Concrete Reinforcement with Chopped Fiber

Along with the widespread usage of reinforced concrete a special attention, in our opinion, should be paid to composite materials, that perform the role of the cement stone matrix obtained on the basis of Portland cement, as well as rebars various mineral and polymer fibers, metal mesh and chips are used. Fibers provide three-dimensional consolidation of concrete in comparison with traditional rebar, which provides two-dimensional reinforcement.

Currently, there are two possible directions of composite materials development:

- High-modulus fibers in the composite (steel, asbestos, glass, basalt);
- Low-modulus composites fibers (nylon, polyethylene, polypropylene, etc.).

Each of the composite have advantages and disadvantages, but most researchers prefer to use composites as a reinforcing material of basalt fibers.

Artificial porous masonry materials (concrete), characterized by low resistance to tearing and the formation of shrinkage cracks in the curing. One of the major drawbacks of such products is the destruction of the corner made structures. Avoid the formation of cracks and chips in several ways, including secondary reinforcement steel mesh or reinforcement, welded wire. But it is the most effective way to modify the binding of mixtures of basalt, polypropylene and metallic fibers. It allows you to solve the problems associated with welded reinforcement in slabs, which allows you to save on metal. Since polypropylene fiber replacement of welded wire mesh to prevent the formation of cracks in the structure and increases its flexural strength by more than 2%. At a certain percentage of fibers in the mixture, it replaces the secondary reinforcement and provides flexibility, but does not replace constructive steel bars. In addition, the polypropylene fiber has its drawbacks: it is deformed at low loads in tension, loses its properties over time, and burns when exposed to open flame.

The structure of concrete when using basalt fibers is close to the structure of reinforcement with steel mesh, but basalt-concrete has a higher reinforcement strength, due to higher degree of dispersion of basalt fiber in the reinforced stone, but the very fiber has a higher strength than the steel mesh. Bazaltobetonnye design can withstand a lot of stress deformation due to the fact that the very fiber tensile plastic deformation does not have, and on the elasticity than steel. The relative deformation of the cement stone without cracking up 0.9 - 1.1%. Such a deformation in the 45-55 times higher than the boundary extension of non-reinforced cement. However, the hardening cement paste is formed aggressive environment, which destroys the surface of the fibers, forming a shell, and the fiber strength decreases slightly to 15%. But due to the adhesion strength of stone sinks and fiber increases, and correspondingly increases the strength of the structure itself. When using the coarse fibers (40 microns), their strength is practically not reduced. The increase in the strength of cement paste is due to the influence of basalt fiber on the stress concentration in the field weakened by structural defects, or high porosity (in foams).

Fibers made from chemically inert rocks do not react with the salts or dyes, and therefore binding mixture with the addition of fibers can be used in the construction of offshore structures in the architectural construction of the production of structures with complex surfaces, decorative concrete. In the production of road surfaces using basalt fiber, it protects the asphalt coating from penetrating antiobledenyayuschih salts and corrosive substances, increases the stiffness of the surface.

In NIIISV (Bucha) studies were conducted to obtain composite materials with chopped continuous basalt fiber length of 10-20mm. We studied the parameters of the composite fibers when exposed to the liquid phase of hardening of Portland cement for 3.5 hours, 1.3 and 6 months at normal temperature (200 deg.C), as well as by heating the samples for 6 hours to a temperature of 96 deg.C, and then holding for 45 hours at normal temperature.

The second method was used to simulate the effects of steaming concrete products in order to accelerate the curing process of concrete stone. In both cases, the resistance of basalt fibers to the effects of the liquid phase of hardening concrete strength characteristics of fibers was estimated.

Basalt fiber diameter of 18-60 microns practically does not change its strength during long-term (one month) stay in the environment of hardening Portland cement. The strength of thinner fibers in the same conditions will gradually decrease. The intensity of the loss of strength increases with decreasing fiber diameter. This position is also confirmed in the work (12). According to the author, the diameter of basalt fiber to be in the aisles 40 - 200 mm, and length of sections 10 - 20 mm, and its tensile strength of 1500 MPa.

According to the research NIISV found that laboratory samples of Portland cement, reinforced with basalt fibers have bending strength is 1.7 times higher than in normal hardening and 1.5 times higher for steaming than samples of the same cement, reinforced with fiberglass. At the same time the strength of specimens reinforced with basalt fiber increases with time, whereas the samples fiberglass reinforced this phenomenon is not observed.

Stay of basalt fiber for 6 hours in an environment of hardening concrete, heated to a temperature of 960S, and then holding for 45 hours at normal temperature does not lead to significant changes in the strength properties of fibers. In the same conditions as glass fiber loses its strength at 23-35%. The studies found that the introduction of the cement matrix of basalt fibers allows you to:

- To increase the strength of the specimens in compression at 30 - 40%;
- To increase the axial tensile strength of three - four times;
- To improve the toughness of the composite in 3 - 4 times.

The strength of composite products depends on the anchoring of reinforcing fibers in the cement matrix. Theoretically, the strength of the composite increases with increasing content in the fibers. However, the reinforcing properties of the concrete matrix with the number of fibers decreases. When the amount of fiber tends to 1, the volume of the cement matrix tends to 0, and the strength of the composite will also be zero. Therefore, there is a certain volume ratio of fiber and matrix in which the matrix can provide a maximum degree of anchoring filaments. According to some researchers the optimal number of basalt fiber in the composite should be up to 20% by weight of cement (9, 10, 12).

The length of sections of continuous basalt fiber on the one hand determined by the conditions of uniform distribution of fibers in the cement matrix (too long fiber contributes to the formation of tangled fibers in the form of "hedgehogs"), and short fibers degrade the degree of reinforcement of the cement matrix. In this context, the optimal length of the cut taken in the aisles and 10-20mm.

Preparation of fiber-cement mixtures based on basalt fiber is the most critical operation in the technology of reinforced voloknistotsementnyh dispersed mixtures, as the most important factor for the stability of their properties, is the uniform distribution of basalt fibers by volume of the mixture. The most acceptable method is to vibroekstruzivny, with which a uniform introduction of fibers into the concrete matrix.

In (12) based on a generalization of the domestic and international experience formulated the direction of the effective use of basalt fiber as a reinforcing material:

- For the perception of the principal tensile and shear stresses instead of shear reinforcement rod;
- To reduce the length of fixtures because of the possibility of failing to pursue it in the area to reduce the bending moment, due to the high adhesion rebar rod with a fiber-reinforced concrete possibility of reducing the length of the anchor;
- To reduce the rate of distribution of reinforcement and concrete in thin-walled cells in which most of the reinforcement shall be appointed from the design considerations, and a protective layer of concrete is a significant portion of the thickness of the element.

There are also applications of composite materials based on basalt fibers:

- In construction, which increased requirements on rigidity and treschenovatosti;
- In buildings experiencing the impact of shock and alternating loads;
- In the thin-walled structures and designs of complex geometric shapes;
- When itinerant reinforcing the most intense parts of structures;
- In construction, transverse reinforcement which is intended mainly for the perception of assembly and transport loads;
- In the designs, which are increased requirements for frost resistance, water resistance, abrasion resistance and thermal shock.

Effective use of composite materials in the centrifuged tubes for slabs in road construction and support networks of contacts, concrete water channels, fireproof structures, earthquake-resistant buildings and military installations, concrete floors, airport runways, highways, industrial floors in shops, where found heavy equipment for internal reinforcement of tunnels and channels, strengthening the slopes, repair and reconstruction of buildings, covering the metal surfaces of steel structures. The main advantages of concrete reinforced with basalt fibers are a reduction in the thickness of the concrete layer to half comparing with conventional concrete, respectively, the total cost of construction, reducing labor costs associated with installing wire mesh in the reservoirs and underground water channels, the thickness of concrete cover significantly reduced the cost of repairing and service significantly reduced due to fiber reinforced concrete durability. It is also not unimportant point is that the fibers are not amenable to electrochemical corrosion, unlike conventional fittings, which is an electrical conductor and is subjected to cathodic effect. According to many years of research NIISK, durability coarse basalt fiber in the environment of the cement stone is not less than one hundred years . It should also be a significant improvement in the performance of a number of fiber-reinforced concrete (frost resistance, impact resistance, water resistance, abrasion), increasing reliability and durability of structures, as well as the ability to create a continuous automated process of formation of structures.

In NIISK Construction Committee of Ukraine, Kiev, developed specific technology for preparation of concrete, reinforced with basalt fibers (bazaltofibrobeton). The technology of manufacturing designs using traditional technological schemes and equipment, special supply lines of basalt fiber in the mixer with the required compaction of the mix on the shaker table, without the deep vibration. Scope of the new composite material: flat and thin-walled products, bulk items, rings, tubes, plates lining of canals and ditches silos, road and paving slabs, concrete panel elements, wall panels, building foundations, etc. The economy of steel reinforcement for certain types of production ranges from 80 to 100%.

Despite the obvious advantages of such a composite material, its production has not left the stage, experimental work, because of the lack of large-scale production technology sections of continuous basalt fiber as raw material for manufacture of concrete products.

Such a technology company developed a "Mineral 7", the Sycamores, Lviv region. With the development of fiber instead of the traditional rhodium spinneret plate is applied to the installation plate zhelezohromonikelevogo alloy, which provides a low temperature gradient over the area of ??fiber. Applied formerly reels like "us" are replaced by the device of original design with semi-automatic threading. What is possible to increase the production of fiber-hour by the number of nozzles.

The performance of the unit of feedstock (basalt) - 12 kg / h of finished product - 10 kg / h or 80 t / year. Cost of gas for melting - 10 nm / h for 2 burner one smelter. Cost of electricity for heating spinneret plate - 20 kW / h The chemical composition of basalt source (in% by weight) used in the production of fibers for concrete reinforcement, is given in Table 1.

Table 1: The chemical composition of processed rocks.

Oxides	Basalt, Ivanovo-Dolinskoye	Andesite-basalt, Podgornyansk
SiO2	48.9	52.84
TiO2	2.7	0.50
Al2O3	15	17.28
Fe2O3	8.8	8.97
FeO	6.4	1.66
MnO	0.2	-
MgO	5.1	6.30
CaO	8.4	7.10
Na2O	2.3	2.20
K2O	0.7	1.60
P2O5	0.3	-

H2O	0.75	-
Other	2.0	1.77
Total	99.7	100.23
Mk	4.9	5.23
Mb	1.97	2.6

Table 2: Physical and mechanical properties of the fibers

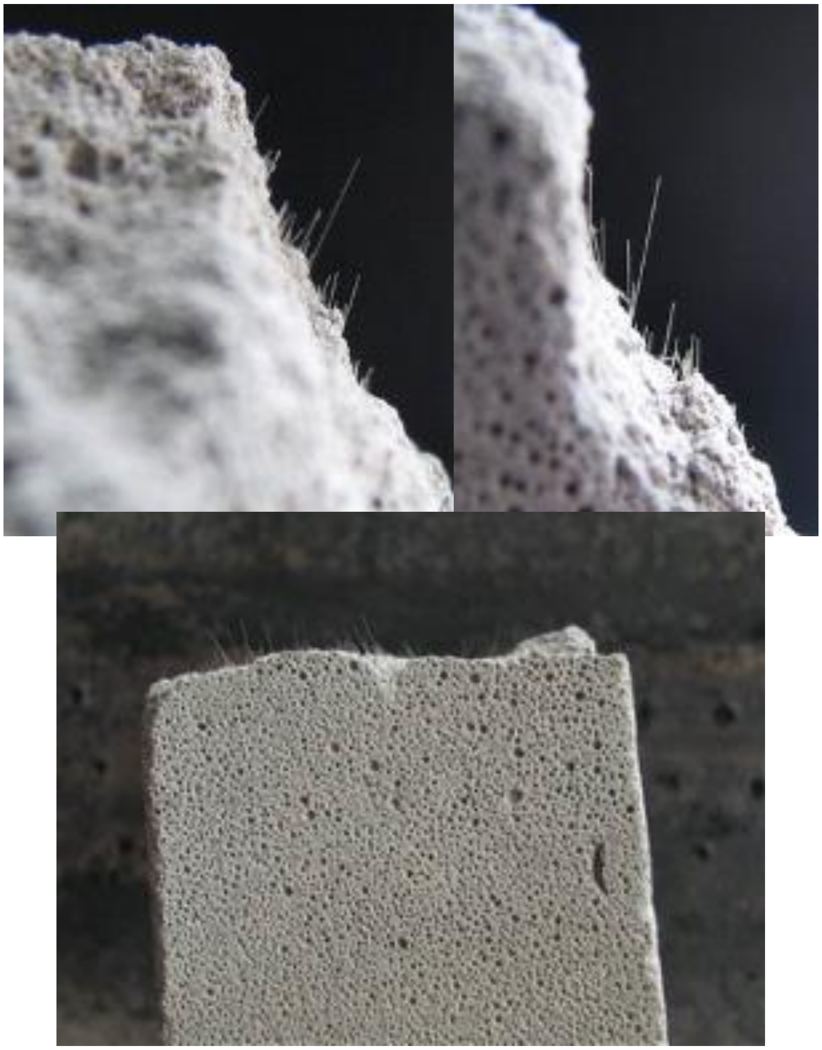
Rock Mine	Diameter, micron	Ultimate tensile strength, MPa	Dynamic m elasticity,
Basalt, Ivanovo-Dolinskoye	15.3	1700	9x10
	30	1000	7x10
Andesite-basalt, Podgornyanskoe	17.0	1500	8.5x1

Table 3: Chemical stability ofcontinuous fibers

Agressive media	Basalt, Ivanovo-Dolinskoye, d=15.3 micron	Andesite-basalt, Podgornyanskoe, micron
H2O Stability, %	96.2	99.0
0.5 N NaOH Stability, %	96.7	84.4
2N NaOH, Stabilty %	81.3	77.3
2N HCl	76.1	82.5

The test results of fiber segments with a diameter of 30-60 mm and a length of 5 to 15 mm. Fiber content in the concrete of 0.2%.

1. Distribution in the concrete mix - even without the additional time;
2. Compressive strength after 10 days of above 10% in comparison with samples without fibers;
3. Flexural strength after 10 days of above 80% in comparison with samples without fiber.



It is also one of the promising directions of chopped basalt fiber is its use as a reinforcing additive in bituminous mastics. The main bituminous mastics, adhesives, sealants and fillers is a homogeneous mass of petroleum products, dust or fibrous fillers (limestone, dolomite, quartz powder, talc, mineral fiber), antiseptics and a variety of additives, in particular gum. Fillers can reduce the consumption of bitumen and its fragility, increase the heat resistance. Additives can be used for plasticizing wax, enhance hardiness, freezing temperature.

Basalt fibers as a filler can improve the mechanical properties of mastics, prevent the formation of cracks in the coating in the cold, reduce the flow of mastic under the action of heat. The fibers do not stretch nearly the pores on the surface of the fibers are filled, thereby creating reinforcement coating. Basalt rock is alkaline on the classification of chasing rocks, so you must use for the production of mastic is preferred anionic bitumen emulsion. In the application of a specially introduced surface-active agents (surfactants) should be borne in mind that some bitumens are carriers of oxygen, sulfur and nitrogen compounds, which act as surfactants. Because the bitumen is present predominantly anionic surfactant type hemsorbtsionnye processes are possible only on the surface of mineral materials containing oxides of alkaline earth and heavy metals. On the surface of mineral materials as acidic species adsorption is usually physical. The positive surface charge of basic rocks of mineral materials favors the adsorption of anionic surfactants, but it is not always positively charged.

Adsorption processes and molecular-surface phenomena related to the adsorption of surfactant, change the structure of the boundary layers of bitumen and affect the properties of bituminous mixtures. The introduction of surfactant can improve the adhesion of bitumen to mineral components, to improve their technological properties. What gives the background to enhance the durability of bituminous coatings, based on basalt fiber.

The production of roofing mastics using basalt fibers little practiced in the absence of the latter in the construction market. But recently, the production of fibers was intensively developed, which makes it reliable for their wider use.

Thus, the material can be used in the manufacture of composite material for use in civil, hydraulic engineering and road transport construction, the manufacture of light frame and decorative panels, as well as defensive backs in the construction of nuclear power plants.

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