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INTEGRATED PHYSICO-CHEMICAL STUDY OF THE INFLUENCE OF A MICROFILLER ON THE FORMATION OF THE STRUCTURE AND PROPERTIES OF LIGHTWEIGHT CONCRETE

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Abstract. *The article deals with complex physical and chemical studies of the influence of micro filler on the formation of the structure and properties of lightweight concrete.*

Key words*: Cement, sand, fly ash, lightweight concrete, porous aggregate, quartz porphyry, carburized clay, strength, average density, structure.*

A powerful reserve for saving material and energy resources for the conservation of natural resources and at the same time a solution to a particularly acute environmental issue - the use of industrial waste and local rocks of Uzbekistan in the production of building materials.

The introduction of mineral additives into Portland cement is one of the most important directions in solving the problems of resource and energy saving, as well as environmental protection in the production and use of building materials.

The strength characteristics of lightweight concrete depend not only on the density and hardening conditions, but also on the processes of hydration, structure formation, microstructure and neoplasms formed during the hardening process.

Fly ash from the Angren Thermal Power Plant (TPP) was used as a micro filler [1].

The analysis of the results showed that the following components were identified in the infrared spectrum of the fly ash of the Angren District State Power Plant: quartz amorphous 470,15 cm^{-1}, 1098,09 cm^{-1}; α quartz -787,93 cm^{-1}; calcite - 1084,49 cm^{-1}, 1785,62 cm^{-1}; feldspath -555,02 cm^{-1} (fig.1.1.)

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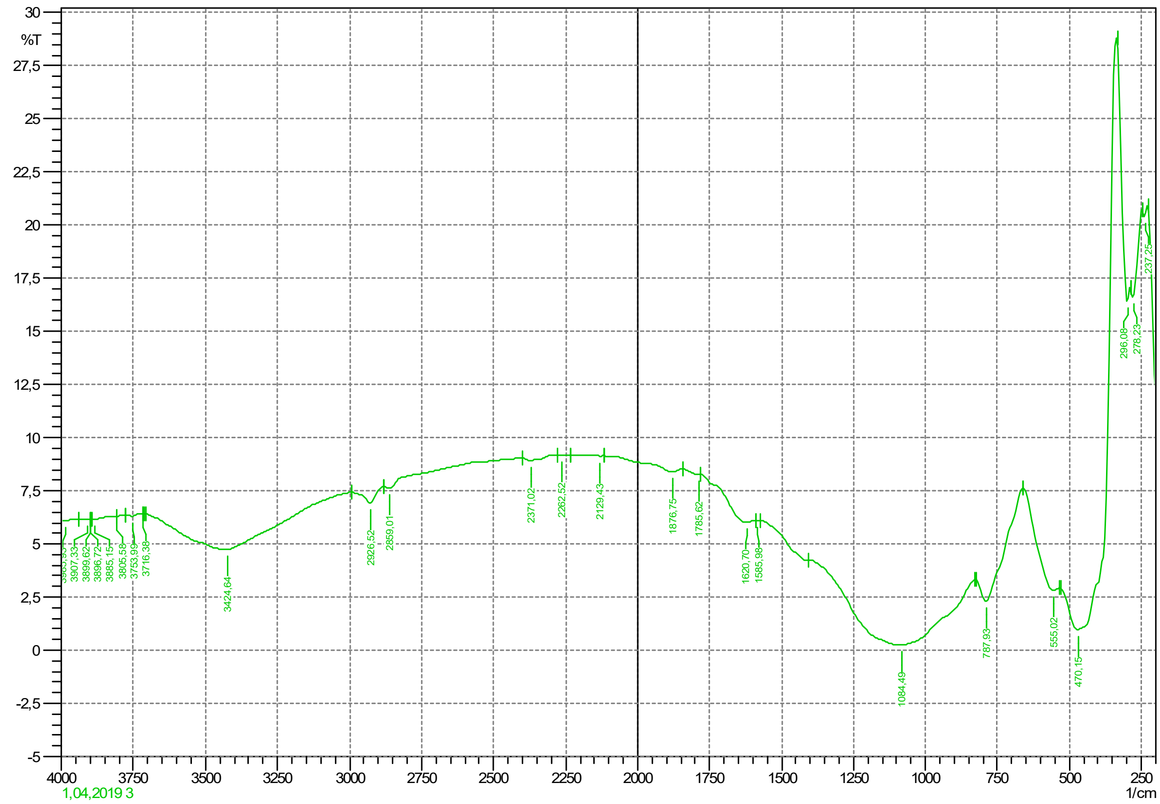

Fig. 1.1. Infrared spectrum of fly ash Angrensky district power plant of the state

To determine the effect of the fly ash microfiller on the structure formation of lightweight concrete, physical and chemical studies of the optimal compositions of concrete were carried out.

The first stage of the study was the infrared spectrum analysis of cement mortar: cement, sand, fly ash [2].

The results of the analysis of the tests carried out showed that the following components were identified in the spectrum Infrared spectrum: calcite - 873,75 cm^{-1}; α quartzite-777,31 cm^{-1}; dolomite 694,37 cm^{-1}; feldspath-648,08 $cм^{-1}$; albite -993,34 cm^{-1}; feldspath-437,84 cm^{-1}; gypsum- 365,78 cm^{-1}; quartzite - 511,14 cm^{-1}; feldspath-437,84 cm^{-1} ; feldspath -555,50 cm^{-1} (fig.1.2.).

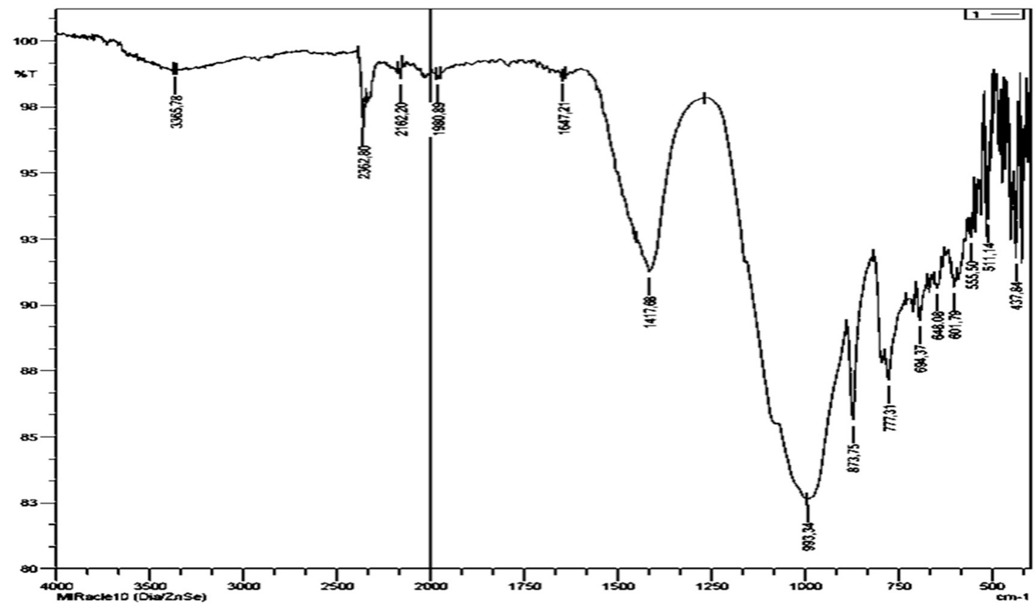

Fig. 1.2. Infrared spectrum analysis of cement mortar: cement, sand, fly ash.

The next step was the infrared spectrum analysis carried out in optimal lightweight concretes, namely in compositions consisting of cement, sand, fly ash and aggregate. It can be seen from the table that the line identification calcite - 1417,68 cm^{-1}; feldspath -650,01 cm^{-1}; feldspath - 549,71 cm^{-1}; calcite -1083,99 cm^{-1}; calcite-873,75 cm^{-1}; α quartzite -962,48 cm^{-1}; gypsum - 2645,28 cm^{-1}; gypsum -725,28 cm^{-1}; gypsum -3404,36 cm^{-1}; quartzite - 592,15 cm^{-1}.

During the hardening of Portland cement, a number of very complex chemical and physical phenomena occur. The properties formed during the hydration of calcium hydrosilicates are similar to the properties of a gel. This gel is the main binder in Portland cement hardened dough [3]. Diorthosilicate or pentamer formations from silicon-oxygen anions stand out in the gel structure. The process of polymerization of silica in the hydrosilicates of cement stone occurs very slowly. In structure, such chains are similar to the chains in the fly ash mineral. This similarity causes a positive effect during cement hardening, which can be explained by the effect of the fly ash surface on the formation of the phase composition of the cement stone [4, 5, 6, 7, 8, 9].

The most promising areas in terms of fly ash reserves is Central Asia, where there are more than 40 deposits. The largest of them are Anrgenskoye and Akhangaranskoye. The reserves of the Angren deposit amount to 9.8 million tons.

The objects of research are waste products from the industry of quartz porphyry and carbonized clay. Angren thermal power plant and clinker cement plants. For research, modern methods of analysis of raw mixtures and reaction products were used. Chemical analysis of raw materials was determined according to the state standard 5382-91. The dependence of the properties of cements on individual factors was studied in accordance with the state standard 310-89. The most widespread and aggressive in practice 3% $MgSO_4$ solution and 5% Na_2SO_4 solution, corresponding to subsoil and ground waters, were used as aggressive media. The samples were tested after 3, 7, 14, 28, 90, 180, 360 days. The assessment of sulfate resistance of cements was carried out according to the resistance coefficient, which after 6 months is at least 0.8. The hydraulic activity test of the lead-zinc concentrator and copper concentrator waste was determined by the standard method of absorbing the amount of lime from a saturated solution by grams of additive. X-ray phase analysis was carried out by taking a sample in a powder state on a DRON-3 diffractometer. Hydrated samples were dehydrated with acetone at t≈20°C. The shooting parameters are as follows: 2θ angle range from 6 to 65o, CuKα radiation, tube voltage 24 kV, anode tube current 14 mA [7, 8, 9].

Table 1.

Chemical composition of raw materials, mass. %

Starting materials	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	$CaO_{СВ}$	R_2O	П.п.п.	Проч.	Σ
Akhangaran Portland cement	22,68	4,55	3,65	65,48	2,45	0,30	0,12	-	-	0,87	100
Bekabad portlandcement	20,63	4,52	4,05	65,92	1,73	2,15	0,43	-	-	0,70	100
Kuvasay Portland cement	21,78	4,81	4,08	64,14	1,89	0,64	0,37	-	-	0,60	98,31
Tailings of a lead-zinc concentrator	45,75	8,72	7,19	14,59	7,10	2,98	-	2,98	8,83	-	98,14
Flotation waste from a copper processing plant	60,68	14,02	9,54	1,37	0,11	5,69	-	4,13	4,11	-	99,65

The following were used for the study: non-additive Portland cement grade 400 AOO "Akhangarancement", AOO "Bekabadcement" and "Kuvasaycement" tailings of the lead concentrating and flotation wastes of the copper concentrating plants, the chemical composition of which is given in Table 1.

Using X-ray phase analysis, the phase compositions of the matrix material for the production of cement slurries based on clinkers from the Akhangaran, Bekabad and Kuvasay cement plants and additives for the lead-zinc concentrating plant and the copper concentrating plant were revealed.

Table 2.

Estimated mineralogical composition of clinkers

	KH	n	p	The content of minerals, mass. %

Name of the plant				C_3S	C_2S	C_2A	C_4AF	∑
Akhangaran	0,91	2,29	1,33	64,0	18,0	7,2	11,3	100,5
Bekabadsky	0,91	2,33	1,19	65,3	10,8	7,5	12,1	95,7
Kuvasaysky	0,95	2,45	1,18	57,5	19,1	5,8	12,4	99,4

Clinkers of cement plants are mainly represented: C3S – d=0,303; 0,296; 0,260; 0,218; 0,192; 0,176 nm., C2S – d=0,385;0,277; 0,272; 0,260; 0,208 nm., C3A – d=0,273; 0,269; 0,216; 0,202; 0,192; 0,154nm., C4AF– d=0,269; 0,264; 0,218; 0,204; 0,192; 0,182 *nm*.
Table 3 presents the results of changes in the salt resistance of Akhangaran, Kuvasai, Bekabad Portland cements without additives, depending on the effect of additives from the copper concentration plant (MOF) and the lead-zinc concentration plant (SOF) [7, 8, 9].

Table 3.

The strength of cements for sulfate resistance with an additive metallurgical waste from a copper concentrating plant (MOF) and a lead-zinc concentrating plant (SOF)

№	Introduced additive	Aggressive environment	Tensile strength of the sample in compression, MPa, day						
			3	7	14	28	90	180	360
Akhangaran portlandcement									
1.	**MOF**	3% $MgSO_4$	30	38	40	46	66	80	94
2.	**SOF**	-”-	38	42	48	59	71	87	103
3.	-	-”-	14	19	20	29	33	36	50
4.	**MOF**	5% Na_2SO_4	32	38	41	50	73	75	80
5.	**SOF**	-”-	38	41	47	58	64	77	89
6.	-	-”-	15	19	25	33	39	38	38
Kuvasay Portland cement									
1.	**MOF**	3% $MgSO_4$	38	42	43	49	77	82	96
2.	**SOF**	-”-	30	48	75	87	88	90	90
3.	-	-”-	24	26	27	30	33	35	37
4.	**MOF**	5% Na_2SO_4	35	38	40	47	75	81	97
5.	**SOF**	-”-	30	40	60	74	75	91	95
6.	-	-”-	18	18	20	23	25	37	45
Bekabad portlandcement									
1.	**MOF**	3% $MgSO_4$	43	48	54	63	79	98	106
2.	**SOF**	-”-	33	36	40	54	78	96	102
3.	-	-”-	33	41	50	53	50	51	48
4.	**MOF**	5% Na_2SO_4	41	50	54	62	85	106	110

5.	**SOF**	-"-	35	40	48	66	84	102	109
6.	-	-"-	26	28	35	41	45	46	47

The data obtained are consistent with the results of determining the resistance coefficient of samples in aggressive environments depending on the time of their hardening.

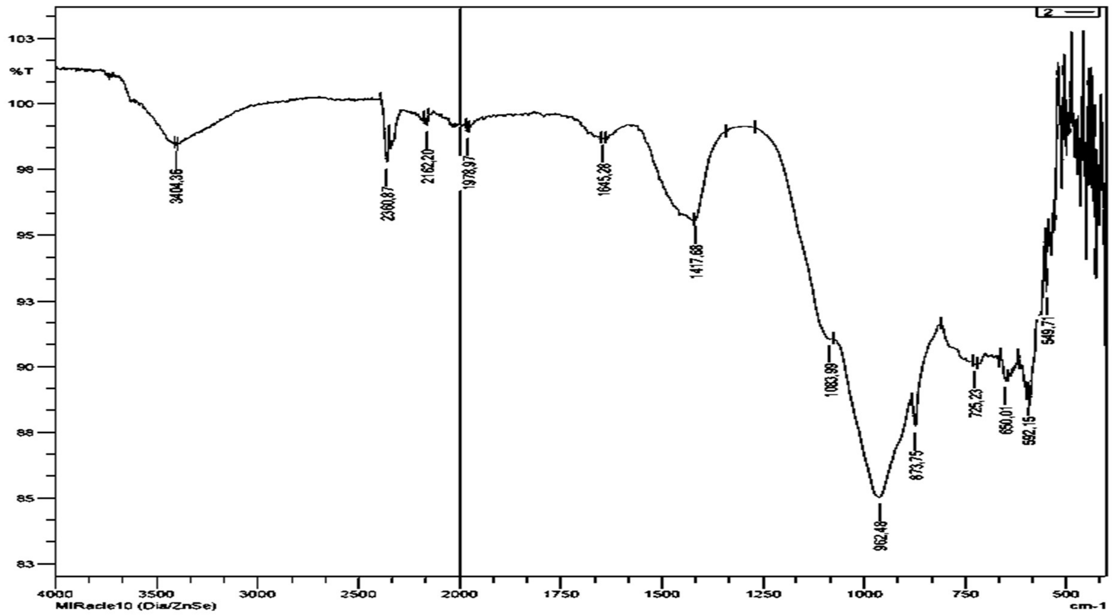

Fig. 1.3. Infrared spectrum analysis of concrete composition: cement, sand, fly ash, lightweight aggregate.

Results the infrared spectrum of the absorption analysis of a concrete sample of 28-day hardening is characterized by frequencies characteristic of calcite - 1417.68 cm^{-1}, feldspath-650.01 cm^{-1}.

Summarizing all the results of the analyzes of the studies of ash, mortar and concrete showed that the components identified in all three compositions are repeated at different frequencies [2, 3, 4].

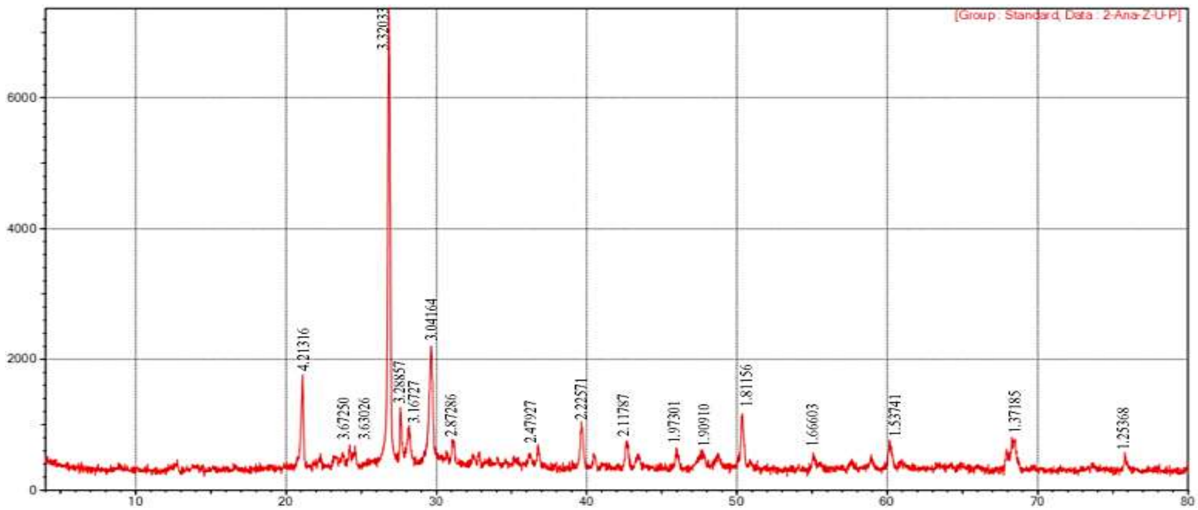

Fig. 1.4. X-ray pattern (28 days) of a sample of the solution: Cement, sand and fly ash.

To study the composition of concrete and its components, X-ray diffraction analysis of the following materials was used: a solution consisting of fly ash, cement and sand, lightweight concrete after 28 days of normal hardening. The tests were carried out on a new generation of SHIMADZU IRAffinity-1 series spectrophotometers.

The x-ray of the solution shows: minerals such as quartz SiO_2 (d=4.27; 3.35; 1.818; 1.543 A^0), calcite $CaCO_3$(d=3.86; 3.04; 2.28; 1.913; 1.876 A^0), dolomite $CaMg(CO_3)_2$ (d=2.90; 2.02 A^0), plagioclase (анортит) (d=4.04; 3.68; 3.22 A^0) calcium feldspath (d=3.77; 3.25; 3.15 A^0), hydromica (d=9.78; 4.49 A^0) diffraction lines are characteristic of low-basic hydrosilicates in the general formula C-S-H, like portlandite (d=4.91; 2.63; 1.927 A^0), four calcium aluminoferrite (d=7.24; 2.78; 2.63 и 1.93 A^0), calcium hydrosilicate (d=7.02; 2.56 A^0), gillebrandite $CaOxSiO_2x3H_2O$(d=10.89;2.63A^0).

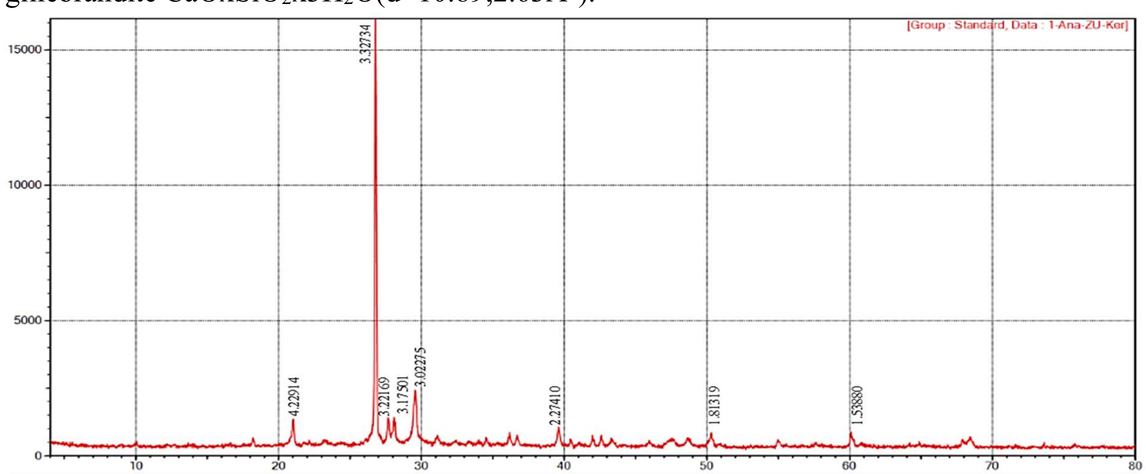

Fig. 1.5. Radiograph (28 days) of a sample of lightweight concrete: Cement, sand, fly ash and aggregate.

The radiograph of lightweight concrete is represented by: the mineral quartz (d=4.27; 3.35; 2.46; 1.818; A^0), calcite $CaCO_3$ (d=3.86; 3.04; 2.28; 1.875 A^0), plagioclase (anorthite) (d=3.71 A^0), portlandite d=4.91; 2.63; 1.927 A^0), calcium feldspath (d=3.77; 3.25; 3.15 A^0), hydromica (d=9.78; 4.49 A^0) as well as low-basic hydrosilicates, tetracalcium aluminoferrite (d=7.24; 2.78; 2.63 и 1.93 A^0), calcium hydrosilicate (d=7.02; 2.56 A^0), gillebrandite - $2CaOxSiO_2x3H_2O$ (d=10.89; 2.63 A^0), dolomite (d=2.90; 2.02 A^0), mullite -$3AlO_3x2SiO_2$, cristoballite - SiO_2 (d=10.889; 2.56 A^0).

The obtained results show that the addition of natural fly ash in the amount of 10-15% gives results close to those of control samples. The introduction of fly ash contributes to an increase in the strength of the cement stone, which means that the introduction of such an additive will ensure a reduction in the consumption of an expensive binder [1]. Physical and chemical studies (X-ray structural and infrared spectrum) confirm the participation in the structure formation of quartz amorphously. It has been established that fly ash microfiller, due to the increase in the formation of low-basic hydration products, will provide strength, therefore, improve the construction, technical and operational characteristics of lightweight concrete.

REFERENCES

1. Хасанов Б.Б. Особенности технологии и свойств легкого бетона на пористом заполнителе из отходов угледобычи для ограждающих конструкций. Диссертация (PhD), Ташкент-2021 год.
2. Khasanov B.B. // Cube and prismatic strength characteristic lightweight concrete on porous aggregates. European science review № 11-12 2018 November-December Volume 1 Vienna, Austria, 2018.
3. Shakirov T.T., Yusupov U.T., Khasanov B.B. Physical and Chemical Research Methods of Lightweight Concrete. ISSN: 1475-7192.International Journal of Psychosocial Rehabilitation, Буюк Британия, Скопус. International Journal of Psychosocial Rehabilitation, Vol. 24, Issue 05, 2020.
4. Hasanov B.B., S.Saydaliyev. O’zbekiston sharoitida ko'pikbeton bloklarning uzoqqa chidamlilik xossalarini oshirish. Research and Education. Scientific Journal Impact Factor 2022: Vol. 1, Issue 8, 26-31 pages, November, 2022.
5. Hasanov B.B., S.Saydaliyev. Gazobeton bloklarining uzoqqa chidamliligi, mustahkamligi, o’rtacha zichligi va sovuqqa chidamliligi. Research and Education. Scientific Journal Impact Factor 2022: Vol. 1, Issue 8, 4-9 pages, November, 2022.
6. Хасанов Б.Б. Прочность, плотность, морозостойкость и долговечность газобетонных блоков. Research and Education. Scientific Journal Impact Factor 2022: Vol. 1, Issue 7, 68-73 pages, October, 2022.
7. Инновационные технологии в производстве строительных материалов и конструкций. // Сборник научных трудов Международного симпозиума. – Ташкент, Министерство строительства РУз, ТАСИ, 2020. - 324 с.
8. Исаходжаев Б.А., Ходжаев Н.Т. Минерально-сырьевая база Республики Узбекистан для получения композиционных материалов / Композиционные материалы. – Т. №3. 2003г. – С. 58-60.

9. Кузнецова Т.В., Атакузиев Т.А., Искандарова М. Использование высокожелезистых отходов цветной металлургии в качестве добавки к цветным сульфоцементам. Ташкент, 1984.

10. Файзиев Х., Байматов Ш. Х., Рахимов Ш. А. К расчету неустановившейся фильтрации в анизотропных грунтовых плотинах без дренажа //Экспериментальные и теоретические исследования в современной науке. – 2019. – С. 32-37.

11. Jonibek F. The Role and Importance of the Production of Building Materials in the Development of the Economy of Uzbekistan //Бюллетень науки и практики. – 2020. – Т. 6. – №. 12. – С. 292-296.

12. Machmudov S. M., Samieva S. K. Quantitative assessment of the reliability of the system" foundation-seismic isolation foundation-building" //Central Asian Journal of STEM. – 2021. – Т. 2. – №. 2. – С. 445-452.

13. Jonibek F. Industrial development and role in the national economy //Бюллетень науки и практики. – 2022. – Т. 8. – №. 4. – С. 445-449.

14. Qambarov M. Geotermal energy, use of earth temperature as an effective energy resource //Web of Scientist: International Scientific Research Journal. – 2022. – Т. 3. – №. 12. – С. 56-62.

15. Rakhmankulovna A. K. H., Makhmudovich M. S. Innovative designs and technologies in foundation engineering and geotechnics //International Journal of Scientific and Technology Research. – 2020. – Т. 9. – №. 1. – С. 3803-3807.

16. Sobirov Z. A., Eshimbetov M. R. Fokas method for the heat equation on metric graphs //Contemporary Mathematics. Fundamental Directions. – 2021. – Т. 67. – №. 4. – С. 766-782.