Strengthening of brickwork composite reinforcement cage

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Abstract. The article discusses methods of strengthening brickwork using composite materials. These techniques have not been widely used in Uzbekistan due to the lack of a regulatory framework that would regulate their use. The article analyzes the existing methods of reinforcement of brickwork, and also suggests a method for calculating these methods of reinforcement with conclusions and recommendations based on it. The purpose of the work was to review the technology and analyze the advantages and disadvantages of each of the methods that should be used when choosing solutions to strengthen masonry. In conclusion, the need for further tests was confirmed in order to confirm the theoretical conclusions with practical results.

1 Introduction

Many buildings in Uzbekistan are made of brick. Brick as a building material combines such qualities as: strength, durability, environmental friendliness, low thermal conductivity, architectural expressiveness and many others. Uneven precipitation of soils, the effects of atmospheric precipitation, temperature differences, shortcomings and errors of design solutions, non-compliance with technological and operational standards and regulations—all this accelerates the process of destruction of masonry. Timely repair and reinforcement of the building’s load-bearing structures keep it in working condition. The issue of ensuring the durability of brickwork has always been relevant [5]. The purpose of the work is a technical and economic analysis of the reinforcement of brickwork with composite materials of building structures of buildings and structures, as well as a description of the general technology with an analysis of the advantages, disadvantages and effectiveness of each of the methods that will serve as recommendations when choosing works to strengthen brickwork.

The main methods of strengthening brick structures are:
- strengthening with clips,
- strengthening with strained belts made of steel,
- strengthening with composite materials.

The first study of the strength of masonry reinforced with a cage was carried out in 1936 by V.A. Kameiko. Brick pillars with a cross section of $51 \times 51$ sm and a height of 2.5 m were...
2 Materials and methods
Alternative methods of strengthening stone structures:

1. Strengthening of brickwork with composite materials

Description of elements and technology for strengthening prototypes:

Prototypes of brick pillars with a cross section of 380 × 510 mm at a height of 1183 mm were manufactured and tested in the laboratory of the Fergana Polytechnic Institute. Figure 1 shows the diagrams of experimental samples of brick pillars.

To determine the value of tensile strength (average tensile strength) and the calculated compressive strength of the masonry, compression and bending tests were carried out on 6÷10 control samples of bricks selected from each batch supplied by the brick factory, and mortar cubes measuring 7.07×7.07×7.07 mm, manufactured in the process of laying experimental samples of brick pillars [5][10].

Determination of the load-bearing capacity of masonry reinforced with plaster casing.

The following material and dimensions were adopted for this research work; Brick brand - M10.

M solution – M75.

Column cross-section b×h = 510х380 mm.

Column height = 1183 mm.

Coefficient mg =1.

Coefficient mb =1.

The characteristics of the plaster casing were assigned:

Cement-sand mortar M75. Layer thickness 50 mm.

Reinforcing mesh made of glass composite with a diameter of Ø4 mm (A_s = 10.03 mm²). R_s = 330 MPa. Grid cell – 100×100 mm.

Calculated masonry resistance

\[
\lambda = \frac{H_{col}}{h_{col}} = \frac{1183}{380} = 3.11
\]

\[
\varphi = \frac{1}{1}
\]

\[
R = \frac{n}{MPa}
\]

\[
\mu = \frac{A_s(h_c + b_c)}{h_c \times b_c \times S} = \frac{10.03(380 + 510)}{380 \times 510} = 0.033
\]

\[
\psi = \frac{1}{n} = \frac{1}{n}
\]

\[
m_k = \frac{1}{n}
\]

\[
A = b_c \times h_c = 380 \times 1183 = mm
\]
Thus, the bearing capacity of brick pillars reinforced with composite reinforcement is 663 kN.

Tests of control brick samples for compression and bending were carried out in accordance with the requirements of GOST 530-2007 “Ceramic bricks and stone. General technical conditions.” The strength of the mortar in the joints of the brickwork of the prototypes was determined in accordance with the instructions of GOST 5802-86 “Building mortars. Test methods.”

To strengthen the brick pillars, RGC glass-composite reinforcement, developed by local manufacturers, was used. The glass composite reinforcement used in the experiment has the following characteristics (properties of the original fiber):

- Elastic modulus: 55000 MPa
- Tensile strength: 1200 MPa
- Elongation at break: 2.2%
- Durability: Predicted durability of at least 80 years

Experimental samples of brick pillars were tested in the structural testing laboratory of the Fergana Polytechnic Institute according to the methodology developed and used at the institute.

The adopted scheme for fastening the column at the upper and lower levels corresponded to the hinged connection of the structure with the press supports.

Figure 3 shows a diagram of the arrangement of measuring instruments for measuring the magnitude of vertical and horizontal deformations of the masonry during its compression. Deformation measurements were carried out using dial indicators with a division value of 0.01 mm.

Fig. 1. View of experimental samples of brick pillars. Reference sample (a, b) and prototype (c).
The load on the prototype brick pillars was applied in steps of approximately 10% of the expected value of the breaking load. The interval between loading steps was 8÷10 minutes.

At the beginning and at the end of each loading stage, masonry deformations were measured.

3 Results and discussion

Based on the analysis of the test results of brick pillars reinforced with glass-composite reinforcement samples, and comparing them with the test results of reference (non-reinforced) prototypes, the following was established.

1. The nature of the deformations of the brickwork of the reference samples allows us to state that the loading of the reference samples was close to central compression. Herein:
   - the values of the eccentricities of the load application relative to the longitudinal axis (according to the thickness of the sample h = 380 mm) changed in the test samples in the range from 0.46 to 1.10 mm;
   - the first hairline vertical cracks appeared in the middle part along the length (b=510 mm) of brick pillars under loads of (0.8÷0.85) x N failure;
   - the destruction of the brickwork of the reference samples occurred at loads equal to 429.2kN, 424.3kN and 431.0 kN. At the same time, the average value of the temporary compressive strength of the brick masonry pillars corresponded to R_u = 2.26 MPa with the calculated compressive resistance of the masonry = 1.3 MPa (brick grade M100, mortar – M7.5).
   - the destruction of the brickwork of the samples occurred at loads equal to 668, 674, 6681 kN. At the same time, the temporary compressive strength of the brickwork of the pillars was 3.51, 3.48, 3.51 MPa. The coefficient K varied in the range from 3.47 to 4.17 with a normalized value of K=2. Those. with the reinforcement scheme adopted in the samples, the strength of the masonry increased in comparison with the reference samples by more than 2 times;
   - in the reference (unstrengthen) test samples under loads close to destructive (350kN ≈ 350N kN), the values of the maximum transverse deformations of the masonry averaged (30.5 x 10^{-10}) µ,
   - under loads close to destructive, in the reference samples, due to large transverse deformations of the masonry, vertical cracks formed in the section averaged over the height.
of the sample, with the division of the sample masonry into separate columns with their subsequent crushing.

At the moment of destruction of the prototypes, the brick was crushed and split (due to large transverse deformations) along the contour of the pillar. At the same time, the formation of vertical cracks in the samples was not detected; (Table 1)

Table 1. Test results of samples

<table>
<thead>
<tr>
<th>Sample series</th>
<th>Sample cross-section size (mm)</th>
<th>Brand of brick/mortar</th>
<th>Experimental breaking load N (kN)</th>
<th>Temporary compressive resistance of masonry $R = \frac{N}{A}$ (kN)</th>
<th>Eccentricities of load application relative to the transverse and longitudinal axes $e_x$, $e_y$ (mm)</th>
<th>$\psi = \frac{e_x}{e_y}$</th>
<th>$\omega$</th>
<th>$R_{rel} = \frac{R_0 \cdot k}{\omega \cdot \psi}$ (MPa)</th>
<th>Relative strength of masonry (%)</th>
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4 Conclusion

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