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ТЕХНИКАЛЫҚ ҒЫЛЫМДАР ЖӘНЕ ТЕХНОЛОГИЯЛАР СЕРИЯСЫ / TECHNICAL SCIENCES AND TECHNOLOGY SERIES/ СЕРИЯ ТЕХНИЧЕСКИЕ НАУКИ И ТЕХНОЛОГИИ

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Increase of physical and mechanical parameters of arbolite-concrete composites by deep impregnation with liquid sulfur

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Abstract. The article deals with the influence of molten liquid sulfur on the physical and mechanical properties of porous arbolite concrete composites. For the manufacture of arbolite-concrete composites we used porous waste corn cob crushed with sizes from 10 to 40 mm. To compare the results of research we also adopted more dense waste vegetation crushed walnut shells with sizes from 10 to 20mm.To conduct the study adopted the method of complete impregnation of arbolitobetonnyh samples liquid molten sulfur. As impregnation, material used sulfur - waste oil production in Kazakhstan. The results of the study found that with an increase in the composition of arbolite concrete composites content of cellulose organic aggregates, there is a significant increase in compressive strength and average density of lightweight concrete depending on the duration of impregnation. We have revealed that physical and mechanical properties and corrosion resistance of impregnated arbolite concrete samples are very high and these data prove that they can be recommended for use in underground and engineering structures.
Key words: Industrial sulfur, petroleum waste, impregnation of samples, arbolite concrete composites, porous organic aggregates, strengthening, average density, mechanical strength

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Introduction

In Kazakhstan, especially in the cities of Atyrau and Pavlodar oil refineries for processing and purification of high sulfur oil with a capacity of up to 12 tons of oil per year have been put into operation, which is expected to allow to obtain from oil processing annually from 220 to 230 thousand tons of technical sulfur. The safe storage of sulfurous waste requires special measures for environmental safety and land allocation for storage of these toxic wastes. For this reason, the processing of high-sulfur oil wastes becomes a priority industrial direction and ecological-economic, technical and technological tasks of which become relevant for the states of Central Asia and the Russian Federation. Increased physical-mechanical and construction-operational characteristics of building materials of products made on the basis of technical sulfur proved the assumption of its effectiveness when used as an impregnation material for surface treatment, pore and intergranular space of concretes and products for various purposes.

Technical sulfur as an impregnating material and as a binding agent in the production of building materials began to be used in the twentieth century in the United States and Great Britain and then it began to be used in the former Soviet Union. This novelty is based on the properties of technical sulfur, which melts at temperatures from 112 to 115 ° C and when cooled to a temperature of 100 ° C crystallizes and prevails increased strength. Sulfur concretes are obtained by mixing coarse and fine aggregates in a heated state with the melt of sulfur. On cooling, the mixture hardens. Such concrete gains strength faster than ordinary concrete and has high chemical and acid resistance. The disadvantage of these concretes is that they are very energy-consuming, since during the manufacture of sulfur concretes must be constant to be heated states [1-3]. The works also indicate that in the first half of the twentieth century, sulfur began to be used for fixing metal bolts in concrete foundations, posts of stairway handrails and flights of stairs. In these works, technological factors affecting the impregnation process such as age and moisture content of concrete, viscosity of the impregnation composition and the effect of surfactants on the structure of concrete are studied. Recommendations on waterproofing of reinforced concrete pavement slabs by impregnation with sulfur compositions in dry hot climates have also been made [1-3]. The conducted research on impregnation of concrete with sulfur was aimed at improving the technology of partial impregnation and at studying the physical and mechanical properties of concrete with regard to durability. It was found that impregnation of concrete with sulfur can significantly improve its initial characteristics. The improvement of these characteristics depends on the weight of sulfur and the depth of impregnation. The influence of concrete humidity on the intensity of impregnation has been studied and the necessity of preliminary drying of concrete has been established to exclude the possibility of polysulfide formation, which with time can turn into sulfates, which are agents of concrete destruction. In the first case there is a volume increase due to the expansion of calcium hydrosulfoaluminates, and in the second case - sulfur leaching without concrete destruction [4-6]. Recently in Kazakhstan and especially in the oil-producing countries of the world the attention of scientific researchers is especially attracted to the method of sealing the pore intergrain space of concrete by impregnation with monomers, oligomers and also oil and gas industry waste, molten liquid technical sulfur. The influence of concrete age, water-cement ratio, impregnation time, curing method, sulfur and concrete temperature at immersion on the properties of impregnated concrete has been studied. It was found that concrete temperature at immersion and sulfur curing method do not significantly affect the impregnation results. [7-9].

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Methods of impregnation with monomers, oligomers and molten sulfur for their subsequent polymerization in the pore structure of concrete are used to increase durability and improve physical and mechanical characteristics of construction materials and products used under various aggressive environments. The research results showed that concrete treated with monomers has high sulfate resistance, frost resistance, wear resistance and resistance to distilled water. Methyl methacrylate, butyl acrylate were used as impregnation compositions. Polymerization was carried out by radiation method or in the presence of catalysts at elevated temperatures - by thermocatalytic method [10, 11]. The papers describe research work on impregnation of slag-alkali and sulfur-containing arbolite concretes with molten liquid sulfur. The results of the study showed that sulfur impregnation has a very significant effect on improving the physical and mechanical properties of arbolite concretes. The disadvantage of this study is that in the process of impregnation sulfur-containing arbolite concrete melts and loses geometric shapes [12-14]. The works show methods of impregnation of building materials and products of organic and inorganic origin possessing a system of closed-open capillaries. Systematic search for new ways of their antifiltration protection shows that the existing methods for one reason or another do not fully satisfy the requirements to them. In our opinion, that at contact with the solid surface of dispersoid grains or solid matrix molecules of impregnating liquid under the action of physical and chemical phenomena penetrate into voids and remain there in their original form or under the influence of temperature, catalysts and radiation pass into irreversible state [15-16]. Arbolite are varieties of lightweight concrete, as a coarse aggregate mainly enters various waste vegetation. Also arbolitobetonnye composites depending on the components has an average density ranging from 400 to 1200 kg/m3 and has a strength of 1.0 MPa to 5.0 MPa. The disadvantages of these arbolitobetonnyh composites can be attributed to their low strength and resistance. To protect against the effects of aggressive external factors and also to increase the construction and technical parameters of porous arbolite concrete products of plant origin can be impregnated with technical sulfur [17, 18].

The purpose of the study is to improve the performance of lightweight arbolite concrete by impregnation with technical sulfur for use in underground and engineering structures.

To achieve the goal the following tasks were set:

1. investigation of the effect of the influence of molten liquid sulfur on the physical and mechanical properties of less durable arbolite concrete products.

2. Comparing the results of the study to determine the optimal arbolite-concrete product with higher physical-mechanical and construction-technical indicators.

The methodology

Arbolite concrete composites are varieties of lightweight concrete made on the basis of vegetation waste and binders. For the manufacture of arbolite-concrete composites used porous waste corn cob crushed with sizes from 10 to 40 mm. At the time of experimental work moisture characteristics of corn cob waste was 3-5%. The chemical composition of corn cob waste is given in Table 1.

For comparison of research results we also adopted more dense waste vegetation crushed walnut shells with sizes from 10 to 20mm.

Table 1. Chemical composition of corn cob waste

№ b/o	Name of composition	Chemical formula	Number, in %
1	Cellulose	$C_6H_{10}O_5$	46,17
2	Lignin	$C_{41}H_{40}O_{15}$	29,76
3	Pentosan	$C_5H_8O_4$	22,00
4	Resins and soluble components	-	2,07

At the time of experimental work moisture characteristics of walnut waste also amounted to 3-5%. The chemical composition of walnut shell waste is presented in Table 2.

Table 2. Chemical composition of walnut shells

№ b/o	Name of composition	Chemical formula	Number, in %
1	Cellulose	$C_6H_{10}O_5$	45,7
2	Lignin	$C_{41}H_{40}O_{15}$	23,2
3	Pentosan	$C_5H_8O_4$	26,4
4	Resins and soluble components	-	4,7

Portland cement of 400 grade from Kyzylkum cement plant of Navoi region of Navoi region of the Republic of Uzbekistan was also used for the manufacture of arbolite concrete composites. The chemical composition of cement is given in Table 3.

Table 3. Chemical composition of Kyzylkum cement plant

Content, %									
Basic oxides						Major minerals			
CaO	SiO_2	$A1_2O_3$	Fe_2O_3	R_2O	SO_3	C_3S	C_2S	C_3A	C_4AF
61,48	23,38	6,38	6,09	0,38	0,60	57,60	17,40	7,90	13,10

Fly ash from Aktobe TEC, meeting the requirements of GOST 10181-2000 [19], was used as an active mineral additive. Chemical composition of fly ash is presented in Table 4.

Table 4. Chemical composition of fly ash mineral additive

Losses on ignition, wt. %	Oxide content, wt. %						
	SiO_2	AI_2O_3+TiO_2	Fe_2O_3	CaO	MgO	NaO_2	SO_2
7,33	48,3	23,92	5,94	9	1,9	0,18	0,52

In the experimental and research work as an impregnating agent we used waste high-sulfur oil of Aktobe oil and gas production of the Republic of Kazakhstan. Technical sulfur is a solid crystalline substance with yellowish color shade and melting point from 115 to 119°C. When the temperature rises to 200°C passes into a viscous state and at 450°C passes to the process of boiling, from then sharply burns.

Table 5 shows the chemical composition of technical sulfur grade No. 9998.

Table 5. Chemical composition of sulfur grade № 9998

№ b/o	Name of fraction of substances in the composition of sulphur	Number, %
1	Mass fraction of sulfur, %	99,060
2	Mass fraction of ash, %	0,400
3	Mass fraction of organic matter, %	0,053
4	Mass fraction of water, %	0,010

Two series of cemented arbolite specimens with different compositions were manufactured for experimental work. Each series consisted of four sample cubes with dimensions 100x100x100mm with different binder compositions. The first four series of sample cubes were made using porous corn cob waste with dimensions of 15-30mm and the second series of samples were made using crushed walnut shells with dimensions of 18-25mm. After that all these cube samples we used for sulfur impregnation.

Table 6. Compositions and properties of arbolite-concrete samples of series №1

Name of indicators	Unit of measurement	Indicator values for arbolite
Consumption of cement grade 400	kg/m^3	325
Corn cob waste consumption	kg/m^3	235
Water consumption with dry organic aggregates	l/m^3	350
Fly ash consumption	kg/m^3	90
Density in dried state	kg/m^3	600–630
Compressive strength	MPa	2,9
Water absorption by mass	%	67
Frost resistance	cycle	50
Heat transfer coefficient	W/m^{2}K	0,10

Since the purpose of our study was to investigate the effect of molten liquid sulfur on the physical and mechanical properties of less durable arbolite concrete composites, we prepared two series of simple cement arbolite concrete composites with different compositions and physical and mechanical properties for impregnation. The compositions and properties of arbolite concrete composites prepared for impregnation with sulfur-waste are given in tables 6 and 7.

Preparation and determination of properties of lightweight arbolite-concrete compositions were determined according to standard methods in accordance with GOST 31108-2003 and GOST

7473-2010 [20, 21]. Determination of tensile and bending strength of binders was carried out on specimen beams with dimensions 40x40x160 mm on the device IP 2710.

Determination of tensile strength of sulfur-waste impregnated arbolite samples was carried out according to the standard methodology. Impregnation of arbolite concrete samples with molten liquid technical sulfur can be carried out in the following technological sequence. To carry out dehydration in capillary-porous structures of arbolite-concrete composites it is necessary to perform pre-drying with heating for 6 to 10 hours at a temperature of 125-145°C. For arbolitobeton composites dried to a constant mass, impregnate with molten sulfur at a temperature of 125 to 185 ° C for 2 to 24 hours. Gradual uniform cooling of impregnated molten liquid sulfur impregnated arbolitobetonnyh samples to the required depth brings to the ambient temperature within 2 to 4 hours. Given all these factors technology impregnation of arbolite with molten liquid sulfur can be argued that the entire technological cycle of impregnation of arbolite concrete samples with liquid sulfur will last from 2 to 24 hours.

Table 7. Compositions and properties of arbolite-concrete samples of series №2

Name of indicators	Unit of measurement	Indicator values for arbolite
Consumption of cement grade 400	kg/m³	350
Consumption of walnut shells	kg/m³	250
Water consumption with dry organic aggregates	l/m³	370
Fly ash consumption	kg/m³	90
Density in dried state	kg/m³	600–660
Compressive strength	MPa	3,7
Water absorption by mass	%	45
Frost resistance	cycle	75
Heat transfer coefficient	W/m²K	0,135

During the impregnation of molten sulfur with waste arbolite concrete samples workers must strictly observe technical safety measures in accordance with GOST R 58965-2020, GOST 9.010-80 and GOST 12.4.034-2001 [22 - 24]. Workers engaged with the sulfur impregnation process should have self-contained protective breathing apparatus at their disposal, especially when melting sulfur. Smoking should be prohibited during transportation and processing of sulphur and in places where it is stored. Contact of liquid or transfused sulphur with a source of sunburn should be avoided

Findings/Discussion

In accordance with the purpose and task of the study at impregnation of arbolite concrete composites with molten sulfur wastes depending on the duration of impregnation time we obtained the following results. It is established that after impregnation of arbolite concrete composites with molten sulfur wastes, in all samples of arbolite concrete composites substituted improvement of physical and mechanical characteristics, such as, average density and strength. In the study of impregnation with sulfur-containing waste samples of arbolite concrete composites of different compositions, as well as different organic cellulose aggregates, the following results were obtained. As can be seen from the results of the study, presented in Figure 1 and Table 8, it can be seen that the strength characteristics of samples subjected to impregnation in liquid molten technical sulfur for compositions 1-4 (series №1), made on the basis of porous corn cob waste, increased and amounted to 3.7; 4.8; 7.9 and 8.7 MPa.

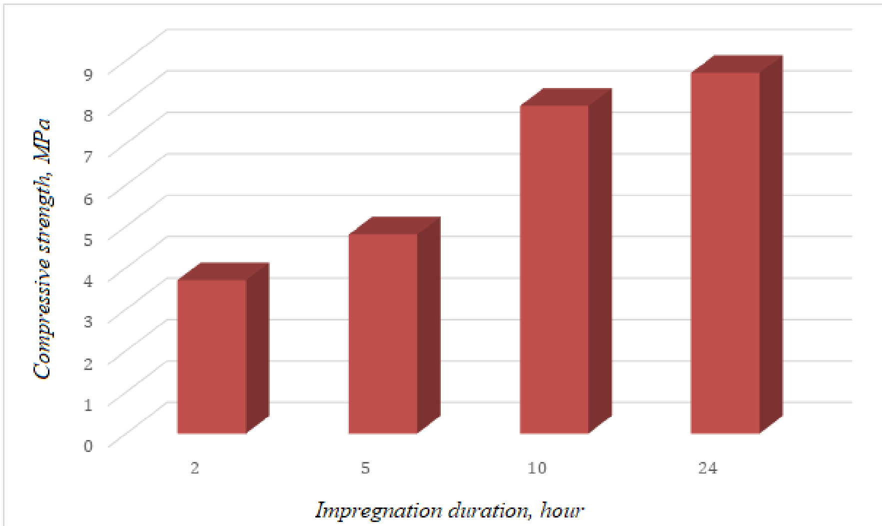

Figure 1. Increases in the strength of arbolite concrete composites based on corn waste depending on the duration of impregnation

We also found that at impregnation with molten liquid sulfur-containing waste arbolite-concrete composite samples based on walnut shell waste depending on the duration of impregnation time (compositions 1-4, series №2), we noted an increase in their strength from 3.8; 4.2; 5.9 to 8.1 MPa.

Table 8. Change of physical and mechanical properties of arbolite concrete samples based on corn cob waste after impregnation with sulfur

Series of prototypes prototypes	Impregnation time, hour	Sulfur gain, %	Compressive strength of samples before impregnation,	Compressive strength of samples after impregnation, MPa	Average density of samples before impregnation, kg/m³	Average density of samples after impregnation, kg/m³	Coefficient hardening factor, MPa
1-series	2	4,1	2,75	3,7	600	624,6	1,041
2-series	5	7,2	2,90	4,8	610	653,92	1,072
3-series	10	9,2	2,91	7,9	620	677,04	1,092
4-series	24	10,3	2,95	8,7	630	694,89	1,103

The results of the obtained studies are shown in Figure 2 and Table 9.

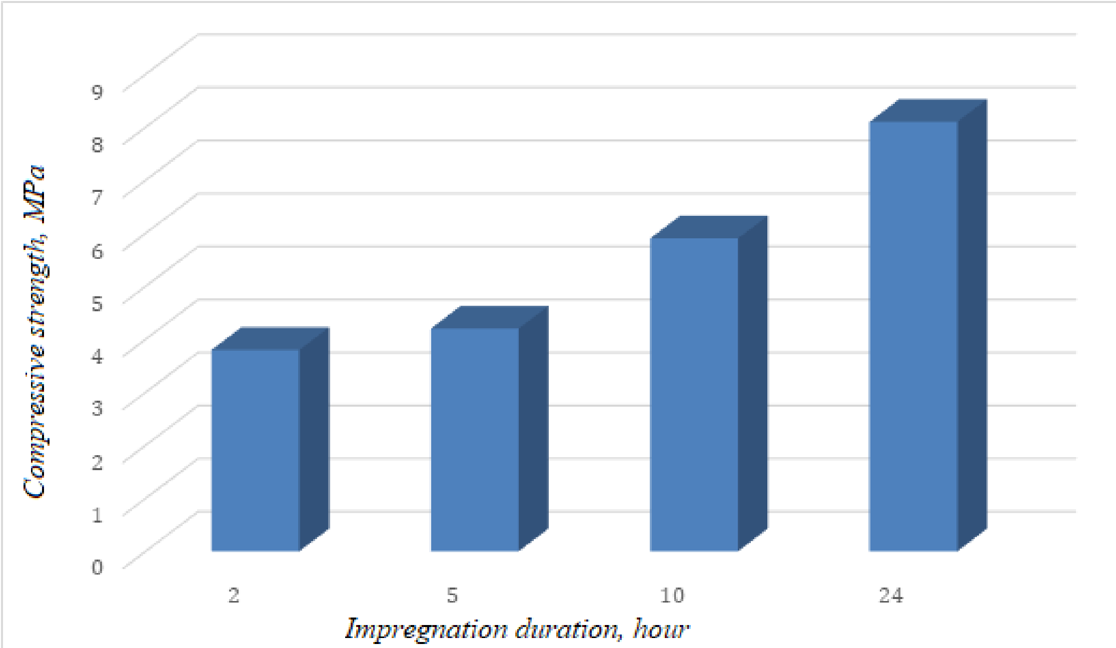

Figure 2. Increases in the strength of arbolite-concrete composites based on walnut shell waste depending on the duration of impregnation

The results of experimental work have established that with increasing the content of cellulose-organic aggregates consisting of corn cob waste and crushed walnut shells in the composition of arbolite concrete composites, there is a significant increase in the mass of sulfur and average density of lightweight concrete depending on the duration of impregnation with sulfur-containing waste.

Table 9. Change in physical and mechanical properties of arbolite concrete samples based on walnut shell waste after impregnation with sulfur

Series of prototypes prototypes	Impregnation time, hour	Sulfur gain, %	Compressive strength of samples before impregnation, MPa	Compressive strength of samples after impregnation, MPa	Average density of samples before impregnation, kg/m^3	Average density of samples after impregnation, kg/m^3	Coefficient hardening factor, MPa
1-series	2	2,9	3,6	3,8	600	617,4	1,029
2-series	5	4,9	3,7	4,2	620	650,38	1,049
3-series	10	7,7	3,75	5,9	640	689,28	1,077
4-series	24	8,9	3,83	8,1	660	718,74	1,089

For the samples of arbolite concrete based on corn cob waste, the increase in average density and sulfur weight were (Table 8 and Fig. 3):

-after 2-hour impregnation, the sulfur weight increased by 4.1% and the average density increased to 624.6 kg/m³;

- after 5-hour impregnation, the weight of sulfur increased by 7.2% and the average density increased to 653.92 kg/m³;

- after 10-hour impregnation, the weight of sulfur increased by 9.2% and the average density increased to 677.04 kg/m³;

- after 24-hour impregnation, the sulfur weight increased by 10.3% and the average density increased to 694.89 kg/m³.

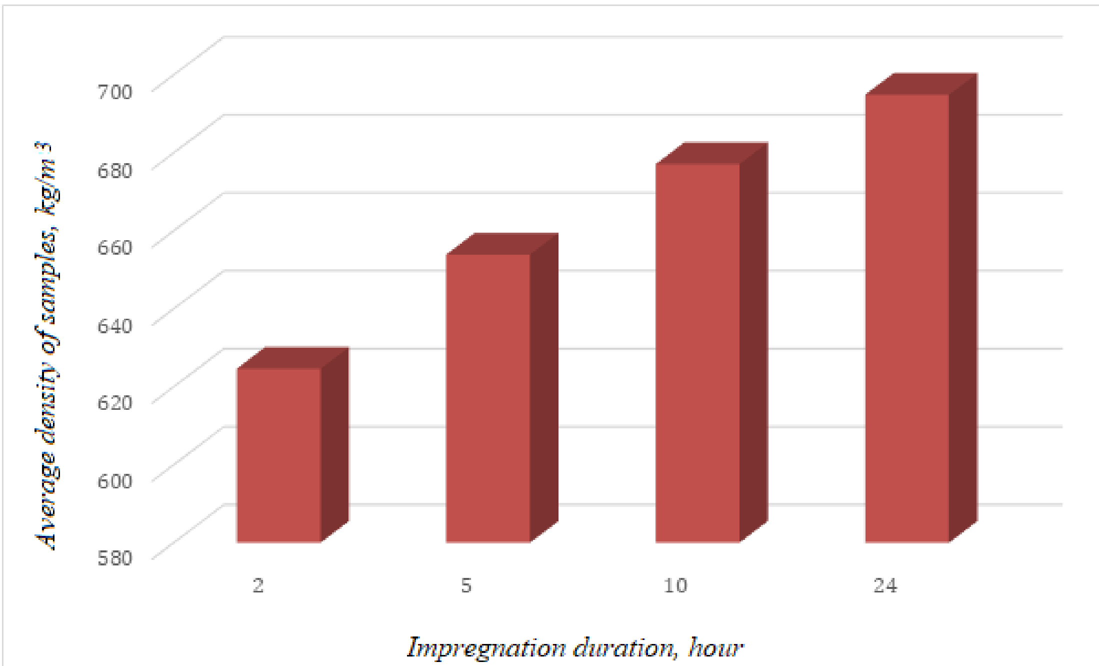

Figure 3. Increase in the average density of arbolite concrete samples based on corn cob waste depending on the duration of sulfur impregnation

When impregnated with sulfur waste arbolite concrete samples based on walnut shell waste, an increase in average density and an increase in the weight of sulfur are observed. The obtained results are presented in Table 9 and Fig. 4:

-after 2-hour impregnation, the sulfur weight gain by 4.1% and the average density increased to 617.4 kg/m³;

-after 5-hour impregnation sulfur weight gain by 7.2% and average density increased to 650.38 kg/m³;

- after 10-hour impregnation sulfur weight gain by 9.2%, and the average density increased to 689.28 kg/m³;

- after 24-hour impregnation, sulfur weight gain by 10.3% and average density increased to 718.74 kg/m³.

Weight gain and increase in the average density of impregnated arbolite concrete samples can be explained by the content and change in the structural porosity of cellulose organic aggregates in the composition of impregnated lightweight concrete. On this value and also the change of physical and mechanical properties of impregnated arbolite concrete samples is significantly influenced by the duration and methods of impregnation. It can be noted here that in all impregnated specimens there is an increase in mechanical strength and average density. Test impregnated with sulfur waste arbolite concrete samples in compression showed that all samples without exception increased their mechanical strength from 1,5 to 3,5 times.

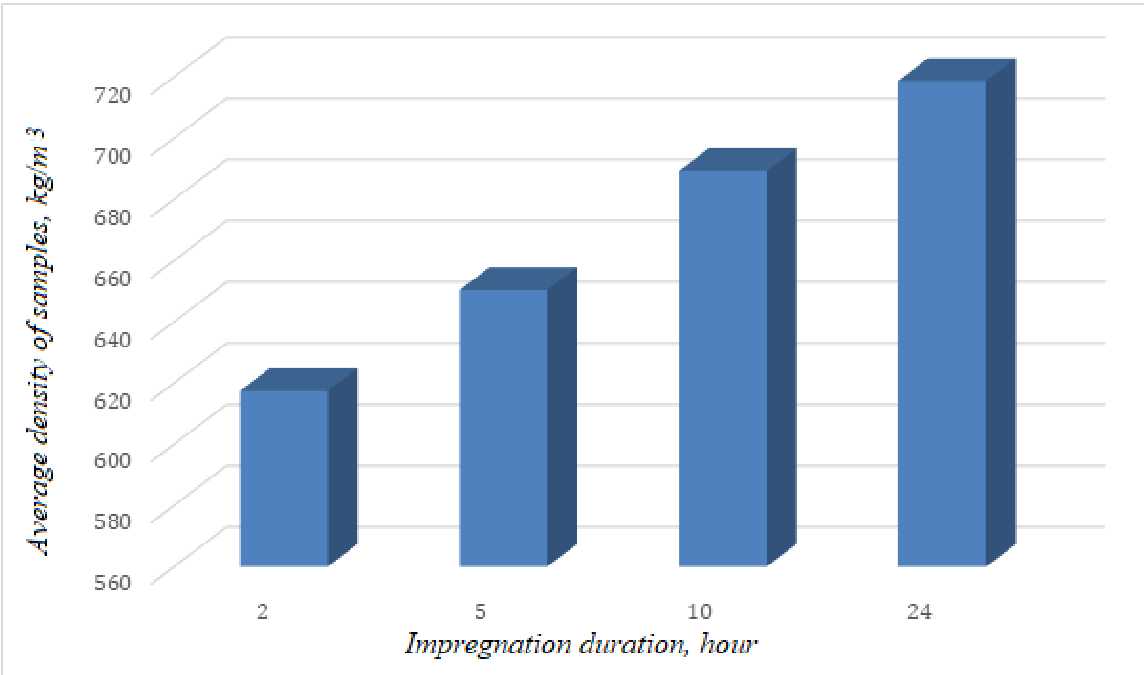

Figure 4. Increase in the average density of arbolite concrete samples based on walnut shell waste depending on the duration of sulfur impregnation

We found that with increasing the time and duration of impregnation from 2 to 24 hours there is an intensive increase in strength of impregnated samples (Tables 8 and 9). Further impregnation and exposure of arbolite concrete samples in molten sulfur does not significantly affect the physical and mechanical characteristics of arbolite concrete composites. Growth of the compressive strength of arbolitobeton in the process of impregnation with sulfur-waste showed that the greatest relative increase in the compressive strength of arbolitobeton samples made on the basis of porous waste corn cob and the results are shown in Table 8. In this case, the value of hardening coefficient for all types of arbolitobeton concrete samples does not differ significantly from each other, and they are in the range from 1.041 to 1.103. The impregnation of arbolite concrete composites with molten liquid sulfur shows the high capable qualities of the studied lightweight concrete.

In Figure 5 shows the samples of unimpregnated (a) and sulfur waste impregnated (b) arbolite concrete composites. From Figure 5 and Tables 8, 9, it can be seen that compared to the unimpregnated samples, the impregnated samples of arbolite concrete composites differ in appearance and construction and performance.

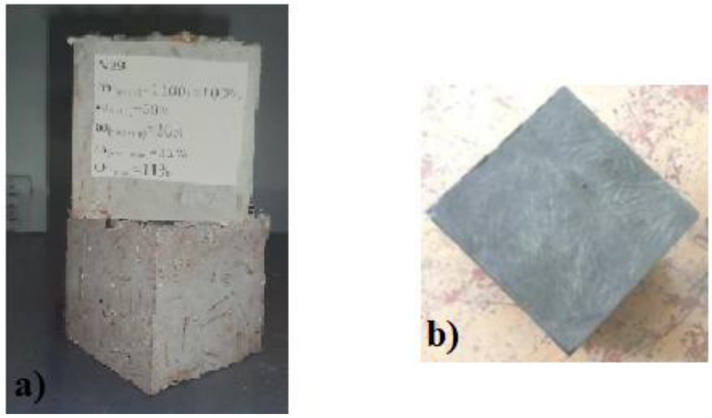

Figure 5. Samples of unimpregnated (a) and impregnated with sulphurous waste (b) arbolite concrete composites

In accordance with the goal and objective of our study it was found that the optimal arbolitoconcrete products with higher physical-mechanical and construction-technical indicators is arbolitoconcrete composites made on the basis of corn waste. After impregnation with gray waste, the density of the studied samples increased to 694.89 kg/m3 and the strength increased to 8.7 MPa. These results are explained by the fact that the porous structure of organic aggregates in the composition of arbolitoconcrete, causing suction of liquid sulfur of corn waste immediately after its impregnation and leading to the strengthening of its physical and mechanical properties.

The character of structure formation of arbolite-concrete composites to some extent obeys the laws of “binder - cellulose organic aggregate”. After impregnation of arbolite concrete samples with molten liquid sulfur in the contact “arbolite - impregnating material” physical and chemical processes occur, which determine the bonding characters between porous lightweight arbolite concrete and liquid technical sulfur. In this case, a very significant influence has porous structure of arbolite concrete, causing suction of liquid sulfur by arbolite immediately after its impregnation, which leads to the strengthening of its bonding properties between molten liquid sulfur and uneven rough surfaces of organic aggregate.

Our experimental studies also lead to the conclusion to clarify the hypothesis on structure formation of strength of arbolite concrete composites impregnated with monomers, oligomers and also technical liquid sulfur. Based on our developed data and theories of numerous authors [11-15], we concluded that in the case of using technical liquid sulfur as an impregnating material, the most significant are the presence of three-dimensional framework in porous organic aggregates arbolitobetonnyh composite. While increasing the bonding strengths of the contact zone of organic aggregates and binders, due to the joint adhesive effect of arbolite and technical sulfur, which contribute to the volumetric filling of pores and cracks with molten liquid sulfur and leading to the strengthening of the contact zone of the developed materials.

Conclusions

In the construction industry to increase the durability of building materials and structures operated under various aggressive environments, various materials and different progressive methods are used. Dealing with this urgent problem it is established that molten liquid technical sulfur is a very cheap and promising impregnation building material to increase the durability of building materials. The obtained results on impregnation of arbolite concrete composites with molten liquid sulfur indicate high physical and mechanical qualities of the studied material. We also found that sulfur-impregnated waste arbolite-concrete materials and structures can be recommended for underground and engineering structures. To solve possible negative consequences of liquid technical sulfur in impregnated arbolite concrete composites and risks of residual sulfur for the durability of structures after impregnation of arbolite concrete composites the following work is carried out. When melting technical sulfur a large amount of carbon dioxide contained in it volatilizes outward, when re-curing from it emanates an unpleasant odor in very small quantities. To eliminate the residual toxic odor in underground and engineering structures after impregnating them with technical sulfur, measures are taken to plaster the surface of the walls of the above-mentioned structures [25]. When plastering the surface of walls of underground and engineering structures consisting of wall arbolite concrete blocks, the toxic odor of sulfur remains under the cement sand plaster and does not spread into the environment. Based on this research, impregnation methods can be developed for low-strength lightweight concrete based on different formulations. The results of the study provide valuable ideas in practical terms for their use in the construction industry in the construction of underground structures. Although the study on impregnation of low-strength arbolite concrete composites with gray waste covers important aspects of the topic, this study only addresses a limited area of the construction industry for underground structure. Despite the significance of the findings, more extensive research is needed to set up additional experimental work to investigate the strength and deformability of arbolite concrete products.

The contribution of the authors

Isakulov B.R. - concept, methodology, resources, data collection, testing of experimental samples;
Balmagambetova F.T. - modeling, analysis;
Sundetova A.R. - visualization, interpretation,
Isakulov A.B. - writing;
Dakir B.M. - editing.

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References

1. Kasimov, I.K. Impregnated slabs of factory readiness. Construction and Architecture of Uzbekistan. 1972. № 8. C. 33-39.

2. Mikhailov, K.V. Polymer concretes and constructions on their bases. Moscow: Stroyizdat, 1989. 304 с.
3. Orlovskiy, Yu.I. Concrete and products on the basis of sulfur-containing wastes. Concrete and Reinforced Concrete. 1995. № 3. С. 21-24.
4. Paturoev, V.V. Properties and prospects of application of sulfur concrete. Concrete and Reinforced Concrete. 1985. № 5. С. 16-17.
5. Parfenyuk, S.A. Experience of using sulphur and sulphur-containing wastes in asphalt-concrete pavement construction. Automobile roads. 1987. № 2. С. 16.
6. Paturoev, V.V. Technology of polymer concretes. Moscow: Stroyizdat, 1977. 240 с.
7. Paturoev, V.V. Sulfur impregnated concretes. Building materials. Moscow, I985. С. 59.
8. Isakulov, B.R. Improvement of physical and mechanical properties of lightweight concrete by impregnation with sulfur-waste of oil and gas industry of Kazakhstan. Scientific and Technical Bulletin of the Volga Region. Kazan, 2011. № 4. С. 163-167.
9. Kulsharov, B., Isakulov, B., Sokolova, Y., Akulova, M., Sokolova, A. Slag-alkali lightweight concrete with corn waste aggregate. E3S Web of Conferences, 2023, 457, 01003.
10. Isakulov, B., Abdullaev, H., Mukasheva, A., Akishev, U., Ordabayeva, G. Investigation of the formation of microstructure and strength characteristics of slag-alkaline arbolite. Eureka, Physics and Engineering, 2023, 2023(2), pp. 209–221.
11. Issakulov, A., Omarov, A., Zhussupbekov, A., Mussakhanova, S., Issakulov, B. Investigation of the interaction of the bored micro pile by dds (fdp) technology with the soil ground. International Journal of GEOMATE, 2023, 24(105), pp. 11–17.
12. Sokolova, Y., Akulova, M., Isakulov, B., Sokolova, A., Isakulov, A. The Study of the Impact of Iron and Sulfur Containing Additives on the Strength Properties of Sulfur Containing Binders. Solid State Phenomena, 2022, 334, pp. 195–201.
13. Bazhirov N.S., Dauletiyarov M.S., Bazhirov T.S., Serikbayev B.E., Bazhirova K.N. Research of waste of aluminum production as the raw components in technology of composite cementing materials. News of the national academy of sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224-5278. 2018. Vol. 1, N 427. P. 93-98.
14. Sokolova, Y., Akulova, M., Isakulov, B.R., Sokolova, A., Isakulov, A.B. The study of structure formation and mechanical strength properties of sulfur-containing woodcrete composites exposed to permanently acting loads. IOP Conference Series: Materials Science and Engineering, 2020, 869 (3), 032005.
15. Sokolova, Y.A., Akulova, M.V., Isakulov, B.R., Kul'sharov, B.B., Isakulov, A.B. The study of creep and deformation properties of sulfur-containing arbolit exposed to various compression stresses. Key Engineering Materials, 2021, 899 KEM, pp. 137–143.
16. Sokolova, YA; Akulova, MV ; Isakulov, BR; Sokolova, AG; Kul'sharov, BB; Isakulov, AB. Detoxication of by-products of oil and gas industry accompaniied by obtaining iron and sulfur-containing binders for structural building materials. News of the National Academy of sciences of the Republic of Kazakhstan-series chemistry and technology. Volume 6 , pp. 2020 , 65-72 . DOI: 10.32014/2020.2518-1491.99.

17. Sokolova, Y., Akulova, M., Isakulov, B., Zhekeyev, S., Isakulov, A.The Study of Deformation Properties and Creep of Sulfur-containing Wood Concrete Composites._AIP Conference Proceedings, 2023, 2497, 020031.
18. Features of testing piles for high-rise buildings in difficult soil conditions in Astana. Mussakhanova, S., Zhussupbekov, A., Omarov, A., Abilmazhenov, T., Issakulov, A. International Journal of GEOMATE, 2023, 25(110), Page 106–113.
19. GOST 10181-2000. Interstate standard concrete mixtures test methods Interstate Scientific and Technical Commission for Standardization, Technical Norming and Certification in Construction (ISTCS). Moscow, 2000.
20. GOST 31108-2003. Cements for general construction. Specifications Interstate Scientific and Technical Commission for Standardization, Technical Norming and Certification in Construction (ISTCS). Moscow, 2003.
21. GOST 7473-2010. Interstate standard concrete mixtures. Technical conditions. Moscow, 2012.
22. GOST R 58965-2020. Protection of wood by through impregnation. National standard of the Russian Federation. Approved and put into effect by Order of the Federal Agency for Technical Regulation and Metrology of August 18, 2020 No 502-st.
23. GOST 9.010-80. Unified system of protection against corrosion and aging. Air compressed for atomization of paint and varnish materials. Technical requirements and methods of control.
24. GOST 12.4.034-2001. System of labor safety standards. Means of individual protection of respiratory organs. Classification and labeling.
25. Method of manufacturing arbolite products with obtaining a base for plaster on their surface. Akulova M.V., Shchepochkina Y.A., Isakulov B.R. Innovation patent of the Russian Federation for invention from 28. 03. 2014, reg. No. 2517308, Moscow, 2014. https://patentdb.ru/patent/2517308

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Арболит бетон композиттерінің физикалық-механикалық сипаттамаларын сұйық күкіртпен терең сіңіру арқылы жақсарту

Аңдатпа. Мақалада балқытылған сұйық күкірттің кеуекті арболит-бетон композиттерінің физикалық-механикалық қасиеттеріне әсері қаралады. Арболит-бетон композиттерін дайындау үшін көлемі 10-нан 40 мм дейінгі кеуекті жүгері собықтары пайдаланылды. Зерттеу нәтижелерін салыстыру үшін біз сондай-ақ 10-нан 20 мм-ге дейінгі көлемдегі жаңғақтың ұсақталған қабығын алып тастадық. Зерттеу жүргізу үшін арболит бетон үлгілерін ерітілген сұйық күкіртпен толық сіңіру әдісі қабылданған. Сіңдіру материалы ретінде күкірт - Қазақстандағы мұнай өндіру қалдықтары пайдаланылды. Зерттеу нәтижелері бойынша арболит-бетон композиттерінің құрамында целлюлоздыорганикалық толтырғыштардың болуының ұлғаюымен сіңдіру ұзақтығына байланысты жеңіл бетонның қысылу беріктігі мен орташа тығыздығының едәуір ұлғаюы байқалады. Сіңірілген арболит-бетон үлгілерінің физикалық-механикалық қасиеттері мен коррозиялық төзімділігі өте жоғары екені анықталды және бұл деректер олардың жер асты және инженерлік құрылыстарда пайдалану үшін ұсынылуы мүмкін екенін көрсетеді.

Түйін сөздер: Өнеркәсіптік күкірт, мұнай өңдеу қалдықтары, үлгілерді сіңдіру, арболит бетон композиттері, кеуекті органикалық толтырғыштар, нығайту, орташа тығыздығы, механикалық беріктігі.

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Повышение физико-механических показателей арболитобетонных композитов путем глубокой пропитки жидкой серой

Аннотация. В статье рассматривается влияние расплавленной жидкой серы на физико-механические свойства пористых арболитобетонных композитов. Для изготовления арболитобетонных композитов использовались пористые отходы кукурузных початков размером от 10 до 40 мм. Для сравнения результатов исследования мы также взяли более плотные отходы растительного происхождения дробленую скорлупу грецкого ореха размером от 10 до 20 мм. Для проведения исследования принят метод полной пропитки арболитобетонных образцов жидкой расплавленной серой. В качестве пропиточного материала использовалась сера - отходы нефтедобычи в Казахстане. По результатам исследования установлено, что с увеличением в составе арболитобетонных композитов содержания целлюлозно-органических заполнителей, происходит значительное увеличение прочности на сжатие и средней плотности легкого бетона в зависимости от продолжительности пропитки. Выявлено, что физико-механические свойства и коррозионная стойкость пропитанных арболитобетонных образцов очень высоки, и эти данные свидетельствуют о том, что они могут быть рекомендованы для использования в подземных и инженерных сооружениях.

Ключевые слова: Промышленная сера, отходы нефтепереработки, пропитка образцов, арболитобетонные композиты, пористые органические заполнители, упрочнение, средняя плотность, механическая прочность.

References

1. Kasimov, I.K. Propitannye plity zavodskoj gotovnosti. Stroitel'stvo i arhitektura Uzbekistana. 1972. № 8. S. 33–39.
2. Mihajlov, K.V. Polimerbetony i konstrukcii na ih osnovy. Moskva: Strojizdat, 1989. 304 s.

3. Orlovskij, YU.I. Beton i izdeliya na osnove serosoderzhashchih othodov. Beton i zhelezobeton. 1995. № 3. S. 21–24.
4. Paturoev, V.V. Svojstva i perspektivy primeneniya sernogo betona. Beton i zhelezobeton. 1985. № 5. S. 16–17.
5. Parfenyuk, S.A. Opyt ispol'zovaniya sery i serosoderzhashchih othodov pri ustrojstve asfal'tobetonnyh pokrytij. Avtomobil'nye dorogi. 1987. № 2. S. 16.
6. Paturoev, V.V. Tekhnologiya polimerbetonov. Moskva: Strojizdat, 1977. 240 s.
7. Paturoev, V.V. Sernye betony, propitannye seroj. Stroitel'nye materialy. Moskva, I985. C. 59.
8. Isakulov, B.R. Uluchshenie fiziko-mekhanicheskih svojstv legkih betonov putem propitki seroj-othodom neftegazovoj promyshlennosti Kazahstana. Nauchno-tekhnicheskij vestnik Povolzh'ya. Kazan', 2011. № 4. S. 163–167.
9. Kulsharov, B., Isakulov, B., Sokolova, Y., Akulova, M., Sokolova, A. Slag-alkali lightweight concrete with corn waste aggregate. E3S Web of Conferences, 2023, 457, 01003.
10. Isakulov, B., Abdullaev, H., Mukasheva, A., Akishev, U., Ordabayeva, G. Investigation of the formation of microstructure and strength characteristics of slag-alkaline arbolite. Eureka, Physics and Engineering, 2023, 2023(2), pp. 209–221.
11. Issakulov, A., Omarov, A., Zhussupbekov, A., Mussakhanova, S., Issakulov, B. Investigation of the interaction of the bored micro pile by dds (fdp) technology with the soil ground. International Journal of GEOMATE, 2023, 24(105), pp. 11–17.
12. Sokolova, Y., Akulova, M., Isakulov, B., Sokolova, A., Isakulov, A. The Study of the Impact of Iron and Sulfur Containing Additives on the Strength Properties of Sulfur Containing Binders. Solid State Phenomena, 2022, 334, pp. 195–201.
13. Bazhirov N.S., Dauletiyarov M.S., Bazhirov T.S., Serikbayev B.E., Bazhirova K.N. Research of waste of aluminum production as the raw components in technology of composite cementing materials. News of the national academy of sciences of the Republic of Kazakhstan. Series of geology and technical sciences. ISSN 2224-5278. 2018. Vol. 1, N 427. P. 93-98.
14. Sokolova, Y., Akulova, M., Isakulov, B.R., Sokolova, A., Isakulov, A.B. The study of structure formation and mechanical strength properties of sulfur-containing woodcrete composites exposed to permanently acting loads. IOP Conference Series: Materials Science and Engineering, 2020, 869 (3), 032005.
15. Sokolova, Y.A., Akulova, M.V., Isakulov, B.R., Kul'sharov, B.B., Isakulov, A.B. The study of creep and deformation properties of sulfur-containing arbolit exposed to various compression stresses. Key Engineering Materials, 2021, 899 KEM, pp. 137–143.
16. Sokolova, YA; Akulova, MV ; Isakulov, BR; Sokolova, AG; Kul'sharov, BB; Isakulov, AB. Detoxication of by-products of oil and gas industry accompaniied by obtaining iron and sulfur-containing binders for structural building materials. News of the National Academy of sciences of the Republic of Kazakhstan-series chemistry and technology. Volume 6 , pp. 2020 , 65-72 . DOI: 10.32014/2020.2518-1491.99.
17. Sokolova, Y., Akulova, M., Isakulov, B., Zhekeyev, S., Isakulov, A.The Study of Deformation Properties and Creep of Sulfur-containing Wood Concrete Composites. AIP Conference Proceedings, 2023, 2497, 020031.
18. Features of testing piles for high-rise buildings in difficult soil conditions in Astana. Mussakhanova, S., Zhussupbekov, A., Omarov, A., Abilmazhenov, T., Issakulov, A. International Journal of GEOMATE, 2023, 25(110), Page 106–113.

19. GOST 10181-2000. Interstate standard concrete mixtures test methods Interstate Scientific and Technical Commission for Standardization, Technical Norming and Certification in Construction (ISTCS). Moscow, 2000.
20. GOST 31108-2003. Cements for general construction. Specifications Interstate Scientific and Technical Commission for Standardization, Technical Norming and Certification in Construction (ISTCS). Moscow, 2003.
21. GOST 7473-2010. Interstate standard concrete mixtures. Technical conditions. Moscow, 2012.
22. GOST R 58965-2020. Protection of wood by through impregnation. National standard of the Russian Federation. Approved and put into effect by Order of the Federal Agency for Technical Regulation and Metrology of August 18, 2020 No 502-st.
23. GOST 9.010-80. Unified system of protection against corrosion and aging. Air compressed for atomization of paint and varnish materials. Technical requirements and methods of control.
24. GOST 12.4.034-2001. System of labor safety standards. Means of individual protection of respiratory organs. Classification and labeling.
25. Method of manufacturing arbolite products with obtaining a base for plaster on their surface. Akulova M.V., Shchepochkina Y.A., Isakulov B.R. Innovation patent of the Russian Federation for invention from 28. 03. 2014, reg. No. 2517308, Moscow, 2014. https://patentdb.ru/patent/2517308

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