STRESS-DEFORMATION STATE OF CONCRETE BEAMS WITH COMBINED REINFORCEMENT

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Annotation. *This article describes the analysis of the results of the research carried out on the study of the work of composite reinforced elements, which are widely used in the restoration of concrete structures in the buildings and structures currently being built in the Republic of Uzbekistan and in foreign* *countries. The article includes the types of composite reinforcements, the physical and mechanical properties of composite reinforcements, and practical recommendations on ensuring their strength, uniformity and seam resistance.*

Key words: *composite, basalt, concrete, flexibility, strength, messura, polymer.*

Enter: Currently, polymer composite reinforcements are used in road transport infrastructure facilities, in areas where high electromagnetic fields are generated, in the chemical industry, water treatment and purification, land reclamation facilities, in the construction of seaports and pre-port facilities, in urban engineering infrastructure facilities, in mines and metros. It is effectively used in the construction of tunnels, as well as in the construction, repair and reconstruction of load-bearing and barrier structures of buildings and structures.[1]

The use of polymer composite reinforcements instead of steel reinforcements of reinforced concrete structures working in especially corrosive environments is a promising scientific direction.

In the development of the economy of the Republic of Uzbekistan, in the improvement of its material and technical base, it is important to put into practice the elements that have new constructive solutions and are economically effective based on theoretical and experimental research.[2]

In recent years, the President of the Republic of Uzbekistan and the Cabinet of Ministers have been making important decisions to raise the standard of living of the population and improve living conditions. In the implementation of these decisions, it is necessary to create economically inexpensive construction structures with high strength, uniqueness, and their practical application in the construction of production enterprises, residential buildings, and engineering structures, which are necessary for the economy. The issues raised in this direction include the use of composite materials, which are relevant today. The use of composite materials in construction increases the general reliability and technical economic efficiency of industrial, residential, public buildings and engineering structures in accepting permanent, temporary and earthquake stresses.[1]

The use of flexible elements reinforced with composite reinforcements in industrial, residential, public buildings and engineering structures requires a scientific basis based on a new theory, confirmed by the results of experimental research. Appropriate recommendations and practical solutions should be developed based on scientific research.[3]

Year by year, the volume of construction and improvement works is increasing in the Republic of Uzbekistan. In order to successfully implement the planned large-scale construction works, extensive use of new innovative technologies is required. The introduction of polymer composite reinforcements into the construction practice in the conditions of Uzbekistan requires their research in the conditions of our country. Therefore, conducting research in the direction of reinforcement of concrete structures with polymer composite reinforcements is an urgent problem of social and economic importance.[4]

Decisions of the President of the Republic of Uzbekistan and the Cabinet of Ministers in the field of construction.

Activation and development of new standards of building materials, as well as rules used in the construction industry in the decision of the President of the Republic of Uzbekistan No. PQ-4198 dated February 20, 2019 "On measures for the fundamental improvement and comprehensive development of the construction materials industry" participation in the development of the collection, certification of all types of manufactured building materials and products.[5]

In 2019 - 2025, the following forecast indicators have been set for the expansion of the raw material base of the construction industry based on conducting geological exploration, extraction and processing of local raw materials:[6]

Displaced rocks (basalt) in 2025 293.5 thousand tons (180.4 percent of dynamics compared to 2018); 1,656,000 tons of reinforced concrete products of various sizes and shapes (percentage of dynamics compared to 2018 is 101.8);

3,000 tons of basalt composite reinforcement (272.7 percent of dynamics compared to 2018).

Cumulative indicators of 6 types of prospective projects to be implemented in the construction materials industry in 2019-2021, the organization of the production of composite pipes and materials is 1000.0 tons, the limit of allocated loans is 25.0 million dollars; production of basalt-based materials is set at 2,000 tons, the limit of allocated loans is 15.0 million dollars. [7]

In 2019, 1387 international standards were adopted for the use of new construction materials in constructions, and their support was determined by the decision of the President of the Republic of Uzbekistan dated May 23 PQ-4335 until December 31, 2021. [2]

Based on the new construction materials, the technical standards and economic standards of 21 designs are established.

In the implementation of these decisions, the use of structures and elements with a new constructive solution for the restoration of buildings and structures is of great importance. Precisely, bending structures equipped with composite reinforcements form the basis of buildings and constructions, (rafter beams, girders, medium-diameter and thin-diameter plates, corner parts of spatial roof coverings, exposed parts of foundation heels, concrete columns with eccentric compression, engineering structures, engineering communication elements and hakozos are among them).[8]

Main part: The density of the composite polymer reinforcement can be defined as the density of the composite material at a volume fraction of 0.5-0.75 of the fibers (the most characteristic ratio in the composite polymer reinforcement) depending on the density of the composite material components (reinforcing fibers and matrix). The density for carbon-plastic reinforcement is 1430-1670 kg/m^3, for organic plastic reinforcement is 1300-1450 kg/m^3, for fiberglass reinforcement is 1730-2180 kg/m^3, for basalt fiber reinforcement is 1900 kg/m^3 . it is 3.6-6 times smaller than the density of steel reinforcement.[9]

Thermal expansion of composite polymer reinforcement depends on the type of fibers, matrix and their volume ratio. As a rule, composite polymer reinforcement is an orthotropic material, data on the thermal expansion coefficient are presented in Table 1.

Temperature expansion coefficients of composite fittings, x 〖10〗^(-6)/⁰C

1 – table.

Direction	Steel	Concrete	Basalt plastic	Organic plastic	Glass plastic
Across the stern (longitudinal)	11	7 – 13	8-10	-2.. -6	6 – 10
Cross-section (radial)	11	7 – 13	24-26	60 – 80	21 – 23

To conduct experimental studies, test models-sample beams with a rectangular cross-section were prepared. Ordinary heavy concrete was used for the beams. Portland cement of Turon cement plant in Beshariq district of Fergana region with activity of 42.5 MPa was used as a binder for concrete. As fillers, quartz river sand from Akbarabad quarry, Kuva district, Fergana region, with a fraction of 5-15 mm and a bulk modulus of M2.25 was used. The composition of the concrete was chosen so that its cubic strength would have a compressive strength corresponding to the class B20 and B35. Granite limestone was sieved, washed in a special device and then dried (Table 2).[3]

Table 2. Grain composition of ordinary heavy concrete aggregates.

Filler type	Residue in % by weight on a sieve with a hole size of mm								
	20	15	10	5	1,25	0,63	0,315	0,14	0,07
Granite limestone	2-4	4-6	90-95	92-100	-	-	-	-	-
Quartz sand	-	-	-	-	1-2	4-5	12-15	45-50	90-100

For experimental studies, 2 B20, 2 B30 beams with cross-sectional dimensions of 12x24 cm and length of 174 cm equipped with concrete and composite reinforcements were prepared. The beams were made in wooden molds. The inner surface of the molds was covered with metal sheets. In 2 test samples made of B20 class concrete, 2Ø14BKA in the tensile area, 2Ø12BKA in the compression area, and Ø6A-I reinforcements were placed in 7.5 cm increments as working reinforcements (Fig. 1). In 2 test samples made of B30 class concrete, 2Ø14BKA was placed in the tensile area as working reinforcement, 2Ø12BKA in the compressive area, Ø6A-I reinforcements were placed as clamps with a step of 7.5 cm (Fig. 1). The composite reinforcements for the tie rods were welded to the longitudinal reinforcements with mild steel wires. Reinforcement wedges were installed and fixed in the formwork at the project site. Beam samples were made from heavy concrete of B20 and B30 class. Together with the sample beams, cubes of 6 and 9 pieces with a size of 10x10x10cm were made from the same concrete at the same time.[4]

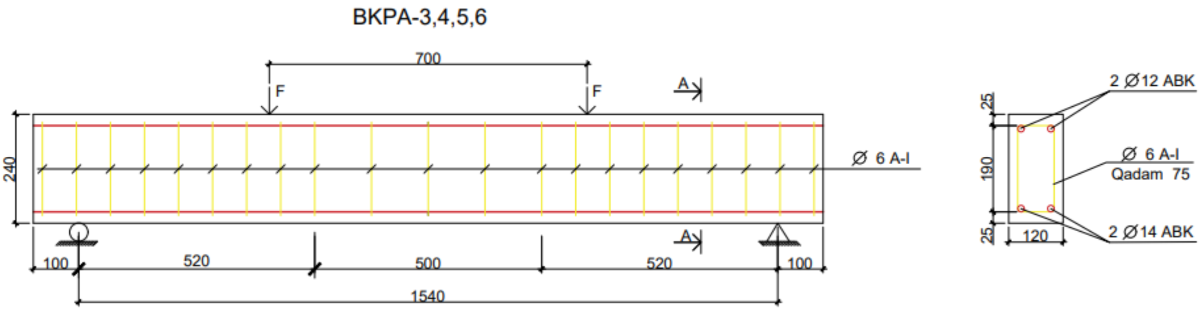


Figure 1. Schemes of reinforcement and loading of sample beams.

Concrete volume equal to 0.25 m3 was prepared in a concrete mixer and poured into molds and compacted using a vibrator.

The beam samples and cubes were kept in the mold for 5-7 days, then they were released from the molds and stored in laboratory conditions until the test. The first cubes were tested 28 days after molding. Then, directly before testing the beams, their cubic strength was determined. After 28 days, according to the results of the compression test of the cubes, it was determined that the concrete of the sample beams corresponds to the B20 compressive strength classes. Tests were conducted on a 50-ton hydraulic press. Cubes were tested until failure. The tests were performed based on the requirements of GOST 10180-2012 according to the standard method. The test results are presented in Table 4.[5]

Reinforcement of sample beams. Table 3.

Sample	Dimensions, cm			Reinforcement			Load range, cm	Design class of concrete
	b	h	h_0	Condala fittings (clamps)	Longitudinal stretchable	Do not enrich compressible		
BKPA -3	12	24	18,5	Ø 6 A-I	2Ø 14 BKA	2Ø 12 BKA	70	B20
BKPA -4	12	24	18,5	Ø 6 A-I	2Ø 14 BKA	2Ø 12 BKA	70	B20
BKPA -5	12	24	18,5	Ø 6 A-I	2Ø 14 BKA	2Ø 12 BKA	70	B30
BKPA -6	12	24	18,5	Ø 6 A-I	2Ø 14 BKA	2Ø 12 BKA	70	B30

Characteristics of concrete used in sample beams. Table 4.

Concrete type	Solidification conditions	Age of concrete, day	R, MPa	R_b, MPa	R_{bt} MPa	E_b*10^3, MPa	ε_{bn}	γ_{bn}	W, %
Normal heavy	In natural conditions	28	25	14,3	1,33	30,1	205	0,82	3,6

The beams were mounted on 2 hinged supports of the stand for testing samples. One of the hinges is fixed and the other is movable. The distance between the forces was 700 mm, and the distance from the supports to the load was 420 mm. The distance from the base to the edge of the beams is 100 mm. The load was delivered using a 24-ton manually operated hydraulic jack. For this, dividing traverses were used.

Before starting the tests, initial measurements were recorded for all fixtures installed on the sample beam. These indicators were accepted as "conditional zero". The download was given slowly in several stages. The step load was approximately 10% of the calculated breaking load. After loading at each stage, its stabilization was waited for up to 20 minutes.[6]

Deformations of concrete and reinforcement, coolness of beams, crack generation time (load) and opening width were measured until samples failed. The value of the load was recorded from the manometer of the jack. After the load reached the specified value, the valve of the jack was closed and kept at this value for 15-20 minutes. After the indicators were recorded through the devices, the load of the next stage was given. In this way, the tests were continued and carried out until the samples were broken[11-19].

Research results: After the tests, the location of the cracks was determined, the samples were photographed and the height of the cracks was measured, the distances between them were determined, the protective layers of the working fittings were determined and the working height was measured.

During the test, the deformations of concrete and reinforcements, the time of formation of normal and oblique cracks and the amount of load, the stiffness of the beam were measured and recorded.

Deformations are measured on a 300 mm base using a portable measuring instrument with clock-type indicators with an accuracy of 0.01 mm, deflections are measured at three points of the beam - between the spans and supports using clock-type indicators with an accuracy of 0.01 mm was measured. The deformations of the tensile and compressive reinforcements, as well as the concrete compressive zone, were measured at three predetermined points on the cross-section height on a 300 mm base.

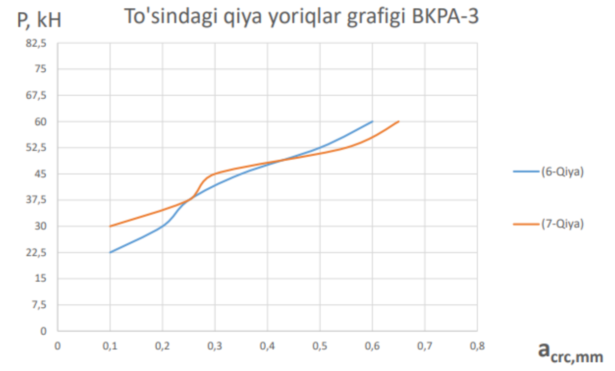
During the experiment, the surface of the sample beams was carefully inspected at each stage, and when the first cracks appeared, they were immediately marked and recorded, and their width was measured. At the same time, the value of the load achieved was also determined.

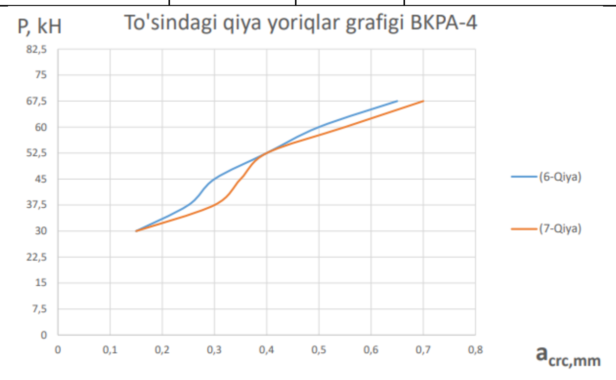
When the BKPA-3,4 sample beams were loaded, at certain stages of loading (II and later) in the area of pure bending, up to 2 or 3 normal cracks first appeared in the beams, and then, as the load increased, new normal cracks formed. The opening width of the initially formed cracks was 0.05-0.09 mm, as the loads increased, normal cracks developed, their tip was observed to rise according to the height of the section, and at the same time, the width of the crack opening also increased.[8-100]

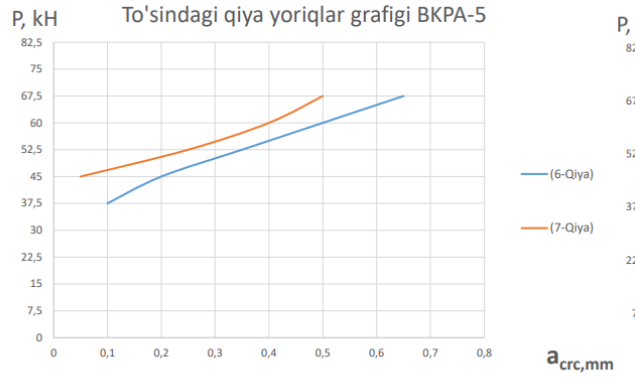
When the BKPA-5.6 specimen beams were loaded, at certain stages of loading (III and later) in the area of pure bending, up to 2 or 3 normal cracks first appeared in the beams, and then, as the load increased, new normal cracks formed. The opening width of the initially formed cracks was 0.04-0.1 mm, as the loads increased, normal cracks developed, their tip was observed to rise according to the height of the section, and at the same time, the width of the crack opening also increased.[9-12]

Formation of oblique cracks in sample beams. Table 5.

Sample beam cipher	Shear span (distance from support to force), cm	Transverse force in the formation of oblique cracks,kN		$\frac{Q^t_{crc}}{Q^x_{crc}}$	Q^t_{ult}, kN	$\frac{Q^t_{crc}}{Q^t_{ult}}$
		Experimental Q^t_{crc}	Accounting Q^x_{crc}			
BKPA -3	42	14,5	12,45	1,16	54	0,27
BKPA -4	42	14,9	12,65	1,18	57	0,26
BKPA -5	42	18,2	15,45	1,18	62	0,29
BKPA -6	42	18,9	15,35	1,23	64	0,30







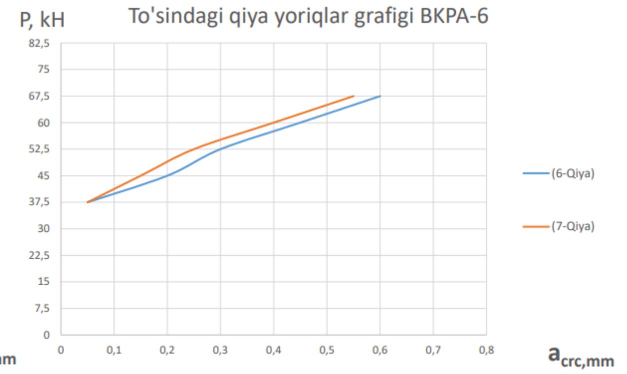


Figure 2. Opening width of oblique cracks in sample beams 3, 4, 5, 6.

Conclusions:

- the load-carrying capacity of single-reinforced flexural concrete elements with basalt-plastic and glass-plastic rods is very close to that of similarly reinforced steel-reinforced elements;

- It is noted that the load-carrying capacity of elements reinforced with composite reinforcements according to the double-reinforcement scheme is lower than the load-carrying capacity of elements reinforced with steel reinforcements according to the same scheme, and this situation is due to the low compressive strength of the composite reinforcement. is explained by;

- It is noted that the crack opening width in flexural concrete elements with basalt-plastic and glass-plastic composite reinforcement is significantly higher (larger) than in elements with steel reinforcement, which is explained by the fact that the composite reinforcement has a small modulus of elasticity (~4 times);[13],[14]

- flexural concrete elements with composite reinforcement are more flexible than elements reinforced with steel rods, this situation is also explained by the low modulus of elasticity in basalt plastic and glass plastic reinforcements; however, it was noted that at the level of normative loads, the amount of slack in flexural concrete beams with composite reinforcement is at the level of requirements for reinforced concrete structures.

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