Hyper plasticizers and basalt fibers as the resistance of concrete that can be affected by vegetable oils

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Abstract. With the development of the agro-industrial complex and the construction of enterprises for processing oleaginous crops, the issue of protecting construction structures from the effects of oil arises. The negative effect of the oils on concrete and reinforced concrete leads to the reduction of reliability and durability of constructions in general, and to different accidents or unscheduled repairs at processing enterprises. In the experimental study of the effective ways to increase the durability of concrete and concrete structures due to the use of modern plasticizing additives, basalt fiber and finely dispersed fillers has been determined. The obtained results of the research can be used in the design of reinforced concrete structures operated with the growth of vegetable or mineral oils, as well as for practical purposes when carrying out a technical survey at industrial plants where vegetable or mineral oil is produced. Basalt fiber reinforced concrete (BFRC) is suggested to be a solution to the effect of oil on concrete. The properties and characteristics of basalt fibers give the fiber advantages when compared to other ways to curing or solving the effects of oil on concrete.

Keywords: basalt fiber, basalt reinforced concrete, vegetable oil, permeability, oil resistance

1. Introduction

1.1. General review

Prevention of accidents and emergencies are one of the most important scientific and technical purposes of design, construction and operation of industrial buildings. At industrial engineering enterprises, metal-working, power, machine tools oil-containing liquids are widely used: mineral oils, oil emulsions, kerosene oil, fuel oil which get on foundations under equipment, on load-bearing structures, and gradually impregnate them. All these kinds of oil also impregnate reinforced concrete tanks, railway sleepers, span structures of bridges, and many other structures.

Oil has negative impact on the strength and reformative properties of impregnated concrete and reinforced concrete elements of building constructions. This decreases the compressive strength of concrete, adhesion to reinforcement deteriorates; all this causes the occurrence of destructive processes in load-bearing concrete and reinforced concrete structures of industrial buildings and destructions of varying degrees of severity [1].

The use of some admixtures and reinforcement materials help in fighting the degradation caused by oil on concrete. Considering the use of hyper-plasticizers and basalt fiber in concrete which have excellent properties as quality materials and admixtures for not only fighting oil effect on concrete but increase the strength of concrete [2, 3].

Basalt fiber reinforced concrete has the capacities to withstand so many environmental factors including the ability to resist corrosion, chemical destructions, and absorption of oil into concrete that will prevent the impregnation of concrete [3].

The purpose of this research is to determine the effectiveness and ways of increasing the durability of concrete by use of hyper-plasticizers on a polycarboxylate basis. Experimenting by checking different variants of hyper-plasticizers and suggesting ways the use of basalt fiber in concrete and the
use of basalt mesh as confinement on the walls and floors can increase the strength of oil affected concrete.

1.2. Analysis of the stated issue
The durability of concrete and reinforced concrete products mean the ability to maintain operational characteristics under the influence of aggressive factors. In this case the most important physical and mechanical indicators are water resistance and cold resistance. The pores size plays an important role and more attention given to the size and quantity of capillary pores [4].

To reduce the permeability of concrete, special binding materials to increase concrete density are used in constructions, and special coatings based on hydrophobization composites are applied [5].

One of the widely used ways to increase concrete resistance is the use of special modifying agents or the additional screed on the surface with basalt reinforced concrete or confinement with basalt grid/mesh. The chopped basalt fiber (mineral fiber) is good fiber due to its excellent properties as potential reinforcement of composite materials [6]. This way is more effective than previous ones. The use of complex additives helps to increase the mobility while maintaining or reducing the water-binding ratio of which leads to the improvement of concrete stone density.

According to author [7], according to Concrete and Reinforced Concrete Research Institute of Moscow “out of the total amount of reinforced constructions about 25% is exploited in aggressive environment. While 25% out was exploited in weakly aggressive environment, in which their secondary corrosion protection is not provided, as a rule. That is why constructions should be designed and manufactured to provide their durability by means of self-endurance”.

The use of concrete mixture with fine dispersed additives and hyper-plasticizers helps to increase strength characteristics of concrete with a decrease in its porosity. The water-binding ratio must not be less than 0.4. The positive effect of plasticizing additives is in a high water-reducing and dispersing effect – the reduction of the necessary amount of mixing water and more even distribution of individual particles of binder and micro filler. Dispersion helps to exclude clumping of particles and evenly distributes the centers of crystallization throughout the volume of the cement stone. However, we should take into account that when the maximum possible concentration of micro fillers is reached, the strength characteristics sharply decrease due to the deterioration of the bond between the cement stone and the aggregate [8].

A study on the effect of Kerosene, gas oil and crude oil on the compressive and tensile strength for ordinary strength concrete and high performance concrete at 30, 60, 90 and 120 days exposure after 28 days normal water curing was done in [9]. The test results showed that the loss in compressive strength and splitting tensile strength resulting from exposure to oil was relatively smaller for high performance concrete compared to normal strength concrete and the difference about 10%. They also found that the reduction in the compressive strength increases with the decrease in viscosity of oil. The decrease in compressive strength was 25, 19 and 15% for normal concrete and 12, 8 and 6% for high performance concrete exposed to kerosene, gas oil and crude respectively after 120 days of exposure.

An investigation conducted by authors on the experiment about the bonding properties of basalt fiber with cementitious material as well as the effect of fiber orientation on the tensile strength of basalt fiber for evaluating basalt fiber’s suitability as a reinforcing fiber. In the experiments, the authors performed single fiber pullout test and tensile strength of fiber measured according to fiber orientation. Their test results showed that basalt fiber has a strong chemical bond with the cementitious matrix, 1.88 times higher than that of polyvinyl alcohol fibers with it. Theoretical fiber-bridging curves showed that the basalt fiber reinforcing system has a higher cracking strength than the polyvinyl alcohol fiber reinforcing system, but the reinforcing system showed softening behavior after cracking [10].

In the research paper [11, 12], the authors presented the results of studies of the effect of petroleum products in the impregnation of concrete and its deformation properties. The results they obtained from their experiment allow assessing changes in deformation characteristics of load-bearing concrete and reinforced concrete of industrial buildings.
Petroleum products, impregnating in concrete and reinforced concrete structures, have a negative impact on their strength and deformation characteristics. The negative impact of petroleum products on concrete and reinforced concrete is associated with changes in the hydration process of cement, as well as changes in the structure of the concrete. Strength and deformation characteristics of concrete change due to hydraulic pressure of petroleum products in the pores exerted on the skeleton of cement stone. In this aspect, the crucial point is the porosity of concrete as a permeability factor for petroleum products [13].

One of the most important factors affecting the physical and mechanical characteristics of oil-impregnated concrete is their viscosity [14].

Basalt fiber used in fiber reinforced polymers FRPs and structural composites has high potential and is expected to grow at a significant rate due to its high temperature resistance, abrasion resistance, ultraviolet resistance and high-energy electromagnetic radiation. Basalt fibers are ideally suited for demanding applications requiring high temperatures, chemical resistance, durability, mechanical strength and low water absorption [15-17]. Such structures combine the best properties of each component to possess enhanced mechanical & superconducting properties for advanced applications.

From some of the above stated characteristics and properties of basalt fibers, it is suggestible that in industries or areas where vegetable oil is produced or highly used, basalt fiber concrete is needed. This will contribute to the solving the damages or cure the negative effect of vegetable oil on concrete.

1.3 Problem statement
This paper has a task on the efficiency of increasing the density of concrete to improve the resistance to the effect of vegetable oils on concrete using hyper-plasticizers on a polycarboxylate basis and the use of basalt fiber.

2. Method of experimental research
The research is based on, analysis, generalization and evaluation of experimental data on the effect of vegetable oil on the physical and mechanical properties of concrete.

The optimum concentration of mineral additives was experimental selected in order to maintain the basalt fiber cement stone strength characteristics at the first stage of this study.

After optimization of the mineral additive concentration, a choice of a hyper-plasticizer took place, which significantly reduces the water requirement of the concrete mix. The effect of the plasticizing additive was evaluated by the diameter of the spreading of the standard cone (Hagermann cone), while there should be no water separation of the mixture. The optimum concentration of plasticizer is 0.3% of the cement mass, with W/C = 0.3.

Absorption of oil samples is determined by the procedure of GOST 12730.5-84 [18], which replaces the water with vegetable (sunflower) oil. The saturation of the samples with oil occurred when the samples were completely immersed oil (the oil level was about 50 mm higher than the samples) at room temperature.

Saturation was assessed by weighing the samples (every 24 hours) until the difference between two consecutive weighs was equal to 0.1%. At the same time, the mass of oil that leaked from the sample was included in the sample mass. The parameters of the basalt fiber used: length 20mm and diameter 1.5µm

2.1 Manufacture and storage of samples
The concrete mixer used in the preparation of fine-grained basalt fiber concrete is BL-10. In the 3PK70.7 forms was placed resulting mixture. Concrete mix was compacted using vibrating table VM-6.4. The samples hardening and the set of strength of the samples were carried out in a chamber of normal hardening. At the end of the period of normal hardening, control samples placed in containers filled with vegetable (sunflower) oil. In accordance with the research plan, after a certain amount of time, the density control checks were done. For each composition, six control samples-cubes with a rib size of 7 cm were made. The values of oil saturation were determined from the series of three samples.
2.2 Study of the influence of vegetable oil on physico-mechanical properties of impregnated concrete

During the work, the compositions of fine-grained basalt fiber cement concrete with the following plasticizing additives were examined (Table 1):

| №  | Name of plasticizer | Manufacturer country | Appearance | Basis of plasticizer |
|----|---------------------|----------------------|------------|----------------------|
| 1  | С-3                 | Russia               | Powder of light brown color | Polynaphthalene-sodium methylene sulphonate |
| 2  | Sika® ViskoCrete®-20 HE | Switzerland         | Yellowish liquid, density 1.085kg/l | Aqueous solution of modified polycarboxylate |
| 3  | Sika® ViskoCrete®-5 Neu | Switzerland       | Unclear colorless liquid, density 1.084 kg/l | Aqueous solution of modified polycarboxylate |

As a binder, Portland cement M400 PC D20 Volsky was used while, as a finely dispersed additive; limestone flour grade A was used in accordance with GOST 14050-93 in the amount of 10% of the mass of the cement, 0.45% basalt fiber (BF) was added in the mixture. The content of the additive in the control compositions is given in table 2.

| №  | Content of additive, % of cement + BF mass | Average density, kg / m³ | Cement-water ratio |
|----|------------------------------------------|--------------------------|--------------------|
|    | C-3 | Sika 20HE | Sika 5Neu |                |                   |
| 1  | -   | -          | -          | 2180             | 0,45              |
| 2  | 0,8 | -          | -          | 2340             | 0,32              |
| 3  | 1,0 | -          | -          | 2350             | 0,31              |
| 4  | -   | 0,8        | -          | 2370             | 0,31              |
| 5  | -   | 1,0        | -          | 2370             | 0,31              |
| 6  | 0,8 |            |            | 2260             | 0,37              |

3. Results

Figure 1 shows the tests results for the saturation of samples of fine-grained basalt fiber concrete. Analysis of the data obtained shows that the application of plasticizing additives has a significant effect on the compaction of concrete (more than 8% in comparison with the control composition).

Dynamics of the increase in the density of the samples under study is regular with a decrease in the water-cement ratio, and consequently, the magnitude of the water-reducing effect of plasticizing additives.

Analysis of the curves shows that when using compacting additives in a concrete mixture, its oil conductivity reduces significantly. The introduction of an additive of plasticizers based on polycarboxylates in the amount of 1% of the weight of cement leads to a decrease in oil conductivity by an average of more than 3 times, and when a superplasticizer C-3 is introduced at a dosage of 0.8%, the oil conductivity decreases on average by 30% compared to concrete without additives.

Figure 2 shows the results of electron microscopy on TESCAN VEGA 3 equipment saturated with vegetable oil control samples of fine-grained basalt fiber concrete. The structure of oil-saturated concrete of increased density (with the use of a hyper plasticizing additive) is distinguished by smaller new growths, destruction along the interface of filler-cement stone phases and a smaller amount of impregnated vegetable oil.
Figure 1. Saturation of vegetable oil samples of fine-grained basalt fiber concrete, depending on the composition.

Figure 2. Microphotographs of the structure of concrete saturated with vegetable oil.

An analysis of the results of an experimental study shows that an increase in the density of concrete due to the introduction of modern plasticizing additives into its composition is an effective method of preventing oil permeability.

4. Conclusion
It is advisable to protect concrete from the negative effects of vegetable oils during the design phase of the composition. Hyper plasticizing, basalt fiber and finely dispersed additives make it possible to increase the resistance of concrete to oil permeability by more than 3 times.

In the designing of reinforced concrete structures operated with the influence of vegetable or mineral oils, the results obtained from the research are used, as well as for practical purposes when carrying out a technical inspection at industrial facilities where the production of vegetable or mineral oil are done.

The use of basalt fiber in concrete will be of great advantage to concrete industrial users. With the characteristics of basalt fiber, it is of sure and certainty that basalt fiber is a solution to the negative effect of oil on concrete.
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