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CALCULATION OF FLEXIBLE CONCRETE BEAMS WITH BASALT REINFORCEMENT

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Abstract
As a result of experimental research, this article presents test-experimental data on the occurrence of stress-deformation states of flexural concrete beams with basalt reinforcement under the influence of force.

Keywords Basalt reinforcements, strength, step load, limit states, coolness, cracks, deformations, breaking moment, moment of inertia.

INTRODUCTION

In construction practice, using mirror composite reinforcements, conducting research in the directions of increasing the fire resistance and elasticity module of concrete, and improving the stress-deformation state, strength, and crack resistance properties of bending elements has become one of the urgent tasks. According to the study and analysis of scientific research works, the operation of flexural concrete structures equipped with basalt reinforcements under the influence of forces in the conditions of our republic has not yet been sufficiently studied.

Basalt reinforcements produced in the Republic of Uzbekistan are the most optimal option for conducting research on normal heavy concretes, which are used in the construction practice in the largest volume and in all types of construction objects.

The main part. The coolness of flexural concrete beams with basalt reinforcement depends on the reinforcement of the beam, the strength of the concrete, the distance between the element supports and the amount of the load.

At small values of the loads in the loading stages, Q=0.2-0.3Qult, the deflections of the sample beams did not become large (f≤0.4mm) and they increased almost linearly. With the increase of the load on the steps, the graph showed a curved character, and in cases where the load values are Q≥0.4Qult, a sharp increase in coolness is observed.

At values of Q>0.6Kult, the thicknesses increased sharply and their amount increased to 2.4-3.0mm. In this case, it is possible to observe the high deformability of baalt reinforcements.

It was observed that before the occurrence of boundary conditions in the beams, the deflections in them reach f=3.4-4.0mm.

Before limit states occur in flexural concrete elements with basalt reinforcement, together with their strength, uniformity is required. In addition to the calculation of stability conditions, they must also be calculated for coolness.

Determining the calculated stiffness in the sample beams was carried out in the following order (1).

Calculation of elements of constructions according to coolness is carried out based on the following condition:

$$f \leq f_{ult} \quad (1)$$

where: f is the cooling of the element due to external load; f_ult is the limiting coolness allowed in the element.

The stiffness of constructions is determined according to the general rules of construction mechanics, depending on the bending, sliding and axial deformation characteristics (curvature, angles, displacement, etc.) of its sections along the length of the element.

For flexural elements with a constant cross-section along the length of the element without cracks, the deflections are determined based on the general rules of construction mechanics using the unity of the cross-sections.

The full curvature of bending elements is determined by the following formulas:

- for sections without cracks in the extension zone:

$$\frac{1}{r} = \left(\frac{1}{r}\right)_1 + \left(\frac{1}{r}\right)_2 \quad (2)$$

- for sections with cracks in the extension zone

$$\frac{1}{r} = \left(\frac{1}{r}\right)_1 - \left(\frac{1}{r}\right)_2 + \left(\frac{1}{r}\right)_3 \quad (3)$$

Here:

$\left(\frac{1}{r}\right)_1$, $\left(\frac{1}{r}\right)_2$- curvatures resulting from the continuous action of short-term loads and temporary long-term loads, respectively.

$\left(\frac{1}{r}\right)_1$ – curvature resulting from the non-continuous effect of all loads, which are calculated according to deformations;

$\left(\frac{1}{r}\right)_2$ – curvature resulting from the non-permanent effects of permanent and temporary long-term loads;

$\left(\frac{1}{r}\right)_3$ – curvature resulting from the continued effect of permanent and temporary long-term loads.

The curvature 1/r caused by the corresponding loads is determined by the following formula:

$$\frac{1}{r} = \frac{M}{D}, \quad (4)$$

where: M is the bending moment caused by the external load (taking into account the moment created by the longitudinal force N), this moment is created with respect to the axis normal to the plane of action, and the given cross section of the element passes through the center of gravity;

D is the bending stiffness of the given cross-section of the element, its value is determined according to the following formula:

$$D = E_{b1} \cdot I_{red}, \quad (5)$$

where: E_b1 is the deformation modulus of compressed concrete, this modulus is determined depending on the duration of the impact of loads and the presence or absence of cracks; I_red is the moment of inertia of the given cross-section relative to the center of gravity of this section, this moment is determined taking into account the presence or absence of cracks.

The values of the deformation modulus of concrete E_b1 and the moment of inertia of the given section I_red for the elements without cracks in the stretching zone and with cracks are determined in accordance with the applicable normative documents, respectively.

The stiffness of the bending element D in the section without cracks is determined by formula (5).

The moment of inertia of the given cross-section of the element relative to the center of gravity of this section Ired is determined according to the general rules of resistance of elastic elements for a solid body, taking into account the entire surface of the concrete cross-section and the coefficient of bringing the reinforcement to concrete and the surface of the cross-section of the reinforcement (2,3):

$$I_{red} = I + I_f \cdot \alpha_f, \quad (6)$$

where: I is the moment of inertia of the cross-section of the concrete section with respect to the center of gravity of the element; I_f-the moment of inertia of the surface of the cross-section of the cross-section of the stretched armature relative to the center of gravity of the element;

α_f is the coefficient of bringing reinforcement to concrete,

$$\alpha_{f1} = \frac{E_f}{E_{b1}} \quad (7)$$

The value of I is determined according to the general rules for calculating geometric classifications of elastic elements.

It is allowed to determine the moment of inertia I_red without taking into account the reinforcement.

The values of concrete deformation in formulas (5) and (7) are taken to be equal to:

- under non-continuous (non-continuous) impact of loads:

$$E_{b1} = 0{,}85 \cdot E_b, \quad (8)$$

- under the continuous (continued) influence of loads

$$E_{b1} = E_{b\tau} = \frac{E_b}{1+\varphi_{b,cr}}, \quad (9)$$

where: φ_(b,cr) is the creep coefficient (characteristic) of concrete.

In compression classes of concrete, the value of φ_(б,cr) is taken as equal to: V15-4.8, V20-4.0, V25-3.6, V30-3.2, V35-3.0, V40-2 ,8, V50-2.4, V55-2.2, V60-2.0.

In the section with cracks in the stretching zone, the integrity of the structural element is determined as follows.

The integrity of structural elements in sections with cracks in the stretched zone is determined taking into account the following conditions (4):

after deformation, the cross-section remains flat;

the tension of concrete in the compression zone is determined as determined for an elastic body;

- the work of prestressed concrete in the section with a normal crack is not taken into account;

- the work of prestressed concrete in the section located between side cracks in the normal direction is determined by means of ps_f.

The uniformity of element D in sections with cracks is determined by formula (5) and its value is not greater than the uniformity of the element without cracks.

The values of the compressed concrete deformation modulus E_(b1) are taken as equal to the values of the deformation modulus E_(b,red), which is determined according to the following formula (5):

$$E_{b,red} = \frac{E_{b,ser}}{\varepsilon_{b1,red}}, \quad (10)$$

where: $\varepsilon_{b1,red}$- relative deformations of concrete, taken as follows:

- 0.0015 for heavy concrete under discontinuous impact of loads;

- 0.0034 for heavy concrete with continuous load.

The value of I_f is determined according to the general rules of resistance of materials, where the distance from the most compressed fiber of concrete (with the lifting coefficient α_{f1})) to the center of gravity of the cross section is taken without taking into account the concrete in the stretched zone. For bending elements:

$$y_{cm} = x_m \quad (11)$$

where x_m is the average height of the concrete compression zone, which takes into account the effect of the stretched concrete work between the cracks (Fig. 1).

The values of I_b and y_{cm} are determined according to the general rules for calculating geometric classifications of sections of elastic elements.

The position of the neutral axis (the height of the concrete compression zone) for bending elements is determined from the following equation:

$$S_{b0} = \alpha_f \cdot S_{f0}, \quad (12)$$

where: S_{b0} and S_{f0} are the static moments of the concrete compression zone and the tensile reinforcement relative to the neutral axis, respectively.

For elements with a rectangular cross-section, the height of the compressed zone is determined according to the following formula (6,7):

$$x_m = h_0\left(\sqrt{(\mu_f\alpha_{f1})^2 + 2\mu_f\alpha_{f1}} - \mu_f \cdot \alpha_{f1}\right), \quad (13)$$

Here: $\mu_f = \frac{A_f}{b \cdot h_0}$

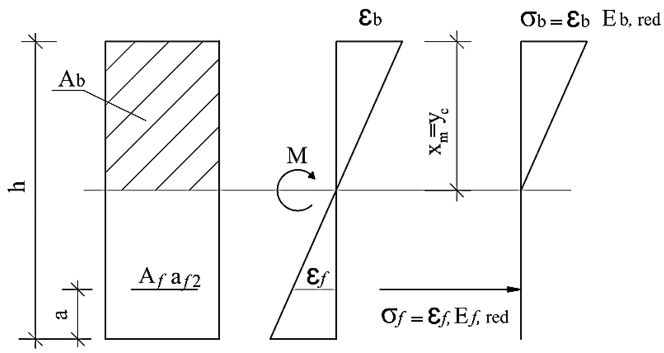


Figure 1. A scheme for calculating the deformations of an element with the given cross-section and cracks under the action of a bending moment in the stressed-strained state.

For eccentrically compressed and eccentrically stretched elements, the position of the neutral axis (the height of the compressed zone) is determined from the following equation:

$$y_N = \frac{I_{b0} + \alpha_{f1} \cdot I_{f0}}{S_{bo} + \alpha_{f1} \cdot S_{f0}} \qquad (14)$$

where: y_N is the distance from the neutral axis to the point of application of the longitudinal force N, which lags behind the center of gravity of the full section (without taking into account cracks)

$e_0 = \frac{M}{N}$;

$I_{b0}, I_{f0}, S_{bo}, S_{f0}$ are the moments of inertia and static moments of the concrete compression zone and the stretched reinforcement relative to the neutral axis, respectively.

The values of the geometric characteristics of the element section are determined by the general rules for calculating the sections of elastic elements.

It is allowed to determine the uniformity of bending concrete elements by the following formula (8):

$$D = E_{b,red} \cdot A_f \cdot z \cdot (h_0 - x_m), \qquad (15)$$

where z is the distance from the center of gravity of the stretched reinforcement section to the point of application of equally acting forces in the compression zone.

For elements with a rectangular cross-section, the value of "z" is determined by the following formula:

$$z = h_0 - \frac{1}{3} x_m, \qquad (16)$$

For elements with a rectangular cross-section, it is allowed to take values of z equal to 0.8ho.

The values of the coefficients of bringing the stretched reinforcement to the concrete are taken to be equal to:

$$\alpha_{f,1} = \frac{E_{f,red}}{E_{b,red}}, \quad (17)$$

where $E_{b,red}$ is the specified modulus of compression of concrete. $E_{f,red}$ -is the specified modulus of deformation of the stretched reinforcement, this modulus is determined by the following formula, taking into account the effect of the behavior of the stretched reinforcement between the cracks:

$$E_{f,red} = \frac{E_f}{\psi_f}, \quad (18)$$

It is allowed to take the value of coefficient ps_f equal to ps_f=1.

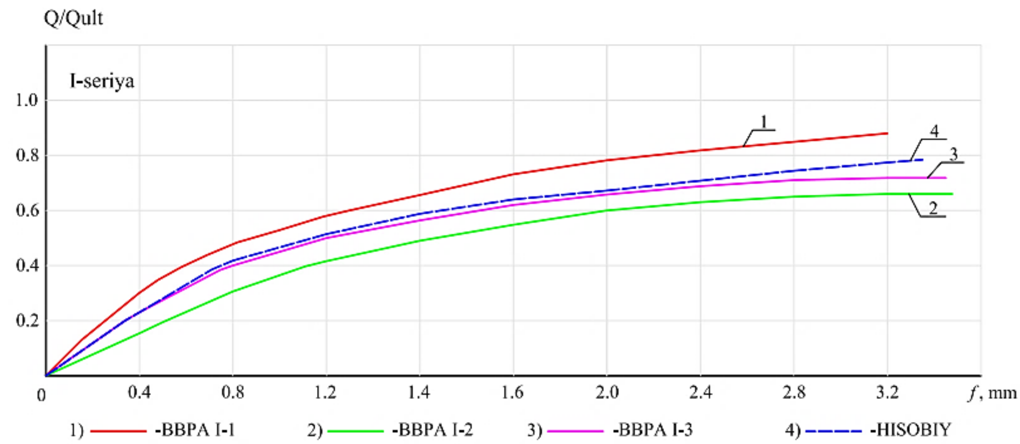
The stiffness of elements (1/r) can be determined according to the general rules of construction mechanics by using direct bending singularity characteristics D instead of curvature, by replacing the elastic bending characteristics EI with the specified classifications of D in the calculation relationships, the classifications of D are calculated according to the following formulas (9, 10).

RESULTS AND DISCUSSION

The full stiffness of the elements without cracks and with cracks in the extended zone when subjected to static loads is determined by adding the stiffness resulting from the corresponding loads in a similar way to the addition of curvatures, where the uniformity classifications D are required to be accepted depending on the duration of exposure of the considered loads specified in this point.

It is allowed to take the coefficient ps_f at the value ps_f=1 when determining the single classification D of elements with cracks in the stretching zone. In this case, the total damping with cracks in the elements due to the combined action of short-term and long-term loads is determined by adding the dampings resulting from the discontinuous effect of the short-term load and the continuous effect of the long-term load, in which the singleness classifications take into account the corresponding values of D as assumed for elements without cracks. required to obtain.

The coolness of the sample beams found by theoretical calculations was found to be in satisfactory agreement with the experimental results (Fig. 2).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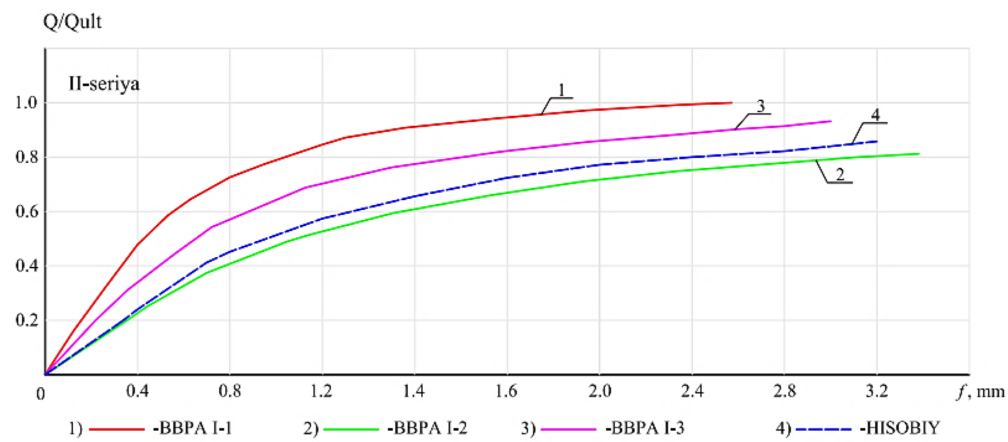
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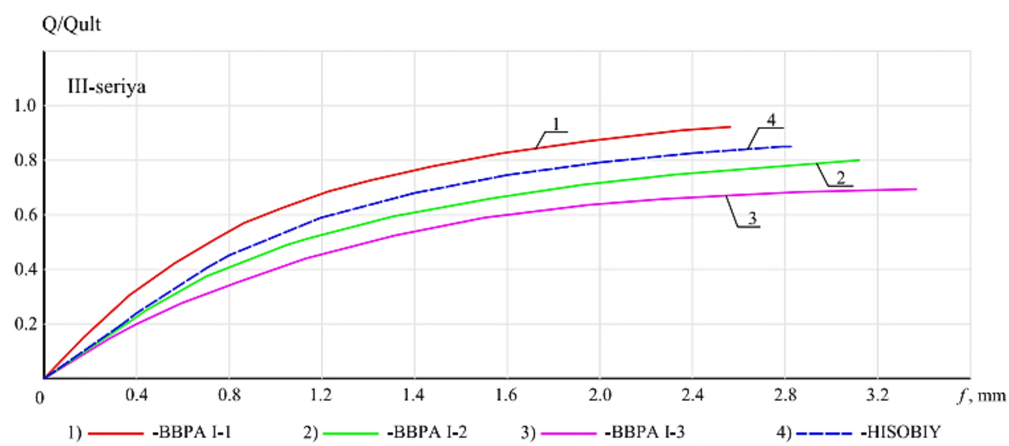
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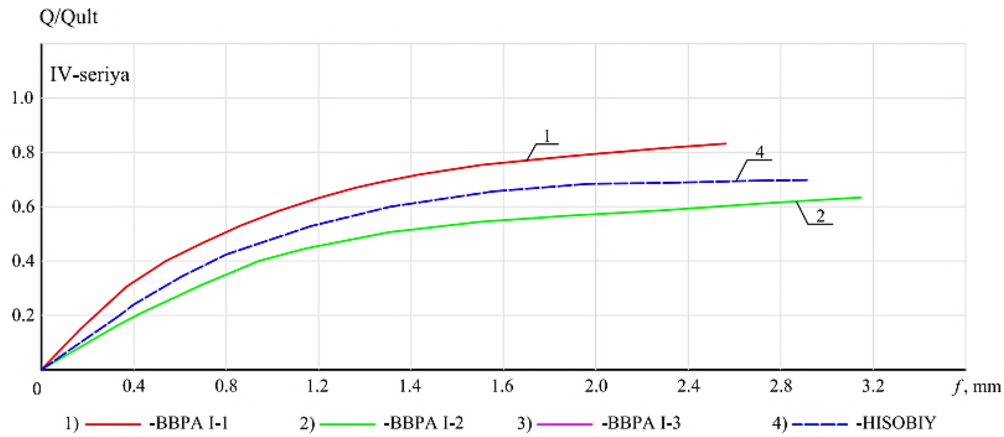

Figure 2. The development of cracks in sample beams

The values of operating loads corresponding to 0.5-0.65 Mult were the following values:

For I-series beams: $f_{ўр} = 2{,}8мм, \quad \frac{f_{ўр}}{l} = \frac{l}{730} < f_{ult} = \frac{l}{200}$

For II-series beams: $f_{ўр} = 2{,}6мм, \quad \frac{f_{ўр}}{l} = \frac{l}{855} < f_{ult} = \frac{l}{200}$

For III-series beams: $f_{ўр} = 3{,}2мм, \quad \frac{f_{ўр}}{l} = \frac{l}{720} < f_{ult} = \frac{l}{200}$

For IV series beams: $f_{ўр} = 3{,}4мм, \quad \frac{f_{ўр}}{l} = \frac{l}{674} < f_{ult} = \frac{l}{200}$

According to the test results, the stiffness of the sample beams does not exceed the limit values allowed in the standards.

CONCLUSIONS

1. The nature of the stress-deformation state of flexural concrete beams reinforced with basalt reinforcements under loads, the development of deformations in the longitudinal stretching and compression area, the increase of stiffness in the elements under the influence of force, the occurrence of limit states, and the form and nature of structural failure with flexural reinforced concrete elements with steel reinforcement. was found to be the same.

2. Under forces, it was observed that the stiffness in the sample beams increased in accordance with the force value: at low loads, the stiffness increased almost linearly, while at high loads, their sharp increase was observed. It was observed that the amount of coolness determined in the experiment satisfactorily agrees with the theoretically calculated values.

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