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Mechanical properties of basalt fiber concrete

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ABSTRACT*:* In this research work, mechanical properties of concrete with basalt fibers are studied. Cube and prism samples were prepared with the addition of 0,1; 0,2; 0,3% of basalt faber and laboratory tests were conducted.

KEYWORDS: Basalt fiber, concrete, fiber concrete, compaction, strength.

I.INTRODUCTION

Interest in the use of basalt fiber as the basis of building structures, in particular the use of basalt fiber as reinforcement, has increased significantly. This interest arose due to the high requirements of modern construction work and the efforts of specialists to improve the physical performance of concrete structures. It also takes into account the increase in the use of natural resources as a result of the growth of production, the increase in energy consumption, the increase in industrial waste and environmental pollution. In particular, it is known that the energy consumption of concrete production is much smaller than the energy consumption of steel, aluminum and glass. Reinforcement of concrete leads to a spontaneous increase in the energy capacity of the product. The use of fiber as a reinforcement in order to overcome the lack of strength in the elongation of concrete materials can be the basis for the creation of a new type of concrete that allows its widespread use in construction[1-4].

As in traditional reinforced constructions, there is a point of view in fiber reinforcement: the concrete matrix material transmits the applied load to the fiber by tensile forces and thus the main part of the tension is received by the fibers. The results of the use of dispersed-reinforced concrete and the world experience of research in this area show that the introduction of fiber into concrete provides the following:
-improvement of strength characteristics of concrete, increase of cracking, increase of resistance to impact and abrasion, increase of static resistance to various forces;
-increasing the operational reliability of structures under the influence of aggressive environments due to the improvement of the concrete structure;
-possibility to reduce the working cross-section of structures, in some cases to reduce the consumption of rebar[5-9].

II. MATERIALS

A. Cement. PS400D20 cement of Okhangarontsement plant was used in this test. Its specific surface area was 3000-3500 cm^2 / g. [9].

Table 1. Physical and mechanical properties of cement.

Actual density, g/cm3	Dispersing density, g/cm3	Normal thickening, %	Solidifying times, min.		Granularity rate, %	28-day strength limit, MPa	
			starting	ending		compression	bending
3,1	1,3	26,0	2-30	4-40	8,2	43,0	7,1

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B. Fillers. Testing of samples complies with the requirements of the current Interstate Standard DAST 27006-2019 [10]. The samples used fine aggregate as fine aggregate with a density of 2670 kg / m3 and dimensions of 0-5 mm and a moisture content of 3.1% - sand, and coarse aggregate as gravel with a density of 2665 kg / m3 and dimensions of 5-20 mm.

C. Basalt fiber. Basalt fibers produced at the “Mega Invest Industrial” in Jizzakh, Uzbekistan, shown in Figure 1, were used in this test. Indicators of fiber properties are given in Table 2.

Figure 1. Appearances of basalt fibers

Table 2. Physical properties of chopped basalt fiber

Fiber name	Density, kg/cm^3	Consistency limit MPa	Modulus of Elasticity, GPa	Fiber diameter, mkm	Length of fiber, mm
Basalt	2650	3000-3500	90-110	17	10, 30

Experimental work was carried out in the laboratory to obtain concrete of class B25 according to the design parameters by adding basalt fibers to the concrete. This test was conducted based on the indicators of the normative documents developed by the requirements of the current interstate standard DAST 27006-2019, as shown in Table 3 below.

Table 3. General characteristics of concrete of class B25

Concrete class in the project	Volumetric weight of concrete mix, kg/m^3	Water, kg	Cement grade PS400D20, kg	5-20 mm coarse aggregate kg	0-5 mm fine aggregate, kg	w/c ratio
B25	2460	180	440	815	1025	0,41

III. RESEARCH METHODOLOGY

The testing was carried out in the testing laboratory of “Namangan sement savdo” LLC. Cube samples of 10x10x10 cm were prepared according to standard requirements to determine the cubic strength of concrete. The cube samples were in 7 series, the total number of cubes was 35. Particular attention was paid to the processes of standard preparation requirements and compaction of samples when placing concrete mixes in molds. The prepared samples were taken from the molds after standing in the room for 1 day and the samples were marked and stored in a normal drying chamber for 28 days. The compressive strength of concrete cubes was determined using a hydraulic press type YAW-2000. An overview of the samples is shown in Figure 2.

Figure 2. General view of the test device and the cube-sample.

The distortion of the cubic samples without the addition of basalt fiber was in the form of two truncated pyramids. Cube-samples with the addition of basalt fiber were broken in a peculiar way. The post-breakdown appearance of the samples is shown in Figure 3.

a)

б)

Figure 3. General view of cube-samples made of non-basalt fiber concrete (a) and basalt fiber concrete (b)

According to the interstate standard DAST 24544-2020, prisms with dimensions of 10x10x40 sm were prepared to determine the prismatic strength of concrete. Prism samples were in 7 series, the total number of prisms was 21. To detect the deformations of prism-samples, a portable messura with a base of 250 mm and a clock-type indicator with an accuracy of 0.01 mm was installed. The samples were mounted in the center of the bottom plate of the press. The load was delivered in stages. At each stage, the amount of load increased continuously and the velocity was 0.6 ± 0.2 MPa / s. Each phase lasted 4-5 minutes. The readings on the clock-type indicator were recorded. When the amount of load

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Vol. 8, Issue 9 , September 2021

breaking the prism reached $0.6R_{ult}$, the devices were removed from the samples. Subsequent loading was carried out continuously until the sample was broken. An overview of the samples is shown in Figure 4.

а) б)

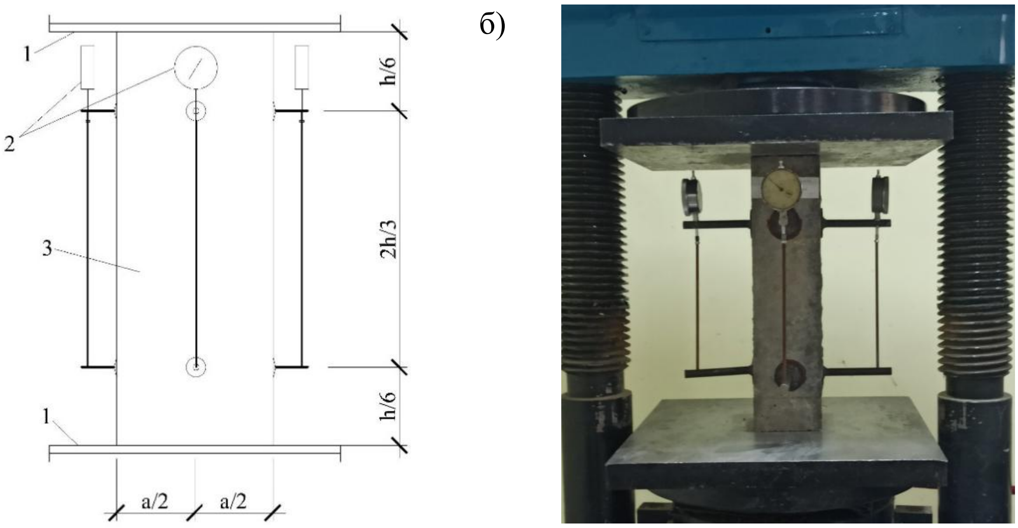

Figure 4. a) Test scheme of prism-sample: base plate 1; 2-hour type indicator; 3-concrete prism. b) general view of the concrete prism

Concrete without basalt fibers and prism-specimens made of concrete with basalt fibers were significantly different in the nature of the failure, as in the crushing cubes. Concrete prisms without the addition of basalt fibers were brittle. As soon as the main crack appeared, the sample was immediately broken into pieces. In prism-specimens made of basalt fiber concrete, the distortion was peculiar. Even after the prism-samples were tested, the parts of the sample remained in a state where the concrete matrix was bonded with many deformed fibers. An overall view of the prism samples after testing is shown in Figure 5.

а) б)

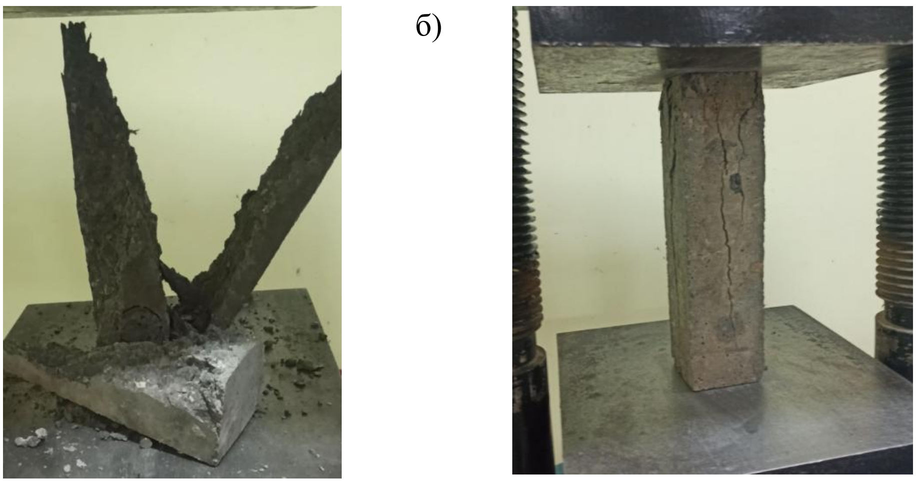

Figure 5. General appearance of the prism sample after the test: a) sample without basalt fiber, b) sample with basalt fiber.

The strength and deformation properties of the cube and prism samples obtained as a result of the test are shown in Table 4.

ISSN: 2350-0328
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Vol. 8, Issue 9 , September 2021

Table 4. Strength and deformation properties of concrete samples without basalt fibers and concrete samples with basalt fibers.

Indicators	The length of basalt fiber, mm	Basalt fiber content, %		
		0,1	0,2	0,3
		Compressive strength, MПa		
The cubic strength at 28 day	0	34,6		
	10	38,7	40,6	38,9
	30	39,8	41,3	38,7
The prismatic strength at 28 day	0	25,8		
	10	28,7	29,8	28,4
	30	28,9	30,4	28,1

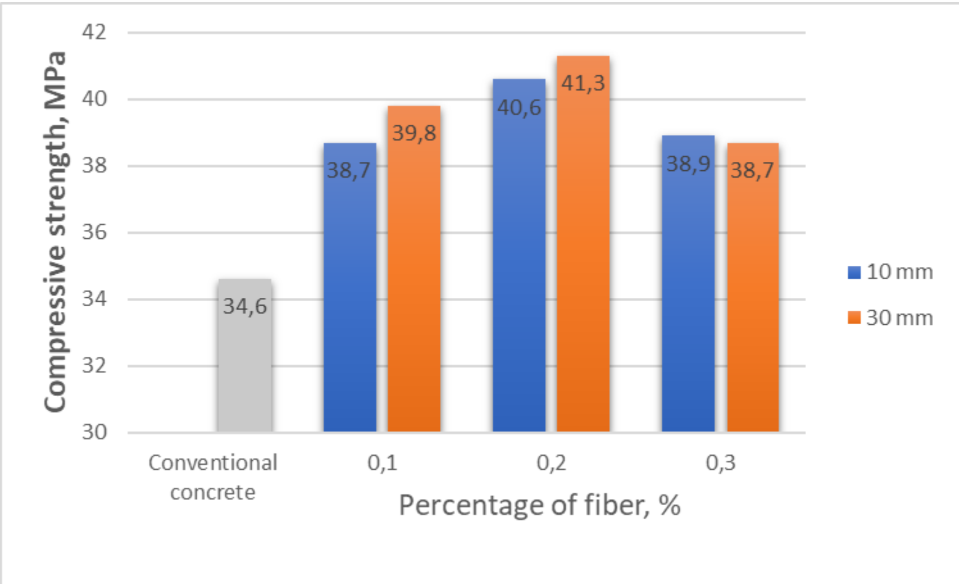

Figure 6. Cube strength of concrete at 28 day

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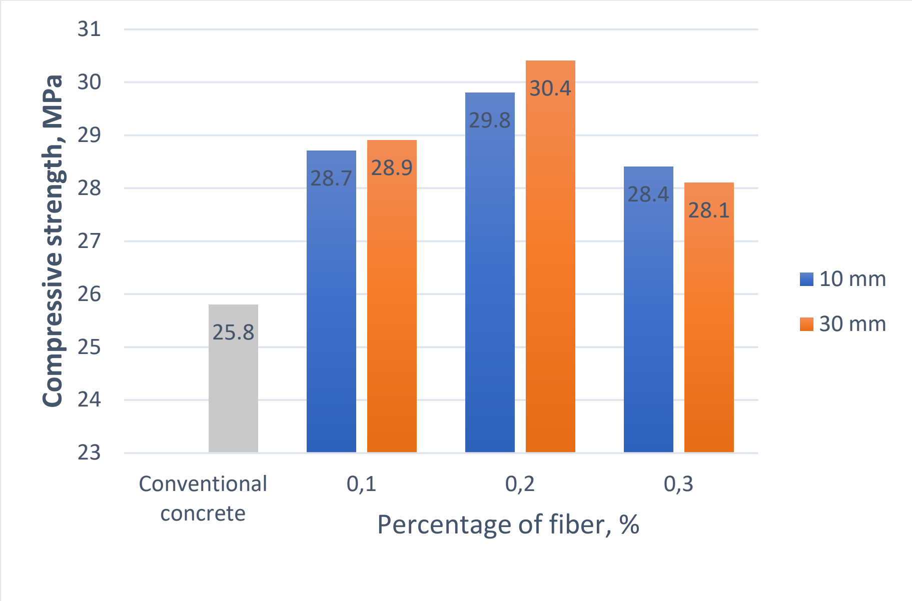

Figure 6. Prism strength of concrete at 28 day

IV. CONCLUSION

Basalt fibers that are the length of 10 mm and 30 mm adding in the content of 0.1; 0.2; 0.3% to concrete increase significant mechanical properties of the concrete.

The failure of cube-samples and prism-samples made of basalt fiber concrete under the influence of force is significantly different from the failure of concrete without basalt. During the test, the bonding of the concrete matrix with the basalt fibers ensured that the concrete was not completely damaged as a result of deformation.

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