International Journal on
Technical and Physical Problems of Engineering
(IJTPE)
Published by International Organization of IOTPE

ISSN 2077-3528
IJTPE Journal
www.iotpe.com
ijtpe@iotpe.com

September 2026 | Issue 68 | Volume 18 | Number 3 | Pages 97-104

PERFORMANCE EVALUATION OF FIBER-MODIFIED CONCRETE UNDER DYNAMIC LOADING FOR DURABLE PAVEMENT SYSTEMS

N.M. Ahmadov [1] I.N. Shirinzade [2] E.V. Khalilov [2] A.M. Zhilkibayeva [3]

1. Department of Civil Engineering, Baku Engineering University, Khirdalan, Azerbaijan
niahmadov@beu.edu.az
2. Department of Material Science, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan
irada.shirinzade@azmiu.edu.az, elxanxalilov@yahoo.com
3. International Educational Corporation (Kazakh Leading Architecture and Civil Engineering Academy), Almaty, Kazakhstan, aliya8706@mail.ru

Abstract- The manuscript addresses an important engineering problem related to improving the performance of rigid pavements through fiber-reinforced concrete and microstructural modification. This study presents experimental work on fiber-reinforced concrete with varying fiber content, focusing on deformation characteristics and strength behavior. The methodology includes laboratory testing, microstructural analysis, and basic modeling of elastic properties, which provides a structured experimental framework. Based on the conducted studies, it has been concluded that the use of dispersed fibers to increase the fracture toughness of concrete increases its strength only at the macro level. However, in order to create transport facilities with high operational and technical properties, it is necessary to increase the strength of concrete at the micro level as well. In order to create transport facilities with high operational and technical properties, it is necessary to increase the strength of concrete at the micro level, and the presented work is dedicated to solving this problem.

Keywords: Transport Structures, Concrete, Road Wear, Fiber Concrete, Modulus of Elasticity.

1. INTRODUCTION

One of the primary challenges faced by construction engineers in achieving efficient building practices is minimizing material usage or selecting more economical alternatives, while at the same time improving material quality. Moreover, contemporary State Standards have become increasingly stringent, imposing higher requirements on the strength and durability of materials used in buildings, roads, and bridge structures. This dictates the need for further improvement of materials and structures that require minimal costs, are reliable and durable. As in other sectors of the construction industry, the performance requirements for concrete used in transport infrastructure have become increasingly demanding.

This is due, on the one hand, to the low resistance of cement concrete to the effects of loads to which it is exposed in transport facilities, and, on the other hand, to the increasing aggressive effects of the environment.

It is known that although cement concrete has relatively high compressive strength, its tensile and bending strengths are low. At the same time, concrete in transport facilities is constantly exposed to dynamic loads, frost in winter, and aggressive water in bridges over rivers. Concrete used in such structures must exhibit high density, significant strength, and strong resistance to cracking. It has been demonstrated that incorporating high-modulus fibers is an effective way to improve crack resistance, which is one of the primary weaknesses of conventional concrete.

Therefore, enhancing the crack resistance of concrete becomes a critical concern, and one of the most effective approaches to address this issue is the incorporation of dispersed fibers. This approach markedly enhances the mechanical performance of concrete, including its strength, crack resistance, and ability to withstand impact. As a result, the overall durability of the structure is increased, along with its ability to withstand aggressive environmental conditions. The higher density reduces the penetration and interaction of harmful substances with the concrete matrix, while the uniformly distributed fibers help inhibit the initiation and growth of cracks [10, 11].

In recent years, the use of fiber-reinforced concrete across various types of structures has shown significant progress in overcoming these challenges. However, it is important to recognize that fibers primarily enhance properties such as strength and crack resistance at the macro scale. Within the concrete matrix, considerable voids still exist between coarse aggregates, fine aggregates, and cement particles. Introducing particles that are finer than cement into these gaps can improve the packing density, resulting in a more compact and refined cement concrete structure.

Registered: 260408 | Article Info: 260315 | Accepted: 269824
Reserved: 260611 | Available: 260930

2. EXPERIMENTAL METHODOLOGY AND MATERIAL COMPOSITION

2.1. Purpose of the Research

To achieve transport structures with superior technical and operational performance, it is necessary to enhance fiber-reinforced concrete by incorporating complex additives, particularly to improve its microstructural strength. By optimizing the internal structure, it becomes possible to produce fiber concrete with improved deformation characteristics. The application of such materials in durable road surfaces, along with the development of appropriate design and calculation methods, remains a highly relevant challenge.

Similar to other composites, the performance of fiber concrete is largely controlled by the properties of its individual components. Experimental studies have shown that fine-grained concretes, modified with highly dispersed particles and chemical admixtures, can serve as a strong and effective matrix for fiber-reinforced concrete [3, 4, 5].

2.2. Research Methodology

Physical, mechanical and physicochemical methods of analysis were used in the research work, as well as the SAP 2000V4 program in the report on road clothes with a fiber concrete structure. Physicochemical research methods were used in fluoroscopy, radiography, differential thermal analysis, microprobe and electron microscopy.

2.3. Results

To produce fiber-reinforced concrete with high operational and technical performance and extended service life, it is necessary to ensure the technological compatibility between the steel fibers and the cementitious matrix, as well as to provide protection of the fibers against corrosion within the matrix. For this purpose, microsilica can be utilized; it is an industrial by-product of ferrosilicon production and consists of approximately 90% spherical amorphous SiO_2, which enhances the concrete matrix at the microstructural level.

The densifying effect of microsilica in cement-based concrete is attributed to its ability to occupy the voids between cement and aggregate particles and participate in the formation of new compounds. The particle size of microsilica is up to 100 times smaller than that of cement grains, which enables its fine particles to react with $Ca(OH)_2$, leading to the formation of low-basic calcium hydrosilicates. These reaction products contribute to further densification of the cement matrix, reducing permeability and limiting the penetration of water and other aggressive agents, thereby suppressing long-term reactions between the environment and hydration products. It should also be noted that due to the high fineness of microsilica, its incorporation increases the water demand of the mixture as its content rises. Therefore, improved performance can be achieved through use of plasticizers and air-entraining admixtures, which help reduce water consumption [1, 7, 8].

The mineralogical analysis of concrete matrix samples after 28 days of curing for fiber concrete was performed at the Institute of Geology and Geophysics of the Azerbaijan National Academy of Sciences. The diffractograms of the samples are presented in Figure 1 [7, 8]. The formation of calcium hydrosilicates is clearly visible from the diffractogram. At the same time, it is clear from the nature of the diffractogram that they are calcium hydrosilicates with a crystalline structure. Unhydrated particles of cement minerals are also significant in the samples. An example of this is the braunmullerite mineral and 2 calcium silicate ($2CaO•SiO_2$) in the diffractogram.

At the same time, as we mentioned above, the applied aviation supplement MasterAir 125 (SikaControl-125 AER MA) has a positive effect on the formation of dense stone. These additives decrease the water/cement ratio and contribute to a more compact structure. In addition, they improve the adhesion between cement paste and filler particles in the interfacial contact region.

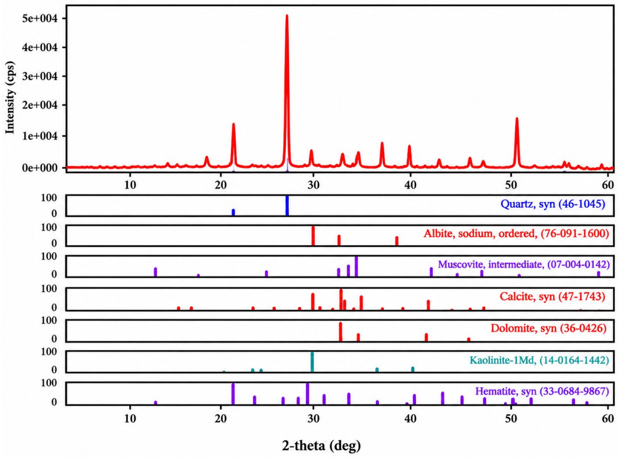
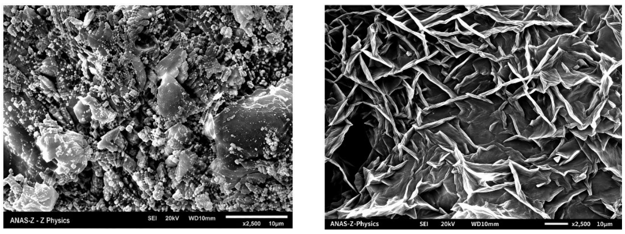


Figure 1. Diffractogram of cement matrix for fiber concrete [8]

2.3.1. Concrete Matrix for Fiber Concrete

Porosity reduction is one of the most effective Various methods are applied to protect cement paste and concrete from corrosion, which leads to a significant improvement in their deformation characteristics. The microstructure of concrete modified with selected additives, as well as fiber-reinforced concrete, was examined using a scanning electron microscope (FEI Quanta 400F, Philips, Netherlands) at the Institute of Geology and Geophysics of the Azerbaijan National Academy of Sciences [1, 7, 8, 9]. The resulting microstructural features of the concrete matrix are illustrated in Figure 2 [7, 8].

As shown in the Figure 2, the concrete microstructure is made up of densely arranged, needle-like crystalline formations. These structures correspond to low-basic calcium hydrosilicates, which are formed due to the reaction between Portland cement and reactive silica. It has been well established that these compounds significantly contribute to the high strength of the cement matrix.



(a) (b)

Figure 2. Microstructure of concrete matrix used in preparation of fiber concrete under an FE-CEM QVANTA 400F electron microscope (microstructure of concrete matrix without microsilica (a) and with microsilica addition (b) [8]

The microstructure of fiber-reinforced concrete was also examined using electron microscopy techniques. At a 700× magnification, the micrographs clearly demonstrate that the fibers are uniformly dispersed throughout the entire volume of the cementitious matrix.

2.3.2. Study of Strength and Deformation Properties of Fiber Concrete

The high deformation properties of concrete used in the construction of road surfaces are of great importance. One of the most important deformation properties of materials used in this type of construction is their elasticity. It is known that in the physical sense, concrete is not considered an elastic material, therefore, the use of the term modulus of elasticity for concrete is not considered correct. Here, the term initial modulus of elasticity, which characterizes the elastic properties of concrete in areas affected by stress, can be used conditionally. Therefore, the modulus of elasticity is defined as the ratio of applied stress to the corresponding elastic (residual) deformation.

$$E = \frac{\sigma}{\varepsilon} \tag{1}$$

The experimental assessment of the elastic modulus of concrete is carried out by measuring its deformation under progressively increasing stress levels. For determining the modulus of elasticity of fiber-reinforced concrete, four specimens with dimensions of 150×150×600 mm were prepared from the designed mixture. The compressive strength (grade strength) was then determined after 28 days of curing under standard conditions.

The deformation was measured using an indicator attached to the tongues of the samples using a metal frame. The loading of the samples (in a hydraulic press) was carried out in stages. The initial loading was 2% of the expected destructive load. The deformation was measured at the moment of loading and 5 minutes after the load was applied.

To determine the strength and deformation properties of concrete, some parameters are determined in the samples under the influence of a minimum load: stress in the samples; deformations; prismatic strength of the samples; modulus of elasticity. 4 samples measuring 150×150×600 mm were prepared for testing in laboratory conditions. Concrete with a compressive strength class of B30 was used in the preparation of the samples.

One of the samples was made of ordinary concrete (without ferromaterial). In the remaining samples, CFB type fiber material was used as follows:
- the amount of fiber material in 1 sample is 20 kg/m^3;
- In 1 sample - 50 kg/m^3;
- In 1 sample - 80 kg/m^3.

As a result of the test, the values of the stress and deformation occurring in the samples at each loading were determined. The results of the study for each sample are given in table 1-5, and the stress-strain diagrams are shown in Figures 1-4 [12].

Table 1. Test results of sample No. 1-1 (without fiber material) [12]

No	Acting load, kN	Indicator No. I readings	Indicator No. II readings	Average readings of indicators	σ, MPa	εx10^3 mm
1	0	0.00	0.00	0.00	0	0
2	100	0.024	0.026	0.025	4.44	0.0001033
3	200	0.066	0.064	0.065	8.89	0.0002803
4	300	0.091	0.089	0.090	13.33	0.0003908
5	400	0.14	0.16	0.150	17.78	0.0004810
6	500	0.18	0.20	0.190	22.22	0.0005882
7	600	0.22	0.21	0.215	26.67	0.0006911
8	700	0.25	0.26	0.255	31.11	0.0008333
9	800	0.33	0.32	0.325	35.56	0.0010154
10	900	0.39	0.40	0.395	40.00	0.0012125
11	1000	0.43	0.44	0.435	44.44	0.0014022
12	1100	0.53	0.52	0.525	48.89	0.0016689
13	1200	0.61	0.60	0.605	53.33	0.0019552
14	1218	0.62	0.63	0.625	54.13	0.0020551

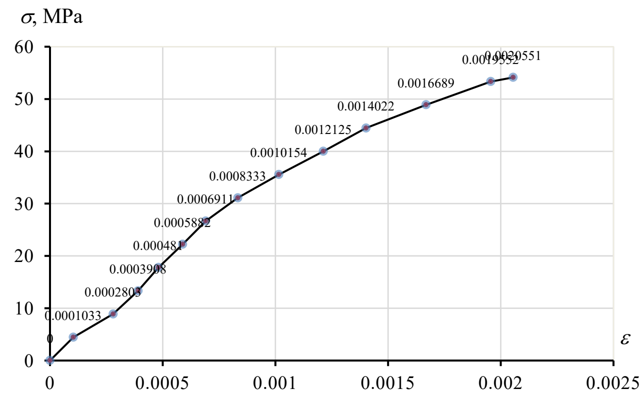


Figure 3. Stress distribution in concrete sample N 1-1 (without fiber material) [12]

Table 2. Test results of sample N 2-1 (fiber material content 20 kg/m^3) [12]

No	Acting load, kN	Indicator No. I readings	Indicator No. II readings	Average readings of indicators	σ, MPa	εx10^3 mm
1	0	0.00	0.00	0.00	0	0
2	100	0.026	0.024	0.025	4.44	0.000095
3	200	0.06	0.06	0.060	8.89	0.000185
4	300	0.099	0.101	0.100	13.33	0.00030
5	400	0.14	0.13	0.135	17.78	0.00046
6	500	0.19	0.15	0.170	22.22	0.00055
7	600	0.22	0.21	0.215	26.67	0.00068
8	700	0.25	0.26	0.255	31.11	0.000855
9	800	0.30	0.33	0.315	35.56	0.001022
10	900	0.40	0.36	0.380	40.00	0.001188
11	1000	0.46	0.44	0.450	44.44	0.001399
12	1100	0.51	0.53	0.520	48.89	0.001621
13	1200	0.61	0.59	0.600	53.33	0.001885
14	1300	0.71	0.72	0.715	57.78	0.002100
15	1380	0.79	0.81	0.800	61.33	0.002334

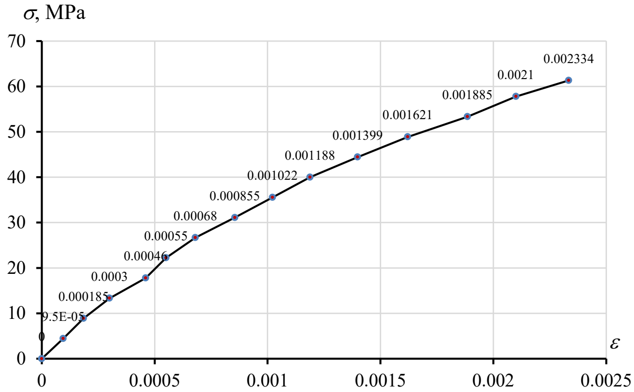


Figure 4. Stress distribution in concrete sample N 2-1 (fiber material content 20 kg/m^3) [12]

Table 3. Test results of sample N 3-1 (fiber material content 50 kg/m^3) [12]

No	Acting load, kN	Indicator No. I readings	Indicator No. II readings	Average readings of indicators	σ, MPa	εx10^3 mm
1	0	0.00	0.00	0.00	0	0
2	100	0.0251	0.0249	0.025	4.44	0.0001
3	200	0.06	0.06	0.060	8.89	0.0002
4	300	0.09	0.09	0.090	13.33	0.00033
5	400	0.14	0.012	0.130	17.78	0.00048
6	500	0.17	0.18	0.175	22.22	0.00058
7	600	0.19	0.21	0.200	26.67	0.00069
8	700	0.26	0.27	0.265	31.11	0.00085
9	800	0.30	0.32	0.310	35.56	0.000988
10	900	0.37	0.38	0.375	40.00	0.001159
11	1000	0.44	0.42	0.430	44.44	0.001327
12	1100	0.52	0.50	0.510	48.89	0.001522
13	1200	0.59	0.57	0.580	53.33	0.001749
14	1300	0.67	0.69	0.680	57.78	0.001983
15	1380	0.74	0.76	0.750	61.33	0.002217

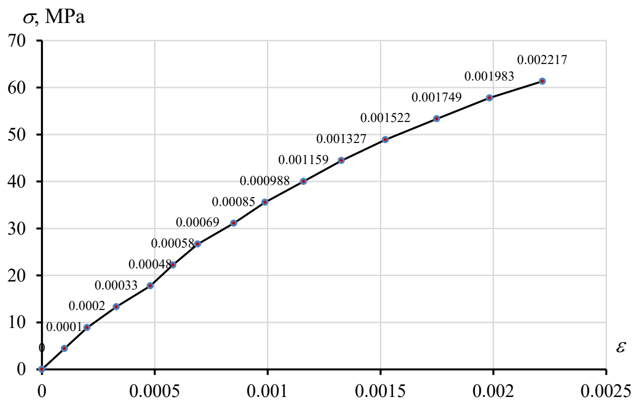


Figure 5. Stress distribution in concrete sample N 3-1 (fiber material content 50 kg/m^3) [12]

Table 4. Test results of sample N 4-1 (fiber material content 80 kg/m^3) [12]

No	Acting load, kN	Indicator No. I readings	Indicator No. II readings	Average readings of indicators	σ, MPa	εx10^3 mm
1	0	0.00	0.00	0.00	0	0
2	100	0.02	0.02	0.020	4.44	0.000091
3	200	0.049	0.051	0.050	8.89	0.000156
4	300	0.091	0.089	0.090	13.33	0.00028
5	400	0.11	0.13	0.120	17.78	0.00035
6	500	0.17	0.15	0.160	22.22	0.00045
7	600	0.21	0.19	0.200	26.67	0.00058
8	700	0.23	0.25	0.240	31.11	0.000711
9	800	0.29	0.27	0.280	35.56	0.000883
10	900	0.34	0.32	0.330	40.00	0.001067
11	1000	0.38	0.40	0.390	44.44	0.001267
12	1100	0.45	0.47	0.460	48.89	0.001482
13	1200	0.52	0.54	0.530	53.33	0.001711
14	1300	0.61	0.59	0.600	57.78	0.001905
15	1400	0.68	0.70	0.690	62.22	0.002201

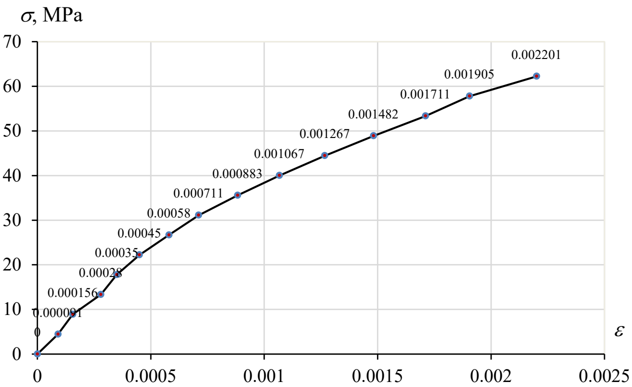


Figure 6. Stress distribution in concrete sample N 4-1 (fiber material content 80 kg/m^3) [12]

The results obtained were analyzed and the prismatic strength and elastic modulus of the samples were determined by calculation. The value of the elastic modulus of fiber concrete, E_{fb}, was determined by Equation (2):

$$E_{fb} = E_b(1-\mu_f) + E_f\mu_f \tag{2}$$

where, E_b is modulus of elasticity of the concrete matrix; μ_f is fiber reinforcement coefficient; and E_f is modulus of elasticity of the fiber material.

The collapse of fiber concrete samples occurs in different ways. In such samples, the formation of cracks is first observed in the outer parts. This is explained by the fact that during the preparation of the samples, the fibrous material is unevenly distributed in the sample and the amount of fiber is less in the corner part of the samples. When the initial crack occurs, a characteristic cracking sound is generated inside the sample. The formation of this cracking sound is explained by the fact that the fibrous material is pulled out of the concrete.

When the loading continues, exceeding the strength limit leads to further opening of cracks, the formation of inclined cracks and the collapse of the samples. Such a collapse pattern is observed in both types of samples, that is, in the content of fibrous material 20 kg/m^3 and 50 kg/m^3. The collapse of samples containing fibrous material 80 kg/m^3 has a different nature. When the destructive load reaches a critical limit, a characteristic cracking sound first appears, then cracks begin to appear in the samples, the corners begin to break off layer by layer, but the sample retains its shape.

Therefore, only the concrete matrix shows resistance to the formation of an initial crack. However, the resistance to the further development of cracks is shown by the fibrous material, and the greater the amount of fibrous material, the greater this resistance will be. The value of the destructive load increases depending on the amount of fibrous material. The tests conducted showed that in samples that collapsed, load did not break fibrous material, but rather, it pulled it out inside concrete.

After testing the samples, the results were analyzed, and their prismatic strength and elastic modulus were determined by calculation. As a result of the analysis of the results obtained, certain conclusions were obtained about the deformation properties of fiber concrete samples. These results showed how the physical and mechanical properties of fiber concrete change.

Table 5 shows the values of the prismatic strength, elastic modulus and ultimate deformation of fiber concrete samples.

Table 5. Indicators of fiber concrete samples according to test results

Naming of samples	Amount of fibrous material, kg/m^3	Breaking load, P_d, kN	Prismatic strength, R_{pr}, MPa	Modulus of elasticity E_b, MPa	Deformation ε_l
N 1-1	0	1218	54.13	35685	0.0020
N 2-1	20	1380	61.33	37474	0.0023
N 3-1	50	1380	61.33	37083	0.0022
N 4-1	80	1400	62.22	41335	0.0022

The obtained results demonstrate that fiber-reinforced concrete specimens have a compressive strength that exceeds that of standard concrete by 9.3%, and an elastic modulus that is 2.7% higher than that of ordinary concrete.

Thus, the resistance to the formation of an initial crack is provided only by the concrete matrix. However, the resistance to the development of cracks is provided by the fiber material, and the value of this resistance increases depending on the amount of fiber material.

3. CALCULATION OF HARD TYPE ROAD SURFACE

When calculating fiber concrete pavement, the composition of the traffic flow, prospective traffic intensity at the end of the service life, soil and climatic conditions are taken into account.

The calculated characteristics of the construction materials used in the structural layers of the road surface are determined in the construction shown below [12].

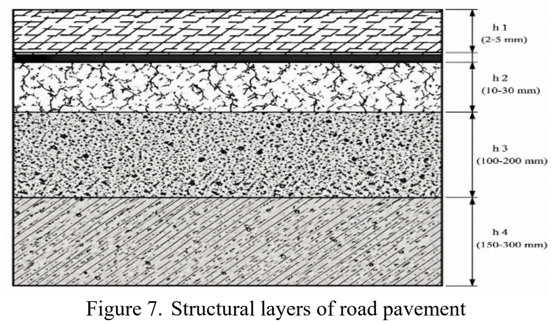


Figure 7. Structural layers of road pavement
$h1$: cover-fiber concrete;
$h2$: leveling layer-sand treated with bitumen;
$h3$: base-fractional crushed stone;
$h4$: additional layer of the base-gravel sand mixture

The report of the steel fiber concrete cover is carried out by checking that the cover provides tensile strength in bending [2, 6]:

$$K_{br}=\frac{R_{br}^{c}}{\sigma_{pt}}\geq K_m=1.0 \tag{3}$$

where, $h=\sqrt{\frac{60\cdot K_c\cdot Q}{B\cdot R_{br}^{c}}(0.25A-R)}$; K_m is the strength coefficient is determined according to table 1 depending on the grade of the road; $R^c{}_{br}$ is the calculated bending resistance of steel fiber concrete; and σ_{pt} is the bending tensile stress arising in the concrete cover due to temperature changes.

Design bending resistance of steel fiber concrete:

$$R^c{}_{br}=B_{btb}\cdot K_{mr}\cdot K_F\cdot K_y \tag{4}$$

where, B_{btb} is tensile class of concrete in bending, $B_{btb}=5.97$ MPa ; and K_{mr} is coefficient of concrete strength acquisition. In natural hardening $K_{mr}=1.0$; K_f is coefficient taking into account freezing and thawing, $K_f=0.95$; and K_y is fatigue coefficient of fiber concrete during repeated loading [6].

$$K_y=1.08\left(\sum N^h\right)^{-0.063} \tag{5}$$

where, N^h is the total number of loads on the road surface during the 25-year service life.

Table 6. The level of reliability of clothing for tough road clothing

Weight of the accounting load, automobile/day	Reliability level K_e	Strength coefficient K_m
more than 1000	0.95	1.00
500-1000	0.90	0.94
less than 500	0.80	0.87

The tensile stress in bending of steel fiber concrete is determined according to one of two calculation schemes that take into account the connection of the slab with the base and the place of application of the load.

The first calculation scheme is used to determine the thickness of the pavements with a soil bed that is guaranteed to be stable and does not have uneven subsidence and bumps. The slab is located on a solid base and has full contact with the base over the entire area. The place of application of the calculated load on the road surface is taken to be the middle of the outer edge of the slab in the longitudinal direction.

The second reporting scheme is used to determine the distance between transverse joints and, in special circumstances, for low-grade roads, where the length is known in advance and where uneven settlement and heaving in the soil bed are expected.

In the first loading scheme, the stresses in the slab are determined by the dependence $\sigma_{pt}(\text{MPa})^h$ reflecting the relationship between the slab and the base based on the theory of elasticity [6].

$$\sigma_{pt=}\frac{60Q\cdot K_m\cdot K_{co}\cdot K_{cp}}{h^2\cdot K_t}\left(0.0592-0.2137\lg\frac{R}{l_y}\right) \tag{6}$$

where, Q is the calculated load; K_m is coefficient taking into account the loading conditions; K_{co} is coefficient taking into account the operating conditions; K_{cp} is coefficient that takes into account the influence of connecting pins; h is the thickness of the ceiling, m; K_t is coefficient taking into account the temperature effect; R is the calculated radius of the wheel track; and l_y is elastic parameter of the ceiling.

Road wear is calculated based on the first loading scheme for the effect of load Q.

$$Q = Q_h \cdot m_d \tag{7}$$

where, Q_h - calculated load on the wheel, kN; and m_d is dynamic coefficient of roads in general use.

The radius of the tire track is determined by the Equation (8) [6]:

$$R = \sqrt{\frac{10 \cdot Q}{\pi \cdot \rho}} \tag{8}$$

where, p = 0.6 MPa is air pressure in tires.

Elastic parameter of the ceiling

$$l_y = h \cdot \sqrt[3]{\frac{E_b\left(1-\mu^2{}_0\right)}{6E_e^0\left(1-\mu^2\right)}} \tag{9}$$

where, E_b is modulus of elasticity of steel fiber concrete; E_e^0 is equivalent modulus of the base; μ_0 is Poisson's ratio of steel fiber concrete; and μ is Poisson's ratio of the base.

The equivalent modulus of elastic E_e^0 is determined by gradually reducing the multilayer system to a two-layer system. The calculation of road wear is carried out in the following sequence [6]:

$$E_e^0 E_e^0 = \frac{E_i}{0.71 \cdot \sqrt[3]{\frac{E_t^{i+1}}{E_i}} \operatorname{arctg}\left(\frac{1.35h_e}{D}\right) + \frac{E_i}{E_t^{i+1}} \cdot \frac{2}{\pi} \operatorname{arctg}\frac{D}{h_e}} \tag{10}$$

where, i is number of road surface layers, counting from top to bottom; E_i is modulus of elasticity of the i-th layer material; E_t^{i+1} is total modulus of elasticity of the sub-area located under the i-th layer; D is calculated diameter of the tire track; and h_e is equivalent thickness of the layer.

$$h_e = 2 \cdot h_4 \sqrt[3]{\frac{E_i}{6E_t^{i+1}}} \tag{11}$$

For each thickness, the fatigue coefficients of concrete are determined at known stresses in the slab:

$$K_y = \frac{\sigma_{pt} \cdot K_m}{B_{btb} \cdot K_e \cdot K_f} \tag{12}$$

where, K_f is coefficient taking into account freezing and thawing, $K_f = 0.95$.

Based on the fatigue coefficients of the specified concrete, a dependence graph is constructed between the fatigue coefficient and the thickness of the ceiling. The thickness of the steel fiber concrete ceiling is determined based on the required fatigue coefficient K_y of the concrete under repeated loading.

According to the second calculation scheme, half the length of the ceiling resting on the foundation A (cm) is determined as follows [6]:

$$A = 4\left(R + \frac{R_{br}^c \cdot B \cdot h^2}{60K_c \cdot Q}\right) \tag{13}$$

where, Q is design load, kN; B is half the width of the ceiling, cm, $A \geq B$; and K_c is coefficient of flatness loss rate, K_c =1.0.

Ceiling thickness h (cm) is calculated as

$$h = \sqrt{\frac{60 \cdot K_c \cdot Q}{B \cdot R_{br}^c}(0.25A - R)} \tag{14}$$

where, B is half the width of the ceiling, cm, $A \geq B$; K_c is coefficient of the rate of loss of flatness: if the subsidence of the base or soil bed exceeds 15 cm, K_c =1.2; for other cases, and K_c =1.0 is assumed.

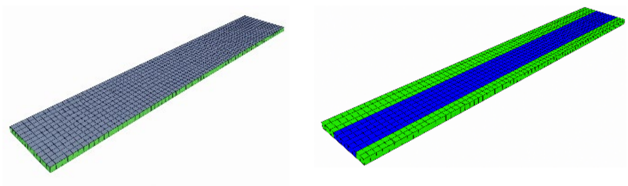


Figure 8. Computational models of hard pavement construction

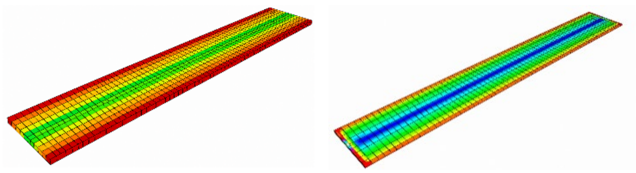


Figure 9. Maximum internal forces in the cross section of a rigid pavement structure

4. RESULTS

The use of fiber concrete in order to improve the deformation properties of concretes used in the construction of transport facilities and the studies conducted in this regard allow us to draw the following general conclusions:

1. The deformation properties of concretes used in the construction of transport facilities have been studied and it has been established that the properties of fiber concrete significantly depend on the nature and ratio of the phases that make it up. When selecting the composition of fiber concrete, the amount of fiber material should be in such an interval that brittle deformation of the product does not occur in this interval.

2. It has been established that the technological compatibility of the concrete matrix and fiber material can be ensured by evenly distributing the fiber material in the concrete matrix, by ensuring that the amount of concrete mixture forming the matrix is sufficient, and at the same time, by conveniently placing the fiber concrete mixture in the mold.

3. It has been experimentally established that the creation of a high-strength matrix for fiber concrete can be achieved by using complex additives (chemical and dispersed additives).

4. It was determined through physical and chemical research methods that the use of complex additives leads to the formation of a denser concrete matrix. Microsilica additive fills the voids, causing the structure of the transition zone to become denser and its strength to increase. At the same time, the formation of calcium hydrosilicates as a result of the reaction of microsilica with the hydration products of cement also densifies the structure. Also, the air-entraining additive further strengthens the structure by reducing the water/cement ratio.

5. The even distribution of metal fibers throughout the entire volume of concrete ensures an even distribution of the stress on the structure, which creates the basis for ensuring the longevity of transport facilities.

6. It has been determined that the use of fibrous materials in concrete increases its plastic deformation during collapse, which leads to an increase in crack resistance and, as a result, the period between repairs increases by 1.8-2 times. At the same time, the use of fiber concrete significantly increases the bending and tensile strength of structures (by 30%) and abrasion resistance. This also increases the reliability of structures and structures exposed to high dynamic and impact loads.

7. The use of fiber concrete in the construction of highways leads to an increase in the service life of road pavement and pavement, and thereby to a decrease in operating costs. By using fiber concrete in artificial structures, up to 30% of capital investment can be saved due to a complete or partial reduction in reinforcement work.

8. Fiber concrete was used in the construction of road pavement and a reduction in the thickness of the pavement (by 2 cm) was achieved. When using cement concrete pavement, the price of the materials used changes little due to the reduction in the thickness of the pavement (from 24 cm to 22 cm). However, despite its economic disadvantage, the use of high-quality materials leads to a decrease in operating costs and an increase in the period between repairs.

REFERENCES

[1] N.M. Ahmadov, I.N. Shirinzade, “Use of Modified Concrete in the Construction of Transportation Facilities”, Journal of Scientific Works of AzMIU, No. 1, pp. 136-141, Baku, Azerbaijan, 2019.

[2] N.M. Ahmadov, “Research on the Properties of Fiber Concrete for Transportation Facilities”, Proceedings of the International Azerbaijani-Ukrainian Scientific and Practical Conference, pp. 338-341, Baku, Azerbaijan, April 2020.

[3] Y.M. Piriyev, “Highways”, Textbook for Higher Education, 2nd Ed., Revised and Expanded, p. 600, Baku, Azerbaijan, 2023.

[4] Y.N. Yusifov, I.N. Shirinzade, “Sustainable Production of High-Strength Artificial Stone Using Limestone Dust Waste and Hyperplasticizers”, International Journal on Technical and Physical Problems of Engineering (IJTPE), Iss. 65, Vol. 17, No. 4, pp. 423-427, December 2025.

[5] T.A. Hagverdiyeva, K.B. Jamalova, “Study of Dynamic Stability of Polypropylene Fiber Reinforced Concrete with Modified Adhesive”, Engineering Mechanics Scientific and Technical Journal, No. 2, pp. 24-27, Baku, Azerbaijan, 2024.

[6] A.G. Malofeev, I.A. Malofeeva, “Methodical Instructions for the Design of Rigid Road Pavements of Highways in the Discipline ‘Research and Design of Highways’”, Siberian State Automobile and Highway Academy (SibADI), Omsk, Russia, p. 56, 2008.

[7] I.N. Shirinzade, N.M. Ahmadov, “Ways to Improve the Efficiency of Fiber-Reinforced Concrete”, International Research Journal, No. 3, pp. 107-110, Yekaterinburg, Russia, 2017.

[8] N.M. Ahmadov, I.N. Shirinzade, “Development of Effective Fiber-Reinforced Concrete Compositions Used in Transportation Structures”, Eastern-European Journal of Enterprise Technologies, No. 2, pp. 6-11, Kharkiv, Ukraine, 2021.

[9] H. Li, C. Ma, Z. Yang, “Durability Improvement Strategies for Concrete Structures of Comprehensive Transport Infrastructure”, Chinese Journal of Engineering Science, China, February 2025.

[10] J.A. Sainz-Aja, M. Sanchez, L. Gonzalez, “Recycled Polyethylene Terephthalate Fibers for Structural Concrete”, Applied Sciences, Vol. 3, March 2022.

[11] T.A. Hagverdiyeva, K.B. Jamalova, “Friction-Resistant Fiber Concrete”, Journal of Scientific Works of AzMIU, No. 2, pp. 22-24, Baku, Azerbaijan, 2017.

[12] N.M. Ahmadov, “Investigation of Methods for Improving the Deformation Properties of Concrete Used in the Construction of Transport Structures”, Abstract of the Dissertation for the Degree of Doctor of Philosophy in Construction Materials and Products, p. 31, Baku, Azerbaijan, 2024.

BIOGRAPHIES

Name: **Nizami**
Middle Name: **Mahamayevich**
Surname: **Ahmadov**
Birthday: 11.10.1976
Birthplace: Berezensky, Ukraine
Master: Transport Construction, Department of Roads, Bridges and Tunnels, Fakulty of Road Construction, Azerbaijan University of Civil Engineers, Baku, Azerbaijan, 1999
Ph.D.: Construction Materials and Products, Department of Transport and Logistics, Faculty of Transport, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan, 2025
Scientific Position: Assoc. Prof., Dean, Faculty of Architecture and Construction, Baku Engineering University, Baku, Azerbaijan, Since 2025
Research Interests: Materials Science, Road Construction Materials, Transportation Construction, Highways
Scientific Publications: 47 Papers, 2 Textbooks, 3 Methodological Instructions

Name: **Irada**
Middle Name: **Nusrat**
Surname: **Shirinzade**
Birthday: 25.01.1963
Birthplace: Aghdam, Azerbaijan
Master: Technology of Construction Materials, Department of Adhesive Materials, Faculty of Construction Technology, Azerbaijan Institute of Civil Engineers, Baku, Azerbaijan, 1985
Ph.D.: Technology of Silicates and Refractory Non-Metallic Materials, Department of Adhesive Materials, Faculty of Silicate Technology, University of Chemical Technology of Russia, Moscow, Russia, 1992
Doctorate: Dr. Sci., Construction Materials and Products. Department of Construction Materials, Faculty of Construction Technology, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan, 2010
Scientific Position: Prof., Head, Department of Materials Science, Faculty of Civil Engineering, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan, Since 2018
Research Interests: Material Science, Construction Materials Physical-Chemical Base of Construction Materials, Building Ceramics
Scientific Publications: 150 Papers, 6 Textbooks, 1 Monograph

Name: **Elkhan**
Middle Name: **Veys**
Surname: **Khalilov**
Birthday: 19.12.1962
Birthplace: Bolnisi, Georgia
Master: Civil Engineering, Department of Reinforced Concrete Structures, Faculty of Civil Engineering, Azerbaijan University of Civil Engineers, Baku, Azerbaijan, 1988
Scientific Position: Senior Lecturer, Department of Materials Science, Faculty of Civil Engineering, Azerbaijan University of Architecture and Construction, Baku, Azerbaijan, Since 2018
Research Interests: Materials Science, Construction Materials
Scientific Publications: 60 Papers

Name: **Aliya**
Middle Name: **Muhametkalievna**
Surname: **Zhilkibayeva**
Birthday: 06.06.1987
Birthplace: Almaty, Kazakhstan
Master: Technology of Construction Materials, Department of Construction Materials Technology and Management, Faculty of Construction Technologies, Infrastructure and Management, International Educational Corporation (Kazakh Leading Architecture and Civil Engineering Academy), Almaty, Kazakhstan, 2014
Ph.D.: Production of Construction Materials, Products, and Structures, Department of Construction Materials Technology and Management, Faculty of Construction Technologies, Infrastructure and Management, International Educational Corporation (Kazakh Leading Architecture and Civil Engineering Academy), Almaty, Kazakhstan, 2024
Scientific Position: Curator of Educational Program "Production of Construction Materials, Products and Structures", International Educational Corporation (Kazakh Leading Architecture and Civil Engineering Academy), Almaty, Kazakhstan, Since 2025
Research Interests: Material Science; Construction Materials; Physico-Chemical Basis of Construction Materials; Sustainable Concrete Technologies (including the use of industrial waste and by-products); Mathematical Modeling of Physico-Mechanical Processes in Construction Materials
Scientific Publications: 20 Papers