jo Urala [High Quality Natural Refractory Raw Materials of the Urals] / V.A. Perepelicyn, I.V. Jukseeva, L.V. Ostrjakov // Mineral'noe syr'jo Urala [Mineral Raw Materials of the Urals]. — 2008. — 3. — P. 14-30. — URL: https://www.elibrary.ru/item.asp?id=11699376 (accessed: 12.01.2023). [in Russian]

[10] Perepelicyn V.A. Mineral'no-syr'evaja baza proizvodstva sovremennyh ogneuporov (prodolzhenie) [Mineral and Raw Material Base of Modern Refractories Production (continued)] / V.A. Perepelicyn, I.V. Jukseeva, L.V. Ostrjakov // Ogneupory i tehnicheskaja keramika [Refractories and Technical Ceramics]. — 2008. — 6. — c. 53-64. — URL: ttps://www.elibrary.ru/download/elibrary_15288902_33279702.pdf (accessed: 14.01.2023). [in Russian]

[11] Kononova O.V. Issledovanie vlijanija mikrokremnezema na svojstva samouplotnjajushhegosja keramzitobetona [Study of the Effect of Microsilica on the Properties of Self-Compacting Claydite Concrete] / O.V. Kononova, A.V. Loskutov // Trudy Povolzhskogo gosudarstvennogo tehnologicheskogo universiteta. Serija: Tehnologicheskaja [Proceedings of the Volga Region State Technological University. Series: Technological]. — 2015. — 3. — p. 193-198. [in Russian]

[12] Andreevskaja T.S. Mikrokremnezem, mehanizm ego obrazovanija i oblasti primenenija [Microsilica, Its Mechanism of Formation and Applications] / T.S. Andreevskaja // Rol' innovacij v transformacii sovremennoj nauki: sbornik statej po itogam Mezhdunarodnoj nauchno-prakticheskoj konferencii [The Role of Innovation in the Transformation of Modern Science: A Collection of Articles from the International Scientific and Practical Conference]. — 2018. — p. 9-11. [in Russian]

[13] Pashkov E.I. Sovremennye tehnologii futerovki gazohodov teplovyh agregatov ogneupornymi materialami [Modern Refractory Technology for Lining Heat Trains with Refractory Materials] / E.I. Pashkov, M.B. Permjakov, T.V. Krasnova // Mezhdunarodnyj nauchno-issledovatel'skij zhurnal [International Research Journal]. — 2021. — 6-1(108). — p. 95-99. [in Russian]

[14] Pashkov E.I. Zashhita teplotehnicheskih agregatov v agressivnoj vysokotemperaturnoj srede stroitel'nymi teploizoljacionnymi materialami [Protection of Heating Units in Aggressive High-Temperature Environments with Building Thermal Insulation Materials] / E.I. Pashkov, M.B. Permjakov, T.V. Krasnova // Vestnik evrazijskoj nauki [Journal of Eurasian Science]. — 2021. — Vol. 13. — 2. — p. 30. [in Russian]

[15] Kramar L.Ja. Vlijanie dobavki mikro kremnezjoma na gidrataciju alita i sul'fatostojkost' cementnogo kamnja [Effect of Microsilica Additive on Alite Hydration and Sulphate Resistance of Cement Cake] / L.Ja. Kramar, B.Ja. Trofimov, L.S. Talisman [et al.] // Cement. — 1989. — 6. — p. 14-17. [in Russian]

[16] Gamalij E.A. Struktura i svojstva cementnogo kamnja s dobavkami mikro kremnezjoma i polikarboksilatnogo plastifikatora [Structure and Properties of Cement Stone with Microsilica Additives and Polycarboxylate Plasticizer] / E.A. Gamalij, B.Ja. Trofimov, L.Ja. Kramar // Vestnik Juzhno-Ural'skogo gosudarstvennogo universiteta. Serija: Stroitel'stvo i arhitektura [Bulletin of South Ural State University. Series: Construction and Architecture]. — 2009. — 16(149). — p. 29-35. [in Russian]

[17] Shuldjakov K.V. Vlijanie dobavki «mikrokremnezem-polikarboksilatnyj super plastifikator» na gidrataciju cementa, strukturu i svojstva cementnogo kamnja [Effect of the Additive "Microsilica-Polycarboxylate Super Plastifier" on Cement Hydration, Structure and Properties of Cement Stone] / K.V. Shuldjakov, L.Ja. Kramar, B.Ja. Trofimov [et al.] // Cement i ego primenenie [Cement and Its Applications]. — 2013. — 2. — p. 114-118. [in Russian].

Information about the author

Akhmadov Sunnatillo Abdulloyevich	Tashkent state transport university "Construction of buildings and industrial structures", assistant E-mail: zakon.axmadov@gmail.com Tel.:+998974936611 https://orcid.org/my-orcid?orcid=0009-0007-0925-0101
Khaidarova Dilfuza Vasitovna	Tashkent Institute of Architecture and Civil Engineering, 3rd year student E-mail: shakir7777777@gmail.com Tel.:+998998450185 https://orcid.org/my-orcid?orcid=0009-0000-9528-842X
Suleymanova Gavkhar Asatullayevna	Tashkent Institute of Architecture and Civil Engineering, 2nd year student E-mail: v0306924@gmail.com Tel.:+998935039735 https://orcid.org/my-orcid?orcid=0009-0000-0992-9404