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Determination of technical characteristics of traditional foam concrete and foam concrete with mineral fiber

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Abstract. Foam concrete is currently enjoying its popularity due to a number of advantages, such as non-toxicity, reduction of thermal insulation costs, noise absorption. Nowadays at the state level the issue of utilisation of waste of different nature and increasing the quality of recycling is constantly being considered. Also a big task is set in the scientific sphere of the country on recycling of utilised waste in different sectors and especially in the construction sector. There are numerous grant programmes in the scientific field, which are aimed at the use of waste in the industrial and construction sector of the country. This paper is devoted to the study of the qualitative characteristics of traditional foam concrete and foam concrete with the addition of mineral fibre. In the construction sphere the main thermal insulating material in the form of mineral boards is widely used and there are factories for the production of basalt boards in the course of production of which there is a lot of basalt waste. Tests have been carried out according to the standard methodology in order to determine the strength and density of the finished product. According to the test results it was determined that the pore structure and strength is uniform over the whole surface of the blocks. It was also determined that the specimens with fibre showed a strength of more than 50% compared to conventional foamed concrete. This work will be a good direction for further in-depth study on the utilisation of basalt slabs in construction.

Keywords: foam concrete, strength, density, pores, mineral fiber, pore structure, binder.

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Introduction

Today, the construction industry is saturated with different building materials, from cement-based materials to organic binders.

The advantages of cement binder are high strength and high density; however, there are materials with lower density, such as lightweight concrete on lightweight aggregate, as well as cellular concrete with low density and pore structure.

Due to the high demand for this cellular material, there has been an increased interest in the research and improvement of this material. Cellular concrete has the purpose as a thermal insulation, thermal insulation and structural and structural, as well as low thermal conductivity and density of 200 to 500 kg/m3 with minimum strength properties, thermal insulation and structural has a density of 600 to 800 kg/m3 low thermal conductivity and strength allowing to build a structure from 2,5 to 4,5 MPa, structural cellular concrete has a density of 900 to 1200 kg/m3 has the purpose as a structural material thermal conductivity is lower than that of concrete and higher than that of heat-insulating-constructive cellular material. The big disadvantage of aerated concrete is its instability during the preparation process. Cellular concrete is of two types: foam concrete and aerated concrete. A distinctive feature of foam concrete is the method of obtaining a cellular structure in foam concrete, it is adding of foam concentrate, which contributes to the formation of a closed pore structure of the material. Foam concrete, over time, has occupied its place in the construction industry and it began to be used as a monolithic thermal insulation material, since the production of structural material was always accompanied by a large number of low-quality products; foam mortar gave a large shrinkage in the mold and the material became unserviceable. However, the use of waste from the production of mineral insulators as a reinforcing component makes it possible to ensure a high-quality structure of foam concrete and increase the strength characteristics of the material.

Research methods

For the foam concrete production using mineral fiber, based on waste from the production of basalt insulation, a comparative analysis with the traditional foam concrete product, manufactured according to the standard method, was conducted. The composition of traditional foam concrete and foam concrete using mineral fiber is presented in Table 1.

Table 1. The composition of foam concrete D 500

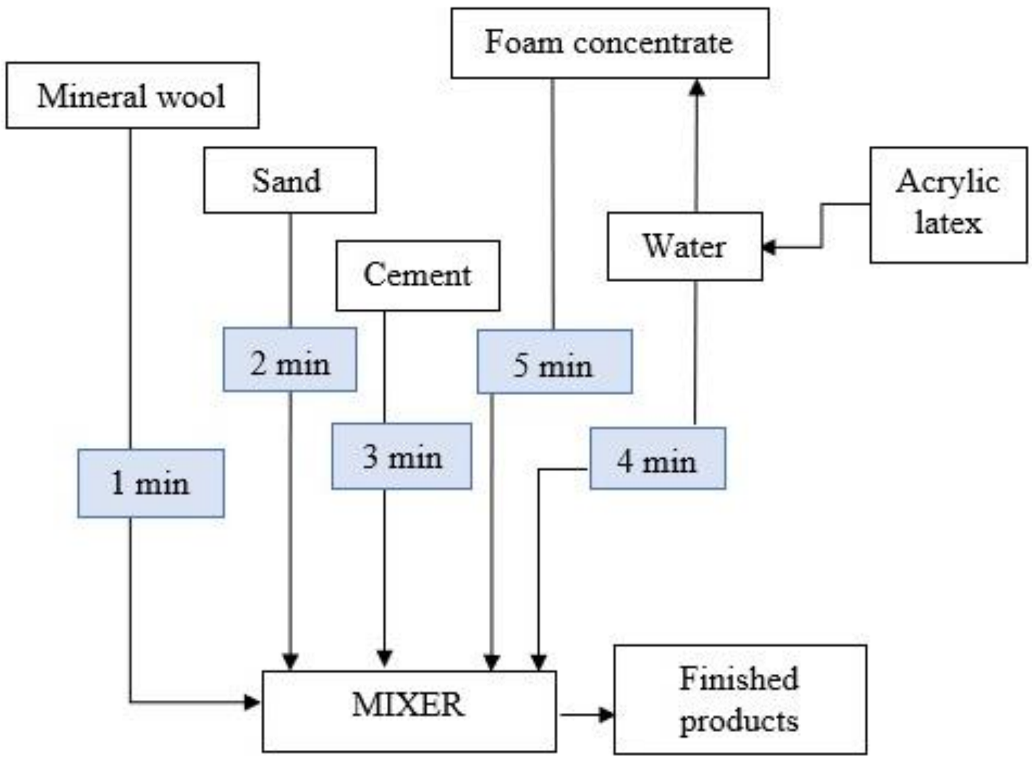
№	Type of foam concrete	Cement, kg	Sand, kg	Foaming agent, kg	Mineral fiber, kg	Polymer, %	Water, kg
1	Traditional foam concrete (Type 1)	300	180	1,5	–	–	150

2	Foam concrete with the use of mineral fiber (Type 2)	230	240	1,5	20	0,1	140

In the production of traditional foam concrete, the mixer is loaded with dry components: sand and cement; then water is poured into the mixer, the water temperature should not be below 22 C. Next, the mixture is thoroughly blended for 5-7 minutes. Afterwards, the foam is prepared as follows: 1.5 liters of foam concentrate is mixed with 40 liters of water, then, the resulting foam is loaded into the mixer and blended with the solution for 3 minutes. And when it is unloaded into molds, after an hour the excess is removed from the top.

To produce foam concrete using mineral fiber, mineral fiber is loaded into the mixer, after which sand is loaded and blended for 2 minutes. Then cement is loaded and mixed for 3 minutes, after which water, previously combined with a water-soluble polymer, is poured into the mixer; the water temperature should not be lower than 22°C. Next, the mixture is thoroughly blended for 4 minutes. After which the foam is prepared as follows: 1,5 liters of foam concentrate is mixed with 40 liters of water, the resulting foam is loaded into the mixer and blended with the solution for 2 minutes. And when it is unloaded into molds, after an hour the excess is removed from the top.

The production diagram of foam concrete using mineral fiber is presented in Picture 1.



Picture 1. Foam concrete production scheme with mineral fiber

After 28 days sampling was carried out. Sampling was carried out according to the methods of GOST 12852-77 "Cellular Concretes. Test methods". Cube samples for the study were sawed out of prepared samples of type 1 and type 2. The dimensions of the samples of type 1 and type 2 were: length 600 mm, width 400 mm and height 400 mm. The test specimens were sawn from the upper middle and lower parts of the product, three specimens from each part. When cutting out cube samples, at least 40 mm were removed from the edge. The room temperature was 19˚C at 35% relative humidity. The specimens were kept in the laboratory for 24 hours before testing. The age of the specimens was 28 days; 54 specimens (cubes) were made: 27 made of composite aerated concrete and 27 prepared in the traditional way. A template was used for sawing even specimens, which allows to obtain specimens with an even geometric surface with an error of up to 1mm.

To start the tests, the density of samples was determined according to GOST 12730.1-78 Concretes. Methods of density determination. The volume was determined using a caliper because the sample (cubes) had the correct geometric shapes 100x100x100.

Density was determined by the formula:

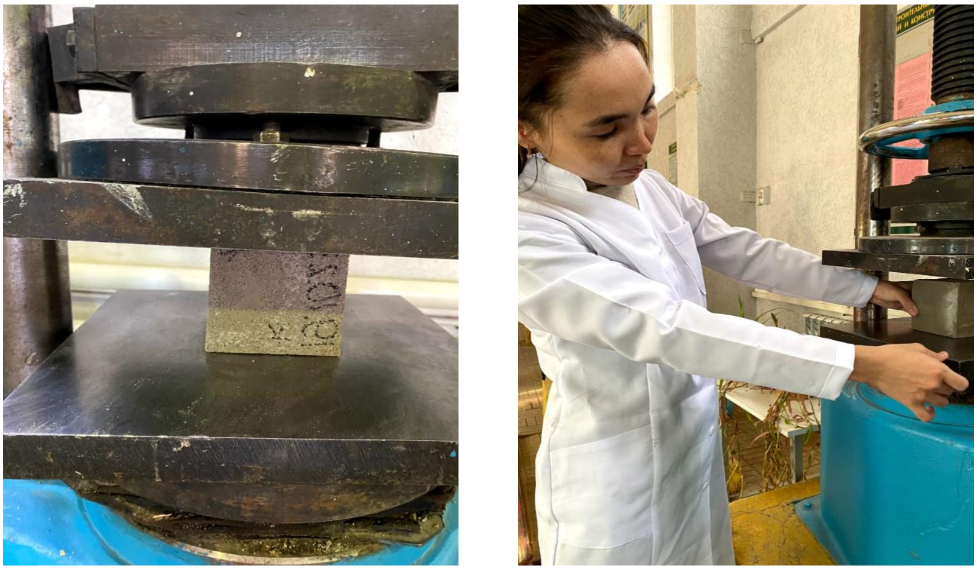
$$\rho_{\omega} = \frac{m}{V} * 1000 \tag{1}$$

Where ρw is the density of the material

m – sample mass gr.

V – sample volume cm.

The strength of foam concrete type 1 and type 2 was determined according to GOST 10180-2012 Concretes. Methods for determining the strength of control samples. Tests were carried out on 100x100x100 specimens prepared in advance by sawing from a solid block 600x400x400. The age of specimens is 28 days.



Picture 2. Compressive strength test

The compression test is presented in Picture 2; the samples were tested on an automatic CONTROLS(Pilot) 500 kH press. Strength from one series was determined as the arithmetic mean value of the tested samples. 18 samples were tested, 9 from each series,

Test results

In the studies of foreign scientists there are works on the approval of the effective use of polymer fibers in the production of cellular concrete, but in these studies the priority determining the efficiency of cellular concrete is its strength; no work has been carried out on compression and dynamic effects regarding the uniformity of the cellular structure. The results of determining the density of foam concrete type 1 in comparison with foam concrete type 2 allowed us to objectively assess the quality of the pore structure of the materials. According to a study of the pore structure of non-autoclaved foam concrete type 1, its heterogeneity and, as a consequence, there is a difference in density in various areas of the material. The quality of the pore structure directly depends on the difference in the density of the material in various areas of the same block.

Table 2. Density of foam concrete type 1 and type 2

№	Sample	Actual density		
		Top samples	Average samples	Lower samples
1	Type 1	420,5	510,7	580,1
		418,5	517,4	582,8
		422,7	516,3	587,2
	Average density	420,5	514,8	583,3
	The average density of all samples			506,2
2	Type 2	508,4	508,9	510,1
		507,7	508,5	510,7
		505,2	509,8	509
	Average density	507,1	509	509,9
	The average density of all samples			508,6

Based on Table 2 in foam concrete type 1, we see a density difference between the upper and lower samples, which indicates an uneven distribution of pore structure, caused by the shrinkage of foam-expanded solution until it is gripped; heavy particles of sand and cement are lowered down, thus increasing the density of the bottom of the foam concrete

Type 2 foam concrete, in contrast to type 1, has a more stable density in all areas of the tested material, which is explained by the composition and technology of its production. We get a positive effect from the use of mineral fiber, which structures and preserves the frame of the foam-expanded solution and the uniform distribution of all components of the solution.

Thus, the use of mineral fiber preserves the structure of foam concrete and provides quality improvement (Table 3).

Table 3. Compressive strength of foam concrete type 1 and type 2

№ №п/п	Sample	Average density, kg/m^2	The strength of the samples, MPa		
			Top samples	Average samples	Lower samples
11	Type 1	506,2	0,9	1,9	2,3
			0,5	1,5	2,1
			1,1	1,8	2,1
	Average strength index	506,2			
	The average strength of all samples				
22	Type 2	508,6	3,1	3,2	3,3
			3,0	3,0	3,3
			3,2	3,1	3,0
	Average strength index	508,6			
	The average strength of all samples				

The strength of type 1 foam concrete is 49,52% lower than type 2 foam concrete. This difference in material strength is a result of the uniformity of pore distribution. One of the first important factors contributing to a decrease in the strength of type 1 foam concrete is the delamination of the foam before the foam solution begins to set.

The explanation for the high strength of type 2 foam concrete is the use of mineral fiber, which provides the structure of the foam concrete frame, thereby facilitating the high- quality distribution of all components, and reinforcement allows to increase the strength.

Conclusion

1. Density difference studies of type 1 foam concrete at three areas of the material (upper, middle, lower) showed density differences from the average density of all samples:

– for the upper samples lower by 20,38 %,

– for the middle samples higher by 1,69%,

– for the lower samples higher by 15,23 %.

The results show that the pore structure of type 1 foam concrete has irregular pores with a certain increase in the density of the material top. The density of type 2 foam concrete samples showed high stability in all areas of the tested material. Density difference of type 2 foam concrete from average density of all samples:

– for the upper samples lower by 0,29 %,

– for the middle samples higher by 0,08%,

– for the lower samples higher by 0,25%.

Thus, having analyzed the results, we can conclude that type 2 foam concrete has a uniform pore structure, providing stable density in all areas of the tested material. Stability of density of type 2 foam concrete in contrast to type 1 is higher by 98%.

2. Compressive strength tests on type 2 foam concrete showed a 98,1% increase in strength. The strength value in three areas (upper, middle, lower) of the tested material showed the difference in strength from the average strength of all samples:

– for the upper samples lower by 0,97 %,
– for the middle samples higher by 0,97 %,
– for the lower samples higher by 2,24 %.

The strength of type 1 foam concrete showed the difference in strength in the material sections (upper, middle, lower) of the samples from the average strength of all samples:

– for the upper samples lower by 90,36 %,
– for the middle samples higher by 9,49%,
– for the lower samples higher by 37,34 %.

According to the results obtained, it can be concluded that type 2 foam concrete has almost uniform strength in all areas of the block, with the exception of an error of ± 0,07%.

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Author contribution:

A.Askerbekova, D.Dyusembinov, R.Lukpanov – conceptualization, approving of final version, funding acquisition

Zh.Shakhmov, A. Jexembayeva – analysis, writing,interpretation of results, data collection, critical review of content.

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Дәстүрлі көбік бетонының және минералды талшықты көбік бетонының техникалық сипаттамаларын анықтау

Аңдатпа. Көбік бетон қазіргі уақытта уыттылық, жылу оқшаулау шығындарының төмендеуі, шуды сіңіру сияқты бірқатар артықшылықтарға байланысты танымал болып келеді. Қазіргі уақытта мемлекеттік деңгейде әртүрлі сипаттағы қалдықтарды кәдеге жарату және қайта өңдеу сапасын арттыру мәселесі үнемі қарастырылуда. Сондай-ақ, еліміздің ғылыми саласында әртүрлі салаларда, әсіресе құрылыс саласында пайдаланылған қалдықтарды кәдеге жарату бойынша үлкен міндет тұр. Ғылыми салада елдің өнеркәсіптік және құрылыс секторында қалдықтарды пайдалануға бағытталған көптеген гранттық бағдарламалар бар. Бұл жұмыс минералды талшық қосылған пенобетон мен дәстүрлі пенобетонның сапалық сипаттамаларын зерттеуге арналған. Құрылыс саласында минералды тақталар түріндегі негізгі жылу оқшаулағыш материал кеңінен қолданылады және өндіріс барысында базальт қалдықтары көп болатын базальт тақталарын шығаратын зауыттар бар. Дайын өнімнің беріктігі мен тығыздығын анықтау мақсатында сынақтар стандартты әдістеме бойынша жүргізілді. Сынақ нәтижелері бойынша кеуектердің құрылымы мен беріктігі блоктардың бүкіл бетінде біркелкі екендігі анықталды. Сондай-ақ, талшықты үлгілердің беріктігі кәдімгі көбіктендірілген бетонмен салыстырғанда 50% - дан астам екендігі анықталды. Бұл жұмыс құрылыста базальт плиталарын пайдалануды одан әрі тереңдетіп зерттеу үшін жақсы бағыт болады.

Түйін сөздер: көбік бетон, беріктік, тығыздық, тері тесігі, минералды талшық, кеуек құрылымы, тұтқыр.

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Определение технических характеристик традиционного пенобетона и пенобетона с минеральной фиброй

Аннотация. Пенобетон в настоящее время пользуется своей популярностью за счет ряда преимуществ, таких, как нетоксичность, уменьшение затрат на термоизоляцию, поглощение шума. Сейчас на государственном уровне постоянно расматривается вопрос по утилизации отходов разного характера и увеличение качества перерработки. Также большая задача поставлена в научной сфере страны по вторичному использованию утилизируемых отходов в разных отраслях и в особенности в строительной сфере. Множественные грантовые программы имеются в научной сфере, которые направлены на использование отходов в промышленной и строительной сфере страны. Данная статья посвящается исследованию качественных характеристик традиционного пенобетона и пенобетона с добавлением минеральной фибры. В строительной сфере широко используется основной теплоизоляционный материал в виде минеральных плит и имеются заводы по производству базальтовых плит, в ходе производства которых остается множество отходов базальта. Проведены испытания по стандартной методике с целью определения показателей прочности и плотности готовой продукции. По результатам испытаний определено, что поровая структура и прочность по всей поверхности блоков является равномерной. Также было определено, что образцы с фиброй показали прочность более 50% по сравнению с обычным пенобетоном. Данная работа будет хорошим направлением для дальнейшего глубоко исследования утилизации базальтовых плит в строительстве.

Ключевые слова: пенобетон, прочность, плотность, поры, минеральная фибра, поровая структура, вяжущее.

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