The Influence of the Central Asian Climate on the Strength Characteristics of Brick Masonry

Sanaeva Nargiza Paizullaevna
Samarkand State Institute of Architecture and Civil Engineering

Annotation: The article presents the results of an experimental study of the influence of temperature and relative humidity of the environment and sunlight on the strength characteristics of brickwork. The strength of the masonry is greater the thicker the stone, as the resistance of the stone to bending and cutting increases. The more correct the shape of the stone, the greater the strength of the masonry, as there is a more uniform transfer of the load.

The climate of Central Asia is sharply continental and the temperature of environment (air), in the hottest days, reaches up to 45-50°C degrees celcius, with relative humidity of 12-17%. At night, the temperature drops to 20°C, at relative humidity of 40%.

Change the in daily temperature on the hotlist day and relative air humidity for the Samarkand city are shown in (fig 1). As it can be seen from the Figure, the daily temperature difference is about 15-17°C, and the humidity is about 15-20%. The strength is also affected by the uneven thickness of the mortar in the joints between the rows, which is created due to the curvature of the surface of the stones. The strength of the masonry varies depending on the thickness of the mortar joints. Increasing the thickness of the seam improves the filling of stone irregularities with mortar, which has a positive effect on the strength of the masonry. However, an increase in the thickness of the seam leads to an increase in tensile forces acting in the masonry in the transverse direction. This is because, during compression, the transverse deformations of the mortar are much greater than the transverse deformations of the stone. Therefore, the masonry is destroyed during compression from tensile forces in the stone, which have arisen under the influence of transverse deformations of the solution. All this ultimately leads to a decrease in strength. Masonry. With this in mind, the thickness of the vertical seams of brickwork is 10mm, horizontal - 12 mm.

Increasing the mobility of the mortar by increasing the water-cement ratio does not reduce the strength and density of the brickwork mortar, since during laying the brick quickly sucks water out of the mortar in an amount exceeding the water-holding capabilities of the mortar. It should be noted that the increase in the mobility of the solution, which is achieved by the introduction of organic plasticizers, leads to a decrease in density and an increase in the deformability of the solution. Therefore, in order to prevent the occurrence of large horizontal forces in the brick, it is not allowed to introduce plasticizers in an amount that reduces the density of the solution by more than 6%, since this leads to a significant decrease in the strength of the masonry.

The strength of the masonry is influenced by the size and shape of the masonry elements, the method of dressing, the adhesion of the mortar to the stone, etc.

Reducing the cross-sectional dimensions leads to some increase in the tensile strength of the masonry.

Round and square cross-sectional elements are more durable than tees and other complex shapes,

The greatest influence on the strength of the masonry has:
a) the strength of the stone; an increase in the compressive strength of the stone by 2 times increases the strength of the masonry by 1.6-1.8 times; the strength of brickwork, in addition, depends to a very large extent on the resistance of the brick to bending and shear;  

b) the size of the stone; the greater the height of the stone, the greater the moment of resistance of its section and, consequently, the less the influence of the resistance of the stone to bending and shear; with an increase in the height of the stone, the strength of the masonry, ceteris paribus, increases significantly (Fig. 1);  

c) the shape of the stone; in masonry of irregularly shaped stones during compression, local stress concentrations are very high and, in addition, the resistance of masonry to shear along poorly tied sections decreases; therefore, for example, masonry made of torn rubble stone of high strength, even on a strong mortar, has a tensile strength equal to only 2-6% of the strength of the stone;  

d) the presence of voids in the stone; masonry from hollow stones, as a rule, is weaker than masonry from solid stones with the same strength of the stone due to the uneven distribution of stresses in the masonry; the degree of this decrease in strength depends on the shape and location of the voids in the masonry and may be minimal for masonry of optimal types of hollow stones;  

e) the strength of the solution is significant and the greater, the smaller the height of the stone; an increase in the strength of the mortar from 4 to 100 kg / cm² increases the strength of ordinary brickwork by 1.8-2 times; the density of the solution is also essential; the use of porous, highly compressible mortars (for example, on light aggregates) reduces the strength of the masonry by 10-30%;  

f) the quality of the masonry; uneven surface and uneven mortar density in horizontal joints, poor filling of joints, etc. significantly reduce the strength of the masonry; if we take as 100% the average tensile strength of manual brickwork established by the norms with its usual quality, then with a lower quality, the strength of the masonry is only 80-85%, and with very high - 150-160%; vibrating brickwork significantly improves the filling of joints, which is one of the reasons for the large increase in the strength of vibro brick work compared to conventional; the use of hard, hard-to-lay mortars worsens the quality of the seams and reduces the strength of the masonry by 10-15%;  

g) Dressing masonry; has a very significant significance for eccentric application of loads, under the action of horizontal loads (for example, seismic), with winter masonry laid out by freezing, etc.;  

h) Adhesion of the solution to the stone; is of decisive importance in cases where the masonry works in tension or bending.  

Deformability of masonry  

As in concrete, deformations of brickwork under load are made up of elastic $\varepsilon_e$ and inelastic $\varepsilon_p$, manifested during prolonged action of the load. Their main source is creep deformations developing in mortar joints.  

$$\sigma = 0.2 \cdot R_u \quad (1)$$  

where $R_u$ is the temporary resistance of the masonry to compression, the masonry works elastically.  

For unreinforced masonry, deformations are expressed by the initial modulus of elasticity  

$$E_0 = \alpha \cdot R_u \quad (2)$$
where \( \alpha \) is the elastic characteristic of the masonry

\[
R_u = k \cdot R
\]

where \( k \) is a coefficient depending on the type of masonry

For reinforced masonry

\[
E_0 = t g \varphi_0(3)
\]

At higher stresses, the strain modulus becomes a variable value equal at each point of the \( \sigma - \varepsilon \) secant strain modulus curve

\[
E = \frac{\sigma}{\varepsilon} = t g \varphi_1(4)
\]

When calculating structures for strength in accordance with the standards

\[
E_0 = 0.5 \cdot E(5)
\]

When determining the deformation of the masonry from longitudinal or transverse forces, the period of oscillation of the masonry, stiffness, the deformation modulus is taken equal to

\[
E_0 = 0.8 \cdot E(6)
\]

Masonry in low and high temperatures

Negative temperature is reflected in the process of conducting stone work. A bricklayer in warm clothes and mittens under the influence of cold leads the masonry less accurately. The properties of materials change, mainly the mortar, which, when frozen, unlike other materials, increases in volume up to 9%, and before freezing it quickly loses mobility and poorly fills narrow cracks in the masonry. As a result, the solution not only loses its strength, but also does not provide the proper solidity of the masonry and contributes to its increased uneven deformability. Consider the physical processes occurring in the winter masonry. When laying a warm mortar on a cooled brick, due to gravity (gravitation to the ground) and a gradient (difference) of temperatures, water goes into the lower bricks when laying the mortar. The solution is dehydrated loses mobility and is not compressed by the upper brick. Upon further cooling, the remaining water turns into ice. Increases in volume, loosening the seam and preventing its adhesion to the bricks. As a result, the hardening of the mortar resumes, but due to the lack of the proper amount of water, the processes of hydrolysis and hydration of the cement proceed sluggishly, the mortar that is not compressed during laying gives a large and uneven shrinkage. As a result, winter masonry differs from summer masonry in greater deformability and lower strength. Moreover, the more, the earlier it was frozen.

With this in mind, a number of methods for performing stone work in winter have been developed. The freezing method lies in the fact that the masonry is carried out in the same way as in summer, but on a heated solution. In this case, at negative temperatures, no more than four floors (15 m) can be erected; it is forbidden to carry out masonry from torn buta. Mortar during laying on average should be warmed up to the absolute temperature of the outside air. Brick and stone must be laid in a single-row dressing system, with full filling of seams. The mortar during laying is spread no more than 2 bricks when making a verst; no more than 6 ... 8 bricks when laying
backfill. During the thawing period, control over the deformation of the masonry should be carried out and, if necessary, measures should be taken to unload it and temporarily strengthen it. Construction practice has shown that if the mortar in the masonry acquires 20% of its design strength (critical strength) before freezing, then this is enough for the further safe operation of the stone structure. This phenomenon is the basis of a number of stonework methods using any masonry bonding system. Masonry on solutions with antifreeze additives can be used at ambient temperatures down to -35 °C. This is based on the property of solutions of a number of salts to freeze at a negative temperature, which provides conditions for the hardening of mortars within certain limits at negative temperatures. At temperatures down to -15 °C, sodium nitrite (NaN02) is used in construction, at lower temperatures - a mixture of nitrites, nitrates and chlorides, as well as potash (K2C03). However, with the exception of sodium nitrite, the listed salts have a number of properties (rapid setting of the mortar, corrosion of reinforcement, efflorescence and hygroscopicity of walls, etc.), which make it difficult to widely use them, especially in the construction of residential buildings. etc.) can only be carried out from inside the enclosed space. At the same time, it is desirable that at this time the masonry is heated from the outside by the sun's rays, since otherwise it may lose balance as a result of one-sided warming. The previously recommended steam heating and electrical heating of the masonry, as well as the use of fast-hardening mortars, have not received wide distribution. Used in some countries (Canada, Germany), laying in greenhouses under a film coating creates working conditions similar to summer ones. In our country, this method has not yet received distribution. For masonry in a hot climate, early work is typical, a break from 12:00 to 17:00, and then work continues. During breaks in work, the masonry is covered with auxiliary sun protection coatings. A complex solution of a cast consistency of composition 1:1:6 ... 1:1:8 is used (cement: lime or clay: sand). Brick before laying is immersed in water and held until full water saturation; before laying the solution, the previously laid out row is wetted. Material storage areas and workplaces are shaded; water tanks, bunkers with a binder component and filler are painted with white paint.

![Figure 1: Change of temperature and relative environmental humidity for the city of Samarkand:](image)

Figure 1: Change of temperature and relative environmental humidity for the city of Samarkand:

- Humidity;   - temperature.

In addition to the temperature and humidity of the environment, the sun's rays also act on the brickwork from the impact of which the temperature on the surface of the masonry cans rich up to 60°C.

The influence of the environment can be considered as a variable effect on the brickwork, which negatively affects the work of the structures [5].

Currently temperature and humidity are not taken into account when designing multi-story brick buildings, only the length of the building is limited on the bases of the requirements without appropriate calculations [2].
Analysis of published results of the study of strength, the bearing capacity and the durability of the structures of brick buildings, led to the conclusion that systematic and targeted studies of the effect of variable temperature and relative humidity on the strength and state of stress and strain were not carried out.

In the published works, devoted to the study of brick structures, mainly methods were considered to prevent cracks in the outer walls of brick buildings and strengthening the corners of the buildings, to eliminate cracks that appear on the sides of window openings. Most of the studies were carried out in laboratory conditions at normal temperature and relative humidity, which are sharply different from the temperature and humidity of the environment.

To assess the effect of temperature and humidity and sunlight on brickwork in accordance with GOST (standard), four series of brickwork samples were made and tested [1].

The strength characteristics of bricks and mortar, were determined in the accordance with the requirements of the GOST by testing brick and mortar samples in the scientific laboratory of the Department of “Building Construction” of the state Architectural and Civil Engineering Institute (fig 2). The strength of the brick was $R = 10$ MPa, and the mortar strength was $R = 2.5$ MPa [3,4].

Samples of the M-1 (masonry) series were kept in an open environment under the influence of sunlight (fig 3, a). Samples of the M-2 series were kept in an open environment and protected from exposure to sunlight (fig 3, a). The third series of the M-3 samples were kept in laboratory conditions at normal temperature and relative humidity (fig 3, b). The fourth series of samples M-4 were made with violations of the masonry technology and were in an open environment under the influence of sunlight (fig 3, a).
The main samples were exposed to climatic influences for 90 days. During this period, the temperature and relative humidity of the environment were measured [6], longitudinal deformations of the masonry (fig 4). On day 90, the samples were brought to destruction (fig 5).

![Figure 4: Longitudinal deformations of masonry: 1-M-1, 2-M-2, 3-M-3.](image)

![Figure 5: Destruction process of samples.](image)

The results of experimental studies are shown in Table. 1 and 2. Based on the results of the experimental studies, it was found that temperature and relative humidity, as well as the sunlight, negatively affect crack resistance (Table 1), and the strength characteristics of brickwork (Table 2).

![Graph showing strain and temperature](image)

**Table 1**

<table>
<thead>
<tr>
<th>Sample series</th>
<th>M-1</th>
<th>M-2</th>
<th>M-3</th>
<th>M-4</th>
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</thead>
<tbody>
<tr>
<td>N&lt;sub&gt;ср&lt;/sub&gt;, kN</td>
<td>698,72</td>
<td>521,11</td>
<td>359,57</td>
<td>301,2</td>
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</tbody>
</table>

**Table 2**

<table>
<thead>
<tr>
<th>Sample series</th>
<th>M-1</th>
<th>M-2</th>
<th>M-3</th>
<th>M-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, kN</td>
<td>723,24</td>
<td>685,47</td>
<td>625,17</td>
<td>416,78</td>
</tr>
</tbody>
</table>

**Conclusion.** As a result of exposure to variable temperatures from 20 °C to 50 °C and relative humidity of the environment from 12 to 40%, the crack resistance of brickwork samples under laboratory conditions by 48%, Durability increased by 13%.
References