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PROPERTIES OF MATERIALS USED FOR DISPERSION-REINFORCED FIBER-REINFORCED CONCRETE

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Abstract
The article presents the compositions and physical and mechanical properties of raw materials for fiber-reinforced concrete based on fibers of igneous volcanic rock and thermoplastic polyme .

Keywords: Dispersed reinforcement, composite fiber, reinforced cement structures, basalt fiber-reinforced concrete, polypropylene, strength characteristics, density, humidity.

Аннотация. В статье приведены составы и физико-механический свойства сыревых материалов для фибробетонов на основе волокон магматической вулканической горной породы и термопластичного полимера.

Ключевые слова: Дисперсное армирование, композитная фибра, армоцементные конструкции, базальтофибробетон,полипропилен, прочностные характеристики, плотность, влажность.

Introduction

One of the main ways of scientific and technological progress in construction, according to modern requirements for improving the physical and economic performance of building products and structures, is the widespread use of efficient or improved materials in building structures. The vast majority of building structures at present and for the next 25-50 years [1] are concrete and reinforced concrete. However, along with the indisputable advantages that have determined its widespread use in construction, there is a known drawback that prevents the effective use of concrete in structural elements - a relatively low tensile strength. For the same reason, due to the development of cracks in concrete, the operational reliability and durability of reinforced concrete structures are reduced.

The structural qualities of concrete, as shown by a number of works, are significantly improved with a special form, reinforcement - distributed over the volume (dispersed), which is confirmed, for example, by more than 30 years of experience in

the use of reinforced cement in domestic and foreign construction [2,3] . Fibre-reinforced concrete, or fiber-reinforced concrete, is another variation of particulate-reinforced concrete with finite length reinforcing elements. There is currently a great interest in fiber-reinforced concrete, which is due, along with other reasons, to the general progress in the materials science of composite materials. The experience of using fiber-reinforced concrete in practical construction is expanding.

However, the areas of rational use of various types of fiber-reinforced concrete in construction and the technical and economic efficiency of their use have not yet been studied enough.

The most studied are concretes with steel fibers. However, such fiber-reinforced concretes require a large consumption of scarce and expensive steel, they are distinguished by their large weight and thermal conductivity.

In order to save steel, concrete with non-metallic fiber reinforcement has attracted increasing attention in recent years. Such alkali-resistant fibers include glass fibers, polypropylene fibers, mineral fibers obtained from metallurgical slag melts, basalt fibers, and others. The efficiency of dispersed concrete reinforcement depends on the properties of the fibers. The latter must be sufficiently flexible, have high tensile strength and an elastic modulus close to that of concrete.

Fibre-reinforced concrete with various fibers, in comparison with concrete without fibers, has increased crack resistance, lower shrinkage and creep, higher impact strength, frost resistance, wear resistance, resistance to force and thermal influences. When using non-metallic fiber in comparison with steel, additional advantages appear - weight reduction and increased corrosion resistance in aggressive environments [3] .

The world experience of research and application of dispersed reinforcement of dry building mixtures shows that the introduction of fibers provides:

- Improvement of strength characteristics, increase of crack resistance, impact and wear resistance, static strength under various force impacts;
- Increasing the operational reliability of structures under the influence of an aggressive environment by improving the structure of concrete;
- The possibility of reducing the working sections of structures, in some cases, reducing the consumption or completely abandoning the use of bar reinforcement.

Research Objectives

The objectives of the study consist of determining the physical and mechanical properties of a dispersion-reinforced mortar, concrete mixture and concrete, including:

- Properties of the materials used;
- Determination of the optimal parameters of dispersed reinforcement;
- Calculation of the composition of heavy concrete;
- Determination of the characteristics of the resulting heavy concrete;

Experience in analyzing the effect of the size, dosage and type of dispersed reinforcement on the properties of concrete on the properties of heavy concrete consists in the formation of samples with different types of fibers, but with the same water-cement ratio.

Problem Solving Methods

In accordance with the goal, the main direction of research is the selection of concrete compositions with the addition of mineral and polymer fibers in the form of additives. In this research work, the following source materials were selected:

- Portland cement CEM I 42.5N;
- Quartz sand;
- Polypropylene fiber, 6 and 12 mm long;
- Basalt fiber, 6 and 12 mm long;
- Granite Crushed stone, fractions 10-20 mm.

Cement studies were carried out in accordance with GOST 30744-2001 and GOST 31108-2016. Characteristics of cement are presented in table 2.1.

The tests were carried out in rooms with an air temperature of (20 ± 2) ° C and a relative humidity of at least 50% when preparing samples to determine strength, at least 65% - when determining the setting time and uniformity of volume change, and not more than 65% - when determining thinness grinding.

The characteristics of the fiber are presented in Table 2. Recommendation for fiber consumption from the manufacturer: from 0.3 to 1.2 kg / m³ of ready-mixed concrete. Basalt fiber (chopped basalt thread) is a piece of basalt fiber, is an effective reinforcing additive for various types of concrete, cement products, plastics.

The used sand was studied according to GOST 8735-88 and GOST 8736-2014. The temperature of the room in which the tests are carried out complied with the requirements of GOST T=25±10 °C. Before the start of the test, the sand and water had a temperature corresponding to the air temperature in the room.

The studies of crushed stone were carried out in accordance with GOST 8269.0-97 Crushed stone and gravel from dense rocks and industrial waste for construction work. Methods of physical and mechanical tests.

Scientific Results and their Analyses

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Characteristics of raw materials obtained empirically in the laboratory fully meet the requirements of regulatory documents and are suitable for testing to assess the effectiveness of additives in accordance with GOST 30459-2008. These raw materials can be used as fiber reinforced concrete components.

According to the type of clinker, we refer our cement to Portland cement. According to the material composition, cement based on Portland cement clinker was classified as type I - Portland cement containing only Portland cement clinker as the main component of the material composition.

According to the speed of hardening, general construction cement belongs to normally hardening (H) with normalization of strength at the age of 2 (7) and 28 days.

According to the setting time, cement is subdivided into normally setting cement - with a normalized setting start time from 45 minutes to 2 hours.

Table 1. Characteristics of Portland cement without additives CEM I 42.5N

Fineness of grinding, %	**Setting time, min**		**Tensile strength, MPa**		**True density, kg/m³**
	Beginning	Ending	When bending	When compressed	
6,5	60	100	9,1	55,2	3100


Picture 1. Determination of the properties of Portland cement in the laboratory

Table 2 - Characterization of fibers

Property	**Polypropylene**	**Basalt**
Material	Polypropylene	Basalt
Fiber density, kg/m³	910	2800
Fiber length, mm	6 va 12	6 va 12
Fiber diameter, μm	20	17
Melting point, °C	160	1450
Alkali and corrosion resistance	Low	High
Tensile strength , MPa	150-200 450-600	450-600
Modulus of elasticity, MPa		

The screening curve is shown in Figure 2.

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The particle size module in accordance with tables 1 and 2 according to GOST 8736-2014 defines sand in the group of medium size of the first class..

Table 3 - Results of determining the grain composition

Residue name	Residues, % by weight, on sieves					
	2,5	1,25	0,63	0,315	0,16	<0,16
Private	0	10	30	35	20	5
Full	0	10	40	75	95	5

The investigated sand complies with GOST 8736 and can be related to the first class, the first group. In accordance with GOST 30459-2008, this sand can be used to assess the effectiveness of the use of fiber in a concrete mixture.

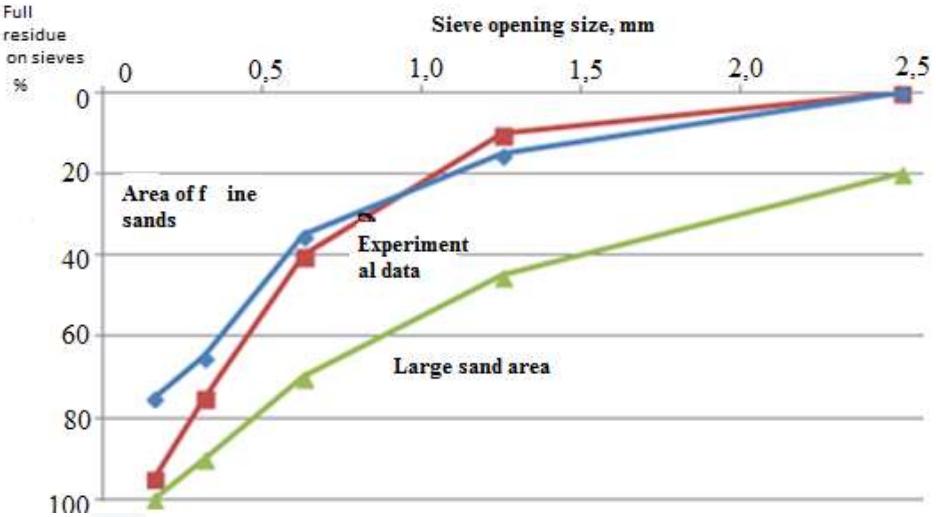

Figure 2 - Sand screening curve

Table 4 - Characteristics of quartz sand

Bulk density, kg/m³	Average density, kg/m ³	Size modulus	Content of dust and clay particles, %
1400	2570	2,2	1,7

Figure-2. Determination of the properties of quartz sand in the laboratory

Based on the results of sieving, a partial residue was determined on each sieve. The results of partial and total residue on the sieve are shown in table 5.

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Complete residues on the sieves meet the requirements of GOST 8267-93.

Table 5 - Results of determining the grain composition

Residue name	Residues, % by weight, on sieves			
	20	15	10	5
Private	10	33	47	10
Full	10	43	90	100

The crushing index of crushed stone, measured using the pressure of the press on a steel cylinder with crushed stone, is 21.8, the crushing grade is in accordance with GOST 8267-93 - 400.

Data on the density and strength of crushed stone are presented in table 6.

Table 6 - Characteristics of crushed stone

Name of indicator	GOST 8267-93	Experimental
Bulk density in natural state, kg/m^3	1455	1500
Average density, kg/m^3	2000-3000	2550
Strength grade	M1200-M1400	M1200

Conclusions

In the course of the research work, the scientific and technical literature on the topic of fiberglass and dispersed-reinforced concrete was studied, the main raw materials for the production of this type of concrete were studied, experiments were carried out to determine the properties of the raw materials, and the calculation of the composition of heavy concrete was obtained. Characteristics of raw materials obtained empirically in the laboratory fully meet the requirements of regulatory documents and are suitable for testing to assess the effectiveness of additives in accordance with GOST 30459-2008. These raw materials can be used as fiber reinforced concrete components.

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