International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 6 Issue 3, March - 2022, Pages:5-10

The Formation and Development of Cracks in Basalt Fiber Reinforced Concrete Beams

Martazayev Abdurasul Shukirillayevich[1] and Jurayeva Asalxon Sobirjonovna[2]

[1]Doctoral student of department of civil engineering, Namangan Engineering Construction Institute, 160103, Namangan, Uzbekistan

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

Abstract - The article presents the results of theoretical and experimental research on the opening and development of cracks in reinforced concrete beams without the addition of basalt fibers and dispersed reinforcement with basalt fibers.

Keywords— reinforced concrete, beam, crack, basalt fiber, flexure, strength, dispersed reinforcement.

1. Introduction

Currently, most of the construction work is done using concrete. Concrete has a number of undeniable advantages as well as disadvantages. Non-reinforced concrete has low resistance to bending and elongation, during the hardening process it enters the concrete and the long-term durability of the structure is reduced as a result of cracks. In order for the concrete to absorb tensile stresses, it will be necessary to reinforce it with steel rods to form reinforced concrete.

In reinforced concrete, reinforcement is placed to receive tensile stresses, while compressive stresses are to be accepted in concrete. The interaction of reinforcement and concrete is explained by the presence of a good bond between them and the temperature coefficients of the linear expansion being approximately the same [1].

About 20% of the cost of reinforced concrete products manufactured at the plant falls on the share of reinforcement, so the organization of reinforcement work in reinforced concrete plants is considered to be technically and economically important [2]. According to the type of reinforcement, reinforced concrete products are divided into simple reinforcement and dispersed reinforcement (scattered, scattered). Reinforcement is carried out using flat nets (grids) and spatial (volume) carcasses made of steel rods of different diameters and welded to each other at the intersections.

Within the structure, the location of the fixture will be strictly defined. The placement of the reinforcement inside the product is ensured by fastening it into the formwork before concreting.

In simple, non-prestressed reinforced concrete structures, cracks may appear in the elongation zones during operation. Pre-stressing of reinforcement in order to generate compressive stresses in the elongation zones of concrete has significantly increased the cracking of the product, reduced deformation, the use of high-strength steel and saved metal consumption [3].

It is known that the operation of reinforced concrete structures in an environment that is aggressive to the metal, which accelerates the deterioration of the structure as a result of corrosion of the metal in it, is a major problem. In such cases, in order to prolong the life of reinforced concrete structures, it is advisable to replace metal fittings with mirror material.

2. Research methodology

The moment of crack formation, taking into account the inelastic deformations of the tensile fiber-reinforced concrete, is determined in accordance with the following provisions:

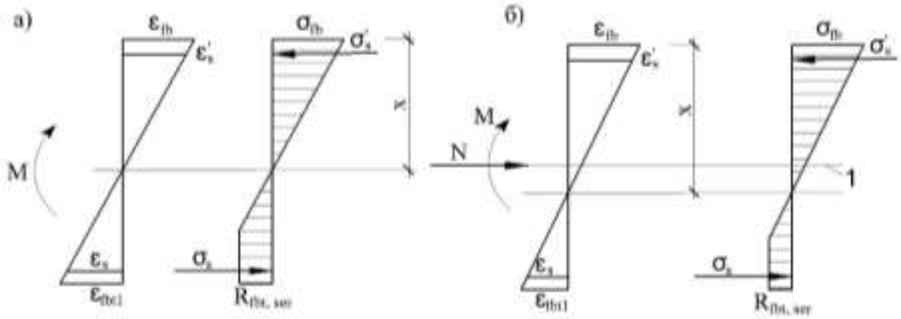
-sections after deformation remain flat;

-the stress diagram in the compressed zone of fiber-reinforced concrete takes a triangular shape, as for an elastic body (figure 1);

-the stress diagram in the tensile zone of fiber-reinforced concrete takes a trapezoidal shape with stresses not exceeding the calculated values of the tensile strength of fiber-reinforced concrete $R_{fbt2,ser}$;

-the relative deformation of the extreme stretched fiber of fiber-reinforced concrete is taken equal to ε_{fbt3};

- the stresses in the reinforcement are taken depending on the relative deformations as for an elastic body.



1 - the level of the center of gravity of the reduced cross section

Fig. 1. *Scheme of the stress-strain state of the section of the element when checking the formation of cracks under the action of a bending moment (a) and a bending moment and a longitudinal force (b).*

The moment of crack formation, taking into account inelastic deformations of tensile fiber-reinforced concrete, is determined by the formula [4]:

$$M_{crc} = R_{fbt,ser} \cdot W_{pl} \tag{1}$$

Where: W_{pl} is the elastoplastic section modulus for the extreme stretched fiber of fiber-reinforced concrete.

For rectangular sections, the value of W_{pl} under the action of a moment in the plane of the axis of symmetry can be taken equal:

$$W_{pl} = \gamma \cdot W_{red} \tag{2}$$

бу ерда: W_{red} is the elastic modulus of the reduced section along the stretched zone of the section.

γ - is a coefficient that takes into account the inelastic properties of fiber-reinforced concrete of the tensile section zone, determined by the formula:

$$\gamma = 1{,}73 - 0{,}005(B - 15) \tag{3}$$

where: B-numerical characteristic of the class of fiber-reinforced concrete in terms of axial compressive strength

W_{red} - is the elastic modulus of the reduced section along the stretched zone of the section, determined by the formula:

$$W_{red} = \frac{I_{red}}{\gamma_t} \tag{4}$$

I_{red} is the moment of inertia of the reduced cross section relative to its center of gravity, determined taking into account the presence or absence of cracks Элементнинг келтирилган кундаланг кесмнинг унинг оғирлик марказига нисбатан инерция моменти.

$$I_{red} = I + I_s \cdot \alpha + I_s^{'} \cdot \alpha \tag{5}$$

where: I - the moment of inertia of the fiber-reinforced concrete section relative to the center of gravity of the reduced cross section of the element.

$I_s, I_s^{'}$ -moments of inertia of the cross-sectional areas of tension and compression reinforcement, respectively, relative to the center of gravity of the reduced cross section of the element.

Normal crack opening width a_{crc} is determined by the following formula:

$$a_{crc} = \varphi_1 \cdot \varphi_2 \cdot \varphi_3 \cdot \psi_s \cdot \frac{\sigma_s}{E_s} \cdot l_s \tag{6}$$

where:

φ_1- is the coefficient taking into account the duration of the load effect, assumed to be equal to the following:

1,0 - under the continuous action of loads;

1,4 - under the continuous influence of loads;

φ_2 – the coefficient taking into account the profile of the longitudinal reinforcement, which is assumed to be 0.5 for periodic profile reinforcement and 0.8 for smooth reinforcement.

φ_3- coefficient taking into account the nature of the load is assumed to be 1.0 for flexible and decentralized compressive elements, 1.2 for elongated elements;

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 6 Issue 3, March - 2022, Pages:5-10

ψ_s- is the coefficient taking into account the uneven distribution of the relative deformations of the elongated reinforcement between the cracks;

3. RESULT AND DISCUSSION

According to the results of the experiment, the onset times of cracking moments in flexible fibro-reinforced concrete beams with the addition of basalt fibers were found to be different from those in conventional beams.
The values of bending moments in the formation of vertical cracks in the beams without the addition of basalt fibers, ie in the beams of the I-series pattern, were 3.24-3.50 kN·m. The ratio of the cracking moment to the breaking moment was $M_{crc}^T / M_{ult}^T = 0.235$.

In the II-series sample beams, ie in the beams made with the addition of 0.1% of basalt fibers, the values of cracking moment were 4.70-4.90 kN·m. The cracking moment was 40-45% higher than the cracking moment in ordinary concrete beams.

The value of cracking moment in fibro-reinforced concrete beams made of III-series basalt fibers with the addition of 0.2% was 5.10-5.60 kN·m. The ratio of the cracking moment to the breaking moment was $M_{crc}^T / M_{ult}^T = 0.325$. The average value of the cracking moment in the samples prepared with the addition of basalt fibers was 59% higher than in the samples prepared without the addition of basalt fibers. The cracking moment in IV-series beams was 4.20-4.35 kN·m. The ratio of the cracking moment to the breaking moment was $M_{crc}^T / M_{ult}^T = 0.268$.

In V-series fibro-reinforced concrete beams, the cracking moment was 5.30-5.54 kN·m and the ratio of cracking moment to breaking moment was $M_{crc}^T / M_{ult}^T = 0.325$.

The cracking moment on the VI-series beams is 4.65-4.82 kN·m and the ratio of the cracking moment to the breaking moment $M_{crc}^T / M_{ult}^T = 0.300$, the cracking moment on the VII-series beams is 4.24-4.40 kN·m and the ratio of the cracking moment to the breaking moment was $M_{crc}^T / M_{ult}^T = 0.285$.

The values of the experimental and calculated bending moments on the beams, which are normally directed to the longitudinal axis, are given in Table 4.3.

Table 1. Formation of cracks in beams

№	Cipher of the beams	The bending moment in the formation of normal cracks, кН·м		The ultimate bending moment M_{ult}^T, кN·м	$\frac{M_{crc}^x}{M_{crc}^T}$	$\frac{M_{crc}^T}{M_{ult}^T}$
		theoretical M_{crc}^x	experimental M_{crc}^T			
1	БО-1	2,03	3,24	14,70	0,62	0,22
2	БО-2		3,50	13,90	0,58	0,25
3	ББ10-I-1	2,98	4,90	17,50	0,61	0,28
4	ББ10-I-2		4,70	16,80	0,63	0,28
5	ББ10-II-1	3,06	5,60	15,80	0,55	0,35
6	ББ10-II-2		5,10	16,74	0,60	0,30
7	ББ10-III-1	2,99	4,20	15,40	0,71	0,27
8	ББ10-III-2		4,35	16,90	0,69	0,26
9	ББ30-I-1	3,00	5,54	16,30	0,54	0,34
10	ББ30-I-2		5,30	17,20	0,57	0,31
11	ББ30-II-1	3,07	4,82	15,80	0,64	0,31
12	ББ30-II-2		4,65	16,10	0,66	0,29
13	ББ30-III-1	2,98	4,24	15,80	0,70	0,27

14	ББ30-III-2		4,40	14,60	0,68	0,30

Theoretical calculations also revealed that the starting times of cracking moments in flexible fibro-reinforced concrete beams with basalt fibers are different from ordinary beams.

The value of the bending moment in the formation of cracks in the beams of the I-series sample was 2.03 kN·m. The value of the bending moment in the formation of cracks in the beams of the I-series sample was 2.03 kN·m. In samples, I, II, III, IV, V, VI, VII-series in samples reinforced with basalt fibers, ie respectively 0.1, 0.2, 0.3 % with the addition of basalt fibers in the beams made, the values of the cracking moment ranged from 2.98 to 3.07 kN·m.

During the loading phases of the experimental samples, the first cracks that were normal to the longitudinal axis of the element appeared at 0.22-0.25 and 0.27-0.35 load levels of breaking strength, respectively, for reinforced concrete and basalt fiber reinforced concrete beams.

The nature of the occurrence, development and opening of cracks in reinforced concrete and basalt fiber flexible fiber reinforced concrete beams varied. In reinforced concrete samples, normal cracks that appeared in the early stages of loading developed rapidly and opened during loading. In basalt fiber reinforced concrete samples, the development of normal cracks along the height of the beam and their opening occurred more slowly. This is explained by the fact that the beams are reinforced with many basalt fibers.

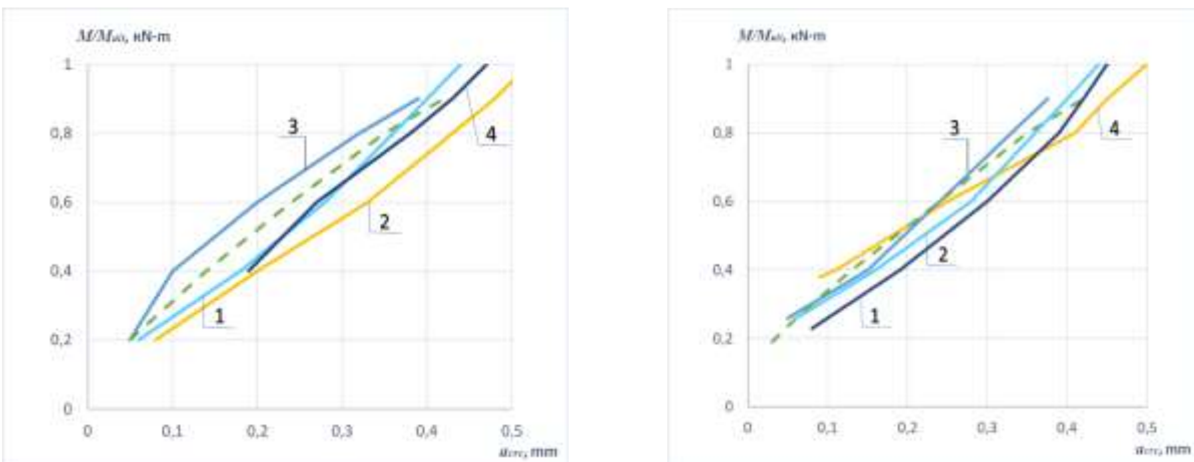


Fig 2. *the opening width of normal cracks in beams I, II-series*

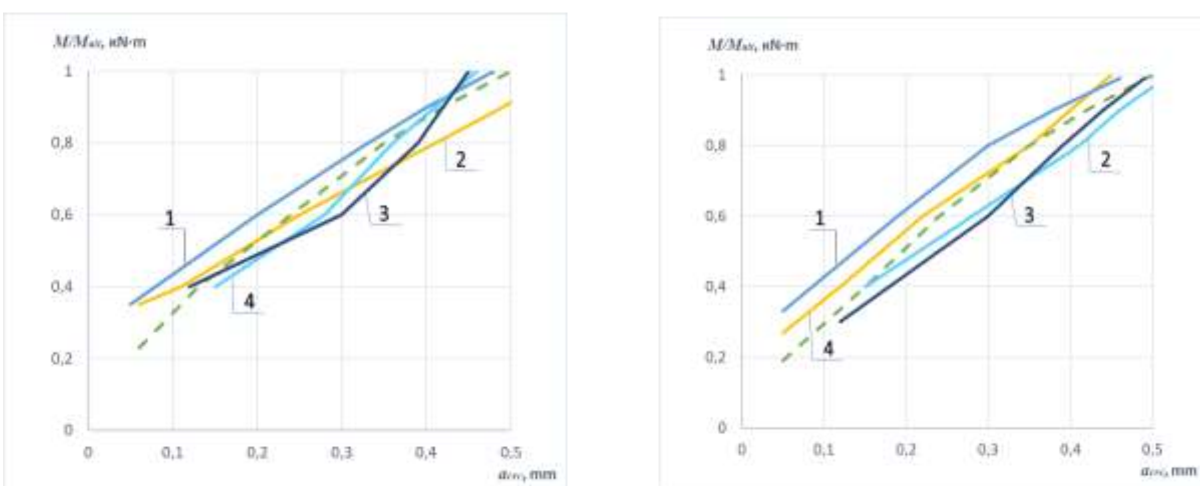


Fig. 3. *the opening width of normal cracks in beams III, IV -series*

International Journal of Engineering and Information Systems (IJEAIS)
ISSN: 2643-640X
Vol. 6 Issue 3, March - 2022, Pages:5-10

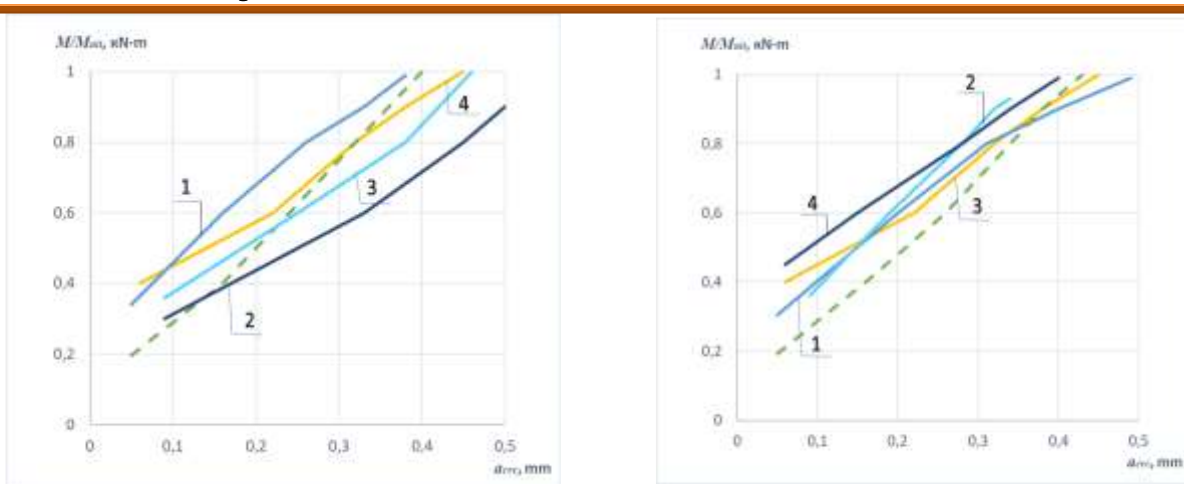


Fig. 4. *the opening width of normal cracks in beams V, VI -series*

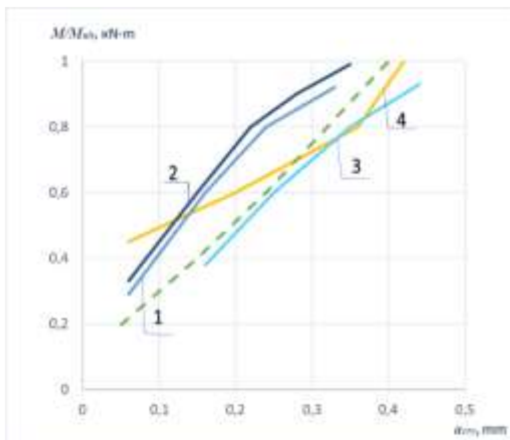


Fig. 5. *the opening width of normal cracks in beams VII-series*
Sequence numbers of cracks 1, 2, 3, 4. ---------- - Theoretical

4. Conclusion

According to theoretical and experimental results, it was found that the starting times of cracking moments in flexible fibro-reinforced concrete beams with basalt fibers are different from ordinary beams.

In the beams without the addition of basalt fibers, ie in the beams of the I-series pattern, the values of the moments of initial cracking were 3.24-3.50 kN·m. In the II-series sample beams, ie in the beams made with the addition of 0.1% of basalt fibers, the values of cracking moment were 4.70-4.90 kN·m.

5. Acknowledgment

The authors would like to thank the laboratory staff of Bunyodkor-3 LLC for their close assistance in conducting this research.

References

[1] Razzakov, S.J., Martazayev, A.Sh. (2021) Mechanical properties of basalt fibre concrete, International Journal of Advanced Research in Science, Engineering and Technology, Vol. 8, Issue 9
[2] Razzakov, S.J., Martazayev, A.Sh. (2021) The Effect of the Length and Amount of Basalt Fiber on the Properties of Concrete, Design Engineering, 11076-11084.
[3] Kudyakov, K.L. Strength and crack resistance of bent concrete elements with basalt fiber and rod glass composite reinforcement under static and short-term dynamic loading, Tomsk 2018.
[4] Gvazdeva A.A., "Fiber reinforced concrete structures and precast products with non-steel fibers" Design rules, DR297.1325800.2017

[5] Razzakov, S.J., (2016) 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, (6), pp.14-19.
[6] Razzakov S.J., Eshonjonov J.B. Собирова Some Aspects of the Theoretical Calculation of Energy-Saving Lightweight Roofing Covers // International journal of advanced research in science, engineering and technology -India. Vol. 7, Issue 12. December 2020. –б. 15925-15931
[7] Razzakov S.J., Eshonjonov J.B. Experimental research of light Wood roofing model //International journal of advanced research in science, engineering and technology -India. Vol. 8, Issue 9. September 2021. –б. 18138-18144
[8] Razzakov S.J., Juraev B. G., Juraev E.S., Sustainability of walls of individual residential houses with a wooden frame // Structural Mechanics of Engineering Constructions and Buildings, 427-435, 2018.
[9] Razzakov S. J., Abdujabbarovich H.S., Gulomovich J.B., The study of seismic stability of a single-storey building with an internal partition with and without taking into account the frame // European science review, 217-220, 2016.
[10] Razzakov S.J., Akhmedov P.S., Chulponov O.G., Mavlonov R.A., Stretching curved wooden frame-type elements "Sinch" // European science review, 2017.
[11] Razzakov S.J., Raimjanova, N.I., Abdurakhmonov A.S., Some structural aspects of heat resistant plates from brick fight, 15990-15996, 2020
[12] Абдурахмонов С. Э., Мартазаев А. Ш., Мавлонов Р. А. Трещинастойкость железобетонных элементов при одностороннем воздействии воды и температуры //Символ науки. – 2016. – №. 1-2.
[13] Насриддинов М. М., Мартазаев А. Ш., Ваккасов Х. С. Трещиностойкость и прочность наклонных сечений, изгибаемых элеменов из бетона на пористых заполнителях из лёссовидных суглинков и золы ТЭС //Символ науки. – 2016. – №. 1-2.
[14] Абдурахмонов С. Э., Мартазаев А. Ш., Эшонжонов Ж. Б. Трещины в железобетонных изделиях при изготовлении их в нестационарном климате //Вестник Науки и Творчества. – 2017. – №. 2. – С. 6-8.
[15] А.Ш. Мартазаев, Ж.Б. Эшонжонов, "Вопросы расчета изгибаемых элементов по наклонным сечениям", Вестник Науки и Творчества, 123-126, (2017).
[16] Абдурахмонов С. Э. и др. Трещинообразование и водоотделение бетонной смеси в железобетонных изделиях при изготовлении в районах с жарким климатом //Вестник Науки и Творчества. – 2018. – №. 2. – С. 35-37.
[17] Ризаев Б. Ш., Мавлонов Р. А., Мартазаев А. Ш. Физико-механические свойства бетона в условиях сухого жаркого климата //Инновационная наука. – 2015. – №. 7-1.
[18] Мартазаев А. Ш., Эшонжонов Ж. Б. Вопросы расчета изгибаемых элементов по наклонным сечениям //Вестник Науки и Творчества. – 2017. – №. 2. – С. 123-126.
[19] Juraevich R. S., Shukirillayevich M. A. Mechanical properties of basalt fiber concrete.
[20] Эгамбердиев И. Х., Мартазаев А. Ш., Фозилов О. К. Значение исследования распространения вибраций от движения поездов //Научное знание современности. – 2017. – №. 3. – С. 350-352.
[21] Мартазаев А. Ш. и др. Проверка несущей способности изгибаемых железобетонных изделий по наклонному сечению //Science Time. – 2018. – №. 6. – С. 42-44.