RESEARCH OF PHYSICAL AND MECHANICAL PROPERTIES OF BASALT FIBER CONCRETE

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Abstract:
This article describes the analysis of the results of research on the composition and properties of concrete with basalt fibers and the mixture without basalt fibers. The article provides information on the optimal composition of basalt fiber for concrete.

Keywords: Basalt, fiber, fiber concrete, fiber, construction.

Introduction

Concrete is the most popular material in modern construction. One of the promising directions of the study of fiber concrete technology is to justify the effectiveness of using basalt fiber as a dispersed reinforcement. It is known that basalt fiber is distinguished not only by high physical and mechanical properties, but also by chemical resistance, temperature - light and weather resistance, as well as simplicity and low cost of production technology.

It consists of conducting a number of experimental and theoretical studies to substantiate the possibilities of using local basalt fiber (production mastered in Jizzakh) as a dispersed fiber additive in the production of basalt fiber concrete. Optimizing the properties of concrete, the composition of basalt fiber concrete with the help of cement binder, concrete mixture and basalt dispersed fiber additive, as well as clarifying the rational directions of using the developed basalt fiber concrete in the construction industry of Uzbekistan.

Table 1 Concrete cube samples without basalt fibers

№	The date of the test	Sample age and hardening condition	Dimensions of the sample, mm			Cross section ***A***, mm^2	The sample size
			a	***b***	***h***		
1.	10.02.2023	28 s, normal	100	99	100	9900	990 000
2.	10.02.2023	28 s, normal	100	99	100	9900	990 000
3.	10.02.2023	28 s, normal	100	99	100	9900	990 000
4.	10.02.2023	28 s, normal	100	99	100	9900	990 000
5.	10.02.2023	28 s, normal	100	99	100	9900	990 000
6.	10.02.2023	28 s, normal	100	99	100	9900	990 000
7.	10.02.2023	28 s, normal	100	99	100	9900	990 000
8.	10.02.2023	28 s, normal	100	99	100	9900	990 000

The compressive strength of concrete cubes is found as follows:

$$R_i = \frac{N}{A}, \text{MPa.} \qquad (1.1)$$

The remaining compressive strengths are found in this order:

$$R_1 = \frac{N_1}{A} = \frac{255 \cdot 1000}{9900} = 25{,}578MPa, \qquad R_2 = \frac{N_2}{A} = \frac{245 \cdot 1000}{9900} = 24{,}747MPa,$$

$$R_3 = \frac{N_3}{A} = \frac{230 \cdot 1000}{9900} = 23{,}232MPa, \qquad R_4 = \frac{N_4}{A} = \frac{240 \cdot 1000}{22499} = 24{,}242MPa,$$

$$R_5 = \frac{N_5}{A} = \frac{255 \cdot 1000}{9900} = 25{,}758MPa, \qquad R_6 = \frac{N_6}{A} = \frac{240 \cdot 1000}{9900} = 24{,}242MPa,$$

$$R_7 = \frac{N_7}{A} = \frac{235 \cdot 1000}{9900} = 23{,}737MPa, \qquad R_8 = \frac{N_8}{A} = \frac{240 \cdot 1000}{9900} = 24{,}242MPa,$$

Table 2 The test results of standard concrete cubes are tabulated:

№	Destructive force R, N, kN	Cross section A, mm	Cubic durability $R_i = \frac{N}{A}$, Pa
1	255	9900	25.758
2	245	9900	24.747
3	230	9900	23.232
4	240	9900	24.242
5	255	9900	25.758
6	240	9900	24.242
7	235	9900	23.737
8	240	9900	24.242

Determining the class of concrete according to its compressive strength is carried out as follows.

a) The average compressive strength of concrete cubes (Rm) is determined as follows.

$$R_m = \frac{R_1+R_2+R_3+\ldots+R_n}{n} \qquad (1.2)$$

$$R_m = \frac{R_1+R_2+R_3+\ldots+R_n}{n} = \frac{25.758+24.74+23.232+24.242+25.758+24.242+23.737+24.242}{8} = 24.3704MPa.$$

b) Mean square limitation of compressive strength of concrete cubes:

$$\sigma = \sqrt{\frac{(\Delta R_1)^2+(\Delta R_2)^2+(\Delta R_3)^2+\cdots+(\Delta R_n)^2}{n-1}} \qquad (1.3)$$

$$\sigma = \sqrt{\frac{(\Delta R_1)^2+(\Delta R_2)^2+(\Delta R_3)^2+\cdots+(\Delta R_n)^2}{n-1}} = \sqrt{\frac{(\Delta R_1)^2+(\Delta R_2)^2+(\Delta R_3)^2+(\Delta R_4)^2+(\Delta R_5)^2}{8-1}} =$$

$$= \sqrt{\frac{1.284+0.017+1.295+0.135+1.284+0.016+0.401+0.016}{7}} = 0{,}301MPa$$

d) The coefficient of variation for concrete strength:

$$v = \frac{\sigma}{R_m} \qquad (1.4)$$

$$v = \frac{\sigma}{R_m} = \frac{0.301}{24.3704} = 0{,}0123 \prec [v = 0.135]$$

e) The compressive strength class of a concrete cube with 95% reliability is determined as follows:

$$B = R_m(1 - 1{,}64v) \qquad (1.5)$$

$$B = R_m(1 - 1{,}64v) = 24.3704 \cdot (1 - 1{,}64 \cdot 0.0123) = 20{,}878MPa \approx B20$$

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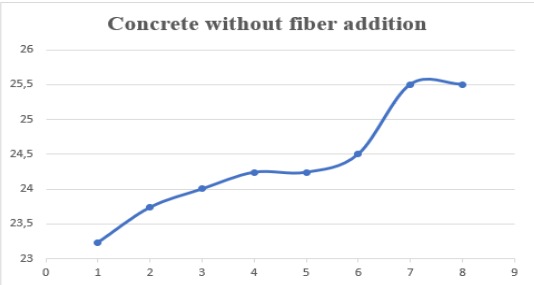
We calculate the modulus of elasticity of concrete for heavy concrete according to the empirical formula adopted in QMQ 2.03.01-98 (Concrete and reinforced concrete structures). $E_b = \frac{55400 \cdot B}{21+B}$, (1.6)

$$E_b = \frac{55400 \cdot R_m}{21 + R_m} = \frac{55400 \cdot 24.3704}{21 + 24.3704} = 28500MPa = 28 \cdot 10^3 MPa$$

Table 3 In order to simplify the calculation process, we include the calculation results in the table:

R_i	The average strength of concrete cubes in compression, R_m	$\Delta R_i = R_m - R_i$	ΔR_i^2	Mean square limitation of compressive strength, σ	Coefficient of variation in concrete strength, v
25.758	24.3704	-1.132625	1.2837	0.301	0.0123
24.747		-0.131625	0.0174		
23.232		1.138375	1.295		
24.242		0.368375	0.1354		
25.758		-1.132625	1.2837		
24.242		0.128375	0.0164		
23.737		0.633375	0.4007		
24.242		0.128375	0.0164		

1st graph.



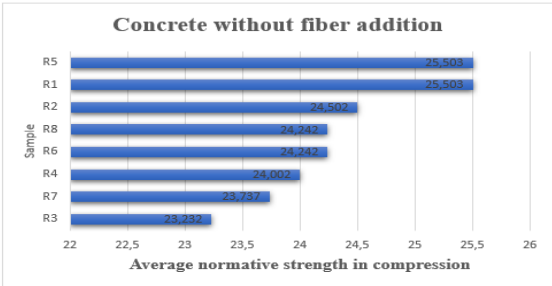


Table 4 Cube samples of concrete with 6 mm basalt fibers added

№	The date of the test	Sample age and hardening condition	Dimensions of the sample, mm			Cross section *A*, mm^2	The sample size
			a	*b*	*h*		
1.	10.02.2023	28 s, normal	100	99	100	9900	990 000
2.	10.02.2023	28 s, normal	100	99	100	9900	990 000
3.	10.02.2023	28 s, normal	100	99	100	9900	990 000
4.	10.02.2023	28 s, normal	100	99	100	9900	990 000
5.	10.02.2023	28 s, normal	100	99	100	9900	990 000
6.	10.02.2023	28 s, normal	100	99	100	9900	990 000
7.	10.02.2023	28 s, normal	100	99	100	9900	990 000
8.	10.02.2023	28 s, normal	100	99	100	9900	990 000

The compressive strength of concrete cubes is found as follows:

$$R_i = \frac{N}{A}, \text{MPa}. \quad (1.7)$$

The remaining compressive strengths are found in this order:

$R_1 = \frac{N_1}{A} = \frac{260 \cdot 1000}{9900} = 26.263MPa,$ $R_2 = \frac{N_2}{A} = \frac{240 \cdot 1000}{9900} = 24.242MPa,$

$R_3 = \frac{N_3}{A} = \frac{255 \cdot 1000}{9900} = 25.758MPa,$ $R_4 = \frac{N_4}{A} = \frac{240 \cdot 1000}{9900} = 24.242MPa,$

$R_5 = \frac{N_5}{A} = \frac{245 \cdot 1000}{9900} = 24.747MPa,$ $R_6 = \frac{N_6}{A} = \frac{220 \cdot 1000}{9900} = 22.222MPa,$

$R_7 = \frac{N_7}{A} = \frac{268 \cdot 1000}{9900} = 27.071MPa,$

Table 5 The test results of standard concrete cubes are tabulated:

№	Destructive force R, N, kN	Cross section A, mm	Cubic durability $R_i = \frac{N}{A}$, Pa
1	260	9900	26.263
2	240	9900	24.242
3	255	9900	25.758
4	240	9900	24.242
5	245	9900	24.747
6	220	9900	22.222
7	268	9900	27.071

Determining the class of concrete according to its compressive strength is carried out as follows.

a) The average compressive strength of concrete cubes (Rm) is determined as follows.

$$R_m = \frac{R_1 + R_2 + R_3 + \ldots\ldots + R_n}{n} \quad (1.8)$$

$$R_m = \frac{R_1 + R_2 + R_3 + \ldots\ldots + R_n}{n} = \frac{26.263 + 24.242 + 25.758 + 24.242 + 24.747 + 22.222 + 27.071}{7} = 24.935MPa.$$

b) Mean square limitation of compressive strength of concrete cubes:

$$\sigma = \sqrt{\frac{(\Delta R_1)^2 + (\Delta R_2)^2 + (\Delta R_3)^2 + \cdots + (\Delta R_n)^2}{n-1}} \quad (1.9)$$

$$\sigma = \sqrt{\frac{(\Delta R_1)^2 + (\Delta R_2)^2 + (\Delta R_3)^2 + \cdots + (\Delta R_n)^2}{n-1}}$$

$$= \sqrt{\frac{(\Delta R_1)^2 + (\Delta R_2)^2 + (\Delta R_3)^2 + (\Delta R_4)^2 + (\Delta R_5)^2}{7-1}} =$$

$$= \sqrt{\frac{1.763 + 0.48 + 0.677 + 0.48 + 0.035 + 7.359 + 4.561}{7}} = 2.1MPa$$

Table 6 In order to simplify the calculation process, we include the calculation results in the table:

R_i	The average strength of concrete cubes in compression, R_m	$\Delta R_i = R_m - R_i$	ΔR_i^2	Mean square limitation of compressive strength, σ	Coefficient of variation in concrete strength, v
26.263	24.3704	-1.32762626	1.7626	0.653	0.0262
24.242		0.69257576	0.4797		
25.758		-0.82257576	0.6766		
24.242		0.69257576	0.4797		
24.747		0.18752525	0.0352		
22.222		2.71277778	7.3592		
27.071		-2.13570707	4.5612		

d) The coefficient of variation for concrete strength:

$$v = \frac{\sigma}{R_m} \qquad (1.10)$$

$$v = \frac{\sigma}{R_m} = \frac{0.653}{24.3704} = 0,0261 \prec [v = 0.135]$$

e) The compressive strength class of a concrete cube with 95% reliability is determined as follows:

$$B = R_m(1 - 1,64v) \qquad (1.11)$$

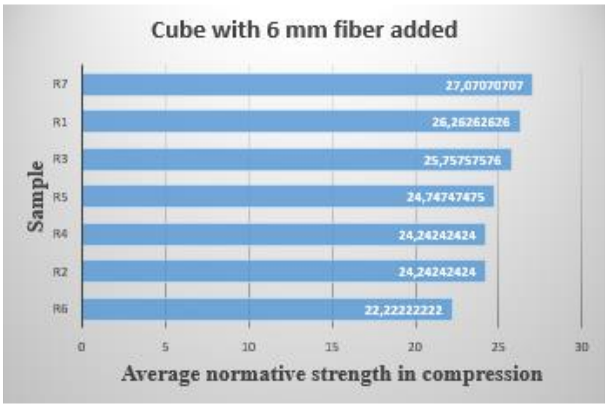
$$B = R_m(1 - 1,64v) = 24.3704 \cdot (1 - 1,64 \cdot 0,0261) = 23.8MPa \approx B22.5$$

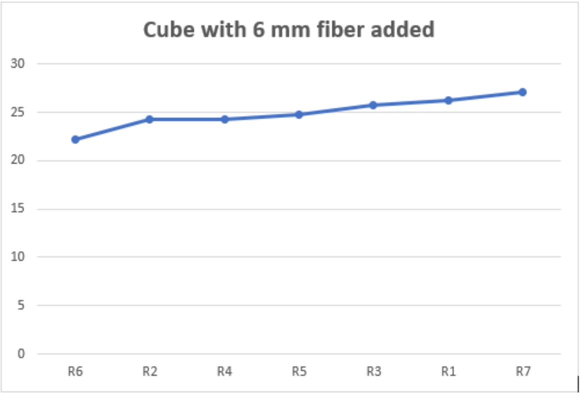
We calculate the modulus of elasticity of concrete for heavy concrete according to the empirical formula adopted in QMQ 2.03.01-98 (Concrete and reinforced concrete structures).

$$E_b = \frac{55400 \cdot B}{21 + B}, \qquad (1.12)$$

$$E_b = \frac{55400 \cdot R_m}{21 + R_m} = \frac{55400 \cdot 24.3704}{21 + 24.3704} = 28500MPa = 28 \cdot 10^3 MPa$$

2nd graph





Conclusion

1. It was found that basaltofibrocement stone with 0.36% content of basalt fibers achieved the greatest strength - the strength increase exceeds the control during all periods of hardening. At the same time, compared to the control composition without basalt fiber, the strength increase of basaltofibrocement stone on the 3rd day of normal storage conditions is 28% (73 MPa), on the 7th day - 32% (84 MPa), on the 28th day - 34% (98 MPa).

2. It was experimentally determined that the introduction of basalt fiber increases the structural viscosity of the cement mixture by 2-3 times, and the transition range is sharply shifted towards higher stresses.

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