



STUDY OF THE TENSILE STRENGTH OF MODIFIED FIBER-REINFORCED CONCRETES DURING BENDING

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Abstract. The current research work is devoted to the study of the tensile strength of fiber concretes modified with organic-mineral additives during bending. It is known that plastic waste pollutes the environment and disrupts the ecological balance. For this reason, in this study, carbonated and still beverage containers were used as fiber after undergoing a certain technological process. According to the normative documents in force in our country, in particular, the requirements of CII 52-101-2003, the tensile strength limit for ordinary heavy concretes is accepted at the level of $R_t=1.55$ MPa. The results of the conducted experimental studies show that the tensile strength limit in fiber concrete samples reinforced with modified polypropylene fibers increased by 54.84% compared to the normative indicator. At the same time, this increase in fiber concrete samples with modified polyethylene terephthalate fibers was 49.03%. The obtained results show that fiber modification has a significant positive effect on the tensile strength of concrete and is an effective method for increasing structural stability.

Keywords: *polypropylene fibers, fiber concrete containing polyethylene terephthalate, tensile strength, durable concrete, sustainable development, industrial waste*

1. INTRODUCTION

As is known, the emergence of fiber concrete is associated with the scientific activities of the Russian scientist V.P. Nekrasov. He first put forward the idea of obtaining fiber concrete in 1907, and in 1909 received the world's first patent for a reinforced concrete structure reinforced with steel fibers. Later, starting from the 60s of the 20th century, fiber concrete became an object of extensive research by researchers from the USA, Great Britain, Canada and other countries. Currently, concrete reinforced with various types of fibers, that is, fiber concrete, is considered a new generation, high-quality type of concrete. In modern times, by reinforcing concrete and construction mortars with various fibers, it is possible to improve their physical, mechanical and operational characteristics, as well as increase their durability. Fiber concrete is considered one of the most promising materials of the 21st century [1].

2. LITERATURE REVIEW AND PROBLEM STATEMENT

This research aims to develop a sustainable artificial stone material from limestone dust waste through optimization of granulometric composition, binder ratio and use of hyper

plasticizers [2,10-12]. Such research is considered an important area of sustainable development of building materials, as it is aimed at utilizing industrial waste and reducing the resource intensity of cement production. The possibility of producing fiber-reinforced concrete with high deformation properties by regulating the microstructure and using it in the design of transport structures was considered. It was found that to create high-performance transport structures, it is necessary to modify fiber mixtures with complex additives, ie increase the strength of fiber-reinforced concrete at the micro-level. To obtain a denser structure of the concrete matrix, complex additives were used—ultrafine additive (silica fume) and Master Air 200 B air-entraining additive. It was experimentally proved that using such additives reduces the water-cement ratio and further strengthens the concrete matrix structure [3].

This article discusses the development of modified fiber-reinforced concrete formulations using finely ground mineral additives containing SiO₂ and hyperplasticizers. A comparative analysis of the properties of conventional concrete and its modifications is provided [4].

It should be noted that the use of mineral additives, partially replacing cement, is of particular importance in the context of high volumes of global cement production, accompanied by significant energy costs and greenhouse gas emissions. In the presented paper, concrete resistance to friction was studied. B25 class heavy concrete was selected as an experimental object. Polypropylene and metal fibers were used to increase friction resistance of the selected concrete. The test was carried out on the LKI-3M friction device in accordance with the requirements of GOST 13087. Based on the test results, it was found that the resistance of the polypropylene fiber concrete to the anti-friction resistance of 0.28 g/cm², whereas in the case of metal fiber concrete, this indicator was 0.30 gr/cm² was. Test results were compared with 112.5% of polypropylene fiber concrete, and 6.25% higher resistance to concrete fibrous concrete compared to B25 grade concrete samples. Based on the results of the experiment it is possible to say that is more effective the application of fiber concrete in the construction of road surfaces [5].

The crack resistance of fiber-reinforced concrete with and without additives was determined. Based on the test results, it was found that crack resistance was higher for concrete samples containing polypropylene and metal fibers than for standard concrete.

Fiber-reinforced concrete using microsilica has shown improved performance. The effectiveness of using such concrete in road pavement construction has been established [6].

Improving the crack resistance and durability of concrete pavements is considered an important factor in the sustainable development of transport infrastructure, allowing for a reduction in repair and maintenance costs.

In the presented paper, concrete resistance to friction was studied. B25 class heavy concrete was selected as an experimental subject. Polypropylene and metal fibers were used to increase the friction resistance of the selected concrete [7].

Efficiency in the construction, reconstruction, and repair of transport structures can be achieved by using fiber-reinforced concrete with high deformation properties. This article examines the possibility of using complex additives to optimize the composition of fiber-reinforced concrete with high deformation properties. It was found that the use of chemical and ultrafine additives in fiber-reinforced concrete significantly increases compressive and flexural strength. This is due to the fact that the use of steel fibers allows for uniform reinforcement of the concrete throughout the entire volume, which favorably affects the distribution of stresses in the concrete mass and leads to a reduction in stresses in hazardous areas [8].

3. RESEARCH MATERIALS AND METHODS

In preliminary experiments, fiber concrete compositions were developed using polypropylene and polyethylene terephthalate fibers [9]. In the presented work, samples were

prepared using polypropylene and polyethylene terephthalate fibers according to the selected compositions. The tensile strength of the prepared fiber concretes was studied. For this purpose, fiber concrete samples were prepared, hardened and tested under normal conditions. The tests were carried out in a GRM-2A tensile press at the test site of the S.A.Dadashov Scientific Research and Design Institute of Building Materials.

4. WORK CONDUCT

The samples for testing were prepared according to ISO 10180-90. The cross-section of the samples is given in the figure below (Figure 1).

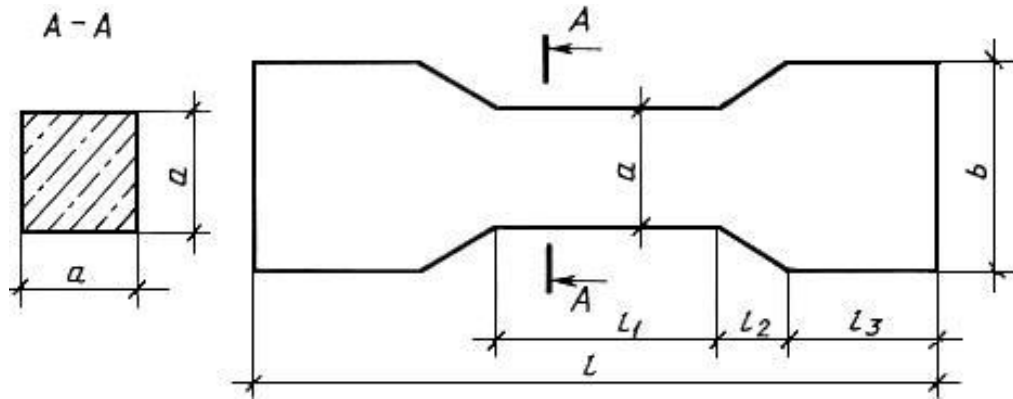


Figure 1. Cross-section of the specimen for tensile testing:
 $a=15\text{ sm}; b=20\text{ sm}; l=60\text{ sm}; l_1=30\text{ sm}; l_2=2\text{ sm}; l_3=13\text{ sm}$

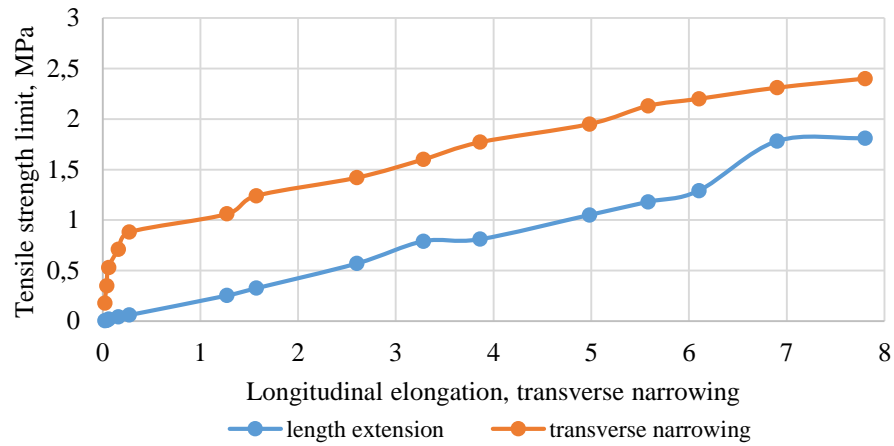
During the test, the tensile force was given at intervals of 4 kN. Electronic strain gauges (gauges) were placed on the test specimen. Through these gauges, the longitudinal (ϵ_1) and transverse (ϵ_2) relative deformations observed in the specimen during the test were recorded. This made it possible to calculate the Poisson ratio.

The tensile test of modified polypropylene fiber reinforced concrete specimens is shown in Table 1, and the dependence graph between tensile force and longitudinal elongation and the dependence graph of tensile strength on longitudinal elongation are shown in Graph 1.

Table 1. Tensile strength test results of modified polypropylene fiber reinforced concrete samples

Tensile force acting, N (kN)	Cross-section, a, mm	Longitudinal elongation, ϵ_1 , mm	Transverse narrowing, ϵ_2 , mm	Puassons ratio, $\mu = \frac{\epsilon_2}{\epsilon_1}$	Tensile strength limit $R_t = \frac{N}{A}$ (MPa)
4	150×150 mm	0.02	0.0024	0.2	0.177
8	150×150 mm	0.04	0.007	0.2	0.35
12	150×150 mm	0.06	0.019	0.212	0.53
16	150×150 mm	0.16	0.04	0.20	0.71
20	150×150 mm	0.27	0,06	0.20	0.88
24	150×150 mm	1.27	0.253	0.215	1.06
28	150×150 mm	1.57	0.325	0.213	1.24
32	150×150 mm	2.6	0.57	0.22	1.42

36	150×150 mm	3.28	0.79	0.22	1.6
40	150×150 mm	3.86	0.81	0.22	1.77
44	150×150 mm	4.98	1.05	0.21	1.95
48	150×150 mm	5.58	1.18	0.211	2.13
50	150×150 mm	6.1	1.29	0.21	2.2
52	150×150 mm	6.9	1.78	0.25	2.31
54	150×150 mm	7.8	1.81	0.23	2.4



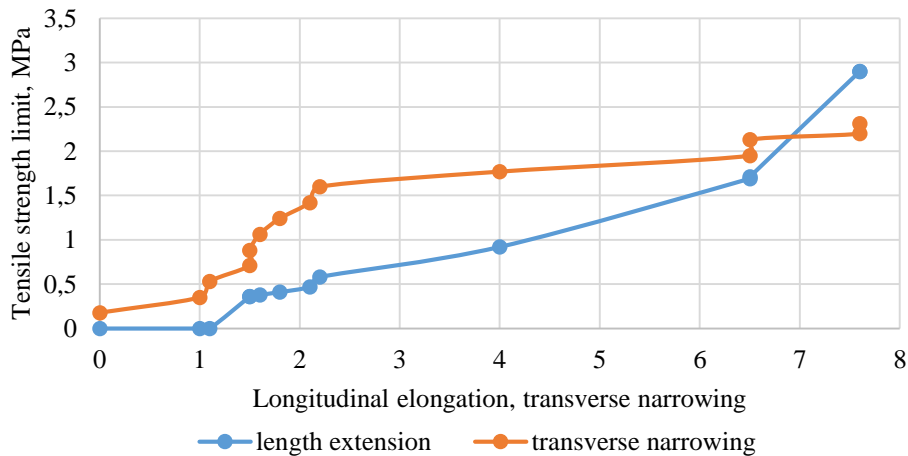
Graph 1. Tensile strength graph of modified polypropylene fiber reinforced concrete samples

The tensile test of modified polyethylene terephthalate fiber-reinforced concrete samples is shown in Table 2, and the dependence graph between tensile force and longitudinal elongation and the dependence graph of tensile strength on longitudinal elongation are shown in Figure 2.

Table 2. Tensile strength test results of modified polyethylene terephthalate fiber reinforced concrete samples

Tensile force acting, N (kN)	Cross-section, a, mm	Longitudinal elongation, ϵ_1 , mm	Transverse narrowing, ϵ_2 , mm	Puassons ratio, $\mu = \frac{\epsilon_2}{\epsilon_1}$	Tensile strength limit $R_t = \frac{N}{A}$ (MPa)
4	150×150 mm	0	0	0	0.177
8	150×150 mm	1.0	0	0	0.35
12	150×150 mm	1.1	0	0	0.53
16	150×150 mm	1.5	0.36	0.24	0.71
20	150×150 mm	1.5	0.36	0.24	0.88
24	150×150 mm	1.6	0.38	0.237	1.06
28	150×150 mm	1.8	0.41	0.227	1.24
32	150×150 mm	2.1	0.47	0.224	1.42

36	150×150 mm	2.2	0.58	0.26	1.6
40	150×150 mm	4.0	0.92	0.23	1.77
44	150×150 mm	6.5	1.69	0.26	1.95
48	150×150 mm	6.5	1.71	0.263	2.13
50	150×150 mm	7.6	2.9	0.38	2.2
52	150×150 mm	7.6	2.9	0.38	2.31



Graph 2. Tensile strength graph of modified polyethylene terephthalate fiber concrete samples

Result: According to the normative documents in force in our country, in particular the requirements of CII 52-101-2003, the tensile strength limit for ordinary heavy concrete is assumed to be $R_t=1.55$ MPa. The results of the conducted experimental studies show that the tensile strength limit in fiber concrete samples reinforced with modified polypropylene fibers increased by 54.84% compared to the normative indicator. At the same time, this increase in fiber concrete samples with modified polyethylene terephthalate fibers was 49.03%. The obtained results show that fiber modification has a significant positive effect on the tensile strength of concrete and is an effective method for increasing structural stability.

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