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INFLUENCE OF WAYS OF MICROFIBER INTRODUCTION ON THE PROPERTIES OF FRESH AND HARDENED CONCRETE

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ABSTRACT

The technology of disperse reinforcement with polyolefin microfiber to obtain high-strength concrete using experimental data and the method of comparison is considered in the paper. It is shown that the optimal demand of microfiber depends on the ways of microfiber introduction as well as on the cement matrix type. Also the ways of microfiber introduction can affect the concrete macrostructure and the properties of hardened concrete. The dependence of the tensile strength of concrete in bending on the maximum demand of microfiber for three different ways of microfiber introduction was stated. The maximum volume of microfiber to increase the properties of concrete was set for the three studied methods of introducing microfiber.

Key words: concrete; microfiber reinforcement; microfiber; ways of microfiber introduction; tensile strength in bending

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1. INTRODUCTION

The requirement for high-quality concrete which is a structural material is not only the high strength. As a rule the fresh concrete mixtures for high-quality concrete have high workability and the hardened concrete has high technical properties at low Portland cement demand per 1 MPa of strength [1-4]. The achievement of such indicators is possible due to the use of modern superplasticizers [5, 6], dispersed reinforcement [7-10], the use of mineral additives of natural and man-made origin with the fineness exceeding the Portland cement fineness [11-14] or technogenic aggregates [15].

A large number of new types of concrete: self-compacting, high-strength, fiber-reinforced, lightweight, architectural concrete, etc. is developed in recent years [2, 3, 6, 8, 16]. The compositions of these concretes are developed within the framework of the concept of high-quality concrete, i.e. one of the criteria for evaluating concrete is the low specific demand of

Portland cement per 1 MPa of strength [16-18]. Portland cement quantity per 1 m^3 of concrete is usually stated for traditional cement concrete. As a rule the improvement of technical properties of high-quality concrete including strength is not obtained by increasing the Portland cement quantity [16]. One of the ways to improve the technical properties of high-quality concrete is the technology of disperse reinforcement with microfiber. This helps to change the structure of concrete at different levels: macro-level and micro-level.

2. PROBLEM STATEMENT AND RESEARCH METHODS

The way of microfiber introduction can affect the concrete structure at different levels and accordingly concrete properties. An increase of the microfiber demand and uniform distribution of microfibers without the formation of lumps will contribute to the significant increase of the tensile strength of concrete [2, 8]. These activities should be carried out at the stages of material selection, preparation and laying of fresh concrete.

The aim of the paper is to study the ways of introduction microfiber and the types of cement matrix on microfiber demand and distribution of fibres in the concrete structure.

The way of introduction of polyolefin microfiber was investigated using the mixer "Digi Mortar Mixer". Three ways of introduction of microfiber were chosen. According to the first method microfiber was introduced into dry components, then all dry components were mixed in dry form for 0.5 min., then the mixing water with the total amount of superplasticizer was introduced. According to the second method the mixing water with superplasticizer was added into dry components, then microfiber was introduced into fresh concrete. According to the third method, the mixing water in the amount of 70% of the total mass of water was added into the dry components, then microfiber was added, then the mixing water in the amount of 30% with the superplasticizer was added.

3. DISCUSSION OF RESULTS

Determination of the optimal quantity of microfiber is an important task in the development of high-quality concrete. It is clear that the tensile strength of concrete will increase with increasing of microfiber amount, however, a large amount of microfiber leads to its poor distribution in the concrete structure and the significant decrease of the workability of fresh concrete and strength characteristics. According to this it can be assumed that the optimal amount of microfiber above which microfibers will be distributed non-uniformly corresponds to each way of microfiber introduction.

Determination of the optimal quantity of microfiber taking into account the way of introduction of microfiber and its distribution in the cement matrix can be proposed in the design of the composition of high-quality concrete. The essence of this determination is to find the optimal percentage of dispersed reinforcement experimentally at which the high values of strength properties will be provided. It is known that microfiber slightly effects the strength characteristics at low demand. Increased tensile strength is observed at higher demand of microfiber.

The fresh mortar with water-to-cement ratio corresponding to the water-to-cement ratio of concrete can be selected as the initial mixture for the experimental determination of the optimal quantity of microfiber. The minimum percentage of concrete reinforcement with microfiber is determined using such mixture.

Samples without microfiber and with microfiber using three ways of microfiber introduction were manufactured. The graph of dependence of "the tensile strength in bending and the volume of microfiber or the percentage of reinforcement" was built using the results of

tests of samples-beams. The position of the point which corresponds to the value of the optimal percentage of reinforcement was determined from the graph. The maximum increase of the tensile strength was observed at values that correspond to the optimal percentage of reinforcement. The mixtures with the water-to-cement ratio equal to 0.3 were selected in this experiment. The workability of the mixture was regulated by a superplasticizer.

Dependences "the tensile strength in bending and the volume of microfiber or the percentage of reinforcement" for different ways of microfiber introduction are shown in Figure 1. The position of the point which corresponds to the optimal percentage of reinforcement can be determined from the graph. The significant increase of tensile strength in bending is observed at values corresponding to the optimal percentage of reinforcement that for the fresh mortar with the water-to-cement ratio equal to 0.3 were 0.31%; 0.57% and 0.42% for the 1st, 2nd and 3rd ways of microfiber introduction, accordingly.

There is the minimum volume of microfiber corresponding to the significant increase of tensile strength in bending for each way of fibers introduction as one can see in Figure 1. The increase of tensile strength is insignificant or practically absent with the increase of this minimum volume of microfiber. This can be explained by the uneven distribution of microfiber and the formation of lumps at the level of macrostructure.

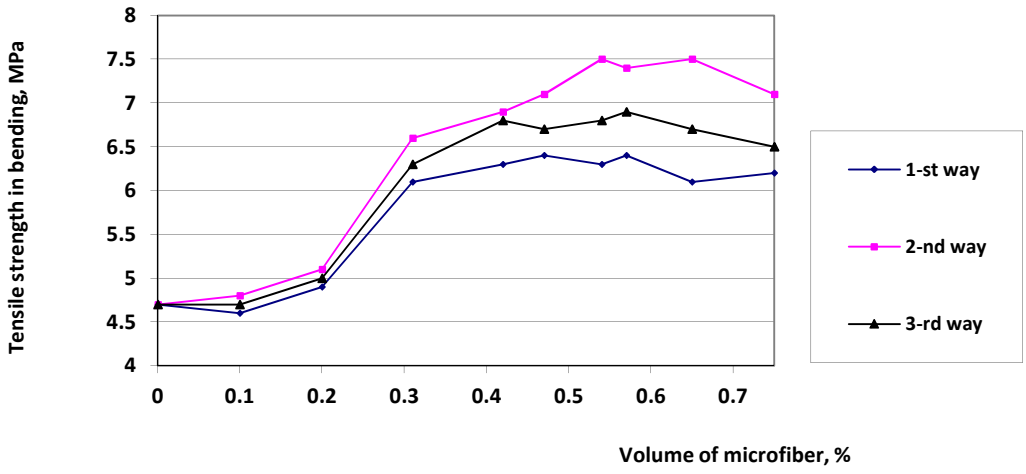

Figure 1. Dependence of tensile strength in bending on the volume of microfiber in different ways of microfiber introduction

Study of the effect of rheologically active matrix on the optimal quantity of microfiber for the selected three ways of its introduction was the next stage of the research. Rheologically active matrices were studied by many researchers [4-6]. It can be assumed that rheologically active matrices will improve the uniform distribution of microfiber in the concrete structure. Rheologically active matrix which was stated in paper [4] with the ratio of Portland cement: ground quartz sand = 1:0.05 as well as the polycarboxylate-based superplasticizer in an amount of 0.8% of the powder mass were chosen for the study.

The dependences of "tensile strength in bending – volume of microfiber" are presented in Figure 2 for different ways of microfiber introduction into the rheologically active matrix. The position of the point which corresponds to the optimal percentage of reinforcement is determined from the graph. There is optimal volume of microfiber for each method of fiber introduction corresponding to the significant increase of tensile strength in bending.

The significant increase of tensile strength in bending is observed at values corresponding to the optimal percentage of reinforcement 0.31%; 0.57% and 0.42% for the 1st, 2nd and 3rd

method of microfiber introduction into rheologically active matrix with the water-to-cement ratio equal to 0.3%. This data is similar to the data for a typical matrix on Portland cement as shown in Figure 1. However, the values of tensile strength in bending of rheologically active matrix became higher comparing the usual matrix on Portland cement. This increase of the tensile strength one can explain by the uniform distribution of microfiber in the structure of the cement matrix as well as along the direction of action of tensile stresses.

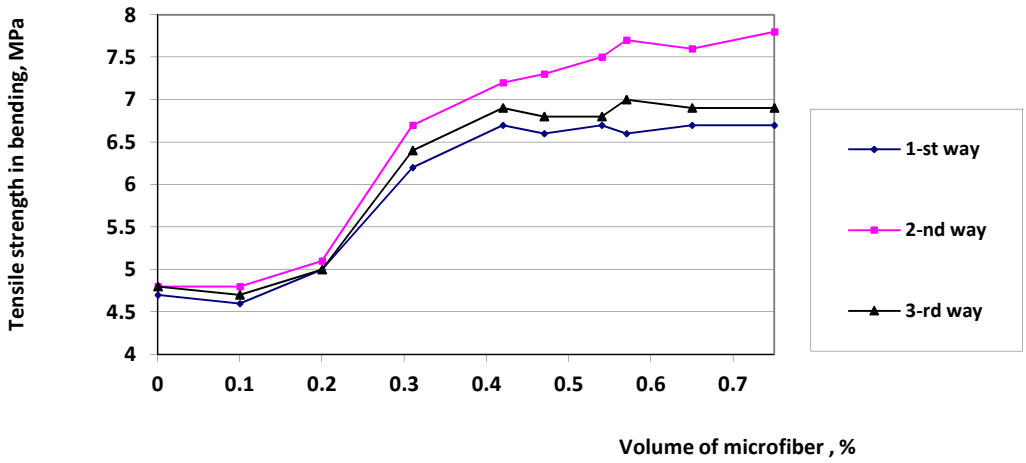

Figure 2. Dependence of tensile strength in bending on the volume of microfiber in different ways of microfiber introduction into rheologically active matrix

Therefore, the increase of the tensile strength of concrete due to the disperse reinforcement of microfiber depends largely on the uniform distribution of microfiber in the structure of the cement matrix as well as along the direction of action of tensile stresses. The bond strength of microfiber and cement matrix determines the nature of the destruction of fiber-reinforced concrete. Cement matrices have destroyed at all studied percentage of microfiber reinforcement. Then the destruction has occurred as a result of pulling the microfiber from the cement matrix or breaking the microfiber.

4. CONCLUSION

The technology of disperse reinforcement with polyolefin microfiber to increase the tensile strength in bending using experimental data and the method of comparison is considered in the paper. It is shown that the optimal volume of microfiber depends on the ways of microfiber introduction as well as on the cement matrix type. Three ways of microfiber introduction were studied in the paper. According to the first method microfiber was introduced into dry components, then all dry components were mixed in dry form for 0.5 min., then the mixing water with the total amount of superplasticizer was introduced. According to the second method the mixing water with superplasticizer was added into dry components, then microfiber was introduced into fresh concrete. According to the third method, the mixing water in the amount of 70% of the total mass of water was added into the dry components, then microfiber was added, then the mixing water in the amount of 30% with the superplasticizer was added.

The significant increase of tensile strength in bending was observed at values corresponding to the optimal percentage of reinforcement 0.31%; 0.57% and 0.42% for the 1st, 2nd and 3rd method of microfiber introduction into rheologically active matrix with the water-to-cement ratio equal to 0.3%. This data was similar to the data for a typical matrix on Portland

cement. However, the values of tensile strength in bending of rheologically active matrix became higher comparing the usual matrix on Portland cement.

Studies of ways of microfiber introduction into rheologically active matrices can be proposed for further investigations.

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