ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

УДК 678.8

PHYSICAL STUDIES OF LIGHTWEIGHT TAMPONADE COMPOSITE MATERIAL BASED ON MICROSILICA AND LOCAL ORGANOMINERAL INGREDIENTS

Panjiev Olimjon Khollievich
Doctoral student, State Unitary Enterprise "Fan va Tarakkiyot"
Uzbekistan, Tashkent.

Abstract: The paper presents the results of selecting the composition of composite gypsum materials using inorganic fillers - ash microspheres, which are formed during the combustion of coal at thermal power plants.

Based on the laboratory studies, composite compositions have been developed for obtaining thermal insulation building products with low bulk density. The rheological properties and physical and mechanical properties of mortar mixtures have been studied and the optimal compositions of composite gypsum mixtures for the production of thermal insulation materials using aluminosilicate ash microspheres have been determined.

Key words: mineral binders, filler, aluminosilicate microsphere, low bulk density, superplasticizer, composite composition, density, thermal insulation materials.

This project considers the development of a composition of lightweight composite cements aimed at improving the quality of well casing and sealing of their lining. Particular attention is paid to fields with low hydraulic fracturing gradients, where the use of lightweight cement slurries is required.

The most effective approach to solving these problems is the use of special composite lightweight expanding cement materials. The main objective of this work was to study the role and mechanisms of action of modifying additives (expanding, lightweight, reinforcing and others) in the composition of cement cements, to conduct a set of studies and improve the formulations of lightweight cement materials.

To achieve this goal, various fillers and modifying additives were studied that can improve the properties of cement cements, including strength, density and resistance to aggressive environments.

One of the key components that determine the properties of cement materials is clinker - the main product of firing the raw mix used in the production of Portland cements. The mineralogical composition of clinker has a significant impact on the rheological and physical-mechanical properties of cement mixtures, which makes its study an important stage in the development of lightweight cementing materials [1].

There is a classification of clinkers by mineralogical composition. If the mass fraction of C_3S exceeds 60%, the clinker is called alite; with a mass fraction of C_2S over 37% - belite; with a C_3A content over 13% - aluminate; and with a mass fraction of C_4AF over 5% - aluminoferrite.

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

Combined types are also distinguished, such as alite-aluminate or belite-aluminate clinkers. Clinkers whose composition is within the specified limits are classified as normal.

For the production of oil well cements, mainly alitic and normal clinkers are used. However, for special conditions, special compositions can be developed that meet specific requirements [2].

Inert mineral additives are additives of mineral origin, which under normal conditions only slightly chemically interact with the main substance of Portland cement during the hardening process. Limestone and quartz sand are most often used as inert mineral additives. If the hardening conditions deviate significantly from normal, inert additives can become active. Quartz, crushed or in the form of sand, becomes an active additive at temperatures above 60 °C [3].

To develop the compositions of composite lightweight oil well cements in this work, Portland cement grade M400, produced by the Navoi Cement Plant, was used as the main binder, and microsilica, a silica-containing technogenic waste from the production of JSC Uzmedkombinat (Bekabad), was used as a microfiller.

Binding construction substances are powdered materials that, when mixed with water, form a plastic, easy-to-process mass that hardens over time into a durable rock-like body. In this paper, the hydraulic binder is Navoi Portland cement grade M400 D0, tested in accordance with the requirements of GOST 10178-85. The chemical and mineralogical composition of Portland cement is presented in Tables 1 and 2.

Table 1 - Chemical composition of Portland cement of the Navoi Cement Plant

Oxide content, wt.%								
SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	R_2O	ПППП	Сумма
23,96	4,7	0,79	66,76	2,86	0,57	0,30	-	100,0

Table 2 - Mineralogical composition of cement from Navoi Cement Plant

Cement	Mineral content, mass, %			
	C_3S	C_2S	C_3A	C_4AF
Cement M400 D 0	56.51	26,08	11,24	2,40

Table 3 - Physical and mechanical characteristics of Portland cement of Navoi cement plant

ORIGINAL ARTICLE
INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE
ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025
Journal: https://www.academicpublishers.org/journals/index.php/ijai

№	Name of parameters	The meaning of the paramete of cement M400 DO
1	Degree of grinding: residue on sieve No. 008,%	6,4
2	Water/binder ratio	0,32
3	Setting time, hours-minutes – beginning of setting – end of setting	2-25 4-50
4	Compressive strength, at the age of 28 days, MPa	49,5
5	Bending strength, 28 days, MPa	6,7

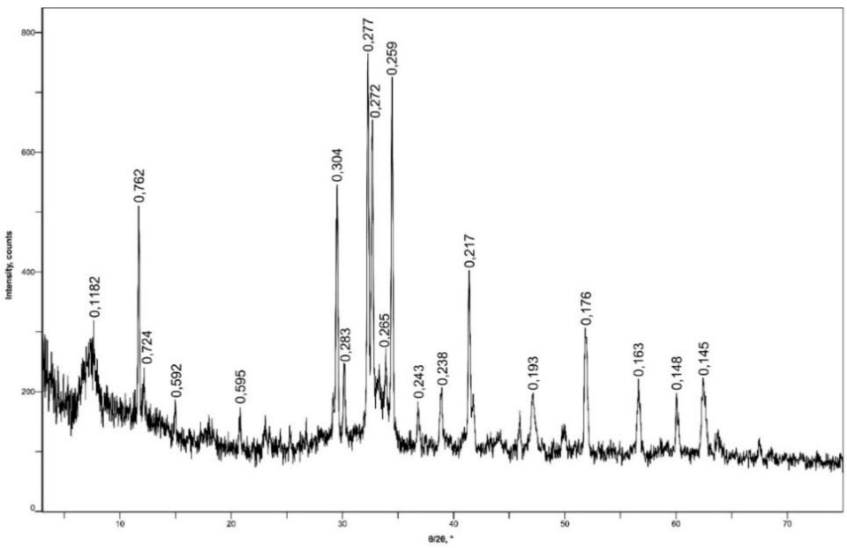


Figure 1 - X-ray diffraction pattern of Portland cement from Navoi Cement Plant

In oil and gas regions with complex geological and technical conditions, problems with high-quality layer isolation often arise. Analysis of literature data [4] shows that the number of wells experiencing complications after cementing remains significant.

One of the main reasons for unsatisfactory well casing may be the use of standard oil well cement. Portland cement without additives often proves ineffective in complex geological and technical conditions and requires modification to ensure reliable isolation.

Table 4 - Physical characteristics of microsilica.

№	Name of indicators	The meaning of the indicators
1	Appearance	Ultrafine material of dark gray light

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025

AMERICAN ACADEMIC PUBLISHER OPEN ACCESS JOURNAL

Journal: https://www.academicpublishers.org/journals/index.php/ijai

2	Ultrafine material of dark gray light	3
3	Loss on ignition (LOI), % no more than	3
4	Mass fraction of silicon dioxide (SiO2) % not less than	85
5	Mass fraction of sulfur dioxide (SO_3) % no more than	0,6
6	Mass fraction of magnesium oxide (MgO), no more than	3
7	Bulk density, kg/m³, not less than	250

Note: bulk density in uncompacted state – 0.25 t/m³; in compacted state – up to 0.40-0.70 t/m³.

According to the results of studies conducted by an accredited laboratory, the chemical composition of microsilica of Uzmedkombinat is presented in Table 5.

Table 5 - Chemical composition of microsilica of Uzmedkombinat

Oxide content, mass %									
SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	SO_3	C	П.п.п.
93,80	0,70	0,90	1,00	1,20	0,50	0,0	0,20	0,80	0,60

Figure 2 shows a diffraction pattern of microsilica, from which it is evident that the main phase of the finely dispersed material is SiO_2

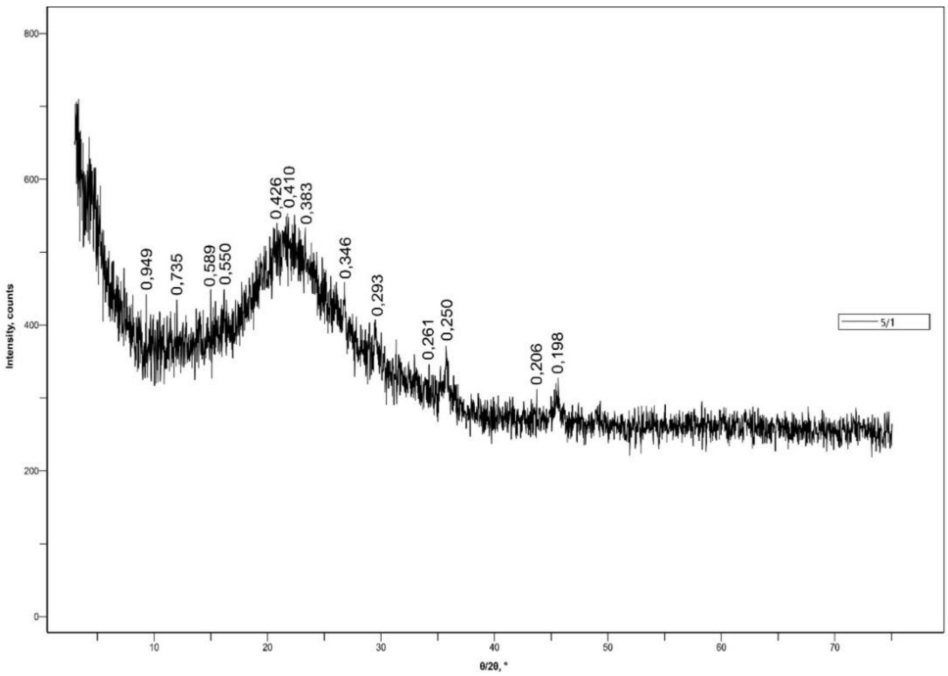


Figure 2 - Diffraction pattern of Uzmedkombinat microsilica

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025
Journal: https://www.academicpublishers.org/journals/index.php/ijai

In the diffraction pattern of Uzmedkombinat microsilica (Fig. 2), the main component of the material is amorphous silica (SiO_2), which is confirmed by the characteristic wide diffuse peak in the range of $2\theta \approx 20–30°$. These characteristics indicate the amorphous state of the substance and confirm the high pozzolanic activity of microsilica, which makes it an effective component for use in composite plugging materials.

Microsilica is a by-product of ferroalloy production, consisting of spherical particles of active silicon oxide. The average particle size of microsilica is 0.05-0.1 μm, which is approximately 100 times smaller than the average particle size of cement. Due to its high dispersion and amorphous state, microsilica has significant pozzolanic activity and acts as an effective microfiller [6].

In concrete, microsilica exhibits two key effects: microfilling and pozzolanic. The microfilling effect consists of filling the voids between cement grains with the smallest particles of microsilica, as well as creating crystallization centers, which contributes to more uniform hardening of the cement stone.

The pozzolanic effect is caused by the chemical interaction of microsilica with calcium hydroxide, which is released during the hydration of cement. As a result of the interaction, strong low-basic calcium hydrosilicates are formed, which significantly improves the properties of cement stone. The use of microsilica helps to increase the volume of gel pores and reduce capillary pores, increases the density, water resistance and frost resistance of concrete.

The use of microsilica is advisable in combination with water-reducing additives, such as superplasticizers (SP). Due to its high dispersion, microsilica absorbs a significant amount of water, which without the use of SP can minimize the positive effect of the active mineral additive, and in some cases even reduce the strength characteristics of concrete.

The new generation superplasticizer "Polyplast SP-1", created on the basis of polycarboxylate esters, ensures high mobility and cohesion of mortar mixtures of lightweight oil well cement at low values of the water-cement ratio, and also preserves their properties for a long time. For SP based on polycarboxylates, the presence of an anionic base and a hydrophobic effect is characteristic, ensuring the repulsion of particles of the solid phase. The type and length of the main chain, as well as the length and frequency of the side chains vary in different SP molecules, which allows for effective control of their adsorption processes on binder grains.

In the oil and gas industry of the republic, an urgent task is the development, implementation and application of lightweight oil well cement compositions using finely dispersed industrial waste as active mineral additives. Such additives, in combination with various chemical modifiers, help to increase the reactivity of oil well cement slurries.

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ORIGINAL ARTICLE

ISSN: 2692-5206, Impact Factor: 12,23

American Academic publishers, volume 05, issue 08,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

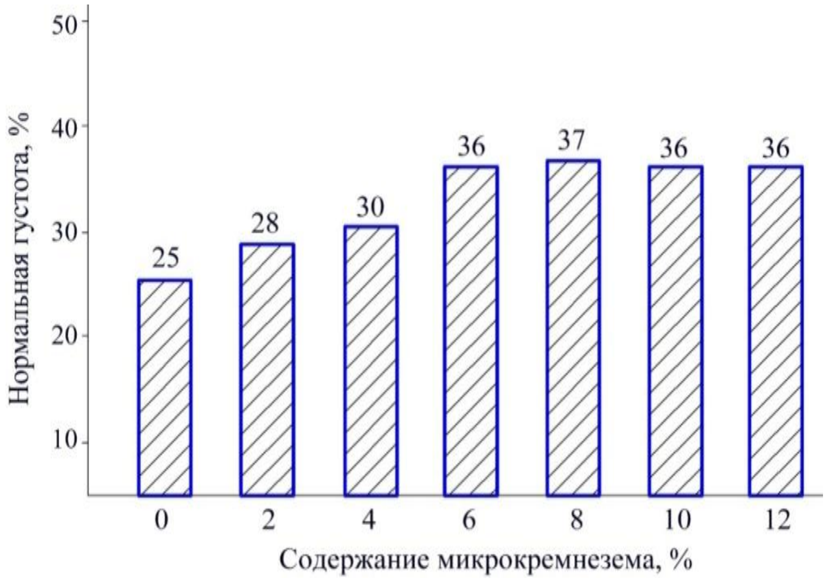


Figure 3 - Change in the normal density of composite binders for the production of thermal insulation materials from the content of microsilica

It is known that the setting time of cements depends on the normal density, fineness of grinding and various additives. In this regard, studies were conducted to study the effect of the content of microsilica on the setting time of composite binders intended for the production of thermal insulation materials.

To determine the setting time of the developed composite binders, the Vika device was used. The results are shown in Figure 4. The studies have shown that with an increase in the content of microsilica, both the beginning and end of the setting of the mortar mixture increase.

It was found that the increased water demand of composite binders, caused by an increase in the content of microsilica, slows down the hydration process, which leads to an extension of the setting time of the composite mortar mixture. To study the effect of microsilica on the strength characteristics of the developed composite binders, standard samples measuring 4×4×16 cm were prepared from normal-density dough.

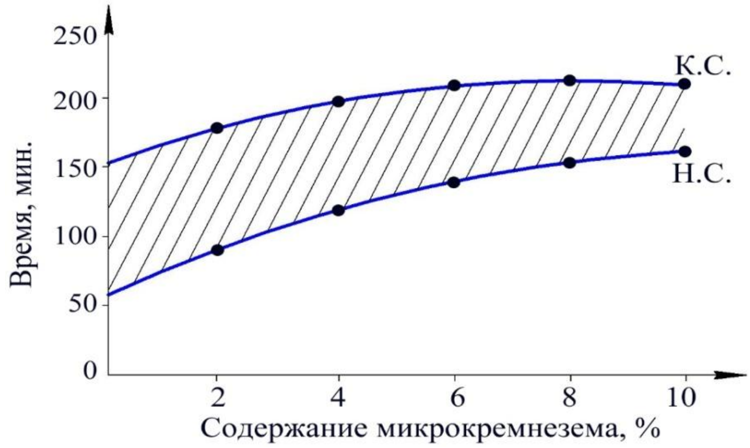
ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23

American Academic publishers, volume 05, issue 08,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai



(Н.С. - beginning of setting, К.С. - end of setting.)

Figure 4 - Effect of microsilica on the setting of composite binders

The results of the studies showed that the addition of microsilica even in the amount of 2-5% helps to compact the structure of the transition zone by filling the free spaces. This leads to a decrease in the size of the crystals and strengthening of the weak zone of the hardened mortar mixture, and also increases the adhesion of the cement matrix.

In addition, the pozzolanic reactions of finely dispersed microsilica have a chemical effect, contributing to a further increase in the strength and durability of lightweight oil well cement.

A study of the hardening process of lightweight oil well cement showed that during the first 7 days of hardening of composite oil well cements, microsilica has a noticeable effect on the strength properties. Its interaction with the hydration products of cement monominerals begins in the early stages of hardening of mortar mixtures based on composite binders and is completed by the 28th day.

Based on the conducted research, it was established that the introduction of microsilica into the composition of the cement mixture and the creation of composite binders has a positive effect on the rheological properties of the cement paste, as well as on the bulk density of products made on their basis.

It was found that the spherical shape of finely dispersed microsilica particles promotes the formation of a porous structure during interaction with a gas-forming reagent in molded products. Finely dispersed microsilica particles fill the volume between coarsely dispersed particles of hydrated cement compounds, which significantly reduces water separation from the composite mortar mixture.

ORIGINAL ARTICLE
INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE
ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025
Journal: https://www.academicpublishers.org/journals/index.php/ijai

The use of cement-microsilica compositions in the production of thermal insulation materials allows obtaining products with a bulk density of 300-500 kg / m³, with a low thermal conductivity coefficient and improved thermal insulation characteristics.

In order to reduce water consumption and increase the fluidity of the cement-microsilica mortar mixture, the study used the superplasticizer of the "Polyplast SP-1" brand. The results of the studies showed that an increase in the microsilica content in the mixture leads to an increase in spreadability, while the addition of a superplasticizer helps to reduce the normal density of the mortar mixture.

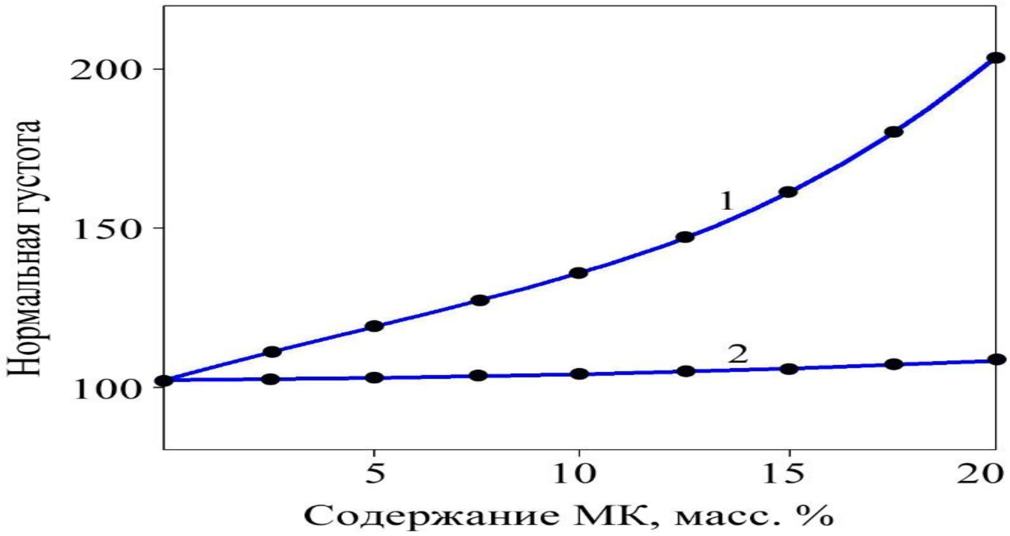


Figure 5 - Effect of superplasticizer content on the normal density of cement-microsilica composite mortar mix

without superplasticizer; 2- 0.75% superplasticizer SP-1

From Figure 5 it is evident that with an increase in the microsilica content in the composition, the normal density of the mortar mix without superplasticizer (curve 1) increases significantly, reaching more than 200% with a content of 20% microsilica. Adding 0.75% superplasticizer SP-1 (curve 2) allows to significantly reduce the normal density: with the same microsilica content, the indicators decrease to 150%, which improves the processability and workability of the mix.

A study of the hardening process of lightweight oil-well cements showed that microsilica has a positive effect on the strength characteristics at all stages of hardening. The interaction of microsilica with hydration products begins at the early stages of hardening and continues up to 28 days, providing a significant improvement in mechanical properties. Laboratory studies have shown that the developed compositions of the cement-microsilica composition have low density and high strength characteristics, which meets the requirements for materials used in the oil and gas industry for cementing casing columns.

ORIGINAL ARTICLE

ISSN: 2692-5206, Impact Factor: 12,23
American Academic publishers, volume 05, issue 08,2025

Journal: https://www.academicpublishers.org/journals/index.php/ijai

References:

1. Негматов С.С., Негматова К.С., Тулягонова В.С., Талипов Н.Х., Негматов Ж.Н, Пирматов Р.Х., Эшмуродов Б.Б. Нефт ва газ қудуқларини бурғилаш жараёнида деворларини маҳкамлаш мақсадида микрокремнезём ва маҳаллий органоминерал ингредиентлар асосида енгил цементлаштирувчи кукунли композицион материалларни ишлаб чиқаришнинг долзарблиги ва уларнинг амалга ошириш усуллари. // Композиционные материалы. - Ташкент, 2024. №1, 250-253.

2. Негматов С.С., Талипов Н.Х., Абед Н.С., Тулягонова В.С., Абдуллаев М.А., Пирматов Р.Х., Эшмуродов Б,Б,Умаров Ш.Ш. Исследование влияние микрокремнезём на свойства композиционных тампонажных материалов, применяющих в процессе бурения нефтегазовых скважин. // Композиционные материалы. - Ташкент, 20204 №2, 181-184.

3. Negmatov S.S., Tolibov N.X. Application of fine-dispered silica wastes in the production of lightweight expansioncements. Internatsional multidiscipliplinary journal for. Research development - INDII, 2024. №11, 91-93.

4. Талипов Н.Х., Абдуллаев М.А. Влияние микрокремнезёма на реологического свойства цементно микрокремнезиместой композиции для получения материалов ячеистой структуры. // Композиционные материалы. - Ташкент, 2024. №3, 212-214.

5. Негматов С.С., Талипов Н.Х., Панжиев О.Х,, Туляганова В.С., Пирматов Р.Х. Процесс расширение композиционных облегченных тампонажных материалов полученных с применением микрокремнезема. Материалы РНТК «Перспективы развития композиционных материалов». -Ташкент. 2024. -С. 117-118.

6. Негматов С.С., Талипов Н.Х., Панжиев О.Х,, Туляганова В.С., Пирматов Р.Х. Свойства композиционного облегченного тампонажного цемента содержащего микрокремнезема. Материалы РНТК «Перспективы развития композиционных материалов». -Ташкент. 2024. -С. 212-214.