INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND ANALYSIS

ISSN(print): 2643-9840, ISSN(online): 2643-9875

Volume 05 Issue 04 April 2022

DOI: 10.47191/ijmra/v5-i4-06, Impact Factor: 6.072

Page No. 782-787

Calculation of Basalt Fiber Reinforced Concrete Beams for Strength

Sobirjon Razzakov Jurayevich[1], Abdurasul Martazayev Shukirillayevich[2]

[1] Doctor of Technical Sciences, Professor of Namangan Engineering Construction Institute, 160103, Namangan, Uzbekistan

[2] PhD student of department of civil engineering, Namangan Engineering Construction Institute, 160103, Namangan, Uzbekistan

ABSTRACT: In the scientific research work, theoretical research work on flexible fiber reinforced concrete beams made with the addition of basalt fibers was carried out.The results of theoretical studies show that the values of the ultimate bending moment in fiber reinforced concrete beams were found to be relatively higher than the values of the bending moment in ordinary beams.

KEYWORDS: basalt fiber, fiber reinforced concrete, beam, strength, rebar, deflection

1. INTRODUCTION

Fiber concrete is a composite material that contains fibers in a cement matrix with an orderly or random distribution. The strength properties of fibrous concrete undoubtedly depend on the type of fiber, fiber geometry, fiber composition, fiber direction and distribution, shape and size of large and fine aggregates. Fiberreinforced concrete improves properties due to fibers.

The world's first patent for fiber reinforced concrete structures was awarded to Russian scientist V.P.Nekrasov obtained in 1909 and extensive development of scientific research on fiber concrete, the development of methods for calculating the structures made of it was carried out in the 60s of the twentieth century. The first large-scale application of fiber reinforced concrete in practice began in 1976 with the construction of runways in Russia. However, at that time, this material was not widely used, because the technology of preparation of fiber reinforced concrete and fiber reinforced concrete itself was not perfect [1].

There are many types of fiber concrete products used in various industries. Scientists from Austria, Australia, Belgium, Germany, the Netherlands, Spain, Canada, China, Poland, the United States, France, the Czech Republic, Switzerland, South Africa, Japan and other countries have made significant contributions to the development of fiber concrete, including Shen X., Singha K., Zhang J., Zhang X., Kudyakov K.,NihalL.P., Shiping Li, Yibei Zhang, Wujun Chen and other scholars deserve special mention [2, 3, 4, 5, 6].

The study and analysis of scientific research on the strength, tensile strength, and deformation of flexible fibrous concrete elements based on basalt fibers have shown that to date, experimental and theoretical data in this area have been collected in foreign countries. However, despite the advantages of basalt material and the positive results obtained during many studies, and the practical experience of experimental projects, basalt fiber is not widely used in reinforced-concrete construction [7].

2. RESEARCH METHODOLOGY

Calculation of strength under the influence of bending moment and longitudinal force of elements of fiber concrete structures is carried out on the normal section relative to the longitudinal axis.When calculating the load-bearing capacity of working reinforcement elements on the normal cross-section, the limit loads that can be accepted by fiber concrete and reinforcement in the normal section are determined based on the following cases:

- it is obtained in the form of residual stresses in which the tensile sresistance of fiber concrete is equal to R_{fbt2} or R_{fbt3} and evenly distributed in the elongation zone of fiber concrete;

- it is obtained in the form of stress in which the compressive strength of fiber concrete is equal to R_{fb} and evenly distributed in the compressive zone of fiber concrete;

- deformation (stress) in the rebar is determined depending on the height of the compression zone of the fiber concrete;
- the tensile stress in rebar is assumed to be no greater than the calculated resistance R_s in elongation;
- the compressive stress in the rebar is assumed to be greater than the calculated resistance R_{sc} in compression.

The normal cross-sectional strength of reinforced concrete elements is calculated based on the ratio of the relative height of the compressive zone $\xi = \frac{x}{h_0}$ to the boundary value of the relative height of the compressive zone in the boundary position of the resulting element when the elongated reinforcement stress is equal to R_s. The value of is determined by the following formula:

$$\xi_R = \frac{x_R}{h_0} = \frac{\omega}{1 + \frac{\varepsilon_s}{\varepsilon_{fb2}}} \qquad (1)$$

where: ω - the characteristic of the compressive zone of fiber concrete; 0.8 for heavy fiber concrete up to class B60 and 0.7 for heavy fiber concrete and fine aggregate concrete class B70-B100;

ε_s - the calculated value of the acceptable limit relative deformation of the reinforcement according to DR63.13330

ε_{fb2} - Relative deformation of compressive fiber beton at Rfb stress; its value is assumed to be equal to the value given in DR63.13330 for ordinary concrete.

The cross-sectional strength of flexible elements is calculated on the basis of the following condition:

$$M \le M_{ult} \qquad (2)$$

where: *M* is the bending moment generated by the external load;

M_{ult} –the ultimate bending moment that can be accepted by a section of an element

The value of M_{ult} in right-angled fiber-reinforced concrete elements is determined by the following formula[8].

$$\sum M = 0$$

$$M_{ult} + R_{fbt3} \cdot b \cdot (h - x) \cdot (\frac{h - x}{2} - a) - R_{sc} \cdot A_s^{'}(h_0 - a^{'}) - R_{fb} \cdot b \cdot x \cdot (h_0 - 0{,}5x) = 0$$

$$M_{ult} = R_{fb} \cdot b \cdot x \cdot (h_0 - 0{,}5x) - R_{fbt3} \cdot b \cdot (h - x) \cdot (\frac{h - x}{2} - a) + R_{sc} \cdot A_s^{'}(h_0 - a^{'}) \qquad (3)$$

In this case, the height of the compression zone is determined by the following formula:

$$\sum F_{kx} = 0$$

$$R_s \cdot A_s + R_{fbt3} \cdot b(h - x) - R_{sc} \cdot A_s^{'} - R_{fb} \cdot bx = 0$$

$$x = \frac{R_s \cdot A_s - R_{sc} \cdot A_s^{'} + R_{fbt3} \cdot b \cdot h}{(R_{fb} + R_{fbt3}) \cdot b} \qquad (4)$$

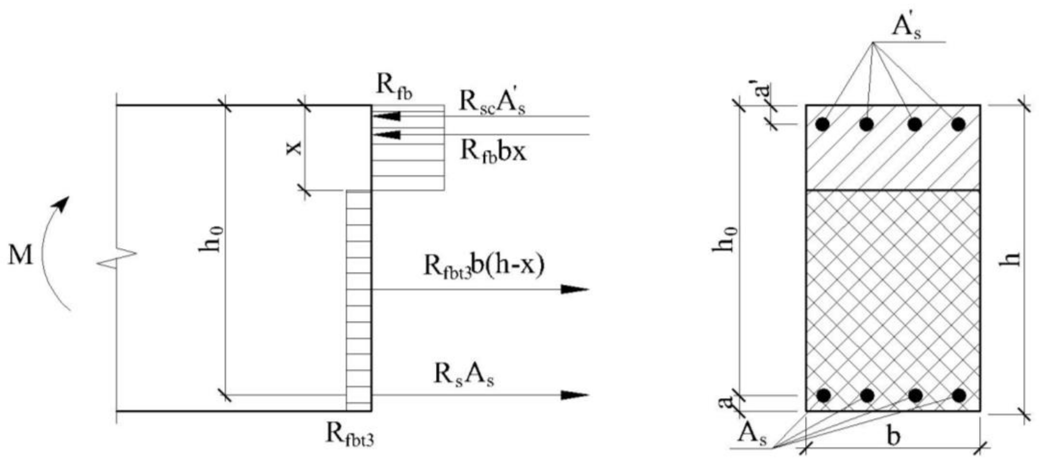

Figure 1. Diagram of forces and stress diagram in a section normal to the longitudinal axis of a bent fiber-reinforced concrete element of rectangular section with reinforcement, when calculating its strength.

Calculation of Basalt Fiber Reinforced Concrete Beams for Strength

In the initial stages of loading on the beams, the amount of stress in the concrete and reinforcement is almost not large, in which case the deformation is in an elastic state. As the load increases, the amount of stress in the elongated zone of the concrete reaches the limit value of elongation. But the concrete does not crack. Plastic deformations occur on the stretched lower surfaces of the concrete, the deformation in these layers being equal to the tensile strength of the concrete.

In this case, as the load increases, the elongated zone of the concrete breaks at the end of the deformation index. As a result, cracks are formed and a new condition on the cutting surface of the element. Once the cracks are formed, the reinforcement accepts the tension in the elongation of the cracked cutting surface, and between the cracks, the connection to the concrete is not broken and the concrete continues to work on elongation, giving the reinforcement a little more tension.

The process of breaking down reinforced concrete takes place over a very short period of time during the test period. With the onset of the flexibility of the reinforcement, deformation begins, resulting in increased bending, and as the crack increases, the height of the compressed part of the concrete cutting surface decreases. Plastic deformation occurs in the compressed zone of the concrete over the cracks. Deformation begins with the crushing of concrete in the compacted zone. In this case, the compressed zone diagram is close to the appearance of a parabola. The cracks in the elongation zone enlarge, the beam stiffness decreases, and the slope increases rapidly, breaking the beam.

The breakdown of normally reinforced reinforced concrete elements begins with elongated reinforcement. When the stress in the reinforcement reaches the leakage limit, the height of the concrete compression zone decreases sharply, which causes the concrete to collapse. In beams with a large number of tensile reinforcement, the collapse begins with the concrete in the compression zone, where the stress in the reinforcement is much smaller than the flow limit. This is definitely the opposite of saving[4-10].

Once the sample beams are loaded, in the initial stages of loading, the concrete and reinforcement work elasticly, with no cracks appearing in them. The amount of stresses in concrete and reinforcement is small and inelastic deformations do not develop.As the number of loads increases, the stresses in the concrete in the elongated area of the beams reach their calculated resistance to elongation and the initial cracks appear. From this point on, the qualitatively different stress-strain state begins in the sample beams, and a redistribution of stresses in the concrete and reinforcement is observed. When the first cracks are formed, the concrete almost loses its resistance in the elongated area, and the reinforcement of the concrete is observed only in the areas between the cracks and the reinforcement.

3. THE RESEARCH FINDINGS AND DISCUSSION

The results of the ultimate moment obtained on the basis of theoretical calculations of ordinary and fiber-reinforced concrete beams are shown in Table 1.

Table 1. The ultimate moment determined by the calculation of the sample beams

№	Fiber length, mm	Fiber dosage,%	R_b, МПа	R_{fbt3}, МПа	M_{ult}^{x}, кН·м	difference
1	-	-	25,8	-	13,56	-
2	10	0,1	28,7	1,12	15,29	+12,80
3	10	0,2	29,8	1,18	15,41	+13,70
4	10	0,3	28,3	1,05	15,18	+11,97
5	30	0,1	28,9	1,10	15,27	+12,64
6	30	0,2	30,4	1,27	15,56	+14,79
7	30	0,3	28,1	0,92	14,98	+10,53

The experimental results of without basalt fiber reinforced concrete beams and fiber reinforced concrete beams dispersed with basalt fibers were compared with the results of theoretical calculations.

The results of theoretical and experimental tests on fiber-reinforced concrete and ordinary reinforced concrete beams reinforced with basalt fibers are shown in Figures 2-4.

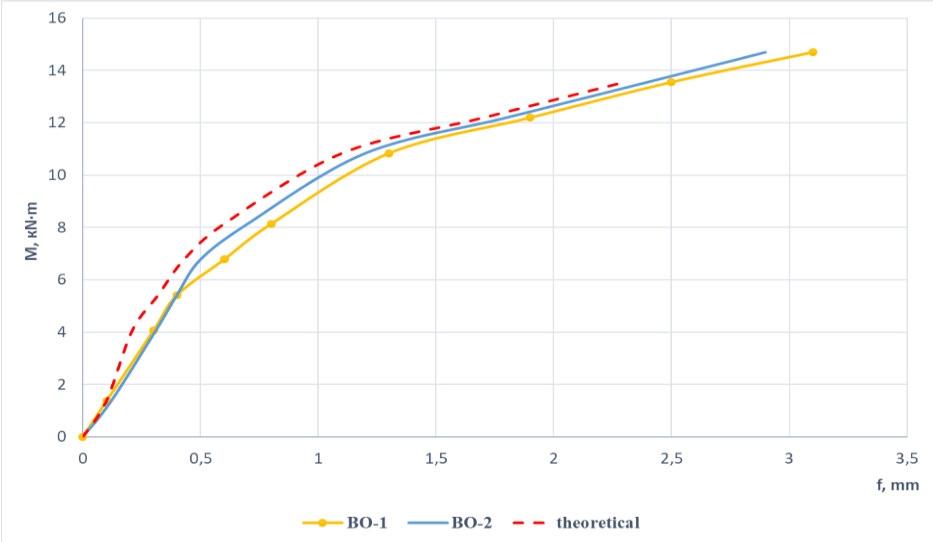

Figure 2. Graph of the dependence of the bending moment on the deflection of the I-series sample beams

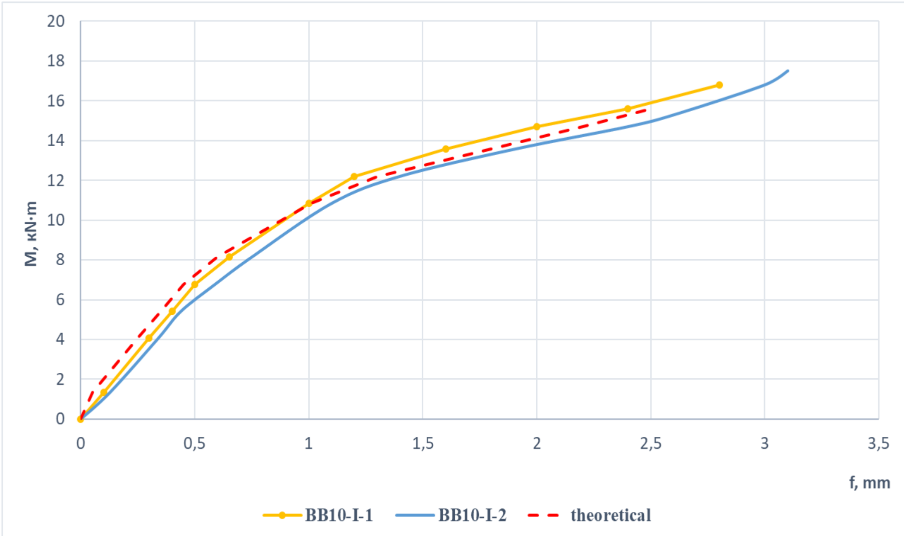

Figure 3. Graph of the dependence of the bending moment on the deflection of the II-series sample beams

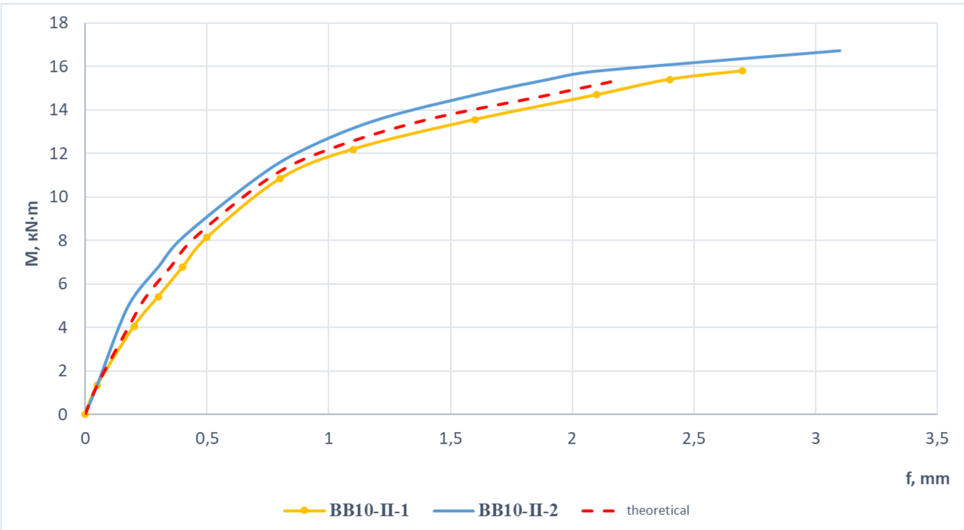

Figure 4. Graph of the dependence of the bending moment on the deflection of the III-series sample beams

The results of experimental and theoretical studies show that the values of the ultimate bending moment in fiber reinforced concrete beams are relatively high than the values of the bending moment in ordinary beams.

4. CONCLUSIONS

1. According to the results of theoretical calculations, the value of the ultimate moment in the beams without the addition of basalt fibers was 13.56 kN·m. The value of breaking moment in flexible fiber reinforced concrete beams made by adding 0.1% of basalt fibers with a length of 10 mm was 15.29 kN·m. The value of ultimate moment increased by 12.80% compared to ordinary reinforced concrete beams.
2. The value of ultimate moment in flexible fiber reinforced concrete beams made by adding basalt fibers with a length of 10 mm in the amount of 0.2 and 0.3% was 15.41 kN·m and 15.18 kN·m, respectively.
3. In fiber reinforced concrete beams with a content of 0.1% and a length of 30 mm, the value of the ultimate moment is 15.27 kN·m, the value of the ultimate moment is 15.56 kN·m, the amount of fibers is 0.3%, the value of the ultimate moment was 14.98 kN·m. It was found that the values of the ultimate moment increased by 10-15% compared to the values of the ultimate moment in ordinary beams.

REFERENCES

1) Li, S., Zhang, Y., & Chen, W. (2020). Bending performance of unbondedprestressedbasalt fiber recycled concrete beams. Engineering Structures, 221, 110937.
2) Jin, S., Zhang, X., Zhang, J., & Shen, X. (2016, May). Experimental study on anti-splitting tensile properties of the chopped basalt fiber reinforced concrete. In International Forum on Energy, Environment and Sustainable Development (pp. 282-289).
3) Raj, S., Gopinath, S., &Iyer, N. R. (2013). Compressive behavior of basalt fiber reinforced composite. In Proc. of the Intl. Conf. on Advances in Civil, Structural and Mechanical Engineering, CSM.
4) Krassowska, J., &Lapko, A. (2013). The influence of steel and basalt fibers on the shear and flexural capacity of reinforced concrete beams. Journal of Civil Engineering and Architecture, 7(7), 789.
5) Kizilkanat, A. B., Kabay, N., Akyüncü, V., Chowdhury, S., &Akça, A. H. (2015). Mechanical properties and fracture behavior of basalt and glass fiber reinforced concrete: An experimental study. Construction and Building Materials, 100, 218-224.
6) Alsayed, S. H. (1993). Flexural deflection of reinforced fibrous concrete beams. Structural Journal, 90(1), 72-76.
7) Scholar, P. G. (2017). Flexural Behaviour of Basalt Chopped Strands Fibre Reinforced Concrete Beams. International Journal of Engineering Science, 5497.
8) Gvazdeva A.A.,(2017)"Fiber reinforced concrete structures and precast products with non-steel fibers" Design rules, DR297.1325800.2017
9) [9]RAZZAKOV S. J. Research of stress-strain state of single-storey buildings with internal partitions under static pulling load of the upper belt of a structure //Structural Mechanics of Engineering Constructions and Buildings. – 2016. – №. 6. – C. 14-19.
10) Razzakov S. Zh., Zhuraev B. G., Zhuraev E. S. U. Stability of the walls of individual residential houses with a wooden frame. - 2018. - T. 14. - No. 5.
11) Razzakov S. Zh., Kholmirzaev S. A., Ugli B. M. Calculation of the forces of cracking of compressed reinforced concrete elements in a dry hot climate // Symbol of Science. – 2015. – no. 3. - S. 57-60.
12) Razzakov S. Zh., Ilyina L. V., Kholmirzaev S. A. Temperature deformations of concrete in a dry hot climate // Proceedings of the Novosibirsk State University of Architecture and Civil Engineering (Sibstrin). - 2018. - T. 21. - No. 3. - S. 22-30.
13) Razzakov S. Zh., Kholmirzae S. A. Influence of frame reinforcement on the stress-strain state of a two-story building made of low-strength materials. – 2017. – no. 4. - S. 43-49.
14) Razzakov S. J. et al. Stretching curved wooden frame-type elements "Sinch" //European science review. – 2017. – no. 1-2. – S. 223-225.
15) Abdurakhmonov S. E., Martazaev A. Sh., Eshonjonov Zh. B. Cracks in reinforced concrete products during their manufacture in a non-stationary climate // Bulletin of Science and Creativity. – 2017. – no. 2. - S. 6-8.
16) Nasriddinov M. M., Martazaev A. Sh., Vakkasov Kh. S. Crack resistance and strength of inclined sections of bent concrete elements on porous aggregates from loess-like loams and TPP ash // Symbol of Science. – 2016. – no. 1-2. - S. 85-87.
17) Abdurakhmonov S. E. et al. Crack formation and water separation of concrete mixture in reinforced concrete products during manufacture in areas with a hot climate // Bulletin of Science and Creativity. – 2018. – no. 2. - S. 35-37.
18) Martazaev A. Sh., Eshonjonov Zh. B. Issues of calculation of bending elements along inclined sections // Bulletin of Science and Creativity. – 2017. – no. 2 (14). - S. 123-126.

19) Juraevich R. S., Shukirillayevich M. A. Mechanical properties of basalt fiber concrete.
20) Juraevich R. S., Shukirillayevich M. A. The Effect of the Length and Amount of Basalt Fiber on the Properties of Concrete //Design Engineering. - 2021. - S. 11076-11084.
21) Shukurillaeich M. A. et al. CHECKING THE BEARING CAPACITY OF BENDING REINFORCED CONCRETE PRODUCTS ON AN INCLINED SECTION //ScienceTime. – 2018. – no. 6 (54). - S. 42-44.
22) I. Kh. – 2017. – no. 3. - S. 350-352.
23) Martazaev A. Sh., Fozilov O. K., Nosirzhonov N. R. Significance of calculations of static and dynamic impact of land dams // Innovative science. – 2016. – no. 5-2 (17). - S. 132-133.