Crossref
DOI: 10.31643/2027/6445.23
Mining & Mineral Processing

Investigation of the effect of a modified additive on the strength characteristics of foam concrete

[1*]Askerbekova A.M., [1]Dyussembinov D.S., [1]Shashpan Zh.A., [2]Abduova A.A., [2]Kambarov M.A.

[1] L.N. Gumilyov Eurasian National University, Astana, Kazakhstan
[2] M. Auezov South Kazakhstan Research University, Shymkent, Kazakhstan

** Corresponding author email: arai_09.91@mail.ru*

Received: *August 1, 2025*
Peer-reviewed: *October 11, 2025*
Accepted: *December 1, 2025*

ABSTRACT
The article presents the second stage of the investigate the effect of the modified additive on the strength characteristics of foam concrete. This work describes a method for manufacturing foam concrete samples, selects a modifying additive composition with different percentages of components, and analyzes their strength characteristics. The purpose of introducing plasticizing additives (post-alcohol bard) in foam concrete D600 to reduce water consumption and the expected increase in strength. To evaluate the changes in strength, samples were made and tested in compression at the age of 3, 7, 14, and 28 days of normal moisture curing. According to research results, the use of such additives can significantly reduce formwork removal times, increase the load-bearing capacity of structures, and expand the scope of application of foam concrete—even to structural and thermal insulation products. Additives improve not only strength but also structural uniformity, reducing the number of macropores and increasing the density of the material.

Keywords: cement paste, post-alcohol bard, modified additive, compressive strength, plasticizer, foaming agent.

Information about authors:

Askerbekova Arailym Myrzakhankyzy	*PhD. student, Department of Technology of Industrial and Civil Construction, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan. Email: aria_09.91@mail.ru; ORCID ID: https://orcid.org/0000-0002-4356-053X*
Dyussembinov Duman Serikovich	*C.t.s., Assistant Professor of the Department of Technology of Industrial and Civil Construction, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan. Email: dusembinov@mail.ru; ORCID ID: https://orcid.org/0000-0001-6118-5238*
Shashpan Zholaman Amangeldievich	*D.t.s., Assistant Professor of the Department of Technology of Industrial and Civil Construction, L.N. Gumilyov Eurasian National University, Astana, Kazakhstan. Email: zholamanalmatykz@gmail.com; ORCID ID: https://orcid.org/0000-0002-6236-0525*
Abduova Aisulu Alshynbekovna	*C.t.s., Assistant Professor of the* Department of Ecology, *M. Auezov South Kazakhstan Research University, Shymkent, Kazakhstan. Email: aisulu.abduova@mail.ru; ORCID ID: https://orcid.org/0000-0001-5389-6953*
Kambarov Medet Abdildaevich	*C.t.s., Assistant Professor of the Department of Building materials and expertise in construction, M. Auezov South Kazakhstan Research University, Shymkent, Kazakhstan. Email: medet_2030@mail.ru; ORCID ID: https://orcid.org/0000-0001-6397-1451*

Introduction

In Kazakhstan, the concentration of the workforce in large cities has led to the widespread construction of apartment buildings and high-rise buildings, as well as the dynamic development of the construction industry. In addition, based on the “Nurly Zher” housing and utilities development program for 2020-2025 and the “7-20-25” program, extended until 2029, it is necessary to use building materials with low raw material consumption to provide the population with quality housing in the shortest possible time [[1] [,2]].

Among such building materials is foam concrete — a lightweight, porous material with excellent thermal and sound insulation properties, distinguished by its economic efficiency and environmental safety, which makes it highly demanded in modern construction [3].

Currently, various methods of improving the efficiency of foam concrete are of particular interest. Research into the strength characteristics of foam concrete, research into the resistance of foam concrete to chemical and physical aggressive factors, and research into the use of various binders in the production of foam concrete are of great importance. In addition, the use of foam concrete significantly reduces the cost and duration of construction, which is important in modern conditions for solving housing problems [[4], [5], [6], [7]].

Also, due to the thermal insulation properties of foam concrete, it saves energy and is an effective material that can be used in construction in regions with a harsh continental climate. This material can be obtained from a mixture of cement, sand, and foam [[8], [9], [10], [11]].

Since it is an inexpensive building material that saves energy spent on heating buildings and consumes less raw materials, its improvement with the addition of modern additives allows for the production of foam concrete with a specified structure.

In modern concrete technology, various organic and inorganic additives are widely used, which significantly affect the physical and chemical processes of cement hardening and modify the structure of concrete, ensuring its strength and durability. An analysis of technical literature shows that among the additives used, plasticizing additives—thinners that significantly reduce the water demand of concrete mixtures without reducing their mobility—are of great importance. Surface-active substances, either specially synthesized or by-products of various industries, many of which are environmentally unsafe, are widely used as plasticizers for cement mixtures [[12], [13], [14]].

The main objective of our research work is to develop a technology for producing non-autoclaved thermal insulation foam concrete from industrial waste. In this article, we must investigate the effect of the modified additive on the strength characteristics of foam concrete.

In this research work to accomplish the objective, the following tasks were carried out:

1. The optimal formulation of the additive was selected based on varying percentages of its components.

2. Samples with different additive compositions were prepared under laboratory conditions.

3. The physical and mechanical properties of the experimental samples were investigated in the laboratory.

Materials and methods of research

In order to successfully achieve the set goals and objectives of this study, as well as to ensure the reliability and accuracy of the experimental results, construction materials that fully comply with current technical standards and regulatory requirements were selected and applied.

Cement – As the primary binding material, Portland cement of grade M400 was used. This type of cement is widely recognized for its high strength characteristics and consistent performance in construction applications. Its use ensured the structural integrity and uniformity of the test samples throughout the experiment.

Modified additive – The key component of the modified mixture was post-alcohol bard, a liquid by-product derived from ethyl alcohol production. This organic waste product was introduced into the cement mixture in varying dosages of 2.5%, 5.0%, 7.5%, and 10%, with 2.5% intervals, in order to assess its effect on the properties of the resulting material. The bard was supplied in liquid form by the Idabul Distillery (JSC "Idabul Distillery"), ensuring consistent quality and composition for laboratory use.

Post-alcohol bard is used as a plasticizing additive and is supplied in liquid form from JSC Aydabul Distillery. In Kazakhstan, the largest producers of ethyl alcohol are several companies, including Talgar-alcohol (Talgar), Adil JSC (Ust-Kamenogorsk), Altyn Omir (Kostanay region), etc. Ethyl alcohol is sold on the Kazakh market mainly through domestic trade. Currently, most bardu distilleries are processed in one way or another, mainly for feed. At the same time, 10-15 liters of bard per 1 liter of alcohol, depending on the technology [[15], [16]].

3. As a hardening accelerator, gypsum was introduced into the cement mixture to intensify the setting and early strength development processes. This additive was applied in varying dosages — specifically 1.0%, 1.5%, 2.0%, and 2.5% of the total mass of cement — with increments of 0.5%. The use of gypsum in these proportions made it possible to evaluate its influence on the rate of hardening and overall physical-mechanical characteristics of the resulting material.

The incorporation of gypsum as a hardening accelerator in foam concrete enhances the cement hydration process, resulting in improved structural uniformity, increased early strength, and reduced setting time [[17], [18]].

The synthetic foaming agent 'Neoplast, art. 55' meets the requirements of TU 2381-008-90275031-2011. It is used to produce thermal insulation (ρ_{avg}=400-500 kg/m^3) and thermal insulation-structural (ρ_{avg}=600-900 kg/m^3) foam concretes based on cement binder using the 'dry mineralisation' method of foam production. The foaming agent is a pore former that provides a cellular structure for concrete, as well as helping to reduce its density, improve its thermal and sound insulation properties, and facilitate the laying and moulding of mixtures [19].

a) b) c)

Polyfractional sand | Post-alcohol bard | The synthetic foaming agent

Figure 1 – Raw materials for foam concrete

a) b) c)

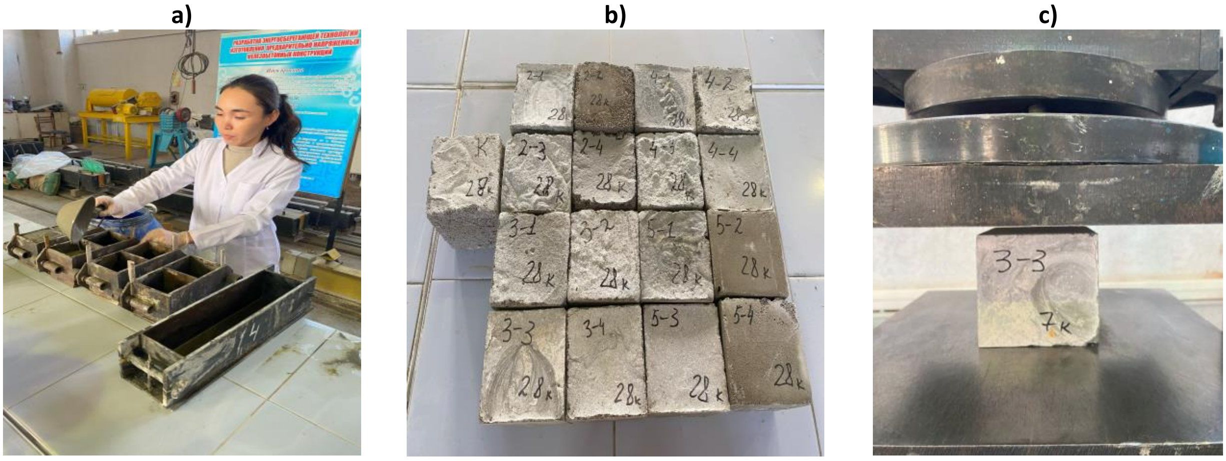

Figure 2 – Samples of the foam concrete D600: The process of foam concrete sample preparation (a), Prepared foam concrete samples (b), Compression test of samples (c)

Figure 1 illustrates several construction materials used in the experiment, while Figure 2 shows the process of sample preparation and testing.

The foam formed by adding a foaming agent is a key factor in foam concrete production technology. Its multiplicity determines the structure of the material, having a significant impact on its porosity, density, and strength characteristics.

The optimal ratio of the modifier additive to cement was evaluated in stages as part of the study. At the initial stage of the research, attention was focused on examining how the composition of the modifying additive influences the setting time of the cement paste. This allowed for the identification of optimal component ratios that contribute to more efficient hardening processes [18]. In the subsequent stage, a series of experiments was conducted to determine the compressive strength of foam concrete samples. These tests were performed in relation to varying concentrations of the modified additive introduced into the mixture, enabling an assessment of its impact on the mechanical performance of the final product.

For each type of sample, cubes measuring 10x10x10 cm were made. The compressive limits were determined in accordance with GOST 10180-2012 "Concrete. Methods for determining strength using control samples" at 3, 7, 14, and 28 days using press equipment. The subject of this study was a foam concrete, prepared using M400-grade cement and the synthetic foaming agent Neoplast. The mixtures were produced both without any additives and with the inclusion of post-alcohol bard, utilizing

Table 1 – Composition of compared samples of the foam concrete D600

Number	Type of sample	Cement, g	Sand, g	Gypsum, g	Post-alcohol bard, g	Foaming agent, g	Water, g
1	Type 1 Reference sample	400	200	-	-	1.25	230
2	Type 2-1	397	200	3	7.5	1.25	222.5
3	Type 2-2	397	200	3	15	1.25	215
4	Type 2-3	397	200	3	22.5	1.25	207.5
5	Type 2-4	397	200	3	30	1.25	200
6	Type 3-1	395.5	200	4.5	7.5	1.25	222.5
7	Type 3-2	395.5	200	4.5	15	1.25	215
8	Type 3-3	395.5	200	4.5	22.5	1.25	207.5
9	Type 3-4	395.5	200	4.5	30	1.25	200
10	Type 4-1	394	200	6	7.5	1.25	222.5
11	Type 4-2	394	200	6	15	1.25	215
12	Type 4-3	394	200	6	22.5	1.25	207.5
13	Type 4-4	394	200	6	30	1.25	200
14	Type 5-1	392.5	200	7.5	7.5	1.25	222.5
15	Type 5-2	392.5	200	7.5	15	1.25	215
16	Type 5-3	392.5	200	7.5	22.5	1.25	207.5
17	Type 5-4	392.5	200	7.5	30	1.25	200

polyfractional sand. The sand was pre-measured and packaged in 200-gram portions to ensure consistency across all test samples.

The study focused on evaluating the impact of a modified additive, introduced in varying percentages, on the strength properties of foam concrete. To achieve this, the preparation of the foam concrete mixture was carried out in two distinct stages. In the first stage, all mineral components—such as cement and sand—were thoroughly mixed to form a homogeneous dry mixture. In the second stage, foam was saturated with air and turned into a persistent fine bubbly foamin in the foam generator and then carefully integrated into the mineral mixture. This stepwise approach ensured uniform distribution of the foam throughout the mass, contributing to the consistency and reliability of the resulting material's properties.

The compressive strength of foam concrete was assessed using six different mixture compositions, comprising a total of 17 test samples. Each composition included a combination of mineral components, modified additives, foam, and water. Among these, the reference mixture—designated as Type-1—contained only cement, gypsum, foam, and water, without any additive. This control mixture served as the baseline for comparing the performance of all other modified formulations.

For each composition, the optimal water-to-binder ratio was individually determined to ensure consistency and reliability in test results. To evaluate the efficiency and compatibility of the modified additive with Portland cement, a series of mixture compositions was developed. The detailed characteristics and component ratios of these formulations are presented in Table 1.

Results and Discussion

In our research, the selection of additives was guided by their primary mechanisms of action and their potential to enhance the performance of the cementitious material. The modified additive used in this study is a combination of gypsum and post-alcohol bard — a by-product of ethyl alcohol production that also serves as a plasticizer. The experimental results demonstrated that the simultaneous application of gypsum and post-alcohol bard has a synergistic effect, significantly improving the physical and mechanical properties of the cement mixture. This combined use enhances the setting behavior, workability, and overall strength development of the material, making it a promising solution for foam concrete production.

Experimental results revealed that foam concrete samples containing the modified additive (post-alcohol bard) maintained their integrity and did not degrade when exposed to water. This observation confirms the effectiveness of the additive as a water-resistant modifier. A key component of post-alcohol bard is casein—a natural protein — which undergoes polymerization upon interaction with the fine aggregates in the concrete mix. This reaction leads to the formation of additional contact films within the structure, which enhance the cohesion between particles and significantly improve the material's overall water resistance.

Studies have shown that the strength of foam concrete with additives at 3 days of age and beyond is higher than that of foam cement mixture without additives (Type 1). In samples with additives, the intensive hardening period lasts up to 28 days, thereby achieving greater strength.

The degradation or failure of foam concrete is closely related to the degree of structural integrity and the quality of the bonds between its cellular elements. The more uniform and well-formed these internal connections are, the greater the material's resistance to external stresses and long-term durability [20].

It is well established that the strength of foam concrete is a complex, integrated property influenced by a variety of interrelated factors. These include the quality and characteristics of the raw components, the precise formulation of the mixture, the consistency and workability (fluidity) of the foam concrete, the molding techniques employed during sample preparation, and the specific conditions under which the hardening and curing processes take place. Each of these factors plays a critical role in determining the final mechanical performance of the material.

Figure 3 shows the compressive strength of D600 foam concrete. It compares the control sample (without additives) with samples containing a modified additive. Tests were done on days 3, 7, 14, and 28 to see how strength developed and how the additive affected the results.

Figure 3 presents a graph illustrating the variation in compressive strength of the samples over the curing period.

The Type 1 reference samples (without additives) exhibited the lowest compressive strength values at all curing stages (3, 7, 14, and 28 days), with average strength ranging from 0.61 to 2.20 MPa.

Type 2-1 samples demonstrated slightly higher strength than the Type 1 reference samples by 1.6% in 3 days, 3.2% in 7 days, 7.5% at 14 days, and 2.3% at 28 days. However, their strength remained lower than that of the Type 2-2 samples by 11.4%, 3%, 1.71%, and 6.25% in the corresponding curing periods. The average compressive strength of Type 2-1 samples ranged from 0.62 to 2.25 MPa.

Samples of Type 2-2 demonstrated compressive strength values exceeding those of the Type 1 reference samples by 14.7% on day 3, 6.4% on day 7, 9.3% on day 14, and 9.1% on day 28. However, their strength was lower than that of Type 2-3 samples by 7.1% (day 3), 2.9% (day 7), 1.13% (day 14), and 2.8% (day 28). The average compressive strength of Type 2-2 samples ranged from 0.7 MPa to 2.4 MPa over the 28-day curing period.

Samples of Type 2-3 showed even greater strength improvements compared to the reference (Type 1) samples, with increases of 22.9% (day 3), 9.6% (day 7), 10.6% (day 14), and 12.2% (day 28). However, their strength remained lower than that of Type 2-4 samples by 5.1% (day 3), 6.8% (day 7), 4.3% (day 14), and 3.9% (day 28). The average strength values for Type 2-3 samples ranged between 0.75 MPa and 2.47 MPa throughout the hardening period.

Samples of Type 2-4 exhibited compressive strength values significantly higher than those of the Type 1 reference samples, with increases of 26.5% at 3 days, 17.6% at 7 days, 15.6% at 14 days, and 16.8% at 28 days. However, compared to Type 3-1 samples, their strength values were 2.5% (3 days), 7.5% (7 days), 7.03% (14 days), and 3.4% (28 days) lower. The average compressive strength of Type 2-4 samples ranged from 0.79 MPa to 2.57 MPa during the 28-day curing period.

Samples of Type 3-1 showed even more pronounced strength gains over the Type 1 reference mix, exceeding it by 32.7% on day 3, 27.2% on day 7, 24.3% on day 14, and 20.9% on day 28. However, when compared to the Type 3-2 samples, their strength values were slightly lower by 4.7% (3 days), 0.6% (7 days), 5.2% (14 days), and 7.6% (28 days). The average strength for Type 3-1 samples ranged from 0.81 MPa to 2.66 MPa throughout the testing period.

Samples of Type 3-2 demonstrated noticeably higher compressive strength values compared to the Type 1 reference samples, with increases of 39.3% at 3 days, 28.0% at 7 days, 31.25% at 14 days, and 30.9% at 28 days. However, when compared to Type 3-3 samples, their strength values were lower by 6.6% (3 days), 5.3% (7 days), 5.8% (14 days), and 2.7% (28 days). The average compressive strength of Type 3-2 samples ranged from 0.85 MPa to 2.88 MPa over the curing period.

a)

b)

c)

d)

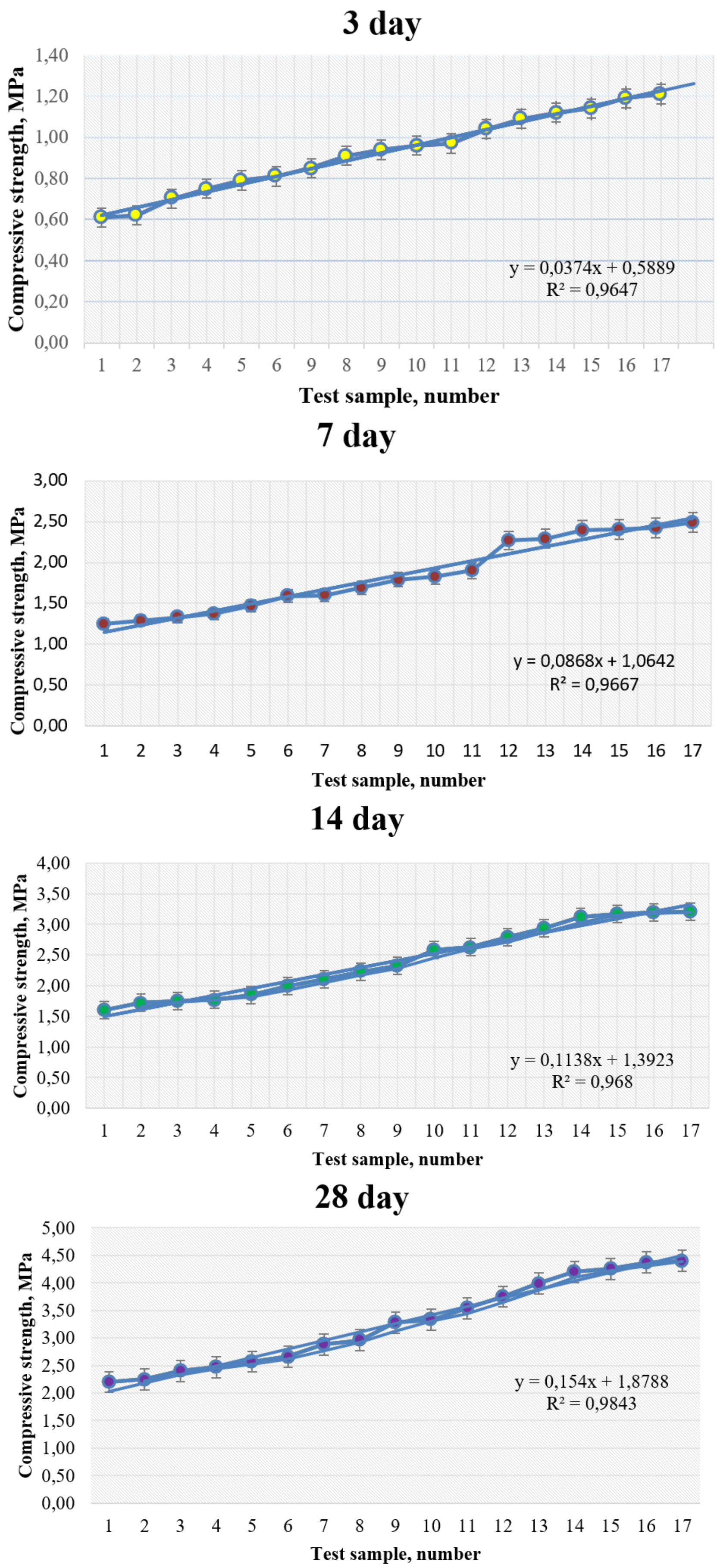

Figure 3 - Plots of growth of compressive strength of the tested samples:
3 day (a) 7 day (b), 14 day (c), 28 day (d)

Samples of Type 3-3 showed even greater improvements in strength relative to the reference Type 1 mix, with increases of 49.2% (3 days), 35.2% (7 days), 39.3% (14 days), and 34.5% (28 days). Nevertheless, they showed slightly lower values compared to Type 3-4 samples—by 3.2% (3 days), 5.6% (7 days), 3.9% (14 days), and 9.7% (28 days). The average compressive strength for Type 3-3 samples ranged from 0.91 MPa to 2.96 MPa.

Samples of Type 3-4 exhibited a significant increase in compressive strength over the Type 1 reference samples: 54.1% at 3 days, 43.2% at 7 days, 45.0% at 14 days, and 49.1% at 28 days. However, these results were still slightly below those of the Type 4-1 samples—by 2.1% (3 days), 2.2% (7 days), 10.0% (14 days), and 2.4% (28 days). The average compressive strength of Type 3-4 samples ranged from 0.94 MPa to 3.28 MPa.

Samples of Type 4-1 demonstrated significant increases in compressive strength compared to the Type 1 reference samples—57.4% at 3 days, 46.4% at 7 days, 61.25% at 14 days, and 51.3% at 28 days. Despite this, their strength values were slightly lower than those of Type 4-2 samples, with differences of 1.03% (3 days), 3.7% (7 days), 1.9% (14 days), and 5.9% (28 days). The average strength values for Type 4-1 ranged from 0.96 MPa to 3.33 MPa.

Samples of Type 4-2 exhibited even greater improvements over the Type 1 reference mix, with compressive strength increases of 59.0% (3 days), 52.0% (7 days), 64.3% (14 days), and 61.0% (28 days). However, when compared to Type 4-3 samples, their strength values were lower by 6.7% (3 days), 16.3% (7 days), 5.7% (14 days), and 32.3% (28 days). The average strength for Type 4-2 samples ranged from 0.97 MPa to 3.54 MPa.

Samples of Type 4-3 showed particularly high compressive strength, outperforming the Type 1 reference samples by 70.5% at 3 days, 81.6% at 7 days, 74.3% at 14 days, and 70.4% at 28 days. Nonetheless, their strength remained slightly below that of Type 4-4 samples—by 4.6% (3 days), 0.87% (7 days), 5.1% (14 days), and 6.0% (28 days). The average strength values for Type 4-3 ranged from 1.04 MPa to 3.75 MPa.

Samples of Type 4-4 demonstrated considerable improvements in compressive strength compared to the Type 1 reference samples, with increases of 78.6% at 3 days, 83.2% at 7 days, 83.7% at 14 days, and 81.1% at 28 days. However, their strength values were slightly lower than those of Type 5-1 samples—by 2.7% (3 days), 4.2% (7 days), 5.8% (14 days), and 5.0% (28 days). The average compressive strength for Type 4-4 samples ranged from 1.09 MPa to 3.99 MPa.

Samples of Type 5-1 outperformed the Type 1 reference mix with compressive strength increases of 83.6% (3 days), 91.2% (7 days), 95.0% (14 days), and 90.0% (28 days). When compared to Type 5-2, however, they showed slightly lower strength values—by 1.7% (3 days), 0.4% (7 days), 1.6% (14 days), and 1.2% (28 days). The average strength ranged from 1.12 MPa to 4.20 MPa.

Samples of Type 5-2 showed further increases in compressive strength relative to Type 1, with gains of 86.8% (3 days), 92.0% (7 days), 98.1% (14 days), and 93.2% (28 days). Nevertheless, they were slightly outperformed by Type 5-3 samples—by 4.2% (3 days), 0.8% (7 days), 0.6% (14 days), and 2.7% (28 days). The average strength values for Type 5-2 ranged from 1.14 MPa to 4.25 MPa.

Samples of Type 5-3 displayed a nearly twofold increase in compressive strength compared to the reference Type 1 samples, with increases of 95.1% (3 days), 93.6% (7 days), 99.3% (14 days), and 98.6% (28 days). However, their values were slightly lower than those of Type 5-4—by 1.6% (3 days), 2.8% (7 days), 0.6% (14 days), and 0.7% (28 days). The average compressive strength of Type 5-3 samples ranged from 1.19 MPa to 4.37 MPa.

Samples of Type 5-4 exhibited the highest compressive strength values among all tested compositions. Compared to the Type 1 reference samples, the strength of Type 5-4 samples increased by 98.4% at 3 days, 99.2% at 7 days, and reached a full 100% improvement at both 14 and 28 days. These results indicate a doubling of strength relative to the control mixture. The average compressive strength of Type 5-4 samples ranged from 1.21 MPa to 4.40 MPa, confirming the superior effectiveness of this composition in enhancing the mechanical performance of foam concrete.

The analysis of the experimental results indicates that for sample types 2-1 through 5-4, the compressive strength at 28 days ranges from 2.25 MPa to 4.40 MPa, whereas the reference sample (Type 1) demonstrated a strength of 2.20 MPa. This means that in the most effective cases, the compressive strength nearly doubles compared to the control sample.

The data also show that the hardening process occurs not only during the early stages but continues progressively over time, with a steady increase in strength. This consistent development of mechanical properties suggests that the use of a plasticizing additive contributes significantly to the long-term structural performance of foam concrete.

Overall, the incorporation of the modified additive positively influences both early and late strength gain, enhancing the material's durability and reliability.

It has been established that all the additives studied have a positive effect on compressive strength, starting from the early stages of hardening (3 days) and especially by 28 days.

The most intense increase in strength is observed between 14 and 28 days, which indicates the prolonged action of the additives and improvement of cement hydration processes in the cellular structure of foam concrete.

Samples of types 2-1 to 3-2 showed a moderate increase in strength, ranging from 2.3% to 30.9% on day 28 compared to the reference sample. This indicates an initial positive effect of the additives, but without a radical change in the structure of the material.

Starting with samples of type 3-3 and above, the increase in strength became more pronounced, which is associated with the use of more effective or combined modifying compositions.

Type 5-4 samples demonstrated the highest strength — up to 4.40 MPa on day 28, which is 100% higher than the reference samples (2.20 MPa). This result indicates the high effectiveness of complex additives in improving the structure and density of foam concrete.

By the third day, strength had increased from 1.6% to 98.4%, confirming the accelerated hardening of foam concrete in the presence of active additives.

On the 7th day, an increase from 3.2% to 99.2% was observed, and on the 14th day, from 7.5% to 100%, reflecting the gradual strengthening of the structure and the completion of the main hydration processes.

Maximum strength values are reached on day 28, with an increase from 2.3% to 100%, depending on the type of sample. The kinetics of foam concrete hardening were studied, and it was found that the modifying additive accelerates the hardening of foam concrete.

Conclusion

The results obtained from the study support the recommendation of incorporating effective complex additives—particularly those used in sample types 4-3 through 5-4—into the production of non-autoclaved foam concrete with a density of D=600. The use of these additives has been shown to significantly enhance the strength and long-term durability of the material.

One of the key factors contributing to this improvement is the reduction in the water-cement ratio, made possible by the hydrophilic properties of the modifying additive. This leads to a denser and stronger concrete matrix. At the same time, the hydrophobic action of the additive reduces the material's water absorption capacity, thereby improving its resistance to moisture and increasing its durability under service conditions.

The integration of such additives into foam concrete mixtures not only improves mechanical performance but also offers important practical advantages: it enables faster formwork removal, increases the load-bearing capacity of structural elements, and broadens the range of possible applications for foam concrete—including its use in both structural and thermal insulation products.

Additives improve not only strength but also structural uniformity, reducing the number of macropores and increasing the density of the material.

The analysis showed that correctly selected and dosed modifying additives can significantly improve the strength characteristics of non-autoclaved foam concrete grade D=600, in some cases almost doubling them. This makes the material more competitive and expands its application in modern construction, including energy-efficient building envelopes.

CRediT author statement: **A. Askerbekova**: conceptualization; **D. Dyusembinov**: writing—original draft preparation; **Zh.Shashpan**: formal analysis; **A. Abduova**: resources; **M. Kambarov**: critical review of content.

Acknowledgements. The authors would like to express their gratitude to the research and production center "ENU-lab" for conducting laboratory tests of foam concrete.

This research has been/was/is funded by the Committee of Science of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. BR21882278 «Establishment of a construction and technical engineering centre to provide a full cycle of accredited services to the construction, road-building sector of the Republic of Kazakhstan»).

All authors have read and agreed to the published version of the manuscript.

Cite this article as: Askerbekova AM, Dyussembinov DS, Shashpan ZhA, Abduova AA, Kambarov MA. Investigation of the effect of a modified additive on the strength characteristics of foam concrete. Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources. 2027; 341(2):117-127. https://doi.org/10.31643/2027/6445.23

Модификацияланған қоспаның көбікті бетонның беріктік сипаттамаларына әсерін зерттеу

[1]Аскербекова А.М., [1]Дюсембинов Д.С., [1]Шашпан Ж.А., [2]Абдуова А.А., [2]Камбаров М.А.

[1]Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан
[2] М.Әуезов атындағы Оңтүстік Қазақстан зерттеу университеті, Шымкент, Қазақстан

Мақала келді: *1 тамыз 2025*
Сараптамадан өтті: *11 қазан 2025*
Қабылданды: *1 желтоқсан 2025*

ТҮЙІНДЕМЕ
Мақалада модификацияланған қоспаның көбікті бетонның беріктік сипаттамаларына әсерін зерттеудің екінші кезеңі ұсынылған. Бұл жұмыста көбікті бетон үлгілерін дайындау әдісі сипатталып, әртүрлі пайыздық құрамдағы компоненттермен модификациялаушы қоспаның құрамы таңдалып, олардың беріктік сипаттамаларына талдау жүргізілді. D600 маркалы көбікті бетонға пластификаторлық қоспа (спирттен кейінгі барда) енгізудің мақсаты – су шығынын азайту және беріктікті арттыру. Беріктік өзгерістерін бағалау үшін 3, 7, 14 және 28 тәулікте қалыпты ылғалдандыру жағдайында қысу сынақтарына арналған үлгілер дайындалды. Зерттеу нәтижелері бойынша мұндай қоспаларды қолдану қалыптан босату уақытын айтарлықтай қысқартуға, конструкциялардың көтергіш қабілетін арттыруға және көбікті бетонды қолдану аясын кеңейтуге – тіпті конструкциялық және жылу оқшаулағыш бұйымдар үшін де – мүмкіндік беретіні анықталды. Қоспалар тек беріктікті ғана емес, сонымен қатар құрылымның біртектілігін де жақсартады, макрокеуектер санын азайтады және материалдың тығыздығын арттырады.

Түйін сөздер: цемент қоспасы, спирттен кейінгі барда, модификацияланған қоспа, қысу кезіндегі беріктік, пластификатор, көбіктендіргіш.

Авторлар туралы ақпарат:

Аскербекова Арайлым Мырзаханкызы — *PhD докторанты, Өнеркәсіптік және азаматтық құрылыс технологиясы кафедрасы, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан. Email: aria_09.91@mail.ru; ORCID ID: https://orcid.org/0000-0002-4356-053X*

Дюсембинов Думан Серикович — *Т.ғ.к., Өнеркәсіптік және азаматтық құрылыс технологиясы кафедрасының доценті, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан. Email: dusembinov@mail.ru; ORCID ID: https://orcid.org/0000-0001-6118-5238*

Шашпан Жоламан Амангелдіұлы — *Т.ғ.д., Өнеркәсіптік және азаматтық құрылыс технологиясы кафедрасының доценті, Л.Н. Гумилев атындағы Еуразия ұлттық университеті, Астана, Қазақстан. Email: zholamanalmatykz@gmail.com; ORCID ID: https://orcid.org/0000-0002-6236-0525*

Абдуова Айсулу Алшынбековна — *Т.ғ.к., Экология кафедрасының доценті, М.Әуезов атындағы Оңтүстік Қазақстан зерттеу университеті, Шымкент, Қазақстан. Email: aisulu.abduova@mail.ru; ORCID ID: https://orcid.org/0000-0001-5389-6953*

Камбаров Медет Абдильдаевич — *Т.ғ.к., Құрылыс материалдары және құрылыстағы сараптама кафедрасының доценті, М.Әуезов атындағы Оңтүстік Қазақстан зерттеу университеті, Шымкент, Қазақстан. Email: medet_2030@mail.ru; ORCID ID: https://orcid.org/0000-0001-6397-1451*

Исследование влияния модифицированной добавки на прочностные характеристики пенобетона

[1]Аскербекова А.М., [1]Дюсембинов Д.С., [1]Шашпан Ж.А., [2]Абдуова А.А., [2]Камбаров М.А.

[1]Евразийский национальный университет имени Л.Н. Гумилева, Астана, Казахстан
[2]Южно-Казахстансикй исследовательский университет имени М.Ауэзова, Шымкент, Казахстан

Поступила: *1 августа 2025*
Рецензирование: *11 октября 2025*
Принята в печать: *1 декабря 2025*

АННОТАЦИЯ
В статье представлен второй этап исследования влияния модифицированной добавки на прочностные характеристики пенобетона. В данной работе описан способ изготовления образцов пенобетона, подобран состав модифицирующей добавки с различным процентным содержанием компонентов и проведен анализ их прочностных характеристик. Цель введения пластифицирующих добавок (послеспиртовой барды) в пенобетон D600 - снижение расхода воды и ожидаемое повышение прочности. Чтобы оценить изменения в прочности, были изготовлены образцы и испытаны на сжатие в возрасте 3, 7, 14 и 28 дней

	при нормальном увлажнении. Согласно результатам исследований, использование таких добавок позволяет значительно сократить сроки распалубки, повысить несущую способность конструкций и расширить сферу применения пенобетона - даже для конструкционных и теплоизоляционных изделий. Добавки улучшают не только прочность, но и однородность структуры, уменьшая количество макропор и повышая плотность материала.
	Ключевые слова: цементная смесь, послеспиртовая барда, модифицирующая добавка, прочность на сжатие, пластификатор, пенообразователь.
Аскербекова Арайлым Мырзаханкызы	***Информация об авторах:*** *Докторант PhD, Кафедра Технология промышленного и гражданского строительства, Евразийский национальный университет имени Л.Н. Гумилева, Астана, Казахстан. Email: aria_09.91@mail.ru; ORCID ID: https://orcid.org/0000-0002-4356-053X*
Дюсембинов Думан Серикович	*К.т.н., доцент кафедры Технология промышленного и гражданского строительства, Евразийский национальный университет имени Л.Н. Гумилева, Астана, Казахстан. Email: dusembinov@mail.ru; ORCID ID: https://orcid.org/0000-0001-6118-5238*
Шашпан Жоламан Амангельдиевич	*Д.т.н., доцент кафедры Технология промышленного и гражданского строительства, Евразийский национальный университет имени Л.Н. Гумилева, Астана, Казахстан. Email: zholamanalmatykz@gmail.com; ORCID ID: https://orcid.org/0000-0002-6236-0525*
Абдуова Айсулу Алшынбековна	*К.т.н., доцент кафедры Экология, Южно-Казахстанский исследовательский университет имени М.Ауэзова, Шымкент, Казахстан. Email: aisulu.abduova@mail.ru; ORCID ID: https://orcid.org/0000-0001-5389-6953*
Камбаров Медет Абдильдаевич	*К.т.н., доцент кафедры Строительные материалы и экспертиза в строительстве, Южно-Казахстансикй исследовательский университет имени М.Ауэзова, Шымкент, Казахстан. Email: medet_2030@mail.ru; ORCID ID: https://orcid.org/0000-0001-6397-1451*

References

[1] Postanovlenie Pravitel'stva Respubliki Kazahstan. Gosudarstvennaya programma zhilishchno-kommunal'nogo razvitiya Nyrly-ZHer na 2020-2025 gody [State Program of Housing and Communal Development Nurly-Zher for 2020-2025]. utv. 31 dekabrya 2019 goda, №1054 (in Russ.). https://adilet.zan.kz/rus/docs/P1900001054

[2] Postanovlenie Pravleniya Natsionalnogo Banka Respubliki Kazakhstan [Resolution of the Board of the National Bank of the Republic of Kazakhstan]. utv. 19 dekabrya 2022 goda № 123. O vnesenii izmeneniy v postanovleniye Pravleniya Natsionalnogo Banka Respubliki Kazakhstan [On Amendments to the Resolution of the Board of the National Bank of the Republic of Kazakhstan]. utv. 31 maya 2018 goda № 107 Ob utverzhdenii Programmy ipotechnogo zhilishchnogo kreditovaniya 7-20-25. Novyye vozmozhnosti priobreteniya zhilia dlya kazhdoy semi [On the Approval of the Mortgage Housing Loan Program 7-20-25: New Opportunities for Every Family to Purchase Housing]. (in Russ.). https://online.zakon.kz/Document/?doc_id=36871886&pos=6;-108#pos=6;-108

[3] Jalalov ShG, Otsokov KA. Sposoby povysheniya effektivnosti penobetona [The ways of increase of efficiency of foam concrete]. Vestnik Dagestanskogo gosudarstvennogo tekhnicheskogo universiteta. Tekhnicheskiye nauki [Herald of Dagestan State Technical University. Technical Sciences]. 2016;42(3):167-174. (In Russ.). https://doi.org/10.21822/2073-6185-2016-42-3-167-175

[4] Liu J, Ge T, Wu Y, Chen R. Effect of Sand-to-Cement Ratio on Mechanical Properties of Foam Concrete. Buildings. 2022; 12(11):1969. https://doi.org/10.3390/buildings12111969

[5] Liu J, Ren Y, Chen R, Wu Y, Lei W. The Effect of Pore Structure on Impact Behavior of Concrete Hollow Brick, Autoclaved Aerated Concrete and Foamed Concrete. Materials. 2022; 15(12):4075. https://doi.org/10.3390/ma15124075

[6] Lukpanov RE, Dyusembinov DS, Altynbekova AD, Yenkebayev SB, Zhantlesova ZhB. Issledovaniye fiziko-mekhanicheskikh svoystv peska i tsementa dlya proizvodstva penobetona [Research physical and mechanical properties of sand and cement for foam concrete production]. Vestnik Kazakhskoy golovnoy arkhitekturno-stroitel'noy akademii. Stroitel'nyye konstruktsii i materialy [Bulletin of Kazakh Leading Academy of Architecture and Construction. Building structures and materials]. 2023; 1(87):217- 228. (In Russ.). https://doi.org/10.51488/1680-080X/2023.1-21

[7] Zhongwei Liu, Kang Zhao, Chi Hu, and Yufei Tang. Effect of water-cement ratio on pore structure and strength of foam concrete. Hindawi Publishing Corporation. Advances in Materials Science and Engineering. 2016. http://dx.doi.org/10.1155/2016/9520294

[8] Abdyushkurov F, Sabitov E, Kirghizbayev A, Duzelbayev S. Building materials and products, Nur-Sultan, L.N. Gumilyov Eurasian National University. 2021, 458.

[9] Al-Khazraji AA. Use of plasticizers in cement concrete. Journal of Advanced Research in Dynamical and Control Systems. 2020; 12(3):599-607. https://doi.org/10.5373/JARDCS/V12I3/20201229

[10] Arvind Vishavkarma, Kizhakkumodom Venkatanarayanan Harish. Development of eco-friendly and cost-effective foam concrete using high-volume supplementary cementitious materials: Analysis of microstructural, mechanical, and durability properties. Construction and Building Materials. 2025; 458. https://doi.org/10.1016/j.conbuildmat.2024.139584

[11] Dhasindrakrishna K, et al. Collapse of fresh foam concrete: Mechanisms and influencing parameters. Cement and Concrete Composites. 2021; 122:104151.

[12] Cherkasov VD, Buzulukov VI, Emelianov AI. Perspektivnaya plastifitsiruyushchaya dobavka dlya tsementnykh sistem iz poslespirtovoy bardy [A promising plasticizing additive for cement systems made from distillery stillage]. Vestnik Volzhskogo regionalnogo otdeleniya Rossiyskoy akademii arkhitektury i stroitelnykh nauk [Bulletin of the Volga Regional Branch of the Russian Academy of Architecture and Construction Sciences]. 2014; 17:264-266. (in Russ.).

[13] Shi M, et al. Mix proportion optimization and early strength development in modified foam concrete: an experimental study. Mater. Res. Express. IOP Publishing. 2023; 10(6):065507.

[14] Baronins J, et al. The Effect of Raw Materials and Mechanical Activation Stages on Properties of Foamed Concrete: SSRN Scholarly Paper. Rochester, NY. 2024, 4728421.

[15] Serova RF, Tkach EV, Seydinova GA, Stasilovich EA. Issledovaniye sposobov utilizatsii promyshlennykh otkhodov dlya proizvodstva gazobetona [Research into methods of industrial waste utilization for aerated concrete production]. Vestnik Trudy universiteta. Seriya: Stroitelstvo. Transport [Bulletin of the University's Proceedings. Series: Construction. Transport]. Karagandy. 2020; 2(79):74-78. (in Russ.).

[16] Altynbekova AD, Lukpanov RE, Dyussembinov DS, Askerbekova AM, Talal Awwad. Effect of a complex modified additive based on post-alcohol bard on the strength behavior of concrete. Kompleksnoe Ispolzovanie Mineralnogo Syra = Complex Use of Mineral Resources. 2023; 327(4):5-14. https://doi.org/10.31643/2023/6445.34

[17] Miryuk OA. Resursosberezheniye v tekhnologii stroitelnykh materialov [Resource conservation in building materials technology]. Almaty. Evero. 2013, 280. (in Russ.).

[18] Askerbekova AM, Dyusembinov DS, Skripnikova NK, Altynbekova AD, Iztleuov GM. The effect of a complex modified additive on the quality of the production of foam concrete products. Bulletin of D. Serikbaev EKTU, Technical sciences. 2024; 2:5-15. https://doi.org/10.51885/1561-4212_2024_2_5

[19] Cherkasov VD, Emelyanov AI, Kiselev EV. Obtaining efficient foam from secondary products of ethyl alcohol production. Expert: theory and practice. 2023; 1(20):160-162. (In Russ.). https://doi.org/10.51608/26867818_2023_1_160

[20] Vinokurova OV, Baranova AA. On the question of choosing the optimal water-cement ratio in the production of thermal insulating foam concrete. Bulletin of BSTU named after V.G. Shukhov. 2022; 11:19–29. https://doi.org/10.34031/2071-7318-2022-7-11-19-290