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Compressive Strength Of Fiber-Reinforced Concrete

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Abstract— *The article presents the findings of research on the distribution's compressive strength of reinforced concrete including basalt fibers as well as the ideal proportion of basalt fiber length. 26 series of concrete cubic samples measuring 100 x 100 x 100 mm on the sides were made in accordance with established procedures for the experiments. When the concrete mixes were being placed in the molds, special attention was given to the quality of preparation requirements and the vibration of samples.*

Keywords— Basalt fiber, Dispersed reinforcement, Fiber concrete, Compaction, Strength

1. INTRODUCTION

Modern construction is closely associated with improving construction production efficiency, lowering the labor intensity and cost of technological processes, consuming less energy and materials, and utilizing new and innovative materials. In this sense, distributed reinforced concrete might be considered one of the contemporary building materials of the future. These concretes come in a variety of composite components and are widely utilized in many different industries today.

Furthermore, a large number of international scholars have carried out in-depth studies in this field and produced noteworthy scientific findings. Including such serious researches were accomplished by Stepanova V.F., Talantova K.V., Tatarintseva O.S., Timashev V.V., Xaydukov G.K., Chernyshev E.M., Chernyshov E.M., Sheynin A.E., Yakovlev G.I., Abdulhadi M., Brik V., Charan SS, Gore KR, Gylltoft K., Jin S., Kizilkanat AB, Raj S., Ramakrishnan V., Shen X., Singha K., Zhang J., Zhang X. Finely, and in their researches respectively, it can be seen that the physical and mechanical properties of concrete and structures reinforced with different fibers have been studied [1].

In recent years, at the Namangan Institute of Civil Engineering (NamMQI, Uzbekistan), under the leadership of prof. S.J. Razzakov a large-scale research is carried out in the field of determining the levels of stress-strain and weaknesses of building structures and buildings [2-8]. In particular, scientific research is being conducted on dispersed reinforced concrete structures with basalt, glass, steel fibers. Based on cement, coarse and fine aggregates produced in the territory of Uzbekistan, effective scientific results are being obtained to increase the strength of the regions depending on the climatic conditions.

Although concrete is thought to be a very strong building material, there are a number of factors that can cause it to weaken over time. Increased stresses in compression, elongation, and bending can cause concrete or reinforced concrete to lose its overall strength as a result of environmental factors and different dynamic influences. As a result, adding additives that strengthen concrete is essential to ensuring and increasing strength. In order to achieve this, fibers that are uniformly distributed throughout the volume of the concrete mix are added as part of the disperse reinforcement process, also known as fiber-concrete or fiber-reinforced concrete [9].

The first patent for fibro concrete structures was obtained by Russian Scientist V.P Nekrasov over the world in 1909. However, research in this area has not been developed since the insufficient data on the fibers to be added. It can be seen that the development of scientific research on fiber concrete and the creation of methods for calculating the structures made of it began in the 60s of the twentieth century. The first large-scale application of fibro concrete in practice began in 1976 with the construction of runways for airports in Russia. This material was not widely used at that time, because the technology of preparation of fibro concrete and fibro itself was not accomplished [10-14].

Nowadays, there is a growing interest in the use of fiber as the basis of building structures, in particular, the use of such fibers as reinforcement. This interest has arisen based on the efforts of specialists to improve the physical and mechanical properties of concrete structures, given the high demands of modern construction. And also it should be considered as the main points of increasing the use of natural resources as a result of improving production, growing energy consumption, increasing industrial waste and environmental pollution. That should be admitted the energy consumption of concrete production is much smaller than the energy consumption of steel, aluminum and glass. At the same time, dispersed reinforcement of concrete leads to a spontaneous increase in the energy capacity of the product. Despite the advantages of such basalt fiber material, the positive results obtained during many studies and the practicality of experimental projects, basalt fiber is not widely used in concrete and reinforced concrete structures of modern constructions [15-16]. The priority of research problems such as dispersion of fibers, insufficient research on the mechanical properties of the fiber, lack of research results, technological difficulties in the distribution of basalt fibers in the concrete volume, insufficient calculation methods and regulatory documents are explained in this area.

2. MATERIAL METHOD

Testing of samples complies with the requirements of the current Interstate Standard DAST 27006-2019. 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. 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 1.

Figure 1. General view of basalt fibers

Table 1. *Physical properties of chopped basalt fiber*

Fiber	Density, kg/cm^3	Consistency limit MPa	Modulus, GPa	Fiber diameter, mkm	Length of fiber, mm
Basalt	2650	3000-3500	90-110	17	5, 10, 15, 20, 30

By adding basalt fibers to the concrete, experimental work was done in the lab to produce concrete of class B25 in accordance with the design parameters. As indicated in Table 2 below, this test was carried out using the normative documents' indicators that were created in accordance with the demands of the most recent interstate standard, DAST 27006-2019.

Table 2. *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

2. RESEARCH METHODOLOGY

The samples were prepared in the “Bunyodkor-3” MCHJ construction testing laboratory. 26 series of 100x100x100 mm concrete cubic samples were prepared for the experiments in accordance with the standard requirements (Figure 2). When the concrete mixes were being placed in the molds, special attention was given to the standard of preparation requirements and the vibration of samples. After a day of standing in the room, the prepared samples were taken out of the molds and labeled before being kept for seven and twenty-eight days in a regular solidifying chamber.

Figure 3. General view of samples during testing

It is well known that the compressive strength of concrete, regardless of the type of concrete, determines its primary strength. As a result, the experiment examined the concrete cubic samples' compressive strength after basalt fibers were added.

4. THE RESEARCH FINDINGS AND DISCUSSION

The primary scientific findings of practical importance from the experiments are displayed in Figures 4 and 5. The findings were examined and incorporated into the relevant tables (Table 4) and graphs (Figure 6).

Figure 4. The general post-test appearance of cubic samples made of ordinary cube samples

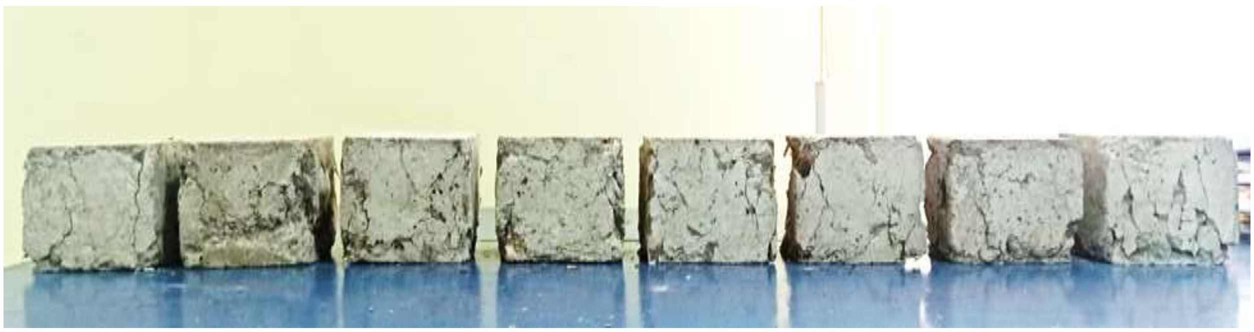
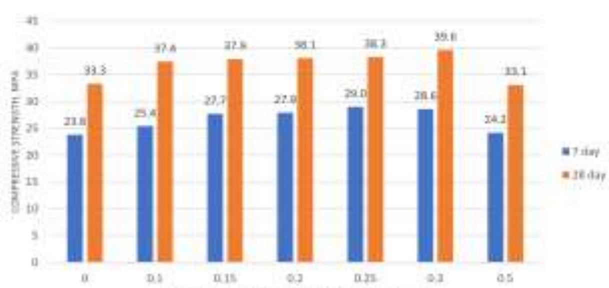


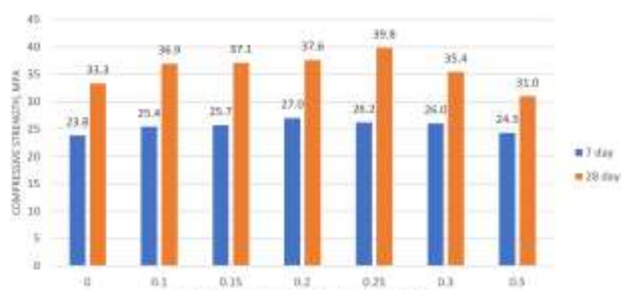
Figure 5. The general post-test appearance of cubic samples made of fibro-concrete

Table 3. *Strength values of cube samples at 7 and 28 days*

Dates	The length of basalt fiber	Basalt fiber content, %					
		0,1	0,15	0,2	0,25	0,3	0,5
		Compressive strength, MPa					
7 days strength	0	23,8					
	5 мм	25,4	27,7	27,9	29,0	28,6	24,2
	10 мм	25,4	25,7	27,0	26,2	26,0	24,3
	15 мм	24,9	25,6	29,0	28,2	27,3	22,9
	20 мм	24,7	24,2	26,3	25,9	25,6	23,1
	30 мм	24,1	24,9	26,1	25,6	25,3	23,9
28 days strength	0	33,3					
	5 мм	37,4	37,9	38,1	38,3	39,8	33,4
	10 мм	36,9	37,1	37,6	39,6	35,4	31,0
	15 мм	34,5	37,2	38,9	38,3	38,2	30,2
	20 мм	34,6	36,0	38,5	37,3	37,0	31,3
	30 мм	34,9	35,4	38,3	35,4	33,6	30,6



a) Cubic strength of concrete with 5 mm long basalt fiber



b) Cubic strength of concrete with 10 mm long basalt fiber

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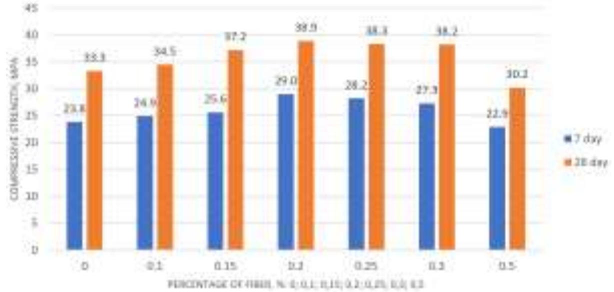
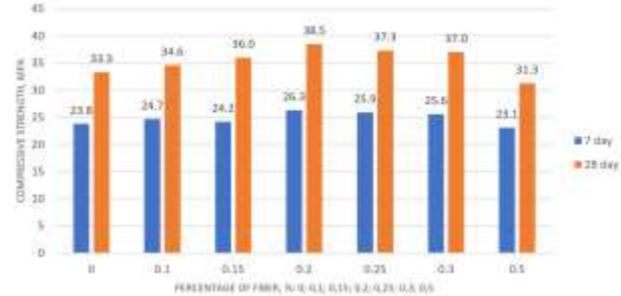


v) Cubic strength of concrete with 15 mm long basalt fiber



g) Cubic strength of concrete with 20 mm long basalt fiber

Figure 6. *Cubic strength of concrete at 7 and 28 days: a-5 mm long; b-10 mm long; v-15 mm long; g-20 mm long; d-30 mm long cubic strength indicators of concrete with basalt fiber added*

5. Results

When the concrete with 5 mm long basalt fibers is reinforced with 0.3% dispersion, the compressive strength of concrete increased by 10-19%. When 10 mm long basalt fibers were added to the concrete by 0.25%, the compressive strength of the concrete increased by 12-20%. 15; When 0.2% of 20 and 30 mm long basalt fibers were added to the concrete, positive results were obtained in relation to the remaining percentages (0.1; 0.15; 0.25; 0.3; 0.5). When 0.5% of basalt fibers were added to the concrete, the compressive strength of the concrete decreased by 5-9%, thus negative results were obtained. When 0.25% of 10 mm long basalt fibers were added to the concrete, the highest result (compressive strength 39.8 MPa) was achieved in comparison with the grade B25 concrete and basalt fibers of the remaining lengths.

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