The Development of Deformation in Concrete and Reinforcement in Concrete Beams Reinforced with Fiberglass Reinforcement

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ABSTRACT
This article presents experimental data on the development of deformations in longitudinal reinforcement and concrete in the compressed zone of the section of bent concrete beams made of ordinary heavy concrete, equipped with fiberglass composite reinforcement under the action of transverse forces.

KEYWORDS: *fiberglass composite reinforcement, heavy concrete, longitudinal reinforcement, clamp, shear force, bending moment, normal, oblique crack, deflection.*

Introduction

The Fergana Polytechnic Institute has carried out complex experimental and theoretical studies to determine the stress-strain state of flexible concrete beams equipped with fiberglass composite reinforcement, under the action of transverse forces, the formation and development of cracks in them, stiffness, deformation and strength. For experimental studies, prototype models of beams were made, equipped with composite reinforcement, with a cross-sectional area of 16x30 cm and a length of 240 cm. The beams were concreted with wooden formwork. The inner surface of the molds was covered with metal sheets. 2Ø12 or 2Ø16SHKA in the elongated zone, 2Ø10SHKA in the compression zone as working reinforcement, Ø4 or Ø8SHKA as clamps were installed with a pitch of 15 (10) cm. The composite reinforcement for the clamps was woven and attached to the longitudinal reinforcement with soft steel wire. The fittings were installed and attached to the molds at the construction site. Simple heavy concrete was used for the beams. The composition of the concrete was selected in such a way that its cubic strength had a compressive strength corresponding to the V20-V25 class.

Methods of experimental research

Samples of beams of four series were tested for bending on a force stand. The stand is specially made, which allows you to check the pure bending of the middle part, loading the beams with two accumulated forces. The beams were installed on 2 hinged supports of the test bench. One of the loops is stationary, and the other is movable. The distance between the forces was 700 and 1300 mm, and the distance from the supports to the load was 700 and 400 mm. The distance from the base to the edge of the beams is 150 mm. The cargo was delivered by a 40-ton hydraulic jack. For this, distributing traverses were used. Prior to testing, initial measurements were recorded on all instruments mounted on the sample beam. These numbers were taken as "conditional zeros". The download took place in several stages slowly.

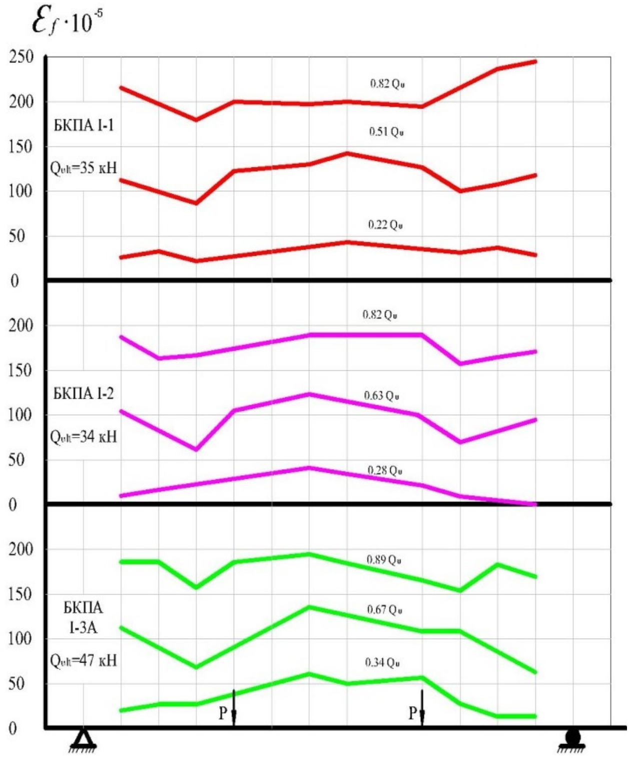
The step load was approximately 10% of the design breaking load. After loading, at each stage, it was expected to stabilize up to 20 min. After applying each phase load and at the end of the phase, the readings of the measuring instruments were recorded. Deformations of concrete and reinforcement, beam cooling, cracking time (load) and opening width were measured prior to specimen failure. The value of the load was recorded from the jack manometer. When the load reached the set value, the jack valve was closed and held at this value for 15-20 minutes. After the readings were recorded by the instruments, the load of the next stage was given.

Thus, the tests were continued, and the samples were kept until they were broken. Deformations were measured using a portable messur with hour indicators with an accuracy of 0.01 mm at bases of 100 and 300 mm, between three points of the center-to-center spacing and on supports using hour indicators of 0.01 mm and 0.001 mm. deflection meter.

Deformations of tensile and compressive reinforcement, as well as the area of concrete compression were measured on bases of 100 and 300 mm at three predetermined points along the section height.

Results

In the case of flexible concrete elements with composite reinforcement, it was found that the deformations of the longitudinal reinforcement along the length of the sample beams under the influence of forces are unevenly distributed (Figures 1, 2).



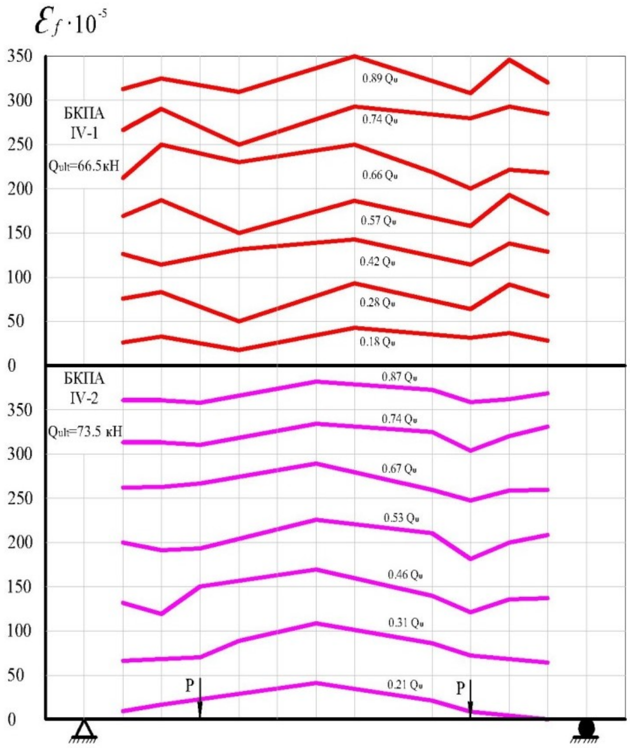


Figure 1. Distribution of deformations of longitudinal elongated reinforcement along the length of the sample beams of series I with reinforcement coefficient $\boldsymbol{\mu_f = 0,64\%}$ with longitudinal elongated reinforcement.

Figure 2. Distribution of deformations of longitudinal elongated reinforcement along the length of the sample beams of series IV with reinforcement coefficient $\boldsymbol{\mu_f = 0,94\%}$ with longitudinal elongated reinforcement.

The deformation increases in proportion to the increase in the load until cracks are formed in the longitudinally stretched reinforcement. In this case, the values of deformations in the region of pure bending were slightly higher than in the region of shear under the action of shear forces. The deformations of the longitudinal reinforcement began to grow faster after the formation of normal cracks along the longitudinal axis of the section in the elongated sections of the beams. This was especially noticeable at the intersections of reinforcement cracks. Deformations of longitudinal reinforcement in the pure bending zone before the formation of normal cracks were 2-3 times greater than in the shear interval. For example, in model beams of series I, the deformations of longitudinal working reinforcement before the formation of normal cracks in the pure bending area were $\varepsilon_f = (44 - 46) \cdot 10^{-5}$, and the deformations in the shear range of these reinforcing elements were equal to $\varepsilon_f = (15 - 25) \cdot 10^{-5}$.

In series IV beams, the deformations of the longitudinal working reinforcement were in the zone of pure bending $(42\text{-}44) \cdot 10^{-5}$, as well as in the shear range $(12\text{-}25) \cdot 10^{-5}$ (Figures 3-5). This case corresponds to the cult values of the loads $Q=(0,18\text{-}0,21)Q_{ult}$.

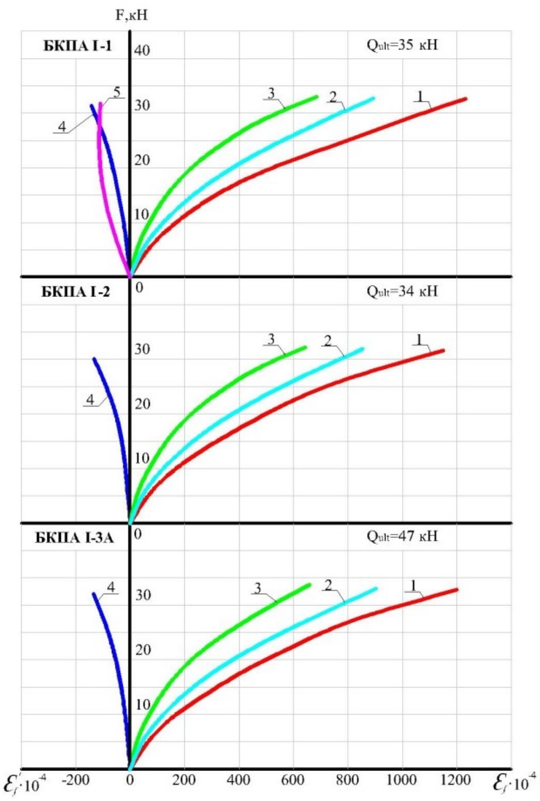


Figure 3. Average relative deformations of sample beam reinforcement of series I: 1 in the pure bending areas of elongated working reinforcement; 2,3 in the cutting

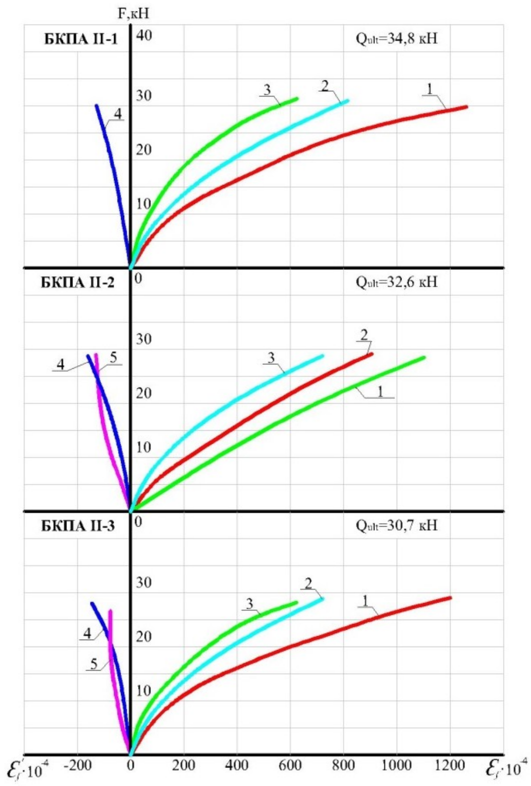


Figure 4. Average relative deformations of the reinforcement of exemplary beams of the II series: 1 - in the zones of pure bending of elongated working

range of elongated working fittings; 4 in the pure bending areas of the compression fittings; 5 In the cutting areas of compression fittings

reinforcement; 2.3 in the cutting range of elongated working reinforcement; 4 in areas of clean bend of compression fittings; 5 Where compression fittings are tapped

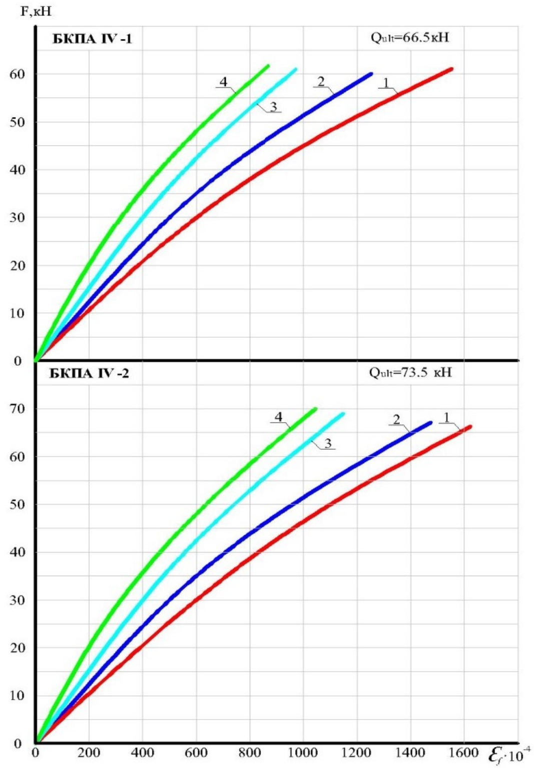


Figure 5. Average relative deformations of beams of samples of beams of series IV: 1 lower elongated reinforcement in the zone of pure bending; 2 upper elongated reinforcement in the pure bend zone; 3 lower elongated fittings in the cutting area; 4 upper elongated fittings in the cutting area

After the formation of normal cracks in the sample beams relative to the longitudinal axis of the cut, the deformations in the longitudinal working reinforcement increased to (150-220)·10^{-5} in the pure bending area and (50-100)·10^{-5} in the shear areas. The formation of sloping cracks also led to an increase in deformations (150-250)·10^{-5} in the longitudinal working reinforcement even at the shear interval.

The subsequent increase in loads led to a slight "flattening" of the deformations of the longitudinal working reinforcement along the length of the beams. Thus, as the loads increase, the deformations in the longitudinal working reinforcements also increase. Deformations of longitudinal working armatures were found to be in the range of (300-400)·10^{-5} when the amount of loads was in the range of (0,8-0,9)Q_{ult}. According to the measurement results, stresses (80-120)MPa are formed in the longitudinally elongated fittings before cracks are formed. The average relative deformations of the elongated working armatures in the net bending area increase continuously according to the curvilinear pattern with increasing load, with a faster increase, especially at high values of load (see Figures 3-5).

It was observed that when the amount of load is close to the breaking forces, the deformations in the reinforcement reach values (1000-1200)·10^{-4}. From the graph it can be determined that in such cases the tensile stresses in the fittings are 520-650 MPa.

The deformations of the beams in the elongated longitudinal reinforcement in the shear range were 1.2–1.5 times less than in the pure bending areas. In these reinforcements, a sharp increase in deformations was observed only when the maximum loads were applied, i.e. before the boundary condition occurred in the girder, and the beams approached the deformations of the reinforcement in the areas of pure bending.

The load on which the deformations are applied in the compressive longitudinal reinforcement (0,4-0,6)Q_{ult} increased slightly along an almost straight line until the culvert values were reached. As a result of the subsequent increase in loads, the graph began to change along the curve, and a slight increase in deformations was observed. Compression deformations up to the values $\varepsilon_f^{'} = (100 \div 150) \cdot 10^{-4}$ were observed in the reinforcement in the compression area when the beam samples were close to the fracture (Figures 3-5). From this it can be concluded that in the boundary conditions in the compressive longitudinal reinforcement stresses exceeding $\sigma_f^{'} = 100$ MPa are formed.

During the preparation of the sample beams, it was possible to measure the longitudinal compressive deformations of concrete on a 30 cm base on bars mounted on 3 levels in the concrete compression zone of the pure bending zone using the PMB-30 portable messura.

Longitudinal compressive deformations of concrete do not have small values when the applied force value is up to 20 kN, and their variation increases almost in a straight line. When the force reached 20 kN in the series I beams, the compressive deformations of the concrete reached $70{\cdot}10^{-5}$, $50{\cdot}10^{-5}$, $35{\cdot}10^{-5}$ respectively, at levels 60, 90, 120 mm below the maximum compressive axis. In the series IV beams, the value of these compression deformations was $45{\cdot}10^{-5}$, $25{\cdot}10^{-5}$, $20{\cdot}10^{-5}$, respectively, at the levels 30, 60, 90 mm below the maximum compressive strength (Figures 6-7).).

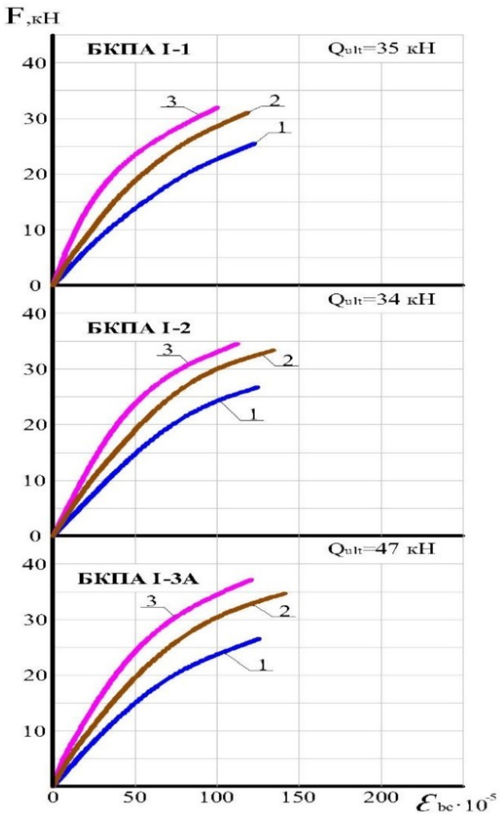


Figure 6. Average relative compressive deformations in the pure bending area of the

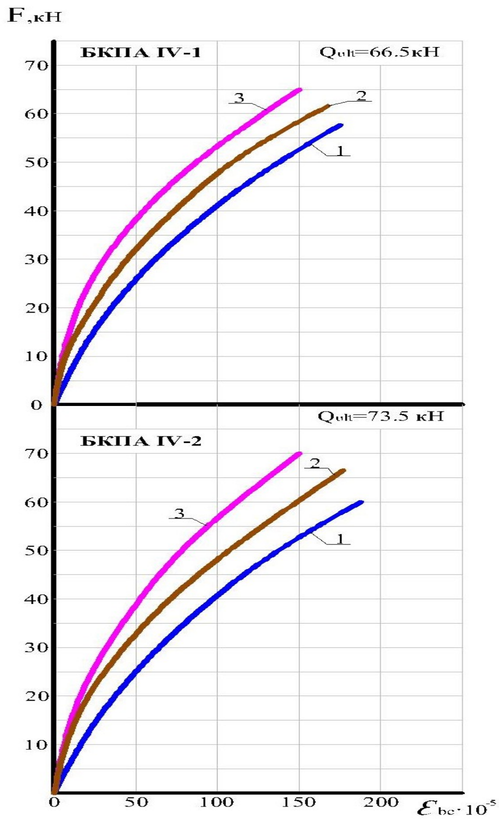


Figure 7. Average relative compressive deformations in the area of pure bending of

concrete of the I-series sample beams:

1 at a level of 60 mm from the maximum compression edge;

2 at the level of 90 mm from the maximum compression edge;

3 at the level of 120 mm from the maximum compression edge.

concrete of sample beams of series IV:

1 at a level of 30 mm from the maximum compression edge;

2 at the level of 60 mm from the maximum compression edge;

3 at the level of 90 mm from the maximum compression edge.

An increase in loads at subsequent stages led to an intensive increase in longitudinal compressive deformations of concrete. It was noticed that when the value of the phase load in the sample beams approaches the breaking load, $Q=(0{,}85\text{-}095)Q_{ult.}$ The value of the maximum compression deformations of the cult reaches $(150\text{-}175)\cdot 10^{-5}$. At the final stage of loading, it was found that longitudinal compressive deformations of concrete reach $(150\text{-}175)\cdot 10^{-5}$, and stresses in concrete reach values within its compressive strength. In this case, the accumulation of inelastic deformations in concrete in the compression zone occurred after the magnitude of the step load reached 35-40% of the breaking load.

Conclusion

1. The nature of the stress-strain state of flexible concrete beams reinforced with fiberglass composite reinforcement, the formation, development and opening (expansion) of normal and oblique cracks, the development of deformations during longitudinal elongation and compression, an increase in the force on the elements, the presence of boundary conditions, the shape and nature of the arrival and destruction structures turned out to be qualitatively the same as for reinforced concrete elements with steel reinforcement.
2. The maximum deformations formed in the longitudinally elongated reinforcement indicate that they develop tensile stresses in amounts that reach the design resistance of the composite reinforcement. Deformations in compressed longitudinal reinforcement reached values $(100\text{-}150)\cdot 10^{-4}$. Deformations of the concrete compressive field indicate the formation of stresses equal to the compressive strength of concrete.
3. In experimental studies, the nature of the development of deformations in fiberglass reinforcement and concrete and the determination of their magnitude additionally enrich the theoretical data and serve as the basis for determining the calculation methods for such structures.

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