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Compressive Strength of Disperse Reinforced Concrete with Basaltic Fiber

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Abstract: The article describes the results of studies on the compressive strength of the distribution of reinforced concrete with basalt fibers and the optimal amount of basalt fiber and fiber length. For the experiments, 26 series of concrete cubic samples with sides of 100x100x100 mm were prepared by the standard requirements. Particular attention was paid to the process of the standard of preparation requirements and vibration of samples during the placement of concrete mixes in the molds. The prepared samples were removed from the molds after standing in the room for 1 day and the samples were marked and stored in a normal solidifying chamber for 7 days and 28 days. Basalt fibers of 5, 10, 15, 20, 30 mm lengths were added to the concrete. The obtained scientific results show that the compressive strength of concrete with the addition of basalt fibers increases by 15-20% compared to ordinary concrete.

Keywords: *Basalt fiber, Dispersed reinforcement, Fiber concrete, Compaction, Strength*

1. Introduction

Modern construction is directly related to increasing the efficiency of construction production, reducing the cost and labor intensity of technological processes, consumption of materials and energy resources, as well as the use of new progressive materials. In this regard, it can be said that one of the modern construction materials of the future is dispersed reinforced concrete. Such concretes are a wide range of composite materials and are broadly used today in various industries.

Moreover, researchers from many foreign countries have conducted significant investigations in this area and obtained important scientific results. Including such serious researches were accomplished by Abolinsh D.S., Ayvazyan E.S., Bajenov Yu.M., Belov V.V., Belova T.K., Berg O.Ya., Berdichevskiy G.I., Bondarenko V.M., Borovskix I.V., Buchkin A.V., Vasilovskaya N.G., Voylokov I.A., Volkov I.V., Gvozdev A.A., Gorb A.M., Gofshteyn F.A., Endjievskaya I.G. ., Juravskaya I.V., Zertsalov M.G., Zimin D.E., Kanaev S.F., Klyuev S.V., Kolbasko E.B., Korolev K.M., Korotyshevskiy O.V., Kravinskiy V.K., Krylov B.A., Kurbatov L.G., Lagutina G.E., Leontev M.P., Lesovik V.S., Lesovik R.V., Lobanov I.A., Mailyan L.R., Mailyan R.L., Morgun V.N., Morgun L .V., Morozov V.I., Nekrasov V.P., Osnos S.P., Pashchenko A.A., Perfilov V.A., Puxarenko Yu.V., Rabinovich F.N., Rozina V.E. ., Romanov V.P., 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]. Besides the scientists from the Tashkent Institute of Architecture and Construction (TAQI), Tashkent Transport University (Tashkent State Technical University), Samarkand Institute of Architecture and Construction (SamDAQI), Jizzakh Polytechnic Institute (JizPI) and Fergana Polytechnic Institute (FarPI) have also proposed in this area and is being carried out and achieved intensively scientific results.

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.

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Concrete is considered a building material with high strength, but over time, concrete can also lose its strength as a result of various influences. Environmental influences, as well as various dynamic influences, can cause concrete or reinforced concrete to lose its overall strength due to increased stresses in compression, elongation, and bending. Therefore, it is necessary to increase and ensure strength by adding additives that increase the strength of the concrete. For this purpose, disperse reinforcement (fibra-concrete or fibre-reinforced concrete) is carried out by adding fibres that are evenly distributed throughout the volume of the concrete mix [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 / m^3 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 / m^3 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

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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 2 below.

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

3. Research Methodology

The samples were prepared in the construction testing laboratory of “Bunyodkor-3” MCHJ. For the experiments, 26 series of concrete cubic samples with sides of 100x100x100 mm were prepared by the standard requirements Figure 2. Particular attention was paid to the process of the standard of preparation requirements and vibration of samples during the placement of concrete mixes in the molds. The prepared samples were removed from the molds after standing in the room for 1 day and the samples were marked and stored in a normal solidifying chamber for 7 days and 28 days.

Figure 2. *Concrete cube samples with basalt fibers*

Figure 3. *General view of samples during testing*

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It is known that the main strength of concrete is determined by its compressive strength, including the class of concrete. Therefore, the experiment studied the compressive strength of concrete cubic samples with the addition of basalt fibers.

4. The Research Findings and Discussion

As shown in Figure 4 and Figure 5, the main scientific results of practical significance were obtained in the experiments, and results were analyzed and included in the corresponding 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

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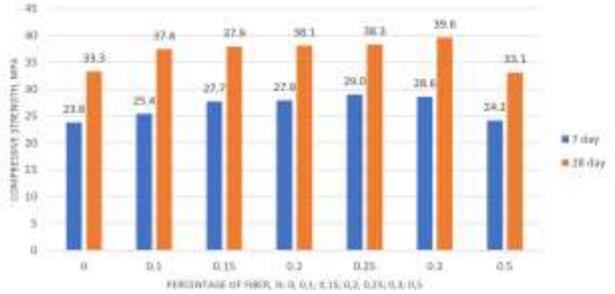
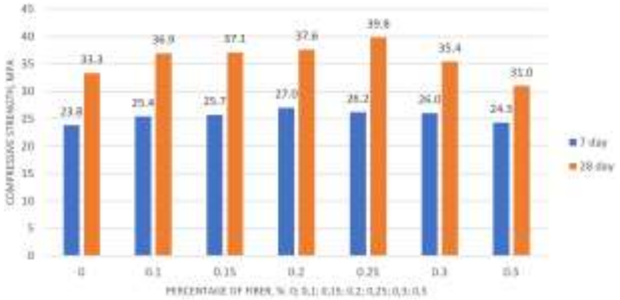
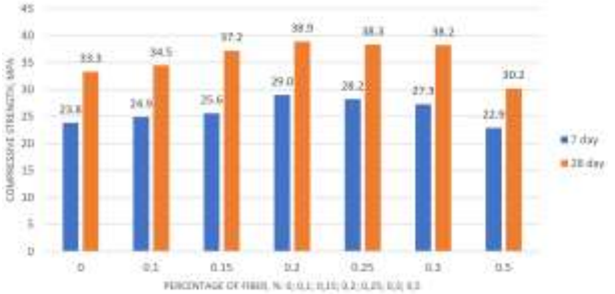


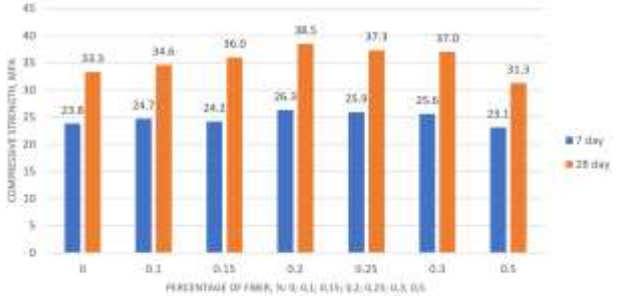
a) Cubic strength of concrete with 5 mm long basalt fiber



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



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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