ENGINEERING ANALYSIS OF STRUCTURES AND ASSESSMENT OF THE TECHNICAL CONDITION OF ARCHITECTURAL MONUMENTS

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https://doi.org/10.5281/zenodo.7550028

Abstract. *Historical monuments that have survived to this day are considered a precious source that reflects the knowledge, experience and development of the handicraft tradition of our people. The contribution to the creation of the invaluable art of the architecture of the East of our ancestors, their mind and efforts deserve respect. Thus, historical monuments created from simple bricks make the whole world admire for many centuries their unique skill of erection and grandeur. The secrets of the longevity of ancient monuments that have been preserved for many centuries, the details of their construction have come down to our times from the rich heritage of history.*

Admirable are the decorations of domes and vaults, their coverings, which still have not lost their brilliance and attractiveness, as well as testifying to the unique and eternal achievements of the ancient art of architecture. In connection with this, the preservation and preservation of historical monuments is considered an important task, which is of great importance for the cultural heritage of the whole world. Unfortunately, the technical condition of most of the monuments today is unsatisfactory.

The emergency state of architectural monuments occurs due to the impact on them over a long period of time of various factors (earthquakes, various man-made, climatic changes), as well as due to the weakening and change in the composition of the soil under the foundation of the monument.

For the reconstruction of architectural monuments, monitoring of structures of the technical condition and the use of non-destructive methods for this purpose are used. The composition of such studies includes certain stages: the space-planning system of the building, constructive solutions for elements, description of damage, study of the composition of the foundation, determination of the previous and current seismicity of the territory, numerical studies of structural movements and their monitoring.

This article provides an assessment of the technical condition of the Kok Gumbaz mosque located in the city of Shakhrisabz based on instrumental checks and visual observations. Suggestions and recommendations for the elimination of certain defects, damages and deformations are given.

Keywords: *art, mosque, galleries, reconstruction, dome, drum, brick, monument, portal, earthquake, foundation, cracks, damage*

Introduction

Survey of modern the state of functioning historical architectural monuments located on the territory of the republic annually indicates an increase in the number of monuments that are in

the process of destruction and have received unacceptable deformations and damage. A deep analysis of literary sources, archival materials and the study of architectural monuments in nature shows that the issues of archeology, architecture, history and art history are quite well studied in these structures [2] .

Unfortunately, the design features of these structures, on which the stability and durability of structures mainly depend, have been little studied. Therefore, for various reasons (technogenic impacts, raising the level of groundwater, violation of operating conditions, etc.), it greatly worsens the condition of architectural monuments. For specific objects, there is no documentation and data on space-planning and design solutions, engineering and geological conditions. These documents are often developed in cases where unique architectural monuments are in disrepair. For example, the destruction in 1995 of one minaret of the Chor-Minor complex in Bukhara, the extremely emergency state of the structures of the Tilla Kori mosque in Samarkand, the Oksaroy palace, Dorus Saodat and Dorut Tilovat in Shakhrisabz and the inclination of two in Khiva, etc.

This article discusses the criteria for visual inspection for the examination of the current state of domed and vaulted historical monumental stone structures in Uzbekistan. Part of the data presented is based on the author's PhD research. Examination of the state of the Kok Gumbaz mosque given as a building.

Methods

From 1925 to the present , significant research work has been carried out on the study of archeology, history, art and architecture of the Kokgumbaz mosque.

As is known from archival materials, the real mosque built in the time of Ulugbek has survived to this day in the form of a main array without galleries adjoining it from the north and south sides (Fig. 1) [3] .

In 1947-51, under the leadership of the architect A. Vinogradov, during the reconstruction and restoration work, the constructive outer side of the dome, as well as the coatings of the remnants of the drum, were covered with bricks and covered with lime cement. These measures prevented the destruction of the drum and the penetration of moisture into the dome.

According to the remains of bricks found during excavations carried out in the mausoleum of Qozizoda-Rumiy in the city of Samarkand, it can be concluded that the outer dome, as well as the dome of the mausoleum, was blue. The very name of the mosque Kok gumbaz testifies to the blue flowers in the dome [4] .

In 1973, with the assistance of a group led by the architect of the main department for the protection of historical monuments Sobirov V.G. measurement and research work was carried out in order to develop a project for the restoration of the mosque. And in 1976, under the guidance of architect Aronov A. and engineer Goldenstein Yu.E. a technical project for the restoration of the portal and the drum part of the Kok Gumbaz mosque was developed and implemented.

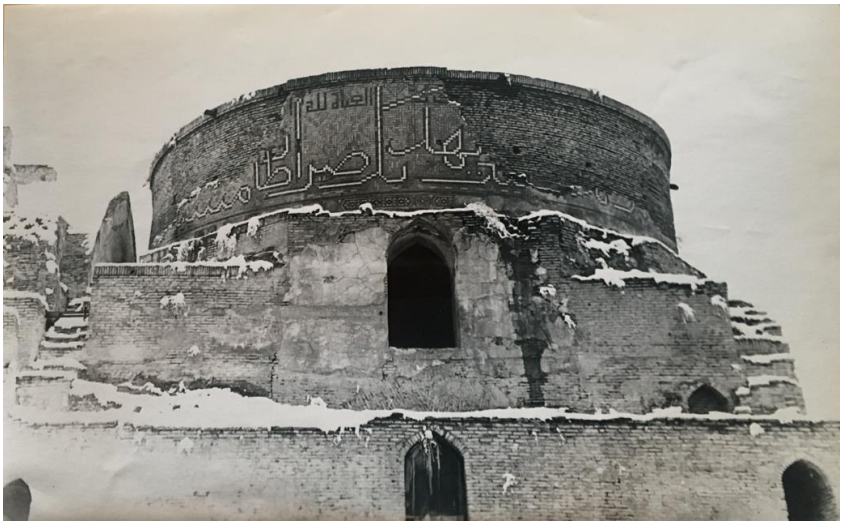
Results

The dimensions of today's mosque, if measured from the outer walls, are 38.7x84.0 m, in terms of the average mosque has a square shape and dimensions of 20.7x24.0 m, the internal dimensions of the room are 12.5x12.5 m, there are openings in all walls dimensions 4.6x4.6 m, depth up to 3.0 meters. The entrance to the mosque is made with a portal. The height of the entrance portal is 22.38 m. The roof of the mosque is designed with an inner and outer dome, the diameter of the inner dome is Ø13.5 meters, the outer one is 16.92 m. The total height (the highest point of the dome) of the monument is 31.65 meters. The dimensions in the balcony in the right

wing are 21.10x24.0 m. The balcony in the left wing is in the shape of “L” and has dimensions in terms of 39.85x38.70 meters. The prayer room of the mosque is rectangular in plan and has large gates and 4 auxiliary entrance doors on three sides [5] .

1 fig.

Facade of the northern part of the mosque (1976)



Judging by archival materials, in ancient times, the side parts of the mosque were destroyed under the influence of earthquakes and due to the fact that the density of soils in the surrounding area was low. In 1993-1994, these parts of the mosque were rebuilt. But the study revealed that the columns were erected on unfinished foundations, soft soils.

Mosque building structures. Mosque walls - from dense Muslim brick, 250x250x50 mm in size, the walls of other galleries are made of bricks made of M-75 cement and M-25 sand.

The walls between the doors and columns are brickwork in the shape of an arch.

Covers - domes

Around the structure - there is a masonry of limestone, concrete and sand 250x250x30.

Windows: only in the mosque, fences with national ornaments are installed.

The foundations of the mosque are brickwork on stucco mortar with dimensions of 250x250x50 mm and 300x150x50 mm. With high humidity, the foundation can be seriously jeopardized. Soil moisture increased by 37-48%. The foundations of the gallery parts are made at different heights and are located on the surface of construction debris. After a certain time, this circumstance can lead to trouble. The parts of the mosque erected in antiquity were destroyed under the influence of external forces. For several years, the foundations have been adapted to reduce the impact of a constant load. Not taking into account this circumstance, an additional load was added to the gallery of the monument during the reconstruction. When studying cracks, cracks and damages were found in the outer southern part of the drum (Fig. 2).

The foundation of the building "Kuk Gumboz Mosque" is made of brickwork. At the base of the foundation there are loose clastic soils, consisting of fragments of bricks, ceramics, sand with sandy-loamy aggregate. These soils are distributed to a depth of about 1.8-2.0 meters on the western side of the facade and 4.0-4.2 meters on the eastern side of the facade. Below lie loams with inclusions of sand and gravel. The soils of this layer have low density (ϬSK - 1.47-1.59 g/cm3) and strength (φ - 190) indicators.

The groundwater level lies at a depth of 4.5 meters at the western facade and 7.5 meters at the eastern one. Mineralization of groundwater is

2.66 g / l and water are characterized by a high content of nitrates, sulfates, hydrocarbonates, high hardness.

Of particular interest are the western and eastern facades.

On the western side of the façade, a waterlogged zone in the near-surface layer, up to 45 meters wide, was revealed, which adjoins directly to the dome. Within the same area, under the foundation, a zone of very weakly compacted rocks was revealed to a depth of about 4.5 meters.

On the eastern side of the facade, two waterlogged zones were also identified, adjacent to the structure, one 25 meters wide and the other 15 meters wide.

According to seismic tomographic data, the soils lying on the side of the eastern facade, to a depth of 4.0-4.5 meters, are in a very weakly compacted state. Based on the results of seismological observations, it was revealed that the seismicity of the territory is very high and is in the stage of seismic activation. An example is the 2016 Kitab earthquake with a magnitude of M-5.1, the source of which was located 15-20 km from the structure and caused a 6-point shaking in this area. It has also been established that the greatest risk is not distant, but near seismic events with a frequency of about 2.5-3.5 Hz. The natural oscillation frequency of the structure is 2.48-2.65 Hz. The frequency of short-range seismic events varies within 2.5-3.6 Hz, hence the probability of the occurrence of the resonance effect, which will lead to an increase in the amplitude of the vibrations of the structure, which, in turn, will give impetus to the development of deformation processes [6] .

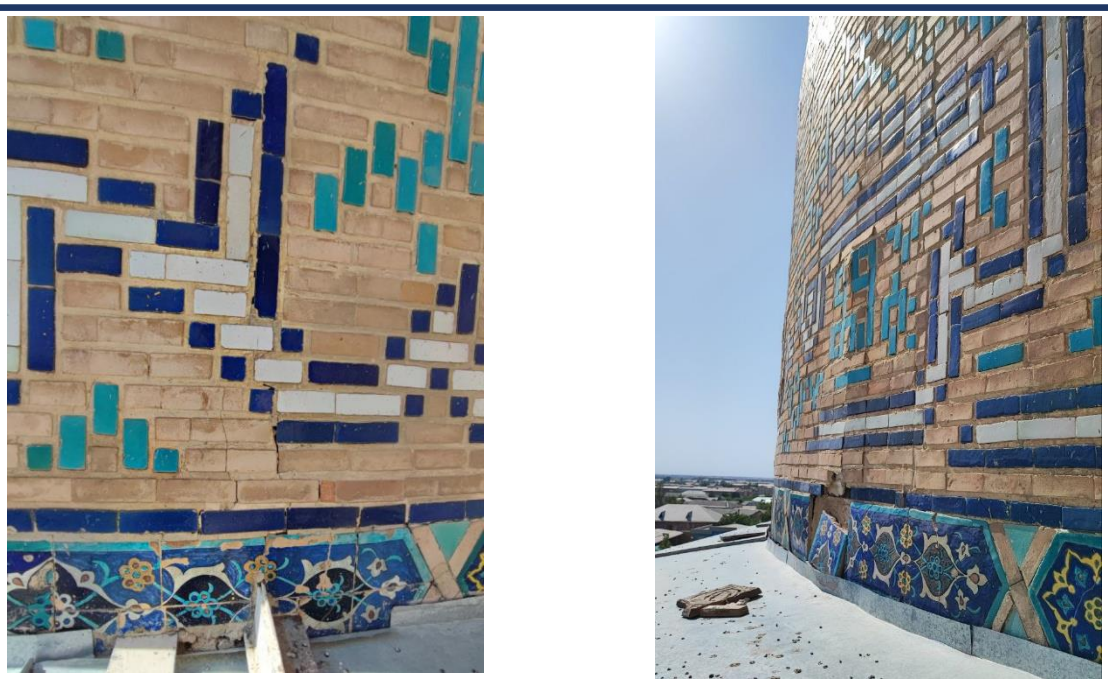
The mosque consists of two domes and no cracks were found during observations on the second floor, which means that these changes relate to cracks that appeared on the colored coating installed above the dome. There are 3-4 cracks on the surface of the southern wall. There are serious cracks in both balconies and they mainly appear from the shrinkage of the columns (3-fig.). Of the four parts of the mosque, pits were drilled and studied, on the basis of these studies it was found out that the foundations were built from various building materials over construction debris and at different heights.

The territory of the mosque is completely concreted, as a result, the evaporation that appears from underground moisture changes its direction, rises between the walls of the mosque and the walls of the entire historical monument are completely moistened (Fig. 4).

At a distance of 1.20 m from the western side of the mosque, pipes 300-D were laid, this pipe broke right under the mosque building, as a result, the surface under the foundations was filled with water. Under the strong influence of moisture, the soil under the platform began to change its position and settlement occurred.

2 fig.

Crack and deformation in the south outer side of the drum.



The back part of the arch of the historical monument, a certain part of the inner dome, as well as the octahedron are in a deplorable state, due to improper organization of wastewater drainage, for many years this water penetrated through the walls and managed to get moldy (Fig. 5). During the restoration work, the ventilation hatches intended for ventilation were closed, due to the lack of ventilation, the humidity had a serious impact on the brick and clay walls. Humidity on the walls had a negative impact on the finishing work of the interior of the mosque building and, as a result of damage in the exterior finishing parts, ceramic tiles were displaced from their original positions (Fig. 6).

There are cracks along the entire length and from bottom to top on the arches (chillakhons) of the room for the solitude of a Muslim for the purpose of fervent prayers and spiritual practices, in the side part of the mosque wall niche, indicating the direction to Mecca (qibla) (Fig. 7).

3-fig.

Cracks in the building of the mosque and between the galleries adjacent to it.

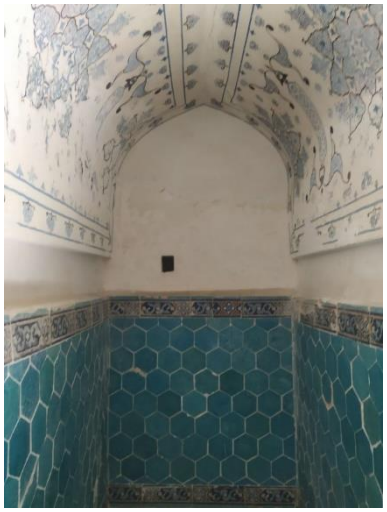
4-fig. Coverage on the territory of the mosque and its impact on the mosque


5-fig.

Mold caused by the accumulation of moisture on the walls of the mosque

7-fig.

Cracks that appeared on the arches are a room for the solitude of a Muslim for the purpose of fervent prayers and spiritual practices

Discussion

Although space-planning and constructive solution The buildings of the mosque were created to perfection, but due to the fact that, to date, due attention is not paid, the lack of control

and insufficient protection from external climatic factors had a strong negative impact on the complex.

As a result of studying changes in the prayer and gallery parts The main reasons for the appearance of cracks in the walls are the following:

- increasing the humidity of underground soils ***;***
- the hanging wings of a gallery built in 1944 over the walls of the mosque;
- uneven erection of the columns of the gallery and the foundation of the outer wall, as well as errors made in constructive solutions.

Several factors influenced the development of deformations in the mosque building.

The first factor is natural, these include long-term atmospheric precipitation, the location of groundwater close to the surface of the earth, loose tamping of soils under the base of foundations, and seismic activity of the territory.

The second factor has a technical characteristic, that is, poor sewage disposal due to malfunctions in structures, improper direction of sewage disposal, water leakage from underground utilities, irrigation of trees and green spaces on the territory of the structure, poor quality of work carried out on reconstruction.

Conclusions

By eliminating these negative factors, the stability of the structure can be ensured.

It is necessary to take measures to reduce the level of underground water in the territory of the structure by creating a horizontalth or vertical drainage.

Tidy up the drainage system from surface runoff from the roof and surrounding area. Drains are recommended to be diverted outside area mosques.

To put in order the system of underground communications (water supply and sewer) With purpose exceptions leaks.

Limit irrigation of plantings through the use of water-saving technologies.

To control the condition of the foundation soils of the structure and the hydrogeological conditions are recommended:

to organize an observation network of wells for carrying out regime measurements level positions ground waters;

organize a monitoring system for monitoring the condition, moisture, soil compaction grounds foundation;

organize regime seismometric observations for the purpose of monitoring level seismic impacts and estimates them consequences.

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