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Strength characteristics of foam concrete samples with various additives

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Abstract. The article presents the results of researched moisture indicators and strength characteristics of foam concrete with the various additives using. Foam concrete is produced both in a factory and on a construction site, has a density of 200 kg/m3 and is used in the innovative building structures type - lightweight steel concrete structures (LSCS). Diatomite, microsilica, granite, perlite and vermiculite were used in sample production. As a part of the research, tests were carried out under the P-20 pressure to determine the ultimate limit load that the samples withstood. Then they were placed in a drying oven to determine the moisture mass removed from the samples during drying to a completely dry state, after which the moisture content values were set. The dependence between the moisture index and the strength characteristics of foam concrete is shown. It is established that samples of foam concrete with the perlite addition are the most durable. In addition, it is shown that the foam concrete with the vermiculite addition has the lowest moisture. It was determined that only for samples with the vermiculite addition, the correction coefficient depending on the moisture index differs in its value from the coefficients for the other samples, and, therefore, it had the greatest influence on the strength characteristics value of this series.

1 Introduction

Construction is an industry whose development never stops. More and more innovative types of building products are entering the market. One of them is a monolithic foam concrete technology "Intech LB". This material may be applied in both new construction and reconstruction.

In this technology, foam concrete acts as a heat-insulating material, works in conjunction with lightweight steel concrete structures. Undoubtedly, it has certain advantages in comparison with other types of thermal insulation. They are described more detailed in the article [1].

This structure is quite widespread in foreign construction, and it is only beginning to develop in Russia [2-3].

The use of additives in the concrete composition affects such properties of a building material as strength, density, permeability, ductility, frost resistance, fire resistance, water absorption. Consequently, the characteristics of the building material can vary significantly, and the cost of the construction process with them.

These relationships were considered in the articles [4-6].

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Widespread use of nano-modified and mineral additives are in the various concretes compositions [7-9]. There is an active research of the modifying additives effect on shrinkable deformations of the foam concrete mix [10], as well as on density in normal moisture content conditions, on compressive strength and tensile strength during bending of cement composites [11-13], is being conducted. More attention is also paid to the development and improvement of the additives by themselves, hence, the mechanical characteristics of the materials [14].

While consideration of low density cellular concretes, which is also a monolithic foam concrete of Intech LB, special attention should be paid to its thermophysical characteristics, namely moisture content and temperature. This topic research was carried out in article [15]. Not taking into account of the temperature effect on the heat generation process in the tasks of ensuring the crack resistance of concrete and reinforced concrete massive leads to a noticeable increase in the required thickness of the required thermal insulation, and consequently, to an increase in construction costs [16].

When the temperature of isothermal exposure after heat and moisture treatment decreases, the strength of concrete may decrease. To avoid this, polycarboxylate superplasticizers are used, which can contribute to an increase in the concrete early strength [17].

To increase the reliability and increase the service life of building structures with the use of fine-grained concrete, reinforcement can be performed using various types of fiber. The articles [18-19] present the results of the dispersed reinforcement and fiber material parameters effect research on the dispersion-reinforced fine-grained concrete in tensile bending strength. This method effectiveness assessment and the possibility of taking into account when calculating building structures are given.

Nowadays, composite surface reinforcement is most often used to reinforce damaged structures. The masonry walls and reinforcing meshes behavior definition during their joint work, taking into account their deformation characteristics, is described in [20]. However, in the modern regulatory literature there is not enough information about the methods for calculating such reinforced structures. In article [21], a numerical model was proposed for evaluating the effect of composite reinforcement on the bearing capacity of a compressible-bending stone wall, built on the basis of walls, made of concrete blocks, experimental research.

The work's aim is to identify the nature of the work, the strength characteristics and humidity of 5 series of foam concrete samples with various additives evaluation.

Tasks of the research:

1) The research of foam samples to the bearing capacity loss;

2) Determination of moisture content of foam concrete samples with various additives;

3) Establishing the relationship between moisture content and strength of foam concrete.

The research sequence:

1) Samples testing and the strength characteristics determination of the standard samples;

2) Destroyed foam concrete samples' fragments moisture content determination after the strength test;

3) The compressive strength indicators final calculation, taking into account the coefficient taking into account the moisture content.

2 Test methods and main results

During the research, 5 series of 4 foam concrete cubes samples with various additives were considered.

Foam concrete with various additives sample series' initial data is presented in Table 1 and Fig. 1.

Table 1. The samples' strength characteristics

Additive	Sample	Average density, kg/m^3		Length, mm	Width, mm	Height, mm
		initial	5 days after concrete spouting			
Diatomite	1	300	238	102	92	100
	2			100	100	100
	3			97	97	100
	4			95	94	100
Microsilica	1	273	223	98	103	100
	2			103	97	100
	3			102	100	100
	4			95	96	100
Granite	1	365	237	97	96	100
	2			98	97	100
	3			95	100	100
	4			100	97	100
Perlite	1	350	264	100	90	100
	2			100	100	100
	3			96	100	100
	4			100	95	100
Vermiculite	1	320	220	98	95	100
	2			90	100	100
	3			95	100	100
	4			95	95	100

Fig. 1. The samples' strength characteristics determination. Initial samples.

The strength characteristics research was carried out according to GOST 10180-2012. Concretes. Methods for strength determination using reference specimens.

To determine the cube shape samples' strength characteristics, they were placed under the press P-20, and then the data on the maximum load were recorded.

The experiment course is presented in Fig. 2.

Fig. 2. The samples' strength characteristics determination.

The research results are presented in Table 2.

Table 2. The samples' strength characteristics

Additive	Sample	Ultimate load, kN	Ultimate load average value, kN
Diatomite	1	1.02	1.02
	2	1.02	
	3	1.41	
	4	0.63	
Microsilica	1	0.86	0.80
	2	0.86	
	3	0.86	
	4	0.66	
Granite	1	2.20	1.88
	2	2.04	
	3	1.41	
	4	1.88	
Perlite	1	1.57	1.90
	2	1.65	
	3	2.20	
	4	2.20	
Vermiculite	1	1.41	1.31
	2	1.10	
	3	1.26	
	4	1.49	

Foam concrete moisture content determination is carried out according to GOST 12730.2-78. Concretes. Method of determination of moisture content.

To determine the moisture content of samples, the destroyed samples remains were cut to be placed in the molds, weighed, then placed in a drying oven to establish a constant weight at a temperature of (105±5) °C. The cut fragments of the samples, before placing in an oven, are in Figure 3.

Fig. 3. The fragments of samples in the molds before placing in a drying oven

Table 3. Sample moisture content determination parameters

Additive	Sample	Foam concrete sample mass before drying, g	Foam concrete sample mass after drying, g	Foam concrete moisture content mass, %
Diatomite	1	63.1	46.8	34.83
	2	50.3	39.0	28.97
	3	43.9	34.3	27.99
	Moisture content average value, %			**30.60**
Microsilica	1	57. 3	42.5	34.82
	2	34.5	24.8	39.11
	3	52.5	35.8	46.65
	Moisture content average value, %			**40.19**
Granite	1	65.6	54.3	20.81
	2	71.5	55.6	28.60
	3	82.7	63.2	30.85
	Moisture content average value, %			**26.75**
Perlite	1	86.2	65.5	31.60
	2	85.9	69.2	24.13
	3	86.8	66.3	30.92
	Moisture content average value, %			**28.89**
Vermiculite	1	64.,9	54.5	19.08
	2	74.6	59.1	26.23
	3	66.9	52.9	26.47
	Moisture content average value, %			**23.92**

The drying method essence consists in determining the moisture mass removed from the samples during a drying to a completely dry state. The constant sample mass is that mass, in which the results of two consecutive weighings differ by no more than 0.1%. Herewith, the time between weighings should be at least 4 hours.

The research results are shown in Table 3.

3 Results and Discussion

The compression strength of concrete R, MPa, is calculated with an accuracy of 0.1 MPa by the formula:

$$R = \alpha \frac{F}{A} K_W \quad (1)$$

where F - breaking load, N;

A - sample working section square, mm²;

α - scale factor to bring the concrete strength to the concrete strength in samples of basic size and shape;

For cellular concrete with an average density less than 400 kg /m³ the scale factor α is taken equal to 1.0, regardless of the size and shape of the samples.

K_w - correction factor for cellular concrete, taking into account the samples' moisture content at the time of testing, is determined according to GOST 10180-2012. Concretes. Methods for strength determination using reference samples.

The foam concrete with various additives compressive strength calculation results are presented in Table 4:

Table 4. The samples' strength results during data processing

Additive	Sample	Working section square, mm²	Breaking load, N	Correction factor	Strength, MPa	Strength average value, MPa
Diatomite	1	9384	1020.24	1.15	0.125	0.124
	2	10000	1020.24	1.15	0.117	
	3	9409	1412.64	1.15	0.173	
	4	8930	627.84	1.15	0.081	
Microsilica	1	10094	863.28	1.15	0.098	0.094
	2	9991	863.28	1.15	0.099	
	3	10200	863.28	1.15	0.097	
	4	9120	627.84	1.15	0.079	
Granite	1	9312	2197.44	1.15	0.271	0.228
	2	9506	2040.48	1.15	0.247	
	3	9500	1412.64	1.15	0.171	
	4	9700	1883.52	1.15	0.223	
Perlite	1	9000	1569.60	1.15	0.201	0.230
	2	10000	1648.08	1.15	0.190	
	3	9600	2197.44	1.15	0.263	
	4	9500	2197.44	1.15	0.266	
Vermiculite	1	9310	1412.64	1.1392	0.173	0.163
	2	9000	1098.72	1.1392	0.139	
	3	9500	1255.68	1.1392	0.151	
	4	9025	1491.12	1.1392	0.188	

4 Conclusion

1. The research has shown that foam concrete samples with perlite additives can withstand the greatest ultimate load, and samples with the microsilica addition - the smallest. The difference between the ultimate loads is 57.89%.

2. In determining the foam concrete moisture content, it was found that samples with vermiculite additives have the lowest moisture content – 23.92%, and the samples with the microsilica addition – the highest – 40.19%.

3. It was established that foam concrete samples with perlite additives have the highest strength characteristics, and the samples with the addition of perlite – the lowest. The difference between the foam concrete compressive strength average values is 59.13%.

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